Proceedings of the
International Expert Meeting on

Air Pollution Control in Urban Asia-Pacific

27-29 October 2014
Beijing Normal University, Zhuhai, China

ASIA-PACIFIC NETWORK FOR GLOBAL CHANGE RESEARCH

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BEIJING NORMAL UNIVERSITY, ZHUHAI

兵庫県
Hyogo Prefecture

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1. Background

1.1 Rationale

It is estimated that more than 1 billion people are exposed to outdoor air pollution each year at the global scale, and urban air pollution is linked to up to 1 million premature deaths annually. A lot is yet to be done, especially in developing countries and economies in transition, to introduce appropriate technology and institutional measures to tackle this issue for the wellbeing of this generation and those to come.

Many APN member countries have experienced rapid economic growth since the late twentieth century, which comes alongside growing energy consumption that has led to rapidly increased amount of pollutants in the atmosphere, leading to evident urban air pollution issues in countries in the region.

In response to the problem, national and local governments are taking stringent measures to monitor, analyse and control air pollutants. In order to address the issue in a concerted manner using the best available knowledge, there is a need for countries to share information and experience, and to identify needs and gaps in aspects of science, technology and policy measures for enhanced action.

The expert meeting will be hosted by Beijing Normal University (Zhuhai Campus), in the city of Zhuhai, which is located at the heart of Pearl River Delta, China's industrial powerhouse. The city is well known for its efforts to protect the environment while ensuring development, which include rigorous measures on air pollution control.

1.2 Objectives

The main objectives of the expert meeting are:

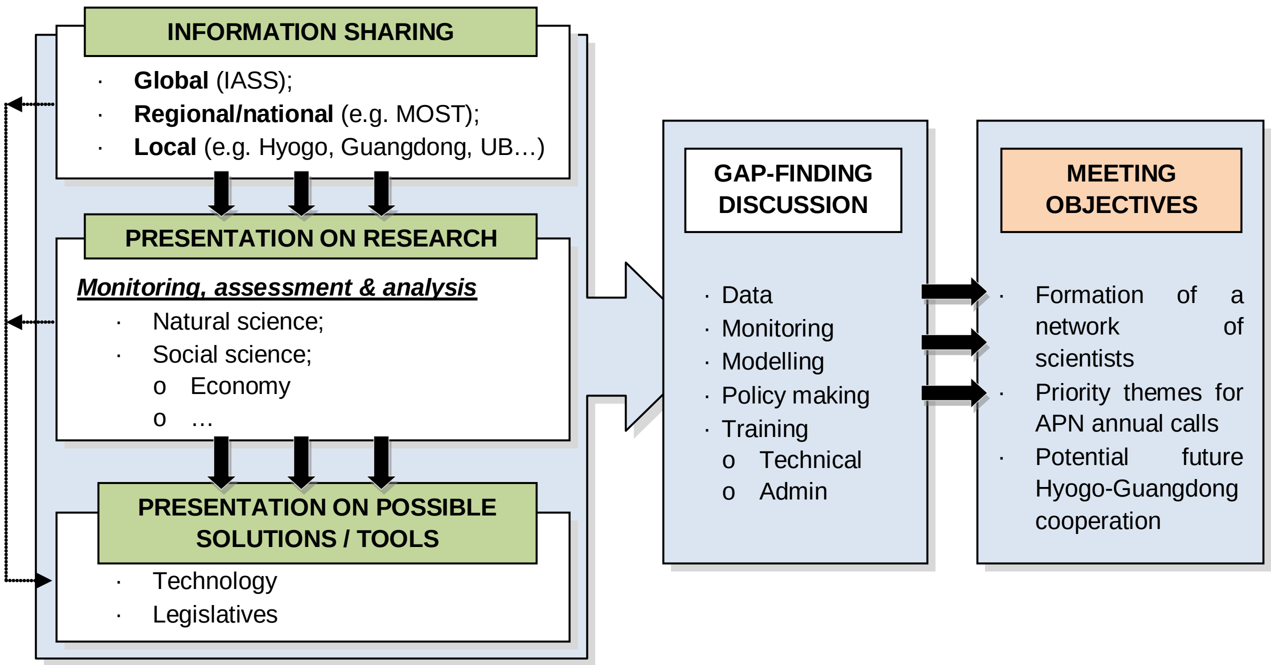
- to share information on air pollution in urban areas in countries the Asia-Pacific region, including the status of the air quality, recent research findings, technologies applied in relevant sectors, and policies and measures for air quality control;
- to identify thematic areas and effective approaches that should be enhanced under APN funding programmes.

1.3 Expected Output

The expert meeting is expected to produce the following outputs:

- A final report on the presentations, discussions and outcome of the meeting;
- A set of thematic priorities for APN funding programmes;
- Formation of a network of policy makers, experts and practitioners working in the area of air pollution control in the region.

1.4 Conceptual Structure



2. Agenda

Day 1, 27 October 2014, Lecture Hall (2F)

Session I. Opening Session

Time	Agenda Item	Presenter
09:00-09:30	Registration	All participants
09:30-09:40	Opening remarks	Dr. Zhongkui Wu, BNUZ Vice President
09:40-09:50	Welcome remarks	Ms. Junko UMETANI, Chief Executive Officer for the Environment, Hyogo
09:50-10:00	Welcome remarks	Dr. Jiutian Zhang, nFP Alternate for China
10:00-10:20	Welcome remarks, about APN, and meeting introduction	Mr. Hiroshi Tsujihara, APN Secretariat Director
10:20-11:00	*Group photo and coffee break*	

Session II. Air Pollution Control: Global, Regional and Local Status and Actions (1)
Chair: Dr Jiutian Zhang, nFP Alternate for China

Time	Agenda Item	Presenter
11:00-11:30	01. Air pollution in Asia-Pacific: A major environmental challenge to the development goals	Dr. Maheswar Rupakheti, IASS
11:30-11:50	02. China's actions in air pollution control	Prof. Yuanhang Zhang, PKU
11:50 – 13:20	*Lunch break*	

Session II. Air Pollution Control: Global, Regional and Local Status and Actions (2)
~ International Cooperation between Local Governments ~
Chair: Mr. Hideaki Koyanagi, Director, IGES Beijing office

Time	Agenda Item	Presenter
13:30-13:50	Introduction	Mr. Hideaki Koyanagi, Director, IGES Beijing office
13:50-14:10	03. Status of Air Pollution in Hyogo and Countermeasures	Mr. Kazuhiro Akiyama, Director General of Environmental Management Bureau, Hyogo
14:10-14:20	Q&A	

14:20-14:40	04. Status of Air Pollution in Guangdong and Countermeasures	Dr. Chen Duohong, Guangdong Province Environment Monitoring Center
14:40-15:00	05. Research Activities of The Hyogo prefectural Institute of Environmental Sciences (HIES)	Mr. Yasuhiro Kanda, Director The Hyogo prefectural Institute of Environmental Sciences, Hyogo Environmental Advancement Association
15:00-15:10	Q&A	
15:10-15:30	*Coffee Break*	
15:30-15:50	06. Air Pollution Prevention and Control Policies of Guangdong	Dr. Liao Chenghao, Guangdong Institute of Environmental Sciences
15:50-16:10	07. Environmental Measures at Kobe Steel, Ltd.	Mr. Yoshinobu Nakane, General Manager, Environmental Control & Disaster Prevention Dept., Kobe Steel, LTD.
16:10-16:20	Q&A	
16:20-16:40	Feedback from observers	Hyogo, Guangdong
16:40-17:20	Audience interaction	All participants
17:20-17:30	Wrap-up of the session	Mr. Hideaki Koyanagi, Director, IGES Beijing office
18:30-20:00	*Reception dinner*	

--- End of Day 1 ---

Day 2, 28 October 2014, Meeting Room 3, 2F

Session II. Air Pollution Control: Global, Regional and Local Status and Actions (3)

Chair: Dr. Madan Lall Shrestha, SPG Member for Nepal

Time	Agenda Item	Presenter
09:00-09:10	Participants self-introduction	All participants
09:10-09:35	08. Seoul Metropolitan Air Quality Management: Current Achievement and Future Challenges	Prof. Jung-Hun Woo
09:35-10:00	09. Thailand case study	Dr. Jariya Boonjawat
10:00-10:25	10. Indonesia case study	Dr. Erna Sri Adiningsih
10:25-10:40	Q&A, discussion	All participants
10:40-11:00	*Coffee break*	

Session III.
Monitoring, Assessment & Analysis: Perspectives of Science, Economics & Health (1)
Chair: Dr Jariya Boonjawat, SPG Member for Thailand

Time	Agenda Item	Presenter
11:00-11:25	11. Air Pollution Control in Japan	Prof. Niizawa Hidenori
11:25-11:50	12. The role of developed/developing world sulphur emissions on climate system change	Ms. Di Tian
11:50-12:15	13. Current priority concerns of research on industry-related air quality issues at Roshydromet, Russia; international collaboration	Mr. Anton Uspensky
12:15-12:40	Q&A, discussion	All participants
12:40 – 14:00	*Lunch break*	

Session III.
Monitoring, Assessment & Analysis: Perspectives of Science, Economics & Health (2)
Chair: Dr. Erna Adiningsih, SPG Member for Indonesia

Time	Agenda Item	Presenter
14:00-14:25	14. Implications of energy trade on GHGs emission and air pollution	Prof. Wenping Yuan
14:25-15:10	15. Air pollution and human health in Guangdong, China	Dr. Hualiang Lin
15:10-15:35	16. Experience and practice of vehicle emissions control in Japan	Prof. Shinya Koyama
15:35-16:00	*Coffee break*	

Session IV
Possible Tools and Solutions for Air Pollution Control
Chair: Dr Jariya Boonjawat, SPG Member for Thailand

Time	Agenda Item	Presenter
16:00-16:25	17. Possible tools and solution, overview	Prof. Tian Hezhong, BNU
16:25-16:50	18. Mongolian experience on air pollution reduction	Mrs. Tsendsuren D.
16:50-17:30	Q&A, Discussion	All participant
18:30-	*Dinner*	

--- End of Day 2 ---

Day 3, 29 October 2014, Meeting Room 3, 2F

Session V
Gap-finding Discussion
Chairs: Dr. Madan Lall Shrestha & Dr. Erna Adiningsih

Time	Agenda Item	Presenter
09:00-10:45	Discussion: research and capacity needs for air pollution control in Asia-Pacific countries	All participants
10:45-11:05	*Coffee break*	
11:05-12:30	Development of a list/matrix of research and capacity gaps for future actions	All participants
12:30-12:45	Closing remarks	Dr. Madan Lall Shrestha

--- End of Day 3 ---

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4. Opening Addresses

4.1 Ms. Junko Umetani, CEO for the Environment, Hyogo Prefectural Government

I am Junko Umetani, CEO for the Environment at Hyogo Prefectural Government. It is my great pleasure and honor to see you all in the International Expert Meeting on Air Pollution Control in Urban Asia-Pacific being held with so many participants in attendance, here in Guangdong Province, a friendly state of Hyogo Prefecture.

Currently, we have observed a temporary increase in PM 2.5 in Hyogo. We need to take proper actions to deal with health damage caused by air pollution, and to ensure the safety of local residents. To achieve this, it is essential to implement measures against air pollution not only as local initiatives, but also as a joint project of countries in the Asia-Pacific region.

At the 16th Tripartite Environment Ministers Meeting held in Daegu, Korea this April, it was agreed to further strengthen joint initiatives regarding air pollution prevention and control, and the reinforcement and enhancement of cooperative relations among various entities, including local governments, companies and institutions, has been encouraged.

The APN and its activities play a very important role for the environmental issues in the Asia-Pacific region. As a representative of the Hyogo Prefectural Government, I would like to extend my sincere respect for their activities. Also I am proud that Hyogo has been providing various kind of support to APN.

I hope that the APN will continue active scientific research and policy promotion regarding air pollution control and other global environmental issues, in coalition with the governments and organizations of its member countries.

In today's afternoon sessions, I understand specialists, researchers and business operators from both Guangdong and Hyogo will make presentations on regional initiatives to control air pollution. I would like to expect significant discussions will be held among participants.

To conclude my address, please allow me to express my best wishes for the success of the conference and all of the participants. Thank you very much.

4.2 Mr. Hiroshi Tsujihara, Director, APN Secretariat

Distinguished Dr. Zhang Jiutian, nFP Alternate for China, Dr. Wu, Vice President, Beijing Normal University Zhuhai, Ms. Umetani, CEO for the Environment, Hyogo Prefectural Government, Participants, Invited Experts, Ladies and Gentlemen, Good morning.

At the opening of the Meeting, I would like to express my special thanks to all participants who have travelled to attend this meeting.

First of all, let me introduce myself. My name is Hiroshi Tsujihara. I am the Director of APN secretariat.

APN is an Inter-Governmental organization of 22 member countries in the Asia-Pacific region. It was established in 1996 as a result of Japan-US initiative to promote global change research. It means next year is the 20th anniversary for APN.

The Asia-Pacific Network for Global Change Research (APN)'s research and capacity building programs manage up to sixty national/regional projects every year across a broad range of global change disciplines. In addition to its core programs, APN has also initiated three new frameworks established in 2012 and 2013 which are the Climate Adaptation Framework; the Biodiversity & Ecosystems Services; and the Low Carbon Initiatives Framework.

As one of these activities, we today have a meeting on air pollution counter measures in cities that many member countries might be interested in.

APN established its secretariat in Kobe in 1999 with support of Hyogo prefectural government of Japan. Since then, Hyogo prefectural government has continuously supported APN. On behalf of APN secretariat, I would like to express my sincere gratitude for this support.

This meeting is held as one of Hyogo Activities. This meeting is also supported by Beijing Normal University. I would like to express my sincere gratitude for this support.

This meeting, which starts today and continues until the day after tomorrow, can be thought as a scoping workshop.

First of all, we would like to share information and knowledge about air pollution in city areas and example of countermeasures for this problem in this meeting. Based on information and advice from experts, we would like to discuss gaps that we have now, and further approach to address these problems. APN would like to use the information shared in this workshop to make next strategic plan that starts 2015. It is also our pleasure if we can make international network of experts through this workshop.

Finally, I hope this 3 days meeting will have fruitful outcomes and help many countries to address air pollution.

Thank you again for your attendance and cooperation.

5. Outcome Document: Matrix of Possible Thematic Areas and Types of Activities

Thematic Areas	Scope	Activities
Research, Monitoring and Analysis		
I. Scientific Aspects 1. Data and information on air pollution including standards.	National/Regional	ü Data collection (field data, airborne data, satellite data) ü Data processing and analysis ü Production of information ü Data sharing and access
2. Emission inventory	Urban/Local, National, Regional (including CAPs & HAPs)	ü Development of comprehensive inventory (temporal and spatial) for modeling and control purposes
3. Weather, climate and air pollution interactions	Urban/Local, National, Regional	ü Field campaign and regional/mesoscale modeling
4. Status of black carbon	Urban/Local, National, Regional	ü Research on impacts of black carbon on climate, health, air quality and hydrological cycle
5. Transboundary air pollution	Regional	ü Research on long-range transboundary transport of air pollution from biomass burning, coal burning, and volcano eruption (man-made and natural sources)
II. Impacts of Air Pollution 1. Impacts on human health	Urban/Local, National	ü Comprehensive research on the effects of PM air pollution (PM10 or smaller PM) and gaseous air pollutants on human health (including particle size, chemical composition and emission source) ü Assessing the short-term and long-term effects of air pollution impacts on health
2. Impacts on agriculture and ecosystem	National, Regional	ü Promotion of pollutant monitoring, especially ozone, in the area of agriculture ü Impact of air pollution on photosynthetic activity and crop production

Mitigation and Countermeasure		
III. Mitigation of Air Pollution 1. Energy use, economy, climate change, and air pollution relationships	National, Regional	ü Energy use efficiency and air pollution control
2. Air pollution control and reduction actions	Urban/Local, National, Regional	ü Development and assessment of low carbon city/society
3. Technology transfer on air pollution control	Regional	ü Cooperation in technology transfer cooperation on air pollution control
4. Reduction of air pollutants from biomass burning and coal burning	Urban/Local, National, Regional	ü Development and assessment best practices
IV. Science-Policy Interfacing on Air Pollution Control	Urban/Local, National, Regional	ü Production and dissemination of policy briefs on air pollution control and actions ü Science-Policy-Private Sector dialogue on air pollution control
V. Public Awareness and Education on Air Pollution	Urban/Local, National	ü Dissemination of air pollution information and control actions to various communities: development of dissemination system (such as through mobile phone application) ü Training and/or education tool kits for local people

6. Presentations

6.1 Air pollution in Asia-Pacific: A major environmental challenge to the development goals (Maheswar Rupakheti)

Short-Lived Climate-forcing Pollutants (SLCP)

IASS POTSDAM

Long-lived GHGs

- **Gases:**
  - Carbon dioxide (CO_2)
  - Nitrous oxide (N_2O)
  - Chlorofluorocarbons (CFCs)

SLCP (air pollutants)

- **Aerosol Particles:**
  - Soot, incl. Black Carbon (BC)
  - Organic Carbon (OC), incl. BrC.
  - Sulfate (SO_4^{2-})
  - Nitrate (NO_3^-)
  - Ammonium (NH_4^+)
- **Gases:**
  - Methane (CH_4)
  - Ozone (O_3)
  - Hydrofluorocarbons (HFCs)
  - Nitrogen oxides (NO_x)
  - Carbon monoxide (CO)
  - Volatile Organic Compounds (VOCs)
  - Sulfur dioxide (SO_2)

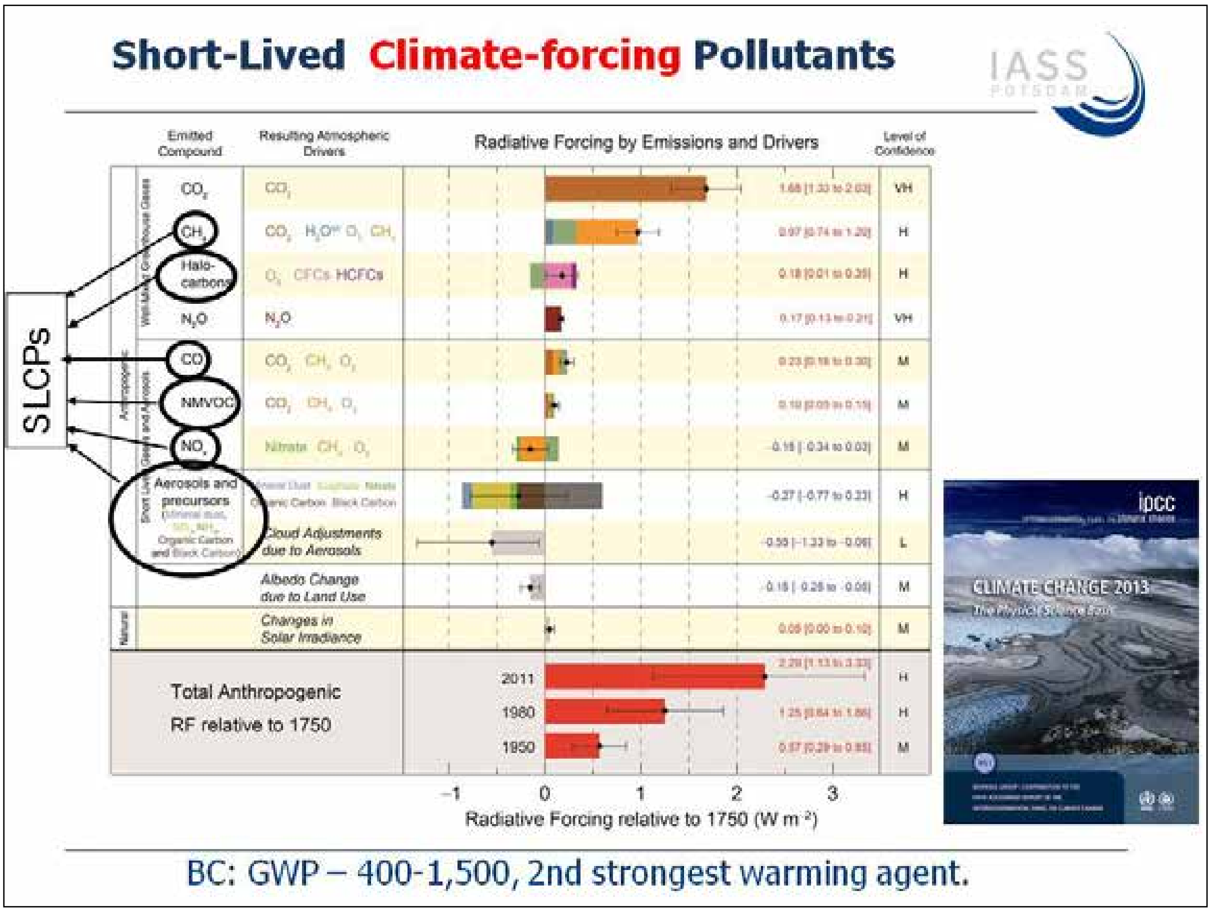
Short-Lived Climate-forcing Pollutants

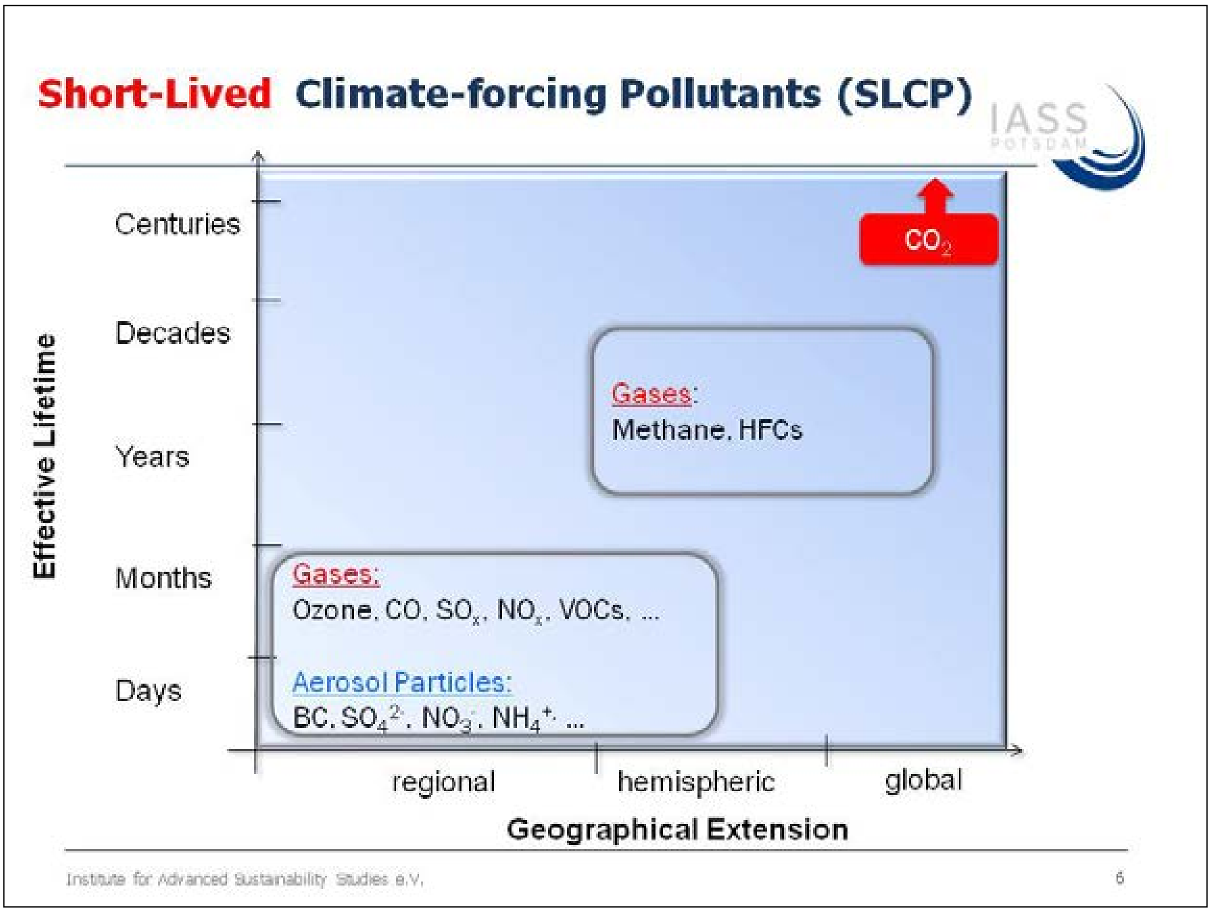
IASS POTSDAM

Filter used for PM10 sampling, 16 L/min., Bode, Kathmandu (SusKat-ABC Supersite)

After... 24 Hours!

Institute for Advanced Sustainability Studies e.V. Courtesy: Jinsoo, Khadak, Dipesh, Bhogendra 4


Short-Lived Climate-forcing Pollutants
IASS
POTSDAM
Emitted Compound
Resulting Atmospheric Drivers
Radiative Forcing by Emissions and Drivers
Level of Confidence
SLCPs
Total Anthropogenic
RF relative to 1750
2011
1980
1950
Radiative Forcing relative to 1750 (W m⁻²)
ipcc
CLIMATE CHANGE 2013
The Physical Science Basis
BC: GWP – 400-1,500, 2nd strongest warming agent.


Short-Lived Climate-forcing Pollutants (SLCP)
IASS
POTSDAM
Effective Lifetime
Centuries
Decades
Years
Months
Days
CO2
Gases:
Methane, HFCs
Gases:
Ozone, CO, SOx, NOx, VOCs, ...
Aerosol Particles:
BC, SO4 2-, NO3 -, NH4 +, ...
regional
hemispheric
global
Geographical Extension
Institute for Advanced Sustainability Studies e.V.
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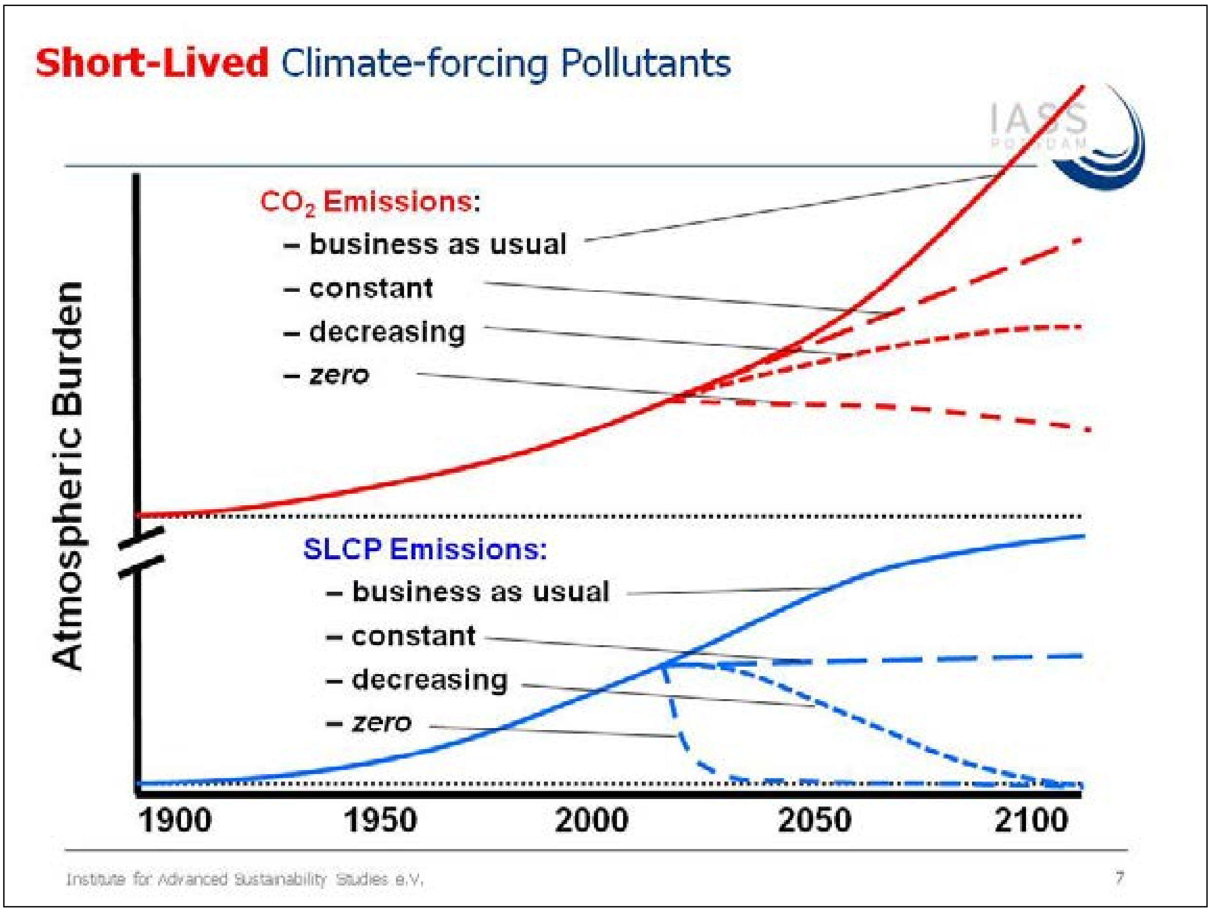
Short-Lived Climate-forcing Pollutants
IASS POTSDAM
Atmospheric Burden
CO2 Emissions:
– business as usual
– constant
– decreasing
– zero
SLCP Emissions:
– business as usual
– constant
– decreasing
– zero
1900
1950
2000
2050
2100
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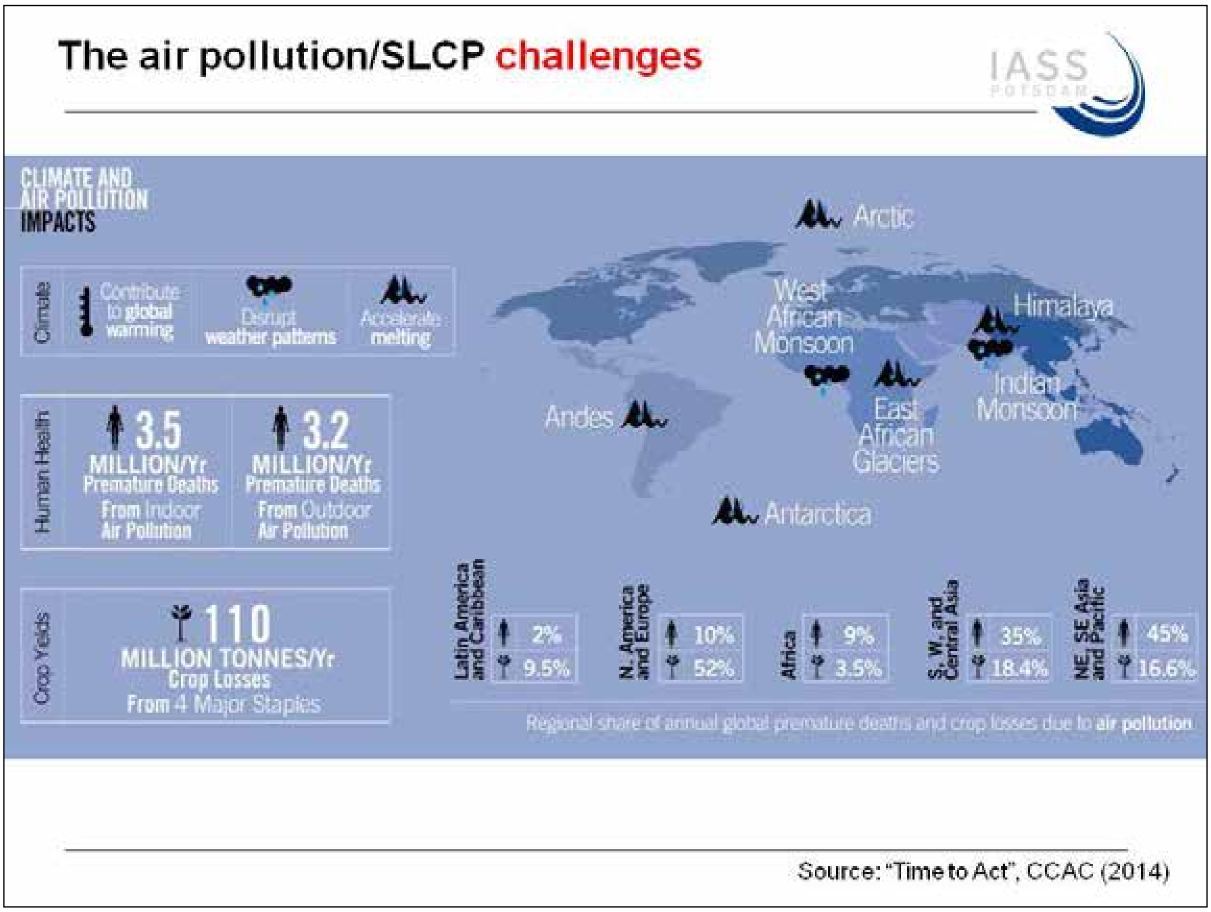
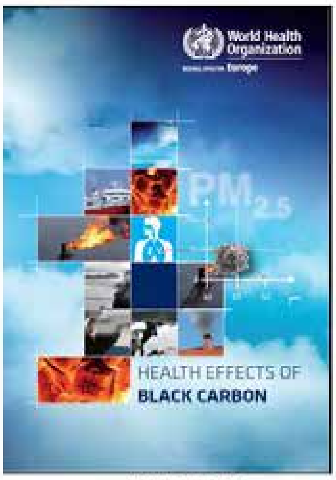

The air pollution/SLCP challenges
IASS POTSDAM
CLIMATE AND AIR POLLUTION IMPACTS
Climate
Contribute to global warming
Disrupt weather patterns
Accelerate melting
Human Health
3.5 MILLION/Yr Premature Deaths From Indoor Air Pollution
3.2 MILLION/Yr Premature Deaths From Outdoor Air Pollution
Crop Yields
110 MILLION TONNES/Yr Crop Losses From 4 Major Staples
Arctic
West African Monsoon
Himalaya
Indian Monsoon
Andes
East African Glaciers
Antarctica
Latin America and Caribbean 2% 9.5%
N. America and Europe 10% 52%
Africa 9% 3.5%
S, W, and Central Asia 35% 18.4%
NE, SE Asia and Pacific 45% 16.6%
Regional share of annual global premature deaths and crop losses due to air pollution
Source: "Time to Act", CCAC (2014)

Air pollution is the largest environmental health risk

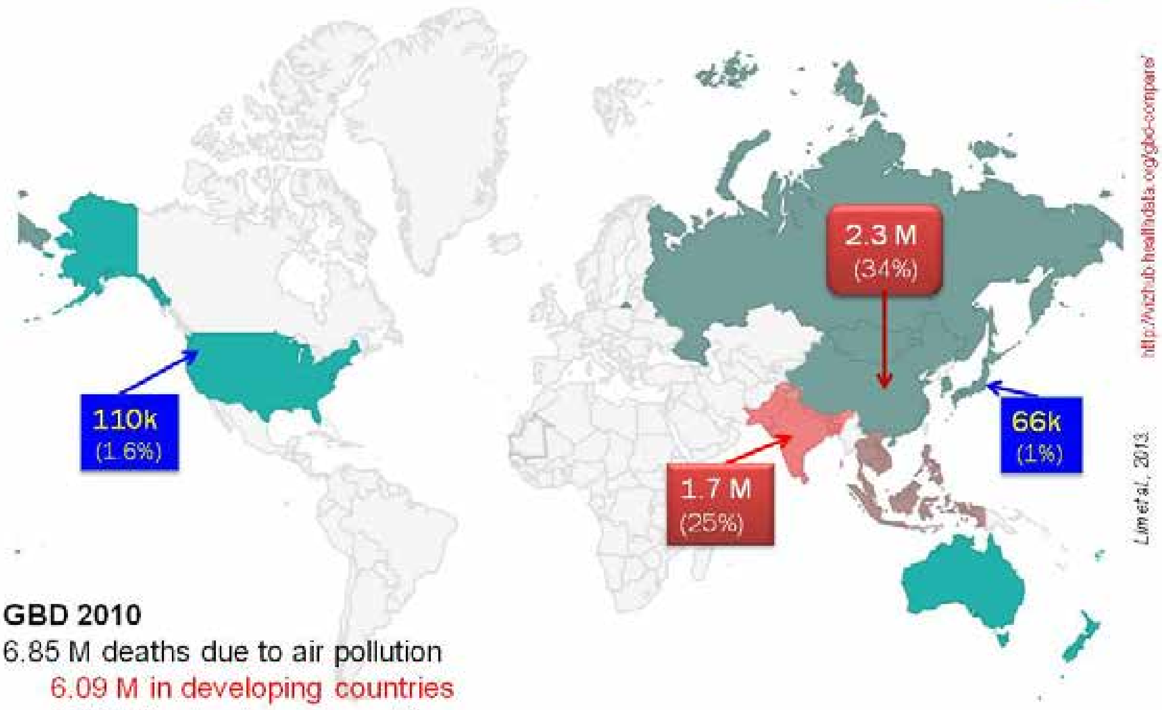
- March 2014
  WHO estimates that air pollution kills 7 million a year
  - Indoor air pollution: 3.5 Million
  - Outdoor air pollution: 3.2 Million
- October 2013
  WHO classified "Air Pollution" as cancer causing agent.
- June 1012
  WHO classified "Diesel exhaust fumes, notably black carbon (BC)" as cancer causing agent



WHO 2012

Institute for Advanced Sustainability Studies e.V. 9

AP is a major environmental health risk in Asia-Pacific



GBD 2010
6.85 M deaths due to air pollution
6.09 M in developing countries
0.76 M in developed countries

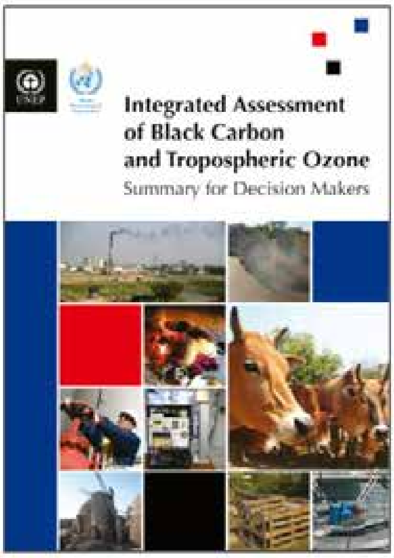
Air Pollution and its effects in Asia-Pacific

IASS POTSDAM

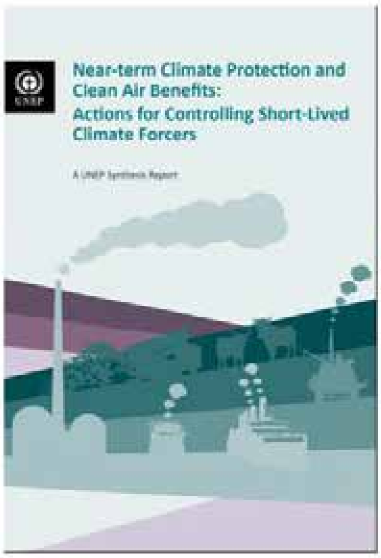
- Poor air quality
  - Reduced Visibility
    - Premature deaths
      - Crop losses
  - Atmospheric heating
    - Solar dimming
      - Surface cooling
        - Snow and glacier melting
          - Disrupt weather pattern (monsoon)
            - Intensification of storms
  - Ecosystem damage
- Socio-economic impacts

Air Pollution (SLCP) Mitigation is possible

IASS POTSDAM



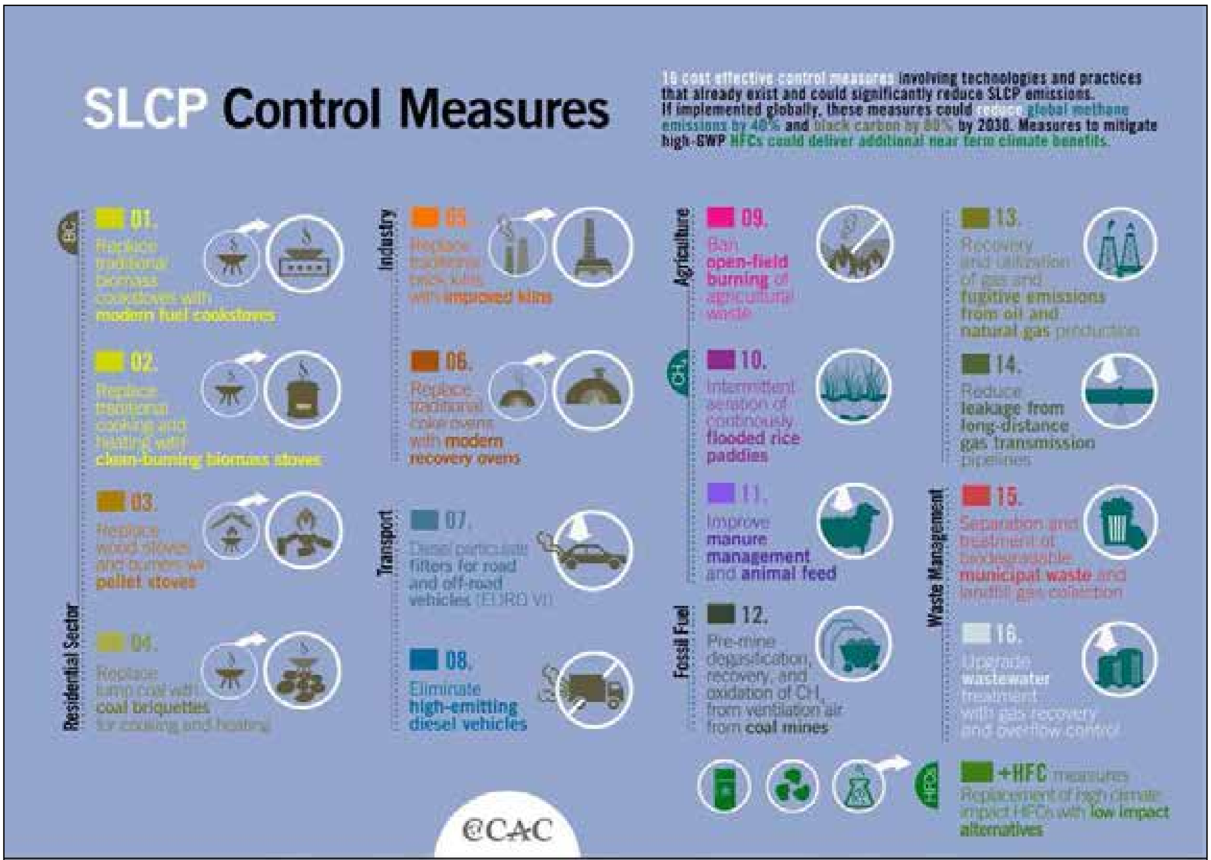
(UNEP/WMO 2011)



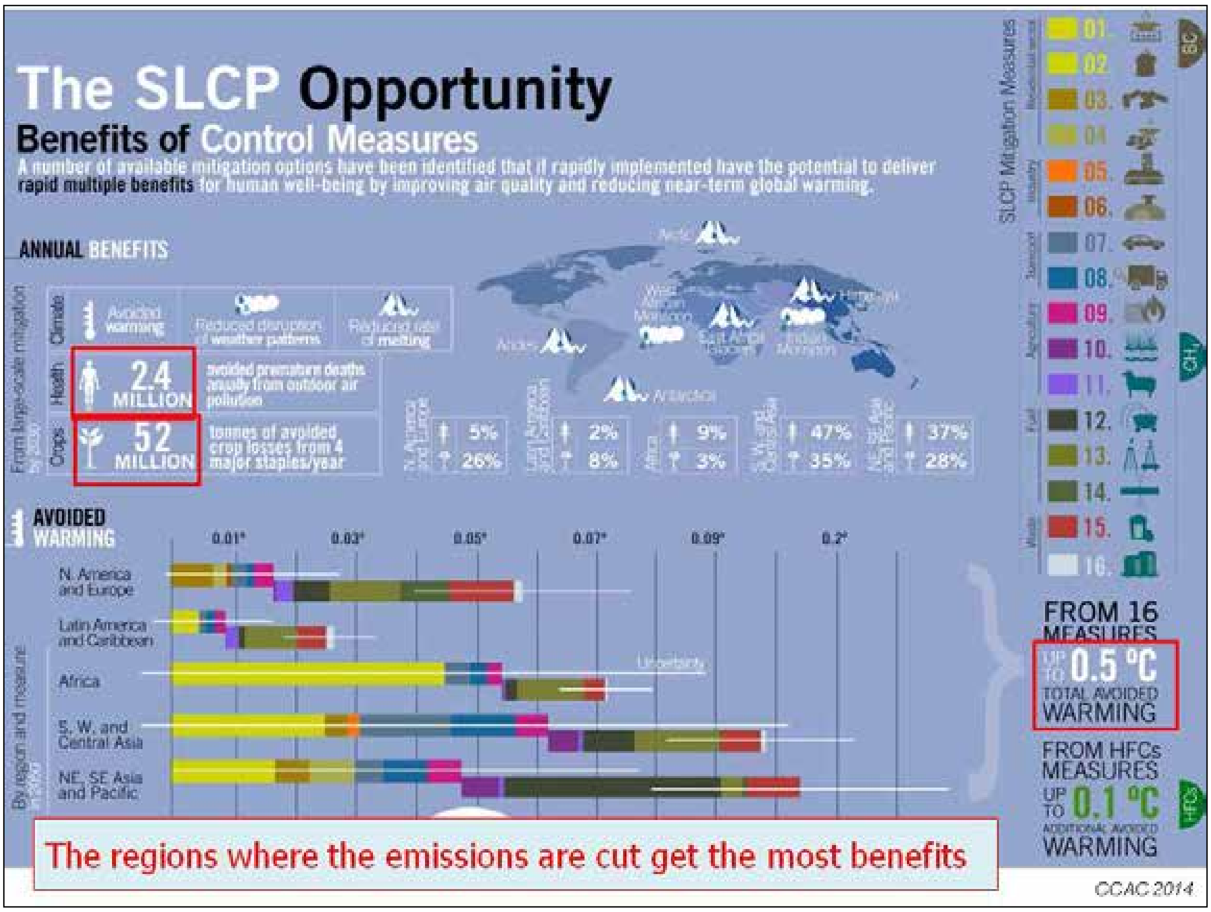
(UNEP 2011)

(World Bank 2014)

(www.unep.org)



CCAC 2014, based on UNEP/WMO 2011 and Shindell et al, Science, 2012



Solutions must be tailored to local context

IASS POTSDAM

Identify the

- **Innovative mitigation solutions** (science, technology, finance, market, institution, policy and regulations, strategies and planning actions)

that are

- **Science-based**

but yet

- **Fit to local/national context and priorities**

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SLCP Activities and Initiatives

CLIMATE AND CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

CCAC

A coordinated action SLCP at the global level

Initiatives

- Reducing Black Carbon Emissions from **Heavy Duty Diesel Vehicles and Engines**
- Mitigating SLCPs from **Municipal Solid Waste Sector**
- Mitigating Black Carbon and Other Pollutants from **Brick Production**
- Promoting **HFC Alternative Technology** and Standards
- Accelerating Methane and Black Carbon Reductions from **Oil and Natural Gas Production**
- Reducing SLCPs from **Household Cooking and Domestic Heating**
- Addressing SLCPs from **Agriculture**
- Supporting **National Planning for Action** on SLCPs (SNAP)
- **Regional Assessments** of SLCPs
- **Financing of** SLCP Mitigation
- Urban health

Membership:
- Voluntary membership
- 88 members (as of June 2014)
  38 State Members
  1 EC
  49 IGOs and NGOs

http://www.unep.org/ccac/

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UNEA United Nations Environment Assembly of the United Nations Environment Programme

18-27 June 2014

- Historic UN Environmental Assembly (UNEA) made a resolution –

  "Air pollution a priority issue",

and called for

  "Strengthened action on air quality".

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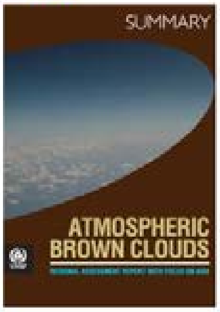
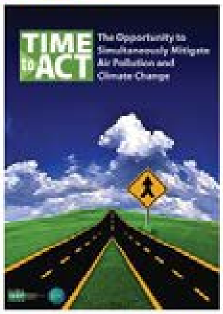
ABC



http://www.rrcap.unep.org/abc/

IGAC



http://www.igacproject.org/AirPolClim

EU

Review of the EU Air policy

http://ec.europa.eu/environment/air/review_air_policy.htm

Asia Pacific Clean Air Partnership MOEJ-UNEP (24 July 2014)

- bring together multiple regional initiatives to provide clear policy options based on the best science to support action on air pollution across the region.

Our (IASS) effort in addressing air pollution

IASS POTSDAM

Kathmandu Valley as a Case Study

Sustainable Atmosphere for the Kathmandu Valley

(SusKat):

Air pollution in the Kathmandu Valley

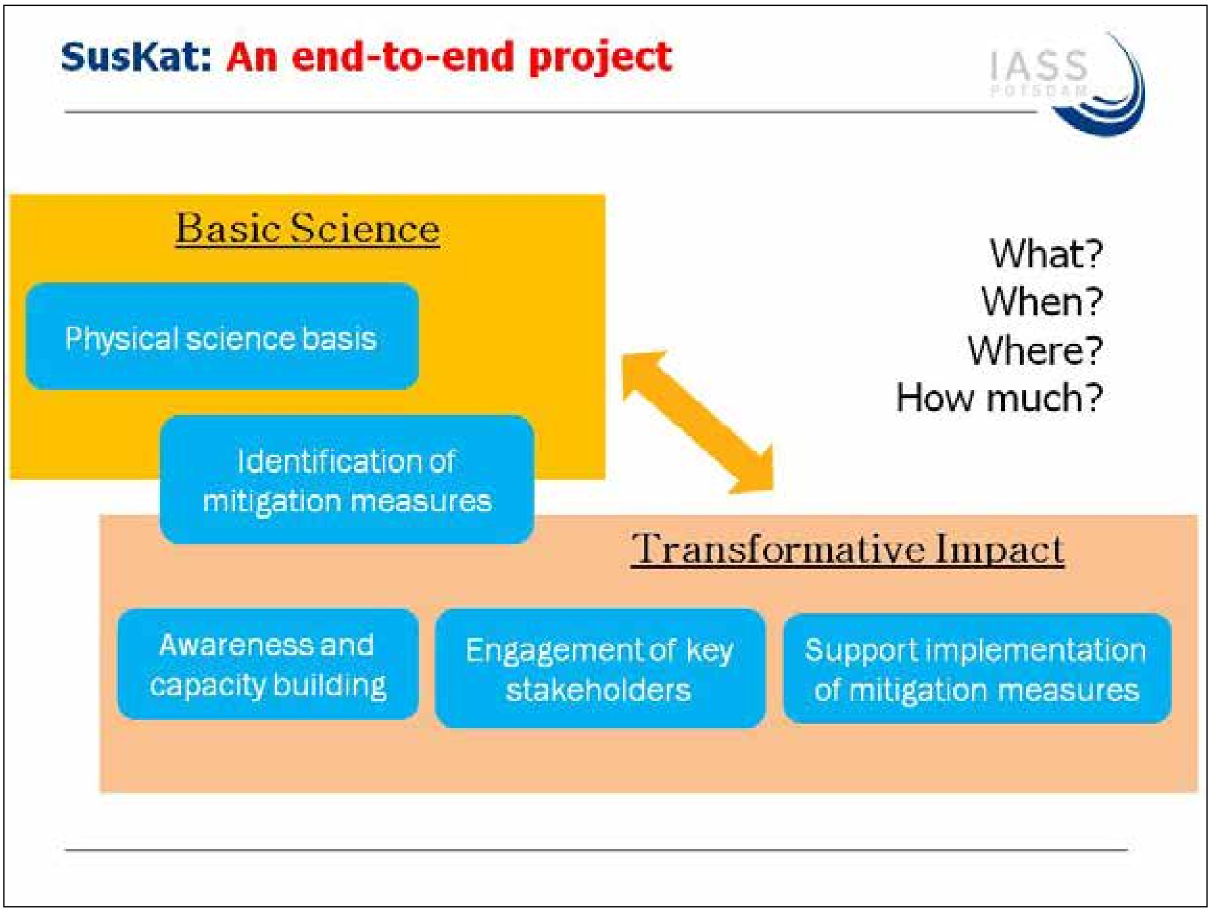
IASS POTSDAM

Photo: Maheswar Rupakheti

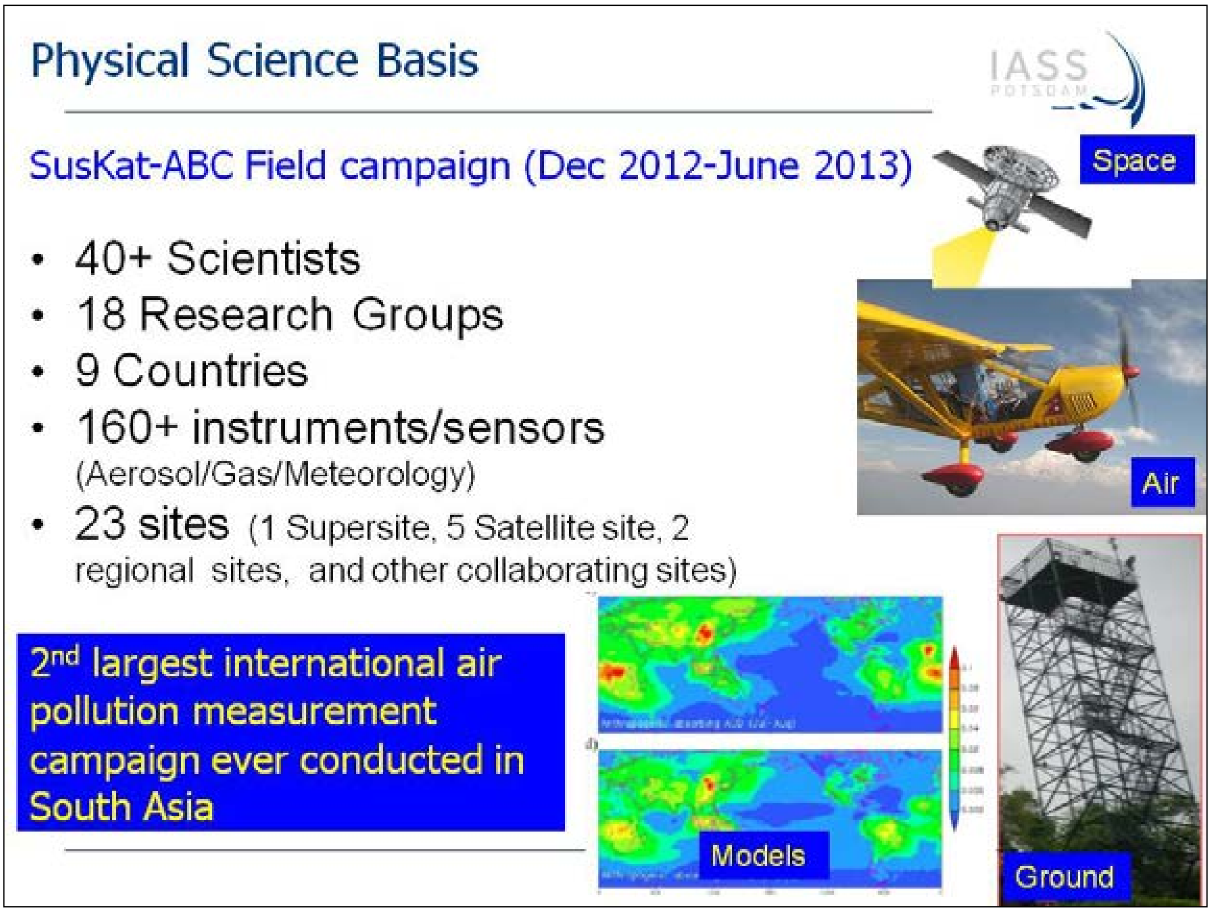
Air pollution in the Kathmandu Valley

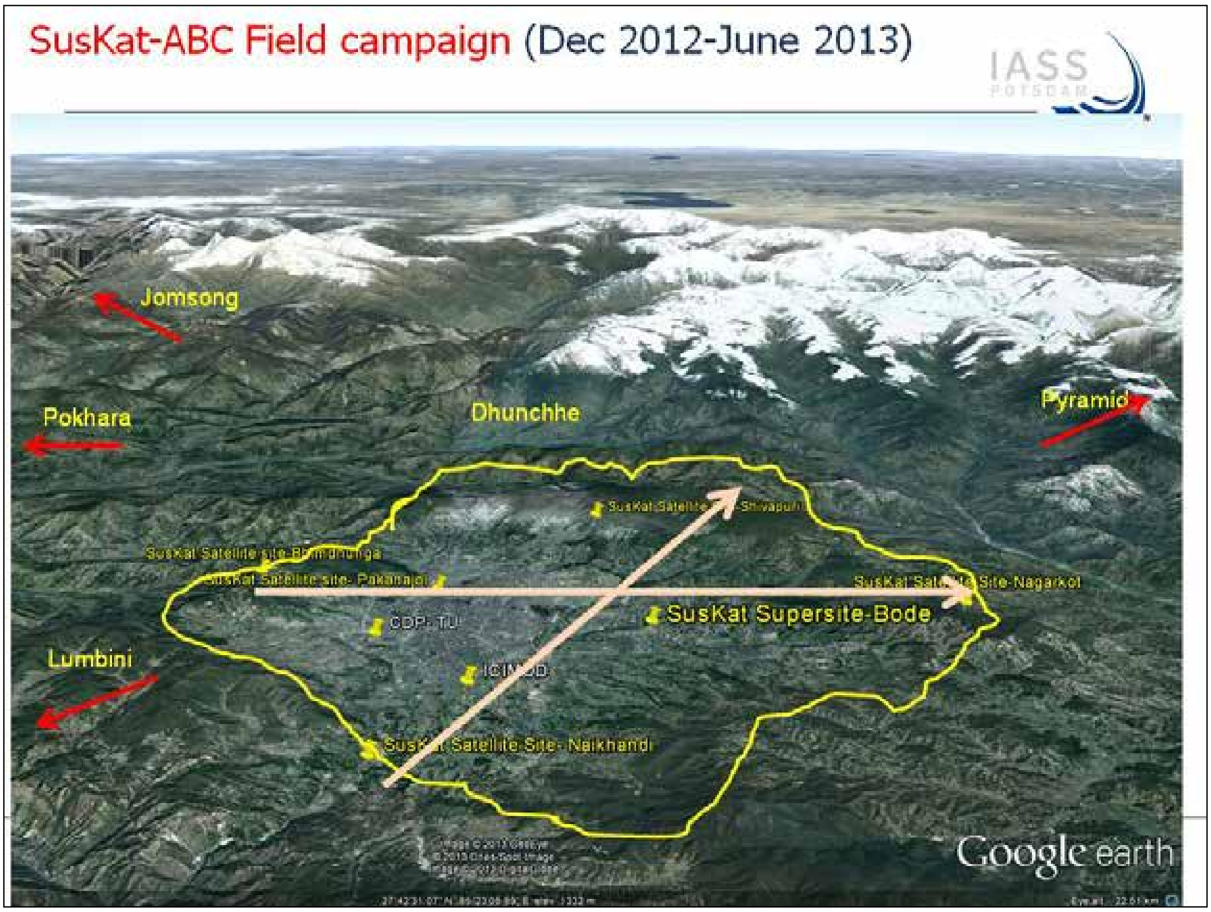
IASS POTSDAM

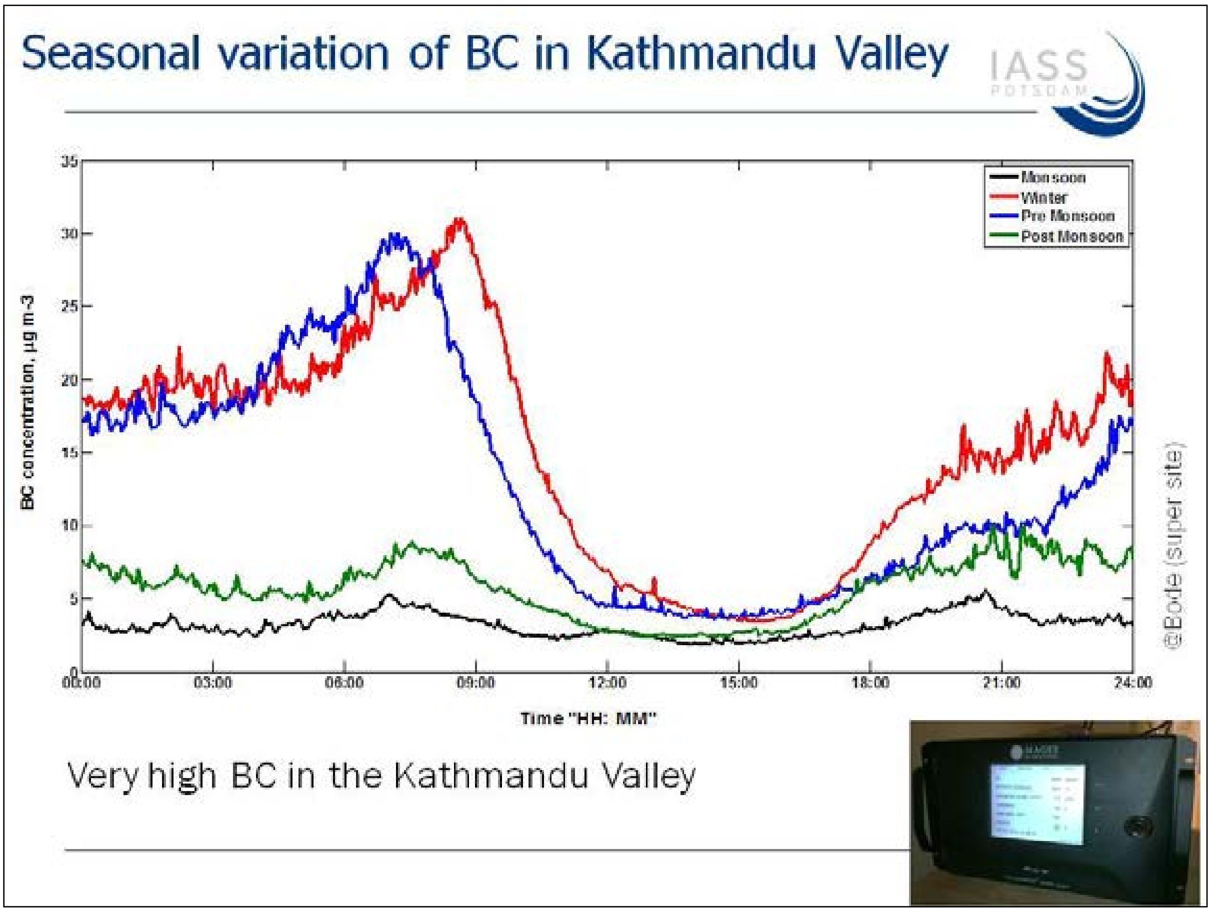
"Sizable pollution but still manageable in terms of interventions"

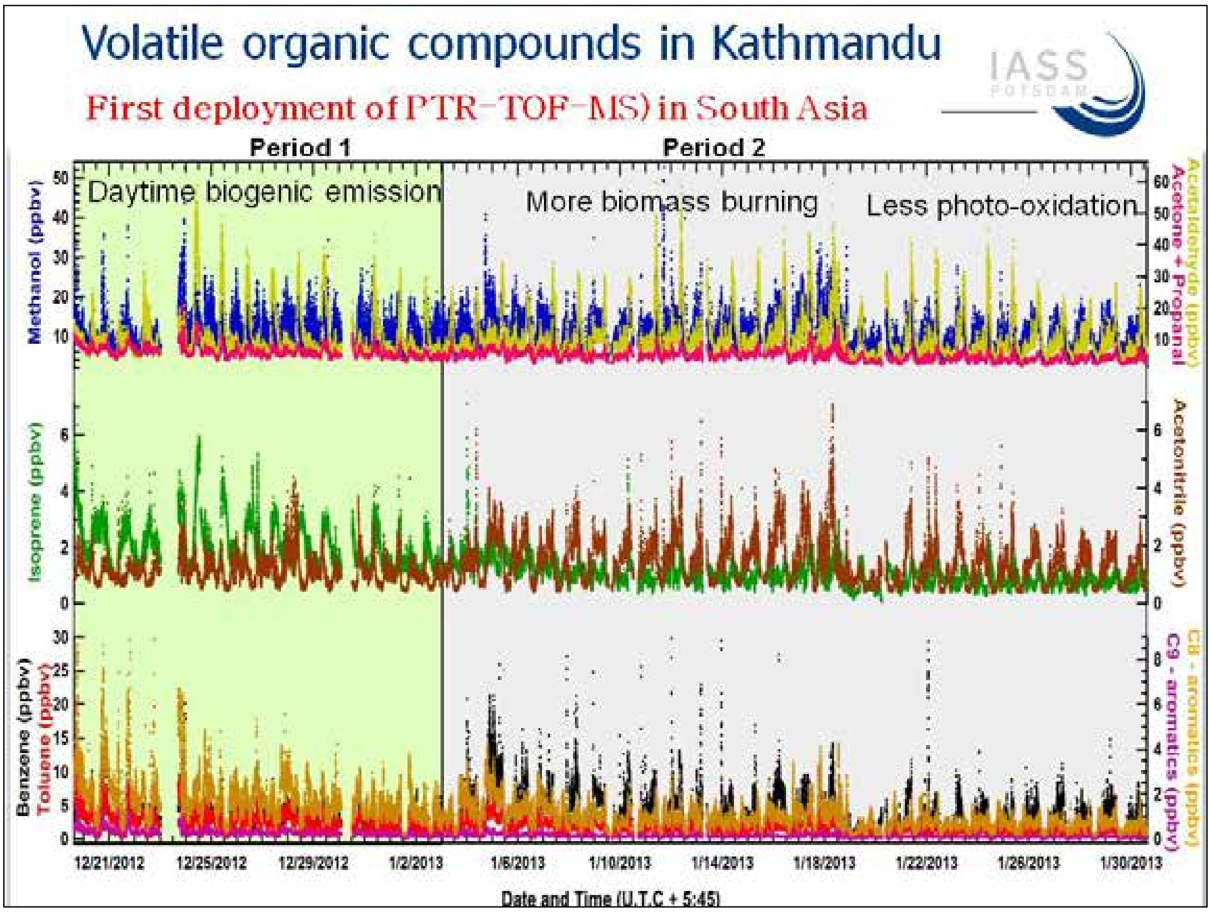

SusKat: An end-to-end project
IASS POTSDAM
Basic Science
Physical science basis
Identification of mitigation measures
What?
When?
Where?
How much?
Transformative Impact
Awareness and capacity building
Engagement of key stakeholders
Support implementation of mitigation measures


A joint Effort of 25 collaborators
IASS POTSDAM
ICIMOD
SEOUL NATIONAL UNIVERSITY
National Institute of Environmental Research
AIT
Aryabhatta Research Institute of Observational Sciences
आर्यभट्ट प्रेक्षण विज्ञान शोध संस्थान
(An autonomous institute under the Department of Science and Technology, Govt. of India)
ARIES
NARL
UMASS AMHERST
中國科学院
CHINESE ACADEMY OF SCIENCES
IASS POTSDAM
Aerosols
ClimPol
ELIAS
JG|U
JOHANNES GUTENBERG UNIVERSITÄT MAINZ
AERONET
Aerosol Robotic Network
KIT
Karlsruhe Institute of Technology
EvK2CNR
Aerosol
Yale University


Physical Science Basis
IASS POTSDAM
SusKat-ABC Field campaign (Dec 2012-June 2013)
Space
• 40+ Scientists
• 18 Research Groups
• 9 Countries
• 160+ instruments/sensors (Aerosol/Gas/Meteorology)
• 23 sites (1 Supersite, 5 Satellite site, 2 regional sites, and other collaborating sites)
Air
2nd largest international air pollution measurement campaign ever conducted in South Asia
Models
Ground


SusKat-ABC Field campaign (Dec 2012-June 2013)
IASS POTSDAM
Jomsong
Pokhara
Dhunchhe
Pyramid
Lumbini
SusKat Satellite- Shivapuri
SusKat Satellite site- Bhimdhunga
SusKat Satellite site- Pakanajol
SusKat Satellite Site-Nagarkot
SusKat Supersite-Bode
CDP-TU
ICIMOD
SusKat Satellite Site- Naikhandi
Google earth

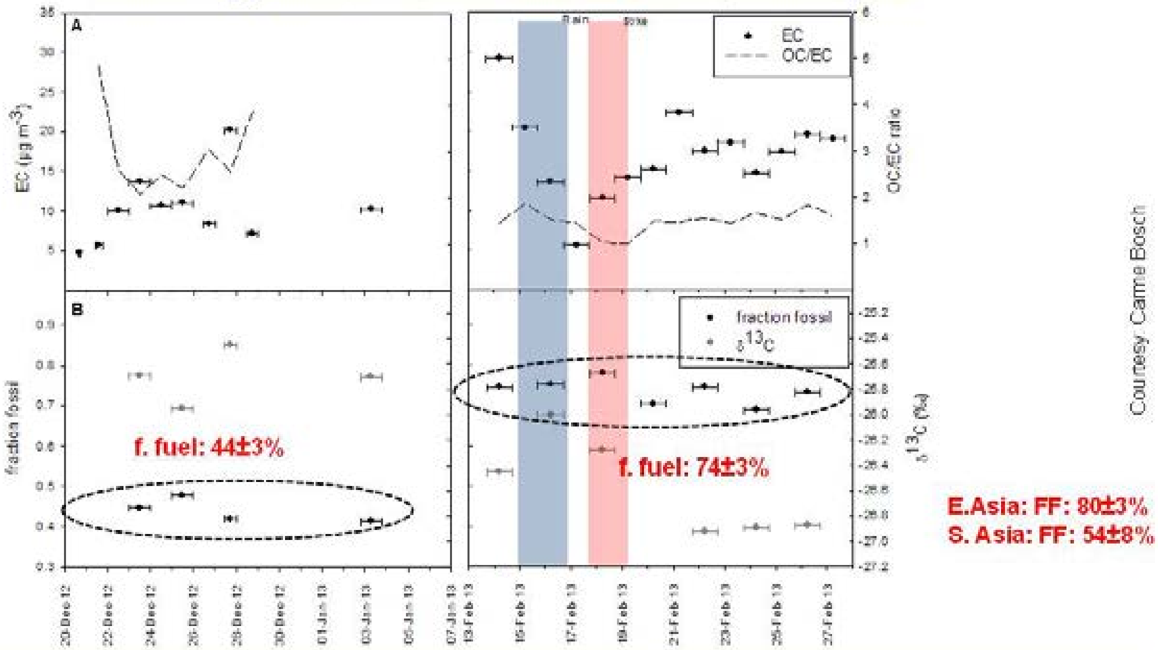

Seasonal variation of BC in Kathmandu Valley
IASS POTSDAM
Monsoon
Winter
Pre Monsoon
Post Monsoon
BC concentration, µg m-3
Time "HH: MM"
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
24:00
©Bode (super site)
Very high BC in the Kathmandu Valley


Volatile organic compounds in Kathmandu
IASS POTSDAM
First deployment of PTR-TOF-MS) in South Asia
Period 1
Period 2
Daytime biogenic emission
More biomass burning
Less photo-oxidation
Methanol (ppbv)
Acetaldehyde (ppbv)
Acetone + Propanal
Isoprene (ppbv)
Acetonitrile (ppbv)
Benzene (ppbv)
Toluene (ppbv)
C8 - aromatics (ppbv)
C9 - aromatics (ppbv)
12/21/2012
12/25/2012
12/29/2012
1/2/2013
1/6/2013
1/10/2013
1/14/2013
1/18/2013
1/22/2013
1/26/2013
1/30/2013
Date and Time (U.T.C + 5:45)

Sources of BC in the Kathmandu Valley

IASS POTSDAM

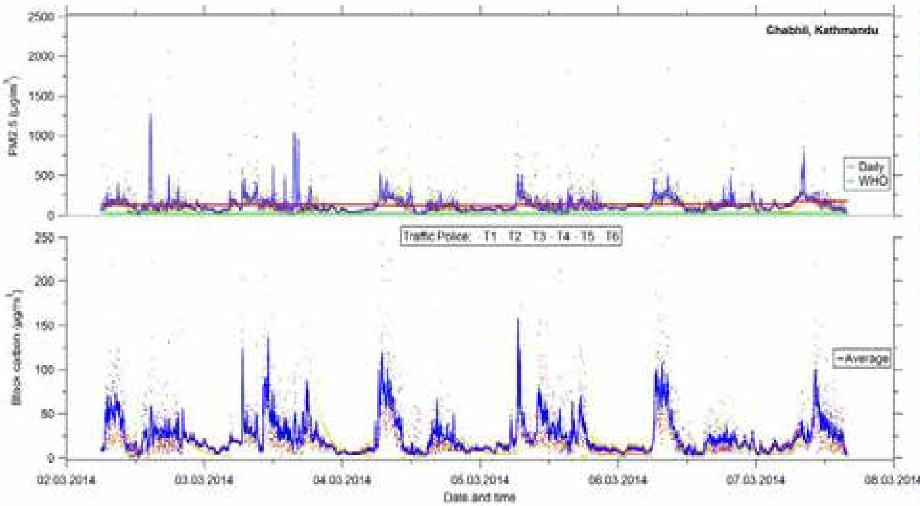
Source apportionment of EC based on C13/14 analysis



Late Jan-Feb: Cold period, all brick kilns operating, power cut hours increased.

Health impact of BC and PM2.5

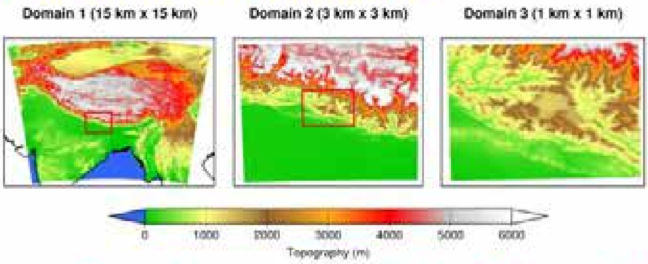
IASS POTSDAM



Traffic policemen and general public are exposed to very high PM2.5 and BC

Analysis of mitigation with model simulations

- Understand the physical processes and mechanisms of emissions, transport, transformation, removal, and impacts of air pollutants

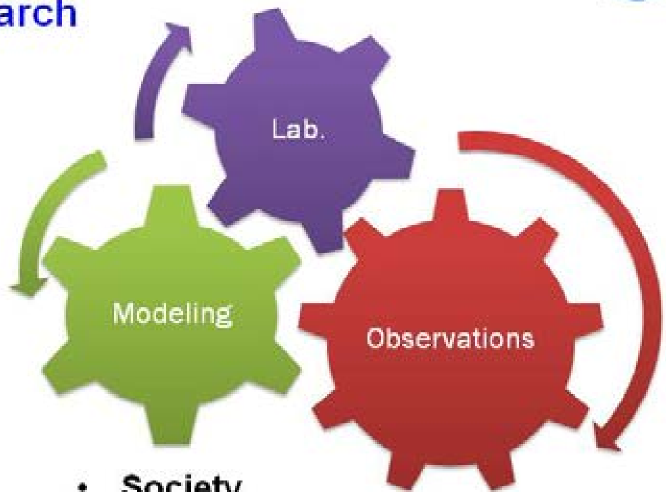


- Analyze mitigation potential of the mitigation options (anticipated impacts of interventions) and identify the ones that fit to local context and priorities in consultation with the key stakeholders

Engagement, Dialogue and Outreach

Air pollution research should go beyond science

- Fundamental Research



- Applied Research

Include human dimension
- Society
- Culture
- Economics
- New technology intrusion
- Behavior
- National Development goals

Thank You

maheswar.rupakheti@iass-potsdam.de

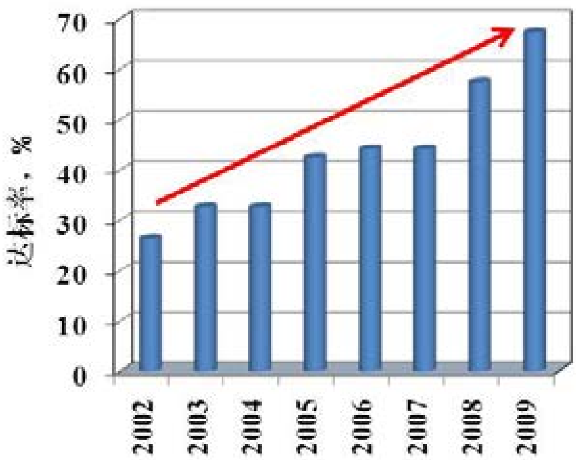
6.2 China's actions on air pollution control — (Yuanhang Zhang)

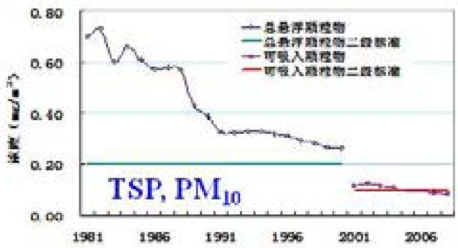
Air pollution and control policy before 2010

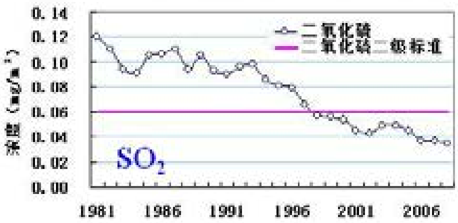
问题	管理	措施
1970-1990 燃煤＋工业＋扬尘 SO_2，TSP 煤烟型	浓度控制 属地管理	消烟除尘
1990-2000 燃煤＋工业＋扬尘＋机动车 SO_2，NOx，TSP 酸雨	浓度控制 SO_2总量 属地管理	消烟除尘 工业污染治理 扬尘治理
2000-2010 燃煤＋工业＋扬尘＋机动车 SO_2，NO_2，PM_{10}， O_3，$PM_{2.5}$，VOC 复合型	SO_2总量 约束减排 属地管理 区域协调	脱硫脱硝除尘 工业污染治理 机动车治理 区域污染治理

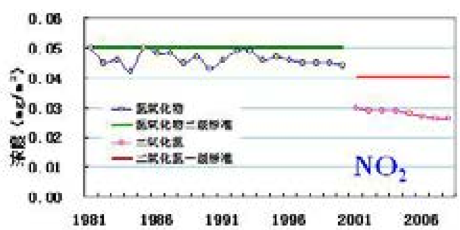
PM_{10}, SO_2, and NO_2 in a trend of decreasing

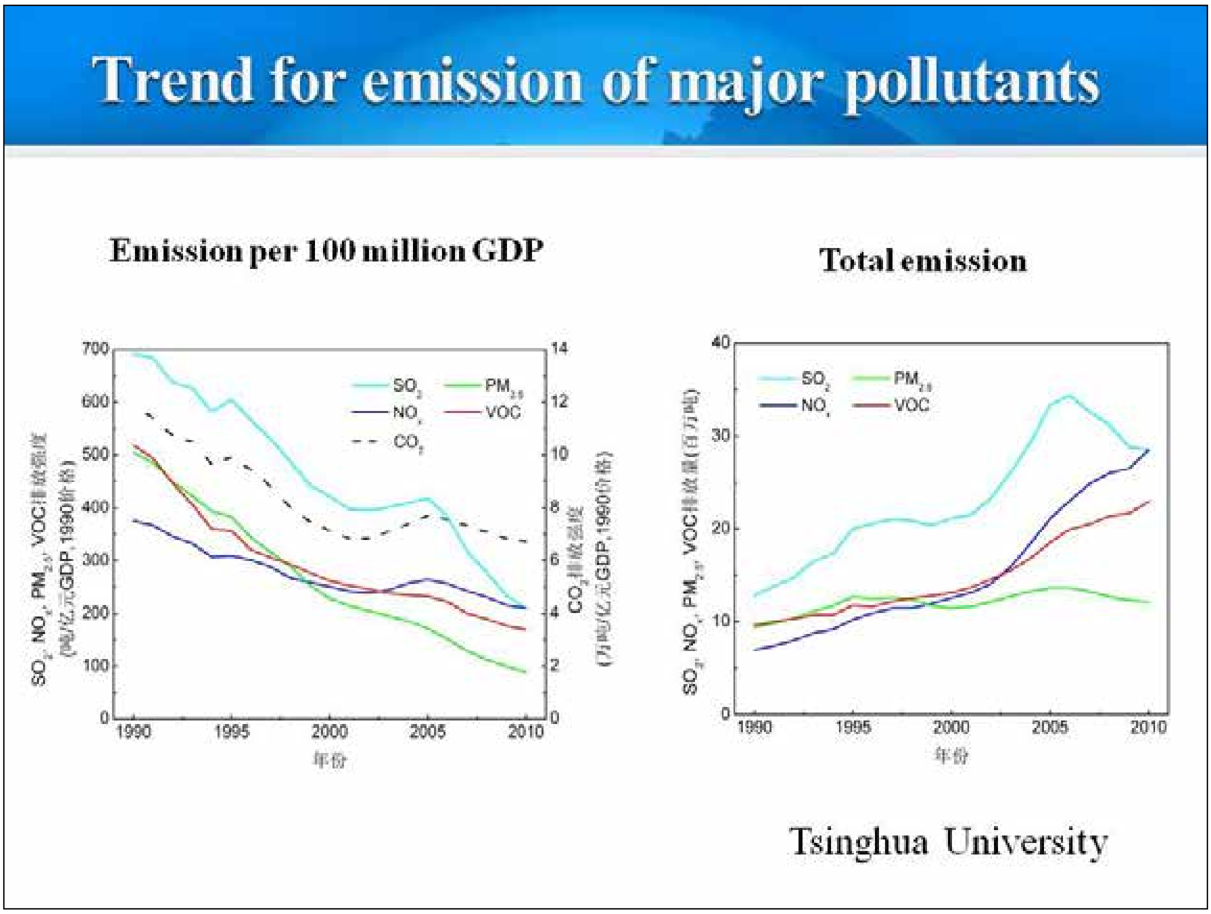
- TSP浓度呈下降趋势，PM_{10}缓慢下降
- SO_2浓度总体呈下降趋势
- NOx (NO_2)浓度总体比较稳定











Trend for emission of major pollutants
Emission per 100 million GDP
Total emission
SO2
NOx
CO2
PM2.5
VOC
年份
Tsinghua University

Fast change of air quality in China city clusters
网络图片（西城区某住宅区）
1月9日08点
1月12日08点
文献图片（广州市区）
11月3日
11月2日
January 2013, Beijing
November 2003, Guangzhou

Strategic transformation of air pollution control

Objective	Total amount of emission control	Air quality target and standard
Criteria pollutants	Single pollutant	Multi-pollutants
Manage Domain	Urban	Urban + Regional
Control Methods	Point source	Multi-sources
Road map	End-of-pipe pollution control	Social-economic-Environment

- Scientific & technical program for blue sky , MOST
- The 12th year's plan of regional air pollution prevention, MEP
- Clean Air Research Program (CARP), MEP

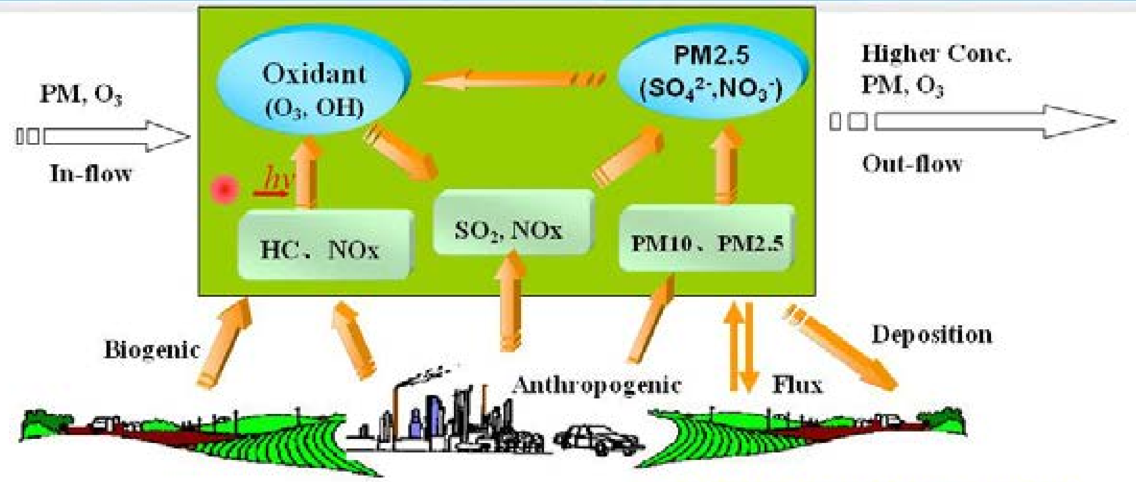
提纲 Outline

1、中国大气污染控制的历程 Evolution of air pollution control in China

2、区域污染防治理论的探索 Exploration of regional pollution prevention theory

3、未来空气质量改善的前景 Perspective of air quality improved in future

Concept of Air Pollution Complex

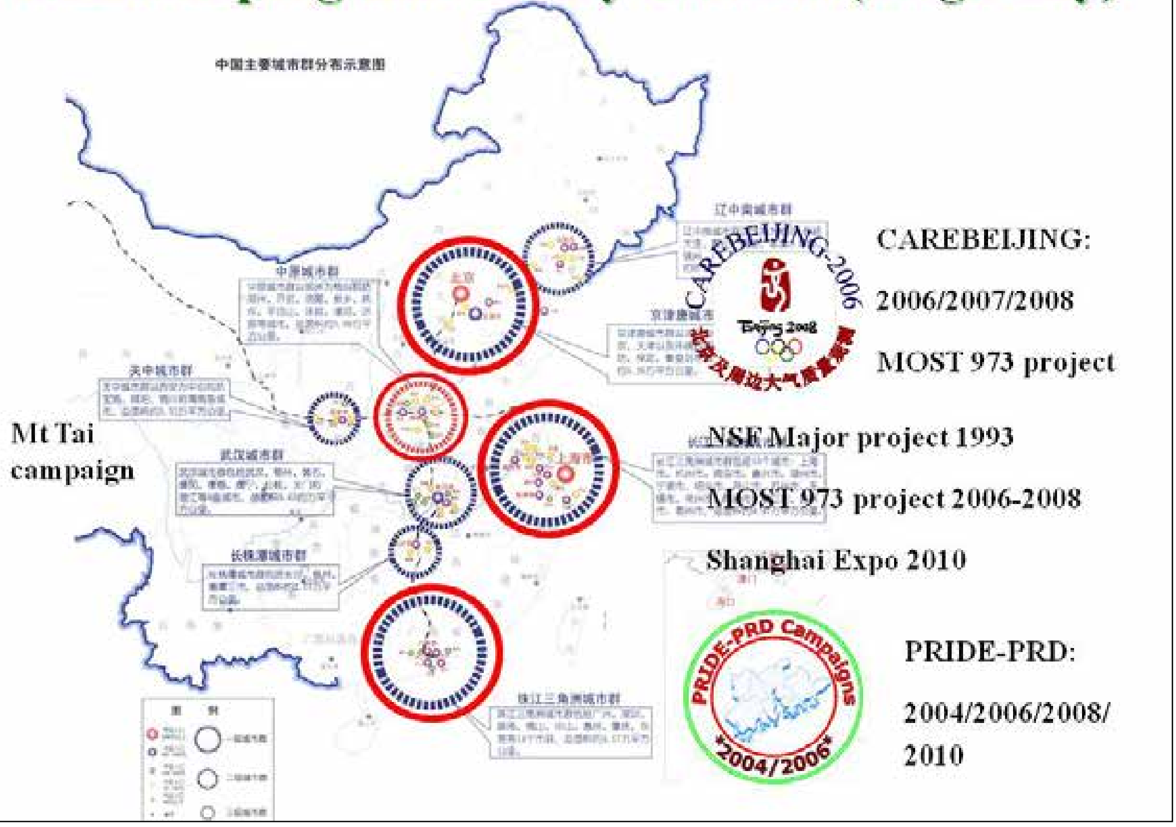


- Coupling between primary emission and photochemical process
- Coupling between gaseous and aerosol interaction,
- Coupling between local and regional air pollution.

- Enhanced atmospheric oxidation capacity: high ground-level of ozone, and secondary aerosol
- High level of fine particles and poor visibility;
- Regional & urban pollution under certain meteorological condition

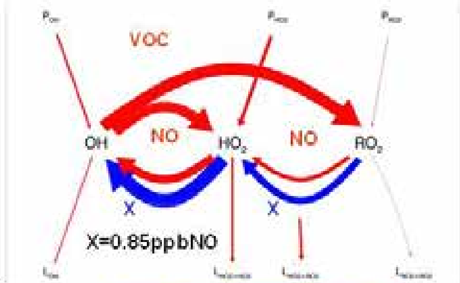
(Shao et al, Frontiers in Ecology and the Environment, 2006)

Research programs in City Clusters (Mega City)

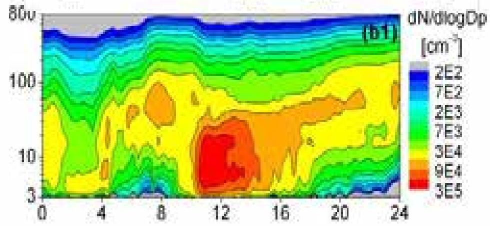


Progress of fundament science on air pollution

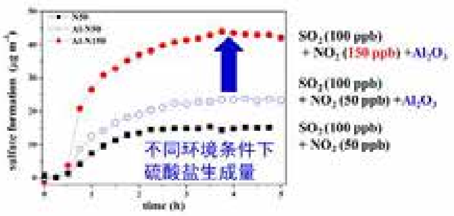
New scheme of radical cycle in China and its application in other campaigns in the world

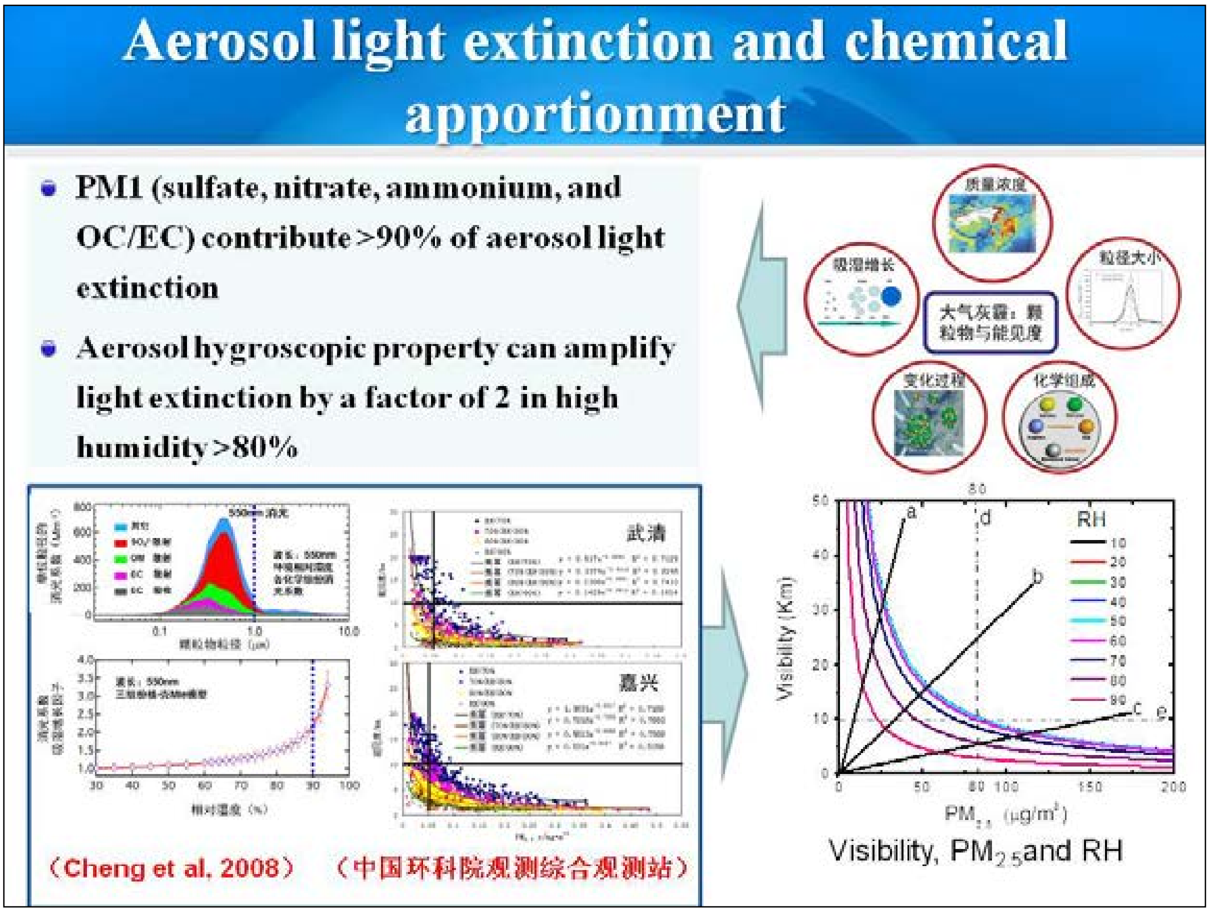


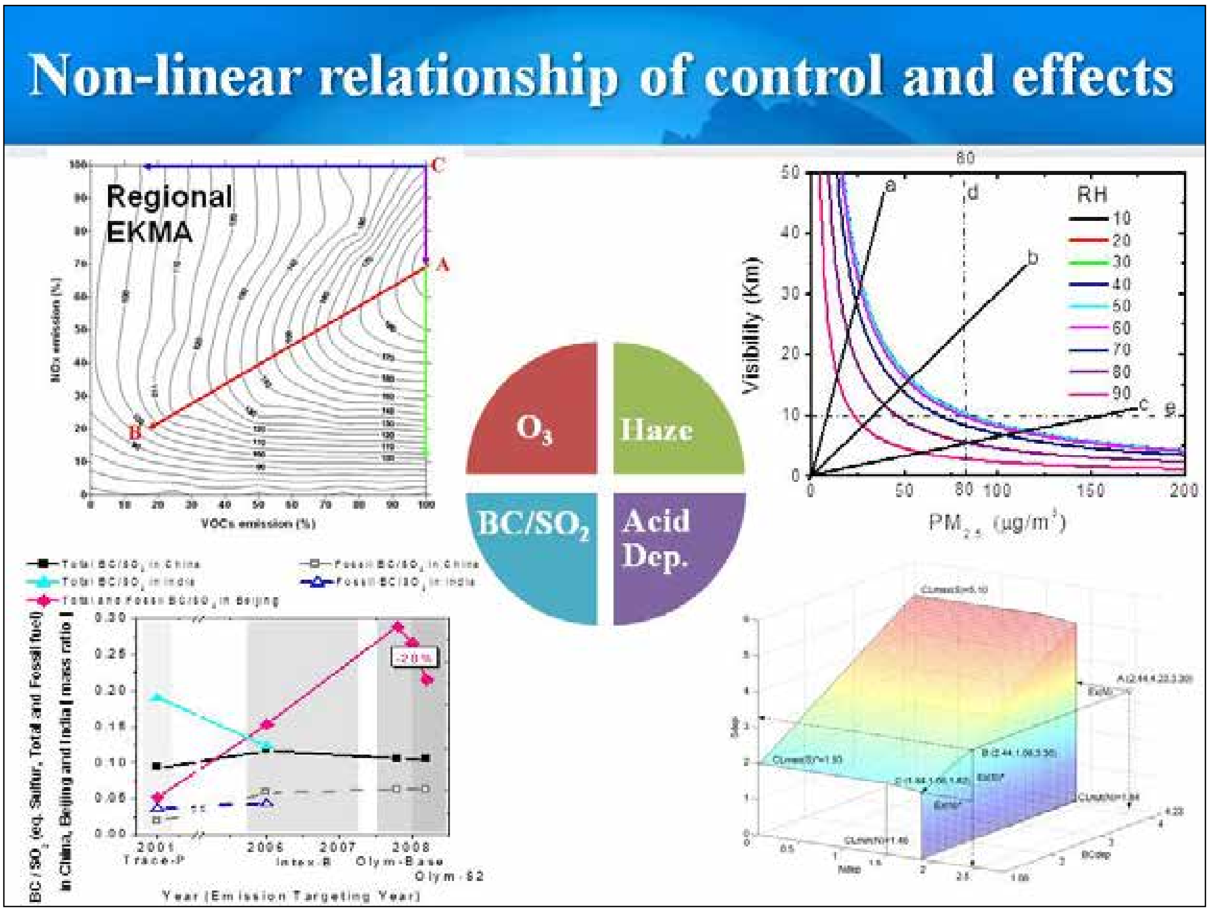
New particle formation phenomenon in polluted air and H_2SO_4-NH_3-H_2O nucleation scheme



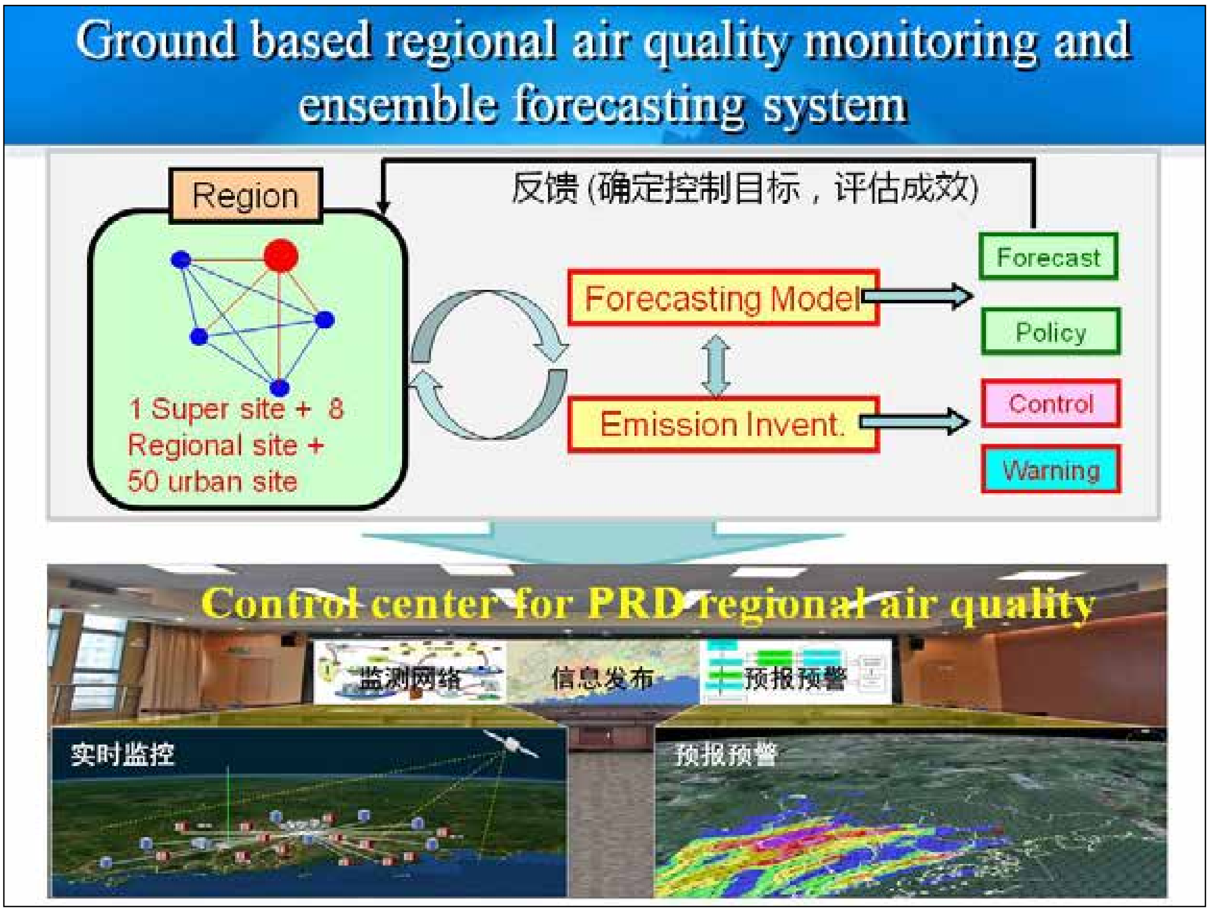
NO_2 and SO_2 heterogeneous reaction in mineral dust, NO_2 might be important for SO_2 conversion in winter haze




Aerosol light extinction and chemical apportionment
PM1 (sulfate, nitrate, ammonium, and OC/EC) contribute >90% of aerosol light extinction
Aerosol hygroscopic property can amplify light extinction by a factor of 2 in high humidity >80%
质量浓度
吸湿增长
粒径大小
大气灰霾：颗粒物与能见度
变化过程
化学组成
武清
嘉兴
（Cheng et al, 2008）
（中国环科院观测综合观测站）
Visibility (Km)
RH
PM2.5 (μg/m³)
Visibility, PM2.5 and RH


Non-linear relationship of control and effects
Regional EKMA
VOCs emission (%)
O3
Haze
BC/SO2
Acid Dep.
Visibility (Km)
RH
PM2.5 (μg/m³)
Year (Emission Targeting Year)


Innovation of monitoring equipment
$PM_{2.5}/PM_{10}$
VOCs-OVOCs
Ram-LIDAR
Aerosol Sizer
Water soluble components
OC/EC
OH, HO_2
O_3-Lidar


Ground based regional air quality monitoring and ensemble forecasting system
Region
反馈 (确定控制目标，评估成效)
1 Super site + 8 Regional site + 50 urban site
Forecasting Model
Emission Invent.
Forecast
Policy
Control
Warning
Control center for PRD regional air quality
监测网络
信息发布
预报预警
实时监控
预报预警

Regional management and operational scheme

EXPO 2010 SHANGHAI CHINA

Beijing 2008

Guangzhou

Universiade Shenzhen 2011

NANJING 2014 YOUTH OLYMPIC GAMES

YOG DNA

重大活动空气质量保障

区域污染联防联控

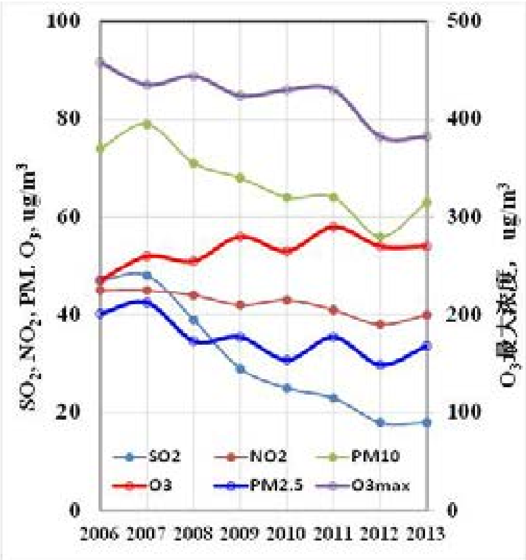
临时管控

常态化机制？

Practice of PRD regional pollution prevention

Actions

- **控制目標**：制定粵港區域多污染物總量和品質改善目標
- **產業結構調整**：強化石化、陶瓷、水泥等准入和淘汰
- **重點源控制**：全面推進脫硫脫硝、提高效率
- **機動車控制**：升級區域機動車排放和油品標準
- **VOCs控制**：制定地方排放標準、開展企業洩漏監控



*$PM_{2.5}$ average for 4 stations

提纲 Outline

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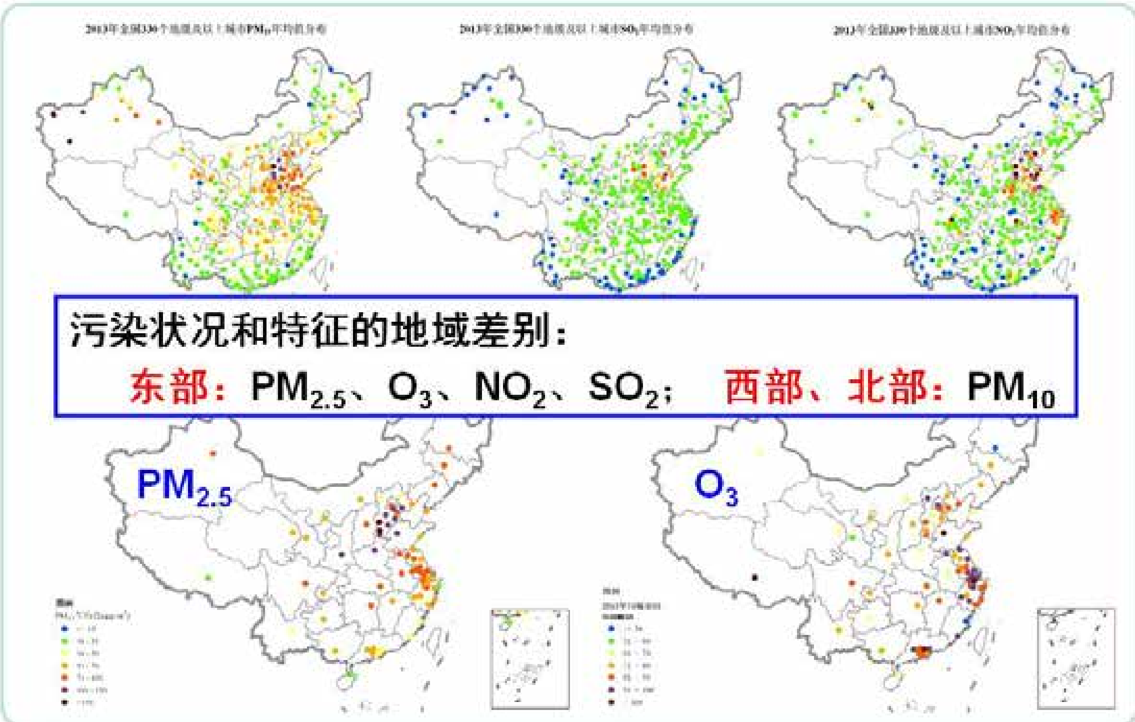
Air Quality in 2013

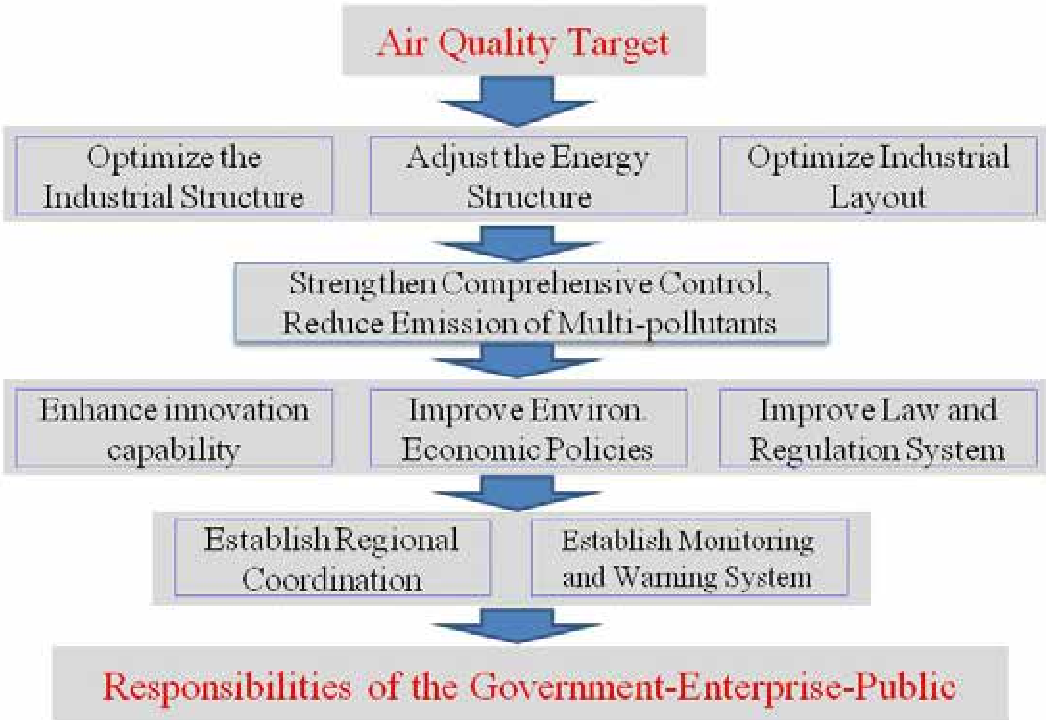


Action plan for air pollution prevention in China (State council, September 2013)

Overall target by 2017

- $PM_{2.5}$ in Beijing-Tianjin-Hebei (BTH), Yangtze River delta (YRD) and Pearl River delta (PRD) will be decreased by 25%, 20% and 15%, respectively.
- PM_{10} concentration in the other cities will be decreased by 10%.

Framework of the Action Plan



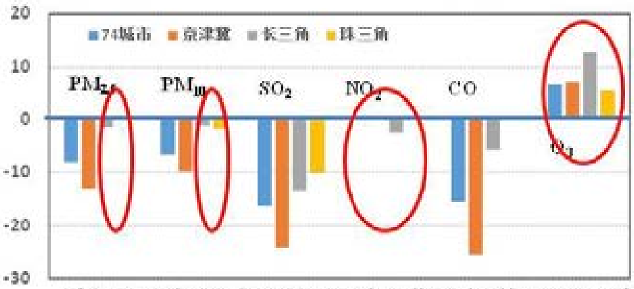
Air quality is improving in general

- 74 cities: improving
- BHT: improving a lot
- YRD：？，$PM_{2.5}$、O_3
- PRD：？，$PM_{2.5}$、O_3

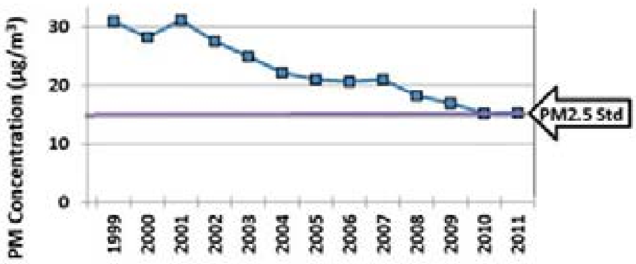
Science: Mechanism

Management: Strategy

Technique: Efficiency

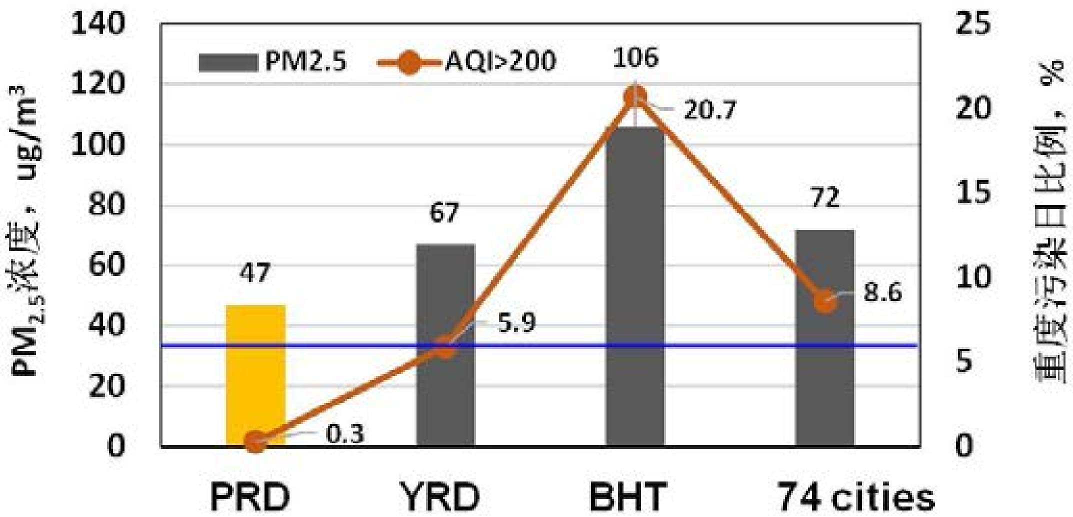


Comparison between the first half years of 2014 and 2013, CEMC



South California $PM_{2.5}$ annual mean

PRD as the pioneer to attain $PM_{2.5}$ standard

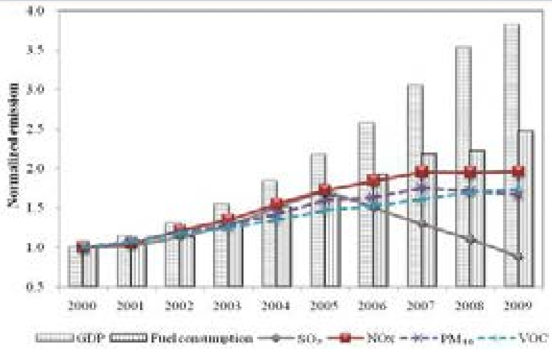


Challenge for the $PM_{2.5}$ compliance

1. **Guideline:** Air quality target and its constrained environment plan is suggested to be reference to other sector plans.

	Target	New emission	total reduction
SO_2	20%	40%	60%
NOx	24%	34%	58%
PM_{10}	10%	56%	66%
VOC	25%	37%	62%

2. **Strategy:** Multi-pollutants non-linearly integrated control strategy should be right way to have effective air quality improvement.

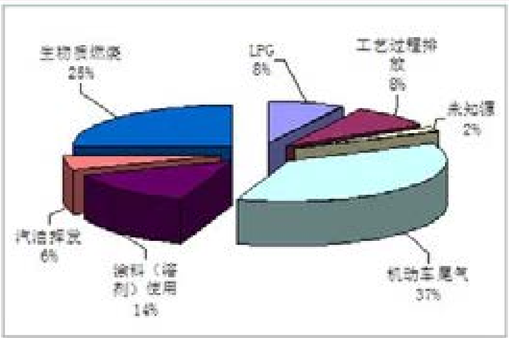


Challenge for the $PM_{2.5}$ compliance

3. **Management:** Regional coordination and joint action plan is crucial for air quality improvement (regional vision, city action).

	$PM_{2.5}$	SO_2	NOx
Jan	46.4%	28.3%	8.4%
April	25.5%	15.7%	3.6%
July	12.7%	2.4%	3.2%
Oct	44.7%	24.3%	5.8%
Average	35.5%	19.7%	7.9%

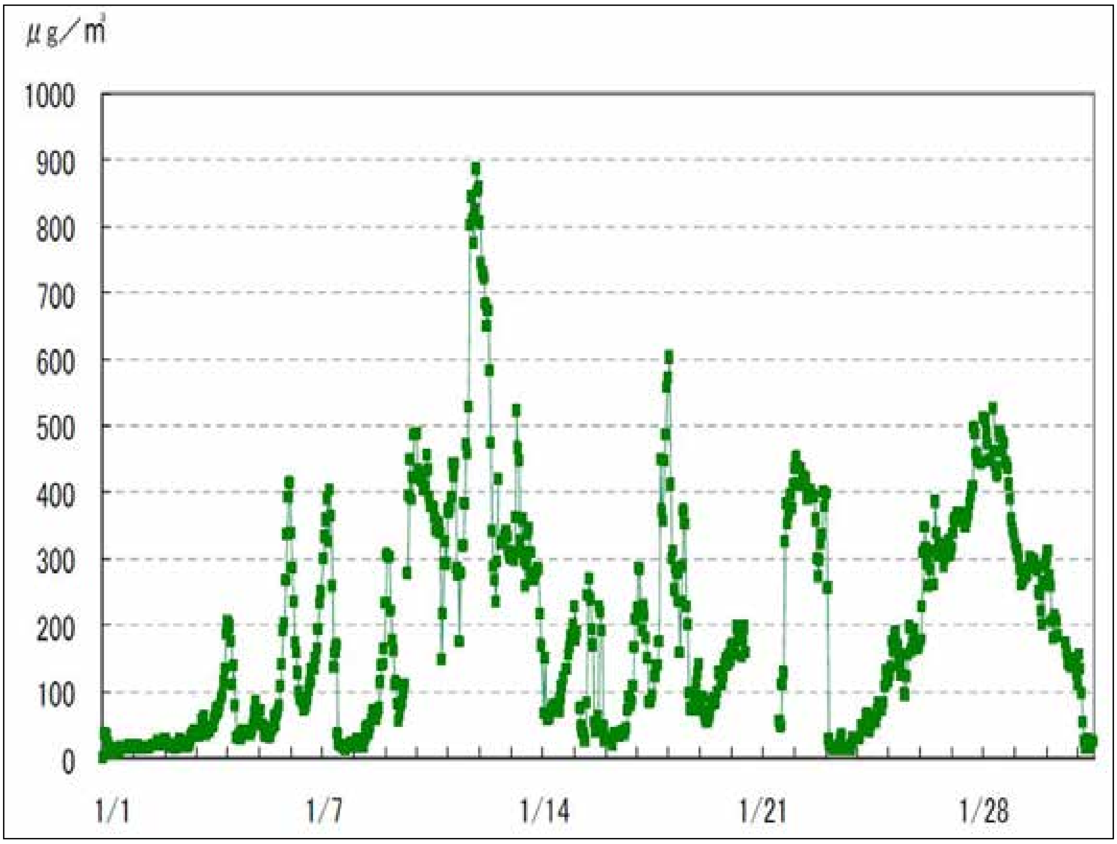
4. Control: Vehicle, power plant, solvent & painting, biomass burning are major sources
   - VOCs control is key and should be put in agenda



Summary

- Regional O_3 and $PM_{2.5}$ pollution is getting severe, it is long term task to attain the air quality standard.
- Multi-pollutants non-linearly integrated control strategy should be right way for air quality improvement.
- China air quality will be getting cleaner continuously by the National Action Plan for Air Pollution Prevention and its follow-up policy.

6.3 Inter-City Cooperation for Air Quality Improvement in China (Hideaki Koyanagi)

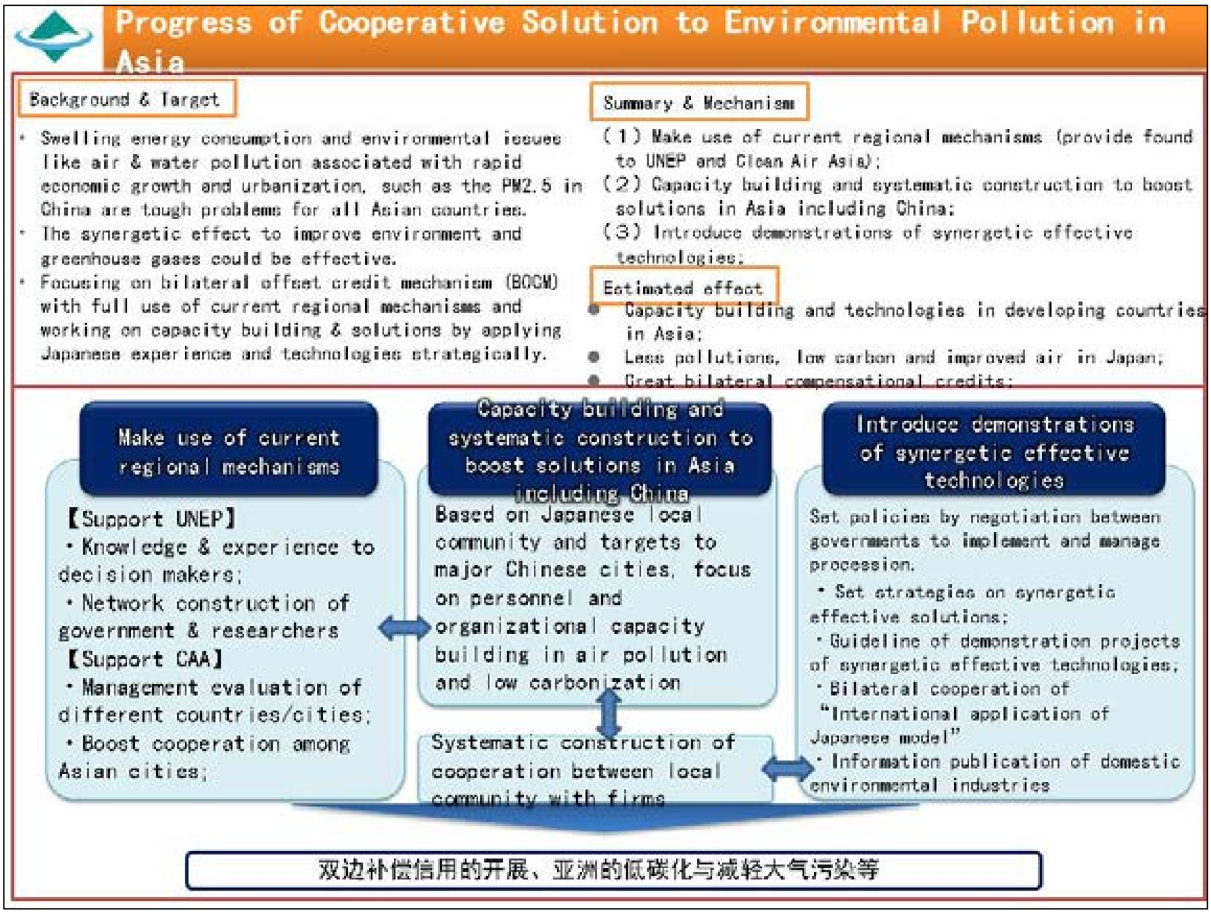


(1) cooperative network with China to improve air pollution in China

(1) Send experts and receive Chinese visitors with exchange activities between the two countries.
(2) A overall chart to list the cooperation opportunities in air pollution that includes hardware (knowledge, experience, technologies) and software from Japan.

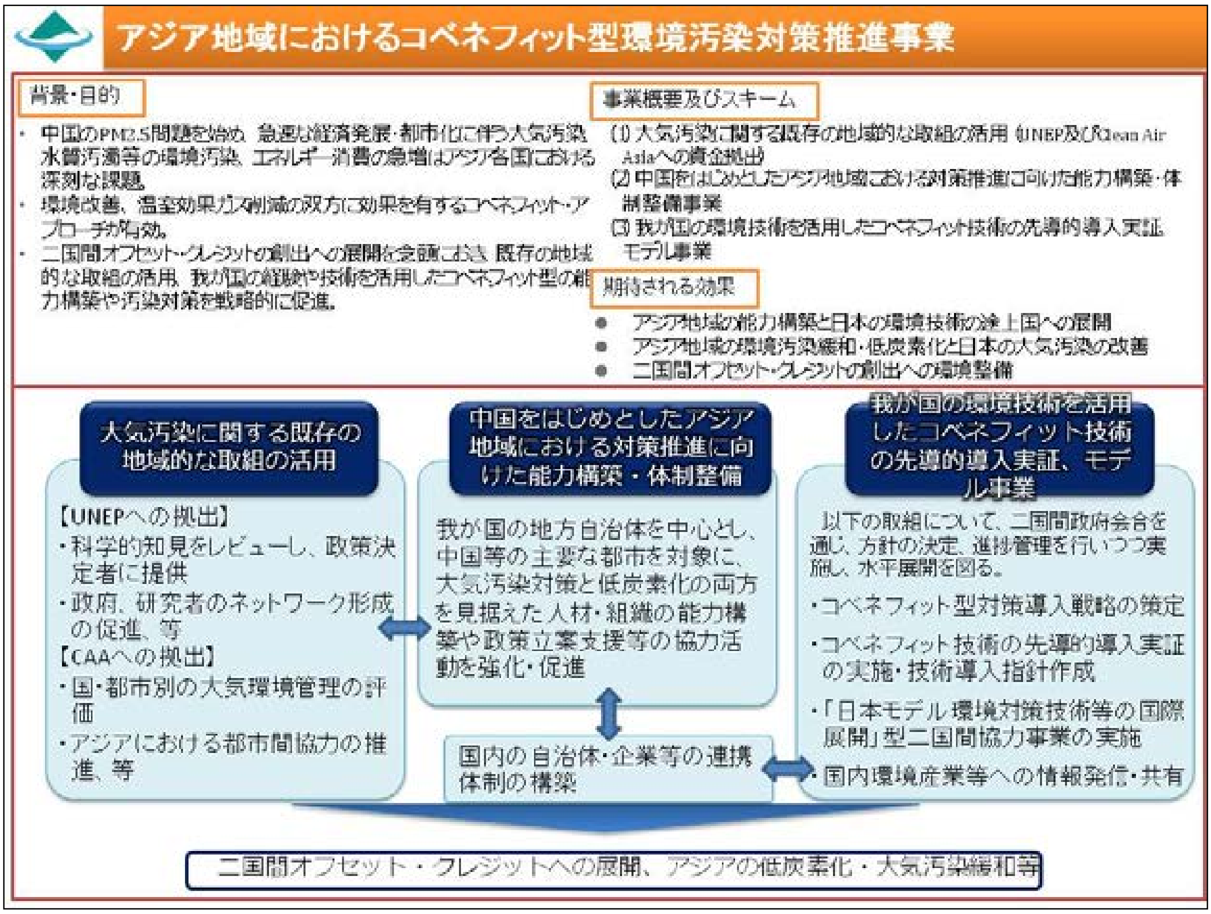
(2) Workshops on air pollution Prevention and treatment

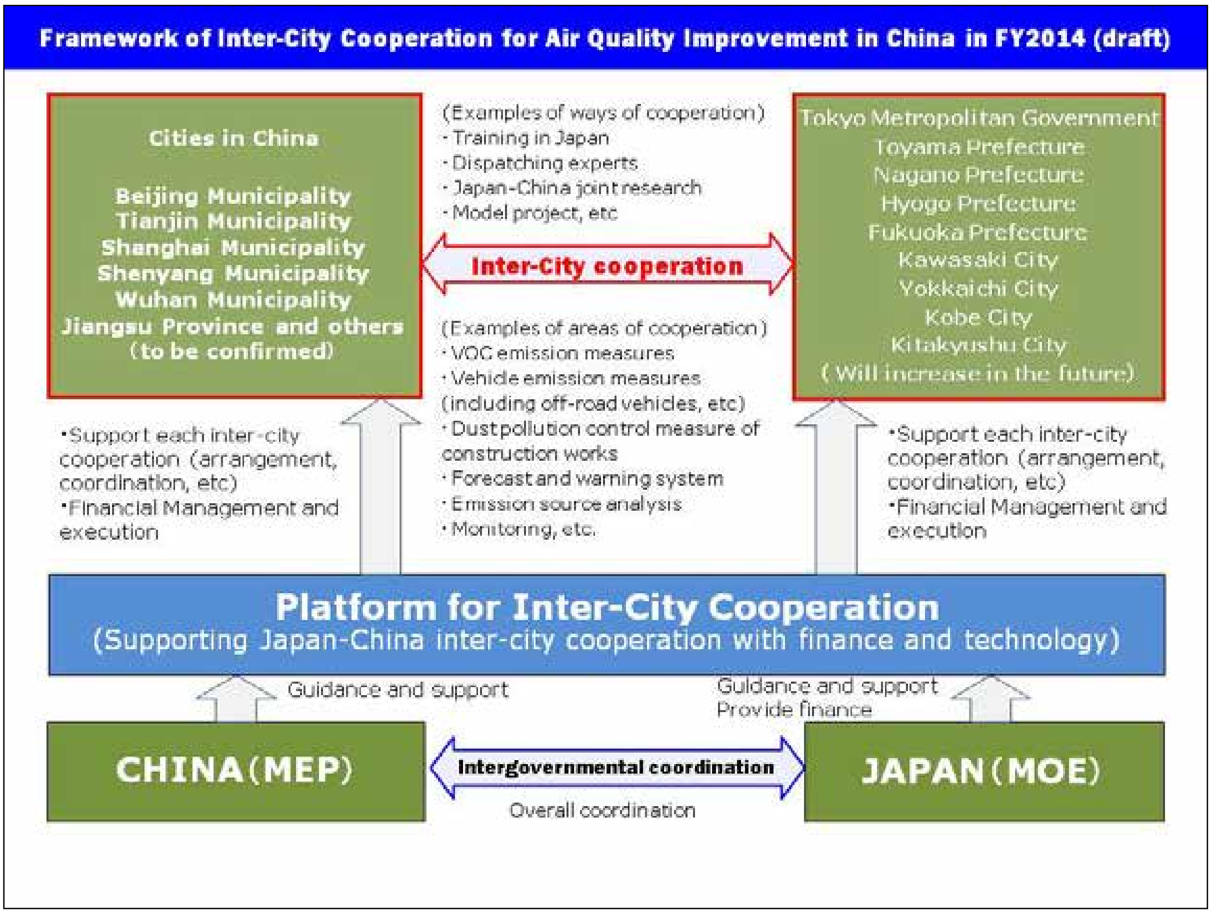
Beijing, April 18, 2013

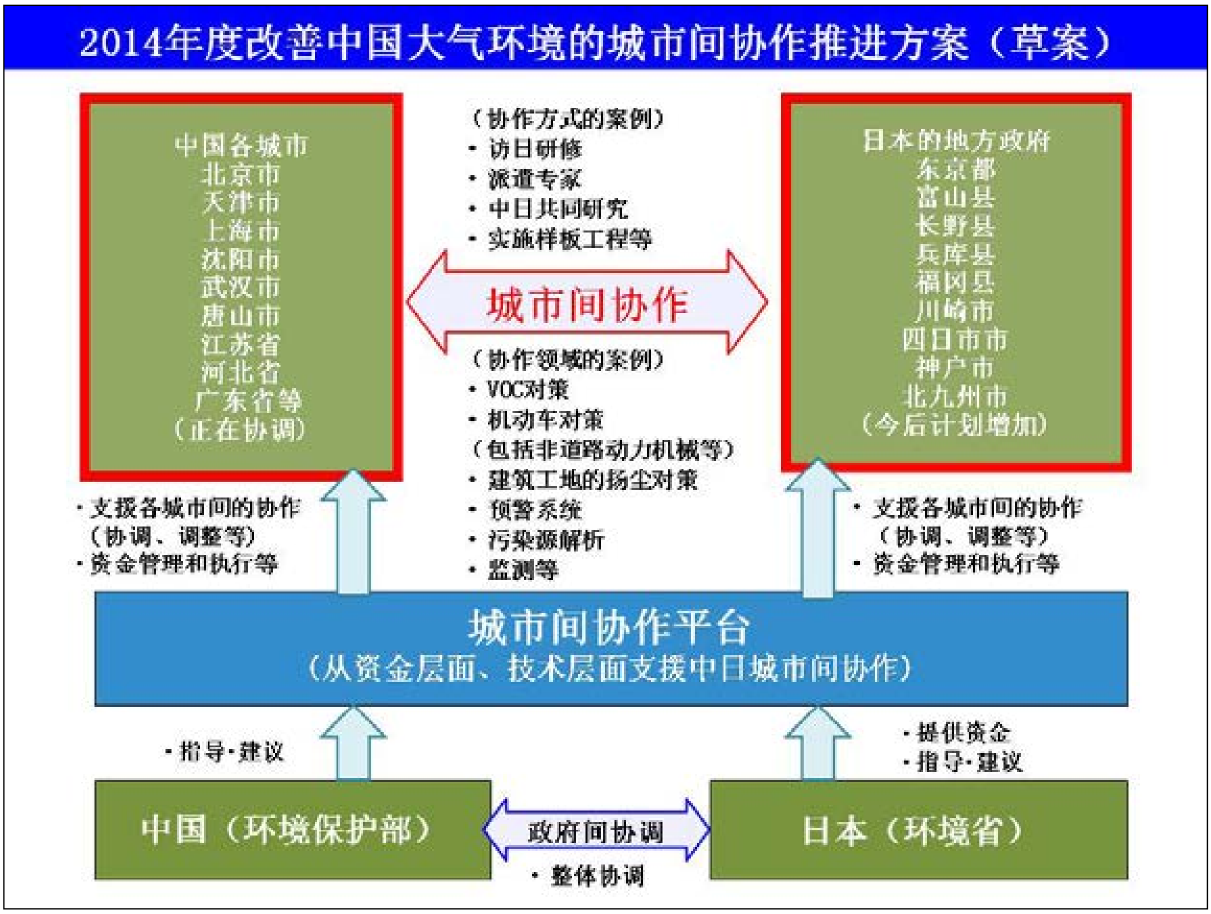


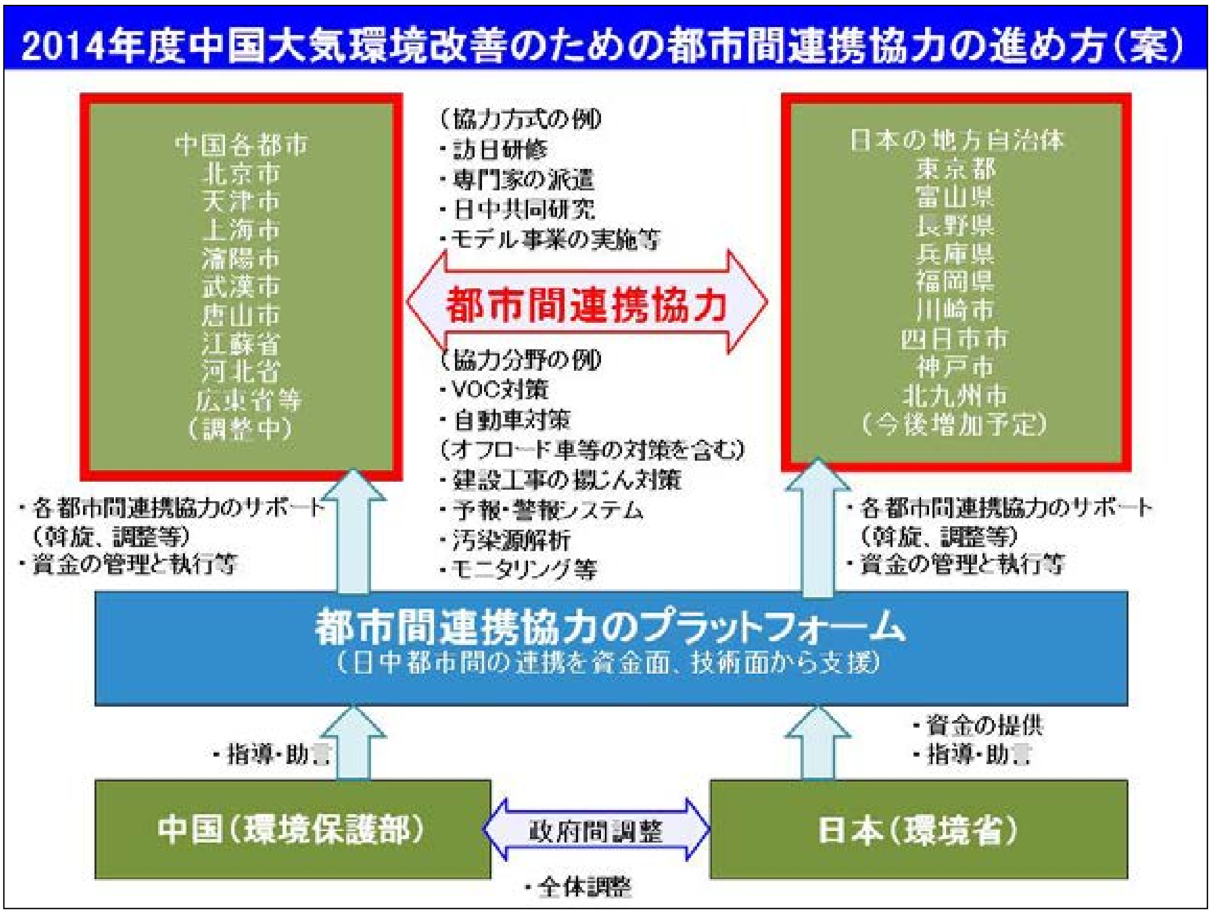
Progress of Cooperative Solution to Environmental Pollution in Asia
Background & Target
・Swelling energy consumption and environmental issues like air & water pollution associated with rapid economic growth and urbanization, such as the PM2.5 in China are tough problems for all Asian countries.
・The synergetic effect to improve environment and greenhouse gases could be effective.
・Focusing on bilateral offset credit mechanism (BOCM) with full use of current regional mechanisms and working on capacity building & solutions by applying Japanese experience and technologies strategically.
Summary & Mechanism
(1) Make use of current regional mechanisms (provide found to UNEP and Clean Air Asia);
(2) Capacity building and systematic construction to boost solutions in Asia including China;
(3) Introduce demonstrations of synergetic effective technologies;
Estimated effect
● Capacity building and technologies in developing countries in Asia;
● Less pollutions, low carbon and improved air in Japan;
● Great bilateral compensational credits;
Make use of current regional mechanisms
【Support UNEP】
・Knowledge & experience to decision makers;
・Network construction of government & researchers
【Support CAA】
・Management evaluation of different countries/cities;
・Boost cooperation among Asian cities;
Capacity building and systematic construction to boost solutions in Asia including China
Based on Japanese local community and targets to major Chinese cities, focus on personnel and organizational capacity building in air pollution and low carbonization
Systematic construction of cooperation between local community with firms
Introduce demonstrations of synergetic effective technologies
Set policies by negotiation between governments to implement and manage procession.
・Set strategies on synergetic effective solutions;
・Guideline of demonstration projects of synergetic effective technologies;
・Bilateral cooperation of "International application of Japanese model"
・Information publication of domestic environmental industries
双边补偿信用的开展、亚洲的低碳化与减轻大气污染等

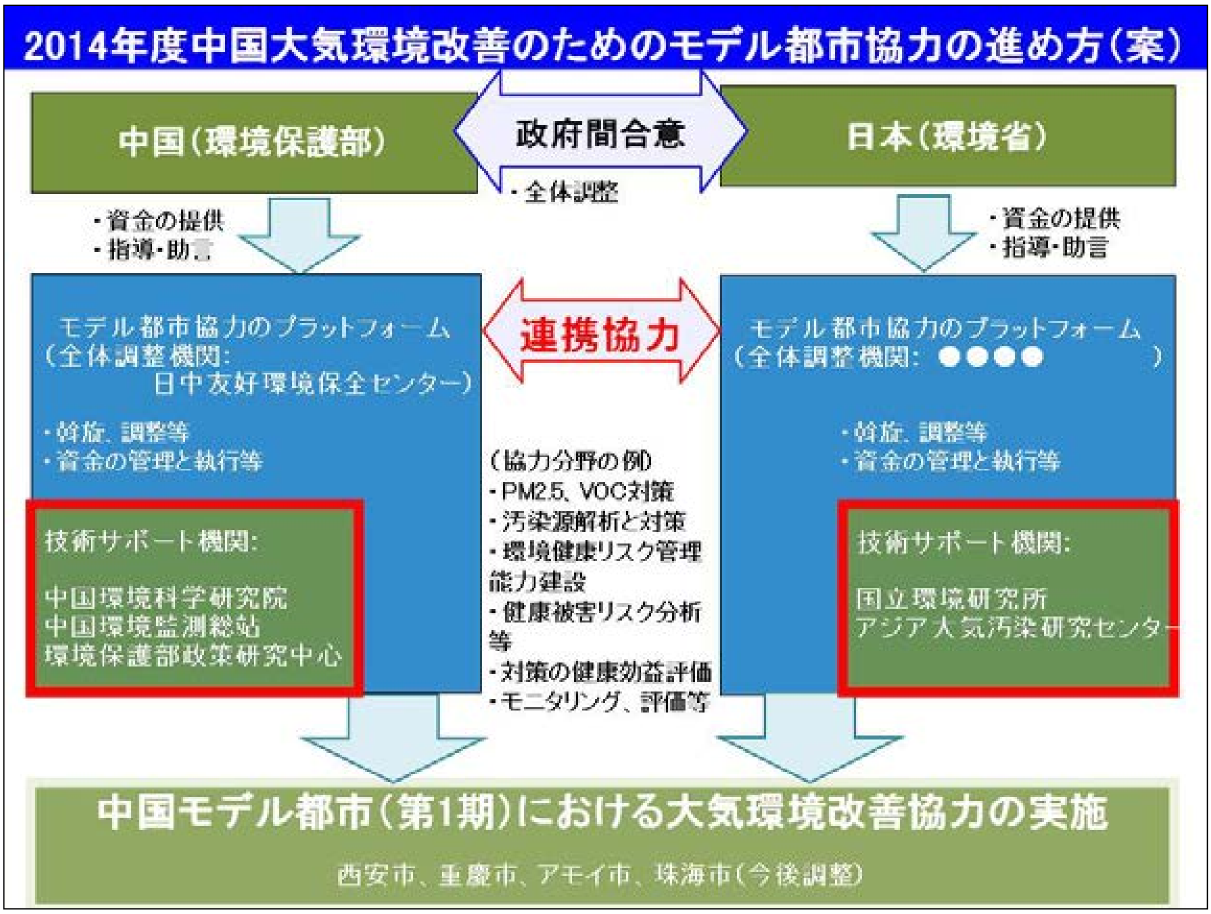
亚洲地区协同效应型环境污染对策推进事业
背景与目的
・包括中国的PM2.5问题，伴随经济飞速发展和城市化引发的大气污染、水污染等环境污染、能源消耗的剧增在亚洲各国成为严峻的课题。
・具有改善环境、温室效应气体减排双重效果的协同效应是有效的方法。
・致力于创造双边补偿信用(BOCM)，充分利用现有的地区性机制，战略性促进利用我国的经验与技术的协同效应型能力建设和污染对策。
事业概要与机制
（1）有效利用有关大气污染的现有的地区性机制（向UNEP及Clean Air Asia提供资金）
（2）为推进包括中国在内的亚洲地区相关对策开展的能力建设和体制建设事业
（3）利用我国的环保技术的协同效应技术实施先导性引进实证、示范项目
预期效果
● 亚洲地区的能力建设与日本环保技术在发展中国家的展开
● 减轻亚洲地区环境污染、实现低碳化与日本大气污染的改善
● 创造双边补偿信用的环境建设
有效利用现有的有关大气污染的地区性机制
【向UNEP提供支持】
・总结科学知识和经验，提供给决策层
・促进政府、研究人员的网络建设等
【向CAA提供支持】
・不同国家和城市的大气环境管理评估
・亚洲城市间合作的推进等
在以中国为首的亚洲地区推动政策实施所需的能力建设和体制建设
以我国的地方自治体为核心，以中国等国家的主要城市为对象，致力于强化和促进大气污染对策与低碳化两方面的人才与组织的能力建设和政策制定支援等的合作活动
国内的自治体与企业等合作的体制建设
利用我国技术先导性引进实证示范项目
针对以下的活动，通过两国政府之间的会谈，确定方针，进行具体实施并开展进度管理，致力于水平展开。
・协同效应型对策引进战略的制定
・协同效应技术的先导性引进示范项目的实施及技术引进指南的编制
・"日本模式环境对策技术等的国际展开"型双边合作事业的实施
・国内环境产业等信息发布与共享
双边补偿信用的开展、亚洲的低碳化与减轻大气污染等


アジア地域におけるコベネフィット型環境汚染対策推進事業
背景・目的
中国のPM2.5問題を始め、急速な経済発展・都市化に伴う大気汚染、水質汚濁等の環境汚染、エネルギー消費の急増はアジア各国における深刻な課題。
環境改善、温室効果ガス削減の双方に効果を有するコベネフィット・アプローチが有効。
二国間オフセット・クレジットの創出への展開を念頭におき、既存の地域的な取組の活用、我が国の経験や技術を活用したコベネフィット型の能力構築や汚染対策を戦略的に促進。
事業概要及びスキーム
(1) 大気汚染に関する既存の地域的な取組の活用（UNEP及びClean Air Asiaへの資金拠出）
(2) 中国をはじめとしたアジア地域における対策推進に向けた能力構築・体制整備事業
(3) 我が国の環境技術を活用したコベネフィット技術の先導的導入実証モデル事業
期待される効果
アジア地域の能力構築と日本の環境技術の途上国への展開
アジア地域の環境汚染緩和・低炭素化と日本の大気汚染の改善
二国間オフセット・クレジットの創出への環境整備
大気汚染に関する既存の地域的な取組の活用
【UNEPへの拠出】
・科学的知見をレビューし、政策決定者に提供
・政府、研究者のネットワーク形成の促進、等
【CAAへの拠出】
・国・都市別の大気環境管理の評価
・アジアにおける都市間協力の推進、等
中国をはじめとしたアジア地域における対策推進に向けた能力構築・体制整備
我が国の地方自治体を中心とし、中国等の主要な都市を対象に、大気汚染対策と低炭素化の両方を見据えた人材・組織の能力構築や政策立案支援等の協力活動を強化・促進
国内の自治体・企業等の連携体制の構築
我が国の環境技術を活用したコベネフィット技術の先導的導入実証、モデル事業
以下の取組について、二国間政府会合を通じ、方針の決定、進捗管理を行いつつ実施し、水平展開を図る。
・コベネフィット型対策導入戦略の策定
・コベネフィット技術の先導的導入実証の実施・技術導入指針作成
・「日本モデル環境対策技術等の国際展開」型二国間協力事業の実施
・国内環境産業等への情報発信・共有
二国間オフセット・クレジットへの展開、アジアの低炭素化・大気汚染緩和等


Framework of Inter-City Cooperation for Air Quality Improvement in China in FY2014 (draft)
Cities in China
Beijing Municipality
Tianjin Municipality
Shanghai Municipality
Shenyang Municipality
Wuhan Municipality
Jiangsu Province and others
(to be confirmed)
(Examples of ways of cooperation)
・Training in Japan
・Dispatching experts
・Japan-China joint research
・Model project, etc
Inter-City cooperation
(Examples of areas of cooperation)
・VOC emission measures
・Vehicle emission measures (including off-road vehicles, etc)
・Dust pollution control measure of construction works
・Forecast and warning system
・Emission source analysis
・Monitoring, etc.
Tokyo Metropolitan Government
Toyama Prefecture
Nagano Prefecture
Hyogo Prefecture
Fukuoka Prefecture
Kawasaki City
Yokkaichi City
Kobe City
Kitakyushu City
(Will increase in the future)
・Support each inter-city cooperation (arrangement, coordination, etc)
・Financial Management and execution
・Support each inter-city cooperation (arrangement, coordination, etc)
・Financial Management and execution
Platform for Inter-City Cooperation
(Supporting Japan-China inter-city cooperation with finance and technology)
Guidance and support
Guidance and support
Provide finance
CHINA (MEP)
Intergovernmental coordination
Overall coordination
JAPAN (MOE)


2014年度改善中国大气环境的城市间协作推进方案（草案）
中国各城市
北京市
天津市
上海市
沈阳市
武汉市
唐山市
江苏省
河北省
广东省等
（正在协调）
（协作方式的案例）
・访日研修
・派遣专家
・中日共同研究
・实施样板工程等
城市间协作
（协作领域的案例）
・VOC对策
・机动车对策
（包括非道路动力机械等）
・建筑工地的扬尘对策
・预警系统
・污染源解析
・监测等
日本的地方政府
东京都
富山县
长野县
兵库县
福冈县
川崎市
四日市市
神户市
北九州市
（今后计划增加）
・支援各城市间的协作
（协调、调整等）
・资金管理和执行等
・支援各城市间的协作
（协调、调整等）
・资金管理和执行等
城市间协作平台
（从资金层面、技术层面支援中日城市间协作）
・指导・建议
・提供资金
・指导・建议
中国（环境保护部）
政府间协调
・整体协调
日本（环境省）


2014年度中国大気環境改善のための都市間連携協力の進め方（案）
中国各都市
北京市
天津市
上海市
瀋陽市
武漢市
唐山市
江蘇省
河北省
広東省等
（調整中）
（協力方式の例）
・訪日研修
・専門家の派遣
・日中共同研究
・モデル事業の実施等
都市間連携協力
（協力分野の例）
・VOC対策
・自動車対策
（オフロード車等の対策を含む）
・建設工事の粉じん対策
・予報・警報システム
・汚染源解析
・モニタリング等
日本の地方自治体
東京都
富山県
長野県
兵庫県
福岡県
川崎市
四日市市
神戸市
北九州市
（今後増加予定）
・各都市間連携協力のサポート
（斡旋、調整等）
・資金の管理と執行等
・各都市間連携協力のサポート
（斡旋、調整等）
・資金の管理と執行等
都市間連携協力のプラットフォーム
（日中都市間の連携を資金面、技術面から支援）
・指導・助言
・資金の提供
・指導・助言
中国（環境保護部）
政府間調整
・全体調整
日本（環境省）



The Basic Concept of City-to-city Cooperation (Draft)

* The concept of “city” in Japan includes prefectures and cities (in case of China, prefectures, autonomous regions and municipalities are included).

1. It aims to strengthen and develop the existing city-to-city cooperative relationships (e.g. friendship city relationships etc.) between Japan and China in the field of air pollution control.

Even if there is no existing friendship city relationships, cooperation in the field of air pollution control can still be strengthened and developed by building new cooperative relationships between cities through arrangements and coordination etc. upon request of cities in both countries.

2. In order to promote cooperation ("city-to-city cooperation") between cities in Japan and China, both the Japanese government and the Chinese government (Ministry of the Environment (MOE), Japan; The Ministry of Environmental Protection (MEP), China) will provide instructions, advice, coordination, arrangements, financial support etc. directly or through a platform. Ministry of the Environment, Japan will provide the required budget as financial support if possible.

3. In order to continue the existing cooperative relationship, as a general rule, each city will keep bearing necessary expenses, but in case of implementing new cooperation activities in the field of air pollution control (including strengthening the existing cooperative relationship), Ministry of the Environment will provide part of the expenses (mainly direct expenses).

4. City-to-city cooperation consists of the following two components.

(1) Exchange and cooperation between government employees in each city (including subsidiary research institutes, foundations, public corporations, etc. In case of China, "public institutions" are included)

(2) Exchange and cooperation between companies in each city

To promote exchange and cooperation between companies, government employees in each city and organizations which work as the platform will provide support including coordination or arrangements, and work closely together with "The Cooperation Network for Abating China's air Pollution (Japan-China Economic Association)".

5. Building/Establishment of a platform and the role of the platform

(1) A platform which consists of organizations designated by the Ministry of the Environment (MOE) and The Ministry of Environmental Protection (MEP) will be established in order to promote city-to-city cooperation smoothly.

(2) The platform plays the following roles with instructions and advice from the government.

1) Support city-to-city cooperation

2) Arrangements, Coordination

3) Management and execution of funds

4) Others

6. Details of Cooperation

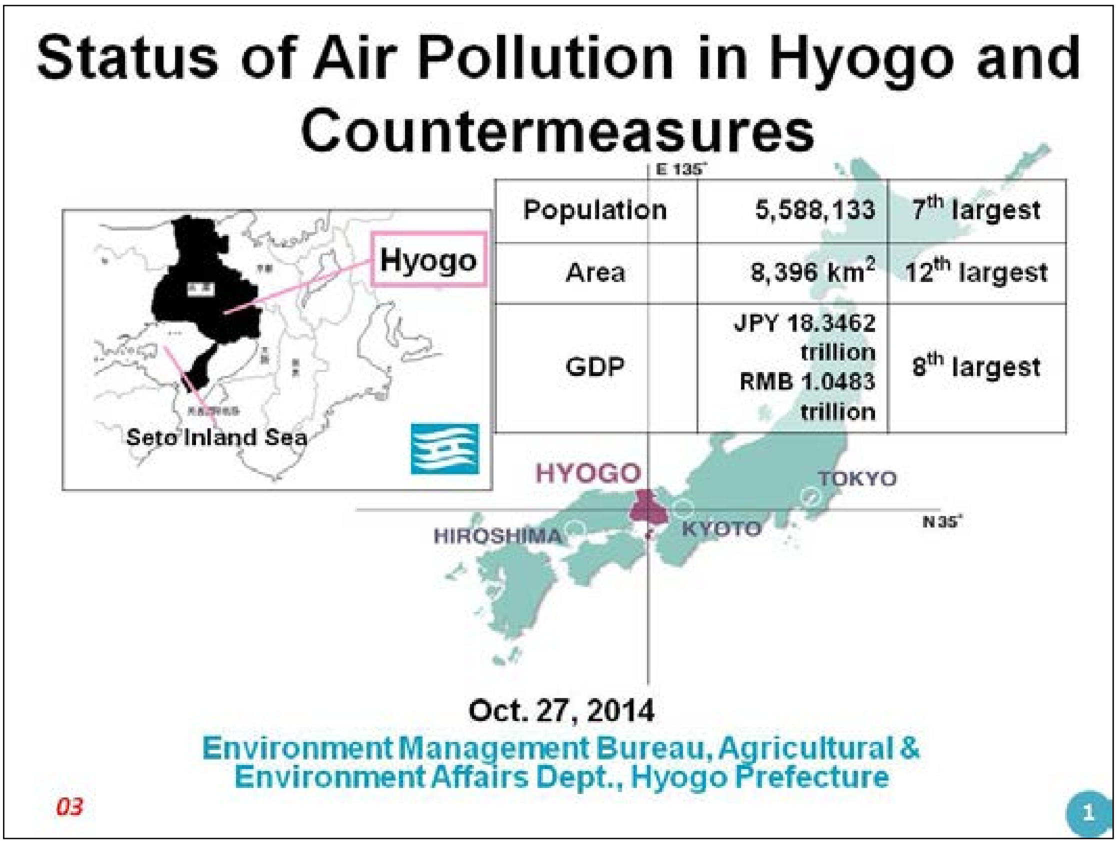
The details of city-to-city cooperation will be determined based on the discussions and coordination between the cities, and the following points should be taken into consideration.

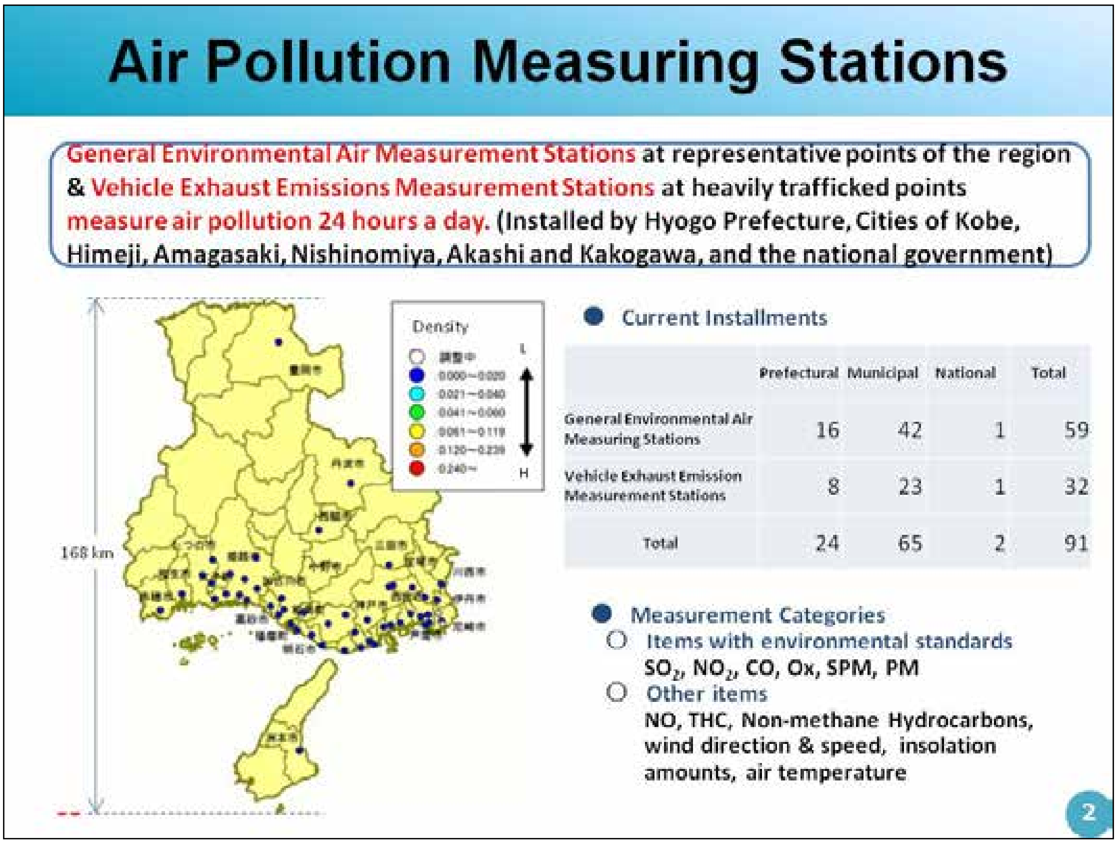
1) The utmost importance should be attached to the cooperation items which the cities in China hope for.

2) The cities in Japan should consider concrete cooperation items they can provide.

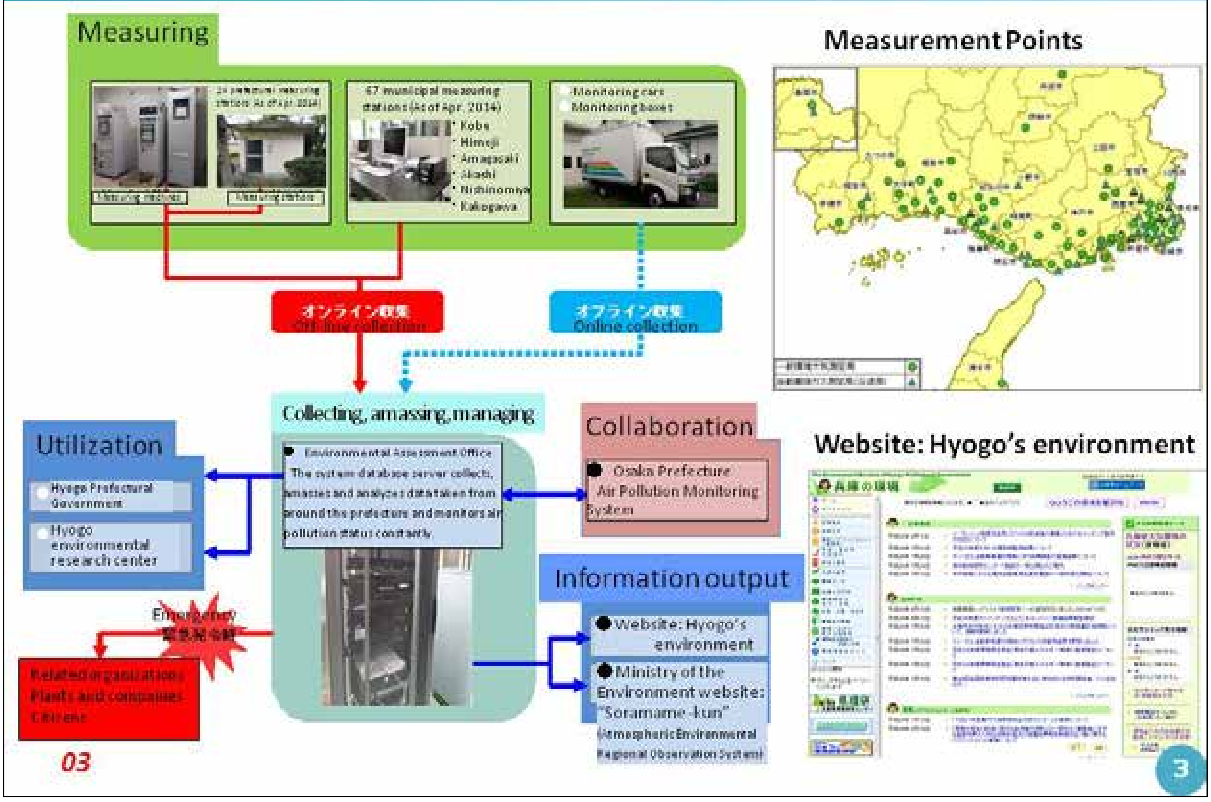
3) If the items in (1) do not match with those in (2) well, the platform should provide necessary coordination etc. and make efforts to realize the items in (1) if possible.

6.4 Status of Air Pollution in Hyogo and Countermeasures (Kazuhiro Akiyama)

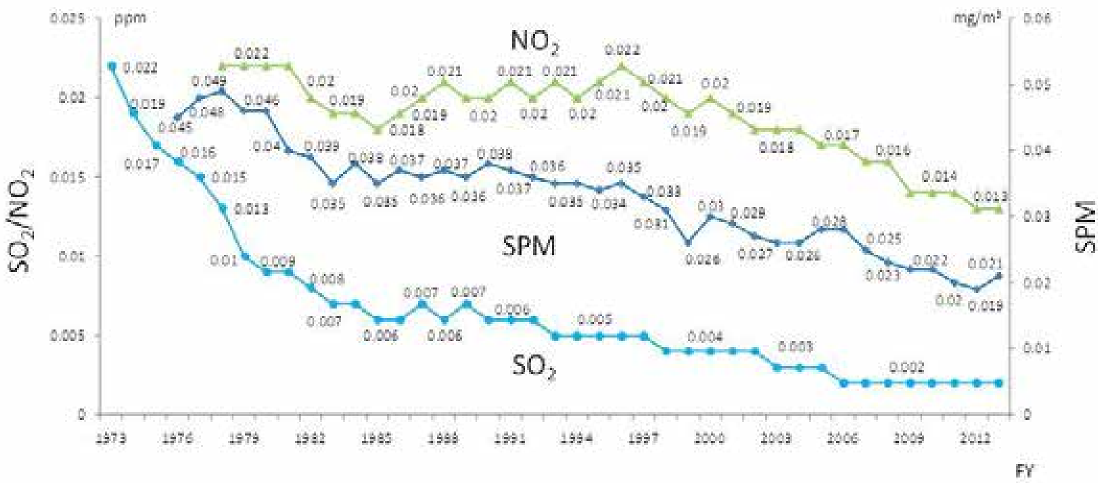




Hyogo Air Pollution Monitoring System



SO_2, NO_2, SPM (General Environmental Air Measuring Stations)

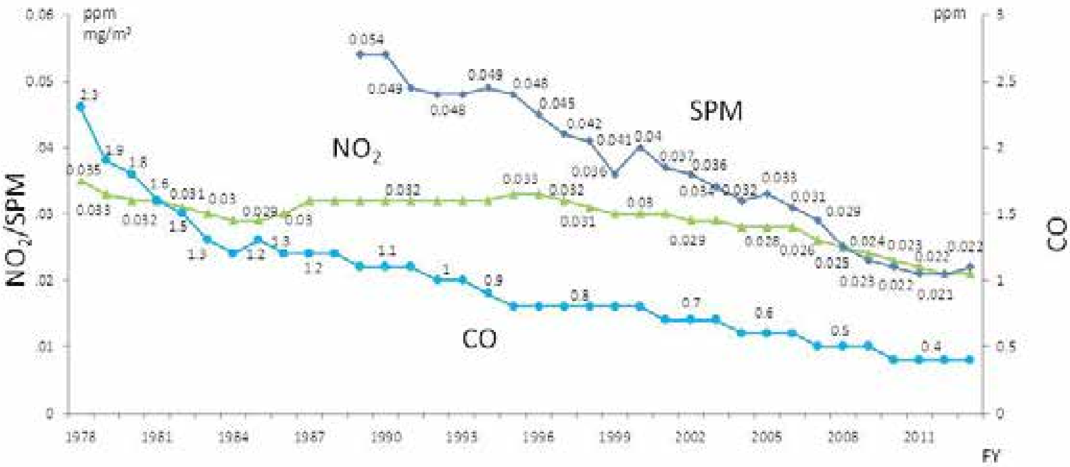


- All categories on a declining trend since 1996
- Environmental standards achieved at all stations for NO_2 and SO_2 and at 56 stations (out of 57) for SPM in 2013

03

4

NO_2, SPM, CO (Vehicle Exhaust Emissions Measurement Stations)

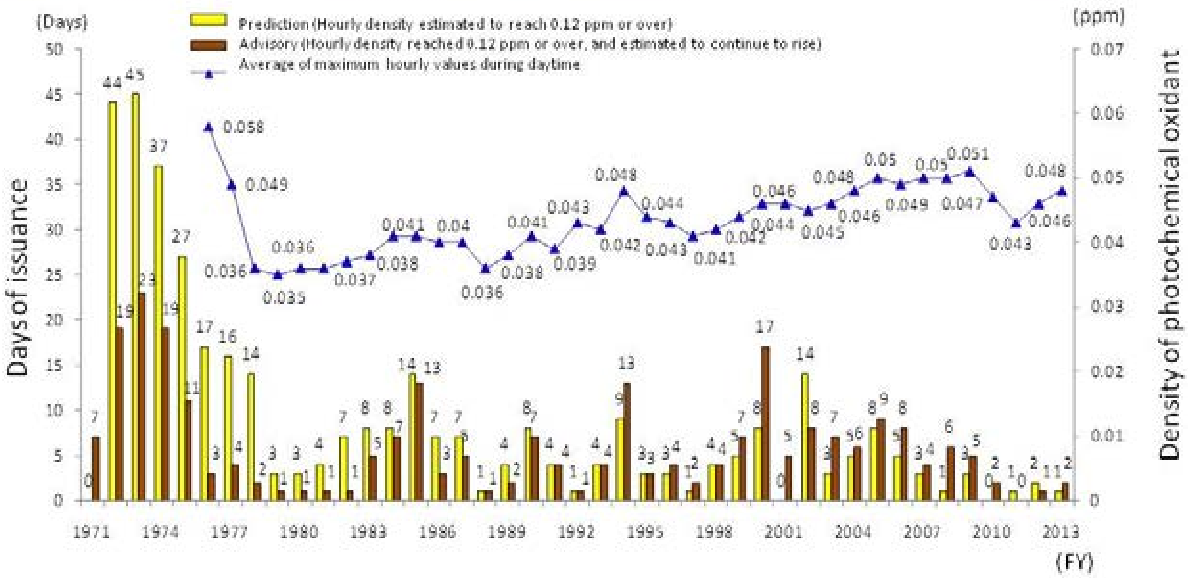


- On a declining trend since 1996 (all items)
- Environmental standards achieved at all stations for NO_2 and CO and at 25 stations (out of 27) for SPM in 2013

03

5

Photochemical Smog



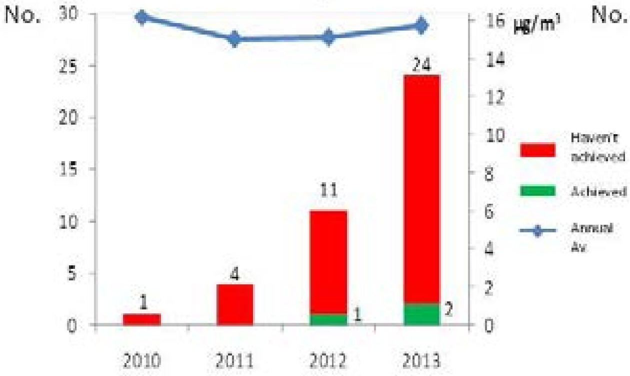
- None of the 52 stations achieved environmental standards for Ox (photochemical oxidant)
- No reports on health damage caused by Ox since 2002 (38 persons)

03

6

PM 2.5

General Environmental
Air Measuring Station



2 stations out of 24 achieved the environmental standard in 2013

Vehicle Exhaust Emissions
Measurement Station

None of the 15 stations achieved the environmental standard in 2013

03

7

PM 2.5 Call for Attention in Hyogo

Issuance standards

1. Hourly value average between 5:00 and 7:00 exceeded 85 μg/m³
2. Hourly value average between 5:00 and 12:00 exceeded 80 μg/m³
3. Daily value average estimated to exceed 70 μg/m³

Call for attention issued
1. Feb 26, 2014
2. May 30, 2014
3. Jun 1, 2014
Eastern Harima region

Number of days of issuance
(As of the end of June, 2014)

8

Measures against Air Pollution in Hyogo

1. Emission from factories/companies

- Registry/examination of facilities producing smoke, based on laws and ordinances
- On-site inspection of factories and companies
- Emission control based on environment conservation agreements
- Comprehensive on-site inspections of air, water, etc. at large-scale factories, etc. ("Mobile anti-pollution unit" since 2007)

2. Photochemical smog

- Surveillance systems, issuance of advisories, emergency measures (banning cars from entering polluted areas, requesting factories to reduce NOx emissions, etc.)

3. Asbestos

- Restriction on factories/companies, on-site inspections at demolition sites

4. PM 2.5

- Notification/alert systems (Since March 9, 2013)
- Automatic monitors to be installed in Hyogo's 66 measuring stations in FY2014

03

9

Measures against Dust from Construction Sites

Demolition/ renovation work	Demolition work		
Scattering-type asbestos Airborne asbestos	Non-scattering type asbestos Includes asbestos		Asbestos not used
Regardless of size	Floor area less than 80 m²	Floor area of/over 80 m²	Floor area of/over 1,000 m²
Registry (Air Pollution Control Act)		Registry (Prefectural ordinance)	

Scattering prevention standards (Both scattering/ non-scattering type)
- Cover site with dustproof sheets
- Moisten the site with water sprinklers
- Removal without demolition (Non-scattering type)

Scattering prevention standards (Scattering-type)
- Remove asbestos before demolition work
- Establish anteroom at separated workspace
- Maintain negative pressure at workspace; install dust collectors

① Registry of demolition works, etc. ＜Business operator → Prefecture＞

↓

② Examination ＜Prefecture＞

↓

③ Implementation of demolition works/scattering prevention standards compliance＜Business operator＞

↓

④ On-site inspection (Asbestos density, measure implementation status) ＜Prefecture＞

Dustproof sheets

Measuring at the workspace gate

○ The prefectural government also conducts patrols (monitoring for unregistered work)

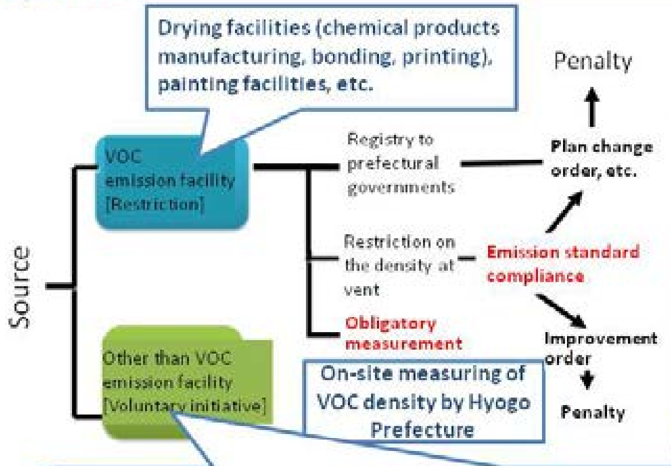
03

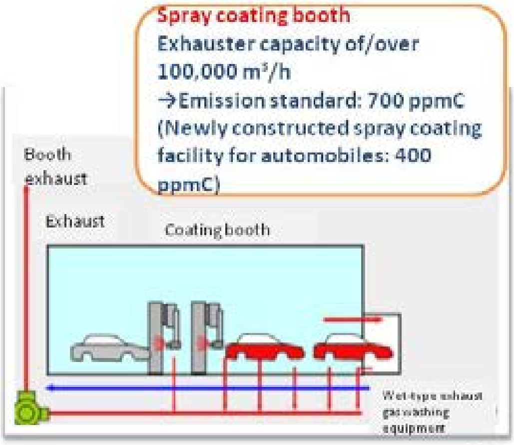
10

Measures against VOC (Volatile Organic Compounds)

Framework of the measures

Effective VOC reduction through **a best-mix** of legal regulation and voluntary initiatives by business operators





The "voluntary initiative" political method supplements the inefficiency and inflexibility of legal restrictions. Business operators voluntarily establish and implement measures, based on its industry group's voluntary action plan → The accomplishment is reported to the national government through the industry group → The result is objectively assessed by specialists

Unique Efforts (1)

Environmental Assessments relating to constructing new/additional large-scale factories

Kobe Steel/Kobe Power Plant (coal-fired power plant in an urban area)

- Location: Kobe Works, Kobe Steel Ltd.
- Power: Plant No. 1/ 0.7 million kW (Since Apr. 2002)
  Plant No. 2/ 0.7 million kW (Since Apr. 2004)
  Total/ 1.4 million kW
- Area: 0.3 million m^2 (Total Kobe Steel site: 1.07 million m^2)

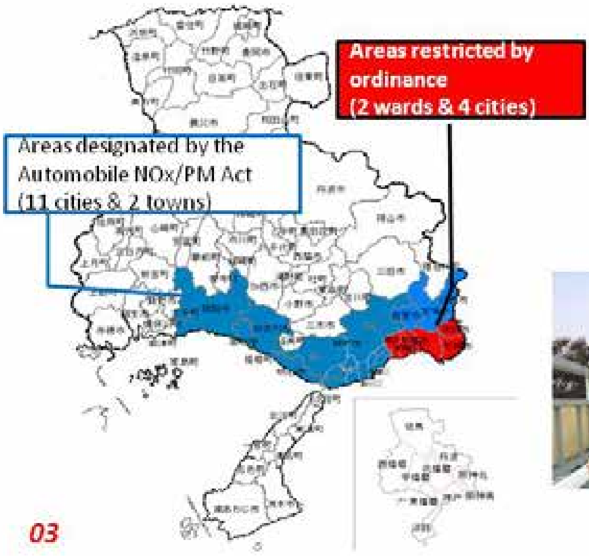
	Air Pollution Control Act	Environment Conservation Agreement	
		Maximum value	Operational target value
SOx	K-value regulation 1.17 Converted density 118.3 ppm	24 ppm	15 ppm
Soot & dust	100 mg/m_N^3	10 mg/m_N^3	5 mg/m_N^3
NOx	200 ppm	24 ppm	8 ppm

Before the establishment of the Environmental Impact Assessment Act, an assessment was conducted based on the prefectural guidelines and municipal ordinance. The process served as an opportunity for communication with citizens, and gas emissions have been controlled within the restriction standard.

12

Unique Efforts (2)
Measures against Vehicle Pollutions

Under the ordinance concerning environmental conservation and creation, entry of old, large-size diesel automobile into the southeast Hanshin area has been regulated since October 2004



- Camera survey: License plate check
- Car registration check at checkpoints
- Support system: Loans for exhaust reduction equipment and vehicles that satisfy regulation standards

Camera survey

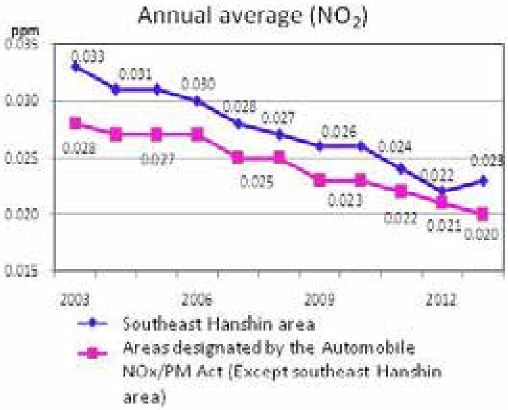
Street checks

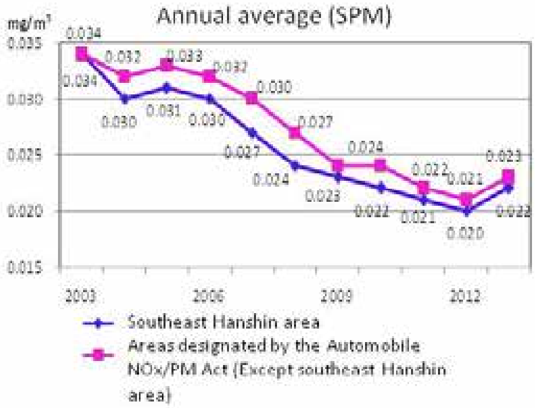
03

13

Unique Efforts (2)
Measures against Vehicle Pollution

【Changes in the density of air pollutants】





- Annual average values in areas restricted by the ordinance and act are improving year by year

03

14

Environmental Exchange between Guangdong and Hyogo

March 1983: Friendship agreement between Guangdong Province and Hyogo Prefecture established

Constant environmental exchange since 1987

1987～2002

1987 Started accepting technical trainees from Guangdong (until 2002)
1993 Jointly established monitoring/measuring plans for Guangdong
1995 Hyogo donated acid rain measuring equipment to Guangdong
⇒ Technical training for measuring and result analysis (until 2002)

2004～2012

2004 Memorandum for exchange of environmental conservation technology between Guangdong and Hyogo
2007 Memorandum for exchange of environmental conservation technology and environmental business between Guangdong and Hyogo
2012 Memorandum for cooperation regarding effective use of resources, a recycling economy, and waste recycling (Between local government affiliated organizations in Guangdong and Hyogo)

Further reinforce cooperation in the field of air environment
(Collaborative research on PM 2.5, technical/human resources exchange and cooperation between private businesses)

03 15

References

- Environmental quality standards (Air quality)
- Mitsubishi Hitachi Power Systems Takasago Works
- Outline of inter-city cooperative projects between Guangdong and Hyogo
- Outline of technical exchange and cooperation between Guangdong and Hyogo

03

Environmental Quality Standards (Air Quality)

Substance	Environmental conditions	Measuring method
Sulfur dioxide (SO_2)	- Daily average for hourly values shall not exceed 0.04 ppm; and - Hourly values shall not exceed 0.1 ppm	Conductometric method or UV fluorescence method
Carbon monoxide (CO)	- Daily average for hourly values shall not exceed 10 ppm; and - Average of hourly values for any consecutive eight hour period shall not exceed 20 ppm	Nondispersive infrared analyzer method
Suspended particulate matter (SPM)	- Daily average for hourly values shall not exceed 0.10 mg/m^3; and - Hourly values shall not exceed 0.20 mg/m^3	Weight concentration measuring methods based on filtration collection; or light scattering method, piezoelectric microbalance method, or β-ray attenuation method that yields values having a linear relation with the values of the above methods
Nitrogen dioxide (NO_2)	- Daily average for hourly values shall be within the 0.04-0.06 ppm zone or below that zone	Colorimetry employing Saltzman reagent or chemiluminescent method using ozone
Photochemical oxidants (Ox)	- Hourly values shall not exceed 0.06 ppm	Absorption spectrophotometry or coulometry using a neutral potassium iodide solution, UV absorption spectrometry, or a chemiluminescent method using ethylene
Fine particulate matter (PM 2.5)	- Annual standard for PM 2.5 is less than or equal to 15.0 μg/m^3; and - 24 hour standard is less than or equal to 35 μg/m^3	Mass measurement with filter sample collection which is designated as a reference method, or alternative automated methods, designated as having measurement performance comparable to the corresponding reference method

Efforts by a Company based in Hyogo
<Mitsubishi Hitachi Power Systems Takasago Works>

Mitsubishi Hitachi Power Systems Takasago Works

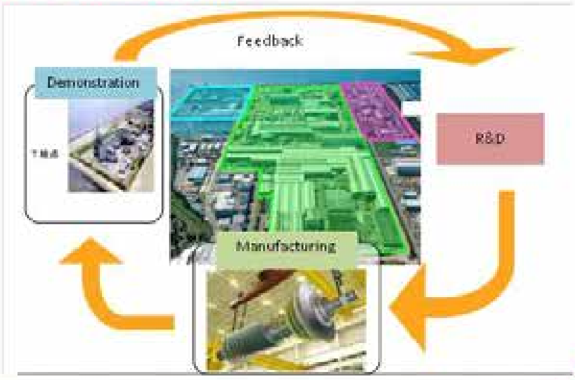
- Location: Takasago City, Hyogo
- Establishment: 1962
- Main products: Gas turbine, steam turbine (thermal power/nuclear power)
- Employees: Approx. 3,800

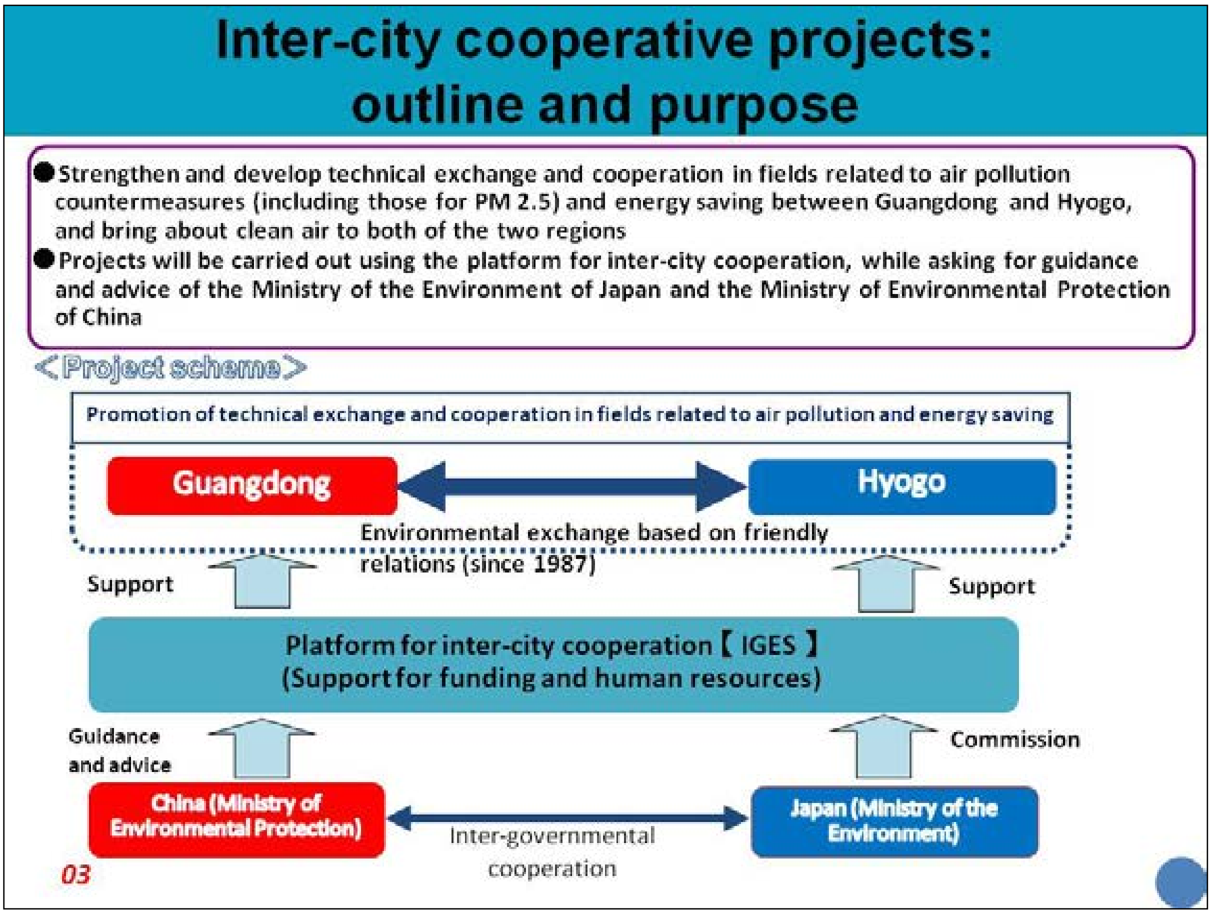
Thermal power generation system divisions of Mitsubishi Heavy Industries and Hitachi merged in Feb 2014

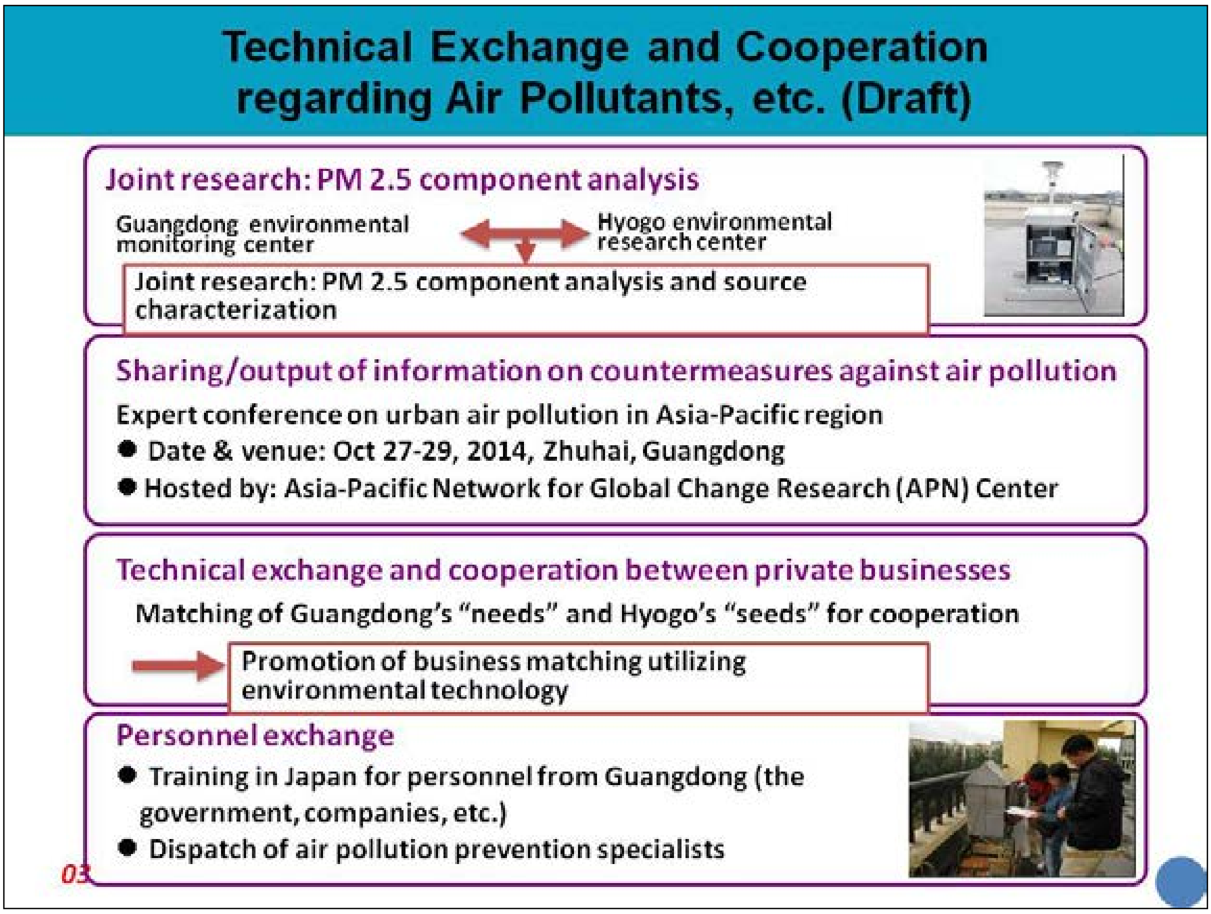
Strength of the plant:
Only plant in the world that conducts development, manufacturing and demonstrations at one place

Demonstrative operation of gas turbines of 1,600℃ class in Takasago

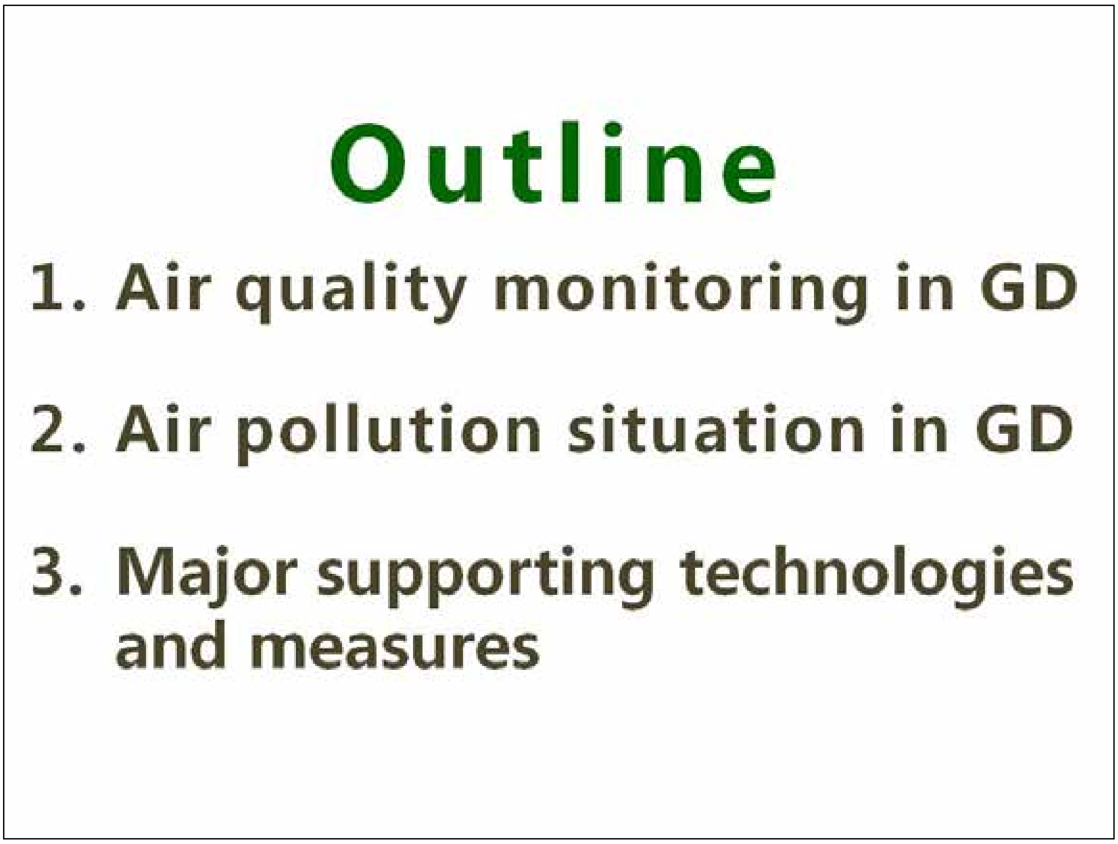
【Outline of the facility】
- Generated power: 389,000 kW
- Generation method: Combined cycle
- Condenser: Air-cooled
- Fuel: Town gas
- NOx: 4 ppm/10.3m$^3{}_N$/h
- SOx, soot & dust: 0 ppm




Inter-city cooperative projects:
outline and purpose
Strengthen and develop technical exchange and cooperation in fields related to air pollution countermeasures (including those for PM 2.5) and energy saving between Guangdong and Hyogo, and bring about clean air to both of the two regions
Projects will be carried out using the platform for inter-city cooperation, while asking for guidance and advice of the Ministry of the Environment of Japan and the Ministry of Environmental Protection of China
<Project scheme>
Promotion of technical exchange and cooperation in fields related to air pollution and energy saving
Guangdong
Hyogo
Environmental exchange based on friendly relations (since 1987)
Support
Support
Platform for inter-city cooperation【IGES】
(Support for funding and human resources)
Guidance and advice
Commission
China (Ministry of Environmental Protection)
Inter-governmental cooperation
Japan (Ministry of the Environment)
03


Technical Exchange and Cooperation
regarding Air Pollutants, etc. (Draft)
Joint research: PM 2.5 component analysis
Guangdong environmental monitoring center
Hyogo environmental research center
Joint research: PM 2.5 component analysis and source characterization
Sharing/output of information on countermeasures against air pollution
Expert conference on urban air pollution in Asia-Pacific region
Date & venue: Oct 27-29, 2014, Zhuhai, Guangdong
Hosted by: Asia-Pacific Network for Global Change Research (APN) Center
Technical exchange and cooperation between private businesses
Matching of Guangdong's "needs" and Hyogo's "seeds" for cooperation
Promotion of business matching utilizing environmental technology
Personnel exchange
Training in Japan for personnel from Guangdong (the government, companies, etc.)
Dispatch of air pollution prevention specialists
03

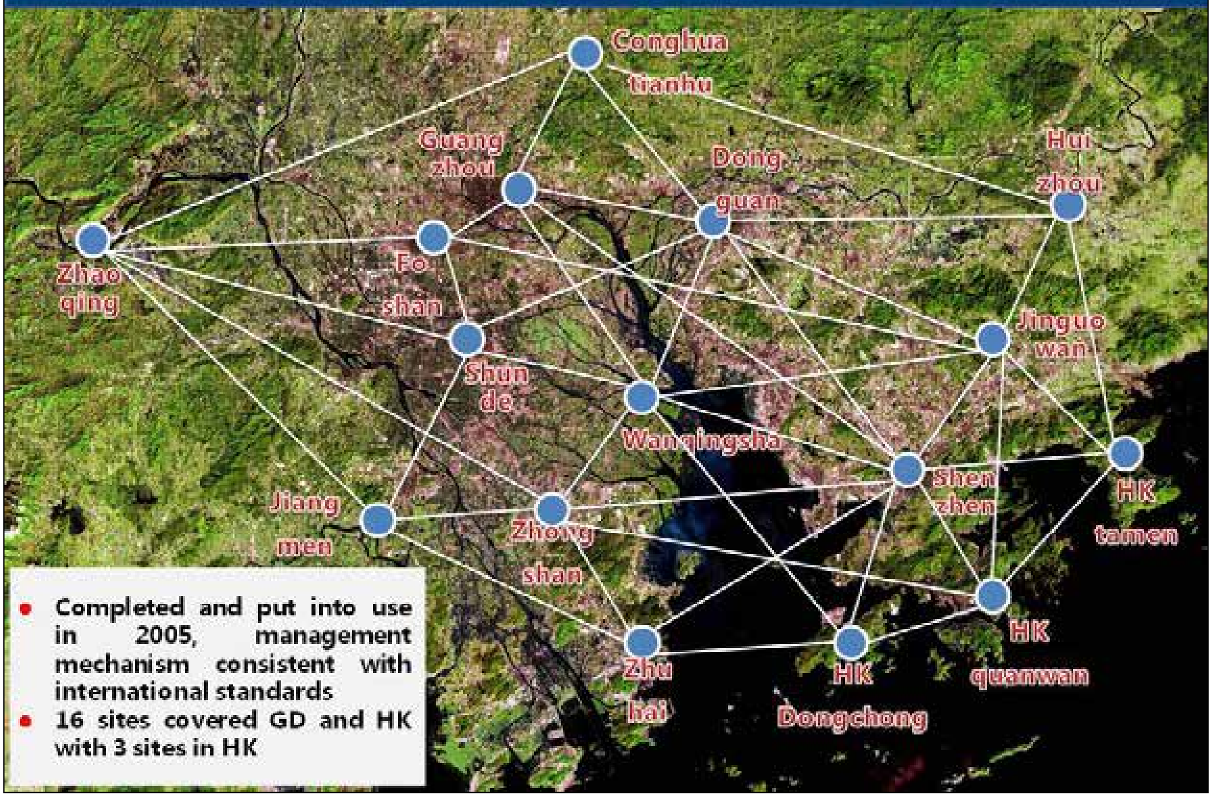
6.5 Air Pollution Situation and Supporting Technologies in Guangdong Province (Duohong Chen)



Outline

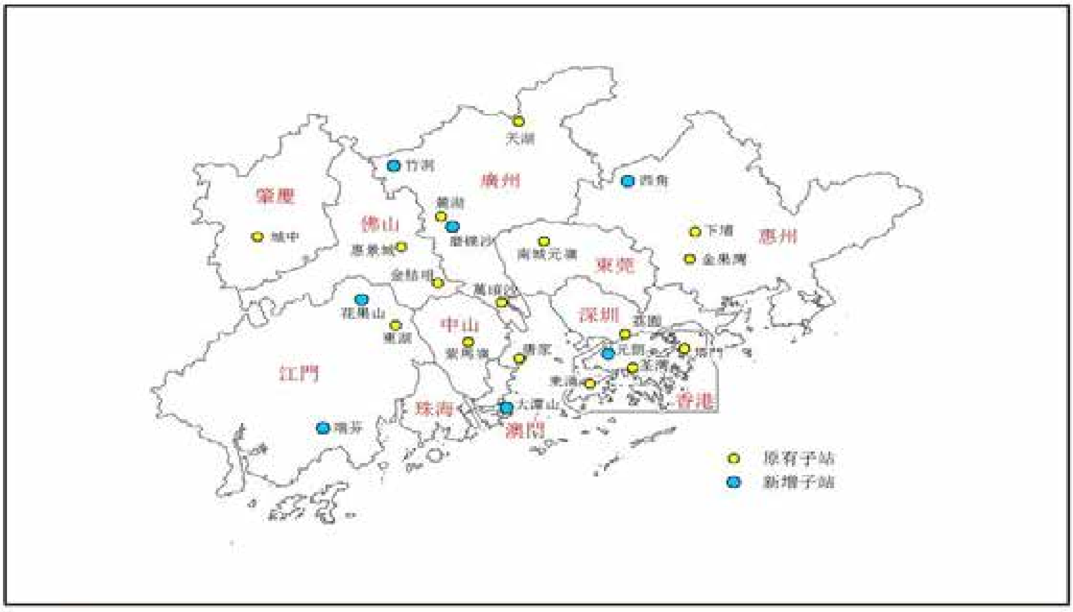
1. Air quality monitoring in GD
2. Air pollution situation in GD
3. Major supporting technologies and measures

GD-HK air quality monitoring network



- Completed and put into use in 2005, management mechanism consistent with international standards
- 16 sites covered GD and HK with 3 sites in HK

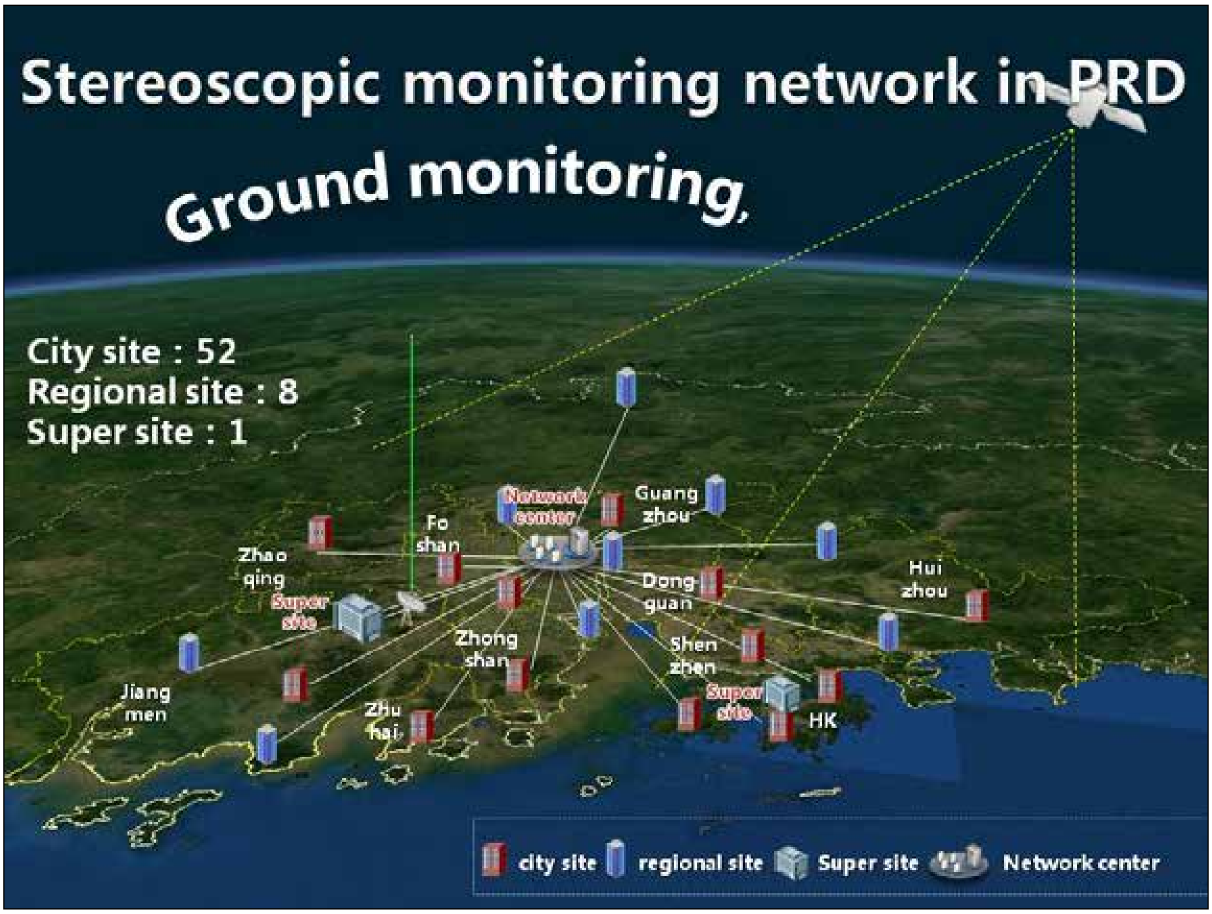
GD-HK-MA air quality monitoring network



Increased sites: 5 in GD , 1 in HK , 1 in Macau , 23 in total

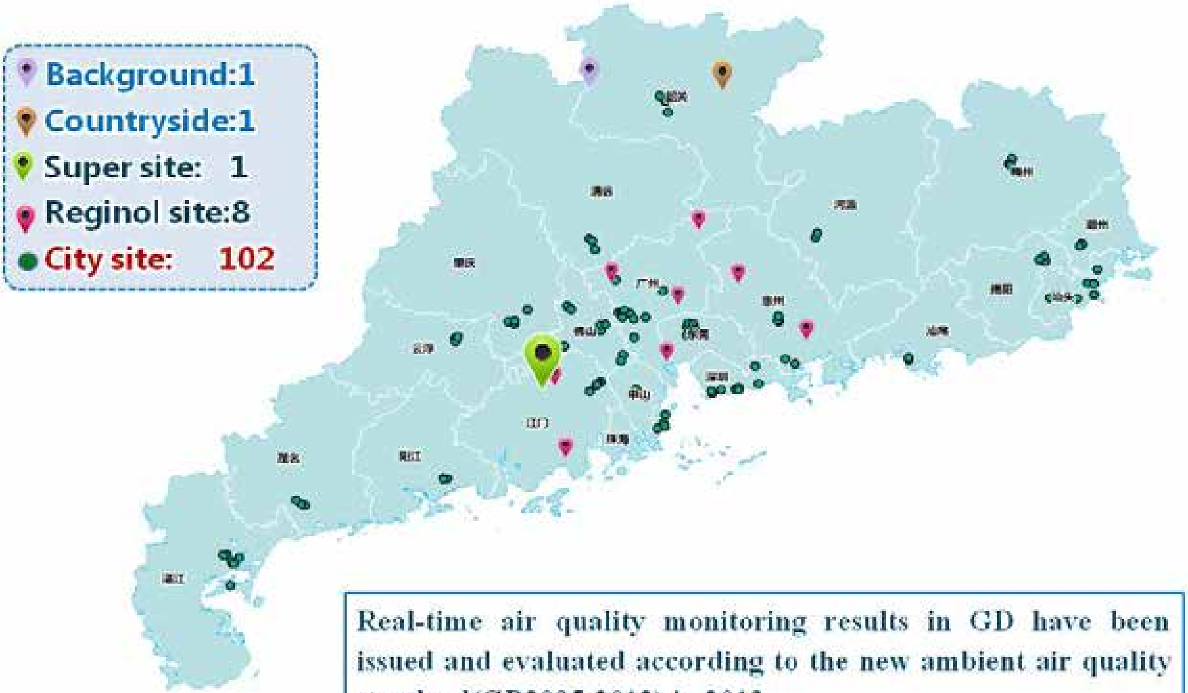
GD-HK-MA air quality monitoring network

On 3rd , September, GD, HK and Macau jointly issued air quality information to the public


Stereoscopic monitoring network in PRD
Ground monitoring
City site : 52
Regional site : 8
Super site : 1
Network center
Guang zhou
Fo shan
Zhao qing
Super site
Hui zhou
Dong guan
Zhong shan
Shen zhen
Jiang men
Zhu hai
Super site
HK
city site
regional site
Super site
Network center


The first supper monitoring sites combining scientific research with vocational work
Multi-parameter observation lab
Suppur site outside look
Aerosal observation lab
Cover an area of 28 mu , with 30 pieces of laboratory equipment , about 200 monitoring items , 2200 m² of lab space and an investment of 30 million RMB
Photo chemical observation lab
Rooftop observation platform
Technical verification lab

Guangdong air quality monitoring network



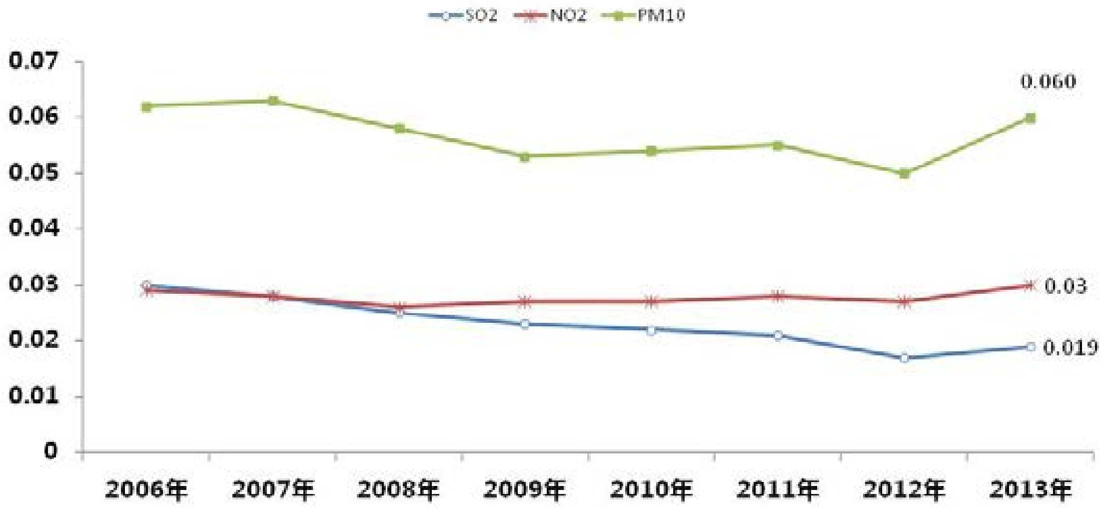
Real-time air quality monitoring results in GD have been issued and evaluated according to the new ambient air quality standard(GB3095-2012) in 2013

Outline

1. Air quality monitoring in GD
2. Air pollution situation in GD
3. Major supporting technologies and measures

Air quality variation trends in recent years

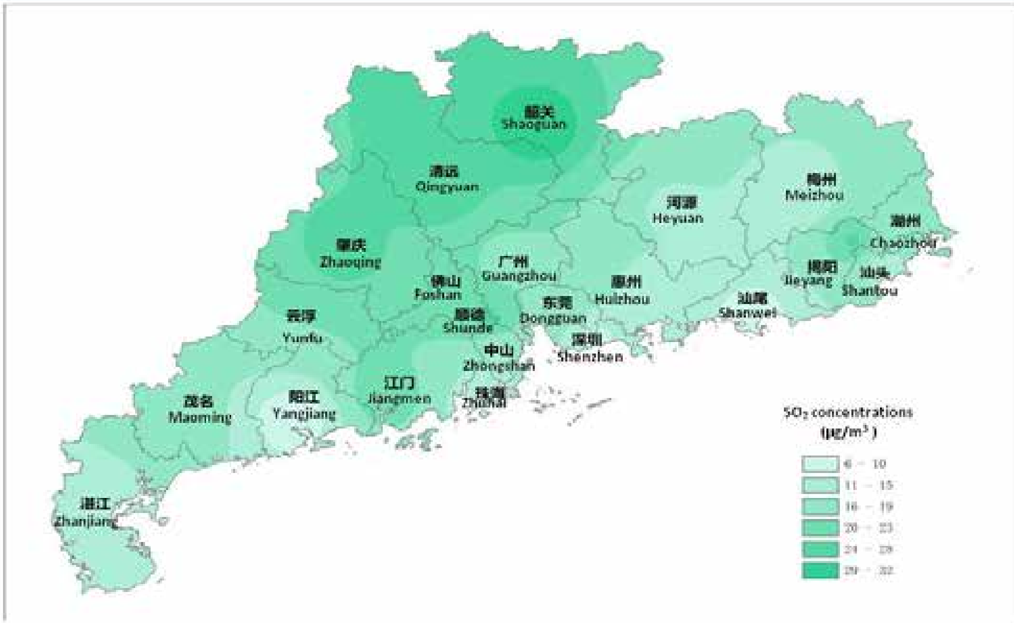
Compared with 2006 , SO_2 concentrations in 2013 decreased by 36.7% ; NO_2 increased by 3.4% ; PM_{10} decreased by 3.2%



Air quality situation during January to September in 2014

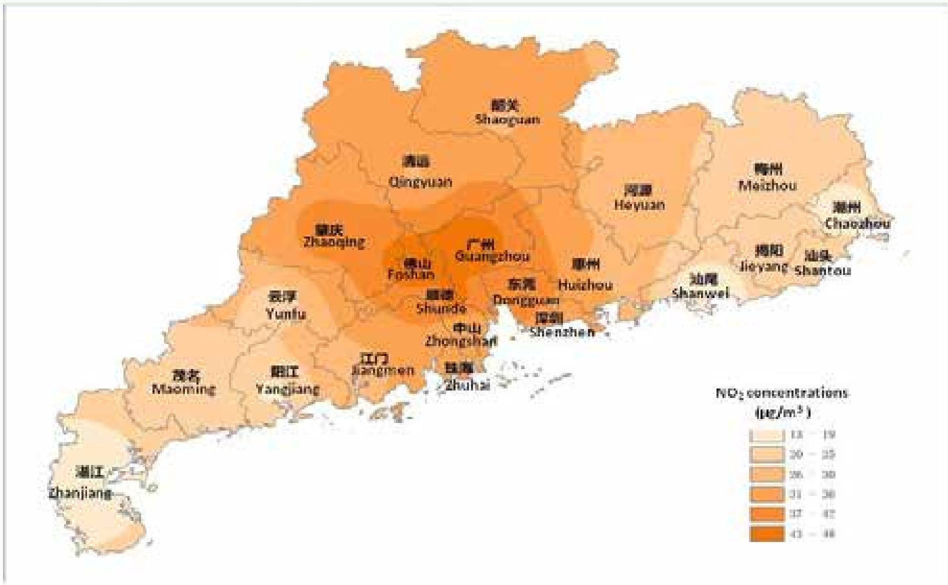
SO_2 concentrations

SO_2 concentrations ranged from **6 to 32** μg/m³
Concentration in Shaoguan and Zhaoqing was higher than other areas



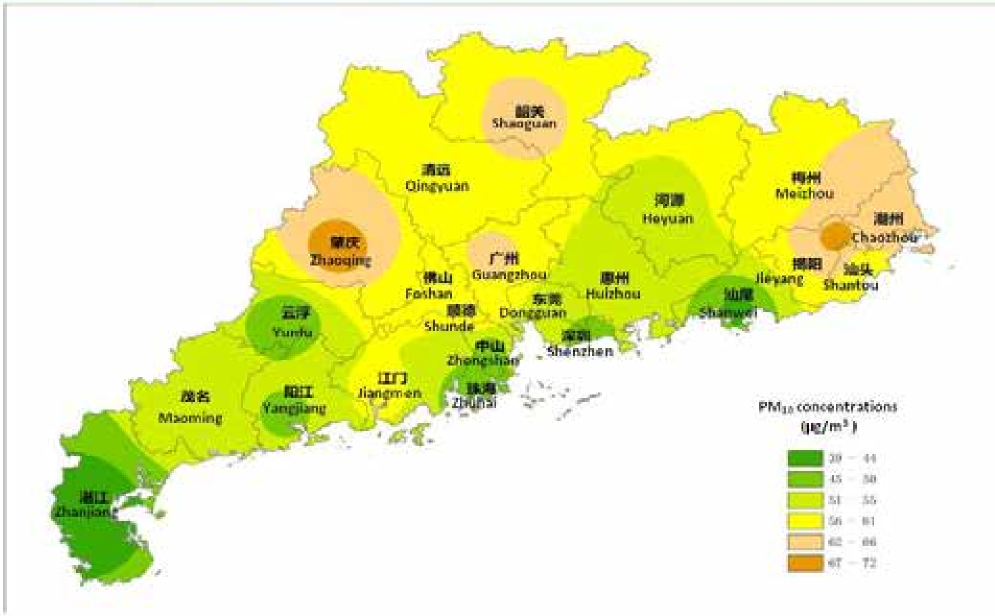
NO_2 concentrations

NO_2 concentrations ranged from 13 to 48 μg/m³
Concentrations in PRD were high, while those in east and west GD were low due to vehicle emissions



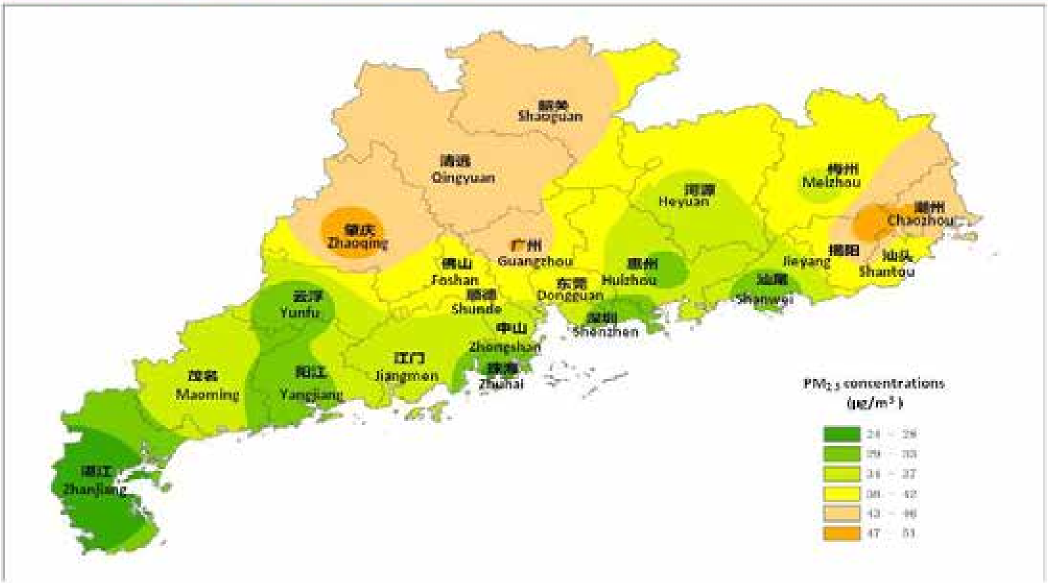
PM_{10} concentrations

PM_{10} concentrations ranged from 39 to 72 μg/m³
Concentrations in Zhaoqing , Shaoguan and Guangzhou were relatively higher; while those in coastal areas were lower



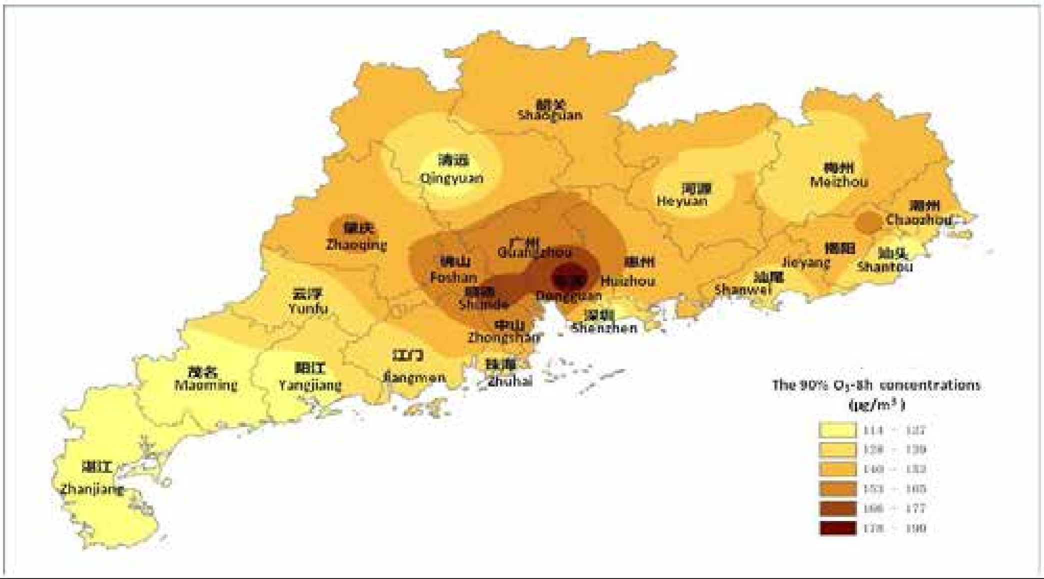
$PM_{2.5}$ concentrations

$PM_{2.5}$ concentrations ranged from 24 to 51 μg/m³
Concentrations in Zhaoqing and Jieyang were relatively higher; while those in coastal areas were lower



O_3 concentrations

The 90% O_3-8h concentrations ranged from 114 to 190 μg/m³
Concentrations in PRD were higher than other areas; while those in west GD were lower

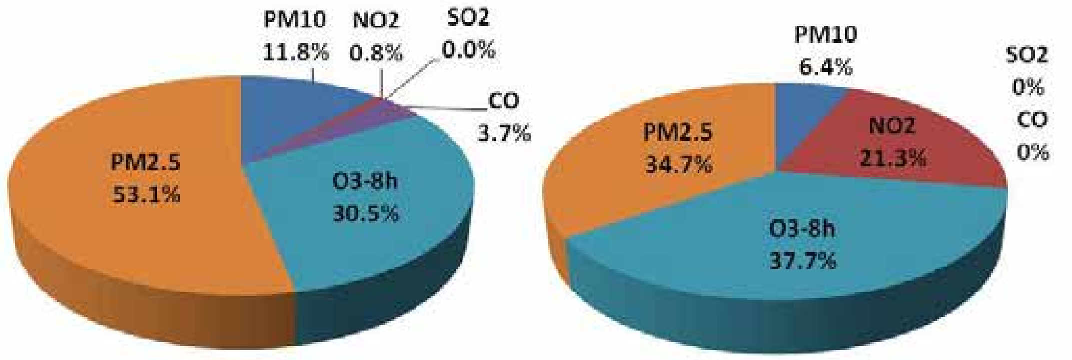


Primary air pollutants

Particles （$PM_{2.5}$, PM_{10}）were major primary pollutants in non-PRD region, accounting for 65%

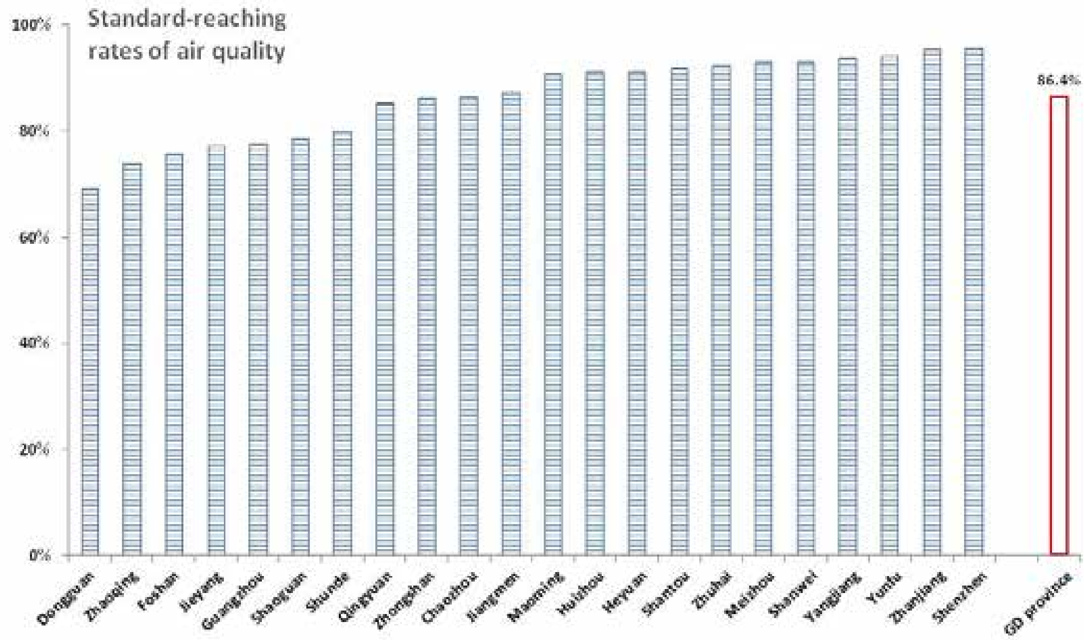
Particles （$PM_{2.5}$, PM_{10}）were also major primary pollutants in PRD region, accounting for 41%

O_3 and NO_2 in PRD accounted for higher proportions than those in Non-PRD region



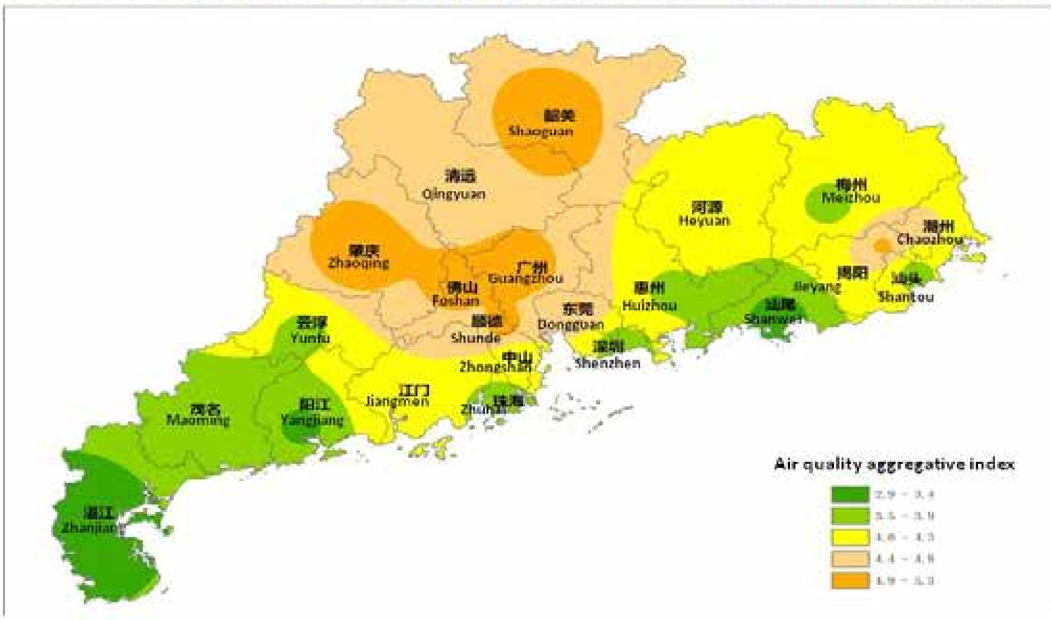
primary pollutants in non-PRD region　　primary pollutants in PRD region

Standard-reaching rates of regional air quality range from 70% to over 90%



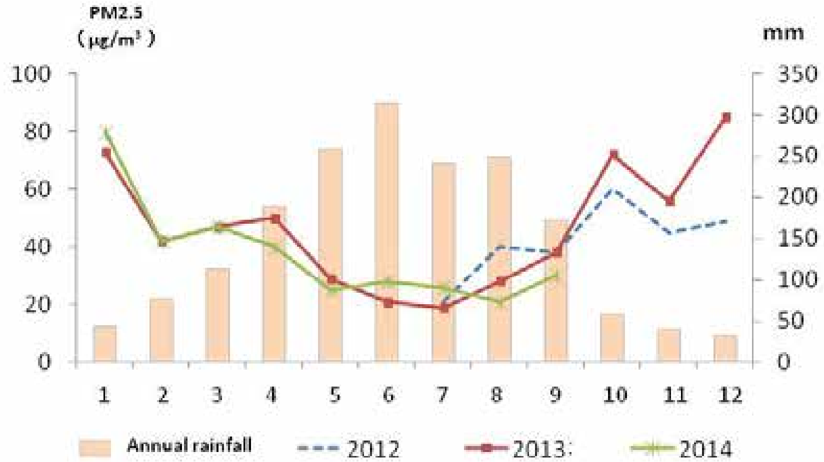
Overall evaluation of air quality

Air quality in middle-north PRD and Shaoguan were poor while those in coastal areas were good



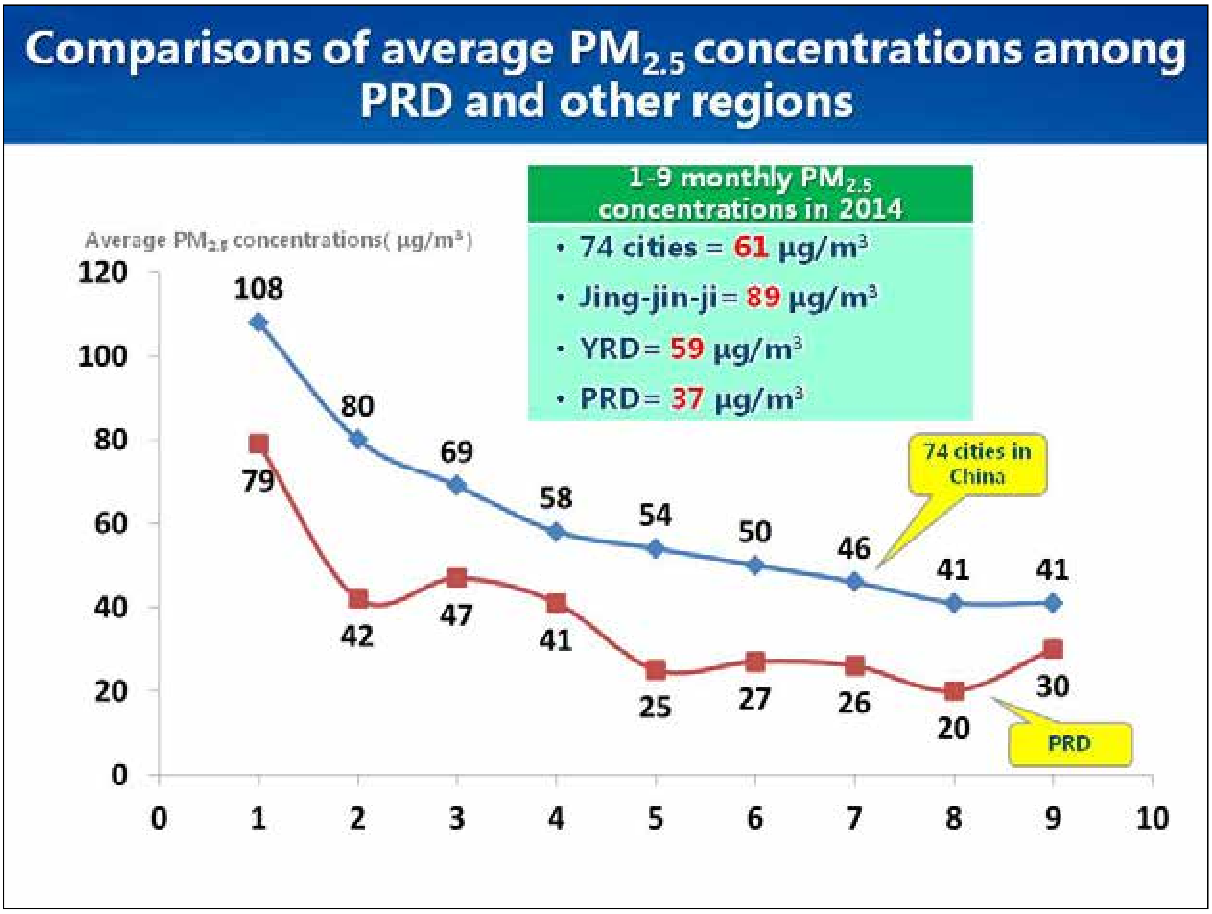
Comparisons of air quality during January to September with last year—$PM_{2.5}$ concentrations in PRD region

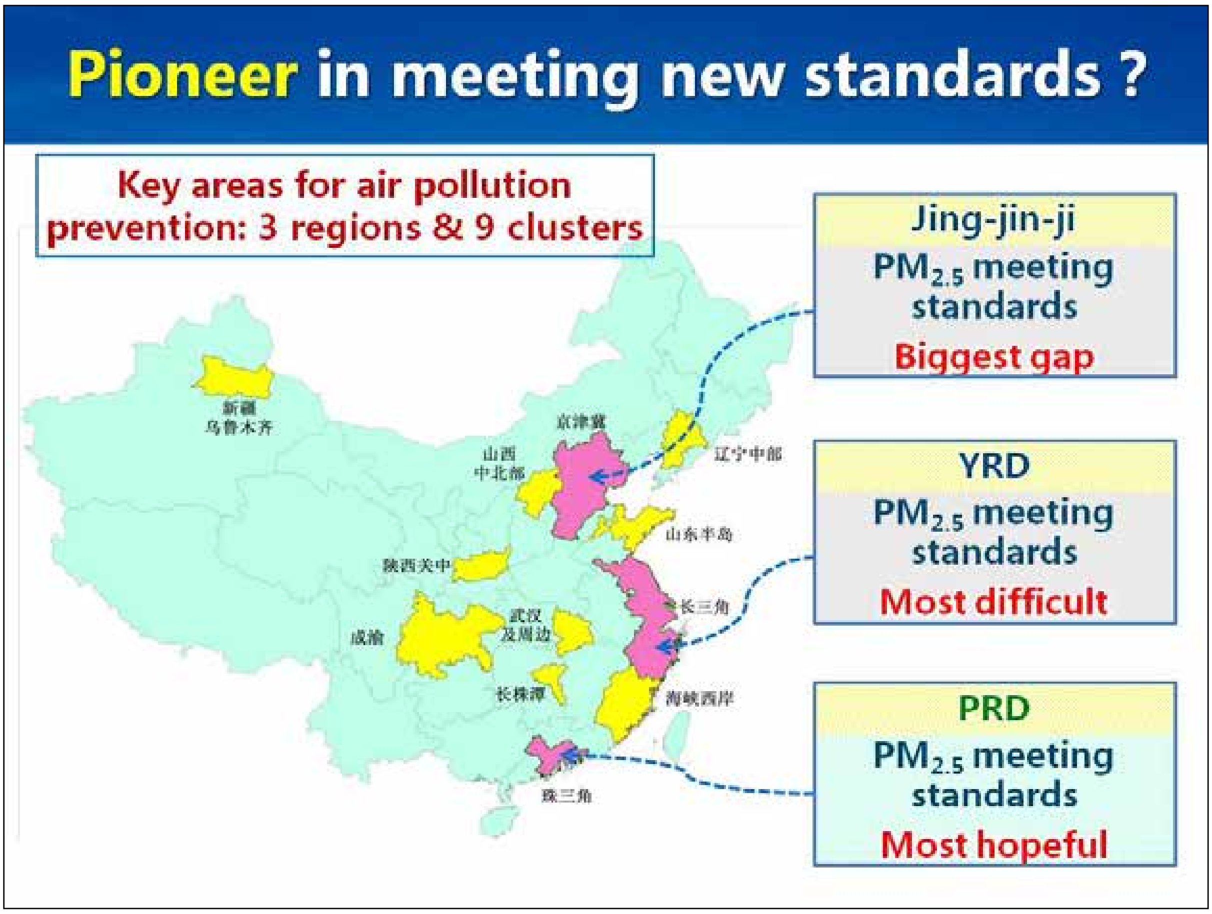
Monthly variations of $PM_{2.5}$ concentrations were obvious with lower values during May to August, due to favorable conditions including high precipitation and southern prevailing wind



Rainfall data source: Guangdong Meteorological Department

Comparisons of PRD and other key cities in China


Comparisons of average $PM_{2.5}$ concentrations among PRD and other regions
1-9 monthly $PM_{2.5}$ concentrations in 2014
• 74 cities = 61 μg/m³
• Jing-jin-ji = 89 μg/m³
• YRD = 59 μg/m³
• PRD = 37 μg/m³
Average $PM_{2.5}$ concentrations(μg/m³)
120
100
80
60
40
20
0
0 1 2 3 4 5 6 7 8 9 10
108
80
69
58
54
50
46
41
41
79
42
47
41
25
27
26
20
30
74 cities in China
PRD


Pioneer in meeting new standards ?
Key areas for air pollution prevention: 3 regions & 9 clusters
Jing-jin-ji
$PM_{2.5}$ meeting standards
Biggest gap
YRD
$PM_{2.5}$ meeting standards
Most difficult
PRD
$PM_{2.5}$ meeting standards
Most hopeful
新疆
乌鲁木齐
京津冀
山西
中北部
辽宁中部
山东半岛
陕西关中
长三角
成渝
武汉
及周边
长株潭
海峡西岸
珠三角

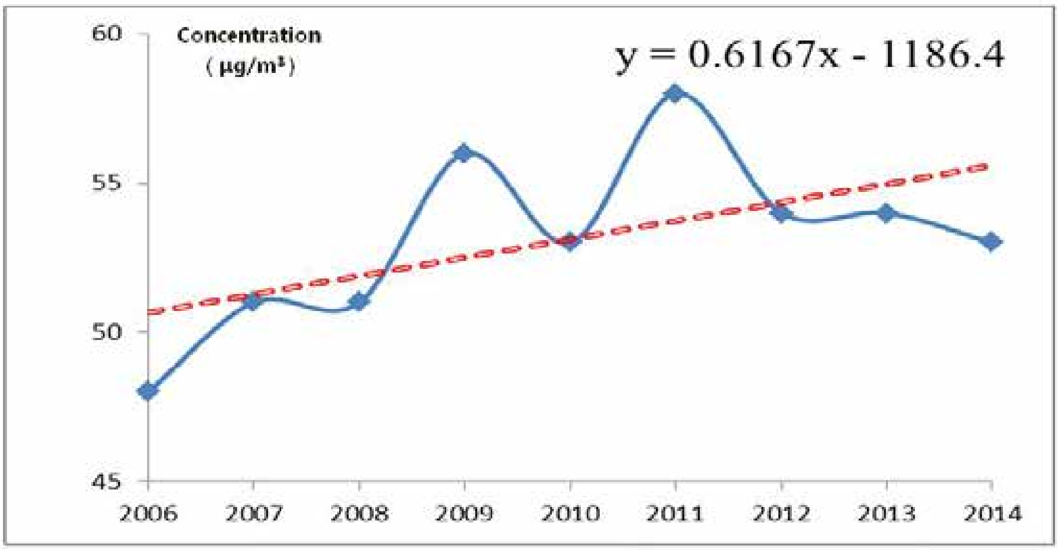
Comparisons of O_3 concentrations between PRD and other regions in China during July to September

In autumn and winters , O_3 standard exceeding rates in PRD may be higher than Jing-jin-ji and YRD

O_3 standard exceeding rate	Jing-jin-ji	YRD	PRD
July 2014	34.8%	16.4%	17.6%
August 2014	24.7%	11.0%	11.5%
September 2014	7.9%	8.6%	21.6%

O_3 concentration trends in recent years

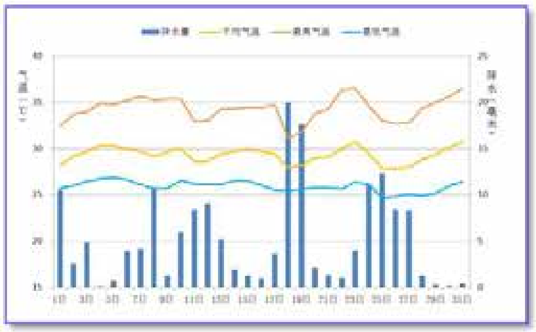
Increasing with fluctuation, but the upward trend has been contained

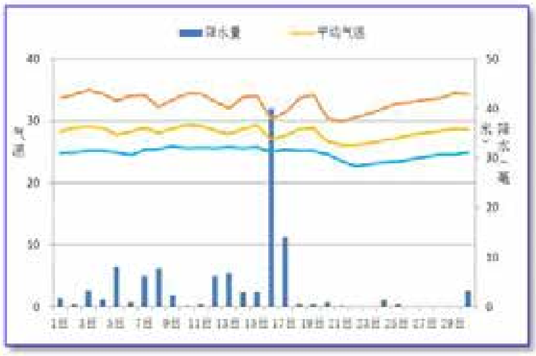


Monitoring data from GD&HK network

Note : statistical data of 1-9 month in 2014 was used

Analysis of weather situation during July to September



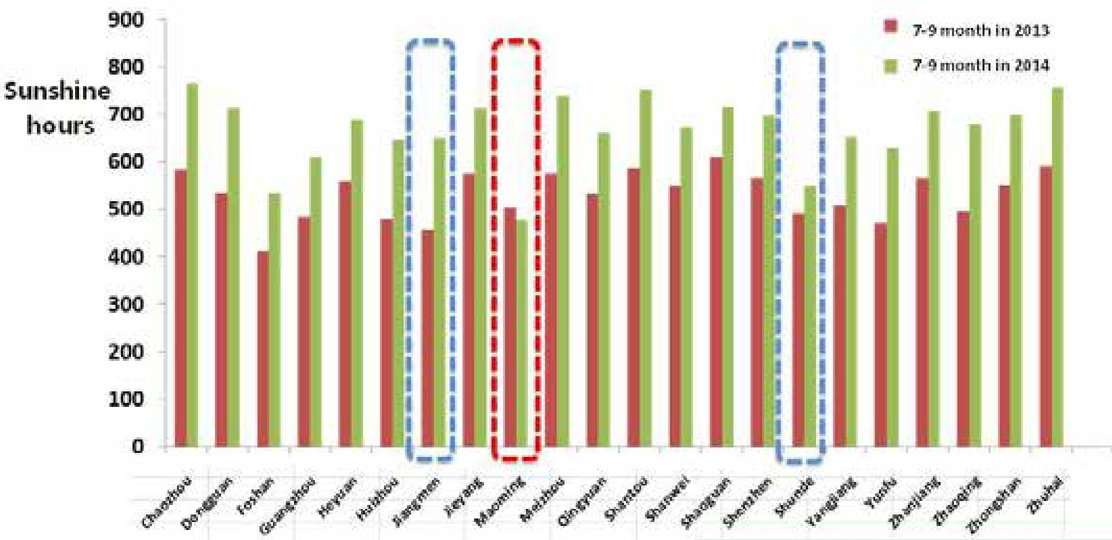


- **Higher temperature** : 0.8℃ higher in July , 0.1℃ in August and 1.3℃ in September
- **Less rainfall** : 32% less in July , 17% in August and 35% in September

source: Guangdong Meteorological Department

Sunshine hours increased obviously during July to September

Sunshine hours increased significantly than last year, by 11(Shunde) to 42(Jiangmen)%, except that in Maoming decreased 5% , Such condition is favorable for photo chemical pollution formation, causing the increase of O_3 concentrations

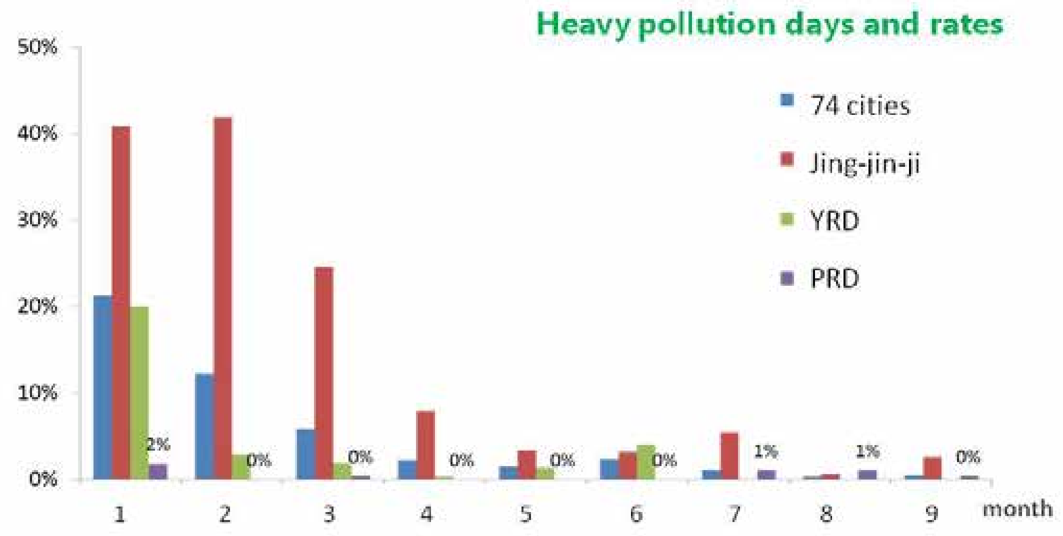


source: Guangdong Meteorological Department

Higher AQI standard-reaching rates in PRD

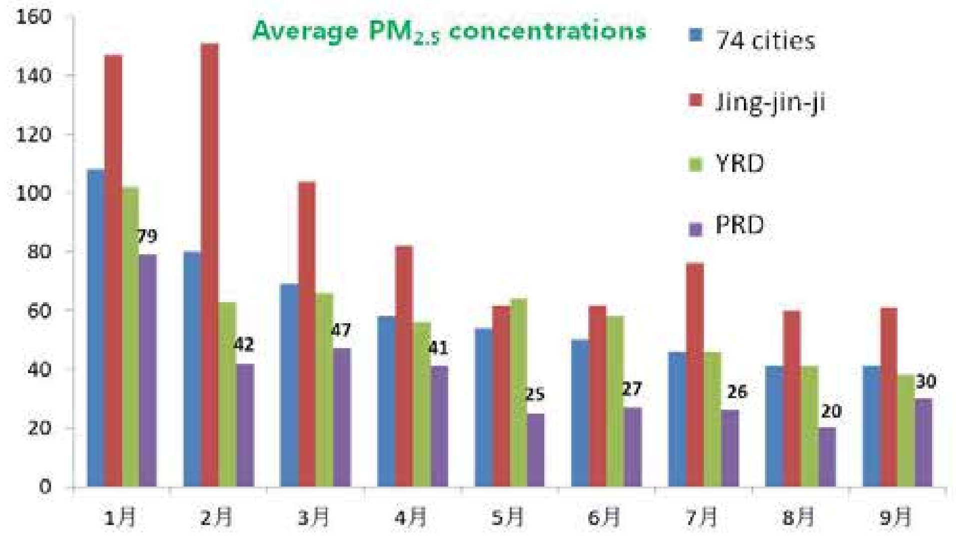
AQI standard-reaching rates were **obviously higher** than Jing-jin-ji, YRD and 74 cities in China

Less heavy pollution days in PRD



Heavy pollution days and rates in PRD were **significantly lower** than Jing-jin-ji, YRD and 74 cities in China

Lower $PM_{2.5}$ concentrations in PRD



Average $PM_{2.5}$ concentrations were much lower in PRD

Ranking of PRD air quality among the 74 cities in China

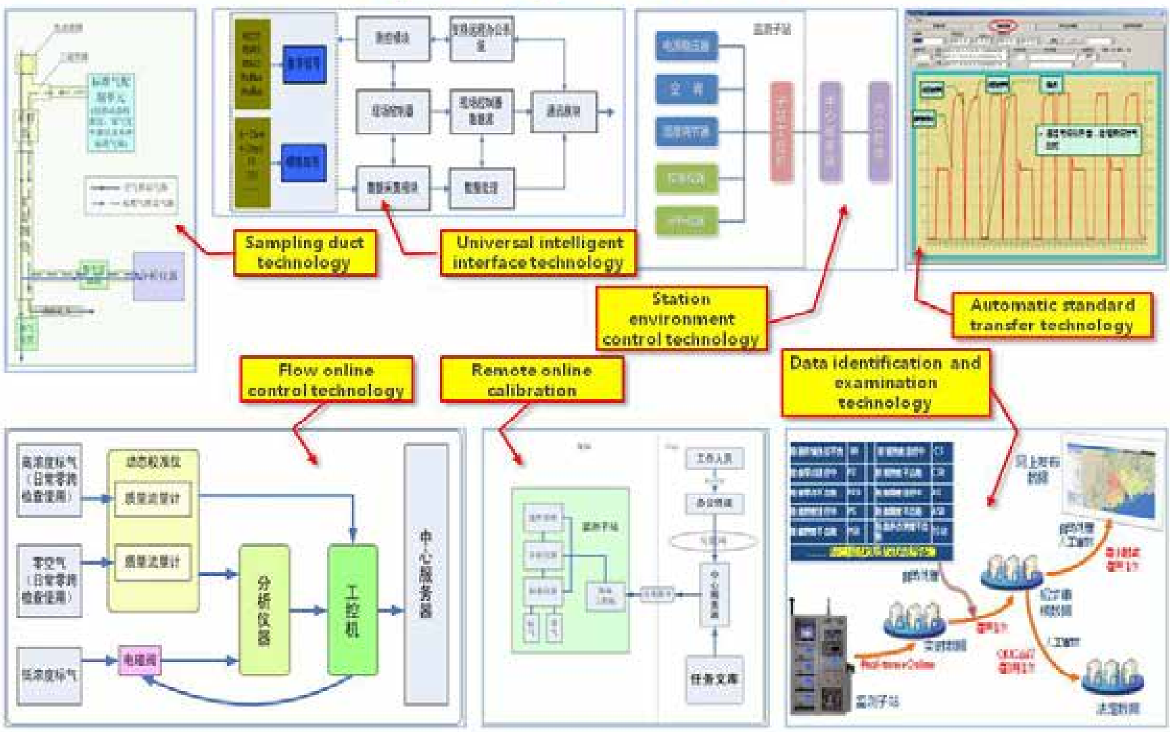
Frequency of entering the top ten of national air quality ranking increased comparing with last year (from 30 to 33 times)

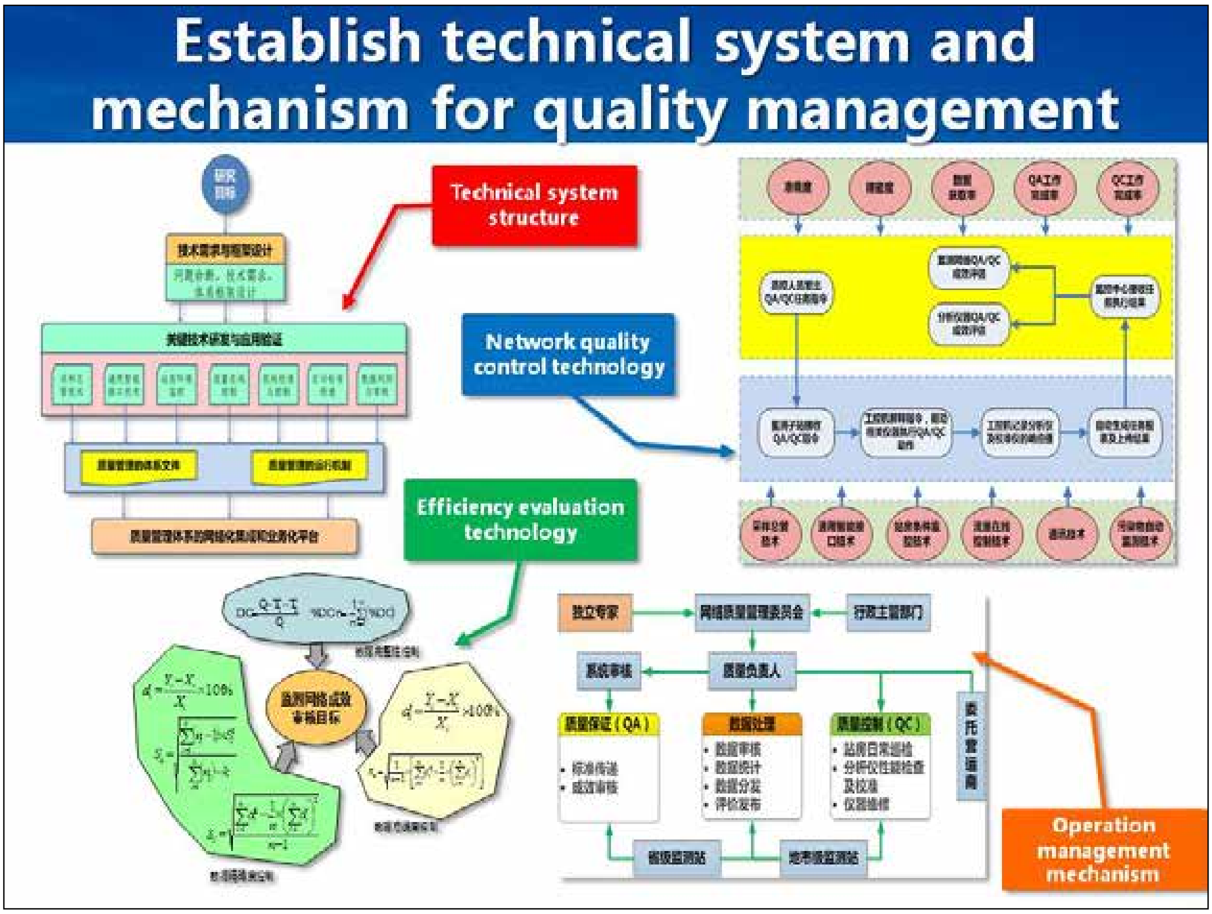
2013	1	2	3	4	5	6	7	8	9	2014	1	2	3	4	5	6	7	8	9
Guangzhou	12	21	45	32	24	22	40	50	52		27	22	26	26	12	25	35	26	37
Shenzhen	7	11	8	14	7	5	9	25	13		7	5	5	4	4	5	12	7	16
Zhuhai	10	9	6	6	4	2	2	6	18		8	7	4	3	2	2	4	2	17
Foshan	23	18	38	30	18	11	34	49	53		37	17	20	24	14	28	20	16	33
Jiangmen	16	8	16	13	8	6	11	15	34		19	20	15	14	5	15	10	4	14
Zhaoqing	6	32	43	50	20	12	17	26	45		36	34	44	40	18	21	21	17	30
Huizhou	5	6	5	5	2	8	7	22	9		9	10	6	5	6	4	14	10	10
Dongguan	13	13	40	27	9	14	28	34	33		23	24	19	20	7	19	30	25	40
Zhongshan	19	14	11	10	6	3	5	11	31		10	13	9	6	3	7	13	3	23

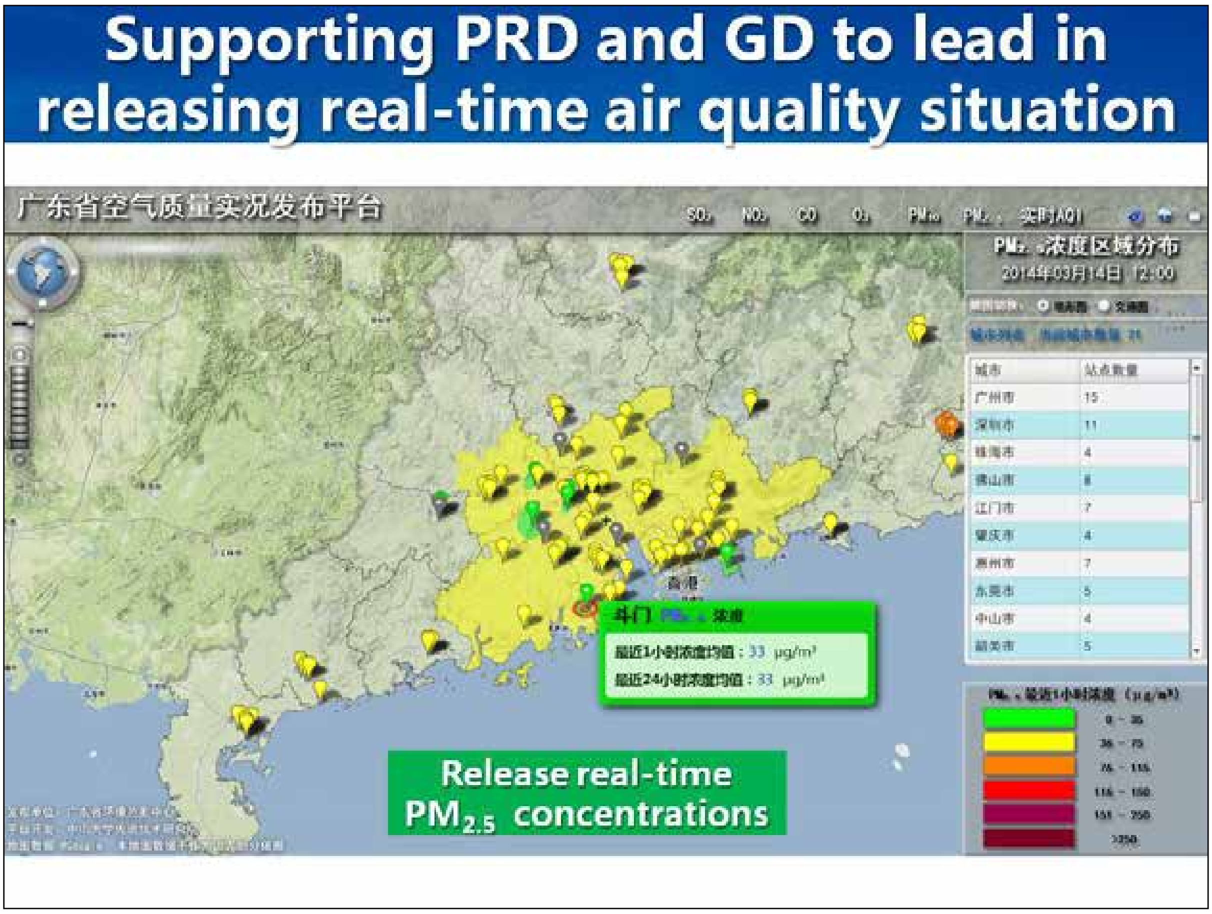
Outline

1. Air quality monitoring in GD
2. Air pollution situation in GD
3. Major supporting technologies and measures

Key technology supporting network quality control




Establish technical system and mechanism for quality management
Technical system structure
Network quality control technology
Efficiency evaluation technology
独立专家
网络质量管理委员会
行政主管部门
系统审核
质量负责人
质量保证（QA）
数据处理
质量控制（QC）
Operation management mechanism

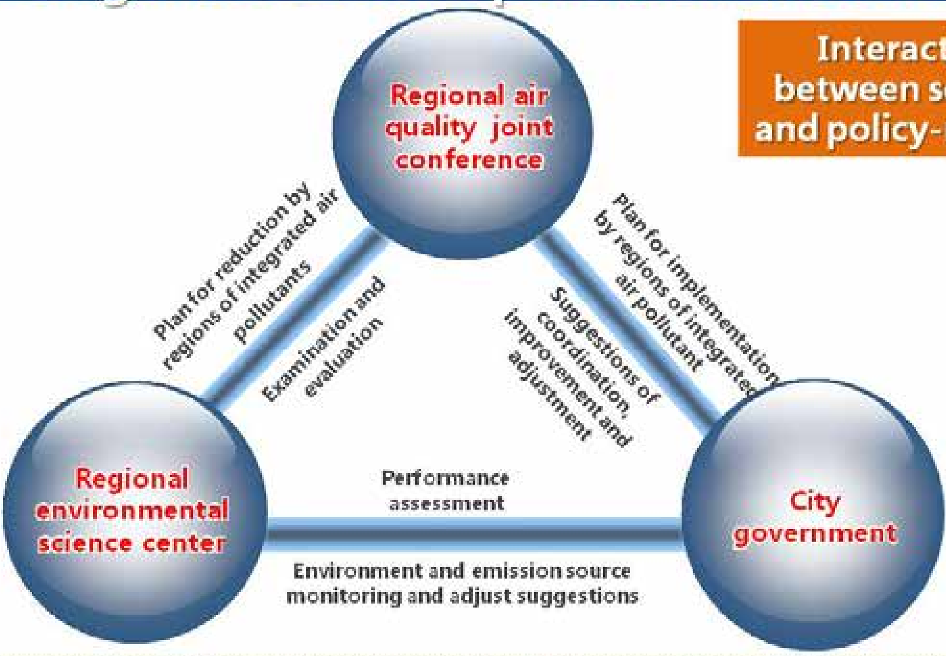

Supporting PRD and GD to lead in releasing real-time air quality situation
广东省空气质量实况发布平台
实时AQI
2014年03月14日 12:00
城市
站点数量
广州市
15
深圳市
11
珠海市
4
佛山市
8
江门市
7
肇庆市
4
惠州市
7
东莞市
5
中山市
4
汕尾市
5
香港
斗门
Release real-time PM2.5 concentrations

Establish the PRD air pollution prevention joint conference system

- Established in 2008, serving as the first joint conference and the highest policy-making organization for regional air pollution prevention
- The first congregant is the vice-governor of GD province
- Further enhance leadership in 2014 by upgrading the first congregant to the governor of GD province

Create regional atmospheric environment manage mode and operational mechanism

Interaction between science and policy-making



Supporting GD to formulate the first regional clean air action plan: the PRD clean air action plan

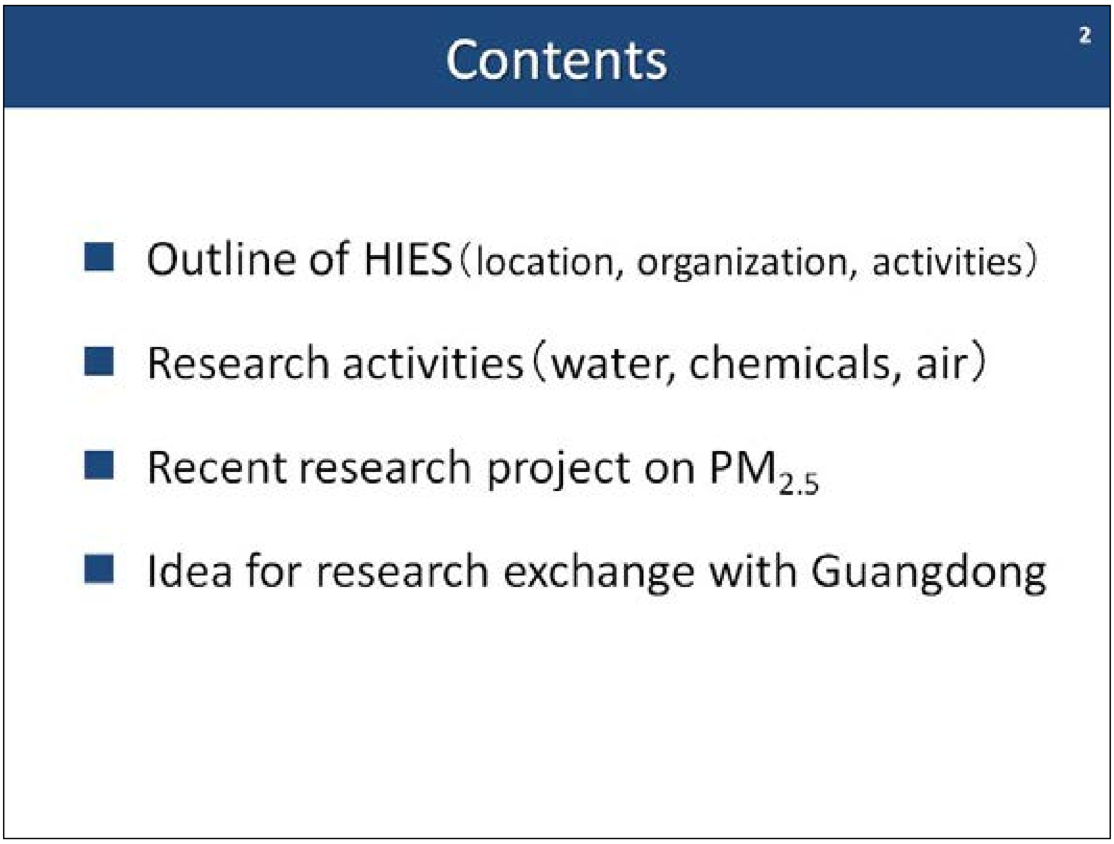
Establishment of the global third technology demonstration zone for air pollution joint prevention

A technology demonstration zone for air pollution joint prevention was established in PRD, being the global third demonstration zone following California in United States and Europe.

广东省环境监测中心
Guangdong Environmental Monitoring Center

Thanks !

6.6 Research Activities of The Hyogo prefectural Institute of Environmental Sciences (Yasuhiro Kanda)



Location

3

Address:
3-1-18, Yukihira-cho, Suma-ku, Kobe,
Hyogo, Japan 654-0037

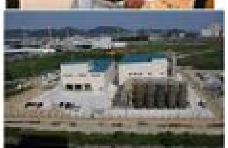
Building where HIES is located

Organization

4

- Hyogo Environmental Advancement Association (public interest incorporated foundation)
  - Management & Planning Dept.
  - Environmental Creation Dept.
  - Resource Circulation Dept.
  - Environmental Technology Dept.

Environmental education



Cement recycle project

Chemical analysis

- Hyogo Prefectural Institute of Environmental Sciences(HIES)

Activities (FY2014 – FY2016)

5

- Research activity
  Research on the measures against
  - Pollution of Enclosed Coastal Sea
  - Pollution of organic chemical materials
  - Regional and local air pollution
- Commissioned work from Hyogo prefectural government
  - Environmental monitoring on heavy metals, etc.
  - Measurement of environmental loads including GHG emissions
  - Response for environmental emergency
- Others
  - Collaboration with national and local environmental institutes, universities, etc. : externally funded projects
  - Dissemination of research results : HIES bulletin, presentations at events
  - International cooperation and human resource development : JICA training course, university student training

Research on Water Environment

6

- Water quality improvement through material circulation of coastal ecosystem
- Estimation of behavior of organic pollutants and nutrients from river basin to coastal sea

Artificial tidal flat

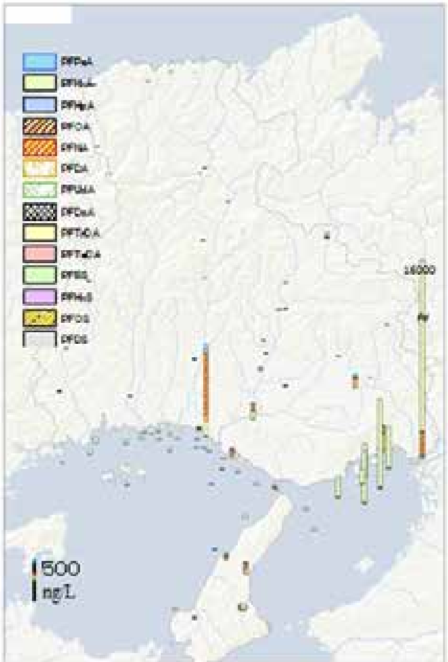
Seto Inland Sea

Research on Chemicals

7

- Assessment of pollution situation,
- Identification of emission sources,
- Development of analytical method of Organic Chemical Materials

LC/MS/MS



PFCs pollution situation

Research on Air Environment

8

- Estimation of emission source contribution ratio by $PM_{2.5}$ composition analysis, statistical analysis, etc.
- Numerical analysis by WRF/CMAQ model

Automatic $PM_{2.5}$ analyzer

Location of $PM_{2.5}$ monitoring stations

Recent Research Project on $PM_{2.5}$

9

Presented at the 55th annual meeting of Japan Society for Atmospheric Environment (2014.9.17)

Analysis of $PM_{2.5}$ Concentration in Hyogo -Transportation Path Analysis using WRF/HYSPLIT-

Purpose

- To estimate categories and locations of $PM_{2.5}$ emission sources

Research Process

Step 1: $PM_{2.5}$ sampling and composition analysis

Step 2: Estimation of emission source categories and their contribution ratios using PMF

Step 3: Reproduction of meteorological field using WRF

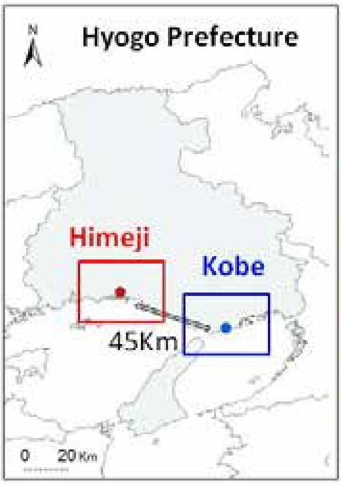
Step 4: Drawing back trajectories using HYSPLIT

Step 5: Estimation of emission source locations using PSCF (heavy oil combustion)

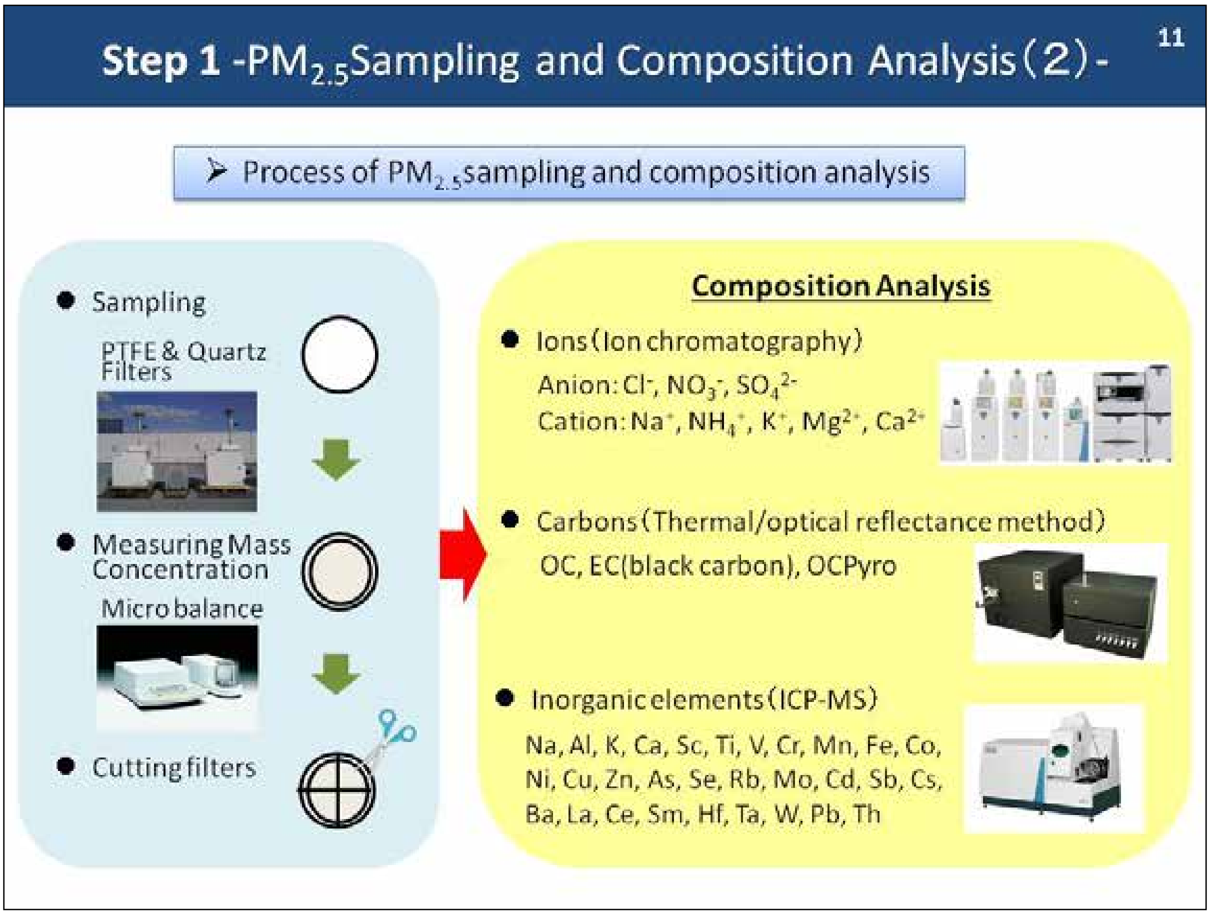
Step 1 -$PM_{2.5}$ Sampling and Composition Analysis (1)-

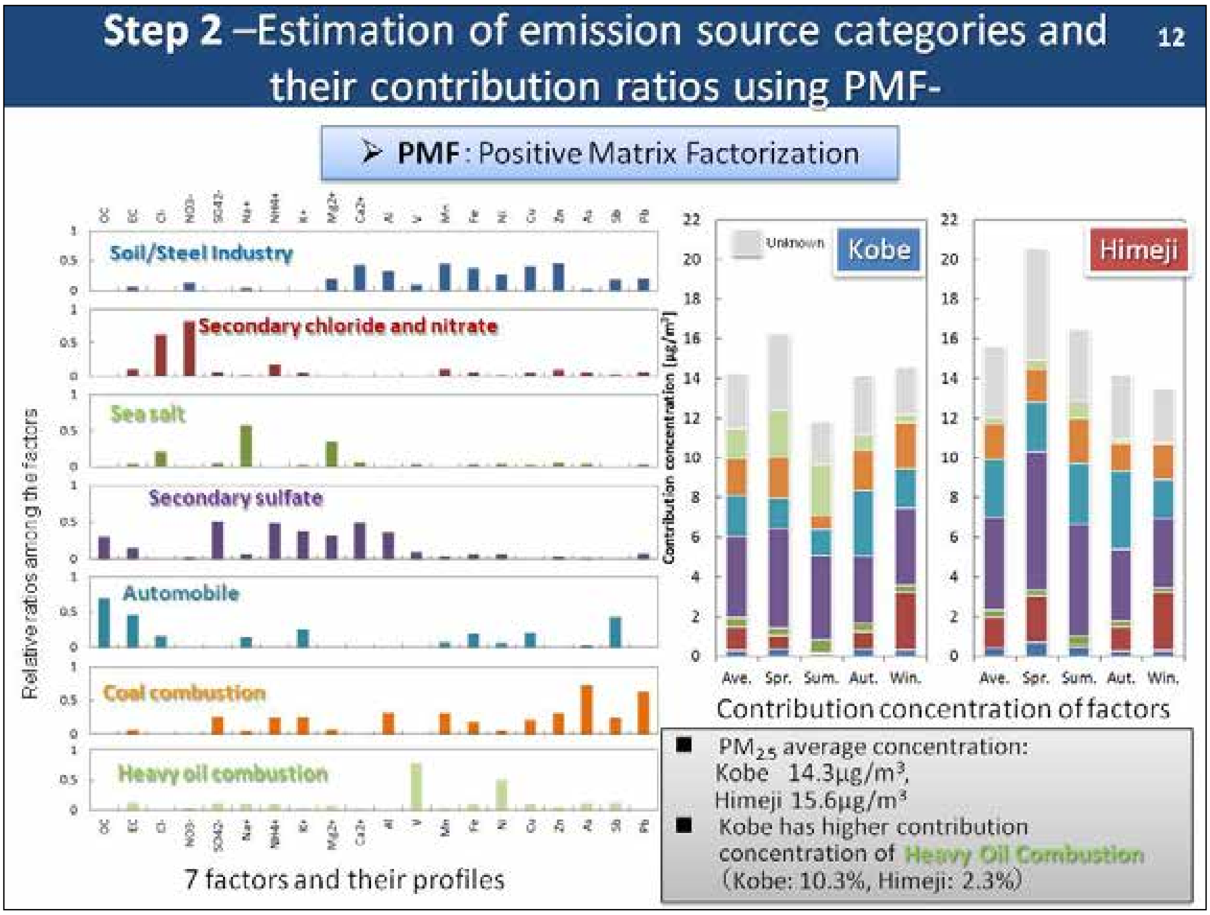
10

- $PM_{2.5}$ sampling sites



■ Suction time: 1day(24hours), Number of sampling days: 20days/season (For each site: 20samples/season × 4seasons/year × 2years = 160samples)

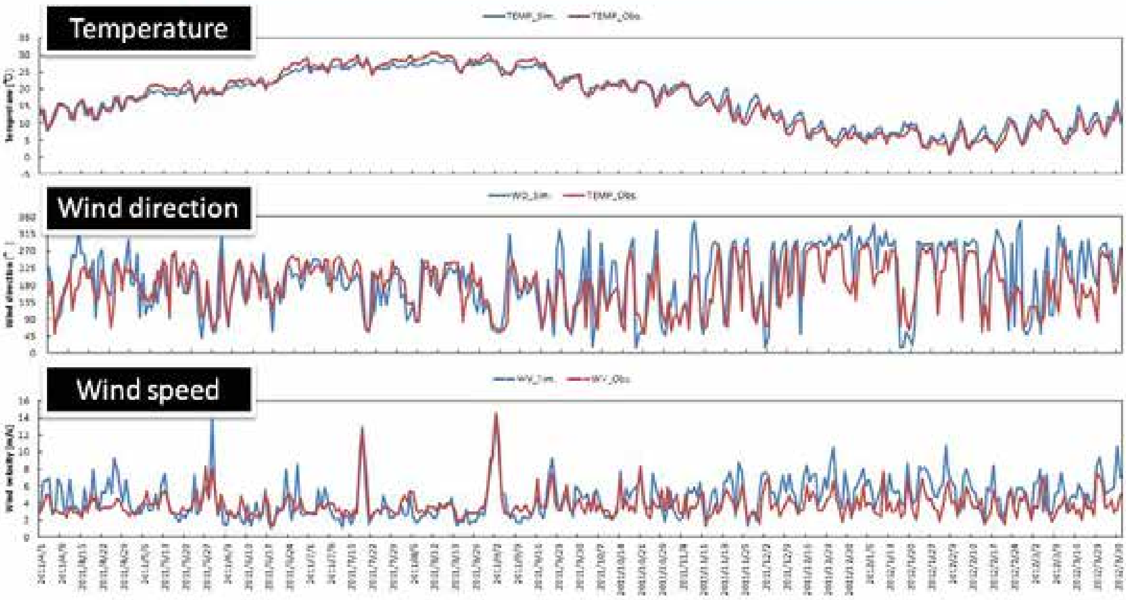

Step 1 -PM2.5Sampling and Composition Analysis(2)-
11
Process of PM2.5sampling and composition analysis
Sampling
PTFE & Quartz Filters
Measuring Mass Concentration
Micro balance
Cutting filters
Composition Analysis
Ions(Ion chromatography)
Anion: Cl-, NO3-, SO42-
Cation: Na+, NH4+, K+, Mg2+, Ca2+
Carbons(Thermal/optical reflectance method)
OC, EC(black carbon), OCPyro
Inorganic elements(ICP-MS)
Na, Al, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Rb, Mo, Cd, Sb, Cs, Ba, La, Ce, Sm, Hf, Ta, W, Pb, Th


Step 2 –Estimation of emission source categories and their contribution ratios using PMF-
12
PMF: Positive Matrix Factorization
Soil/Steel Industry
Secondary chloride and nitrate
Sea salt
Secondary sulfate
Automobile
Coal combustion
Heavy oil combustion
Relative ratios among the factors
7 factors and their profiles
Unknown
Kobe
Himeji
Contribution concentration [μg/m3]
Ave. Spr. Sum. Aut. Win.
Contribution concentration of factors
PM2.5 average concentration:
Kobe 14.3μg/m3,
Himeji 15.6μg/m3
Kobe has higher contribution concentration of Heavy Oil Combustion
(Kobe: 10.3%, Himeji: 2.3%)

Step 3 -Reproduction of meteorological field using WRF-

13

➢ **WRF** : Weather Research and Forecasting model



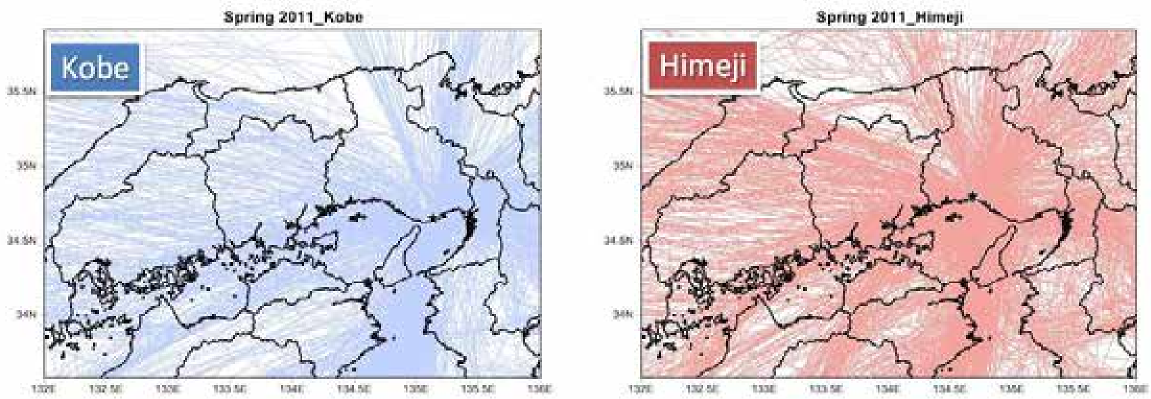
Daily average trend of meteorological data in Kobe (2011.4-2012.3)
(Blue line; simulated(4km × 4km mesh), Red line; observed(Kobe Local Meteorological Office))

Step 4 -Drawing back trajectories using HYSPLIT-

14

➢ **HYSPLIT** : Hybrid Single Particle Lagrangian Integrated Trajectory Model

- Used 4km × 4km mesh meteorological data calculated by WRF.
- Drew lines from the sampling site (height:100m, 300m, 500m) to the sites where the air parcel came for the last 36 hours.



Back trajectories in Kobe and Himeji (Spring 2011)
(24lines/day・site × 3heights × 20days = 1,440lines/site)

Step 5 -Estimation of emission source locations using PSCF (heavy oil combustion) -

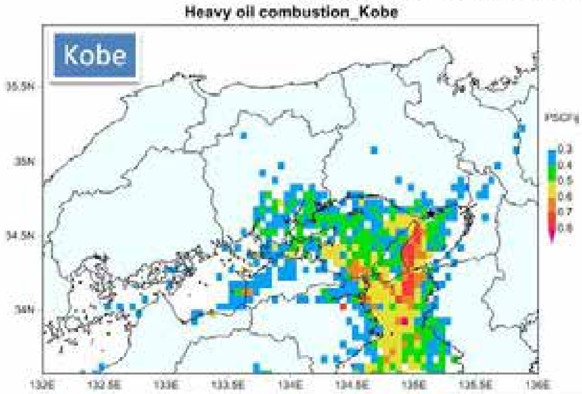
15

➢ **PSCF** : Potential Source Contribution Function

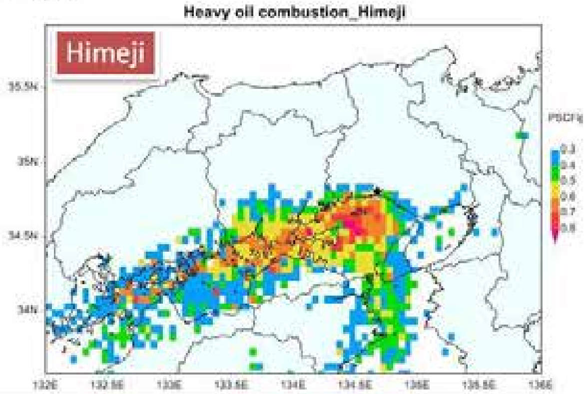
$$PSCF_{ij} = M_{ij} / N_{ij}$$

- N_{ij} :Number of back trajectory endpoints in the *ij*th mesh
- M_{ij} :Number of back trajectory endpoints, of which contribution concentration is in the upper 25 percentile, in the *ij*th mesh

Heavy oil combustion_Kobe

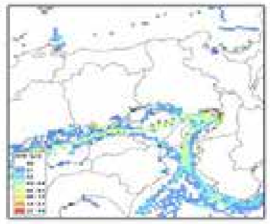


Heavy oil combustion_Himeji



Emission map of SO_4^{2-} generated by ships

●Using the emission database 2005 of Ocean Policy Research Foundation, estimated SO_4^{2-} (g/s) emissions of ships



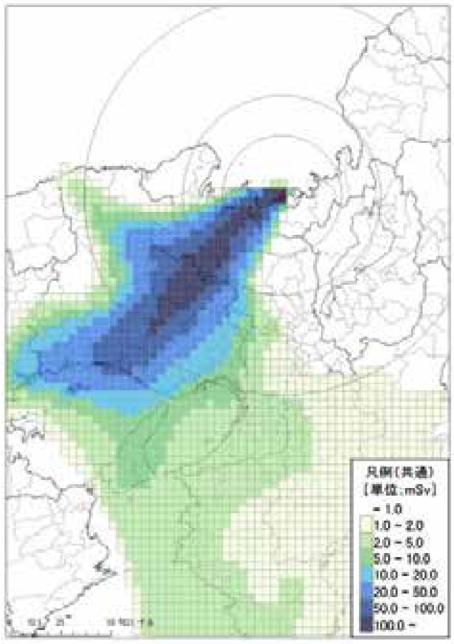
An Application of Simulation Model

16

■ Dispersion simulation of radioactive materials using WRF/CMAQ

- WRF: Weather Research and Forecasting Model
- CMAQ: Community Multi-scale Air Quality Model

➢ Commissioned from Disaster Prevention Department of Hyogo prefectural government.
➢ Applied WRF/CMAQ which is used for dispersion simulation of air pollutants.
➢ Assumed that a nuclear power plant, which is located near Hyogo, occur an accident of the Fukushima Nuclear Power Station disaster level.
➢ Used meteorological data of a normal year, and estimated exposure dose during 7 days in each 4km×4km mesh.
➢ The right figure shows the case that the number of meshes, in which thyroid equivalent dose exceeds 50mSv, becomes maximum.



Idea for Research Exchange with Guangdong (A)

17

☐ Epidemiologic Study on the Characteristics and Health Effects of Air Pollution in Megacities of China

- Purpose : To assess the situation of $PM_{2.5}$ pollution and long/short term effects on respiratory system of elementary students in mega cities in China.
- Study Organization : It is possible to join the collaboration project [JSPS KAKENHI Grant Number 24406020]of Hyogo College of Medicine, Kanazawa University and HIES. (It is possible to add cities in Guangdong to Shenyang, Beijing, Shanghai, Wuhan, where the project is being implemented/planned.)

■ Research Outline

➢ Situational assessment of seasonal air pollution in megacities in China
Measures seasonal $PM_{2.5}$concentration and estimates human exposure. Analyzes $PM_{2.5}$conponents of Polycyclic Aromatic Hydrocarbons (PAHs), carbons (Elementary Carbon: EC, Organic Carbon: OC), ions, and inorganic elements.

➢ Assessment of long/short term effects on respiratory system
Conducts questionnaire survey on respiratory symptom, and measures fractional exhaled nitric oxide concentration and peak flow value of elementary students near ambient air monitoring station, and analyzes long/short term effects of air pollution.

Measurement of fractional exhaled nitric oxide concentration

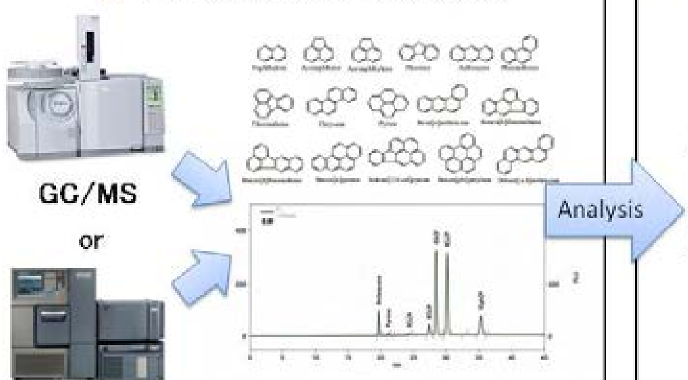
Idea for Research Exchange with Guangdong (B)

18

☐ Analysis on Characteristics and Emission Sources of Polycyclic Aromatic Hydrocarbons (PAHs) bound to PM2.5

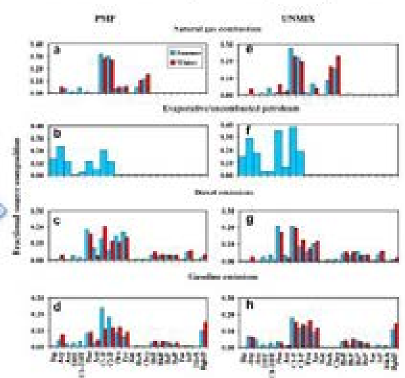
- Purpose : To contribute to measures against health damage by analyzing PAHs bound to $PM_{2.5}$and emission sources.
- Study Organization : Institute of Guangdong and HIES

➢ **PAHs simultaneous analysis**



Chromatograph of PAHs

➢ Emission Source analysis using Receptor Model



Khairy et al. *Chemosphere* 91, 895-903(2013)

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Idea of Schedule for Technological Exchanges

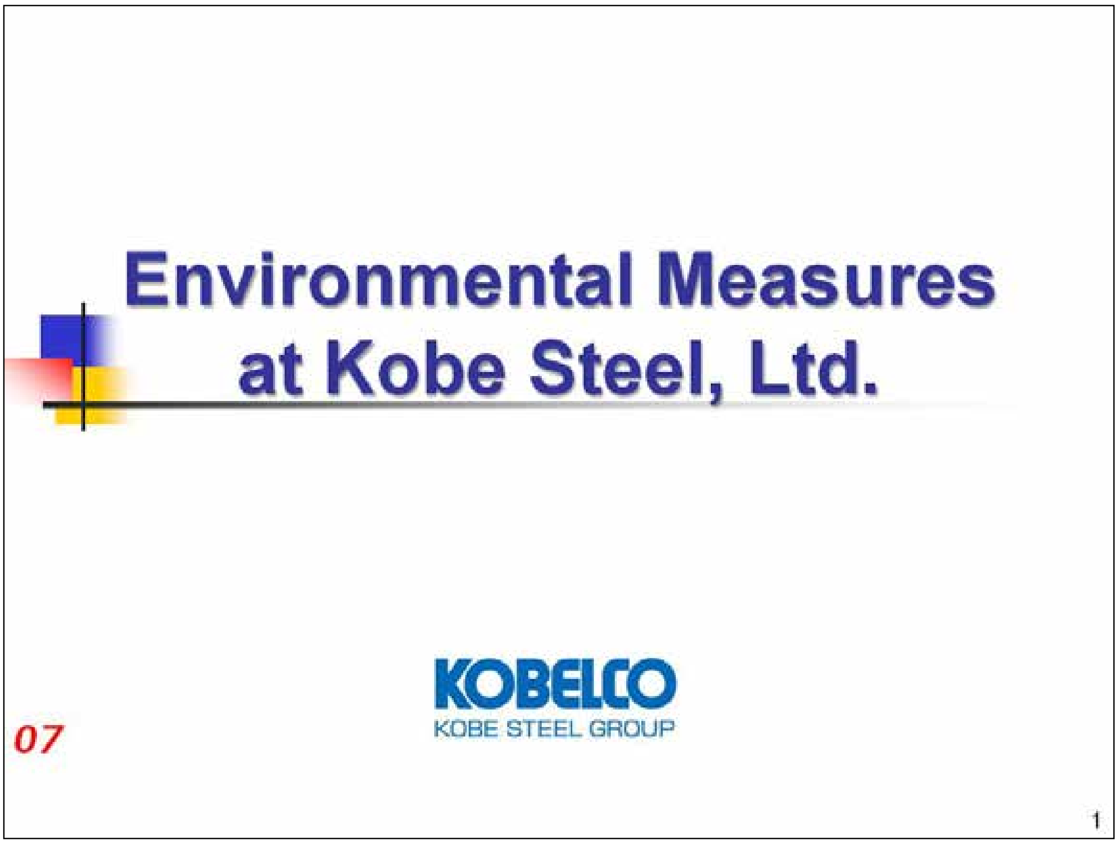
Year/Month	Composition/Emission Source Analysis	Joint Research
2014/11～12	Email exchange on the operation procedures	Preliminary research by Hyogo
2015/1～3	Guangdong's visit to Hyogo	Development of joint research plan
2015/4～6	Hyogo's visit to Guangdong	Data collection (one year)
2015/7～9	Email exchange	
2015/10～12		
2016/1～3	Guangdong's visit to Hyogo	
2016/4～6	Hyogo's visit to Guangdong	Data analysis
2016/7～9	Email exchange	Paper writing
2016/10～12		Joint presentation at international academic conference
2017/1～3		

20

Thank you very much for your attention !

A view from the HIES sampling site

6.7 Environmental Measures at Kobe Steel, Ltd. (Yoshinobu Nakane)



Kakogawa Works and Shinko Kobe Power Station

Kakogawa Works

1970: Began operation as integrated steelworks

1. Transition to urban steelworks due to increase in residential areas
2. Stricter environmental regulations
3. Increased environmental concern among the public

→ **Installation of state-of-the-art facilities**
Steady improvements and equipment modifications
Stronger environmental management; information disclosure

Shinko Kobe Power Station

2002: Start-up of No. 1 Power Plant **2004: Start-up of No. 2 Power Plant**

1. Established in a large city (Kobe) as an urban power station

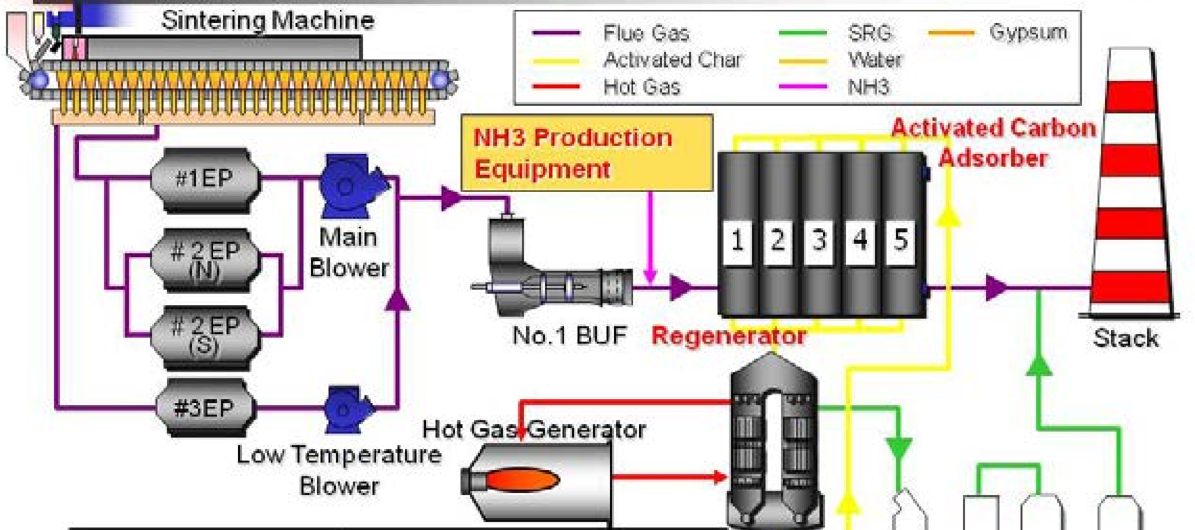
→ **State-of-the-art equipment installed during construction**

3

Location of Kakogawa Works

4

State-of-the-Art Facilities (1)
Flue Gas Cleaning System in Sinter Plant



BUF(Boost Up Fan)	1,800 kNm³/H, 9,000Pa
Adsorber	Gas Volume: 1,500 kNm³/H De-NOx Efficiency: 40% De-SOx Efficiency: 95% Adsorbent: Activated Char
Byproduct	Gypsum

Dust Countermeasures (1)
Spraying Water in Yard

Materials are sprayed down in stockyard (iron ore, coal, coke, etc.).
Moisture helps prevent dust from scattering.

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KOBE STEEL GROUP

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Dust Countermeasures (2)

Tire Washing Equipment

Prevents dirt and dust on tires and vehicle bodies from being carried onto the street

● Locations of tire washers (8 places)

KOBELCO
KOBE STEEL GROUP

eco way

7

Dust Countermeasures (3)

Road Sprinklers

Constant moisture prevents dust from re-scattering.

Automatic sprinklers cover approx. 17 km of road.

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KOBE STEEL GROUP

eco way

8

Dust Countermeasures (4)

Windbreaking Nets

(1) Nets decrease wind speed on leeward side, reducing dust raised (yellow areas).

(2) Nets decrease wind speed, preventing dust from passing over (red areas).

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KOBE STEEL GROUP

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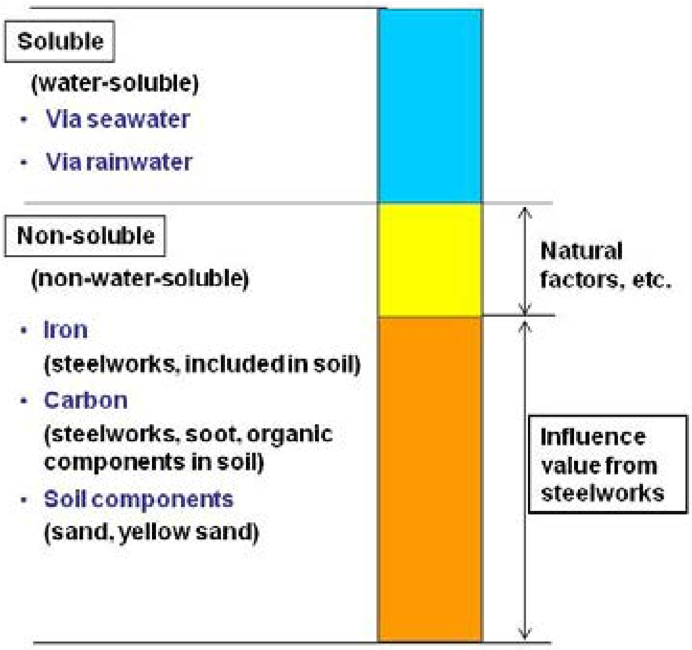
Environmental Management Systems (1)

Managing Dustfall Levels



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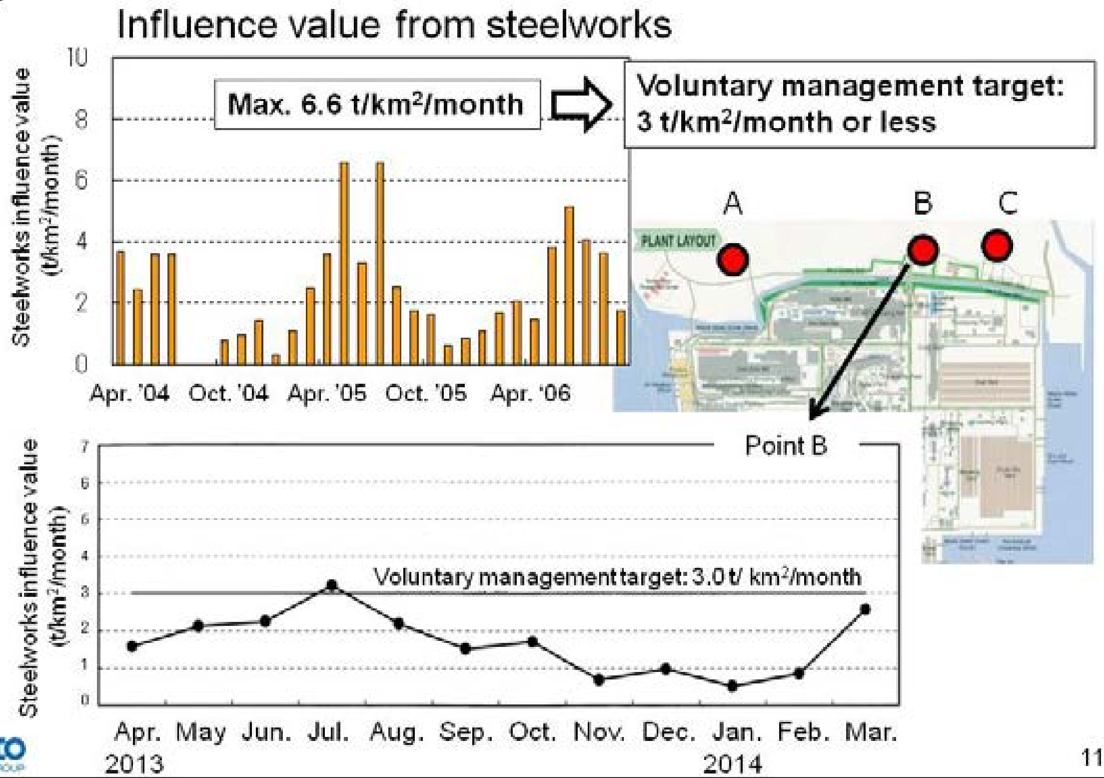
Environmental Management Systems (2)

Managing Dustfall Levels



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Environmental Management Systems (3)

Environmental Risk Management

(1) Daily environmental patrol results

(2) Daily air and water quality data

(3) Dustfall data (deposit gauges, etc.)

⇩

Reporting to steelworks general manager, other works managers, and related departments

⇩

(1) Timely top-down response

(2) Horizontal development and early response through information sharing

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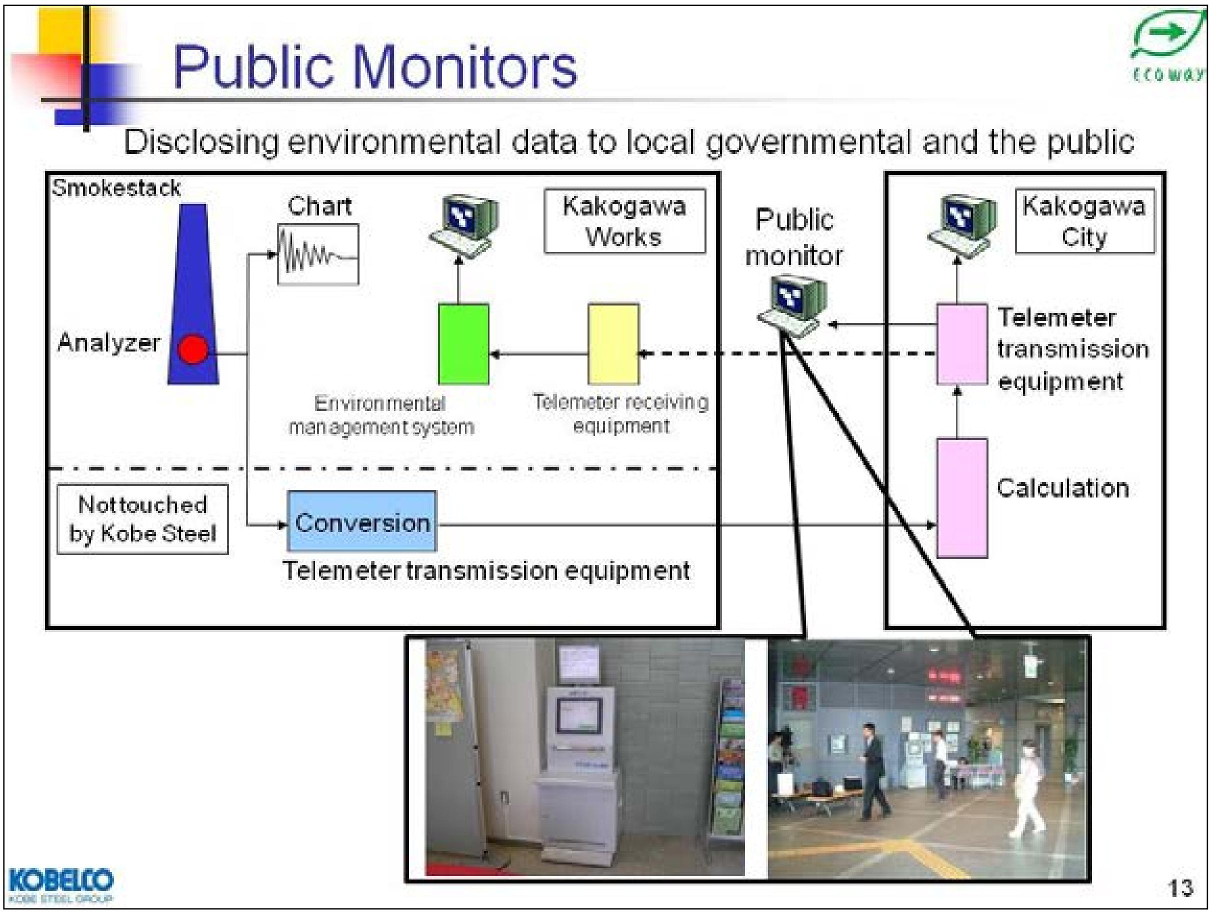
12


Public Monitors
Disclosing environmental data to local governmental and the public
Smokestack
Chart
Kakogawa Works
Public monitor
Kakogawa City
Analyzer
Environmental management system
Telemeter receiving equipment
Telemeter transmission equipment
Calculation
Not touched by Kobe Steel
Conversion
Telemeter transmission equipment
KOBELCO
13

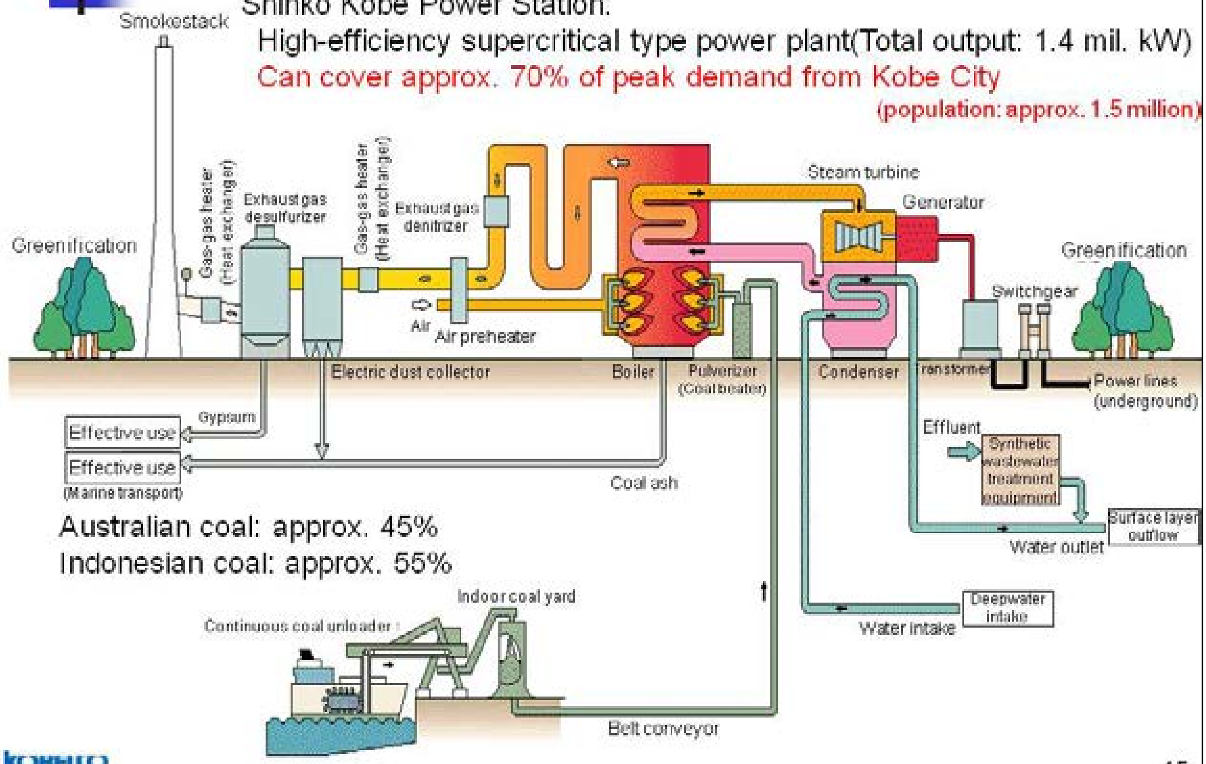

Location of Shinko Kobe Power Station
Kobe Works
Shinko Kobe Power Station
KOBELCO
14

Shinko Kobe Power Station Overview

Shinko Kobe Power Station:

High-efficiency supercritical type power plant(Total output: 1.4 mil. kW)

Can cover approx. 70% of peak demand from Kobe City (population: approx. 1.5 million)



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15

Special Features of Shinko Kobe Power Station

Shinko Kobe Power Station was planned as an urban power station that takes environmental preservation into utmost consideration.

State-of-the-art flue gas treatment systems (exhaust gas denitrizers, electric dust collectors, exhaust gas desulfurizers) remove SOx, NOx, and dust.

Extremely strict standards for maximum emission concentration for the power station were set according to environmental partnership agreements. These standards have been maintained since the start of operations.

Environmental partnership agreements (soot)

		SOx	NOx	Dust
Shinko Kobe Power Station	Max. emission concentration	24 ppm	24 ppm	10 mg/m^3_N
	Management target concentration*1	8 ppm	15 ppm	5 mg/m^3_N
Kobe Works (inc. Shinko Kobe Power Station)	Max. emissions per hour	141 m^3_N/hr.	230 m^3_N/hr.	122 kg/hr.
	Yearly emissions	730 t/yr.	1,500 t/yr.	250 t/yr.

*1 Target values for average concentration necessary to observe partnership agreements for total yearly emissions.

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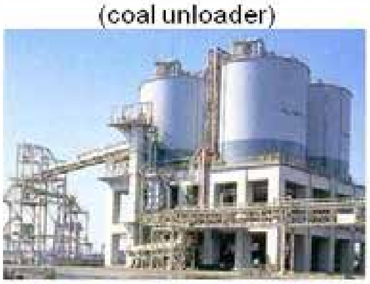
16

Dust Countermeasures

ecoway

Enclosed continuous unloaders (coal unloader)

Coal silos, enclosed belt conveyors



Coal ash storage silos

Gypsum storage silos

- Enclosed systems for the unloading, handling and storage of coal
- Enclosed systems for the handling, storing and shipping of coal ash and gypsum

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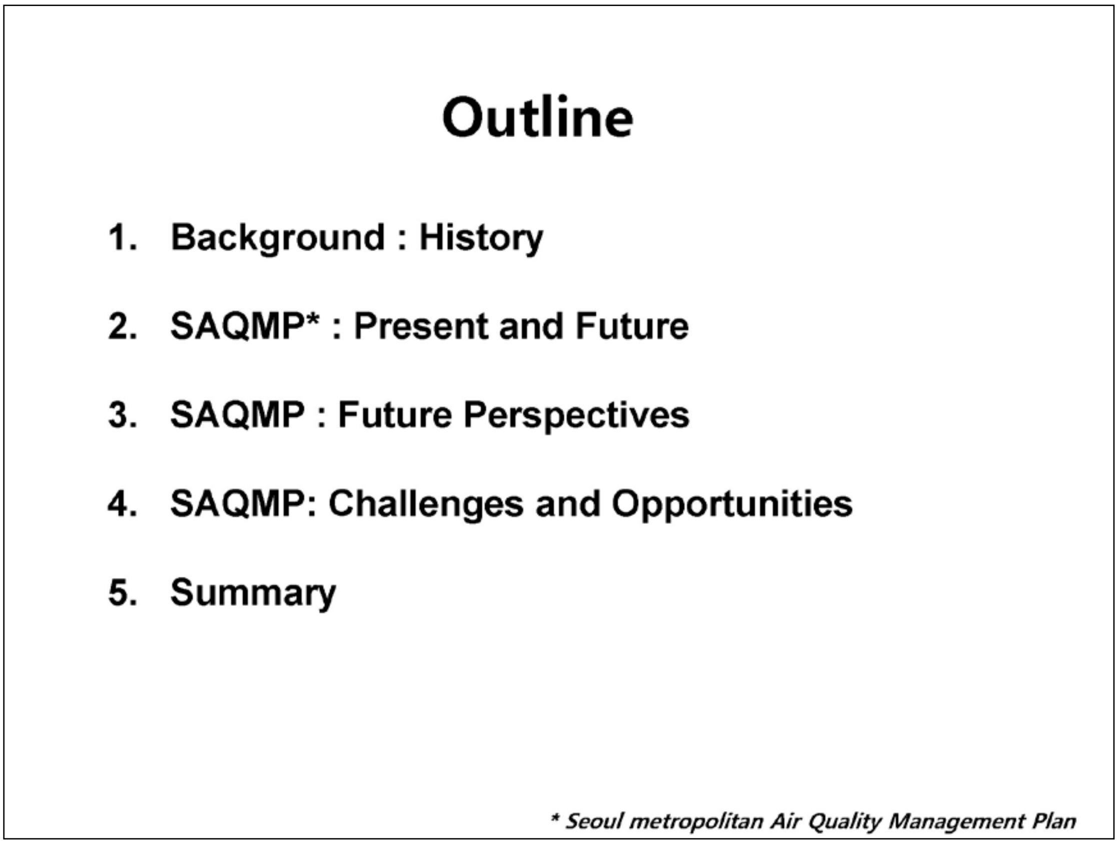
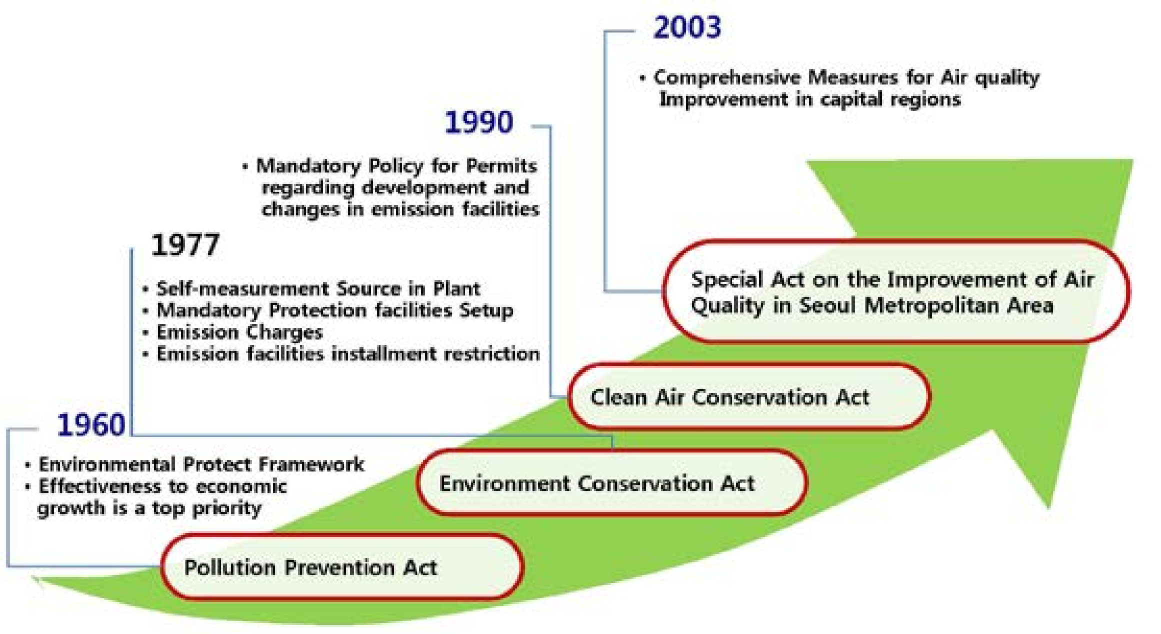
6.8 Seoul Metropolitan Air Quality Management : Current Achievement and Future Challenges (Jung Hun Woo)



Background : History of Clean Air Conservation in Korea



NIER, 2013

3

Background : History of Clean Air Conservation in Korea

- Measures for Air Conservation

1981 ~ 1990

- Low Sulfur, B-C oil Provision (B-C, 4→1.6%)
  - Desulfurization Equipments Installed by '93 ('81)
- Restrict Solid Fuel usage by regions ('85)
- Mandatory LNG fuel ('88)
  - Applied depending on region and emission facilities
- Establishment of Emission Limit for Business areas
- Establishment of Emission Limit for Vehicles ('87)

1991 ~ 2000

- Emission limit standard 3rd reinforcement proclamation
- Emission facilities Inspection and Emission Tax (Polluter-Bearing System)
- Setup the Telemetering System(TMS)
- Appointed management for Special countermeasure areas and regulation area
- Emission Reduction measures for vehicles currently running and in-development

2001 ~ 2013

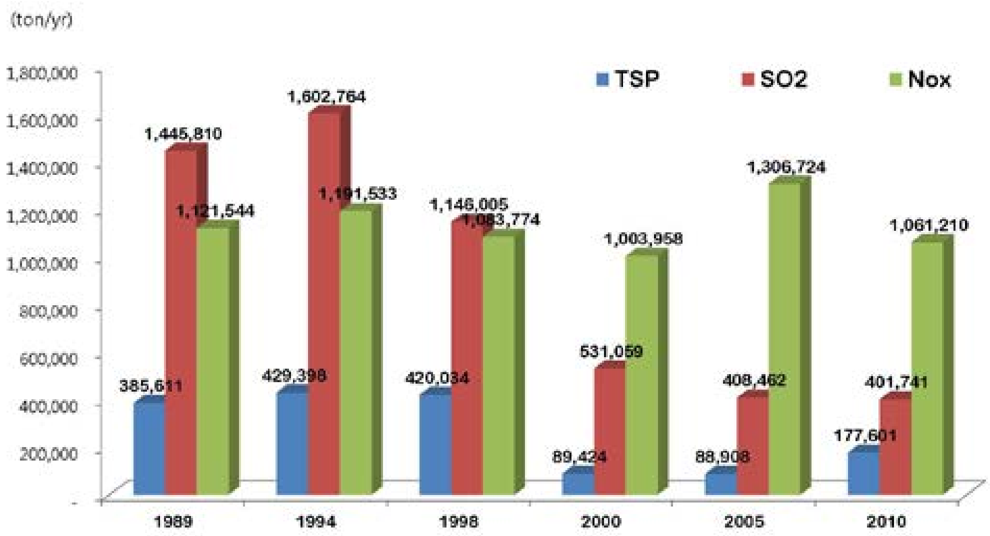
- Emission limit standard 2nd reinforcement proclamation
- Assign 35 types as HAPs
- Low Sulfur required field enlargement and strengthen sulfur content limit
- Ban on Solid fuel usage (20 regions)
- Mandatory usage of Clean Fuel (37 regions)
- Start City air quality management
  - Measures for Capital regions air quality improvement
- Vehicle management policy continuous support and environ-friendly vehicle provision expansion

NIER, 2013

4

Background : History of Clean Air Conservation in Korea

- Changing Air Emissions in Korea

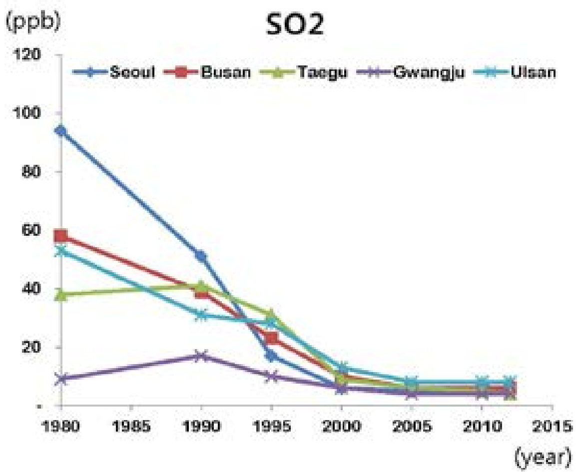


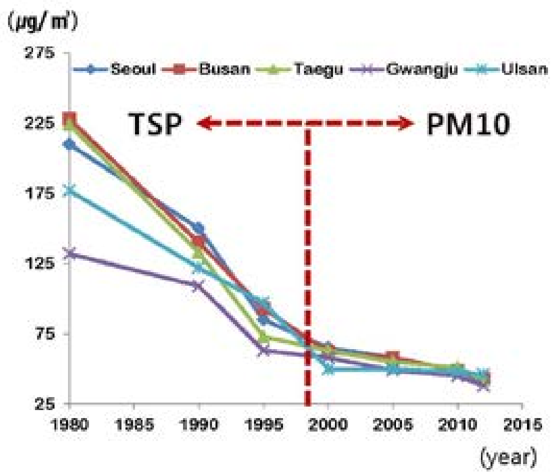
NIER, 2013

5

Background : History of Clean Air Conservation in Korea

- Changing Air Pollution in Korea





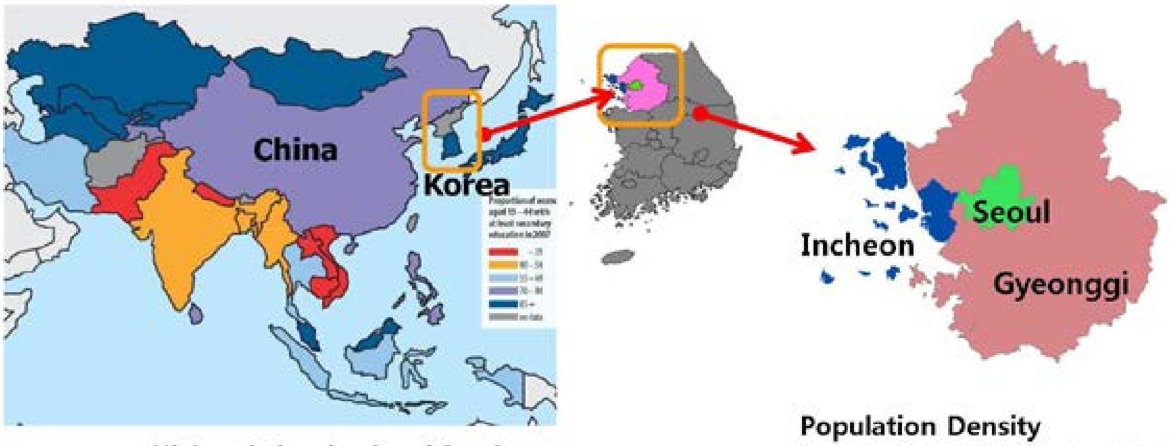
6

Outline

1. Background : History
2. **SAQMP* : Present and Future**
3. SAQMP : Future Perspectives
4. SAQMP: Challenges and Opportunities
5. Summary

** Seoul metropolitan Air Quality Management Plan*

Seoul Metropolitan Area

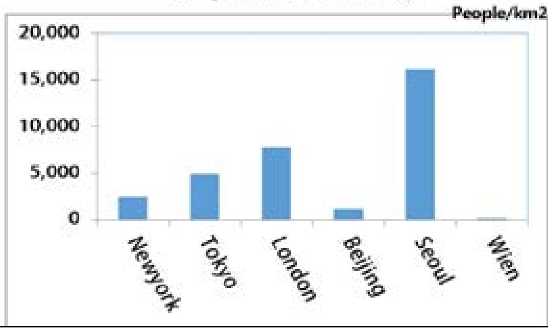


High emission density of Seoul

Area : 11%
Population : 50%
NO. of vehicle : 49%
NO. of company : 46%
NOx emission: 35 %
PM10 emission: 28 %
VOC emission: 54 %

of national total in 2010

Population Density



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Seoul metro Air Quality Management Plan (SAQMP)

Vison : Implementation of Healthy 100 year life with Clean Air!

Base : Special Act for Metropolitan Air Quality Management

Status and *Target* Air Quality over Seoul Metro

	$PM_{2.5}$ (new)	PM_{10}	NO_2	O_3(new)
2024(2nd)	*20㎍/㎥*	*30㎍/㎥*	*21ppb*	*60ppb*
2014(1st)	-	*40㎍/㎥*	*22ppb*	-
2010	-	47㎍/㎥	34ppb	87ppb
2001	-	71㎍/㎥	37ppb	-

1st Phase
2nd Phase(add)

	1st phase (2005~2014)	2nd phase (2015~2024)
Control Measures	4 sectors (49 measures)	4 sectors (62 measures)
Budget	4 billion US $	4.1 billion $

9

Control Measures for SAQMP(1st Phase)

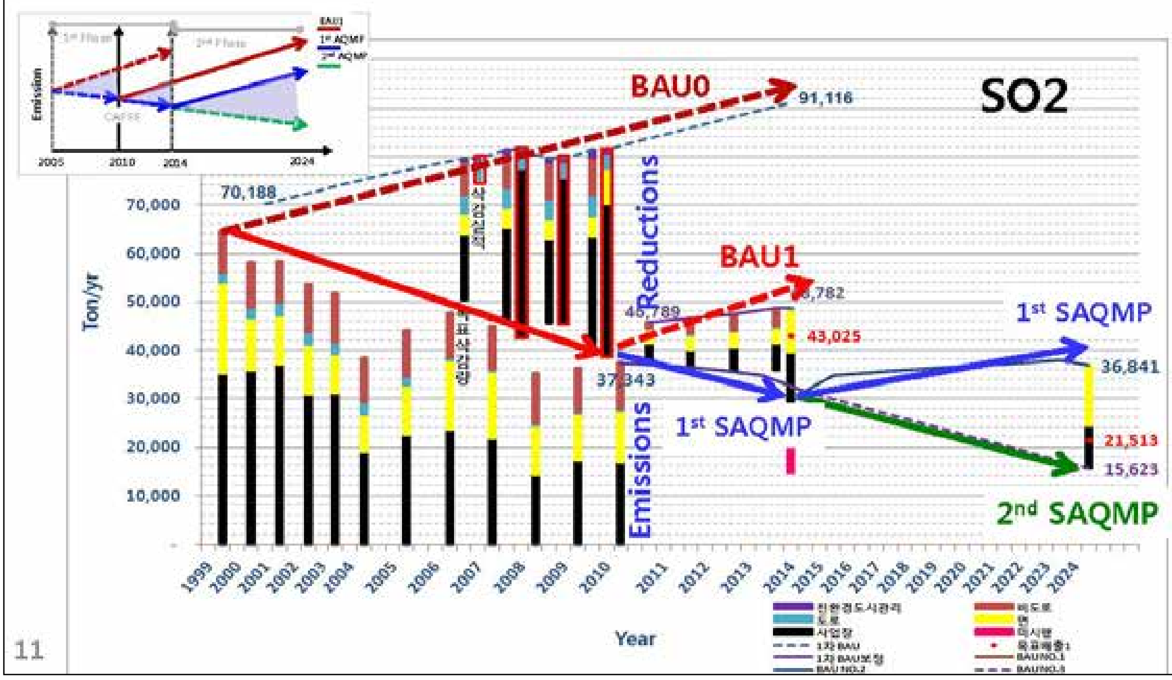
Source	Measure	Description/Example	Air Pollutant Reduction	GHG Reduction
Industrial Sources	Total allowable emissions systems	Total allowable emissions system and emission trading	SO_x, NO_x, PM_{10}	CO_2
	Fuel control	Expand the regions for low-sulfur fuel usage	SO_x, PM_{10}	
	Stringent emission standards	Stringent emission standards and penalty on emission of nitrous oxide	NO_x, PM_{10}	
	Solid waste combustion facility management	Stringent emission standards	SO_x, NO_xX, PM_{10}, VOC	
		Closedown of small-size solid waste incinerators		
		Expansion of products prohibited for incineration		
	Voluntary environment management	More environmentally friendly companies	SO_x, NO_x, PM_{10}	CO_2
		Agreement on voluntary environment management		
	Support/ Education	Distribution of manual for emission facility management and guidance	SO_x, NO_x, PM_{10}	CO_2
		Diagnosis of air quality control, consulting and financial aid for environmental investment for small-and medium-sized businesses		
		Emission reduction partnership between large enterprises and their collaborate firms		
		Support for investment on infrastructure		
Area Sources	Fuel control	Switch from residential smokeless coal to city gas	SO_x, NO_x, PM_{10}, VOC	CO_2
		Expansion of region to use low-sulfur gasoline and clean fuels	SO_x, NO_x, PM_{10}, VOC	
	District air conditioning and heating	Expansion of district air conditioning and heating system	SO_x, NO_x, PM_{10}	CO_2
		Revitalization of small-size community energy system		
	NO_x regulation	Supply low-NO_x boilers	SO_x, NO_x, PM_{10}, VOC	
		Better management of LNG facilities		
	Demand control	Distribution of alternative energy: solar energy	SO_x, NO_x, PM_{10}, VOC	CO_2
		Regulation on indoor air-conditioning and heating	SO_x, NO_x, PM_{10}, VOC	
		Environment friendly building standards and certification programs		
Mobile Sources	Regulations on manufacturer	Stringent emission standards for new vehicles	NO_x, PM_{10}, VOC	
		Distribution of low emission vehicles	NO_x, PM_{10}, VOC	CO_2
	On-road vehicle regulations	Emission reduction plan for specified-diesel-vehicles: SCR/DPF installation	NO_x, PM_{10}, VOC	
		Emission reduction plan for specified-diesel-vehicles: DOC installation	PM_{10}, VOC	
		Emission reduction plan for specified-diesel-vehicles: LPG conversion	NO_x, PM_{10}, VOC	CO_2
		Emission reduction plan for specified-diesel-vehicles: Support for accelerated vehicle retirement program	NO_x, PM_{10}, VOC	CO_2
		Improvement of on-road vehicle emission management: inspection program for on-road vehicles, introduction of remote sensing devices , occasional emission inspection program for on-road vehicles, defect inspection program, introduction of on-board diagnostics , etc	PM_{10},VOC	
	Two-wheeled vehicle regulations	Stringent emission standards	VOC, NO_x	
		Higher quality standards for engine oil		
		Mandatory regular inspection program		
	Fuel Control	Higher quality standards for gasoline fuels	SO_x	
	Traffic demand control	Designation of green district	SO_x, NO_x, PM_{10}	CO_2
		Taxation on causing heavy traffic		
		Improvement of public transportation infrastructure		
		Industrial traffic demand control		
		Parking demand control		
		Encouragement of bicycle ride		

10

Y. Chae, 2013

Seoul Air Quality Management Plan (SAQMP)

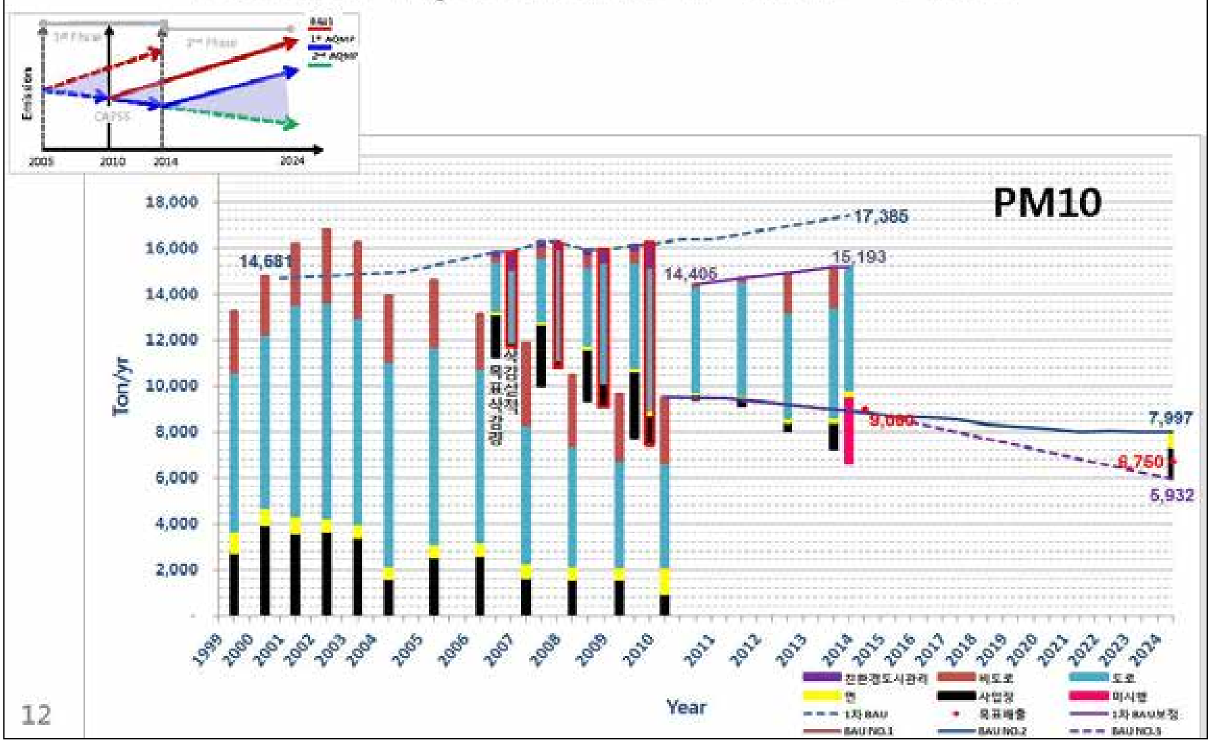
- Emission Trajectories for 1st and 2nd Phase



11

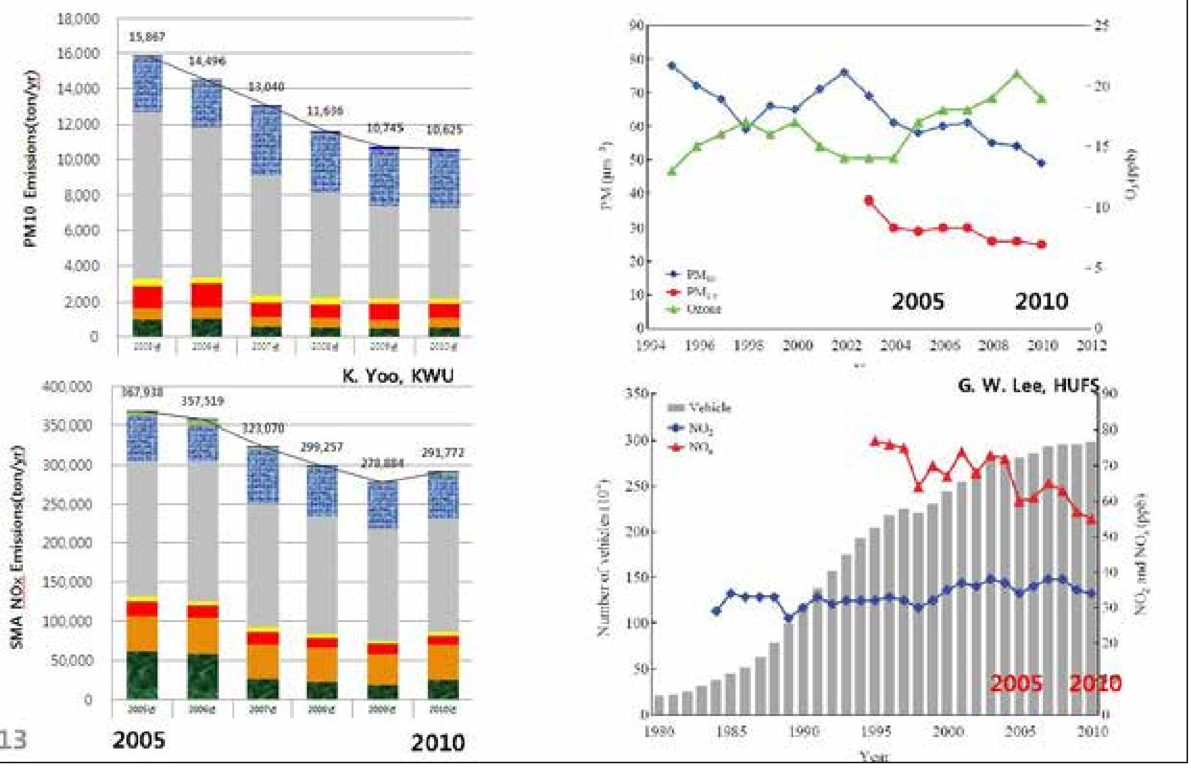
Seoul Air Quality Management Plan (SAQMP)

- Emission Trajectories for 1st and 2nd Phase



12

Seoul Air Quality Management Plan (SAQMP)
- Trend of Emissions and Air Quality



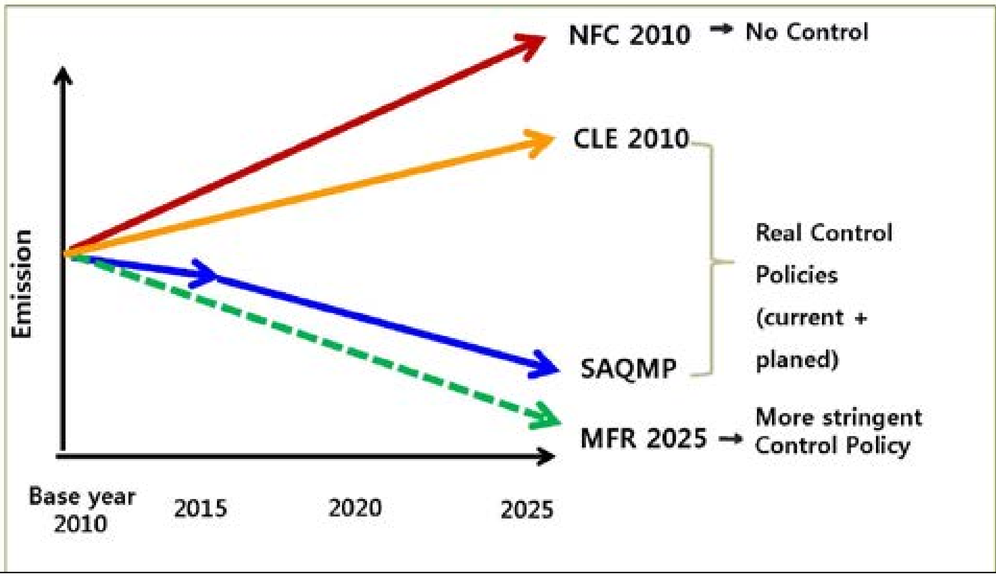
Outline

1. Background : History
2. SAQMP* : Present and Future
3. **SAQMP : Future Perspectives**
4. SAQMP: Challenges and Opportunities
5. Summary

** Seoul metropolitan Air Quality Management Plan*

SAQMP Mitigation and AQ Change
- objectives

Can Seoul Metropolitan Area Air Quality Management Plan(SAQMP) really hit the Target Air Quality by 2025?



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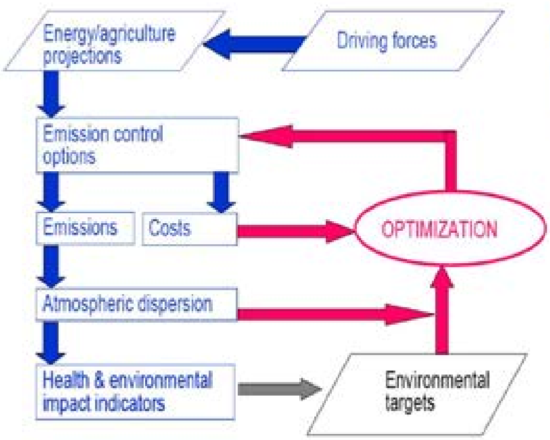
SAQMP Mitigation and AQ Change
- Implementation to GAINS*-Korea Model



igure 2.2: The iterative concept of the GAINS optimisation.

Regions : 17, Year: 2010(base) ~ 2050(Future)

Pollutants: CO_2, CH_4, NOx, N_2O, PM10, PM2.5, SO_2, VOC, NH_3, CO, BC, OC, Mercury

Sectors: Energy, Mobile, Industrial Process, VOCs, Agriculture (detail sectors : 250)

Source-Receptor Impact (CAMx & SMOKE)

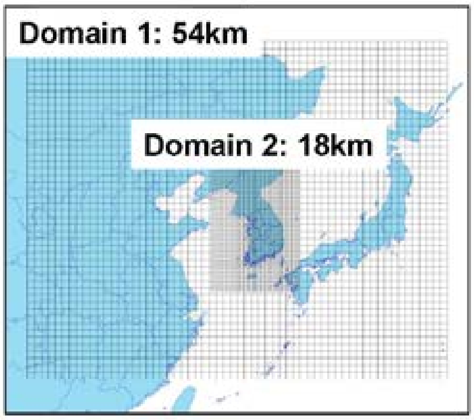
* Greenhouse gases and Air pollutants INteractions and Synergies (IIASA)

16

SAQMP Mitigation and AQ Change

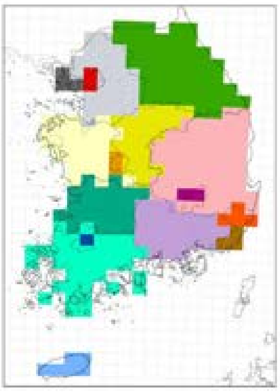
- Air Quality Modeling Framework for Source-Receptor Analysis

Modeling domain



- Meteorological data : **MM5** (**2005**)
- Emissions : **SMOKE-Asia** (Woo et al., 2012) with **CAPSS 2009**
- Air quality model : **CAMx** version 6.0 with **PSAT** (Particulate Source Apportionment Technology)
  - Model option: EBI-CB05, ACM2 diffusion, PPM advection scheme

Definition of S-R region



S-R (CAMx PSAT)

- **Receptor (16 regions)** Metropolitan cities (7 cities) and provinces (9 regions)
- **Source (19 regions)** Same as receptor regions with outside of S. Korea countries (China, N. Korea and Japan)

SR Matrices

$$SR^{sox}_{ijk} = [S_{ox}]_{ijk} / [SO_2]_k$$

$$SR^{nox}_{ijk} = [N_{ox}]_{ijk} / [NO_2]_k$$

$$SR^{nrd}_{ijk} = [N_{rd}]_{ijk} / [NH_3]_k$$

Blame Matrices

$$BL^{sox}_{ie,ir} = \sum_{ij \subset R_{ir}} [S_{ox}]_{ij,ie}$$

$$BL^{nox}_{ie,ir} = \sum_{ij \subset R_{ir}} [N_{ox}]_{ij,ie}$$

$$BL^{nrd}_{ie,ir} = \sum_{ij \subset R_{ir}} [N_{rd}]_{ij,ie}$$

Jerzy Bartnicki, 2000

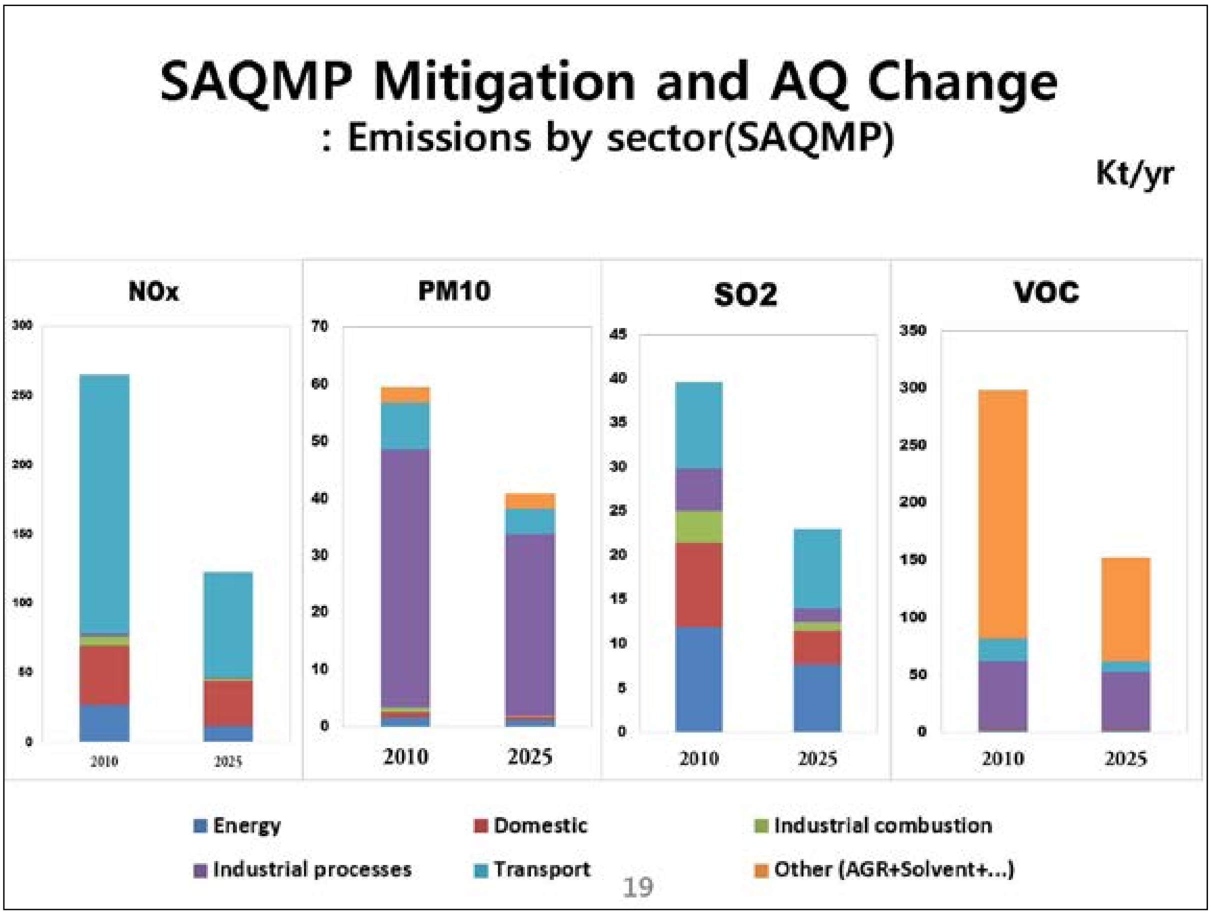
17

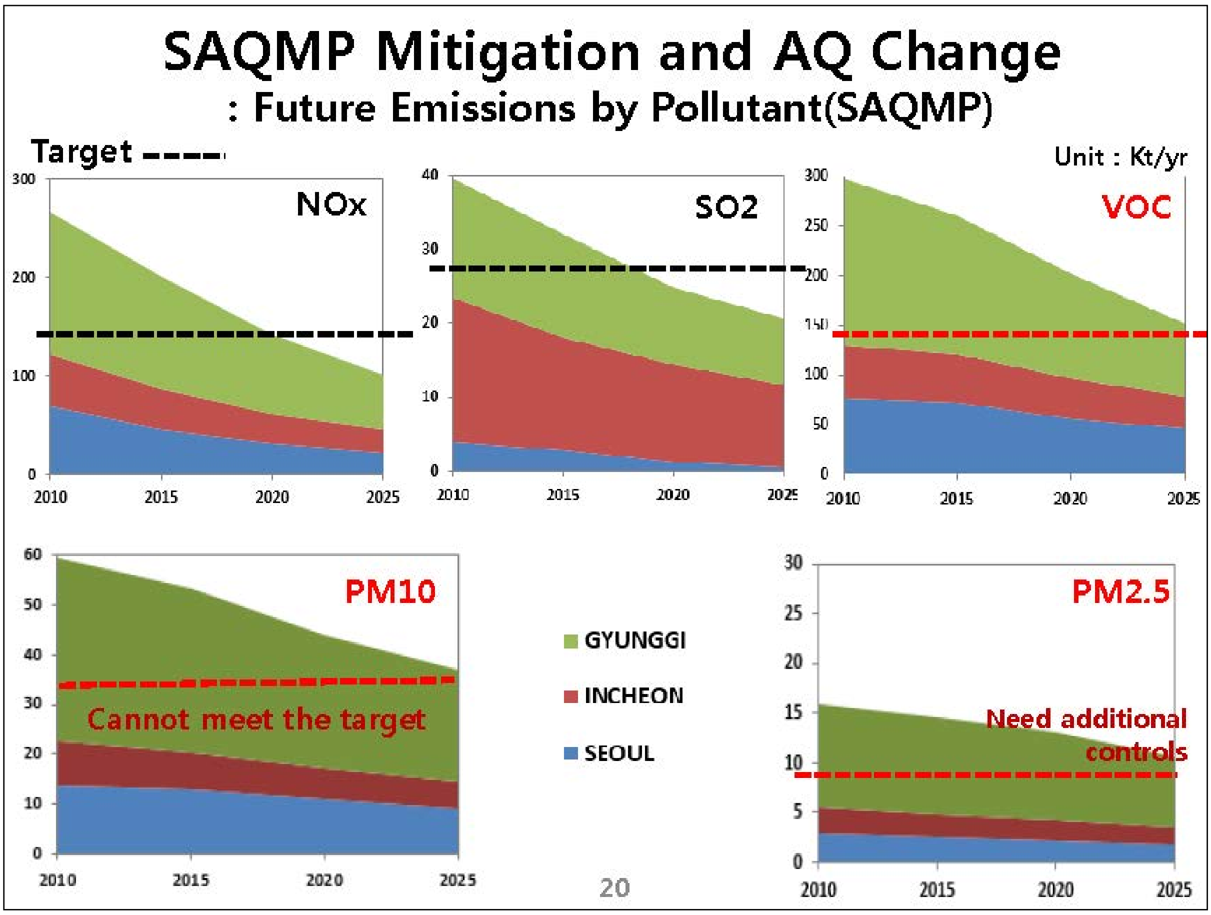
SAQMP Mitigation and AQ Change

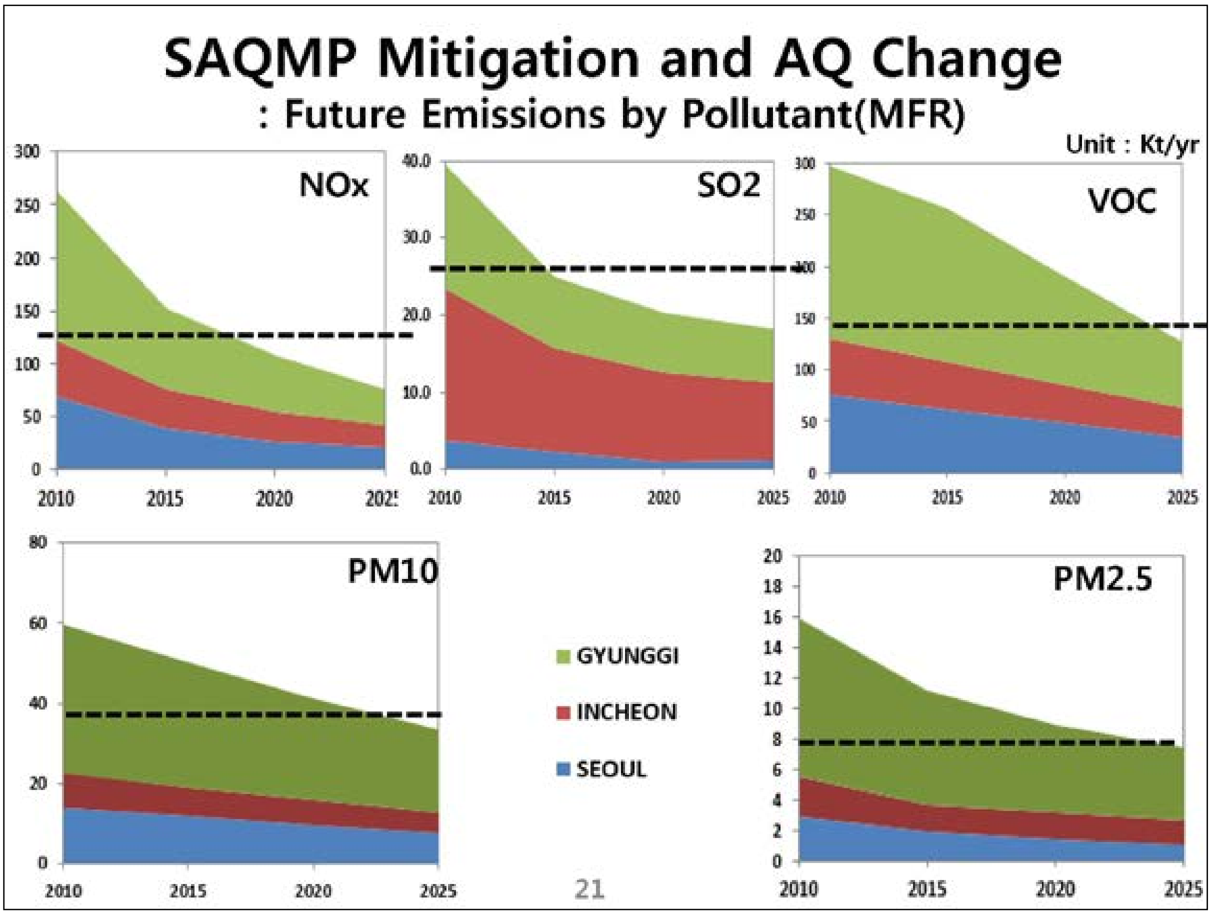
: Selection of Control Measures from SAQMP (1st+2nd)

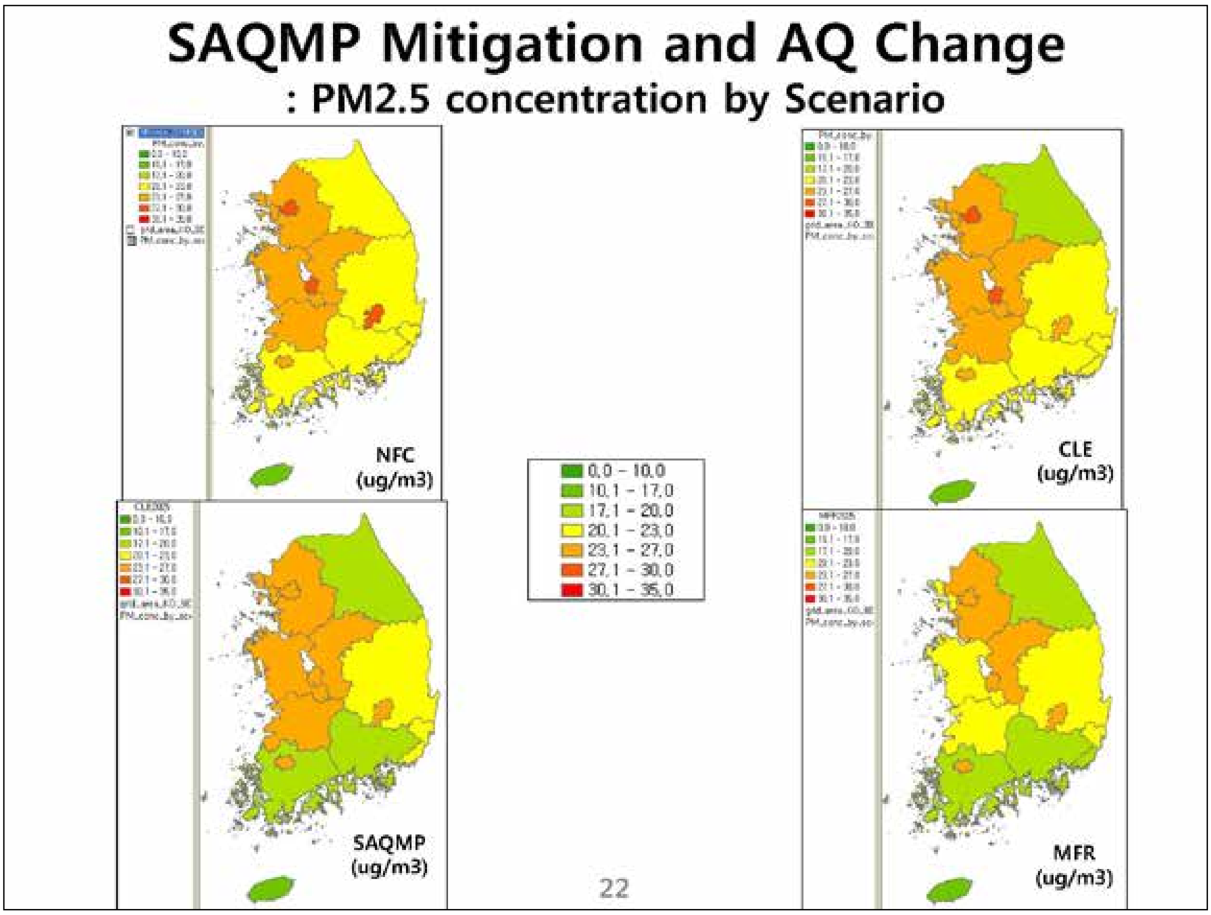
Source	Regulations	Source	Regulations
Point Source	Total amount regulation and Emissions Trading	Mobile	Stringent emission standards for new vehicles
	Expansion of areas using low-Sulfur fuel		Distribution of low emission vehicles
	Fuel switching, from Bituminous coal to LNG		Emission reduction plan for specified-diesel-vehicles: SCR/DPF installation
	Stricter Emission Allowance Standard		Emission reduction plan for specified-diesel-vehicles: DOC installation
	Introduction of emission taxes on Nox		Emission reduction plan for specified-diesel-vehicles: LPG conversion
	Closure of small-scale incineration facilities		Early retirement program
	Increase of environment-friendly firms		Stringent emission standards
	Agreement on voluntary environmental agreement		Higher quality standards for engine oil
	Training of Manuel for Best Facility Management		Mandatory regular inspection program
	Financial support for facility investment		Higher quality standards for gasoline fuels
	Stricter management of facility for PM10 & VOC		Improvement of public transportation infrastructure
Area Source	Expansion of district air conditioning and heating system	Area Source	Stage II controls at gas stations
	Expansion of small-scale Community Energy System		Restriction of the use of cutback asphalt
	Expansion of Low-NOx boilers		Restriction of solvent for consumer products
	Better management of LNG facilities		Solvent Emissions Directive for paint in construction and
	Distribution of alternative energy: solar energy		Expansion of water-paint type in construction and buildings
	Regulation on indoor air-conditioning and heating		Installation oc the control application for Briquettes production
	Eco- building standards and certification programs		Installation of the application for Charbroiling Restaurants
	Conversion of anthracite into natural gas		Clean Road
	Expansion of areas using low-Sulfur and clean fuels		Expansionof low tire wear
	Regulation of fugitive dust in Industrial Process		Ground to Green Infra

18


SAQMP Mitigation and AQ Change
: Emissions by sector(SAQMP)
Kt/yr
NOx
PM10
SO2
VOC
2010
2025
Energy
Domestic
Industrial combustion
Industrial processes
Transport
Other (AGR+Solvent+...)
19


SAQMP Mitigation and AQ Change
: Future Emissions by Pollutant(SAQMP)
Target
Unit : Kt/yr
NOx
SO2
VOC
PM10
Cannot meet the target
GYUNGGI
INCHEON
SEOUL
PM2.5
Need additional controls
2010
2015
2020
2025
20


SAQMP Mitigation and AQ Change
: Future Emissions by Pollutant(MFR)
Unit : Kt/yr
NOx
SO2
VOC
PM10
PM2.5
GYUNGGI
INCHEON
SEOUL
2010
2015
2020
2025
21


SAQMP Mitigation and AQ Change
: PM2.5 concentration by Scenario
NFC
(ug/m3)
CLE
(ug/m3)
SAQMP
(ug/m3)
MFR
(ug/m3)
0.0 - 10.0
10.1 - 17.0
17.1 - 20.0
20.1 - 23.0
23.1 - 27.0
27.1 - 30.0
30.1 - 35.0
22

Outline

1. Background : History
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** Seoul metropolitan Air Quality Management Plan*

SAQMP: Challenges and Opportunities

Fine particle pollution over Seoul

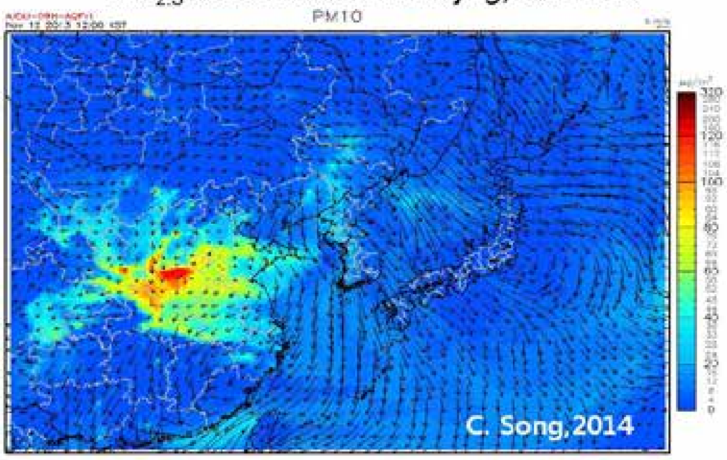
2013, Dec 5th PM_{10}: 166 ug/m³

2013, Dec 6th PM_{10}: 35 ug/m³

Heavy pollution plume transport

NIER National Air Quality Forecasting(Nov. 2013)

$PM_{2.5}$ concentration in Beijing, Jan 2013



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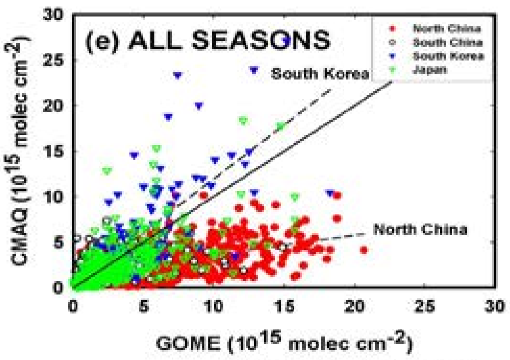
SAQMP: Challenges and Opportunities

: Uncertainties Estimation of Emissions

CMAQ with 2001 ACE-ASIA emission inventory vs GOME-derived NO_2



Han et al., ACP 2009

Overall, it is estimated that the NOx emissions are underestimated by 57.3% in North China and overestimated by 46.1% in South Korea over an entire year

Overall Uncertainty in Anthropogenic Emission Estimates (±95% Confidence Intervals, Unit: %).

Region	SO_2	NO_x	CO_2	CO	CH_4	NMVOC	BC	OC	NH_3
China	13	23	16	156	71	59	484	495	53
Japan	9	19	7	34	52	35	83	181	29
Other East Asia	12	24	13	84	101	49	160	233	31
Southeast Asia	27	92	91	214	95	218	257	345	87
India	26	48	33	238	67	149	359	544	101
Other South Asia	35	63	44	291	109	148	379	531	101
International shipping	44	56	40	72	72	204	402	402	–
All Asia	16	37	31	185	65	130	364	450	72

Streets et al., JGR, (2003).

The overall uncertainties in 2006 INTEX-B Asian emission:
±16% (SO_2), ±37% (NOx),
±130% (NMVOC), ±185% (CO),
±360% (BC), ±450% (OC).

Zhang et al., ACP 2009

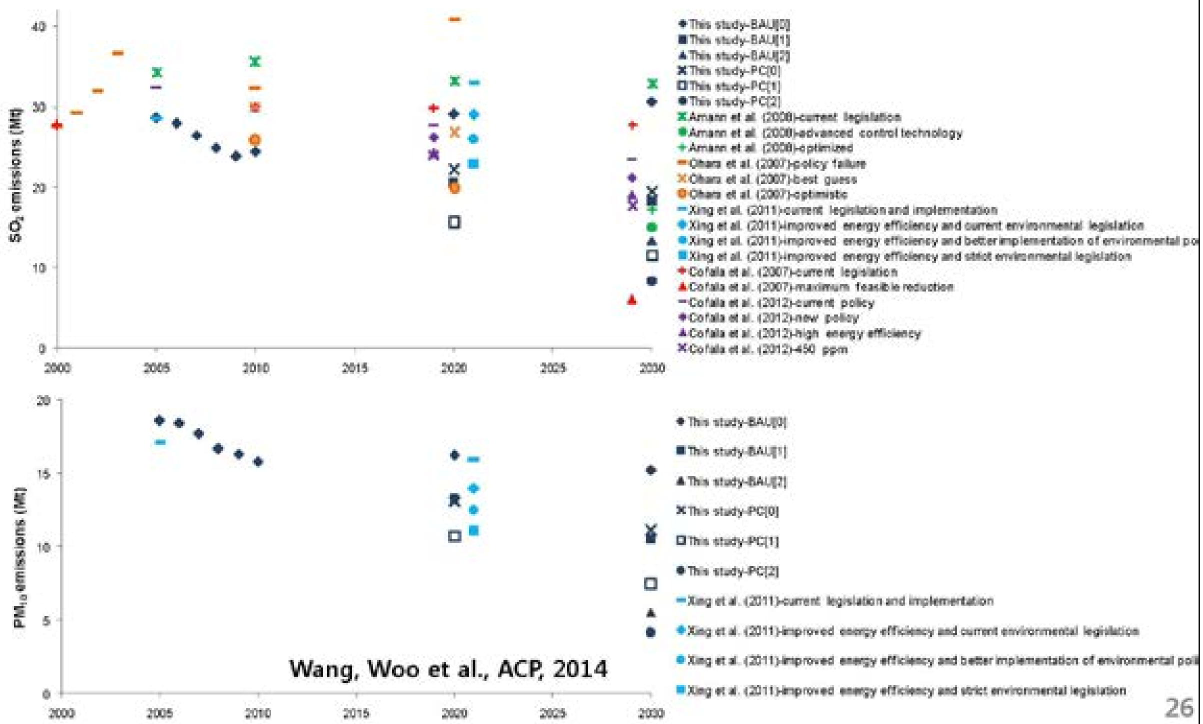
Uncertainties of REAS2.1 emissions in China/India/the rest of Asian countries :
±31/32/35% (SO_2), ±37/49/47% (NOx),
±78/137/111% (NMVOC), ±86/114/131% (CO),
±176/178/257% (BC), ±271/233/286% (OC)

Kurokawa et al., ACP 2013

25

SAQMP: Challenges and Opportunities

Understanding Uncertainties : Emissions Projection (SO_2, PM_{10})



Wang, Woo et al., ACP, 2014

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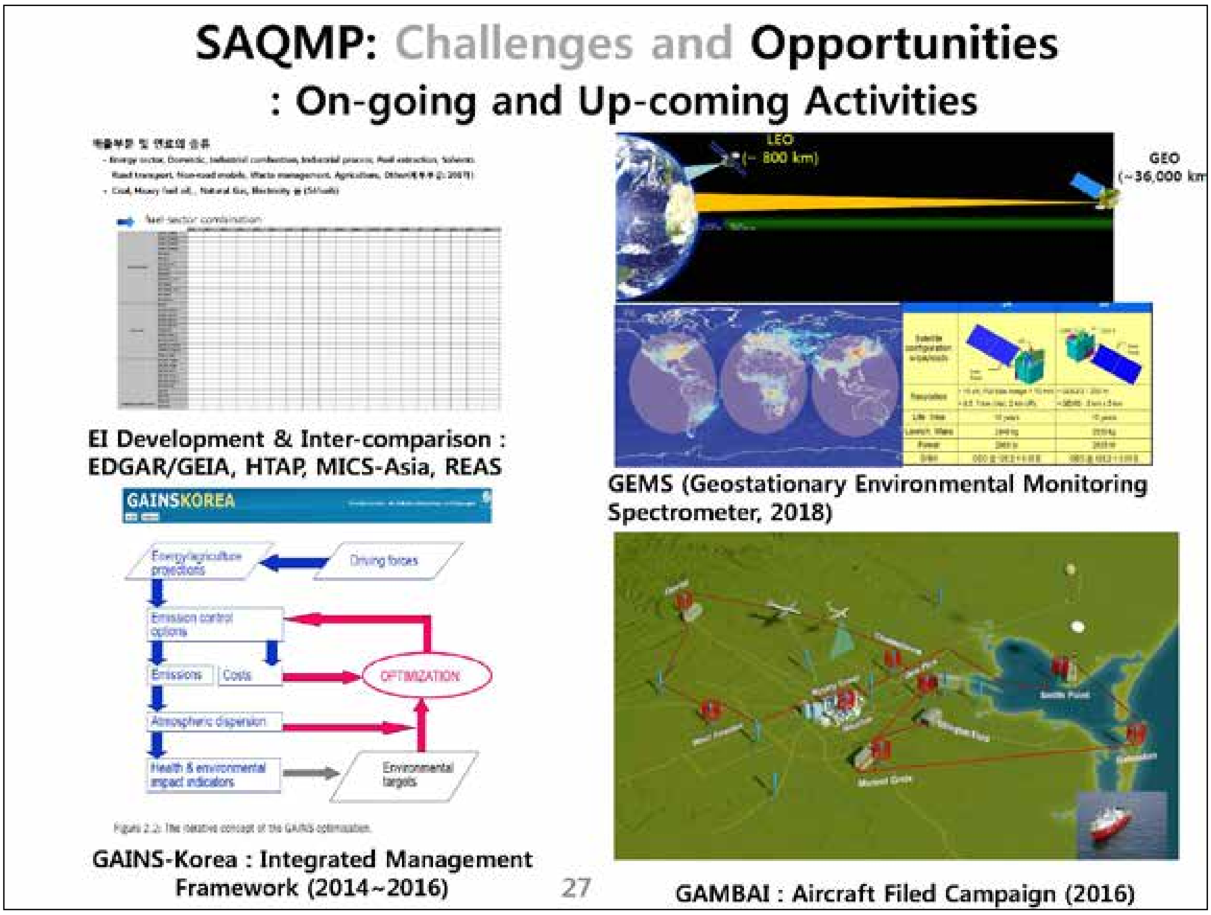
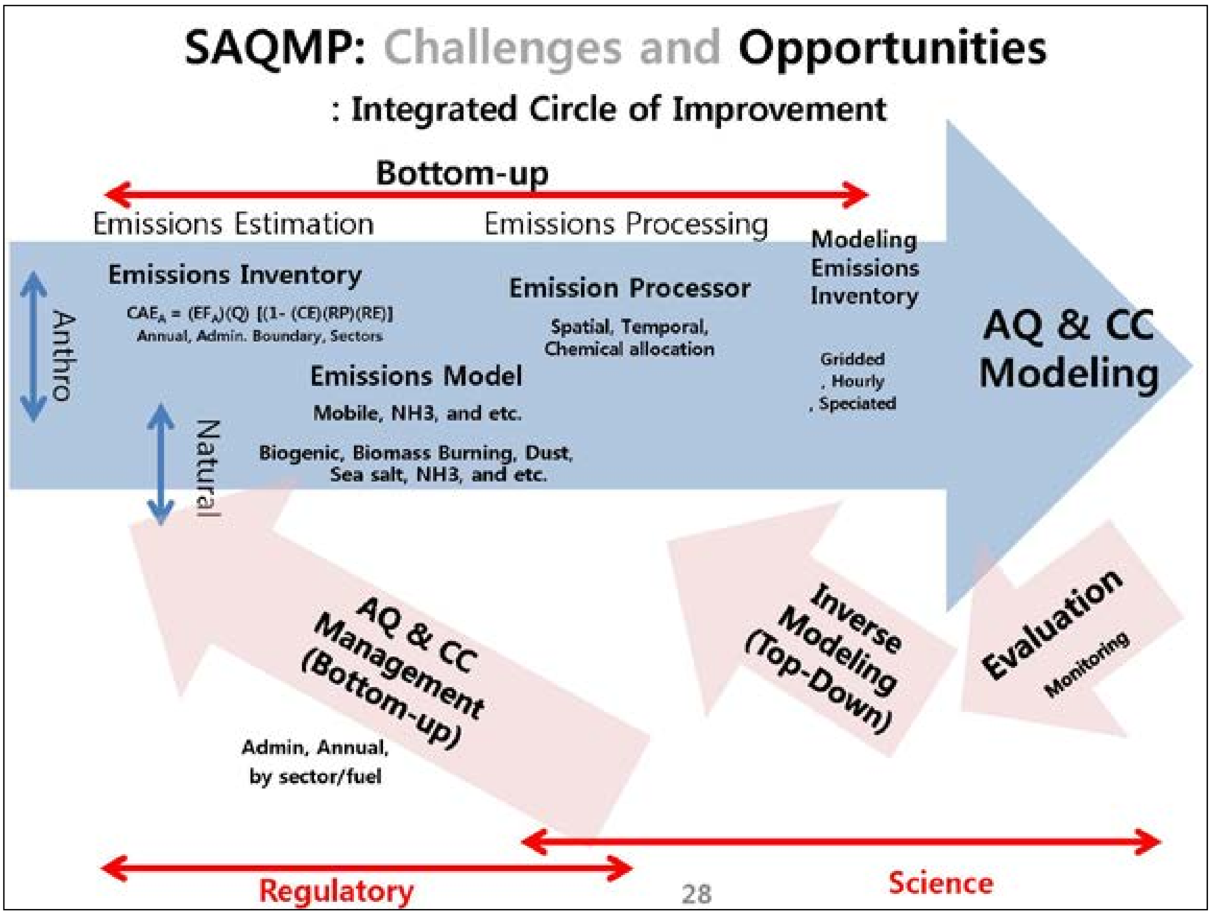


SAQMP: Challenges and Opportunities
: On-going and Up-coming Activities
LEO (~ 800 km)
GEO (~36,000 km
EI Development & Inter-comparison :
EDGAR/GEIA, HTAP, MICS-Asia, REAS
GAINSKOREA
Energy/agriculture projections
Driving forces
Emission control options
Emissions
Costs
OPTIMIZATION
Atmospheric dispersion
Health & environmental impact indicators
Environmental targets
GAINS-Korea : Integrated Management Framework (2014~2016)
GEMS (Geostationary Environmental Monitoring Spectrometer, 2018)
GAMBAI : Aircraft Filed Campaign (2016)
27



SAQMP: Challenges and Opportunities
: Integrated Circle of Improvement
Bottom-up
Emissions Estimation
Emissions Processing
Modeling Emissions Inventory
Emissions Inventory
CAE_A = (EF_A)(Q) [(1- (CE)(RP)(RE)]
Annual, Admin. Boundary, Sectors
Emission Processor
Spatial, Temporal, Chemical allocation
Gridded , Hourly , Speciated
Anthro
Natural
Emissions Model
Mobile, NH3, and etc.
Biogenic, Biomass Burning, Dust, Sea salt, NH3, and etc.
AQ & CC Modeling
AQ & CC Management (Bottom-up)
Admin, Annual, by sector/fuel
Inverse Modeling (Top-Down)
Evaluation
Monitoring
Regulatory
Science
28

Outline

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** Seoul metropolitan Air Quality Management Plan*

Summary

- Air quality in SMA, Korea has been improved due to very aggressive penetration of SAQMP measures. The new challenges from transboundary transport and secondary pollution are becoming more important
- Four different emissions control pathways were set in the GAINS-Korea to assess the effectiveness of SAQMP from emissions reduction and air quality improvement standpoint. The most stringent emission scenario(MFR) can satisfy reduction target, but new challenges from transboundary transport and secondary pollution are becoming more important
- Anticipated top-down sciences, such as, stationary environmental satellite, a massive filed campaign will be helpful from the science viewpoint but the collaborative bottom-up efforts, such as EI inter-comparison, transfer of growth/control measure information, are essential
- The recent cross-border, cross-disciplinary efforts should be the most important component to save our atmosphere

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6.9 Air Pollution Control: Status and Actions in Thailand (Jariya Boonjawat)

Air Pollution Control : Status and Actions in Thailand

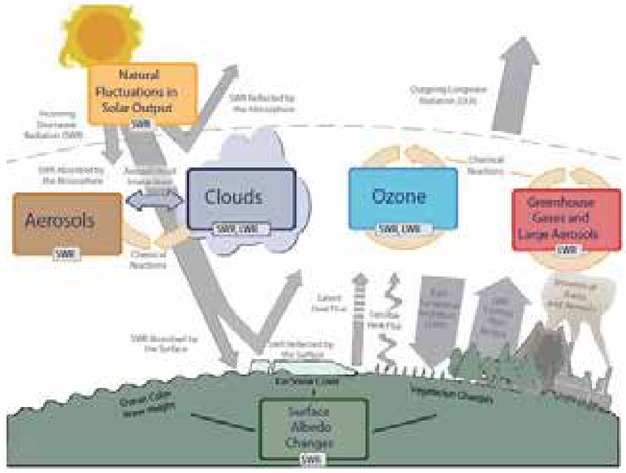
Thailand case study

Jariya Boonjawat

Global status: IGBP/IGAC Release Statement on Air Pollution and Climate Change(2012)

- Air pollution is projected to be the world's top environmental cause of premature mortality worldwide by 2050, ahead of dirty water and lack of sanitation.
- Current climate change mitigation actions will not be enough to prevent the global average temperature from exceeding the internationally agreed goal of $2^{o}C$ above preindustrial level by 2050.
- IGBP and IGAC scientists shows that air pollution and climate change are closely linked.
- It's timely to address short-lived climate forces (SLCF) such as black carbon and tropospheric ozone to simultaneously mitigate both air pollution and climate changes together from science and policy perspectives.

The Earth's climate system is powered by solar radiation-drivers of radiative energy balance (IPCC-AR5)

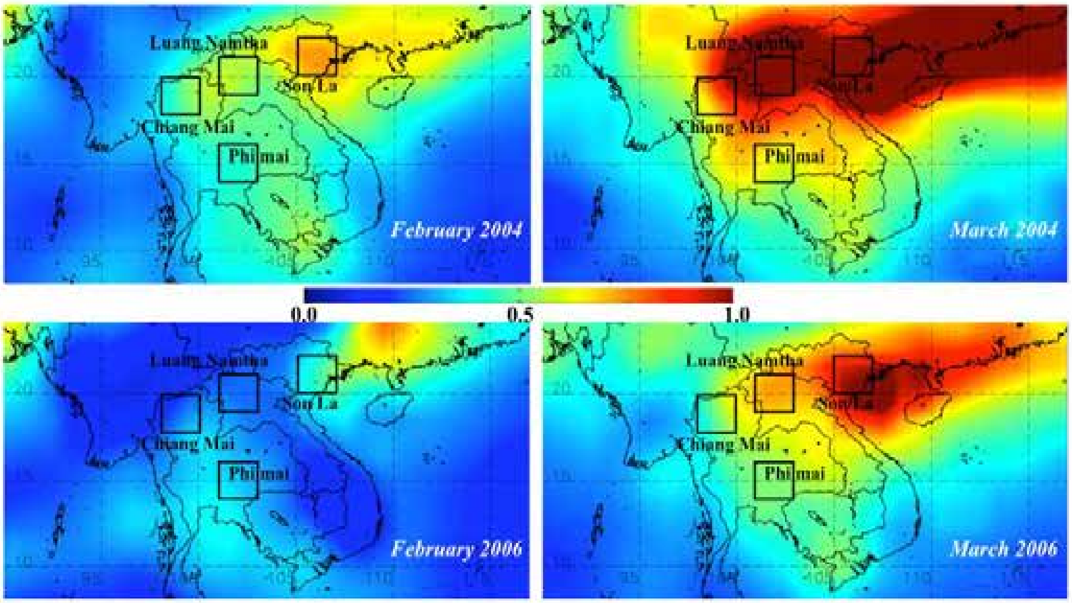


Regional Air Pollution-Southeast Asia

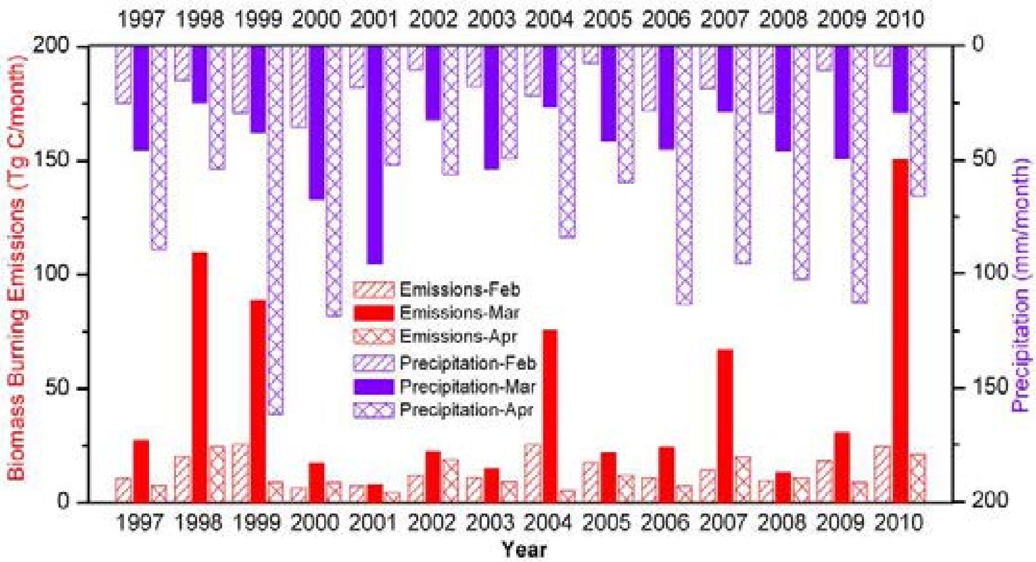
- Satellite- surface monitoring over northern SEA indicated that biomass-burning emissions of GHGs and aerosols (tiny particles) contribute to radiative effect, interact with clouds and burden of atmospheric pollutants in boreal spring (March).
- Biomass-burning always peaks in March and years receiving less precipitation during this month.
- ENSO is one of the prominent systems influencing the Asian monsoon and likely contributed to the stronger biomass-burning years during this period (1998/1999, 2004, 2007 and 2010)

Regional Air Pollution-Southeast Asia

Monthly-mean AOT at 550 nm from MODIS/Terra over Southeast Asia during February and March 2004 and 2006. Four highlighted regions are Chiang Mai (Thailand), Luang Namtha (Lao PDR), Son La (Vietnam) and Phimai (Thailand). AOT close to and exceeding unity (1.00) are observed in March 2006 at Chiang Mai, Luang Namtha and Son La in 2004 &2006.



Monthly-mean (February, March, April) values of total carbon emissions (bars from bottom) due to biomass burning and corresponding precipitation (bar from top) over Southeast Asia (8-26°N, 90-110°E) during 1997-2010 (Source: Tsay et al. Atmospheric Environment 2013).



Thailand: Status of Air Pollution

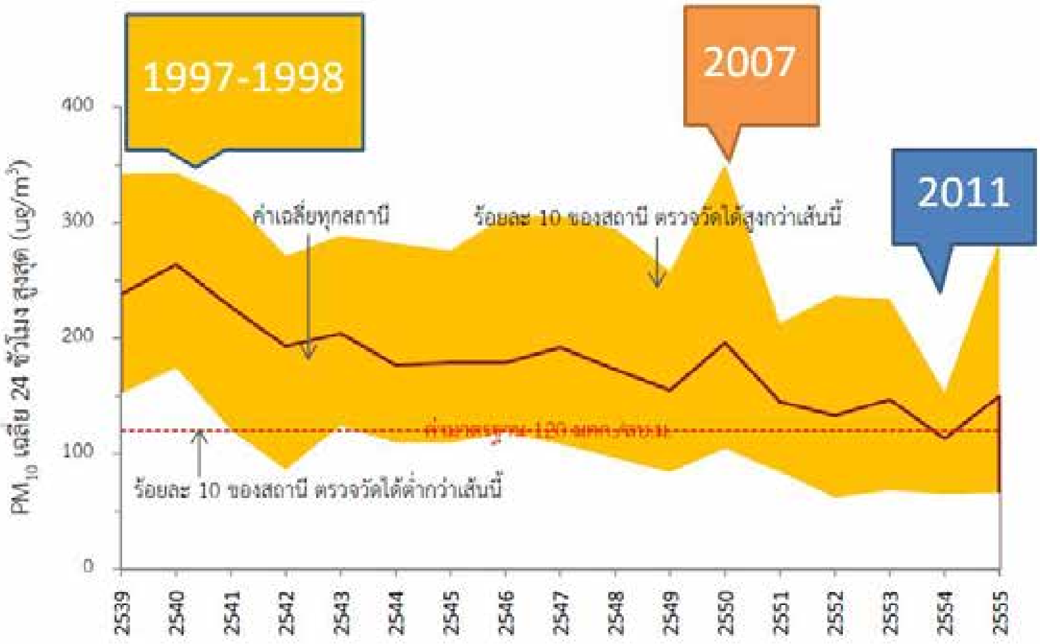
- Thailand State of Pollution Report is compiled every year in accordance with the Enhancement and Conservation of National Environmental Quality Act B.E. 2535 (1992), and submit to the National Environmental Board for supporting policy-making and developing the national pollution development plan.
- The latest Draft Annual Report is for the year 2555 (2012), in which air quality especially particulate matter (PM_{10}) in big cities and provincial areas with large number of industries are the major concern, followed by ozone.
- $PM_{2.5}$ or Particulate Matters with aerodynamic diameter < 2.5 micrometer which can accumulate in the lung and associate with respiratory illness, facilitate cardiovascular diseases and may cause lung cancer due to PAH.

Air quality monitoring network in Thailand

- In 2011 there are 66 automatic air quality stations (8 mobile stations) all over the country for monitoring gaseous pollutants: CO, NO_2, SO_2, O_3 and particulate matters: PM_{10} and $PM_{2.5}$ only in Bangkok.
- Air quality standards for Thailand since 1995 for PM_{10} (24 h average <120 microgram per cubic meter and < 50 microgram per cubic meter for 1-year average), $PM_{2.5}$ (24 h average <50 microgram per cubic meter and 25 microgram per cubic meter for 1-year average).
- Overall air quality in Thailand with respect to PM_{10} seemed to be improved during the past 17 years, but also influenced by climate variation.

Air Quality Monitoring Stations in Thailand

There are 66 automatic air quality stations in 29 provinces all over the country.
35 in central part
14 in northern part
9 in eastern part
3 in north-eastern part
5 in southern part
Main pollutants are PM_{10} and O_3 that exceed national air quality standard



รูปที่ 3 แนวโน้มฝุ่นขนาดไม่เกิน 10 ไมครอน (PM_{10}) เฉลี่ย 24 ชั่วโมงสูงสุด ระหว่างปี 2539-2555

Trends of average PM10 max 24h during 1996-2012

Chiang Mai Magazine, April 2007 เชียงใหม่ปริทัศน์ฉบับพิเศษ เมษายน 2007

1. ไฟจากการจุดประทัด
2. ไฟไหม้ป่า
3. ควันพิษในเมือง
4. ผู้คนเจ็บป่วย
5. ทัศนวิสัยต่ำ
6. หมอกควันพิษปกคลุมอ่างแก้ว

Poor visibility due to smoke haze in March 2007 affected tourism and economy นักท่องเที่ยวลดลง เศรษฐกิจแย่สำหรับสงกรานต์

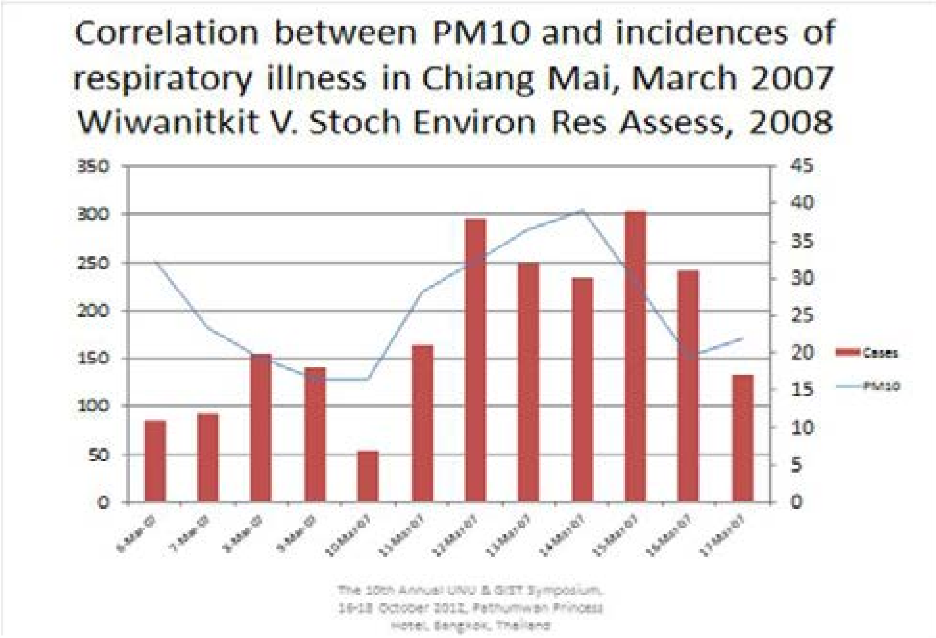
3 มีนาคม ดอยสุเทพหาย

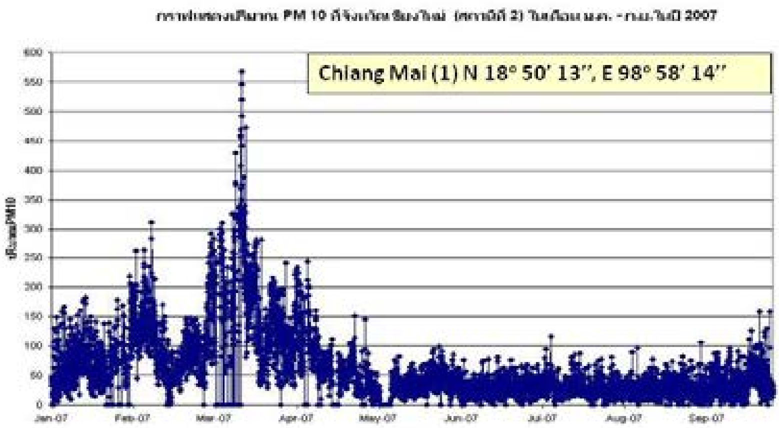
15 มีนาคม ทำฝนหลวงไล่หมอกควันพิษ

21 มีนาคม แม่ฮ่องสอน เชียงใหม่ผู้ป่วยเพิ่ม

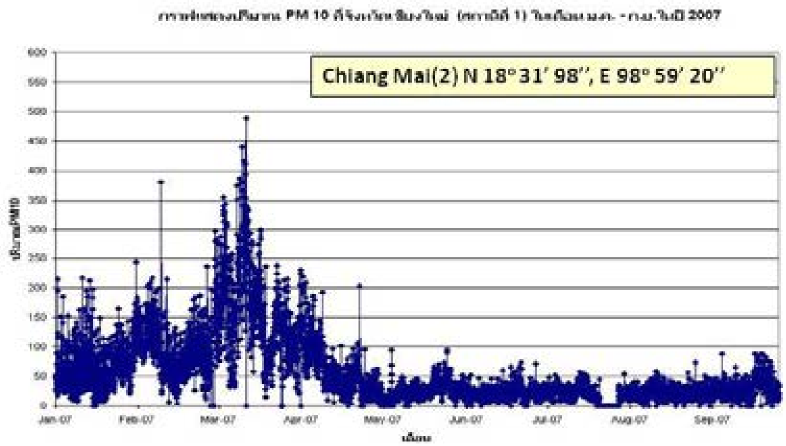
26 มีนาคม กรุ๊ปทัวร์-สัมมนาหนีบลพิษ

PM10 concentration above 120 µm^{-3} associated with "hazardous" health impacts evident by increasing cases of respiratory illness in Chiang Mai .



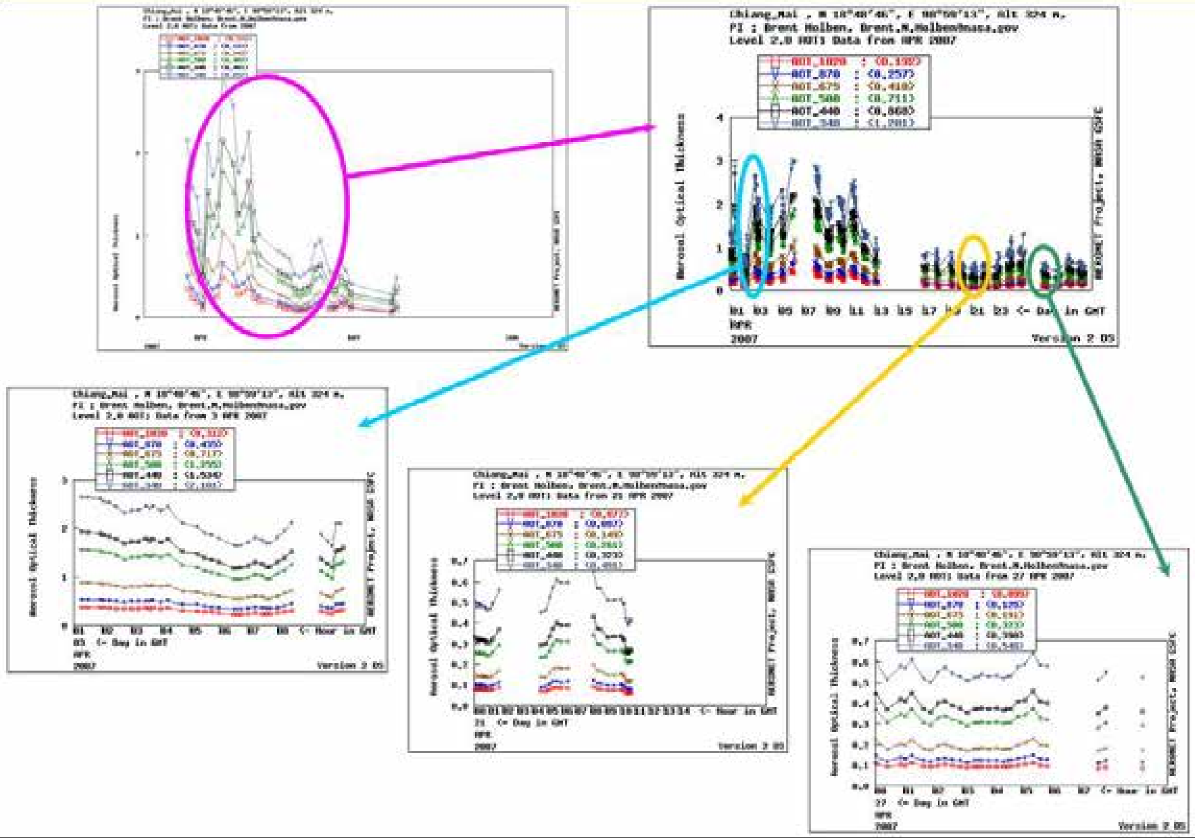


Seasonal variation (2007) observed by PM10 at 2 sites in Chiang Mai, Thailand

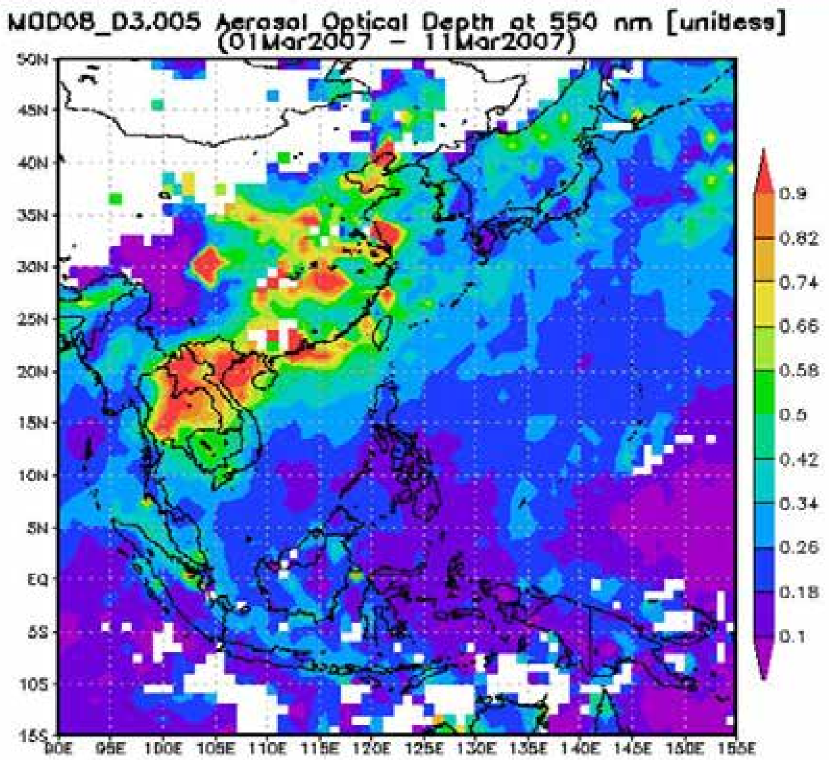


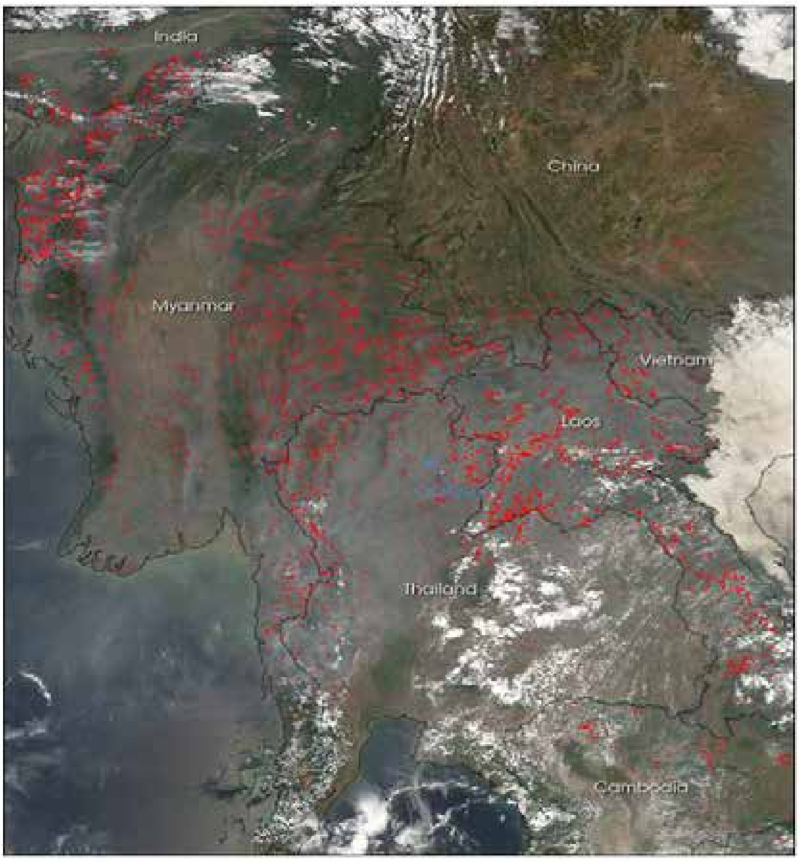
Source: http://www.pcd.go.th

April (2007) –Daily variation of AOD observed on 3, 21, 27 April 2007



March - April (2007)- 10-day composite of AOD observed by MODIS





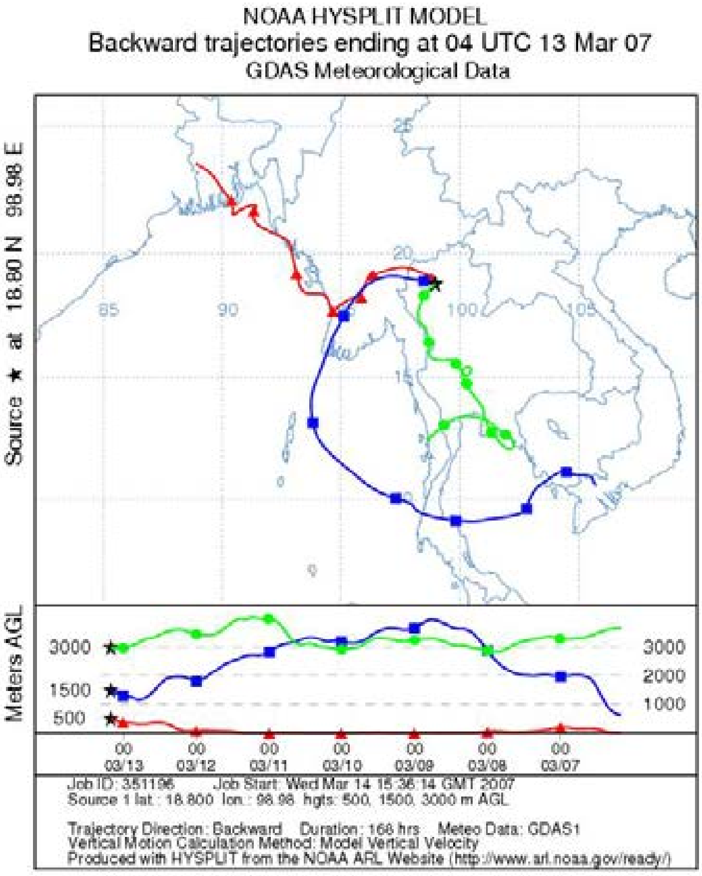
March 13, 2007

MODIS-Aqua

Hot spot and haze in Myamar, Thailand, Lao, Vietnam

ภาพถ่ายดาวเทียมแสดงแผนที่ไฟ

วันที่ 13 มีนาคม เวลา 13:30 และหมอกควันพิษปกคลุมแม่ฮ่องสอน เชียงใหม่ ลำพูน เชียงราย

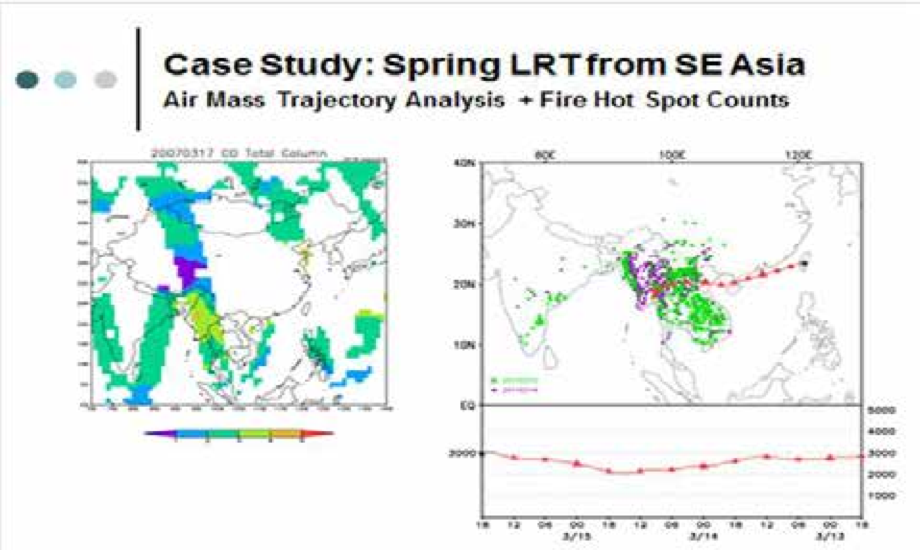


7-Day Back Trajectory to Chiang Mai

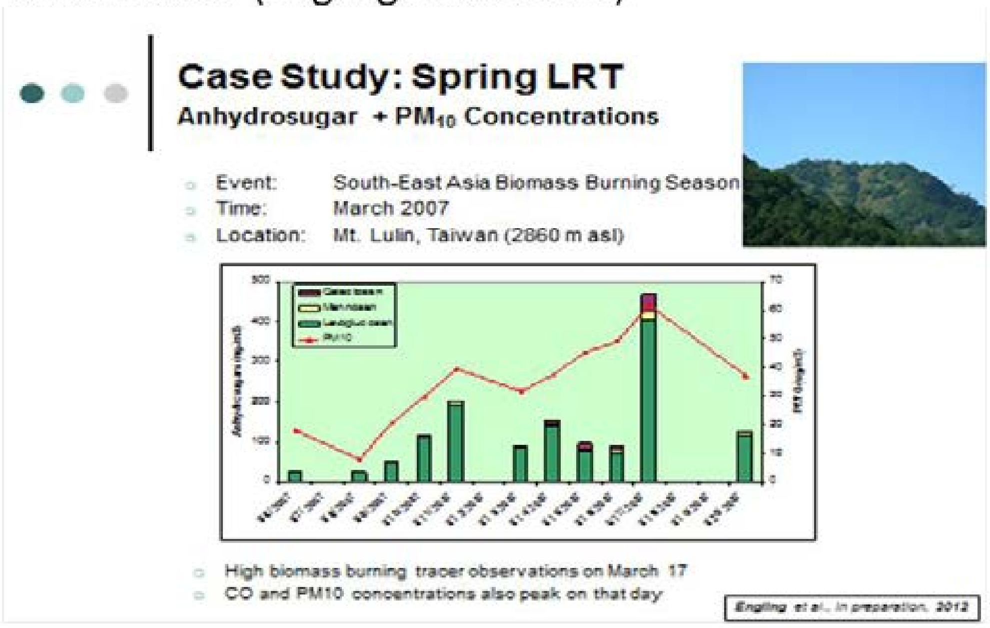
March 13, 2007

การเคลื่อนที่ของมวลอากาศ 7วัน ก่อนถึงเชียงใหม่ในวันที่ 13

Long-range transport (LRT) of biomass-burning aerosol, and interaction with sea-salt aerosol on the way towards China sea (Engling et al., 2013)



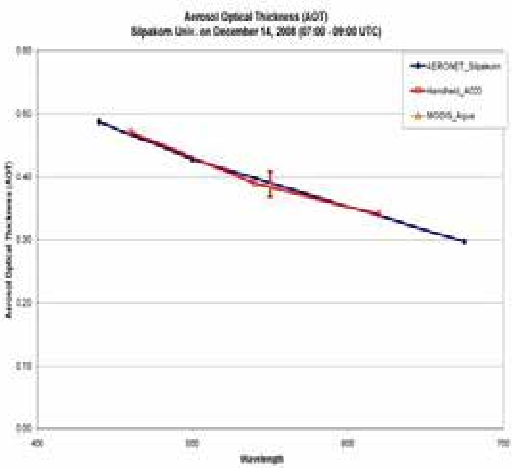
High biomass-burning tracer (Levoglucosan and PM10) observation at Mount Lulin, Taiwan during March 2007 (Engling et al. 2013)

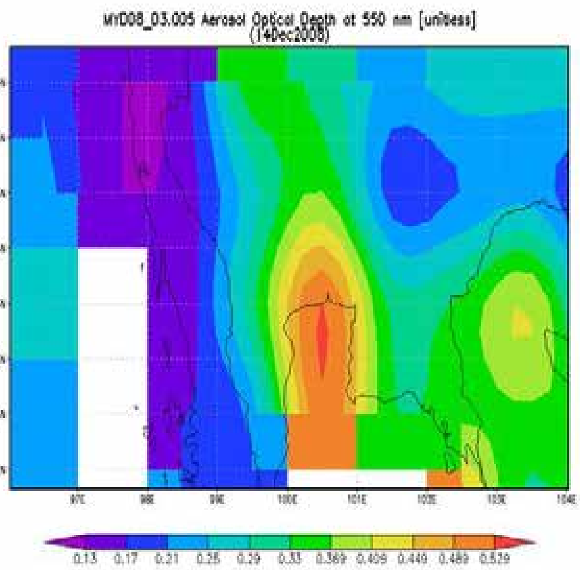


Development of Thai-hand-held sunphotometer and calibrated with AERONET

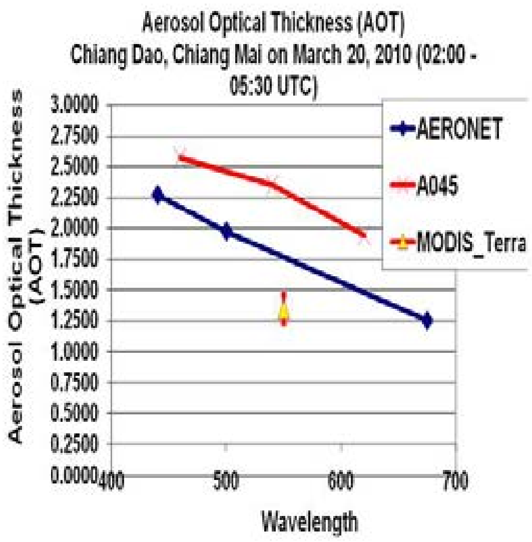
HSP has a Red-Green-Blue (RGB) sensor with peak sensitivity at 620, 540 and 460 nm, whereas AERONET_AOD are 675, 500 and 430 nm, and MODIS- AOT at 550 nm respectively.

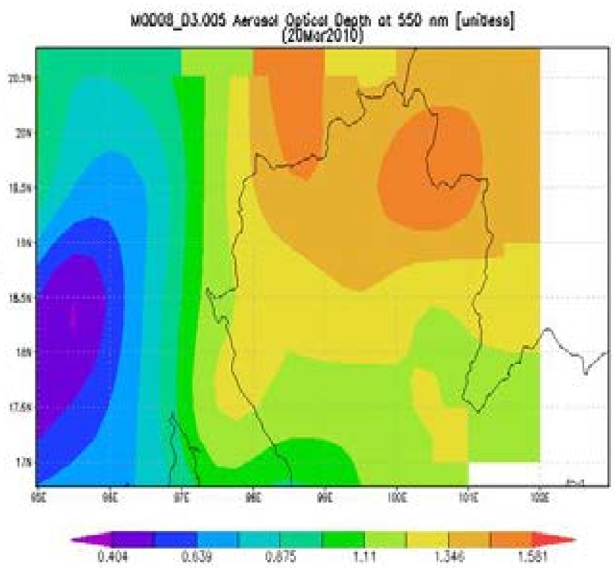
A comparison of AOT between RGB-HSP and 8-wavelength AERONET at Silpakorn U. and MODIS-AOT on the same day , December 14, 2008





Smoke haze from forest fire on March 20, 2010 as measured by HSP in Chiangdao, 70 km from Chiang Mai downtown compared with AERONET and MODIS -550 nm



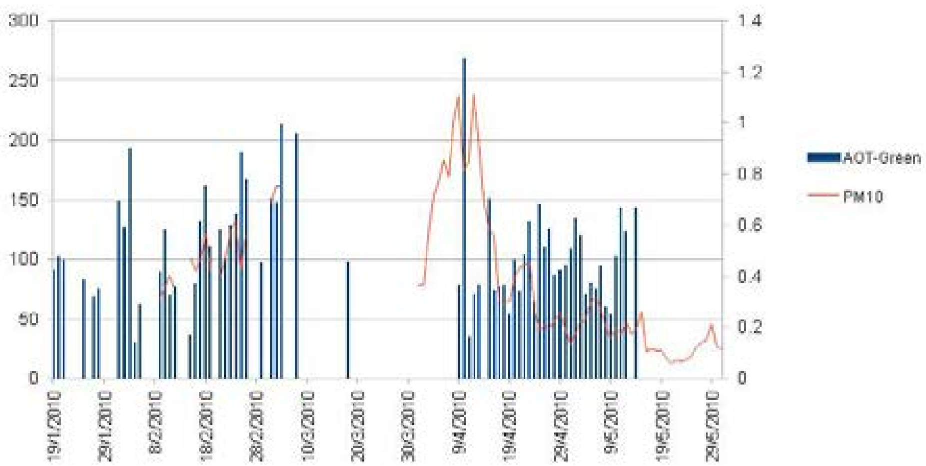


The 10th Annual UNU & GIST Symposium, 16-18 October 2012, Pathumwan Princess Hotel, Bangkok, Thailand

Smoke haze in Chiangdao 12-13 April 2010

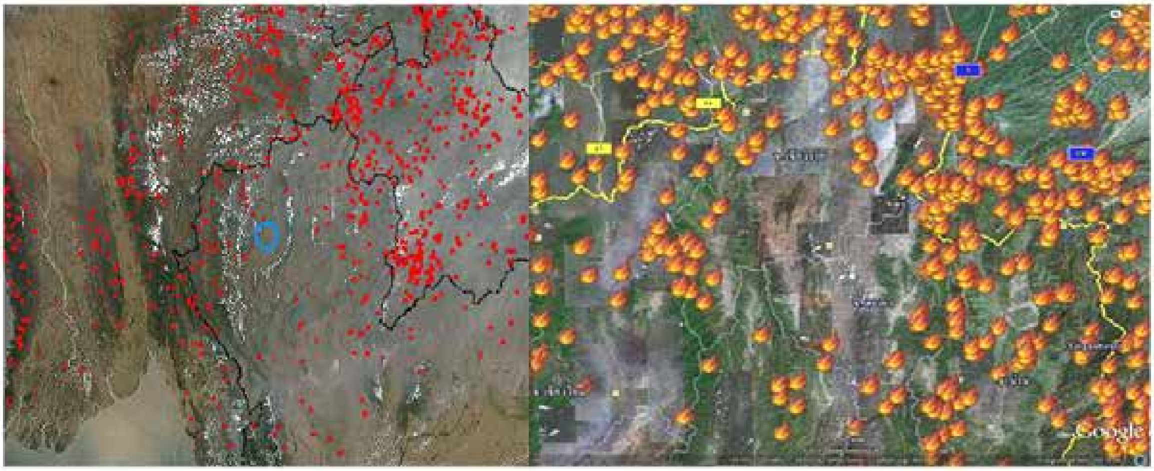
The 10th Annual UNU & GIST Symposium, 16-18 October 2012, Pathumwan Princess Hotel, Bangkok, Thailand

Comparison between HSP-AOT-540nm measured at Tanthong Withaya School in Pan district and PM10 measured in Chiangrai downtown from Jan-May 2010



The 10th Annual UNU & GIST Symposium, 16-18 October 2012, Pathumwan Princess Hotel, Bangkok, Thailand

MODIS fire map and KML-Google map of hotspot in the northern part of Thailand, showing fire also in Myanmar and Lao PDR Date 13 April 2010



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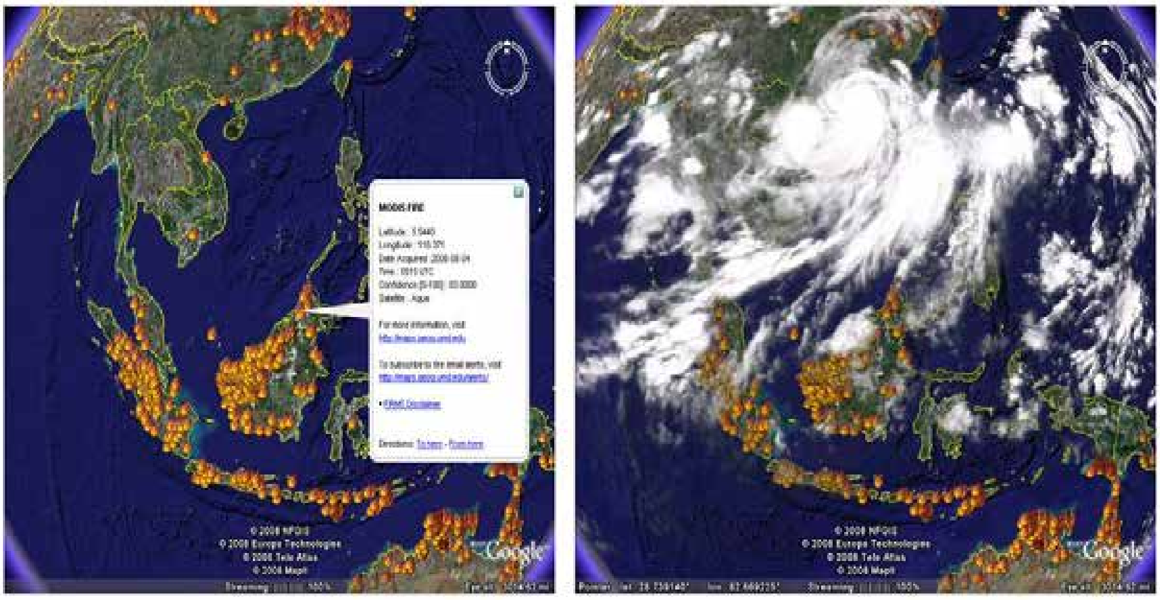
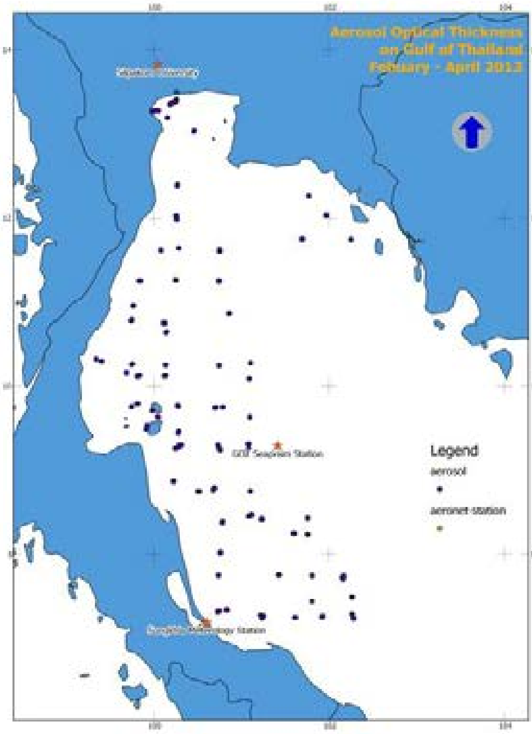
Continental Southeast Asia is located in the north hemisphere with peaks of biomass burning in March and April, while Indonesia and peninsular Malaysia in the south of equator shows hotspots in August and September.



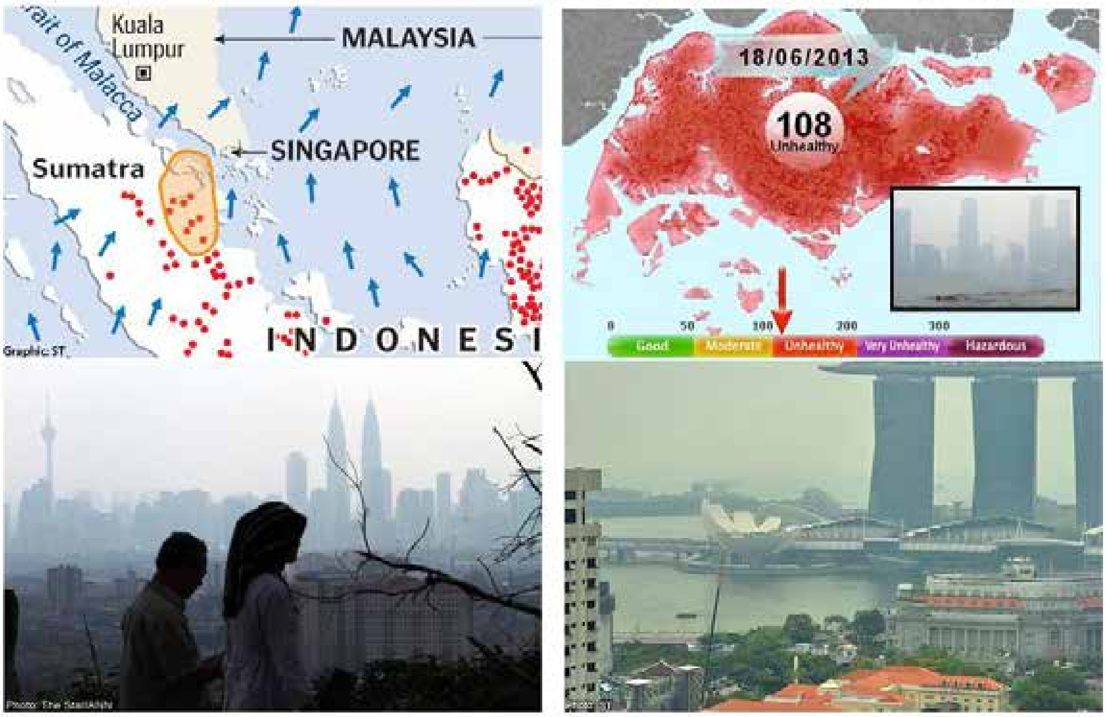
AOT by Hand-held Sun photo meter in GOT March – April, 2013



Average AOT540 nm in the gulf of Thailand (GOT) is 0.53 ± 0.22 indicating low air pollution. Data of AOT measured near the upper part or closer to Bangkok showed higher AOT (0.66 ± 0.20) comparing with 10 Degree below area that exhibit lower values of AOT (0.46 ± 0.21).

	MIN	MAX	Average	N	STDEV
GOT	0.0856	1.1407	0.5323	210	0.2294
10-Degree above	0.2749	1.1407	0.6624	70	0.2078
10-Degree below	0.0856	1.0807	0.4672	140	0.2118

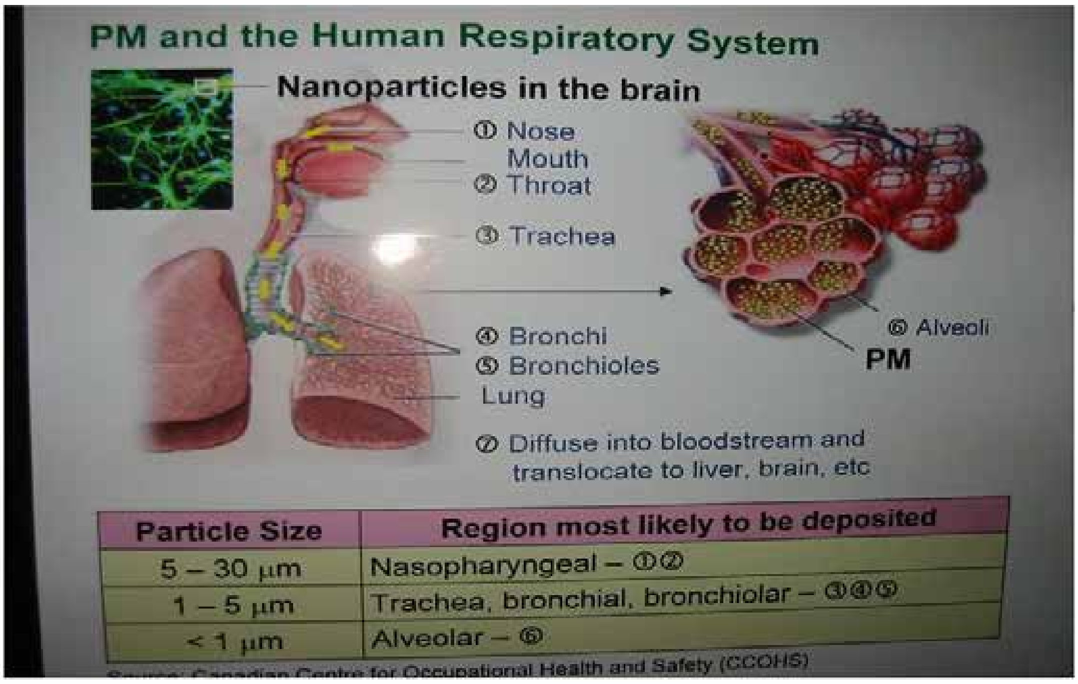
In June 2013 transboundary haze from Indonesia to Malaysia and Singapore



The pollution Standard Index (PSI) soared to 321 which indicates "very hazardous" air quality and also above the previous 226 record in 1997

- It caused widespread health problems.
- It caused regional economy billions of dollars as a result of shipping and air transport disruptions.
- PM2.5 concentration was between 112-143 micrograms per cubic meter.
- Under hazy conditions, the National Environment Agency advised that children, the elderly and those with heart or lung diseases reduce prolong or heavy outdoor activities.

PM10, PM2.5 and respiratory diseases
PM< 1micrometer can diffuse from lung alveoli into blood stream and translocate to liver brain etc



Health Impact of transboundary biomass-burning aerosols and anthropogenic ozone

- Anenberg et al., 2010 estimated that roughly 3.5 million cardiopulmonary and 220,000 lung cancer mortalities per year are associated annually with anthropogenic $PM_{2.5}$ and 0.7 million per year with anthropogenic ozone.
- The death attributable to $PM_{2.5}$ about 6% of all deaths that occur globally, therefore it is important to assess the health impact of transboundary aerosols, not just regional climate impact.

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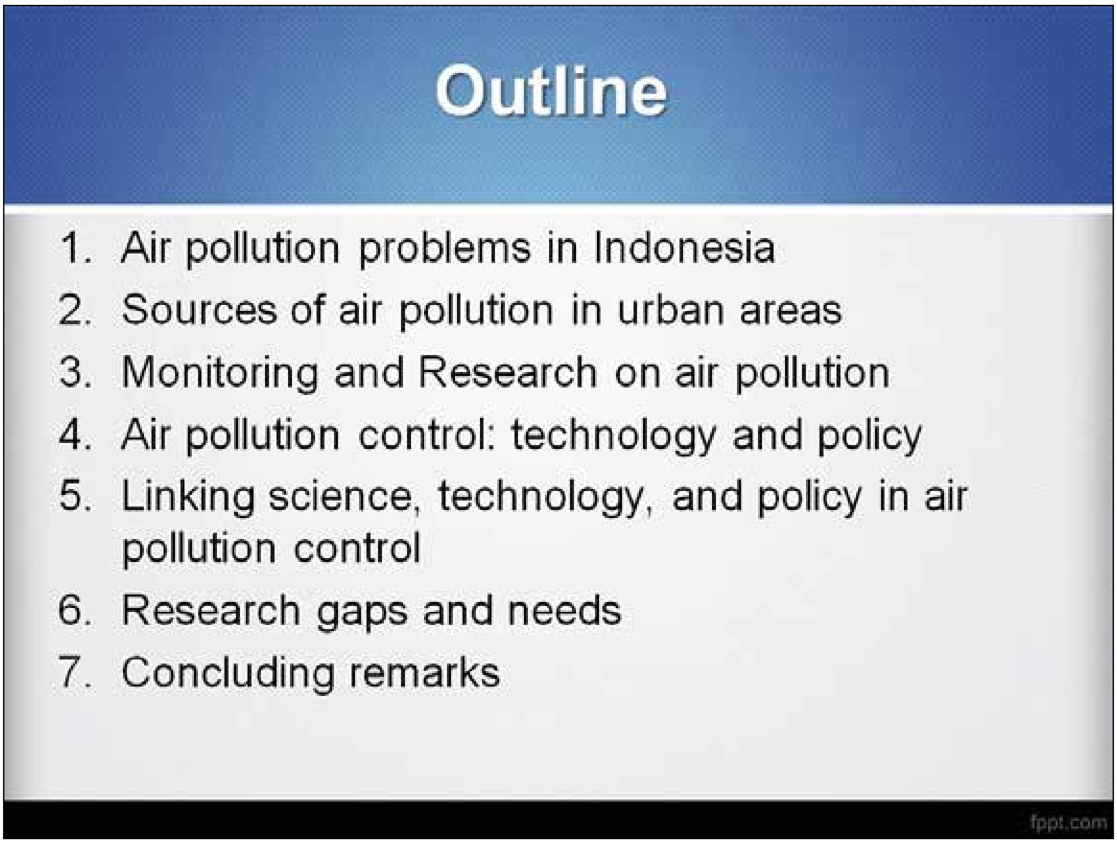
Key messages

- A large fraction the aerosol particles originate from emissions at the Earth's surface caused by the incomplete combustion of fossil fuels and biofuels (biomass). Biomass-burning has been a regular practice for land conversion and land clearing in many countries in Southeast Asia.
- The most serious health impacts of particles associated with biomass-burning [biomass-burning aerosol/ Atmospheric Brown Clouds (ABC)] include cardiovascular and pulmonary effects leading to chronic respiratory problems, hospital admissions and deaths.

The 10th Annual UNU & GIST Symposium, 16-18 October 2012, Pathumwan Princess Hotel, Bangkok, Thailand

6.10 Air Pollution Control in Urban Areas of Indonesia: Problems and Research Gaps (Erna Sri Adiningsih)



Air Pollution Problems in Indonesia

BACKGROUND:

- Dramatic increase of population in urban areas of SEA and Indonesia.
- High urbanization level in Jakarta → increasing population density, energy utilization, transportation, and air pollution.
- If no concrete actions, air polution in Jakarta in 2030 will increase 4 times for PM_{10}, SO_2 and CO, and 7 times for O_3 dan NO_3. Accordingly, GHG or CO2 in particular, will increase 3 times compared with the base-line 2010 (MoE & UNEP – US EPA, 2012).
- Other cities experienced polluted air mainly due to transportation, land/forest fires, and volcano eruption.
- Big forest/land fires in 1997 in Sumatra and Kalimantan, Indonesia caused transboundary haze pollution in several SEA countries including Singapore and Kuala Lumpur. The fires continue until today.

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Air Pollution Problems in Indonesia

World Population: Urbanization Levels [(1)]

Percentage of population residing in urban areas by region and country

Region	1950	1990	2010	2050	1990-1950	2010-1990	2050-2010
World	28.83	42.62	50.46	68.70	13.78	7.85	18.24
Asia Pacific	15.99	29.47	40.56	64.93	13.48	11.09	24.37
East Asia	15.51	32.21	50.17	74.34	16.70	17.96	24.16
South Asia	15.94	25.14	30.38	55.14	6.26	5.24	24.75
South East Asia	15.48	31.26	41.84	65.44	16.14	10.22	23.59
- Indonesia	12.40	30.58	44.28	65.95	18.18	13.70	21.67
Oceania	62.00	70.70	70.22	74.81	8.70	-0.48	4.58

(1) Marcotullio *et al.* (2014) in: Manton & Stevenson (eds). 2014

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Air Pollution Problems in Indonesia

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Air Pollution Problems in Indonesia

Air Quality Condition in Big Cities in Java and Bali in 2006

No	Location/City	HC ppm	NOx ppm	CO ppm	O3 ppm	SPM$_{10}$ µg/m3	SOx ppm
1	Bandung	0,1 –5,0	0,016-0,123	0,01-6,67	0,002-0,081	6,0-212	0,001-050
2	Surakarta	0,10-2,85	0,006-0,050	0,06-4,87	0,008-0,040	10,0-114,0	0,003-0,020
3	Yogyakarta	0,10-6,80	0,019-0,094	1,31-7,86	0,005-0,025	34,0-131,0	0,001-0,010
4	Semarang	2,50-5,12	0,003-0,490	0,64-5,68	0,020-0,040	41,0-189,0	0,003-0,040
5	Surabaya	2,50-6,70	0,016-0,123	0,01-6,67	0,002-0,081	6,0-212,0	0,001-0,050
6	Denpasar (Bali)	2,60-8,30	0,023-0,189	0,48-11,53	0,005-0,035	15,0-239,0	0,001-0,010
7	Serang (Banten)	0,80-8,00	0,001-0,111	0,061-4,206	0,003-0,076	9,0-260,0	0,049-0,276

Source: Kusminingrum & Gunawan, 2006

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Air Pollution Problems in Indonesia

Impacts of air pollution:

- As example, in 2010, about 57.8% of total population in Jakarta suffered respiratory diseases due to long exposure in polluted air, such as *asma*, *bronkopneumonia*, COPD (*Cronical Obstructive Pulmonary Diseases)*, and *Coronary Artery Diseases*, and had to pay health expenses up to IDR 38,5 trillion (USD 3.2 billion).
- If no concrete actions, air polution in Jakarta in 2030 will increase 4 times for PM_{10}, SO_2 and CO, and 7 times for O_3 dan NO_3. Accordingly, GHG or CO2 in particular, will increase 3 times compared with the base-line 2010 (MoE & UNEP – US EPA, 2012)

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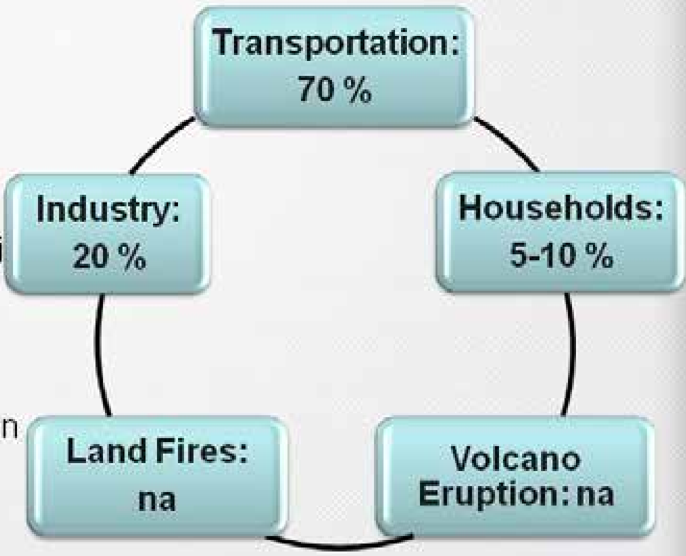
Sources of Air Pollution in Urban Areas

Moving sources

1. Transportation → rapid urbanization

Fixed sources:

1. Industrial emissions → industrialization
2. Volcano eruption → Indonesi is located in the ring of fires
3. Garbage combustion by households.
4. Land/forest fires (slash & burn practices in large plantation areas causes trans-boundary haze pollution)



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Sources of Air Pollution in Urban Areas

Pollutant Types in Urban Areas in Indonesia:

- Particulate matters: solid & liquid
- Gaseous: hydrocarbon (HC), carbon monoxide (CO), sulphur oxides (SOx), nitrogen oxides (NOx), photochemical Oxidant (O_3)

Types of Sources:

- Moving sources - vehicles
- Fixed sources – industries, land fires & combustion, volcano eruption

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Air Pollution Control: Technology

Technology to control air pollution based on sources:

- Industry: pollutant reduction (gas scraper, gravity settling chambers, electrostatic precipitator, pollutant neutralization), low emission material use.
- Transportation: gas fuel vehicles, hybrid car prototype has been produced but still need improvement for manufacture.
- Households: gas fuel stoves (LPG, natural gas), solid waste management.
- Land/forest fires: no burnt technology for land clearing, weather modification to reduce haze thickness.
- Volcano eruption: weather modification to induce precipitation (dust cleaning).

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Air Pollution Control: Policy

National Level:

- **Act no 23 1997 on Environmental Management**
- **Presidential Decree no 41/1999 on Air Pollution Control**
- **Blue Sky Program** : established by MoE of Indonesia consisting of a set of parameters for air quality assessment in big cities.
- **Fuel Economy Policy**
- **Green Economy**
- **Air Pollution Standards (Minister Decree)**

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Air Pollution Control: Policy

Local Level:

- Emission tests of vehicles (regular basis)
- "**3 in 1**" (min 3 passengers in 1 car) regulation in Jakarta, operated on working days from 07:00 – 10:00 and 16:30 – 19:00 for certain routes in down town, implemented since ....
- "**Car free day**" (once a week, i.e. Sunday, with no car passing through certain roads) in Jakarta, implemented since 2002, initiated by NGOs.
- Limited parking areas (for vehicles fulfill air quality standards)
- Clean Air Initiative
- Transportation facilities: Bus Way line, Mass Rapid Transportation
- Progressive vehicle taxation.

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Air Pollution Control: Policy

Study on **Fuel Economy Policy**, in 2012, by MoE of Indonesia & UNEP – US EPA recommended policy actions on transportation:

- Shifting passangers from using private vehicles (cars and motobikes) to the use of public transportations: 5% & 1% in 2011; 10% & 5% in 2014; 20% & 10% in 2018; 40% & 20% in 2025 respectively.
- Establish fuel efficiency of 10% started from 2009.
- Fuel conversion into gas (CNG, LPG, LNG) for public transportation vehicles at least 1% in 2009, 2% in 2011, 5% in 2021.
- Application of *hybrid* technology for public transportation vehicles at least 0,05% in 2009, 0,1% in 2011, 0,5% in 2016, 1% in 2021.
- *Scrapping* 50% vehicles of more than 10 years old since 2009.
- Conversion into bio-fuels for public transportation vehicles at least 1% in 2009, 2% in 2011, 5% in 2021.
- Utilization of (*retrofitting*) *catalytic converter* of 25% for diesel vehicles.
- Implementation of vehicle standards (Euro 2) in 2005 and Euro 4 in 2016.

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Air Pollution Control: Policy

Regional Level:

•Transboundary haze pollution, resulted from land fires, has had serious impacts in the Southeast Asian region.

•**ASEAN Agreement on Transboundary Haze Pollution (AATHP)** was discussed at 2nd ASEAN summit in Kuala Lumpur 1997.

•In 2002 all ASEAN member countries agreed to sign AATHP in Kuala Lumpur, Malaysia.

•AATHP began to enter into force on 25 Nov 2003.

•On 16 September 2014 Indonesian Parliament agreed to approve AATHP.

•Regional collaboration and effort could be enhanced in addressing air pollution control.

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Monitoring and Research on Air Pollution

- Ambient air quality monitoring includes PM_{10}, SO_2, NO_2, Pb, CO, and O_3.
- National level: air quality monitoring is conducted by Meteorological Agency (BMKG).
- City level: air quality monitoring in big cities is conducted by environmental unit of local government (BPLHD).
- Daily air quality monitoring is also conducted in certain big cities.
- BMKG publishes air quality data on-line.
- BPLHDs in big cities broadcast daily air quality status in down town areas.
- BPLHDs publish air quality status annually as the part of environmental status report to the Ministry of Environment.

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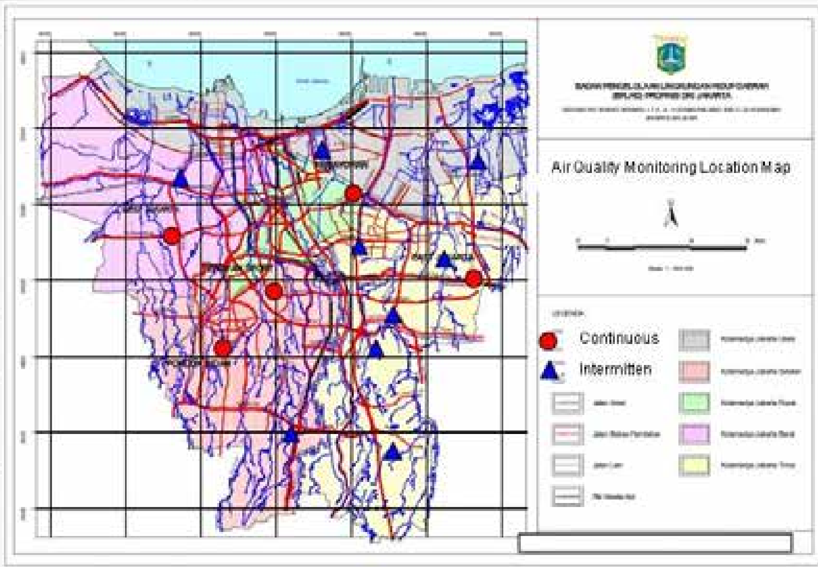
Monitoring and Research on Air Pollution

Air Quality Monitoring Stations in Jakarta



5 continuous stations representing:

1. settlement,
2. industrial areas,
3. business areas,
4. recreation areas,
5. mixed areas.

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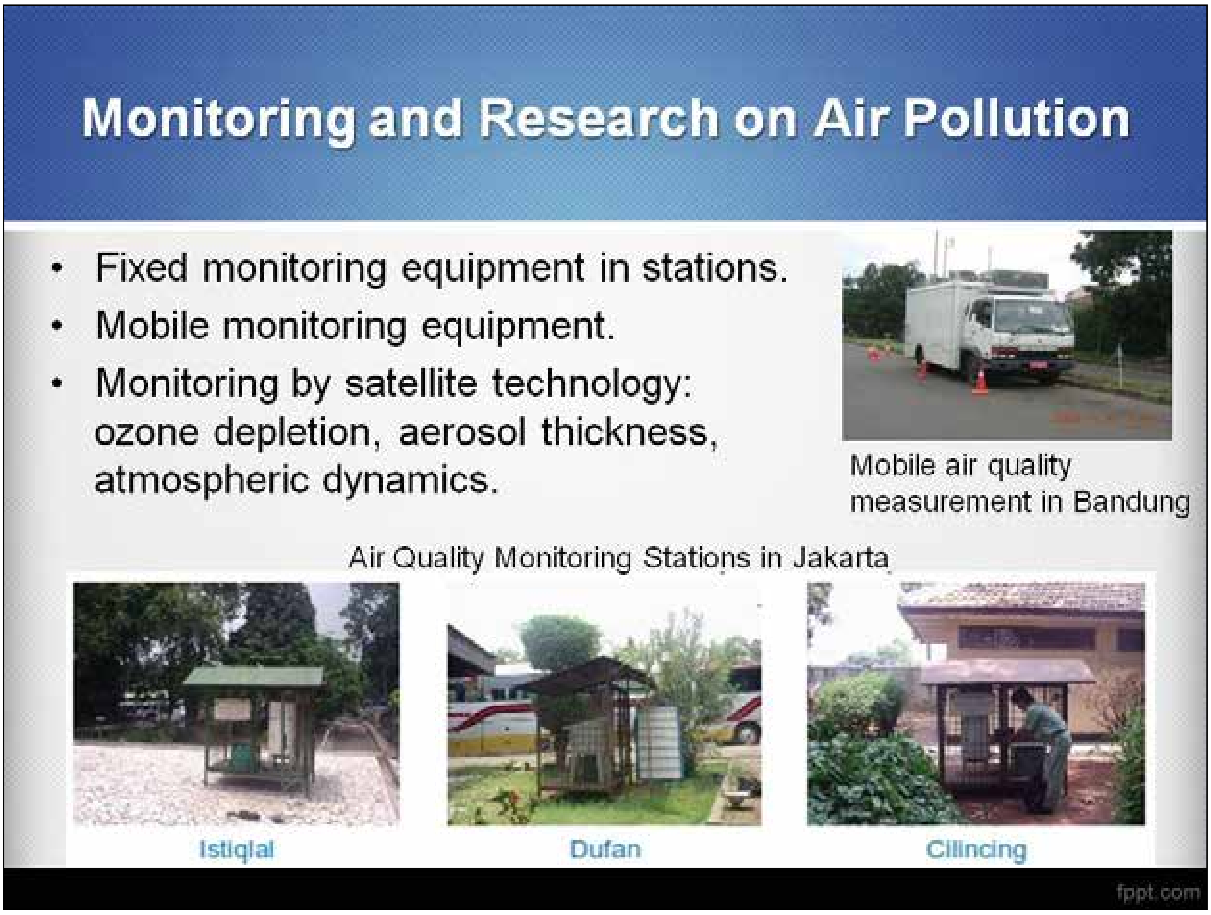
Monitoring and Research on Air Pollution
• Fixed monitoring equipment in stations.
• Mobile monitoring equipment.
• Monitoring by satellite technology: ozone depletion, aerosol thickness, atmospheric dynamics.
Mobile air quality measurement in Bandung
Air Quality Monitoring Stations in Jakarta
Istiqlal
Dufan
Cilincing
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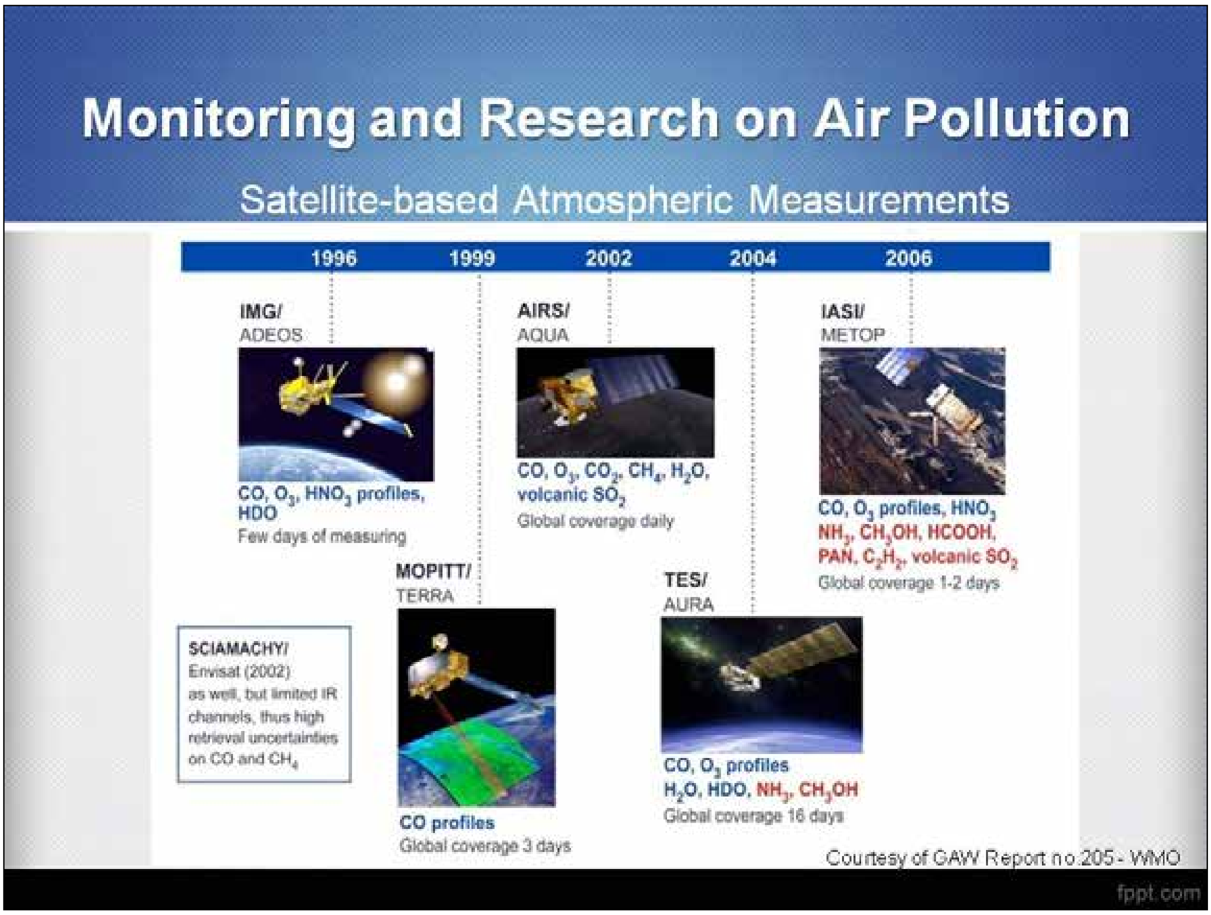
Monitoring and Research on Air Pollution
Satellite-based Atmospheric Measurements
1996
1999
2002
2004
2006
IMG/ ADEOS
CO, O_3, HNO_3 profiles, HDO
Few days of measuring
AIRS/ AQUA
CO, O_3, CO_2, CH_4, H_2O, volcanic SO_2
Global coverage daily
IASI/ METOP
CO, O_3 profiles, HNO_3 NH_3, CH_3OH, HCOOH, PAN, C_2H_2, volcanic SO_2
Global coverage 1-2 days
MOPITT/ TERRA
CO profiles
Global coverage 3 days
TES/ AURA
CO, O_3 profiles
H_2O, HDO, NH_3, CH_3OH
Global coverage 16 days
SCIAMACHY/ Envisat (2002) as well, but limited IR channels, thus high retrieval uncertainties on CO and CH_4
Courtesy of GAW Report no.205 - WMO
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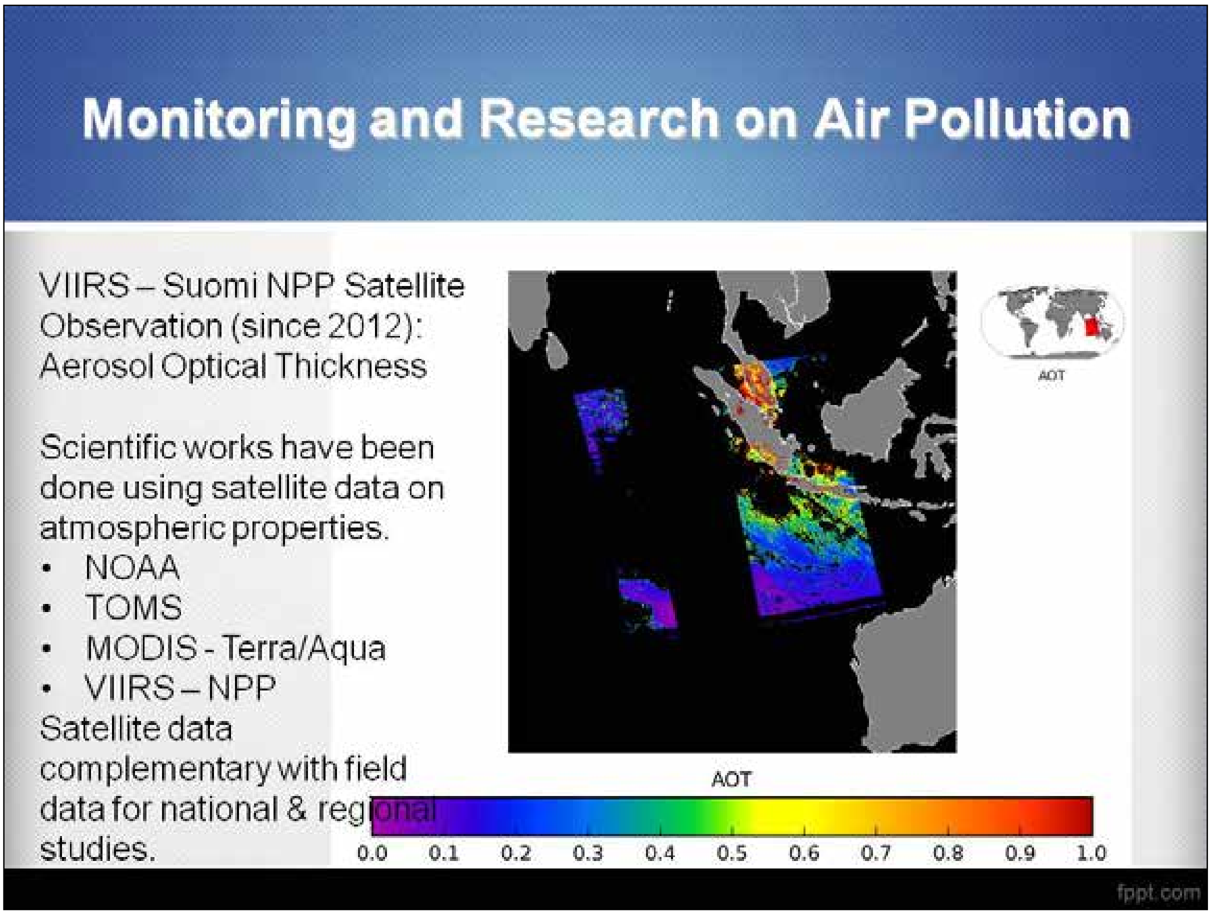
Monitoring and Research on Air Pollution
VIIRS – Suomi NPP Satellite Observation (since 2012): Aerosol Optical Thickness
Scientific works have been done using satellite data on atmospheric properties.
• NOAA
• TOMS
• MODIS - Terra/Aqua
• VIIRS – NPP
Satellite data complementary with field data for national & regional studies.
AOT
AOT
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
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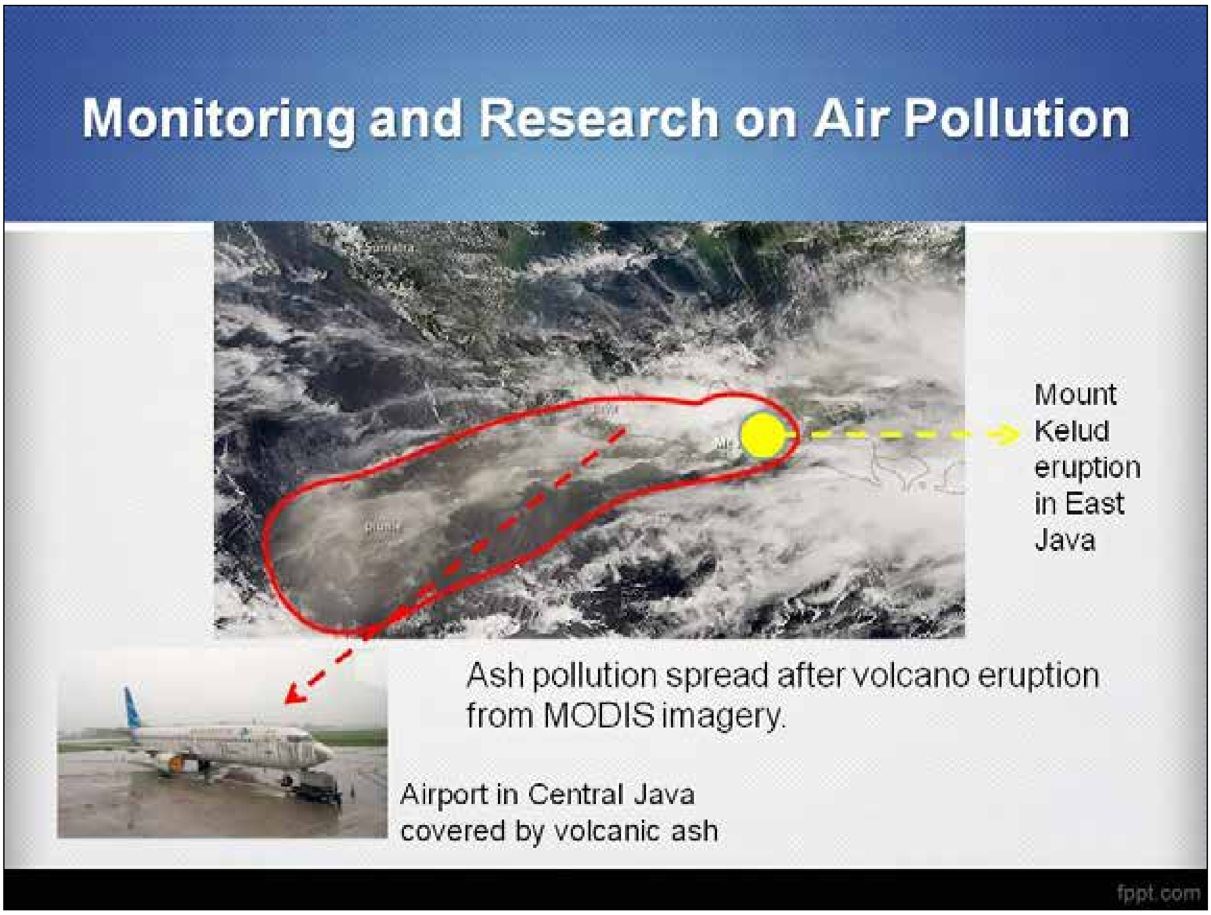
Monitoring and Research on Air Pollution
Mount Kelud eruption in East Java
Ash pollution spread after volcano eruption from MODIS imagery.
Airport in Central Java covered by volcanic ash
fppt.com

Monitoring and Research on Air Pollution

Air Quality Status under Blue Sky Program

•Air Quality Index (AQI) is an indicator of air quality determined by emission rate (CO & NOx) and fuel consumption. High AQI = Good air quality.

•AQIs in big cities of Indonesia in 2010 ranges between 0 and 96.18 (1)

•Highest AQIs:

Sulawesi → Gorontalo (96,18),

Molucca → Ambon (95,95), Ternate (94,29)

Sumatra → Tanjung Pinang (88,25) & Pangkal Pinang (86,94).

•Lowest AQIs (zero):

Java → Jakarta, Surabaya, Bandung, Semarang

Sumatra → Medan, Pekanbaru

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Linking Science – Technology - Policy in Air Pollution Control

- Basic science is needed to understand the mechanisms of pollutant production, distribution, and reduction.
- Based on basic science, technology development is required to produced suitable and proper equipment to monitor and reduce pollutants.
- A set of policies are needed to implement monitoring and reduction of pollutants.
- Linking science – technology – policy is essential to control air pollution.
- Involvement of private sectors and local people in air pollution reduction endeavors.

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Research Gaps and Needs

Research gaps & needs identified for air pollution control:

- Integration of various data sources (field and satellite-based).
- Data management and analysis.
- Low-cost & user friendly equipment and tools for air pollution monitoring, control, and reduction.
- Scientific understanding of standard measures and integrated approaches (science, economy, social, policy) → e.g. trade-off, Cost Benefit Analysis.
- Data/information, knowledge and technology know-how sharing/networking among countries in the region.
- Policy relevant research in effective and low cost methods to control and reduce air pollution.
- Capacity building for practitioners (companies) and local people in the implementation.
- Cooperation at national and regional levels are needed.

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Concluding Remarks

- Air pollution in urban areas has become serious problem to be addressed for decades.
- Technologies and scientific results have contributed to the air pollution control and monitoring.
- A set of regulations at different levels have been established to control air pollution.
- Linking science – technology – policy is important in addressing air pollution control.
- Some research gaps and needs have been identified, but regional and national initiatives and cooperation are required since air pollution could be cross-border phenomena.

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6.11 Air Pollution Control in Japan (Hidenori Niizawa)

International Expert Meeting on Air Pollution Control in Urban Asia-Pacific
Beijing Normal University Zhuhai International Center
Zhuhai, China, 27 – 29 October 2014

Air Pollution Control in Japan

Hidenori Niizawa
School of Economics
Hyogo Institute of Environmental Economic Research
University of Hyogo

Outline

- A lesson from our experience
- Development of air pollution control from large stationary sources in Japan
- Possibility of emissions trading for local air pollution control
- Local air pollution control and transboundary air pollution

2

An important lesson from our experience

Avoidance of small amount of expenditure of pollution control resulted in huge amount of social cost.

3

Air pollution control in Japan

before the Law

emission standards of concentration such as mg per m^3 (ppm)

1967 Fundamental Law of Pollution Control

established environment quality (ambient) standards

1968 Air Pollution Control Law

established “the K value regulation”

1974 amendment of the Air Pollution Control Law

introduced “total mass standard”

4

The K value regulation (SOx)

- $Q = K \times H^2$.
- Q : emission standard (m^3 per hour)
- H : effective stack height which includes updraft height of smoke (m)
- K : a regional factor determined by a prefectural governor
- Each prefecture is divided into areas based on pollution level. Each area has different K value. The smallest K value is applied on the most polluted areas.
- The K was tightened every year from 1968 to 1976. The smallest K for existing sources in the most polluted areas was tightened from 20.4 to 3.0 during the period.
- More stringent K value is applied on the new sources in the designated most polluted area.
- This K value regulation produced higher stacks and diffused pollution in wider areas.
- The K value regulation is still implemented today.

5

Total mass standard 1

- $Q = aW^b$
- Q : mass emission standard (m^3 per hour)
- W : predetermined maximum fuel consumption (liters per hour)
- a and b ($0.8 \leq b < 1$) : regional factors determined by a prefectural governor
  - In case of the most polluted area in Osaka Prefecture, a is 2.0, b is 0.85.
- Emissions from the plants are monitored continuously.

6

Total mass standard 2

- The mass emission standard of SOx is applied in 24 designated urban areas where the environmental standard could not be achieved with K value regulation.
- Small plants in those designated areas are not covered by the mass standard. The small plants are regulated by sulfur content (% of weight) of fuel.

7

Total mass standard 3

- The mass emission standard of SOx was adopted for both existing sources that were operating before October 1, 1977 and for new sources that began operating after that date, although the standard was tighter for new sources than for existing sources.
- In case of Osaka prefecture, the mass standard on new sources is 0.3 times of that on existing sources. Governors can decide it.

8

Total mass standard 4

- The mass emission standard is imposed on a large plant where multiple emission sources of a company are located.
- Therefore it is allowed to adjust emissions among sources of a plant if their total emissions is below the standard although K value regulation is applied on each source. This adjustment is called internal "bubble" in US.

9

Total (?) mass standard 5

- The mass emission standard is based on a predetermined maximum fuel consumption *W* (liters per hour). That is, the maximum amount of emissions from a plant is fixed in the short run.
- However, the amount of fuel consumption can be increased in the long run when a source is modified or a new source is built at the plant. The introduction of new sources at new plants is also allowed. There is no requirement to offset those increases in emissions.

10

Total (?) mass standard 6

- It cannot control the total mass of SOx.
  - The naming by regulators showed their wishful thinking.
  - There was intent to allocate total allowable amount of a pollutant in an environment to each source. But it could not be achieved by this regulation method!
  - *Real* total mass control which does not allow to increase *W* in the long run was so inflexible that it was not possible to implement unless *Q* could be traded.

11

- The same mass control is adopted for NOx in three designated areas of Tokyo, Kanagawa and Osaka.

12

Complemental policies

- Subsidies
- Location Control
- Desulfurization of Fuel Oil
- Introduction of LNG
- Local Governments with reformist local governors or mayors
  - pollution control agreements with individual plants since1964: more than 3000 PCAs today
  - All prefectures had established the ordinances of pollution control until 1971. They impose tighter regulation than Laws do and impose regulation on substances or sources which are not covered by Laws.

13

Multilevel governance

	level of government	authority	
Law (1968 -)	national	approval of the Diet	uniform minimum regulation
Ordinance (1969 -)	prefectures and cities	approval of the local assembly, 1970 amendment of Air Pollution Control Law	tighter than Law, wider coverage than Law, differentiated regulation,
Pollution control agreement (1964 -)	cities	w/o approval of the local assembly	tailored to individual plants

14

External factors

- Oil price rises
  - reduced the share of oil and increased the share of LNG and nuclear as primary energy sources
  - motivated energy saving investments which reduced SOx and NOx and induced structural changes in industry from oil intensive and pollution intensive industries
- Strength of the Yen
  - disadvantaged exporting industries
- Economic growth of NIES
  - led to changes in industrial structure

15

Total mass in an environment can be controlled by emissions trading

- A predetermined amount of allowance in an environment are issued and allocated for sources.
- Allow trade among sources.
  - A existing source who wants to increase their emission can buy allowance.
  - A new source who wants to locate in the environment can buy allowance.
  - Existing sources will reduce their emission when the price of allowance increased.

16

Trans-boundary pollution

- The 1979 Convention on Long-range Trans-boundary Air Pollution
  - The 1985 Protocol on the Reduction of Sulphur Emissions or their Trans-boundary Fluxes by at least 30 per cent
  - The 1994 Oslo Protocol on Further Reduction of Sulfur Emissions
  -

17

The treaty codifies non-cooperative behavior

Murdoch, Sandler, and Sargent (1997)

"once a majority of nations can meet a given standard of reductions, the treaty is drafted and subsequently approved as others catch up. For many participants, the cutbacks already achieved served as a blueprint for the treaty stipulations"

18

Local air pollution control and trans-boundary air pollution

- Common origin
- Control of local air pollution reduces trans-boundary pollution, too.

19

Thank you

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20

6.12 Aerosols in Urban Air of Asia-Pacific Region of Russia (Anton Uspenski)

The Report «Aerosols in Urban Air of Asian-Pacific Region of Russia »

PhD student Uspenski Anton

VOEIKOV MAIN GEOPHYSICAL OBSERVATORY
Saint-Petersburg,Russia

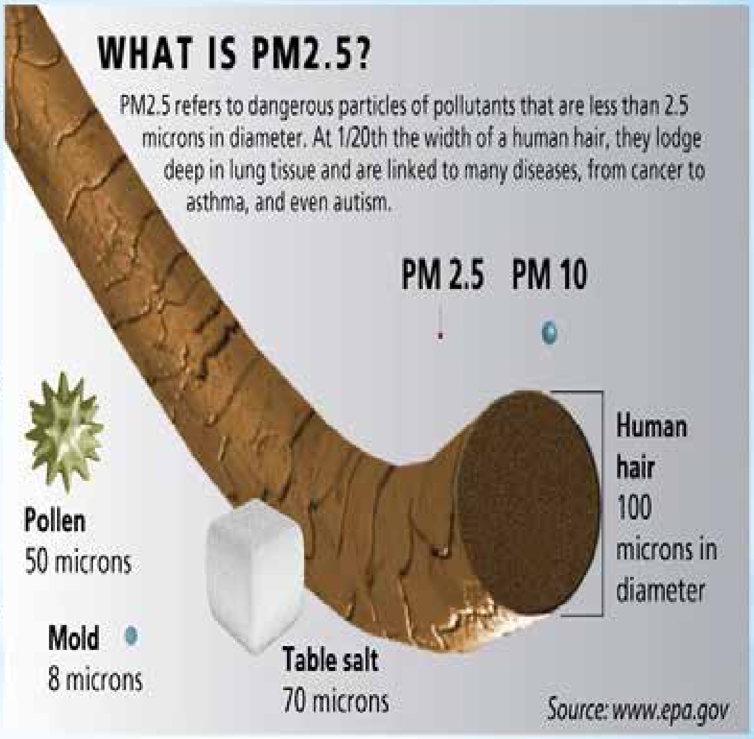
This report describes analysis of particulate matter's pollution from 2007 to 2013 year in Russian urban air of Asian-Pacific Region.In this report I dwell on aerosol's pollution, including dust fractions PM10 PM2.5 and especially on pollution of black carbon. The paper presents an estimate of emission source influence on particulate matter concentrations in some cities. Also I'm going to present you information on contents of metals in ambient air of this area. Besides, this report contains results of my scientifical work since 2012 year

Particle pollution (also called particulate matter or PM) is the term for a mixture of solid particles and liquid droplets found in the air. Some particles, such as dust, dirt, soot, or smoke, are large or dark enough to be seen with the naked eye. Others are so small they can only be detected using an electron microscope. Particle pollution includes "inhalable coarse particles," with diameters larger than 2.5 micrometers and smaller than 10 micrometers and "fine particles," with diameters that are 2.5 micrometers and smaller. How small is 2.5 micrometers? Think about a single hair from your head. The average human hair is about 70 micrometers in diameter – making it 30 times larger than the largest fine particle.

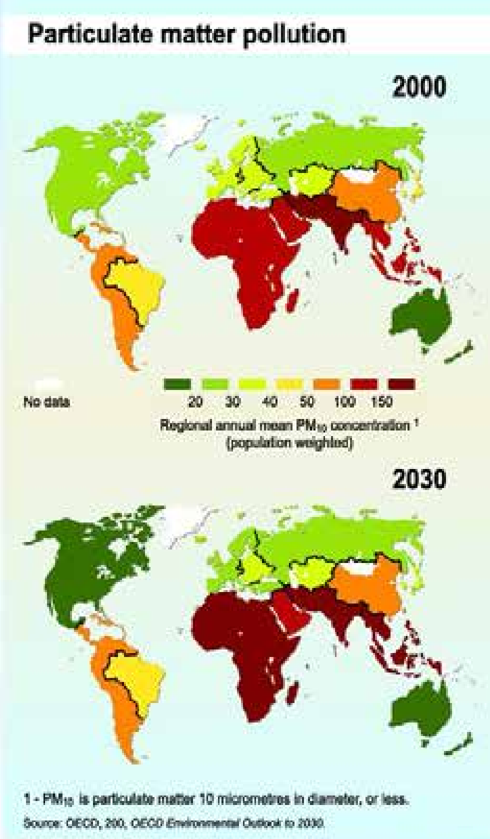
These particles come in many sizes and shapes and can be made up of hundreds of different chemicals. Some particles, known as *primary particles* are emitted directly from a source, such as construction sites, unpaved roads, fields, smokestacks or fires. Others form in complicated reactions in the atmosphere of chemicals such as sulfur dioxides and nitrogen oxides that are emitted from power plants, industries and automobiles. These particles, known as *secondary particles*, make up most of the fine particle pollution in the country.(Environmental Protection Agency)

http://www.epa.gov/pm/basic.html

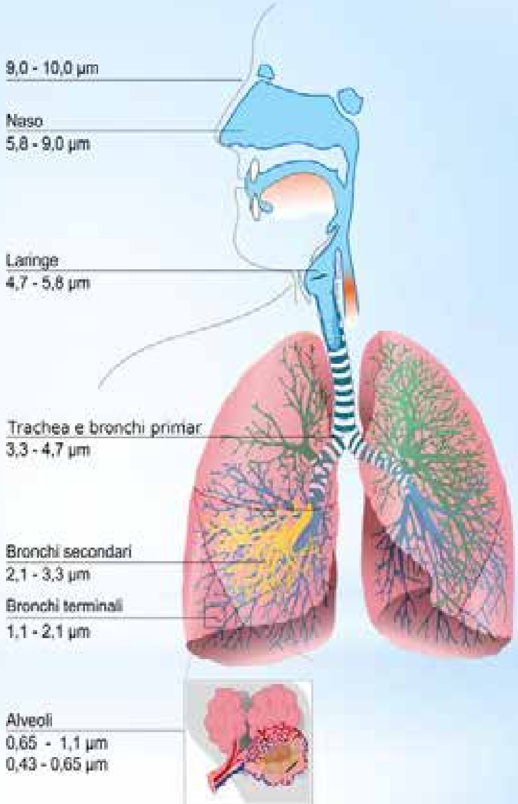
There are things floating around in the air. Most of them, you cannot even see. They are a kind of air pollution called particles or particulate matter. In fact, particulate matter may be the air pollutant that most commonly affects people's health. The big particles are between 2.5 and 10 micrometers (from about 25 to 100 times thinner than a human hair). These particles are called PM10 (we say "P M ten", which stands for Particulate Matter up to 10 micrometers in size). These particles cause less severe health effects [http://www.epa.gov/pm/basic.html] EPA



2 comparable maps showing current (2000) and projected (2030) PM10 regional concentrations (population weighted). (European Environment Agency)
www.eea.europa.eu



Sampling dust and particulate matter is important as dust and particulate matter can affect the health of human populations, as well as the natural environment. Dust and particulate matter can cause respiratory problems when breathed in by humans. Dust and particulates above 10 micrometer (PM10) are filtered and generally do not enter the lungs. Dust and particulates below PM10 are likely to enter the lungs. Dust and particulate matter that is smaller than 2.5 micrometers (PM2.5) can enter into the Alveoli where gas exchange occurs. This PM2.5 is more dangerous as it can affect the exchange of gases within the lungs and even penetrate the lung into the blood stream and cause other health issues. (Environmental Monitoring Solutions)
www.ecotech.com.au



Coarse Particles (PM10)

- smoke, dirt and dust

from factories, farming, and roads

- mold, spores, and pollen

crushing and grinding rocks and soil

then blown by wind

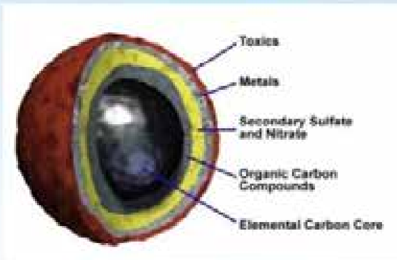
Fine Particles (PM2.5)

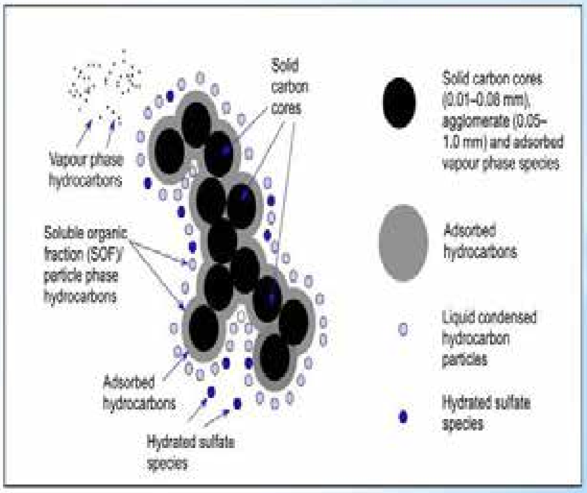
- toxic organic compounds
- heavy metals
- driving automobiles
- burning plants (brush fires and forest fires or yard waste)
- smelting (purifying) and processing metals

* The smaller particles are lighter and they stay in the air longer and travel farther. PM10 (big)particles can stay in the air for minutes or hours while PM2.5 (small) particles can stay in the air for days or weeks. And travel? PM10 particles can travel as little as a hundred yards or as much as30 miles. PM2.5 particles go even farther; many hundreds of miles

Carbon black can form as an air-polluting particle when fuels (like gasoline, diesel fuel and coal) are not completely burned. These carbon black particles are often coated with other chemicals making them more hazardous than commercially produced pure carbon black. The particle coatings may include "polyaromatic hydrocarbons," also called PAHs If it stays in the lungs, the condition may lead to bronchitis and eventually to a chronic condition called "obstructive pulmonary disease. Animal studies suggest long-term exposure to very high doses of pure carbon black may increase a person's risk of cancer.

Carbon black that comes from incomplete burning of hydrocarbons is more likely to contain cancer causing chemicals than pure carbon black.(WISCONSIN DEPARTMENT OF HEALTH SERVICES Carbon Black , Also known as: Lamp black, Furnace black, Thermal black, Channel black Chemical reference number (CAS): 1333-86-4)





BUT... BC absorbs sunlight extremely efficiently:

1 g of BC absorbs as much as ~10 umbrellas!

truck: EF=10 g/kg → 1 umbrella/100 m

Terminology

Black carbon (BC) is a solid form of mostly pure carbon that absorbs solar radiation (light) at all wavelengths. BC is the most effective form of PM, by mass, at absorbing solar energy, and is produced by incomplete combustion.

Organic carbon (OC) generally refers to the mix of compounds containing carbon bound with other elements like hydrogen or oxygen. OC may be a product of incomplete combustion, or formed through the oxidation of VOCs in the atmosphere.[1] Both primary and secondary OC possess radiative properties that fall along a continuum from light-absorbing to light-scattering.

Brown carbon (BrC) refers to a class of OC compounds that absorb ultraviolet (UV) and visible solar radiation. Like BC, BrC is a product of incomplete combustion.[3]

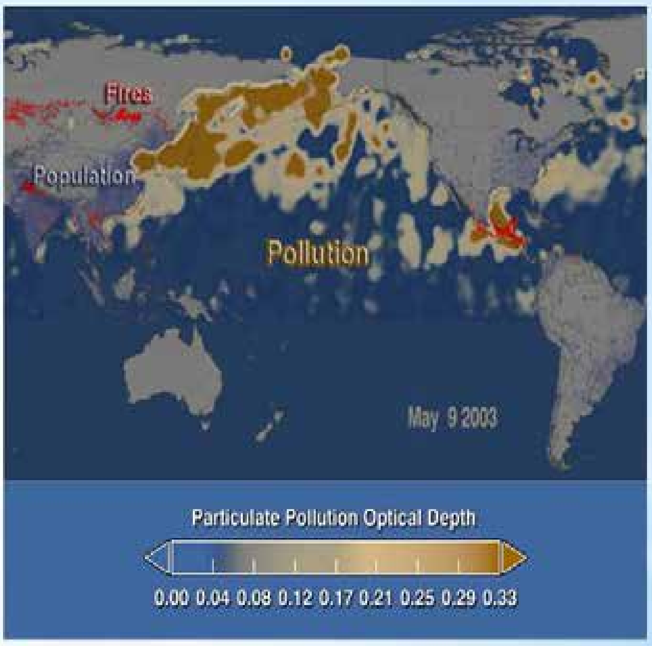
Carbonaceous PM includes BC and OC. Primary combustion particles are largely composed of these materials.

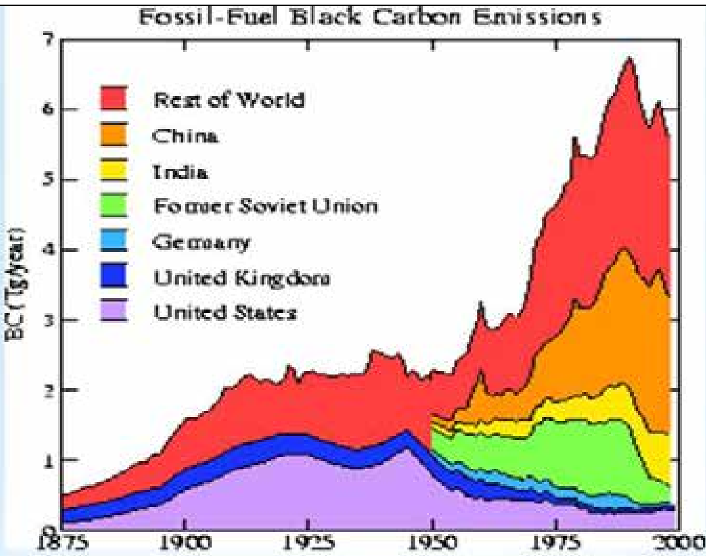
Light absorbing carbon (LAC) consists of BC plus BrC.

Soot, a complex mixture of mostly BC and OC, is the primary light-absorbing pollutant emitted by the incomplete combustion of fossil fuels, biofuels, and biomass.

In a new NASA study, researchers taking advantage of improvements in satellite sensor capabilities offer the first measurement-based estimate of the amount of pollution from East Asian forest fires, urban exhaust, and industrial production that makes its way to western North America. This image generated by data from NASA's instrument called MODIS (Moderate Resolution Imaging Spectroradiometer) onboard the Terra satellite In this picture, heavy aerosol concentrations appear in shades of brown, with darker shades representing greater concentrations. Areas lined in black on the land surface represent human population

http://www.nasa.gov/topics/earth/features/pollution_measure_prt.htm





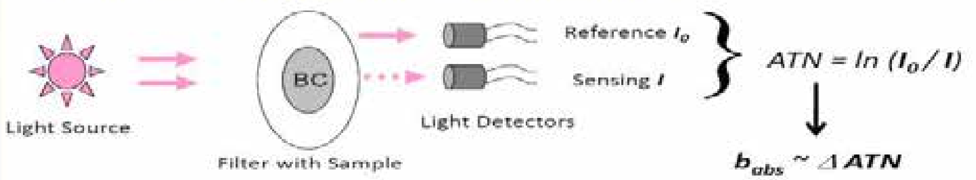
* Estimated fossil-fuel BC emissions" Novakov (2003) http://ramanathan.ucsd.edu/files/pr127.pdf.

* Throughout the course or duration since 2012 till 2014 i used Aethalometer Ae-33 and DustTruck(TSI) for determination of particulate matter and black carbon concentration's. A **patent pending** method(DustTruck) to simultaneously measure size segregated mass fraction concentra-tions (PM1, PM2.5, Respirable/PM4, PM10/Thoracic, and TPM) over a wide concentration range (0.001-150 mg/m3) in real time. This method combines a photometric measurement to cover the mass concentration range and a single particle detection measurement to be able to size discriminate the sampled aerosol(www.tsi.com). The optical method that use in Aethalometer is a measurement of the attenuation of a beam of light transmitted through the sample when collected on a fibrous filter. When calculated as shown, this quantity is linearly proportional to the amount of BC in the filter deposit.

$$ATN = 100 * \ln (Io / I)$$

Define Io as the intensity of light transmitted through the original filter, or through a blank portion of the filter: define I as the intensity of light transmitted through the portion of the filter on which the aerosol deposit is collected. (Aethalometer Book A.D.A.Hansen)

Analytical Instrument : Aethalometer™



- Collect sample **continuously**.
- ***Optical absorption*** ~ change in ATN.
- Measure optical absorption continuously : λ = 370 to 950 nm.
- Convert ***optical absorption*** to ***concentration of BC:***

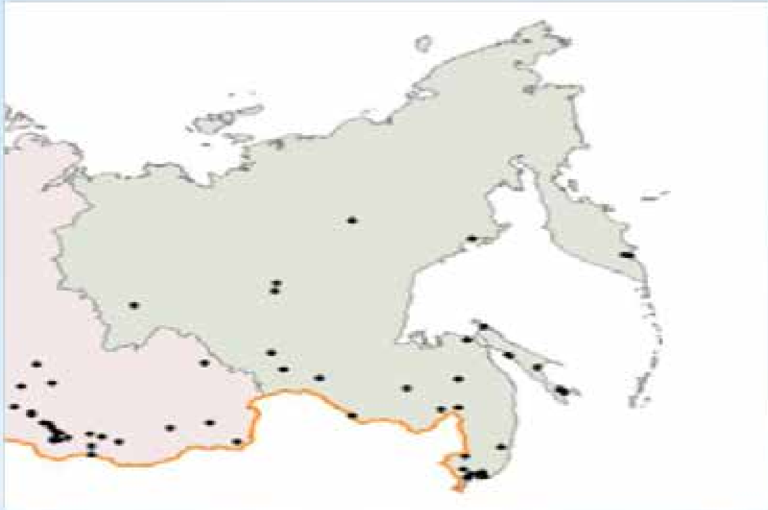
$$BC\ (t) = b(t)\ /\ \sigma$$

- Real-time data: **5 minutes**
  - *Dynamical, real-time measurement, updated each period*

9

Mocnik - Aethalometer Measurement Black Carbon

Method used for determination of total suspended particles is gravimetric Presently used method of determining the concentration of soot in the air has a significant element of uncertainty and needs to be replaced. Currently, is develored a new method of determination the carbonaceous aerosol in the atmosphere . The method includes the steps of: sampling filter, the filter dissolution in solvent, a photometric determination of the concentration of particles in suspension. This method was compared with the data aetalometer(24 h sampling) and convergence was 20%



* Monitoring stations in Asian-Pacific Region of Russia, which measures particulate matter and other compounds in a territiry of

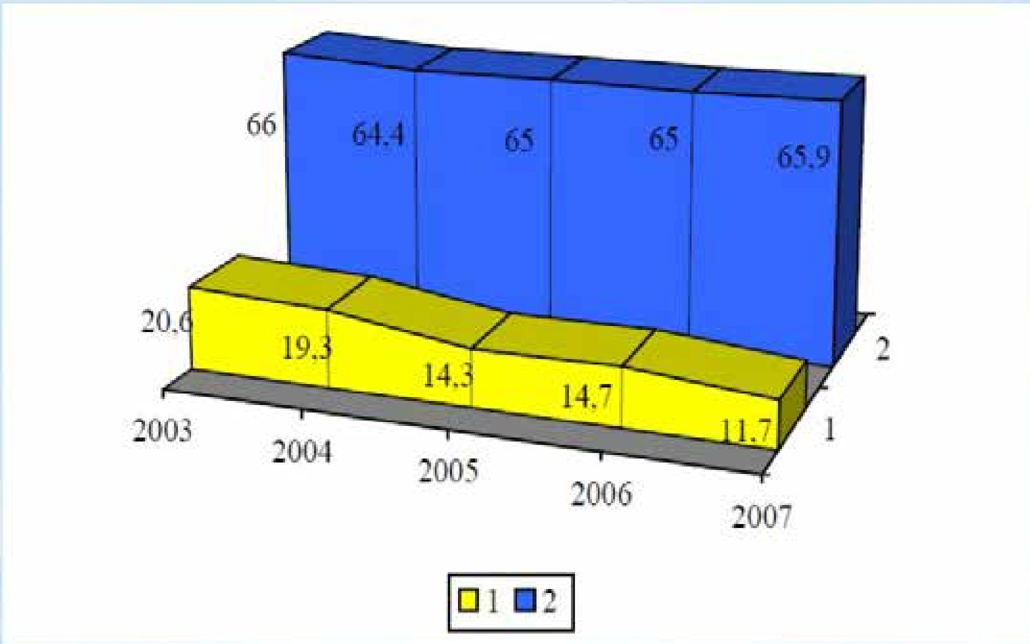
In there are maximum allowable concentration

collected during 20 min

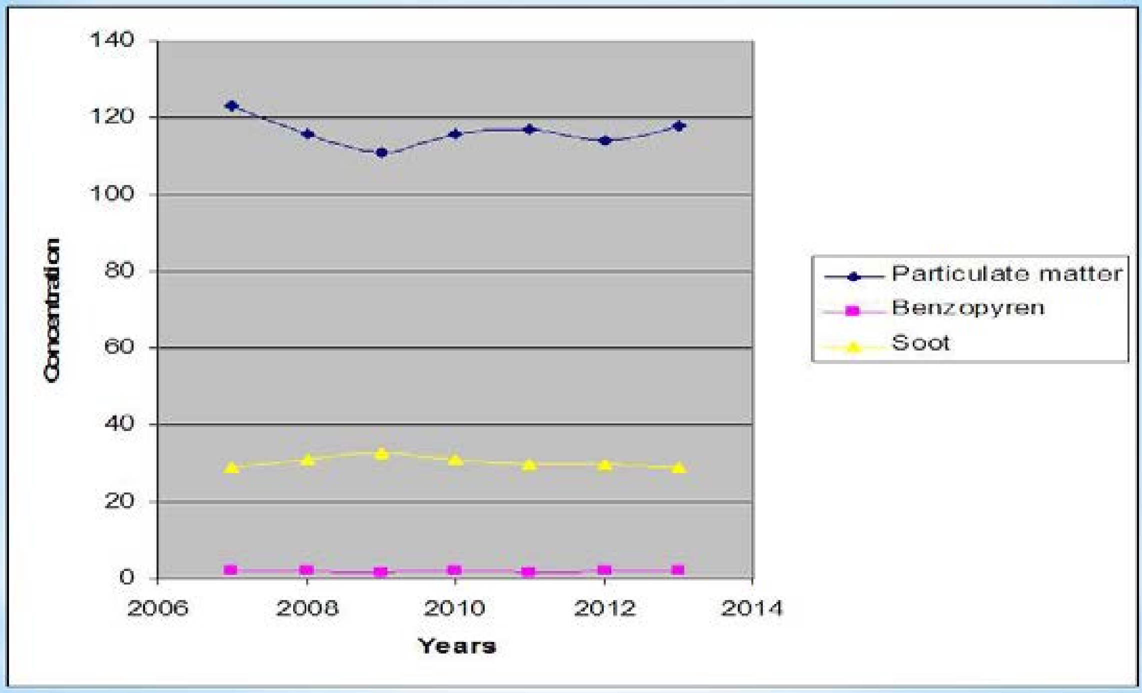
- Total Suspended Particles 500 mcg/m3
- PM10 300 mcg/m3
- PM2.5 160 mcg/m3
- soot 150 mcg/m3

collected during 24 h

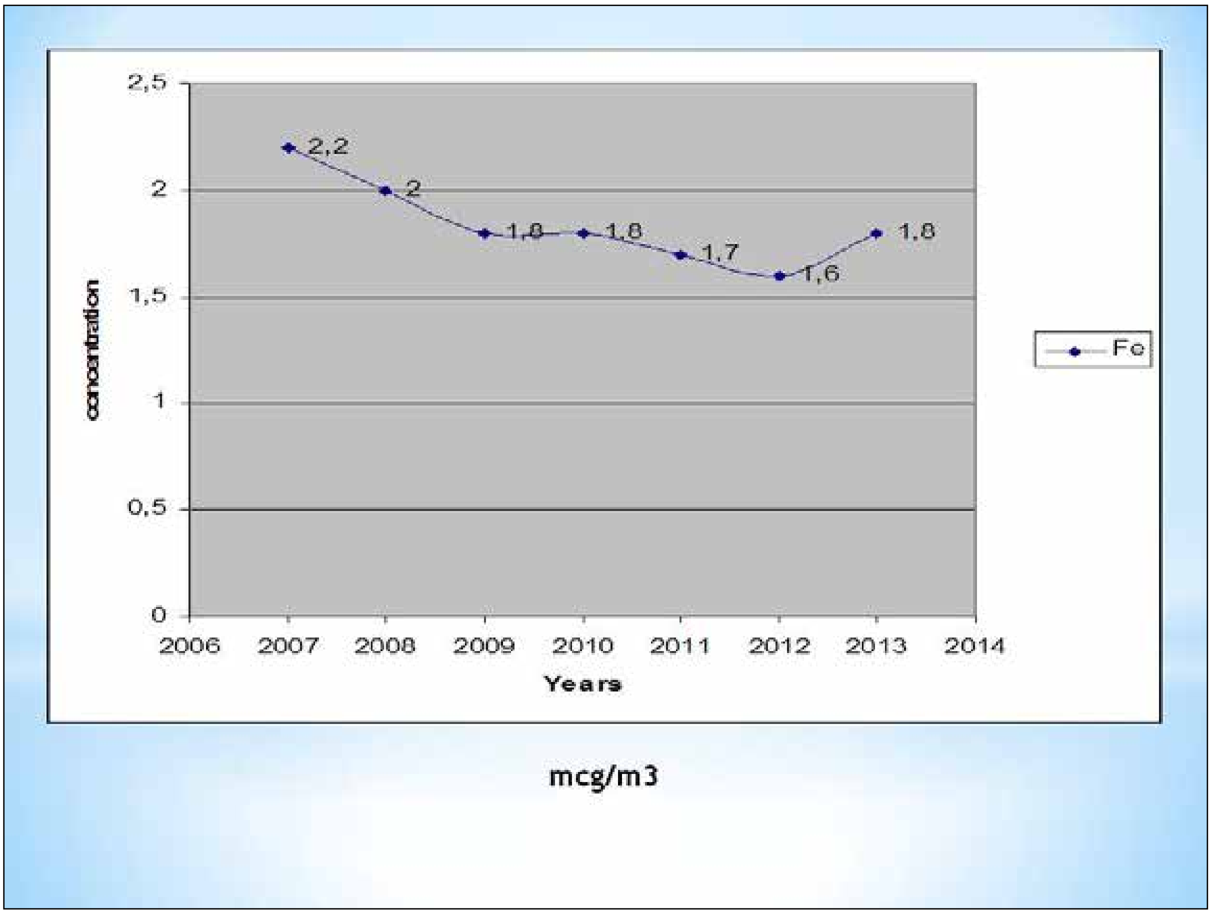
- Total Suspended Particles 150 mcg/m3
- soot 50 mcg/m3
- benzopyren 0.001 mcg/m3



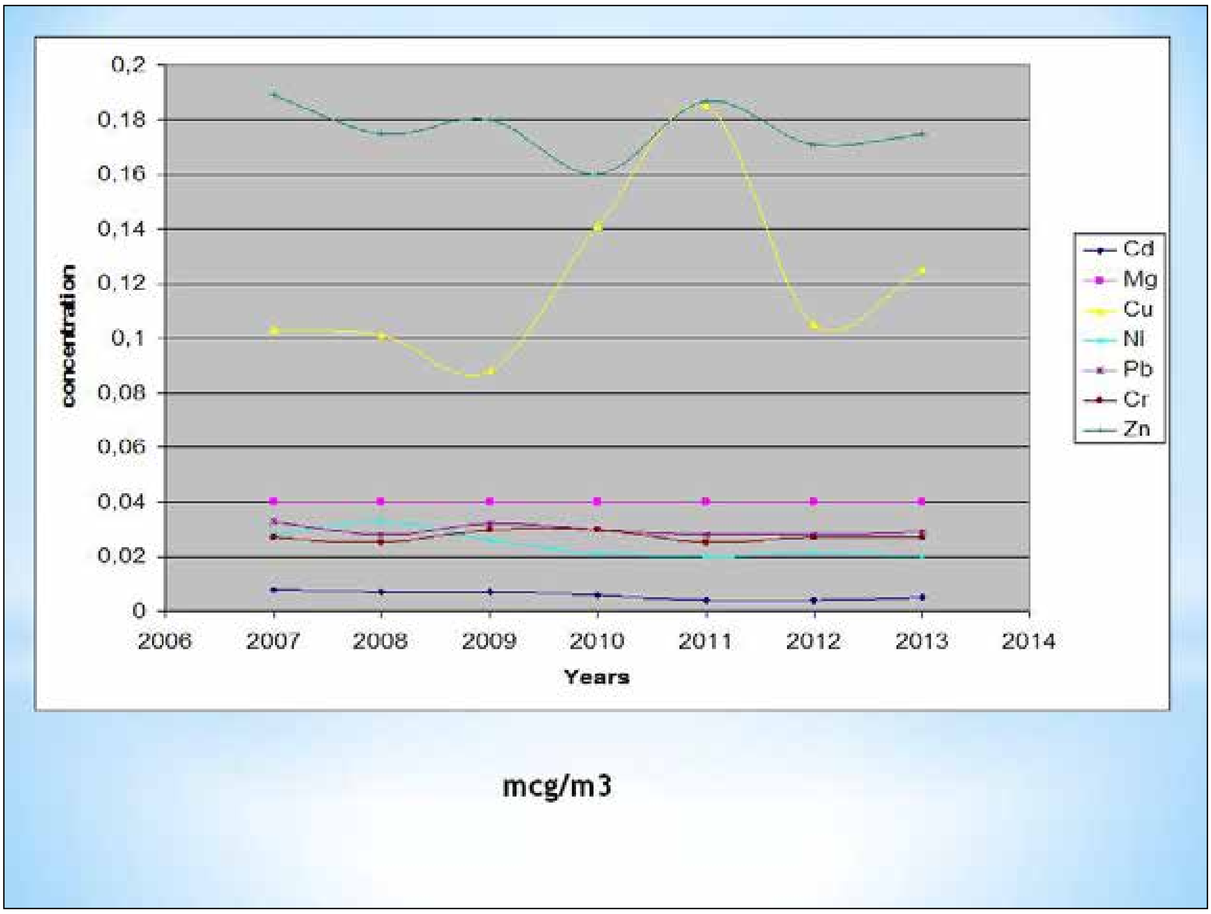
* Colored yellow shows amount of people living in areas where concentration of particulate matter higher than 10 MAC.Colored blue shows amount of people living in areas where concentration of particulate matter higher than 1 MAC



mcg/m3

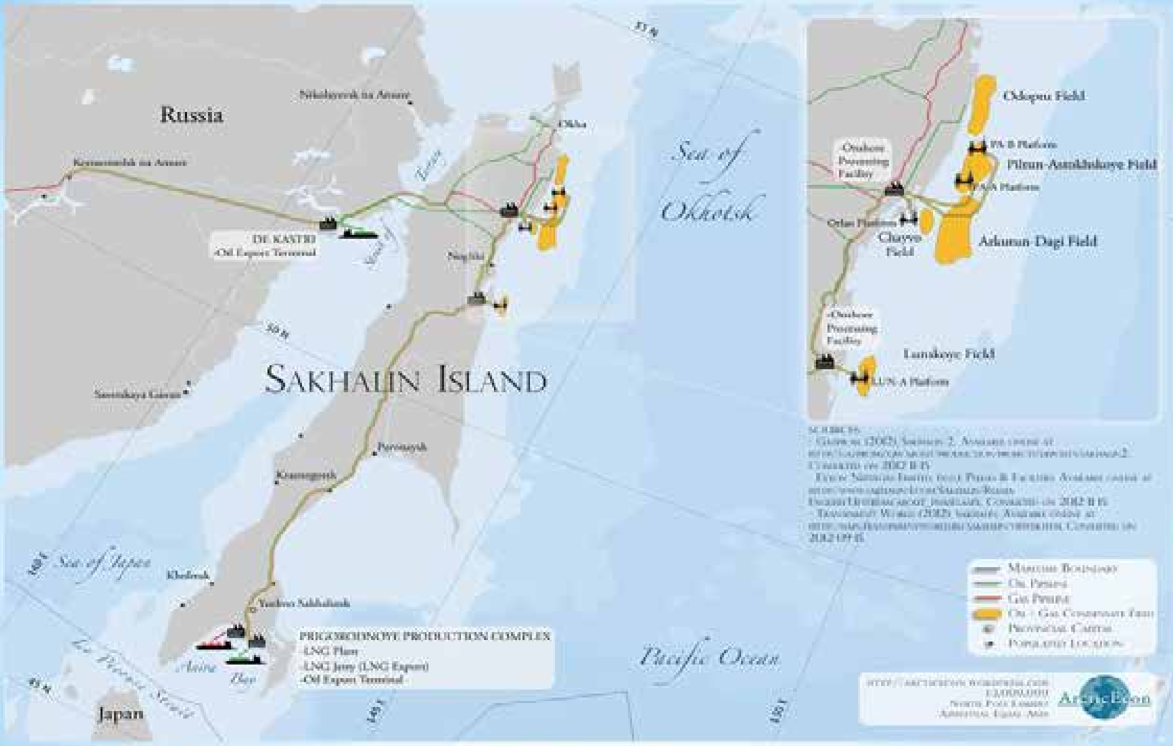


2,5
2
1,5
1
0,5
0
concentration
2,2
2
1,8
1,8
1,7
1,6
1,8
Fe
2006
2007
2008
2009
2010
2011
2012
2013
2014
Years
mcg/m3



0,2
0,18
0,16
0,14
0,12
0,1
0,08
0,06
0,04
0,02
0
concentration
Cd
Mg
Cu
Ni
Pb
Cr
Zn
2006
2007
2008
2009
2010
2011
2012
2013
2014
Years
mcg/m3

Vladiwostok – big industrial centre, situated in east on shore of Japanese sea. Population 616 thousands of people. There are port, railstation, airport, combined heat and power plants Climate- moderately moist. Vladiwostok zone of high potential of pollution.
There are cases of excess MAC of particulate matter and benzopyrene throughout the year.
6 monitornig stations.
Particulate matter – 20 thousands of tons per year. Density of emissions- 32 kg per one people, 36 tons per square km.



* Currently a growing problem in this region is the high concentration of particulate matter and soot particles . There are cases of excess concentration of the value of 17 MAC

- Sakhalin II Project, one of the largest integrated oil and gas projects in the world, located on- and off-shore of Sakhalin Island in the Russian Far East. Community members living just 1.2 kilometers away from a liquefied natural gas ("LNG") plant and LNG and oil export terminals known as the Prigorodnoye Production Complex (the "Complex") have suffered from exposure to harmful pollutants, threats to community safety and food security, and the loss of local environmental resources http://www.accountabilitycounsel.org/communities/current-cases/oil-and-gas-development-sakhalin-island-russia-2/

Thanks For Attention!

6.13 Implications of energy trade on green house gases emission and air pollution (Wenping Yuan)

APN INTERNATIONAL EXPERT MEETING ON
AIR POLLUTION CONTROL IN URBAN ASIA-PACIFIC

ESPRE 北京师范大学
地表过程与资源生态国家重点实验室
State Key Laboratory of Earth Surface Processes and Resource Ecology

Implications of energy trade on green house gases emission and air pollution

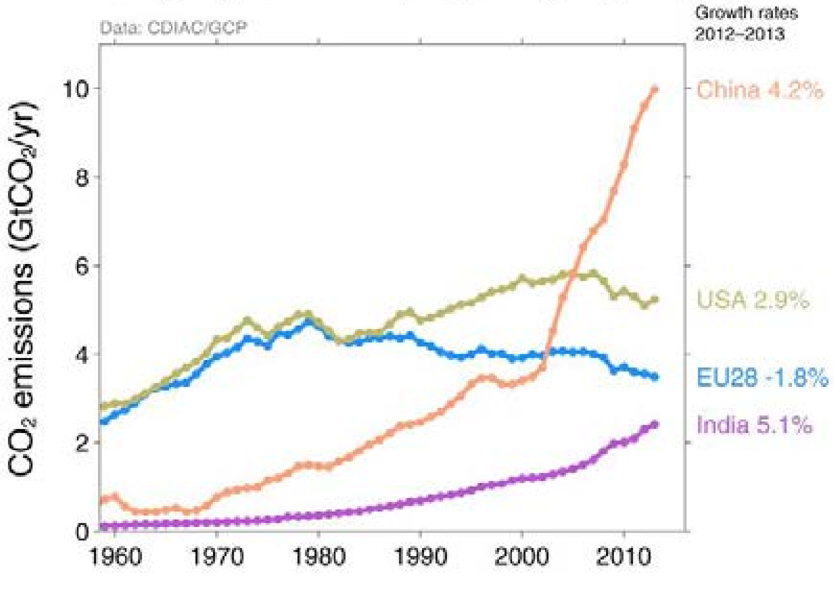
Wenping Yuan, Wenjie Dong

Beijing Normal University

2014. 10. 27, Zhuhai, China

Top Fossil Fuel Emitters (Absolute)

The top four emitters in 2013 covered 58% of global emissions
China (28%), United States (14%), EU28 (10%), India (7%)



Bunkers fuel used for international transport is 3% of global emissions
Statistical differences between the global estimates and sum of national totals is 3% of global emissions
Source: CDIAC; Le Quéré et al 2014; Global Carbon Budget 2014

Dangerous Breathing

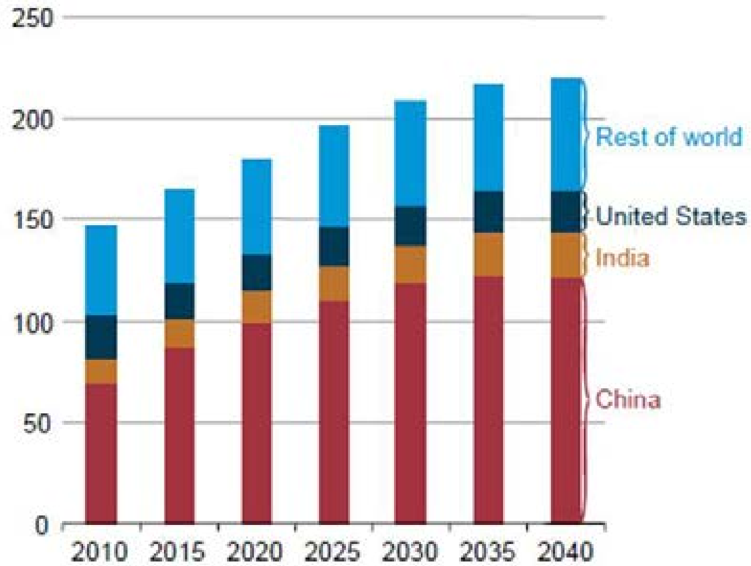
- In 2013, 92% of Chinese cities failed to meet national ambient air-quality standards
- Three major megalopolis (Yangtze River Delta, Pearl River Delta and Beijing–Tianjin–Hebei) suffered more than 100 days with PM2.5 concentrations at least twice the WHO maximum exposure guidelines

Dangerous Breathing

- In 2007, the World Bank, working with the Chinese government, estimated that the cost of outdoor air and water pollution to China's economy around US$100 billion annually, or 5.8% of China's GDP

World Coal Consumption by Country Grouping

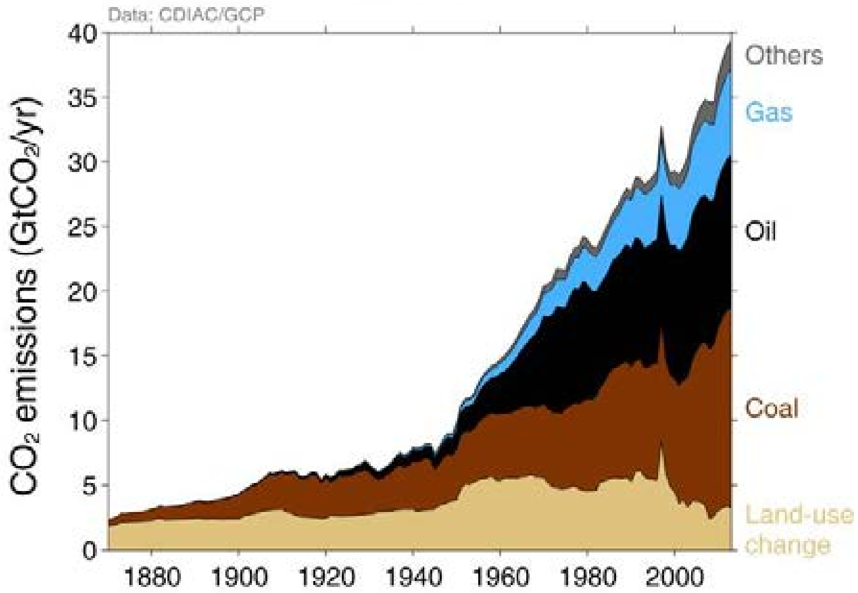
Coal consumption is dominated by China (47 percent), the United States (14 percent), and India (9 percent), with those three countries together accounting for 70 percent of total world coal consumption in 2010.



The International Energy Outlook 2013 was prepared by the U.S. Energy Information Administration (EIA)

Total Global Emissions by Source

Since 1950, coal consumption was the dominant source of annual CO_2 emission.

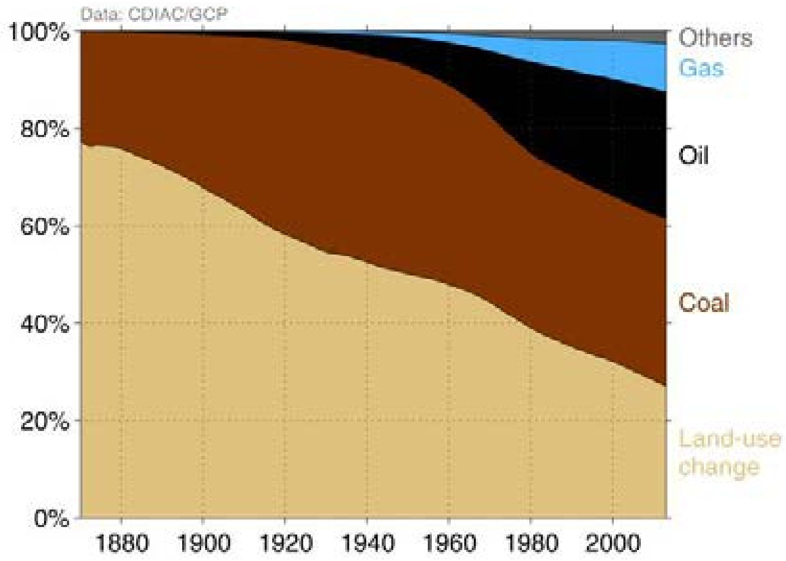


Others: Emissions from cement production and gas flaring

Source: CDIAC; Houghton et al 2012; Giglio et al 2013; Le Quéré et al 2014; Global Carbon Budget 2014

Historical Cumulative Emissions by Source

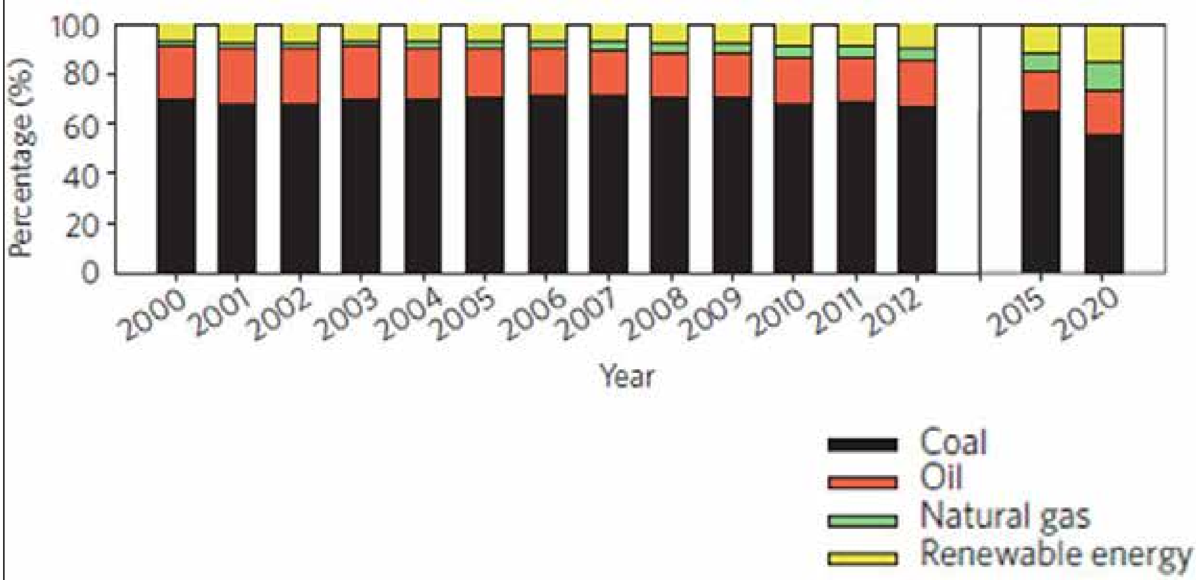
In 2013, coal represents the largest contribution to cumulative GHGs emissions (35%)



Others: Emissions from cement production and gas flaring

Source: CDIAC; Houghton et al 2012; Giglio et al 2013; Le Quéré et al 2014; Global Carbon Budget 2014

Total Energy Consumption in China by Type

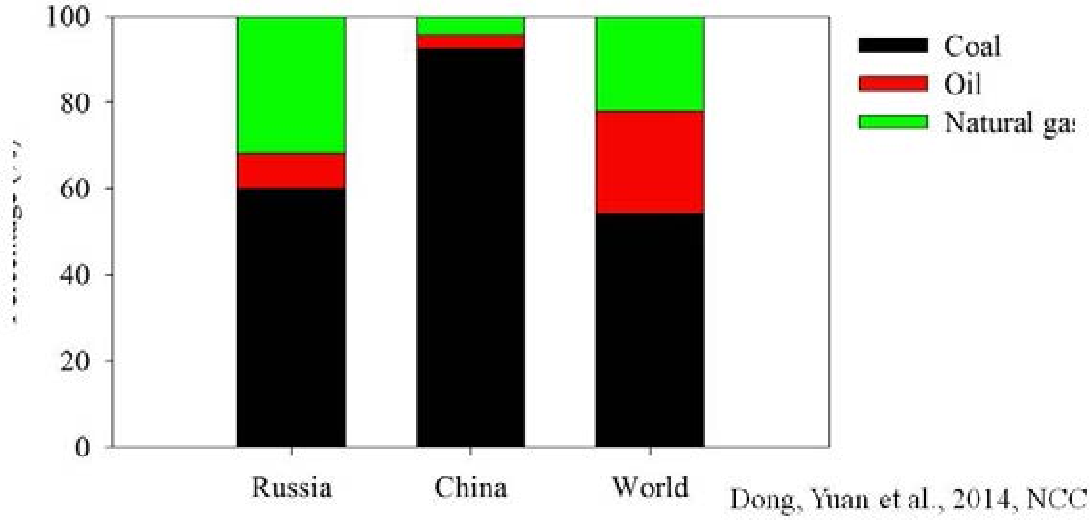


Actions of Government

- In 2009, China's State Council announced that the country will cut the carbon intensity — carbon emissions per unit of gross domestic product (GDP) — by 40–45% from 2005 levels by 2020, and this target is included in the long-term planning of China's socioeconomic development.
- Last September, China's State Council released an Airborne Pollution Prevention and Control Action Plan pledging the Chinese government to make significant reductions in coal consumption.

Energy Resources in China

Much criticism is aimed at China for being the largest consumer of coal in the world, but it is apparent that its large coal consumption was predetermined by its fossil energy resources structure.

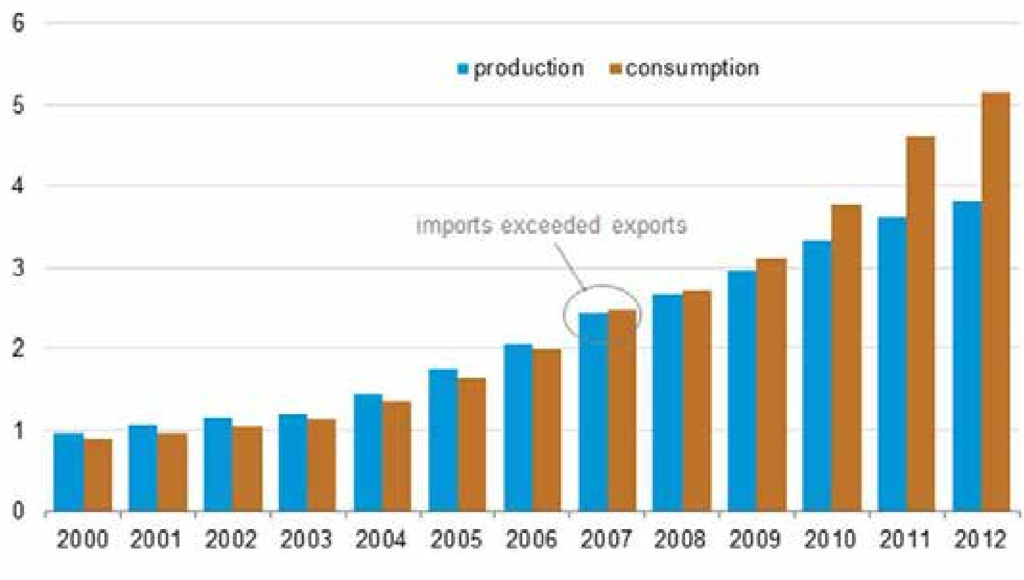


Dong, Yuan et al., 2014, NCC

Energy Trade

- Energy trade will play a critical role in improving the energy structure
- Natural gas is one of the best choices as an alternative energy to replace coal
- Emissions of CO_2 and SO_2 from coal burning are, respectively, 70% and 130% more than those of natural gas
- Natural gas only comprised only 2-5% of the country's total primary energy consumption.
- The Chinese government anticipates boosting the share of natural gas as part of total energy consumption to around 8% by the end of 2015 and 10% by 2020.

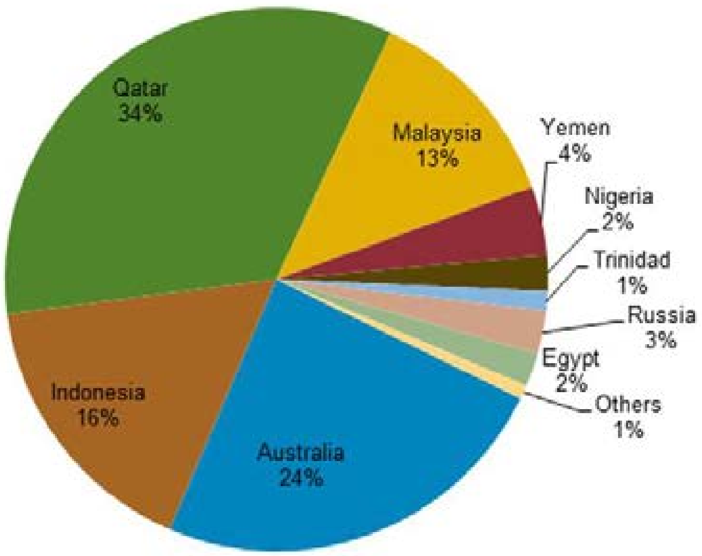
China's Natural Gas Production and Consumption



U.S. Energy Information Administration, International Energy Statistics.

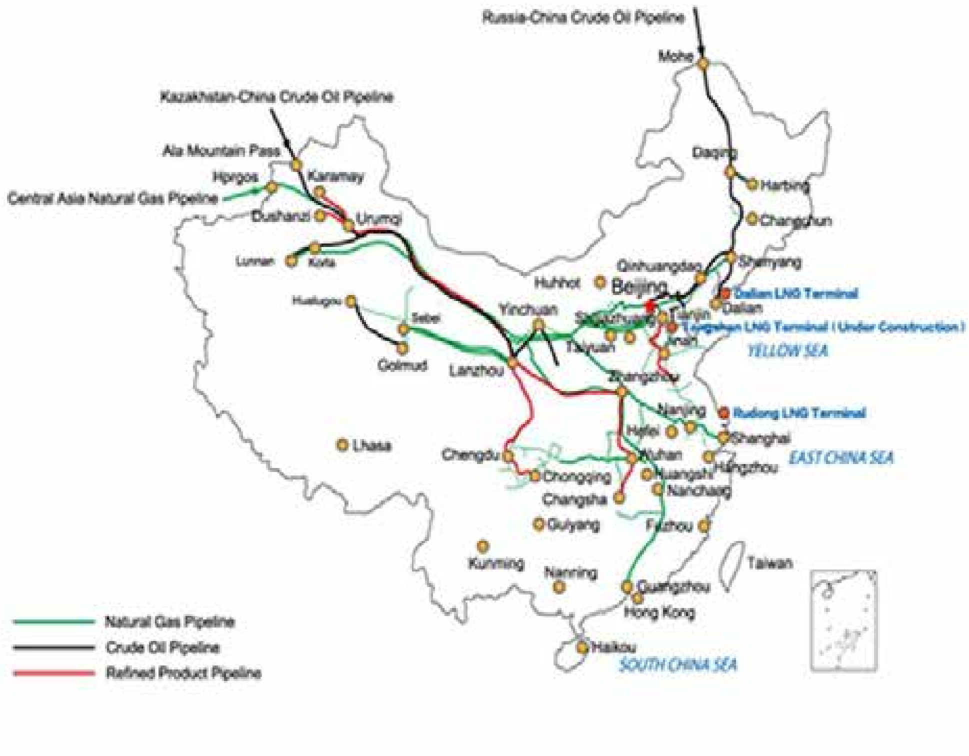
China Liquefied Natural Gas Import Sources, 2012

Natural gas imports have risen dramatically, making China one of the largest LNG consumers in the world.



FACTS Global Energy

Natural Gas Pipeline Connections



Implications of Energy Trade: Case Study

China-Russia Gas Deal: On May 21, 2014, Gazprom and China National Petroleum Corporation signed a 30-year contract stipulating gas supplies of natural gas from Russia to China's populous northeast region

China-Russia Gas Deal

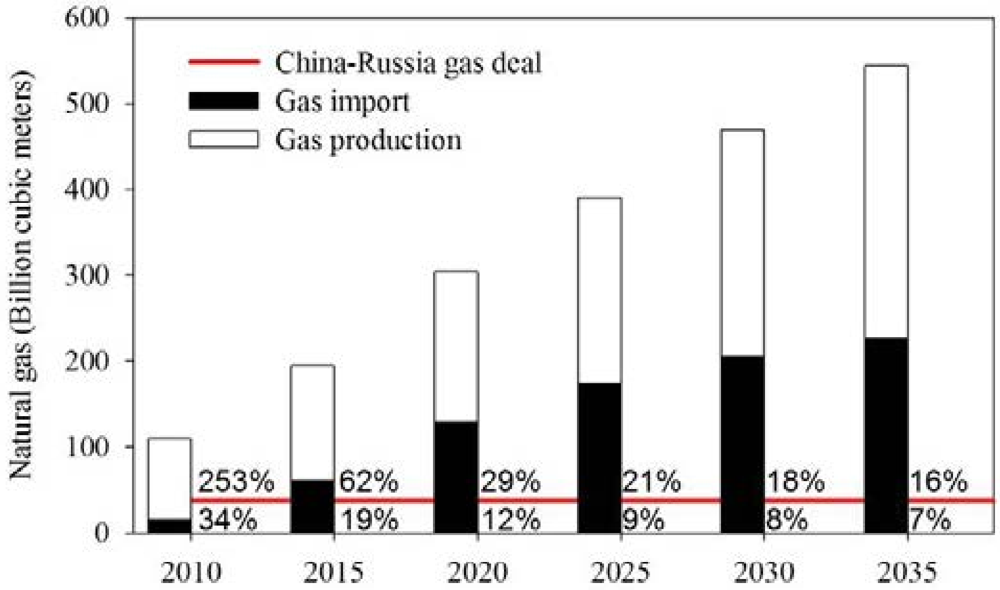
- 38 billion m^3 yr^{-1} of natural gas since 2018, costing 400 billion US$
- Gazprom will start pre-developing the gas deposit in the Chayandinskoye field
- Infrastructure investment from both sides will amount to more than \$70 billion and become the world's largest construction project, with Russia providing \$55 billion up front and China \$22 billion for pipelines on their respective territories

Improving Energy Structure

- The natural gas provided by the Russia–China deal is equivalent to 50.66 million tons of standard coal (2.12% of total coal consumption in 2011)
- The deal play an important role for energy structure improvement in China

Improving Energy Structure

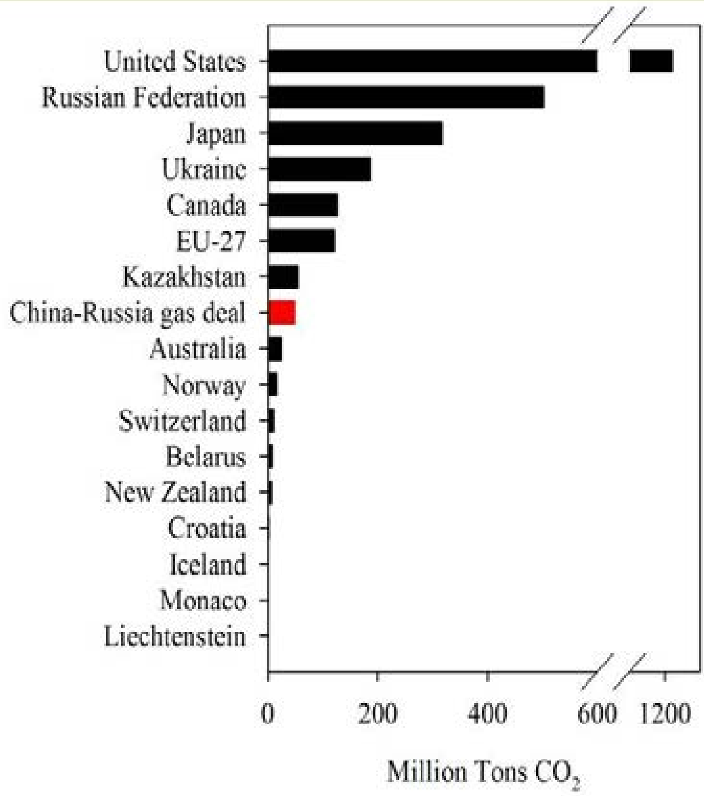
The natural gas provided by this deal is equivalent to 16–29% of imported gas and 7–12% of gas demand from 2020 to 2035 in China



Reducing Greenhouse-gas Emissions

- Coal will emit more 70% CO_2 than natural gas (EPA, 1995; IPCC, 2006)
- Natural gas by this deal can reduce 46 million tons CO_2 emission per year

Reducing Greenhouse-gas Emissions



Cleaning up Air Pollution

- The natural gas provided by the Russia–China deal should reduce SO_2 emissions by 1.11 million tons yr^{-1}, which is about 5.44% of SO_2 emissions in 2011.
- Moreover, industrial smoke discharge can be reduced by 10.13 million tons yr^{-1}.

Not the end

- China is making great efforts to hunt for cleaner energy and improve its coal dominated energy portfolio.
- In June 2014, one month after signing the China–Russia gas deal, the China National Offshore Oil Corporation and British Petroleum signed a long-term deal to supply liquefied natural gas to China worth around $20 billion for 20 years.

Not the end

In June 2014, Chinese President Jinping Xi called for five major actions on energy policy:

- Ensure national energy security — China needs to rein in irrational energy use and control the country's energy consumption by fully implementing energy-saving policies
- Establish a diversified energy portfolio that contains cleaner use of coal and non-coal fuel, including oil, gas, nuclear power and new energy

Not the end

- Energy technology innovation as a new powerhouse to fuel economic growth
- Reforms in pricing mechanism to nurture a competitive energy market
- Expand oil and gas cooperation with countries in central Asia, Middle East, America and Africa, intensify China's energy exploration and exploitation, and build more oil and gas pipelines and storage facilities

International cooperation

- According to the Copenhagen Accord, all countries should cooperate in achieving the peaking of global and national CO2 emissions as soon as possible, and developed countries should provide adequate, predictable and sustainable financial resources, technology and capacity building to support the implementation of adaptation action in developing countries.
- Enhanced action and international cooperation on adaptation is urgently required to ensure the implementation of an agreement on climate change and support the implementation of adaptation actions aimed at reducing vulnerability and building resilience in developing countries.

International cooperation

- The China–Russia gas deal is an example of successful cooperation for mitigating climate change. At present, China plans to acquire gas shipments from countries as far away as Australia. Gas gets more expensive as its travelling distance increases. As such, the chance to acquire huge quantities of gas from a next-door neighbour — up to 38 billion m^3 yr^{-1} by 2018 — is a welcome boon to Chinese policymakers who are desperately seeking alternatives to coal.

Summary

- Energy trade is very important for improving the energy structure in China
- Chinese government put the greenhouse gases and air pollution reduction into the first place for future society development
- More strong international cooperation is critical for solving the air pollution over the east Asia

Thanks!

6.14 Ambient air pollution and human health in Guangdong (Hualiang Lin)

Ambient air pollution and human health in Guangdong

Hualiang Lin
hualianglin@gmail.com

Guangdong Provincial Institute of Public Health

November 28, 2014

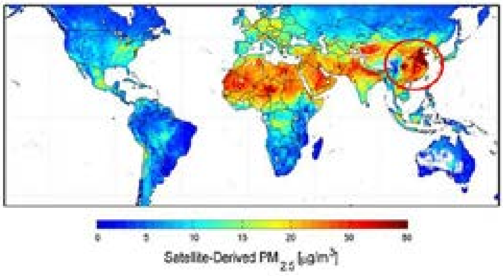
广东省公共卫生研究院
Guangdong Provincial Institute of Public Health

Outline

广东省公共卫生研究院
Guangdong Provincial Institute of Public Health

Air pollution & human health

- An increasing environment and public health concern;
- Serious air pollution episodes reported in China – social wellbeing and international reputation;



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Air pollution regulations

- To protect the public health, air quality guideline and regulations are proposed;
- WHO's Air Quality Guidelines;
- Air quality regulations in various countries;

国家/组织	年平均	24 小时平均	备注
WHO 准则值	10	25	
WHO 过渡期目标-1	35	75	2005 发布
WHO 过渡期目标-2	25	50	
WHO 过渡期目标-3	15	37.5	
澳大利亚	8	25	2003 年发布，非强制标准
美国	15	35	2006 年 12 月 17 日生效，比 1997 年发布的标准更严格
日本	15	35	2009 年 9 月 9 日发布
欧盟	25	无	2010 年 1 月 1 日发布目标值 2015 年 1 月 1 日强制标准生效
中国	35	75	拟于 2016 年实施（征求意见中）

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Health effects of air pollution

- There are both long-term health effects of air pollution – annual air quality standards;
- and short-term health effects, day-to-day variation of air pollution lead to accute health effects – daily air pollution standards;
- Corresponding to different study approaches;

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How to study health effects of air pollution?

- **Short-term health effects:**
  - Time-series studies for short-term/acute health effects.
  - Case-crossover study;
  - Panel study;
- **Long-term health effect:**
  - Geographical studies;
  - Cohort or case-control studies;
- **Animal toxicology and in vitro mechanistic studies;**
- **Controlled human exposures to pollutants (challenge studies);**

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China's regulations

- In 2013, China issued its new ambient air quality regulations;
- $PM_{2.5}$ and O_3 were included;
- Same with the interim-III of WHO's;
- Mainly due to lack of data and evidence;

国家/组织	年平均	24 小时平均	备注
WHO 准则值	10	25	
WHO 过渡期目标-1	35	75	2005 发布
WHO 过渡期目标-2	25	50	
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Our work in Guangzhou

- General air pollutants & daily mortality;
- Particle size & CVD mortality;
- $PM_{2.5}$ chemical constituents & CVD mortality;
- The air pollution control measures during 2010 Asian Games & health benefits;

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Data used

- Time-series data include daily measures of:
  - daily number of health events (e.g., daily mortality)
  - air pollution concentration (e.g., 24-h average $PM_{2.5}$), and
  - weather variables (e.g., daily temperature and relative humidity) for a given area;
  - and others.
- A generalized addtive Poisson model is usually used to estimate the acute health effects of air pollution;
- Various potential confounding factors were controlled for, such as long-term trend, seasonality, day of week, public holidays, temperature, and humidity;

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General air pollutants & mortality

- EPB regularly monitored PM_{10}, SO_2 and NO_2 before 2013;
- Few studies have been done in Guangdong, though it has some of the worst air quality;
- Guangzhou had mortality registration, with high data quality in two districts, Yuexiu and Liwan;

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General air pollutants & mortality

Figure: Guangzhou map

	SO_2		NO_2		PM_{10}	
	ER	95%CI	ER	95%CI	ER	95%CI
Death causes						
Total non-accidental						
Lag0	1.20	0.74–1.66	1.15	0.81–1.48	0.91	0.54–1.28
Lag1	1.01	0.55–1.46	1.06	0.72–1.39	0.91	0.60–1.34
Lag0–1	1.54	1.03–2.06	1.42	1.06–1.78	1.26	0.86–1.66
Lag1–2	0.67	0.17–1.17	0.94	0.58–1.30	0.91	0.51–1.32
Cardiovascular						
Lag0	1.57	0.79–2.36	1.17	0.60–1.73	0.99	0.37–1.62
Lag1	1.64	0.88–2.42	1.59	1.03–2.16	1.60	0.99–2.22
Lag0–1	2.28	1.40–3.16	1.81	1.20–2.41	1.79	1.11–2.47
Lag1–2	1.13	0.28–1.98	1.33	0.72–1.94	1.40	0.73–2.08
Respiratory						
Lag0	1.36	0.23–2.50	1.47	0.66–2.29	0.93	0.03–1.83
Lag1	0.08	−1.02 to 1.19	0.12	−0.70 to 0.94	−0.11	−0.99 to 0.79
Lag0–1	0.89	−0.38 to 2.16	0.95	0.08–1.83	0.05	−0.49 to 1.46
Lag1–2	−0.57	−1.78 to 0.66	0.04	−0.84 to 0.92	−0.39	−1.36 to 0.58

Figure: Results of time series analysis

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General air pollutants & mortality

	SO_2		NO_2		PM_{10}	
	ER	95%CI	ER	95%CI	ER	95%CI
Age group						
<65 years						
Lag0	1.34	0.35–2.34	0.88	0.15–1.62	1.58	0.78–2.39
Lag1	0.45	−0.51 to 1.43	0.33	−0.40 to 1.07	1.09	0.29–1.89
Lag0–1	1.15	0.04–2.26	0.73	−0.06 to 1.52	1.70	0.83–2.59
Lag1–2	-0.02	−1.09 to 1.06	−0.04	−0.83 to 0.76	0.66	−0.21 to 1.54
65 years						
Lag0	1.18	0.66–1.70	1.22	0.84–1.60	0.74	0.32–1.15
Lag1	1.17	0.66–1.68	1.25	0.87–1.63	0.95	0.54–1.37
Lag0–1	1.65	1.07–2.24	1.60	1.20–2.01	1.15	0.69–1.60
Lag1–2	0.86	0.30–1.43	1.21	0.80–1.61	0.99	0.54–1.44
Gender						
Men						
Lag0	0.91	0.29–1.52	1.09	0.64–1.54	0.73	0.24–1.23
Lag1	0.90	0.27–1.48	0.81	0.36–1.26	0.84	0.34–1.33
Lag0–1	1.24	0.55–1.93	1.22	0.73–1.70	1.06	0.52–1.60
Lag1–2	0.47	−0.70 to 1.14	0.81	0.33–1.30	0.80	0.26–1.34
Women						
Lag0	1.59	0.90–2.29	1.23	0.73–1.73	1.13	0.57–[illegible]
Lag1	1.17	0.49–1.85	1.36	0.86–1.86	1.14	0.59–1.69
Lag0–1	1.91	1.13–2.69	1.67	1.13–2.22	1.51	0.91–2.12
Lag1–2	0.88	0.13–1.64	1.11	0.57–1.65	1.05	0.44–1.65

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Figure: Subgroup analysis

General air pollutants & mortality

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Effect of ambient air pollution on daily mortality rates in Guangzhou, China

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ABSTRACT

We aimed to investigate the effects of ambient air pollutants on daily mortality in a relatively stable and homogeneous population in Guangzhou, China. Daily mortality, air pollution, and weather data between 2006 and 2009 were collected. The generalized additive model with poison regression was used to estimate the excessive risks (ERs) of air pollutants (PM_{10}, SO_2, and NO_2) on total, cardiovascular and respiratory mortality. The effects of lag0–1 were the greatest for total non-accidental and cardiovascular deaths. The increments of 10 μg m^{-3} in SO_2, NO_2, and PM_{10} were associated with ERs of 1.54% (95%CI: 1.03–2.06%), 1.42% (95%CI: 1.06–1.78%), and 1.26% (95%CI: 0.86–1.66%) respectively for total non-accidental deaths, and 2.28% (95%CI: 1.40–3.16%), 1.81% (95%CI: 1.20–2.41%), and 1.79% (95%CI: 1.11–2.47%) respectively for cardiovascular deaths. For persons who died from respiratory disease, however, the maximum effects occurred at lag0. The ERs for SO_2, NO_2, and PM_{10} were 1.36% (95%CI: 0.23–2.50%), 1.47% (95%CI: 0.66–2.29%) and 0.93% (95%CI: 0.03–1.83%), respectively. The effects of the three air pollutants on mortality were stronger in elderly and in women. The ERs in the present study were higher than those reported in Europe, the U.S., and most other Asian cities. Our findings show relatively higher ERs of daily mortality by ambient air pollutants in the center of Guangzhou, China, compared with estimates in other cities. Further studies with accurate exposure measurement among homogeneous population are needed to evaluate the precise magnitudes of the effects of the air pollutants.

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Figure: Publication on AE

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Ozone & mortality

- Ozone is another important air pollutant that poses adverse health effects;
- O_3 is a powerful oxidant, far more so than dioxygen;
- China is among the countries with the highest ambient ozone concentration.

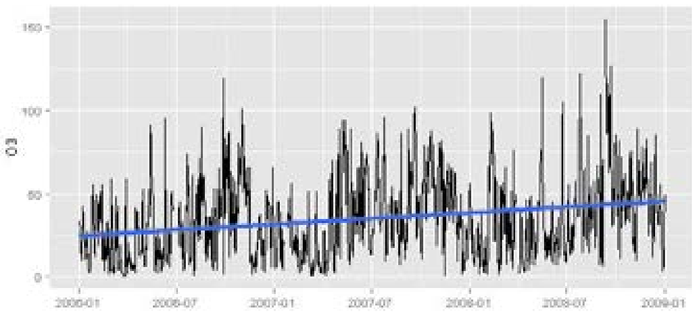

Figure: O_3 in Guangzhou

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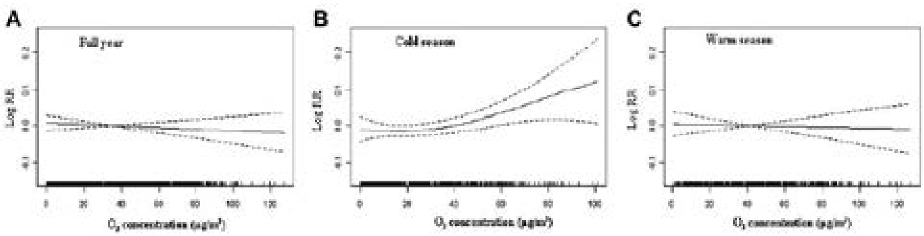
Ozone & mortality

- A distributed lag model was used;
- Season-specific effect was examined;
- More pronounced in winter season.



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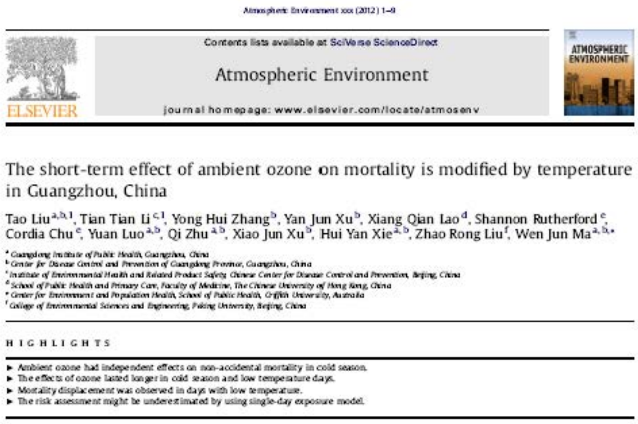
Ozone & mortality


Atmospheric Environment xxx (2012) 1–9

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Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

The short-term effect of ambient ozone on mortality is modified by temperature in Guangzhou, China

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HIGHLIGHTS

- Ambient ozone had independent effects on non-accidental mortality in cold season.
- The effects of ozone lasted longer in cold season and low temperature days.
- Mortality displacement was observed in days with low temperature.
- The risk assessment might be underestimated by using single-day exposure model.

Figure: Publication on AE

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Health benefits of controlling air pollution

- Comprehensive air pollution controlling measure was carried out during the 2010 Asian Games in Guangzhou;
- Transpotation restriction, industry emission control, and others;
- We examined whether mortality reduced after the air pollution control measures.

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Health benefits of controlling air pollution

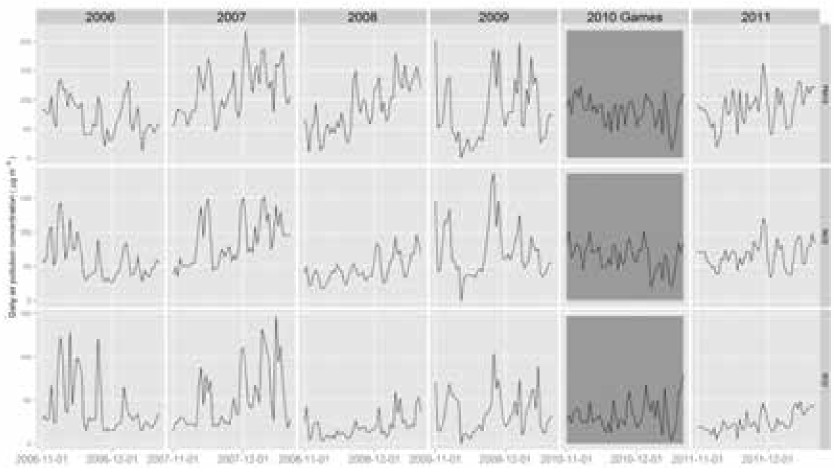

Figure: PM concentration reduced significantly

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My recent analyses

- PM size was an important determinant of the health effect of PM pollution;
- Very fine partiles (PM_1) might have been responsible the observed health effects of PM_{10} and $PM_{2.5}$ in Guangzhou;
- Some PM compositions might be more toxic to human health, such as OC, EC, sulfate, nitrate, etc.

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- Interactive effects of air pollution and meteorological factors on health effects;
- Panel study to examine the association of air pollution and symptoms and biomarkers;
- Cohort study to examine the long-term effects;
- To establish a multi-city air pollution study for both short-term and long-term;
- Animal & toxicity studies;
- Hope to collaborate with other countries in Asian-pacific Region.

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Acknowledgement

Figure: Environmental team in GDIPH

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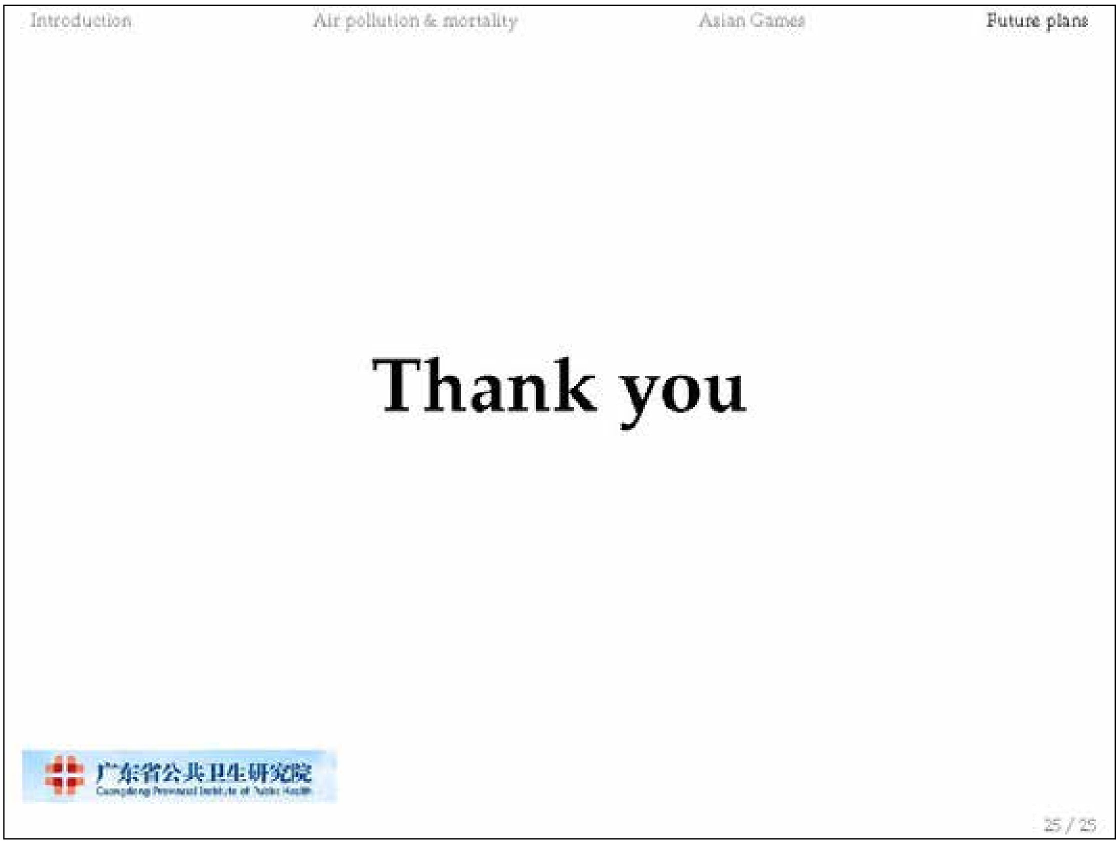
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Thank you
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6.15 Experience and Practice of Vehicles Emissions Control in Japan (Shinya Koyama)

International Expert Meeting on
Air Pollution Control in Urban Asia-Pacific
27-29 October 2014, BNUZ, Zhuhai, China

Experience and Practice of Vehicles Emissions Control in Japan

October 28, 2014

Shinya Koyama (University of Hyogo)

koyama@econ.u-hyogo.ac.jp

1

summary

- Severe human health damages by air pollution had been left until high growth era in Japan.
- Since 1970's air pollution was overcome gradually. However, Improvement was very slow in some sectors such as transport.
- Victims of the pollution and local governments played important roles to make progresses in abatement of pollution, although direct regulation for emission sources by the nation was the main policy measure.

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Contents

1. The Status Quo of Air Pollution in Japan
2. Historical Review of Air Pollution in Japan
3. Air Pollution from Mobile Sources and Emissions Control
4. Success factors of vehicle emissions control measures
5. Summary and Lessons for Asia

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1. The Status Quo of Air Pollution in Japan

- What's the matter of air pollution?
  - Human health, biodiversity, built environment, ・・・
- Human losses (health damages)
  - Illness or death

  ※Disease caused by air pollution is classified as non-specific disease
    - Epidemiological relationship
    - Hard to specify the cause of each case
  - People don't recognize that air pollution can kill human beings

  →hard to understand the importance of air pollutants abatement

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Air pollutants

- Pollutants with environmental standard
  - Traditional 5 pollutants (since 1973)
    - SO_2
    - CO
    - SPM
    - NO_2
    - Photochemical oxidants
  - Benzene (since 1997)
  - dioxin (since 1999)
  - Fine particles (PM2.5) (since 2009)

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sources of air pollutants

	industry	Home and business	nature
Fixed sources	factory	Air-condition Hot-water supply	dust, fire, disaster
Mobile sources	Automobile, Construction Machinery	Automobile, Motorcycle	—

- Fundamental information to specify the target
  - Large-scale sources: relatively easy to control
  - Small- scale sources : high transaction costs

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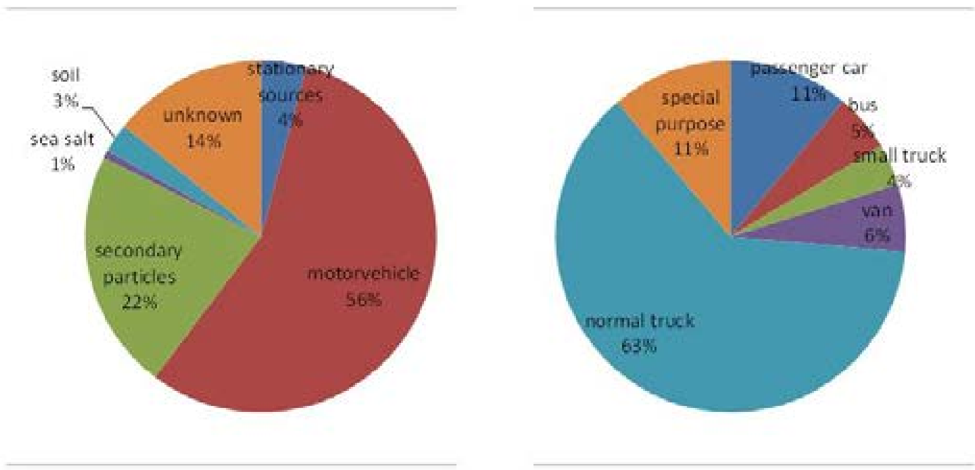
Sources of SPM（example of estimation）



- 56% of fine particles is from motor vehicles, 63% of which is from normal trucks.

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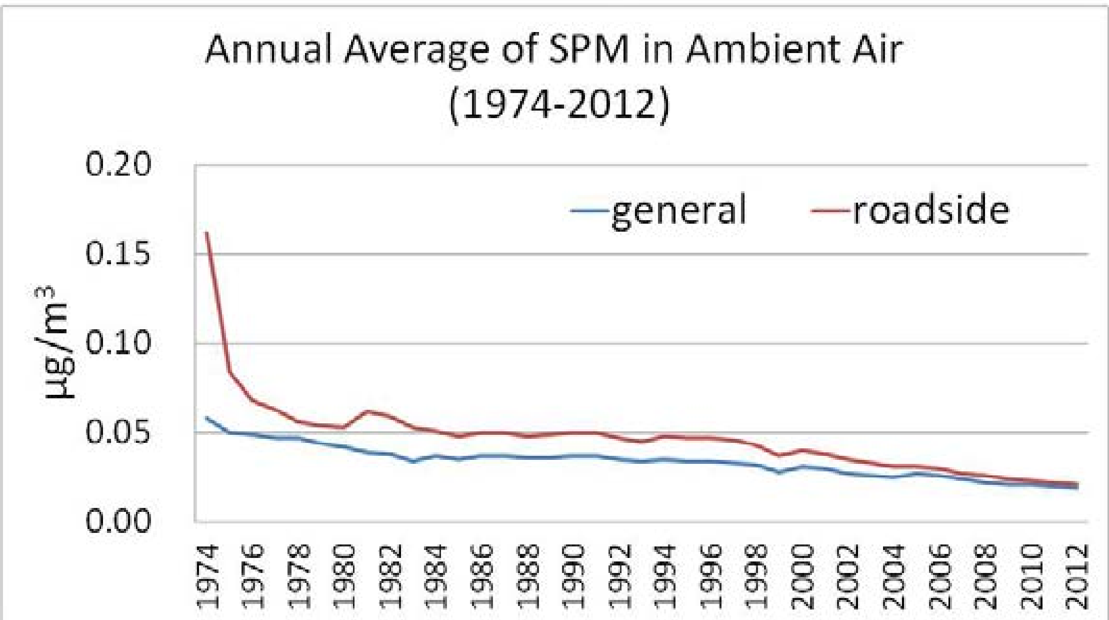
Ambient SPM has been lowered in these ten years



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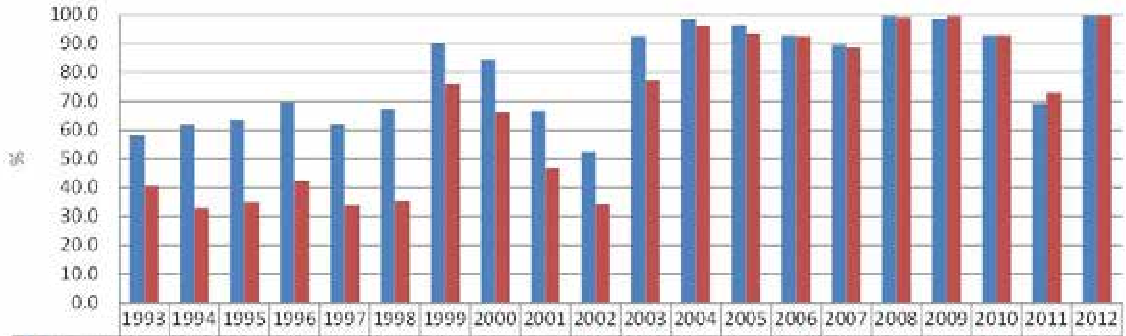
Environmental standard for SPM is almost achieved. Observation sites are more than 1700.

Achievement Rate of Envionmental Standards for SPM



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
general	58.2	61.8	63.5	69.8	61.9	67.3	90.1	84.4	66.6	52.6	92.8	98.5	96.4	93.0	89.5	99.6	98.8	93.0	69.2	99.7
roadside	40.5	32.9	35.2	42.4	34.0	35.7	76.2	66.1	47.0	34.3	77.2	96.1	93.7	92.8	88.6	99.3	99.5	93.0	72.9	99.7

※Improvement was not in the old days.

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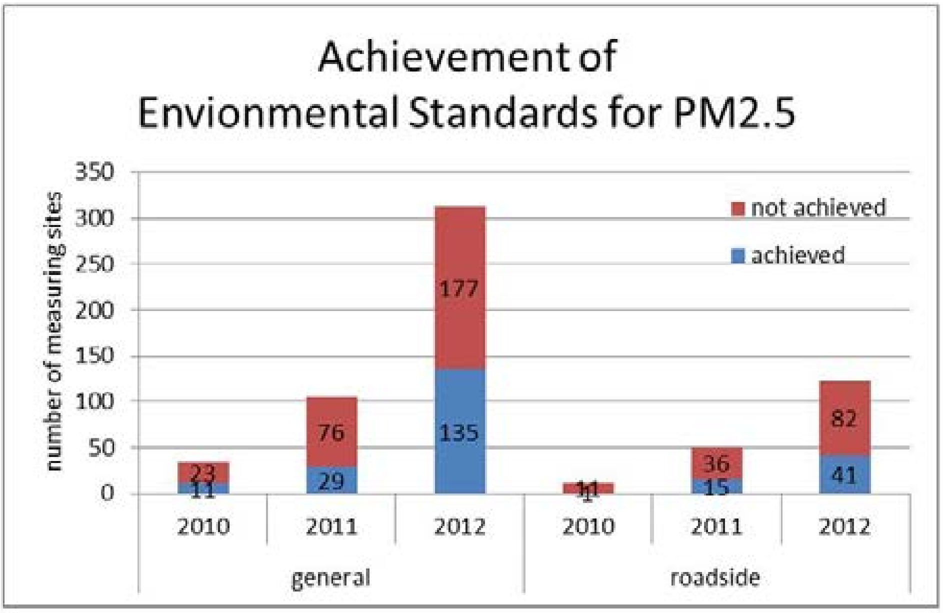
Achievement of Environmental standard for PM2.5 is not sufficient. The number of observation sites is also insufficient.



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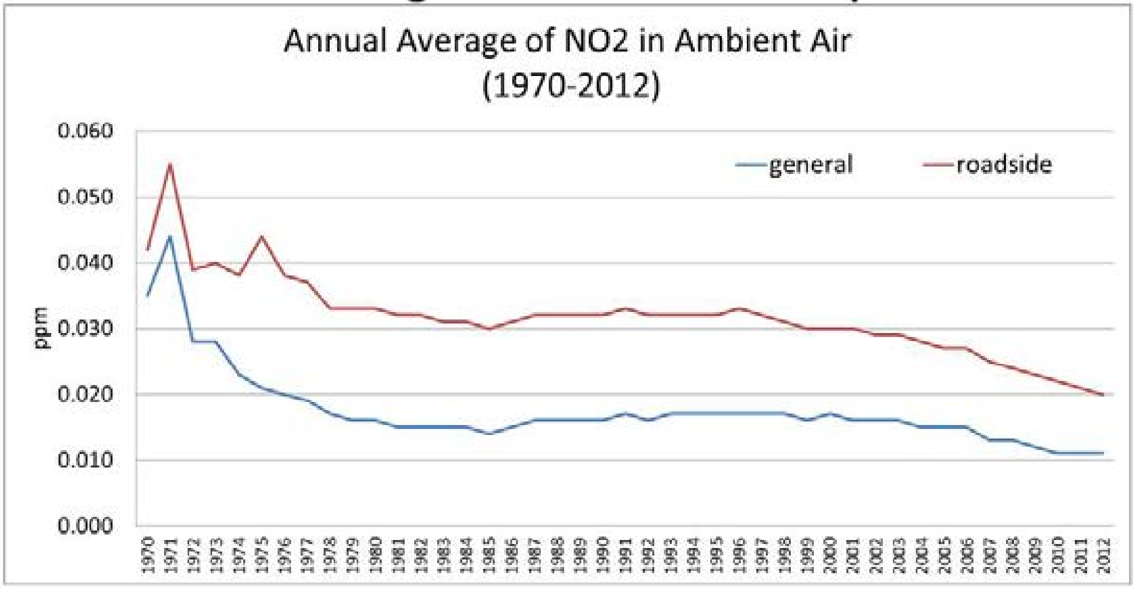
Ambient NO2 was lowered in 1970's. Lowered again in these 10 years



Environmental standard is achieved in most of the stations.

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Achievement rate of environmental standard for photochemical oxidants (Ox) is almost zero

	achieved	not achieved	total
general	3 (0.3%)	1,139 (99.7%)	1,142 (100%)
roadside	0 (0%)	30 (100%)	30 (100%)

- Standard might be too stringent.
  - 0.06ppm (1-hour value)
  - Parts of photochemical oxidants (Ox) are estimated to come from foreign sources transported long distances.

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2. Historical Review of Air Pollution in Japan

(1) Since the end of 19th century
Air pollution by SOx around mines and big cities along with economic development
(2) High growth era (1960-72)
annual growth rate 10%
heavy chemical industry : coastal industrial complex development
serious pollution in industrial zones
Yokkaichi, Kawasaki, Amagasaki, Kitakyusyu
1967 Basic Law for Environmental Pollution Control
1968 Air Pollution Control Act
control the pollution from factories and vehicles
set the emission standards
1970 Pollution Diet (session focused on resolving problems related to pollution)
14 bells related to pollution was approved
1971 Establishment of Environmental Agency
integration of pollution control policy

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(3) Urban pollution in a stable development era (1973-1990)

- Switch to Stable development after two oil shocks (1973, 1979)
- Pollution by industries were stabilized as a result of legislative regulations and efforts by industries.
- From density regulations to gross weight regulations
  - 1974 gross weight regulation for SOx
    - For each factory
  - 1981 gross weight regulation for NOx
- Little progress in control of vehicle emissions

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Japanese air pollution control policies in the late 20th century (appraisal by OECD)

- OECD (1977) *Environmental Policies in Japan*
  - Japan won many of the battles in pollution control
  - However, only in the field where emergent measures were taken
  - Progresses were seen in some fields, but not seen in others
- OECD (1994) *Environmental Performance Reviews: Japan*
  - Obtained dazzling results in SO2, NOx, CO
  - Remained air pollution problems are NO2, Ox, PM and toxic substances

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(4) From pollution to environmental problems (1990-)

- Borderless economy
- Bubble economy, its Collapse and long depression
- Shift of the people's concern to global environmental Issues, wastes and recycles and so on.
- 1993 Basic Law for Environmental Protection
  - Shift from pollution control to conservation of global environment
  - Basic Environmental Plan
- 2001 Environmental agency was raised to the Ministry of Environment as a part of central governmental reform
- Progress in vehicle emission control

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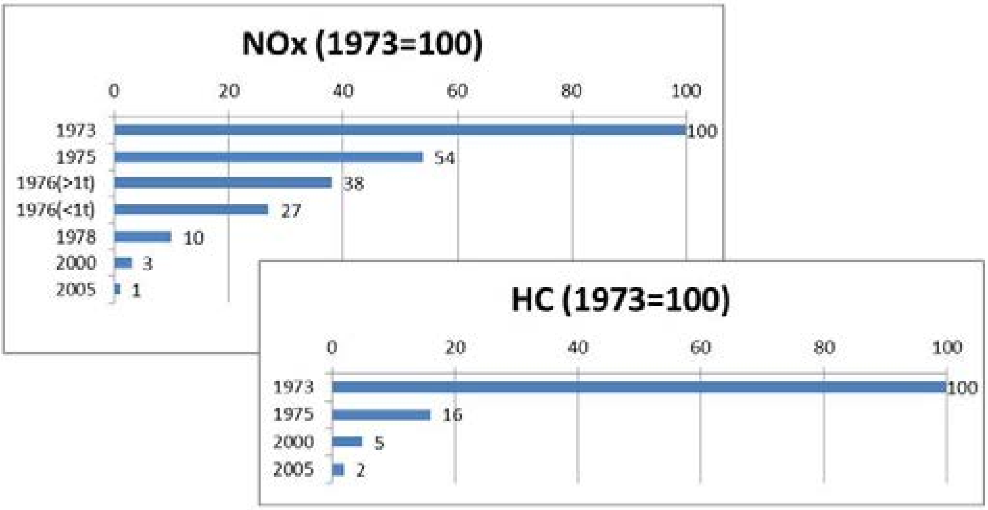
3. Air Pollution from Mobile Sources and Emissions Control

- Emission control for each vehicle has been the central measure

Development of emission standards for gasoline and LPG cars



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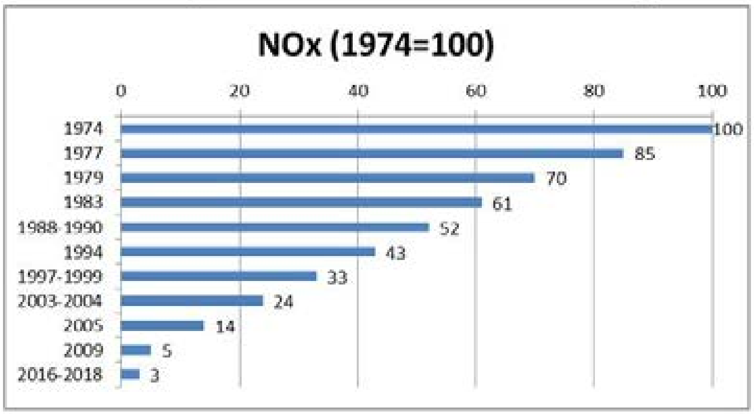
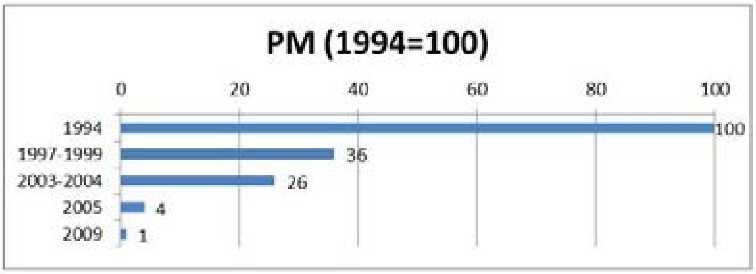
Development of emission standards for heavy diesel vehicles (>3.5t)





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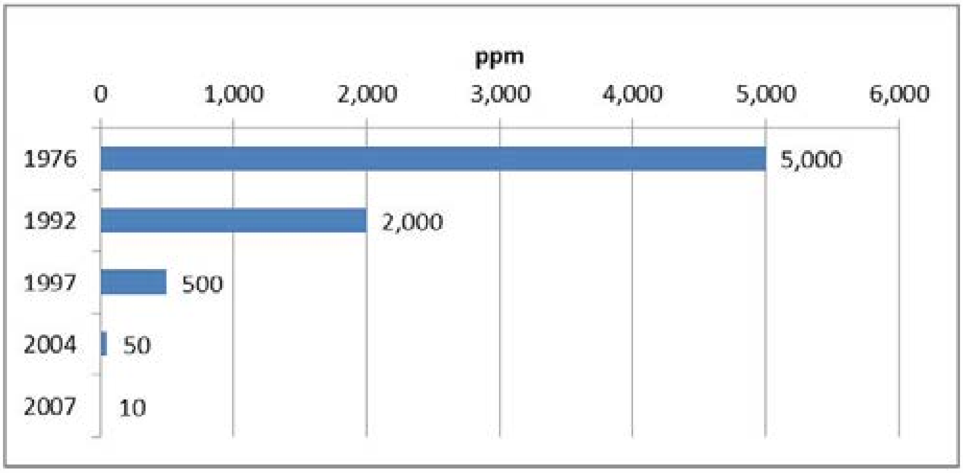
Development of sulfur contents regulation in diesel oil



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4. Success factors of vehicle emissions control measures

(1) The Japanese version of the Muskie Act

- 1976 regulation announced in Japan in 1975, later extended to 1978
- Pursuit of Compatibility between the environment and the economy
- A good example of the "Porter hypothesis"
  - Equivalent to the 1970 Muskie Act in the US
  - more than 90% cut of NOx emission from gasoline cars
- Strong opposition from industry
  - Technical difficulties, fuel economy worsening, competitiveness decline
- In the USA
  - Regulation plan was weakened
- In Japan
  - the seven major cities investigation team
  - Implementation of the regulation as the initial target in 1978 (two years delay)
- To overcome the decrease in fuel efficiency due to comply with the emission regulations, related technologies was developed.
- In 1980s, Japanese cars with excellent fuel economy, was accepted by consumers all over the world.

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(2) Automobile NOx Act

- Issued in June 1992, enforced in December 1992
- Promote a scrap of unregulated vehicles
- Area where NOx pollution is significant
  - The Tokyo metropolitan area, Osaka, Hyogo was designate as "specific area“
  - reduce the total amount of NOx from vehicles

→Prefectures make an abatement plan

- Vehicle regulations
  - The use of aged trucks and buses are not allowed. (They don't pass the inspection for continuation.)

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Automobile NOx/PM Act

- June 2001, revision of the NOx Act
  - substance
    - SPM was added
  - area
    - Aichi and Mie (Chukyo Metropolitan Area including Nagoya) was added

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Abatement plan by industry based on the NOx/PM Act

- The case of Osaka
  - Companies who have more than 30 vehicles
  - "Automobile use and management plan"
  - "Automobile use and management Performance Report" (every year)

※ NOx/PM Act cannot prevent emissions from inflow vehicles.

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Local ordinances to combat the emissions by inflow vehicles

- complement the NOx / PM Act
- Prohibit high emission vehicles to enter the cities
  - Tokyo metropolitan area
    - Oct. 2003
  - (South east of) Hyogo
    - Oct. 2004
  - Osaka
    - Jan. 2009

24

(3) Economic incentive to spread Low-emission vehicles (Green tax reform of vehicle related taxes)

- Since 2001
- Two axes
  - fuel efficiency
  - Emissions of pollutants
- Vehicles with excellent environmental performance
  - Vehicle tax and vehicle acquisition tax are reduced
- Aged vehicles (Diesel vehicles more than 10 years and gasoline vehicles more than 13 years)
  - Vehicle tax is 10% higher

- Examination of system in Tokyo was preceded than in the nation.
  - Local governments can raise the vehicle tax to some extent
  - Addition of vehicle tax by local government was epoch-making at that time

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(4) Air polution lawsuits and compensation

- Pollution from factories
  - The Yokkaichi pollution trial
    - SO_x from industrial complex
    - Judgment of the district court in 1972
      - Responsibility of the six companies were recognized

    → Compensation Act for Pollution Related Health Damage 1973

- Compensation Act for Pollution Related Health Damage 1973
  - Financial resources
    - Companies bear the compensation in proportion to the emissions of SO_x
    - Part of Vehicle Weight tax

  → Polluter Pays Principle

  ※Certification of new patients was stopped in 1988

26

Urban complex pollution (Fixed and mobile sources)

- Since late 1970s
- Factories, nation and Public Roads Administration as administrator of roads.
  - Nishi-yodogawa, Kawasaki, Amagasaki, Nagoya, Tokyo
  - Liability for damages
    - Only private companies in the early stage
    - Also road administrators since the judgment of Nishi-yodogawa trial in 1995,
    - Responsibility of vehicle manufacturers was denied in the judgment to Tokyo trial
  - Pollutants
    - SO_2 → NO_2 → SPM

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(5) "Say No to Diesel Vehicles" Campaign of Tokyo Prefecture (1999.8-2000.12)

- Appointment of Shintaro Ishihara as the Governor of Tokyo in April 1999

- Intensive request and proposals to automotive industry, fuel industry and the nation

"Current diesel vehicles don't suitable for use in Tokyo"

→ Five proposal by the Governor in August

- Don't use, don't buy, and don't sell diesel cars in Tokyo.
- Mandatory substitution of commercial diesel vehicles to gasoline vehicles
- Mandatory DPF (Diesel Particulate Filter) installation
- Correction of tax rate favorable to diesel
- Ahead of schedule of emission restriction for diesel vehicles

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- Ordinance on Environmental Preservation in Dec. 2000
  - Original diesel vehicle control measures
  - Operation ban on diesel vehicles which do not comply with the PM emission standard
    - replacement of non-compliant vehicles
    - DPF (Diesel particulate filter)
  - Enforcement from Oct. 2003
  - Almost the same regulation was introduced in Saitama, Chiba and Kanagawa.
- Sep. 2002 (one year prior to the enforcement of the ordinance)
  - Noncompliant Diesel Vehicle Elimination Campaign
    - Dissemination of regulatory content
    - Improvement of air pollution

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Defects of emissions regulations pointed out by the Tokyo Metropolitan Government

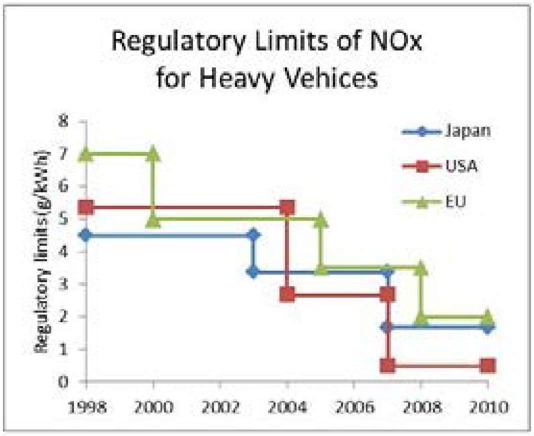
- Delay in introducing appropriate regulations of PM
  - NOx since 1974
  - PM since 1993

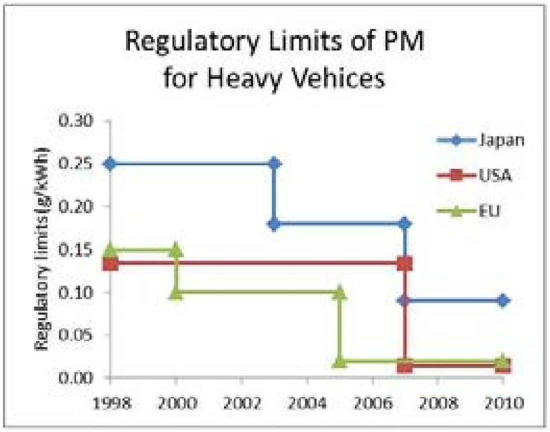
    ※Environmental standard of PM was set in 1972

  →70% of the diesel trucks was unregulated at the end of 1999
- Japan's PM regulation seriously lagging behind that of the U.S. and Europe
  - Regulation had been loose not only for PM but also for NOx.
- Difference between the exhaust gas test driving modes and the driving conditions on the road
- Durable travel distance is short
  - Only 30,000km for passenger car
- Inspection for in-use vehicles is loose.
  - No inspection of NOx and PM at the ongoing inspection

30

Emission standard of NOx and PM for heavy vehicles (Forecast in 2000)





- Japanese standard of NOx is not necessarily stringent.
- Standard in the US has been more stringent since2004

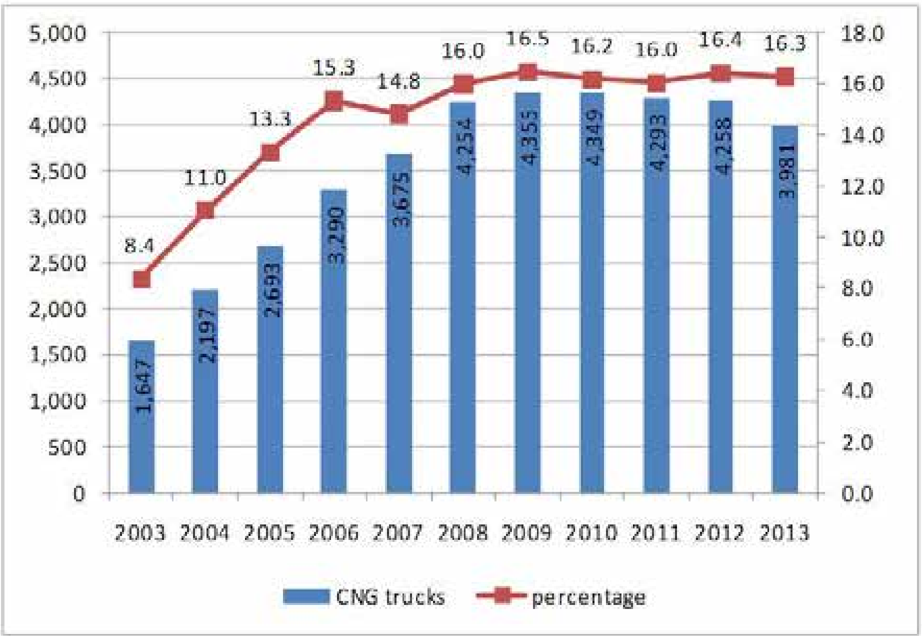
- Japanese standard of PM is least stringent.

31

- CNG vehicles
  - 4,041 vehicles (Sep. 2013)
  - No. 1 truck ownership in the World
- Climate savers program with WWF
  - First Japanese company
  - First logistics company in the world
- Carbon neutral certification by the Ministry of the Environment in 2012
  - Three service centers including Tokyo station

33

CNG Trucks Deployment by Sagawa HD



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5. Summary and Lessons for Asia

- Direct control on fixed and mobile sources has been the main policy measure and outcome has been reasonable.
- Target pollutants has changed in each era.
  - SOx→NOx→SPM→PM2.5、Ozone、Asbestos、・・・?
  - Scientific and epidemiological knowledge has not always been harnessed quickly.
  - PM2.5 has been overlooked until recently. Observation was also delayed
- Measures to some types of the pollution source were delayed in Japan.
  - Diesel vehicles
  - Construction Machinery

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- Public transport system is contributing to avoid the reliance on the vehicles in large cities.
  - Ichizo Kobayashi model since early 20th century
    - Transit Oriented Development led by private sector
    - Diversified management, including residential and commercial facility development
- Economic measures including environmental taxes may improve efficiency, although cases were limited in Japan.
  - Fuel tax and kilometer charge can be the proxy of environmental tax

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6.16 Trend of Energy Use and Hazardous Air Pollutants Emissions in China (Hezhong Tian)

Background

- Owing to the continuous economic growth, China has been the largest energy producers and consumers in the world.
- Also, China is one of a few countries whose energy mix is dominated by the high polluted fuel---coal.
- China has become one of the three large areas suffering from severe acid deposition, mainly owing to huge emissions of SO_2 and NO_X.
- Large amount of coal-dominated fossil fuel burning has lead to substantial discharge of various air pollutants, such as PM_{10}/PM2.5/SO_2/NO_X/Hg/As/Pb/BC, etc. causing very complex atmospheric environmental problems—Haze and ground-level O_3 pollution, as well as heavy metal poisoning.

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Multi-pollutants and Multi-scale pollution Co-exist

- Inferior local urban air quality: primary pollutant: PM_{10}/$PM_{2.5}$;
- Regional acid rain: SO_2, NO_X, etc;
- Regional haze and ground-level O_3 pollution: Beijing-Tianjin-Hebei (JJJ), Yangtze River Delta (YRD), Pearl River Delta (PRD), etc.;
- Emerging/high frequency occurrence of heavy metals poisoning accidents: Hg, Pb, As, Cd, Cd, Ni, Sb, etc.;
- Global warming: CO_2 emissions, CH_4, Hg, Sb, etc.

- It is an ever great challenge to tackle with such a complex air pollution situation in China.

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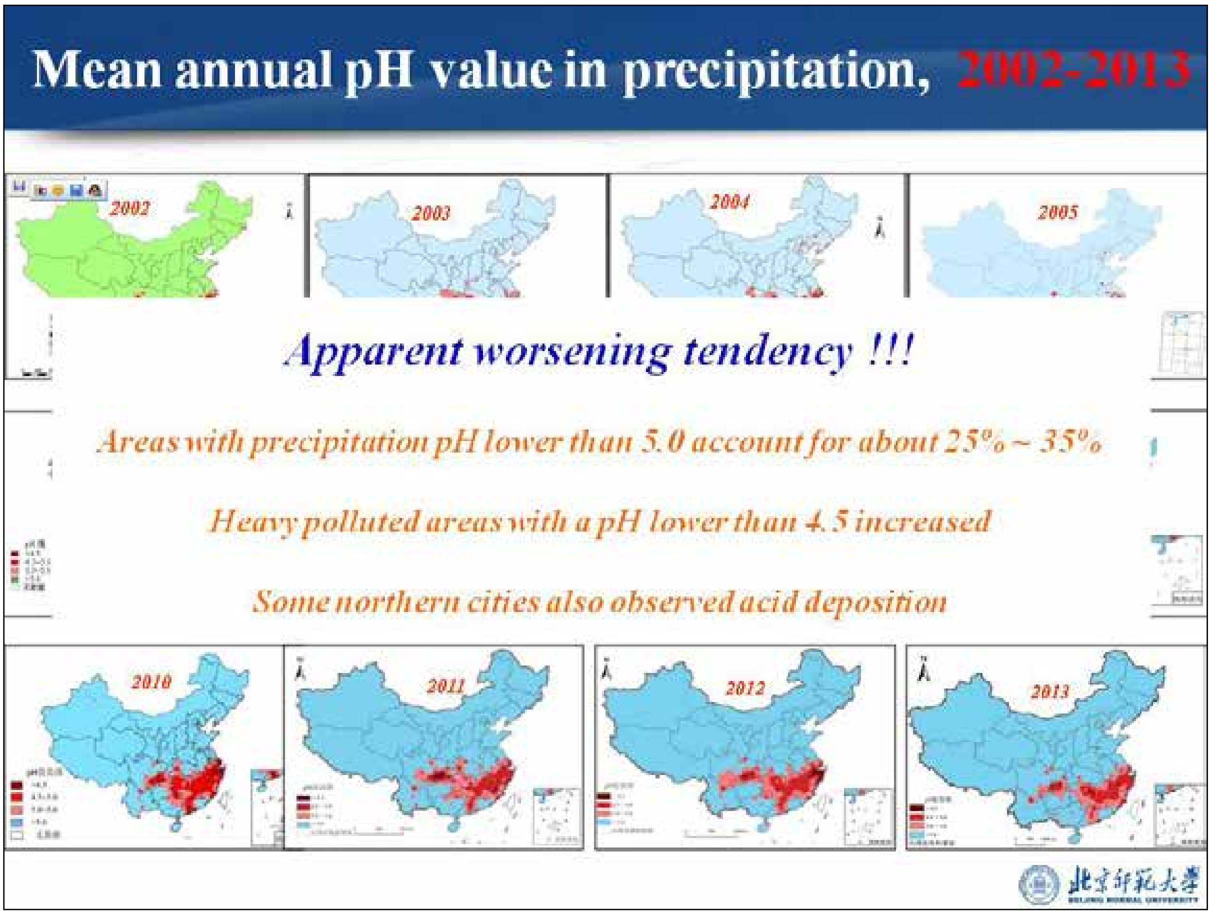


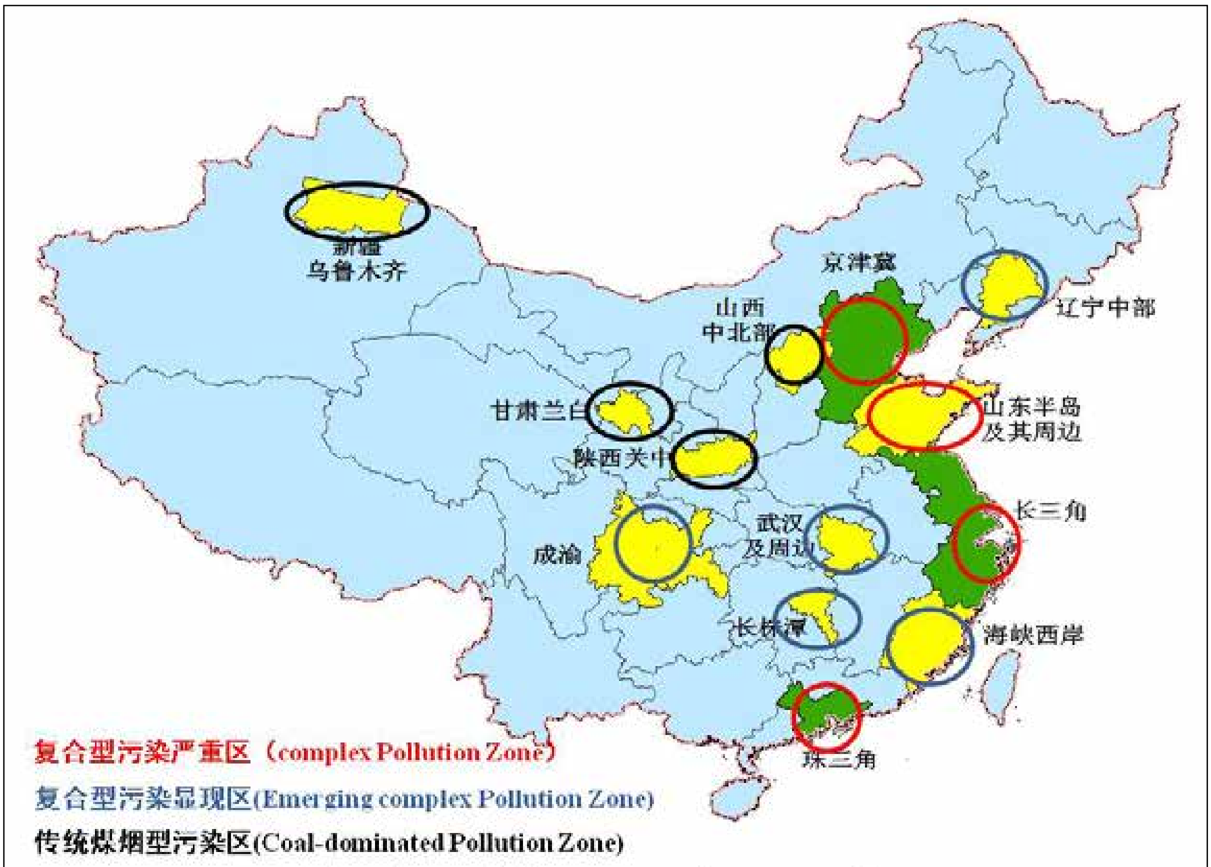


Fig. Distribution of 12 key regions with severe air pollution

Spatial Characteristics of $PM_{2.5}$ pollution in China

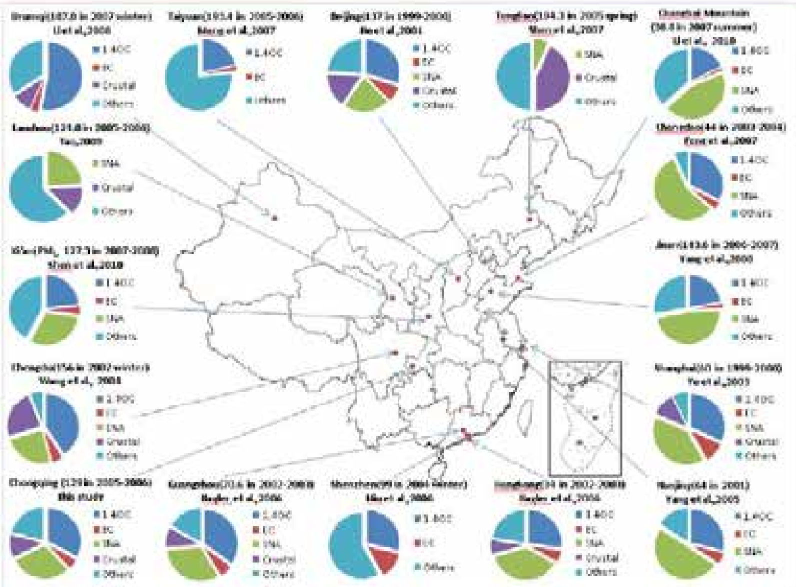
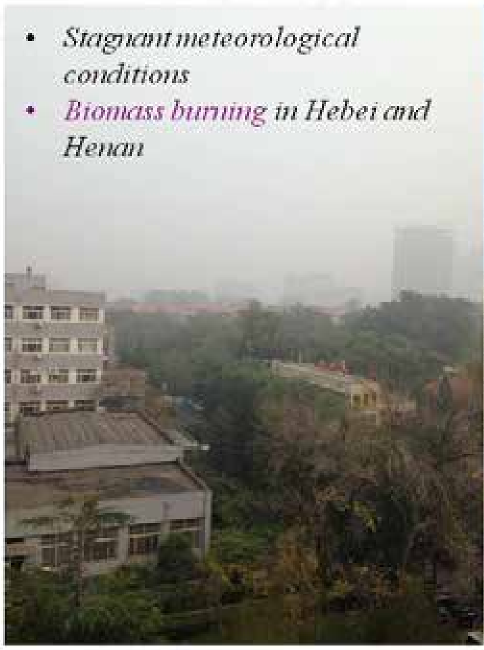


Fig. 3. PM2.5 (except PM1.0 in Xi'an) speciation at urban and rural locations in China. The rural sites are Changbai Mountain, Tonghao, and Changdao. Averaging periods, average PM2.5 mass (μgm−3), and references are indicated. A coefficient of 1.4 to convert OC to OM was adopted for all the sites for fair comparison. For some sites without elements data, crustal material was not reconstructed. In Taiyuan and Shenzhen, only OC and EC were analyzed, while in Lanzhou carbonaceous species were not determined.

Source: Yang et al. ACP, 2011

PM2.5 and visibility in Beijing Normal University (BNU) Campus, Beijing

2014-10-25 AM 9:10



Severe Pollution

2014-10-26 AM 9:10

Clear sky PM2.5<35ug/m3

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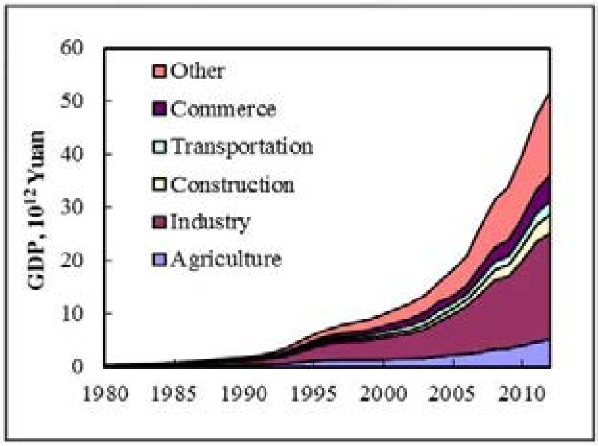
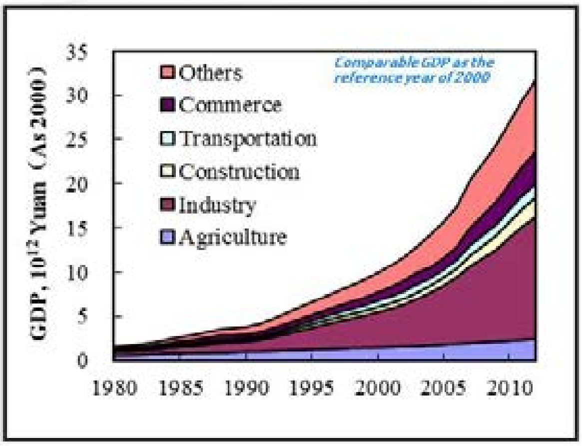
OUTLINE

- Background
- **Trend of National Economy in China**
- Trend of Energy Output and Consumption
- Trend of Hazardous Air Pollutants Emissions
- Possible Tools and Solutions
- Concluding Remarks

Trend of National Economy of China, 1980-2012

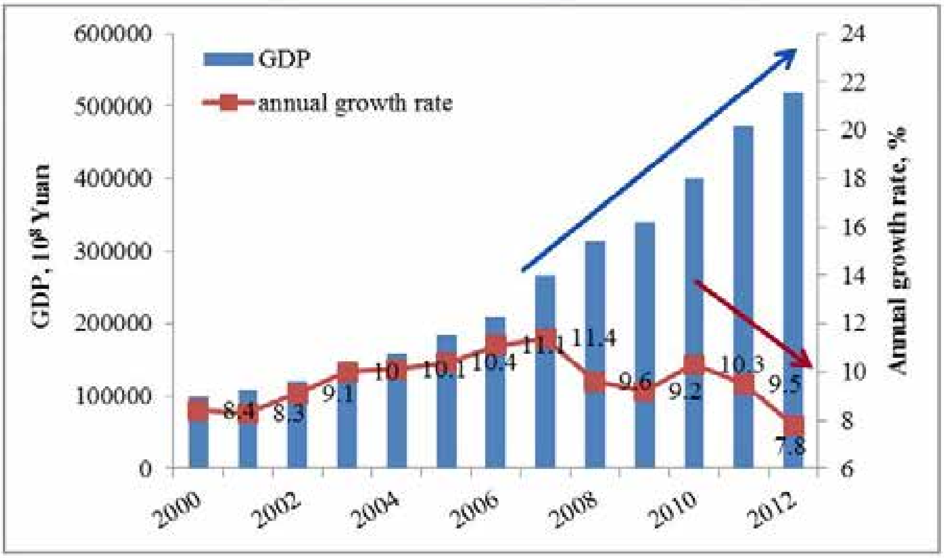




- *By 2012, China's total GDP has reached up 51894 Billion CHY(RMB), and GDP per capita has exceeded 38,420 CHY(RMB);*
- *The average growth rate from 1990-2012 reached as high as 9.8%.*

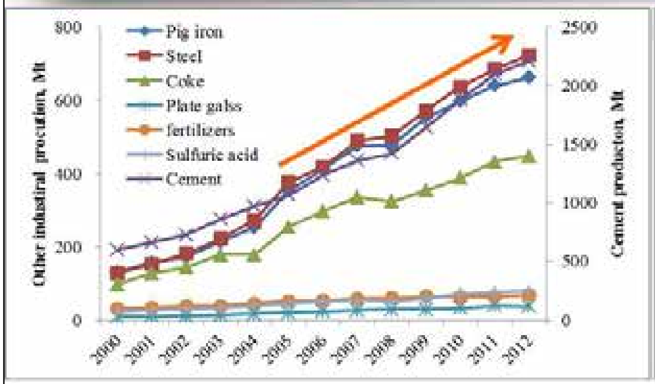
Source: NBS, China

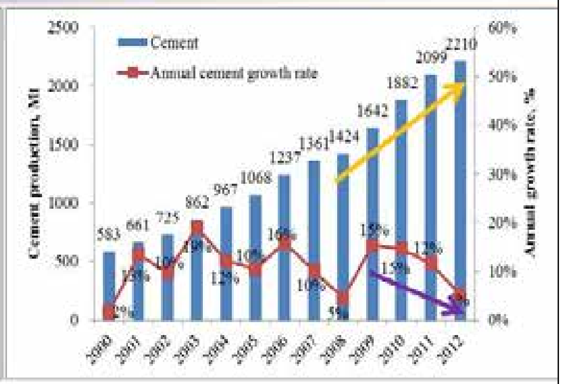
Trend of GDP growth, 2000-2012



Since 2011, annual GPD growth rate slowdown and even decreased mainly due to influence of energy re-structuring and global economic recession.

Trend of industrial products output, 2000-2012





- During 2000-2012, **cement** and **iron and steel production**, which are featured with energy-intensive (mainly coal) and heavy pollution, have kept growing;
- While, the growth rate has begun to fall down since 2010.

OUTLINE

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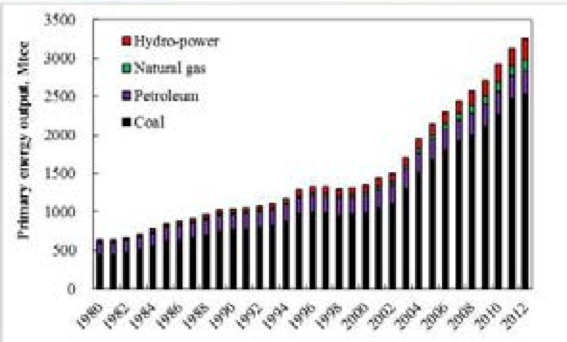
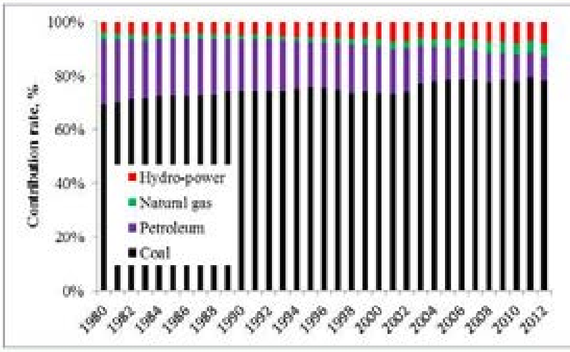
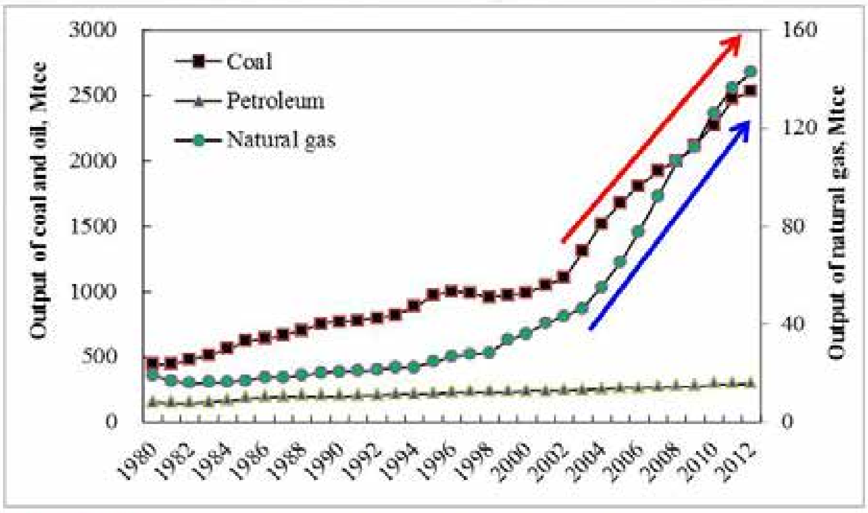
Trend of Primary Energy Output, 1980-2012





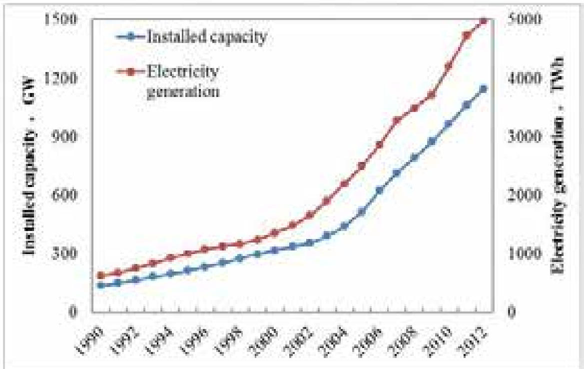
- By 2012, the total primary energy output has grown up to **3318.5Mtce**;
- **Coal output** was 3538.6Mt, accounting for 76.5% of totals in 2012;
- The share of oil has dropped gradually, though output of crude oil has been growing slowly, from 232.8 Mt in 2000 to 295Mt in 2012
- Natural gas still accounting for only small share, though the absolute volume has been increasing rapidly.

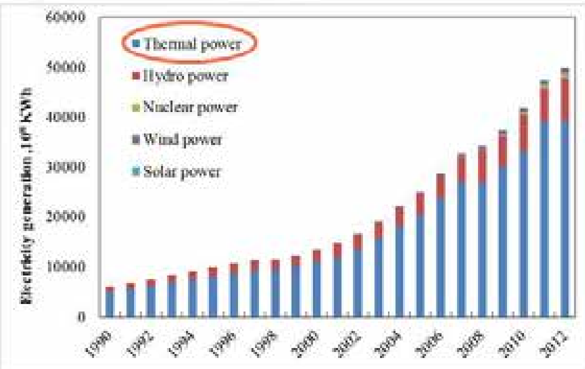
Output of coal, oil and natural gas, 1980-2012



- **Rapid increase in coal production since the early 2002;**
- **Natural gas output has been increasing in the over past 2 decades.**

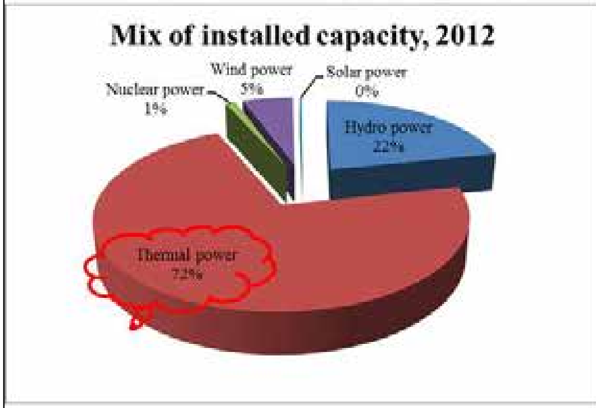
Installed capacity and electricity generation, 1980-2012

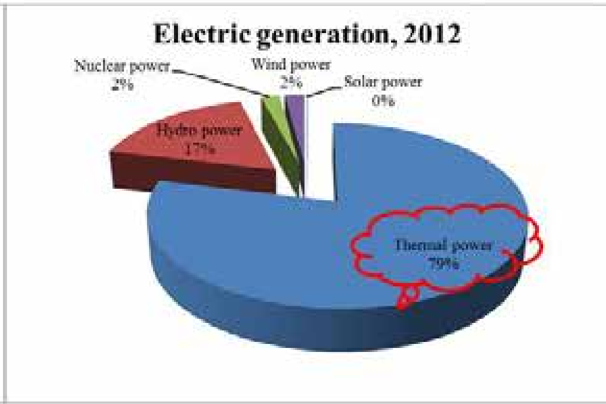




- *By 2012, the total installed electricity capacity and generation reached at 1146.6 GW and 4986.5 TWh, respectively.*
- *About 80% of total electricity were still produced by coal-fired power plants though electricity by hydro and nuclear power has been increasing.*

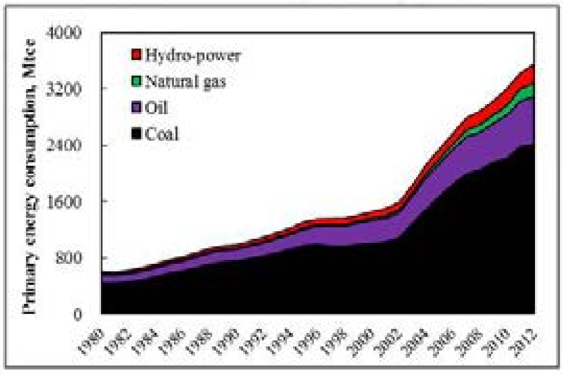
Mix of installed capacity and electricity generation of China, 2012

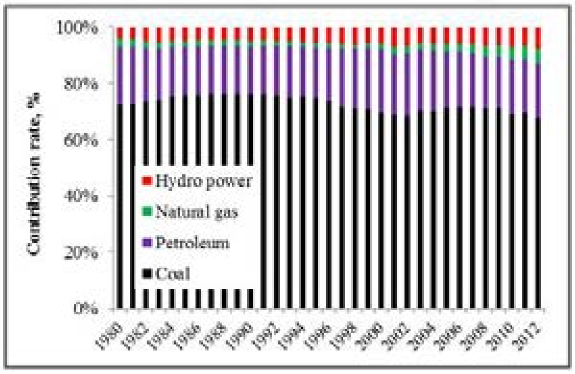




- Substantial progress has been made on **renewable energy**, such as hydro-power, wind, solar, etc.
- Chinese electricity generation were dominantly produced by **coal-fired power plants.**

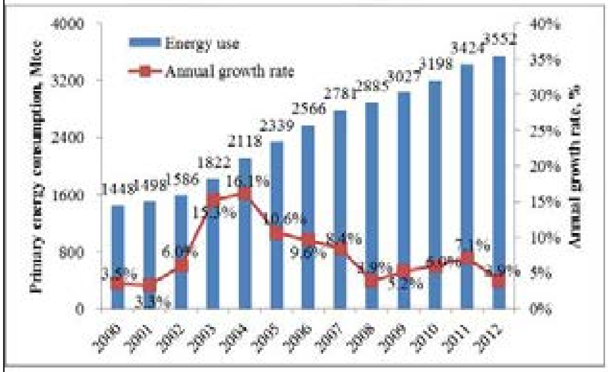
Trend of Primary Energy Consumption, 1980-2012

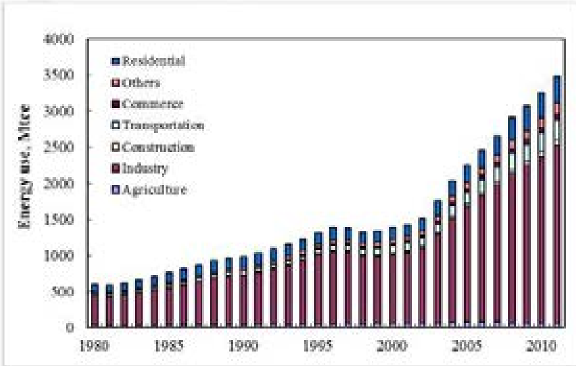




- *By the end of 2012, the total primary energy consumption has increased up to 3617.32 Mtce, an average growth rate of 6.15% compared with 1990;*
- *Coal-dominated energy consumption mix, accounting for about 67 %, though it has dropped from 76.2% in 1990 to 66.6% in 2012.*
- *Total Amount Control of Coal Use is requested at central and local level under the pressure of PM2.5 and Haze pollution prevention.*

Trend of Primary Energy Use and Growth Rate, 2000-2012





- Mainly consumed by industry sector, 70.8% of the totals in 2012;
- Followed by residential use, accounting for about 10.7%.
- Share of transportation has been increasing quickly, mainly owing to rapid growth of private-owned vehicles.

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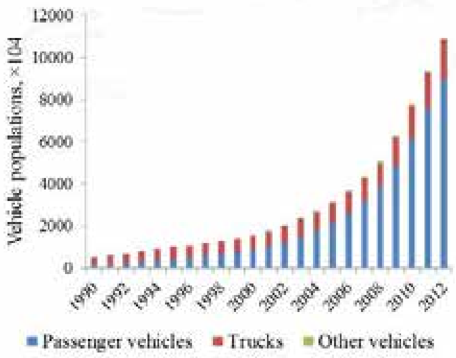
Population of civil vehicles in China, 1990-2012



- *By 2012, the total civil motor vehicles has grown to 109.3 millions;*
- *Passenger Car, especially the private car is the main power for rapid increase of vehicle populations*

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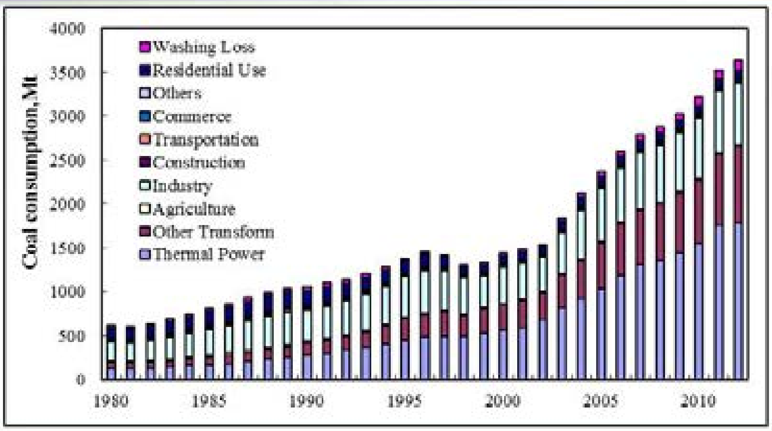
Total vehicle population in Beijing has exceeded 5.20 millions by the end of 2012

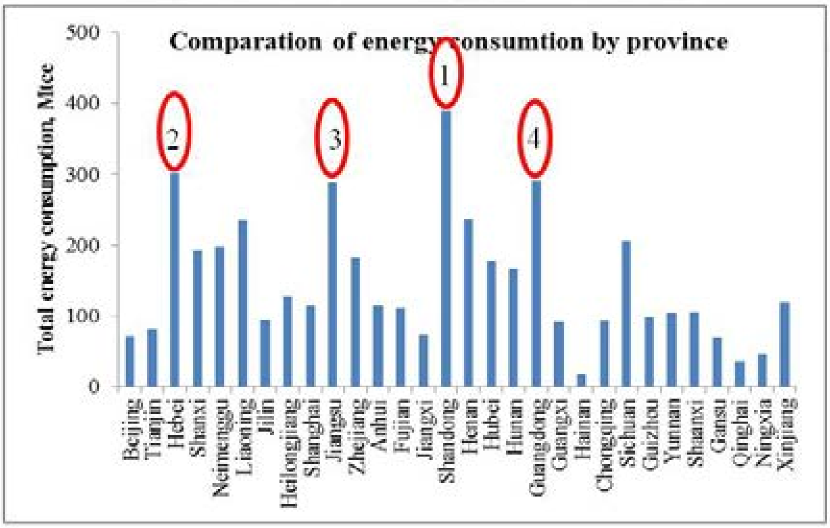
- *The newly registered vehicles is over **1000 per day** in Beijing .*
- *Since Oct.11, 2008, over **20%** of the vehicles were restricted to use on each weekday, for improvement of traffic jam and air quality.*

Coal use by economic sectors, 1980-2012



- By 2012, the total coal consumption is about 3526.5Mt; and 1785.3 Mt coal used for power generation, accounting for only 50.6%.
- The newly added coal output has been mainly used for electricity generation by coal-fired power plants
- Except for power, coal was mainly used by other energy transform (heating, coking, coal gas), and manufacturing industry sector, 21.3% and 19.9% of the totals in 2012, respectively;

Primary energy consumption by province, 2012



- Shandong province ranked the largest energy consumer;
- Next by Hebei, Jiangsu, Guangdong, Liaoning, Henan, etc.

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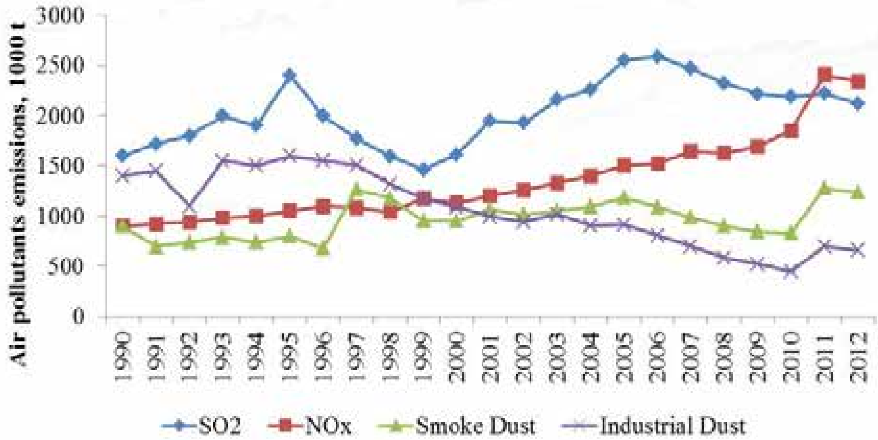
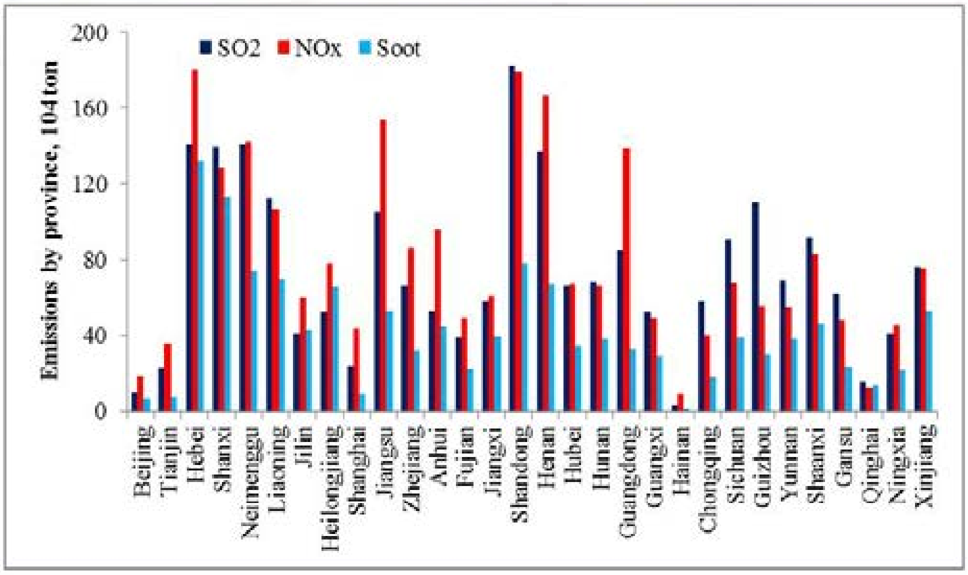
Trends of air pollutants emissions in China, 1990-2012



- **By 2012, the total emissions of SO_2, NOx, Soot, and industrial dust is reported by SEPA at 21.17Mt, 23.37Mt, 12.34Mt, and 6.59Mt, respectively**
- **MEP has reported that the total SO_2 and NO_x emissions decrease by 4.5% and 2.8% compared with 2011, respectively**

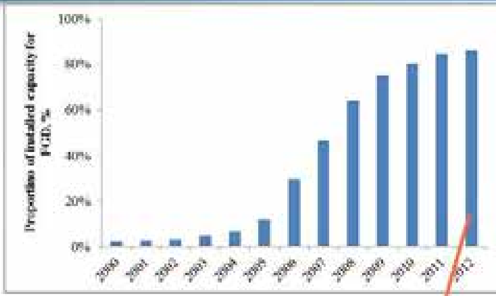
Source: MEP

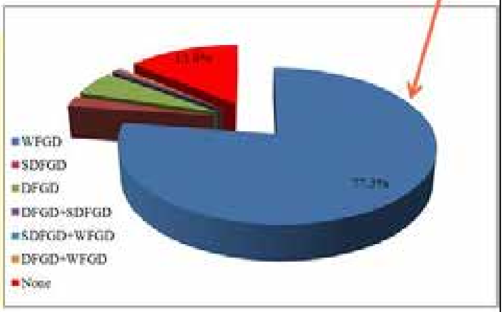
Emissions of primary air pollutants by province, 2012



- Shandong, Hebei, Jiangsu, Guangdong, Liaoning, Henan, province ranked the largest emitters

Trend of national SO_2 emissions, 1985-2012





- In 2012, Coal-fired power plants emitted about 7.97 Mt, accounting for about 37.6% of the total SO_2 emissions in China.
- The decrease of SO_2 emissions since 2007 are mainly owing to the growing installation and operation of FGD in coal-fired power plants.
- By 2012, the installed capacity of FGD reached **706.4 GW**, accounting for **86.2%** of the total thermal power capacity.
- **Limestone-Gym process** accounted for 89.7% of total FGD capacity

Emission Inventory of Heavy Metals (HM)

Why should we know about the emission inventory（**EI**） of

- **Toxic Heavy Metals** ?

PM2.5 health effects: mainly because toxic heavy metals and metalloids are easily adsorbed on the PM2.5 particles and inhaled into the depth of respiratory system.

Increased poisoning accidents related with heavy metals have happened in China during the past years;

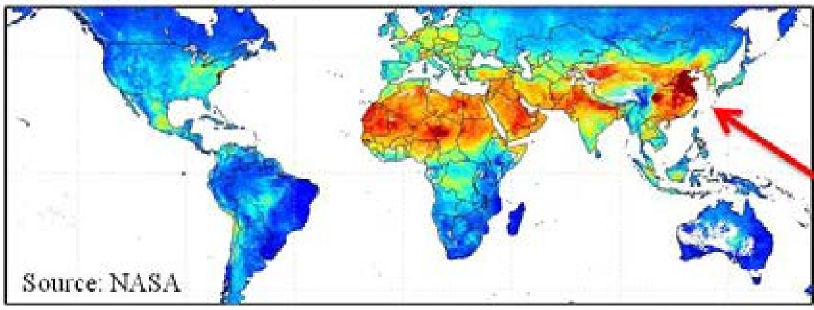
- ✓ Arsenic（As） poisoning owing to coal-burning in Guizhou;
- ✓ Excessive Pb of Children blood nearby Lianzhou coal-fired power plant in Guangdong;
- ✓ Cadmium contaminated rice;
- ✓ etc.

Planning on Heavy Metals Pollution Prevention

On Feb 18, 2011, The State Council of Chinese government ratified a **Special Comprehensive Planning on Heavy Metals Pollution Prevention for the 12th-five-years plan**.

Planning Target: By the end of 2015, the emissions of Hg, Pb, Cd, Cr, and As in the highlighted pollution districts should be **abated more than 15%** compared with the emissions in the year of 2007; while the emissions in the non-highlighted districts should not be exceed those in 2007.

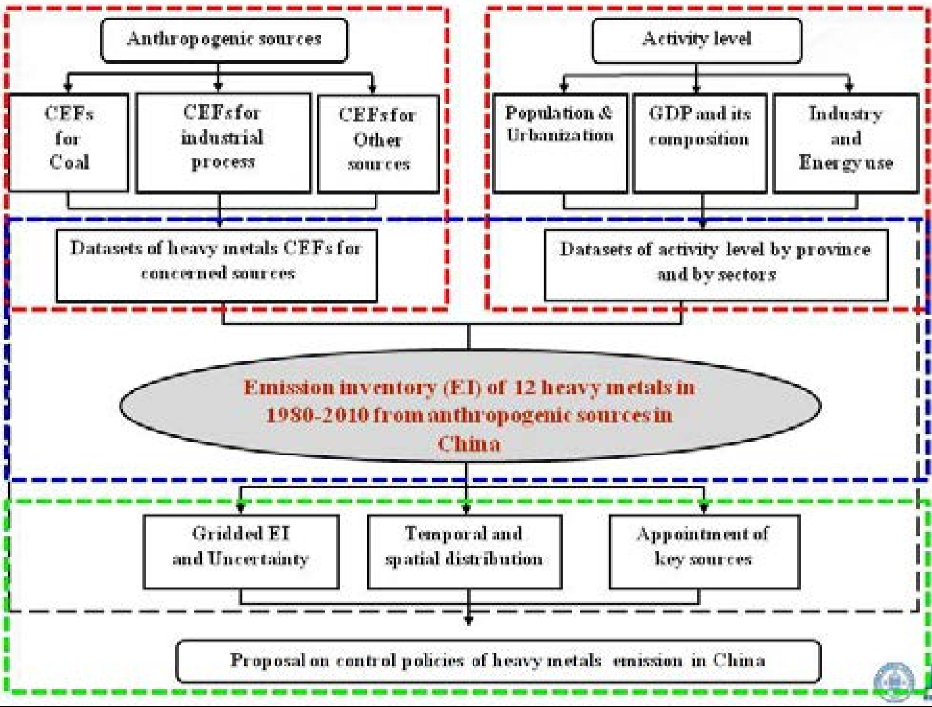
However, the current situation and their temporal and spatial distribution are little known. Thus, An integrated inventory of atmospheric emissions of hazardous trace elements in China is urgently needed.

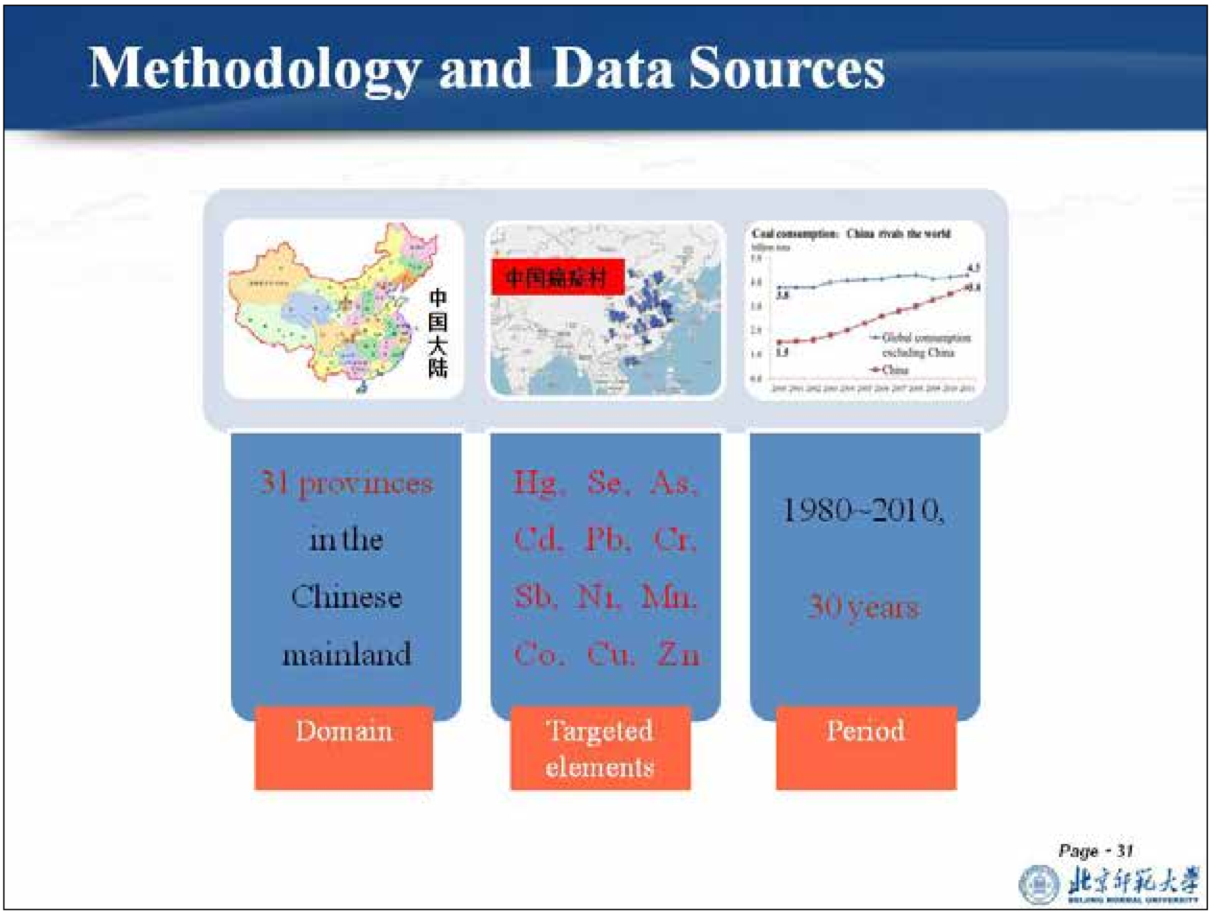


29

Methodology and Data Sources

Roadmap for compiling EI of Heavy Metals and Metalloids in China




Methodology and Data Sources
中国大陆
Coal consumption: China rivals the world
Global consumption excluding China
China
31 provinces in the Chinese mainland
Domain
Hg, Se, As, Cd, Pb, Cr, Sb, Ni, Mn, Co, Cu, Zn
Targeted elements
1980~2010, 30 years
Period
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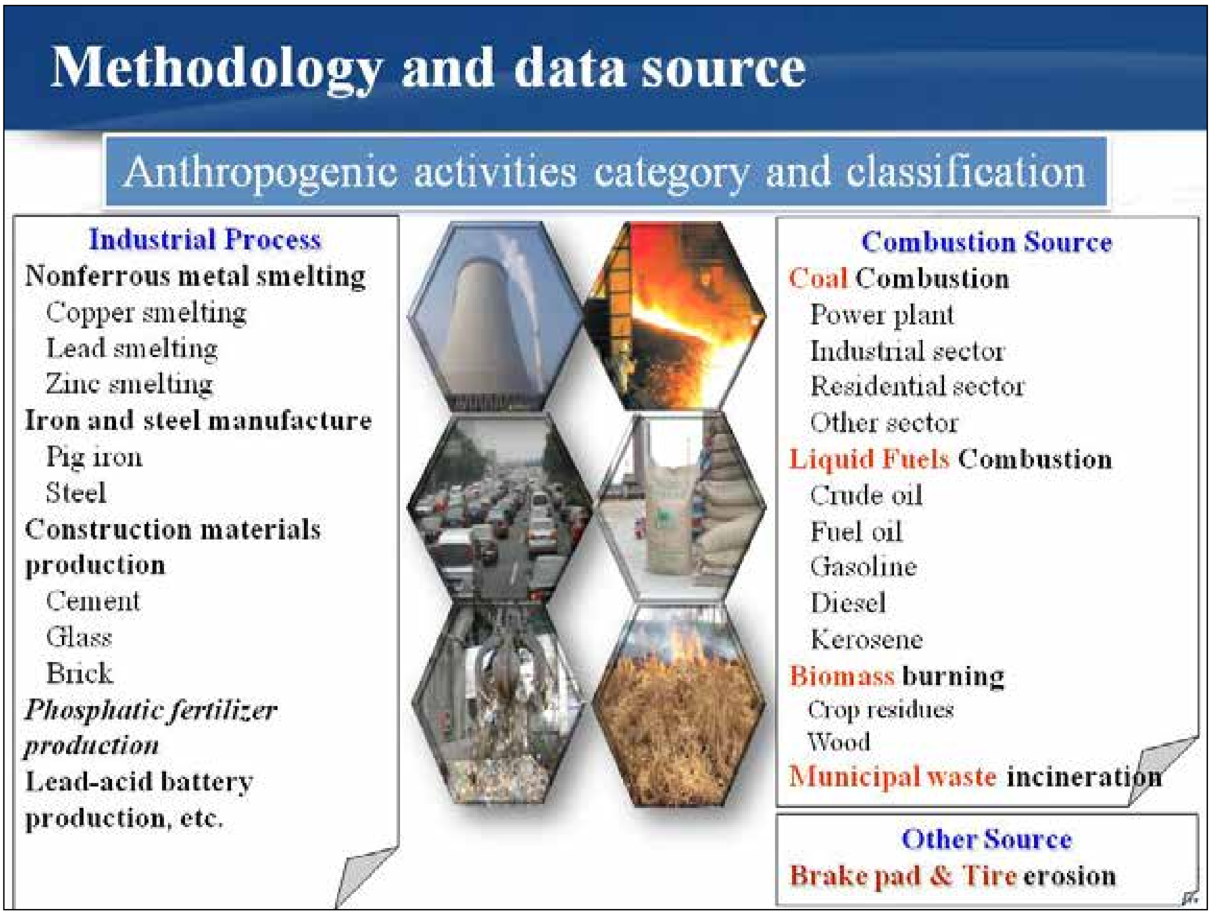
BEIJING NORMAL UNIVERSITY


Methodology and data source
Anthropogenic activities category and classification
Industrial Process
Nonferrous metal smelting
Copper smelting
Lead smelting
Zinc smelting
Iron and steel manufacture
Pig iron
Steel
Construction materials production
Cement
Glass
Brick
Phosphatic fertilizer production
Lead-acid battery production, etc.
Combustion Source
Coal Combustion
Power plant
Industrial sector
Residential sector
Other sector
Liquid Fuels Combustion
Crude oil
Fuel oil
Gasoline
Diesel
Kerosene
Biomass burning
Crop residues
Wood
Municipal waste incineration
Other Source
Brake pad & Tire erosion

Methodology and Data Sources

Overall: **A Bottom-up methodology** is used to estimate emissions of heavy metals where possible:

$$E=\sum_i\sum_j A_{i,j}\times CEF_{i,j}$$

Where, E is the emissions of heavy metals; A is the energy consumption and activity data of other sources; EF is the comprehensive emission factor (CEF); i is the province (autonomous region or municipality); and j is different emission sources.

Coal:

$$E=\sum_i\sum_j A_{i,j}\times CEF_{i,j}=\sum_i\sum_j C_{i,j}M_{i,j}R_{i,j}\left(1-\eta_{PM_j}\right)\left(1-\eta_{FGD_j}\right)$$

Where, E is the emissions from coal combustion; C is the content of heavy metals in consumed raw coals of different province; M is coal consumption; R is the release rate of different combustion devices; η_{PM} is the removal efficiency of dust collector; η_{FGD} is the removal efficiency of de-sulfur devices; j is different emission sources; i is the province (autonomous region or municipality).

Non-Coal sources:

$$E=\sum_i\sum_j M_{i,j}\times CEF_{i,j}$$

Where, E is the emissions of heavy metals; M is MSW Incineration/Industrial production/Biomass burning; EF is the emission factors; j is the emission sources; i is the province (autonomous region or municipality).

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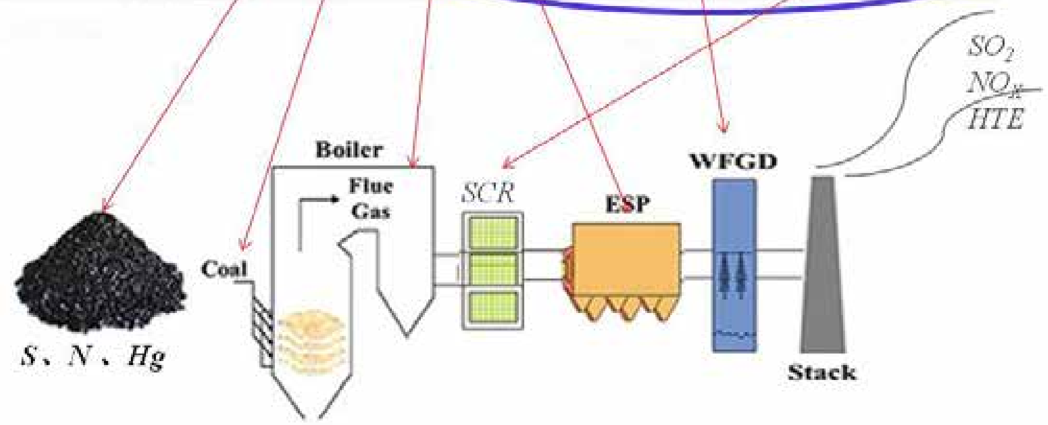
有害痕量元素协同控制技术

$$E_{Total}=\sum_i\sum_k\sum_m\sum_n C_i\times M_{i,k}\times R_m\times(1-\eta_{PM_n})\times(1-\eta_{SO_2})\times(1-\eta_{NOx})\times(1-\eta_{Hg})$$



有害痕量元素主要是吸附在烟气颗粒物上，因此，已安装的常规烟气控制设施对有害痕量元素能够起到协同去除的作用。

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常规烟气治理设备对有害痕量元素的协同控制效果

- 随着"十一五"期间SO_2减排政策的推行，截止到2010年底大部分省区的WFGD装机容量已经超过燃煤电厂总装机容量的75%。
- 北京50%以上燃煤电厂已经投运SCR烟气脱硝技术；上海约30%的燃煤电厂进行了烟气脱硝。但从全国范围来看，各省区燃煤机组的烟气脱硝技术投运率偏低。

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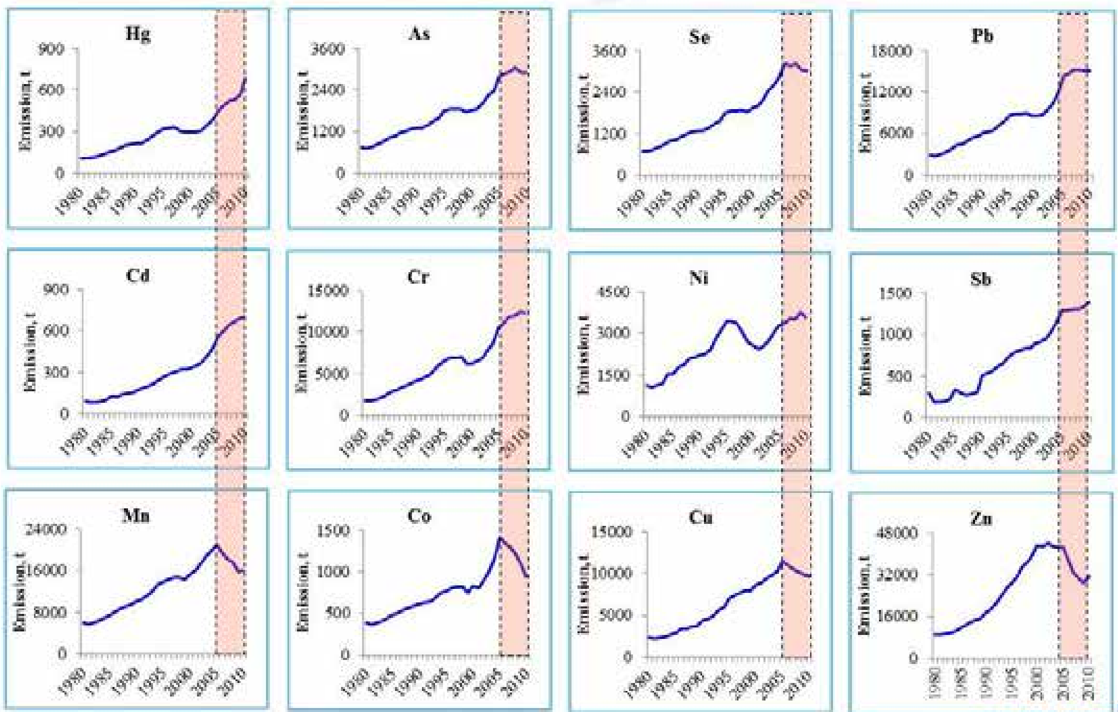
Trend of Heavy Metals Emissions，1980-2010



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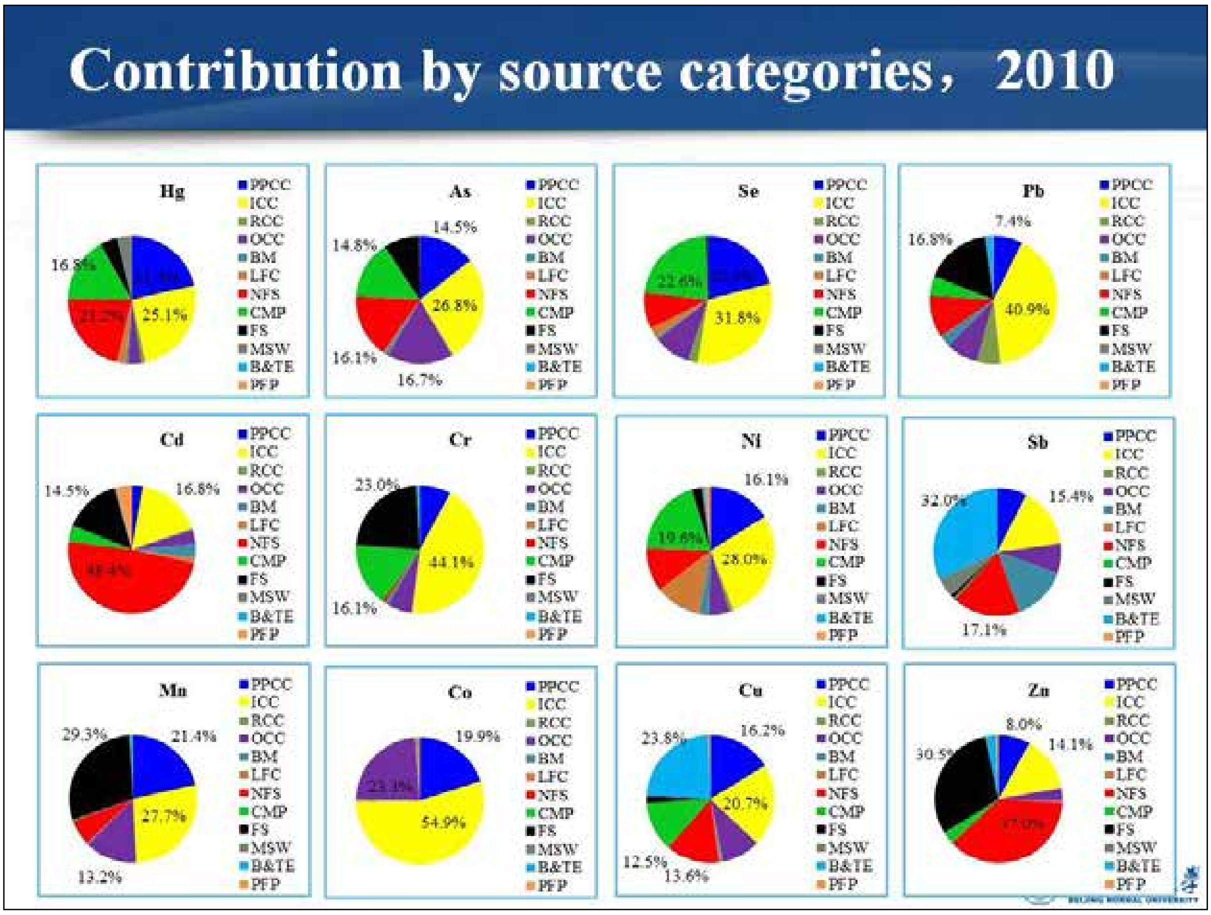
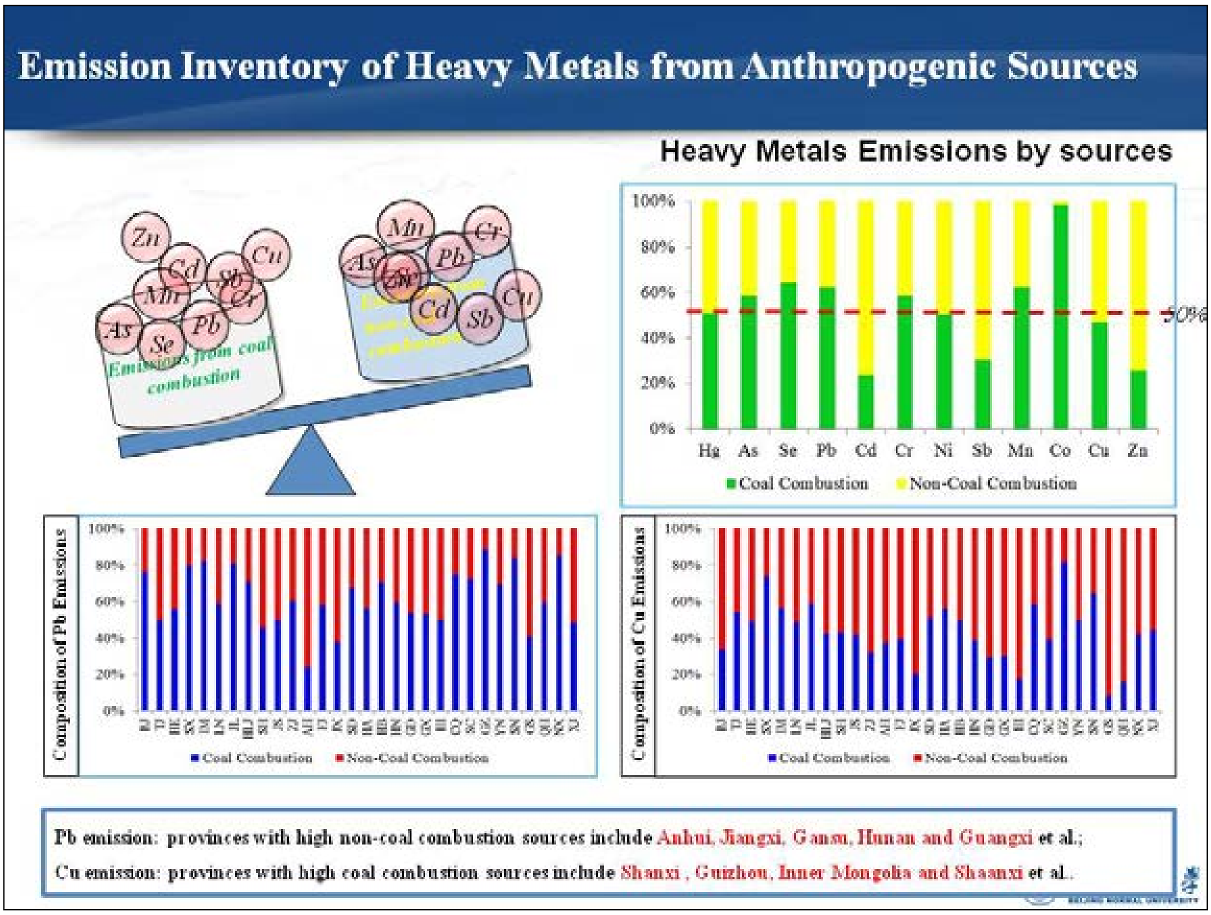
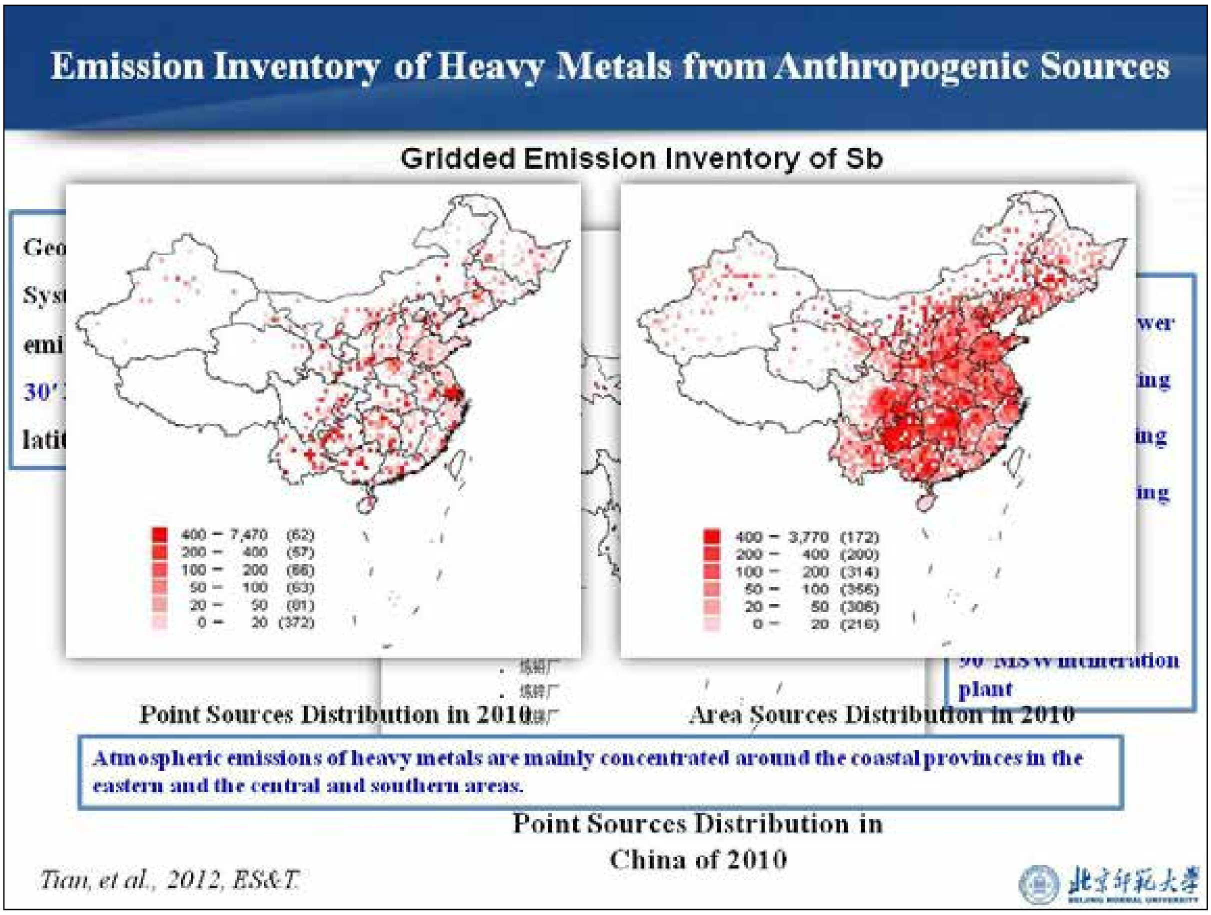

Contribution by source categories, 2010
Hg 16.8% 21.2% 25.1%
As 14.5% 14.8% 26.8% 16.1% 16.7%
Se 22.6% 31.8%
Pb 16.8% 7.4% 40.9%
Cd 14.5% 16.8% 48.4%
Cr 23.0% 44.1% 16.1%
Ni 16.1% 19.6% 28.0%
Sb 32.0% 15.4% 17.1%
Mn 29.3% 21.4% 27.7% 13.2%
Co 19.9% 23.3% 54.9%
Cu 23.8% 16.2% 20.7% 12.5% 13.6%
Zn 8.0% 14.1% 30.5% 37.0%
PPCC
ICC
RCC
OCC
BM
LFC
NFS
CMP
FS
MSW
B&TE
PFP


Emission Inventory of Heavy Metals from Anthropogenic Sources
Heavy Metals Emissions by sources
Zn Cd Cu Mn Sb Cr As Se Pb
Emissions from coal combustion
Mn Cr As Pb Se Cd Sb Cu
100% 80% 60% 40% 20% 0%
50%
Hg As Se Pb Cd Cr Ni Sb Mn Co Cu Zn
Coal Combustion
Non-Coal Combustion
Composition of Pb Emissions
Composition of Cu Emissions
Coal Combustion
Non-Coal Combustion
Pb emission: provinces with high non-coal combustion sources include Anhui, Jiangxi, Gansu, Hunan and Guangxi et al.;
Cu emission: provinces with high coal combustion sources include Shanxi , Guizhou, Inner Mongolia and Shaanxi et al..



Emission Inventory of Heavy Metals from Anthropogenic Sources
Gridded Emission Inventory of Sb
400 – 7,470 (62)
200 – 400 (57)
100 – 200 (66)
50 – 100 (63)
20 – 50 (81)
0 – 20 (372)
400 – 3,770 (172)
200 – 400 (200)
100 – 200 (314)
50 – 100 (356)
20 – 50 (306)
0 – 20 (216)
plant
Point Sources Distribution in 2010
Area Sources Distribution in 2010
Atmospheric emissions of heavy metals are mainly concentrated around the coastal provinces in the eastern and the central and southern areas.
Point Sources Distribution in China of 2010
Tian, et al., 2012, ES&T
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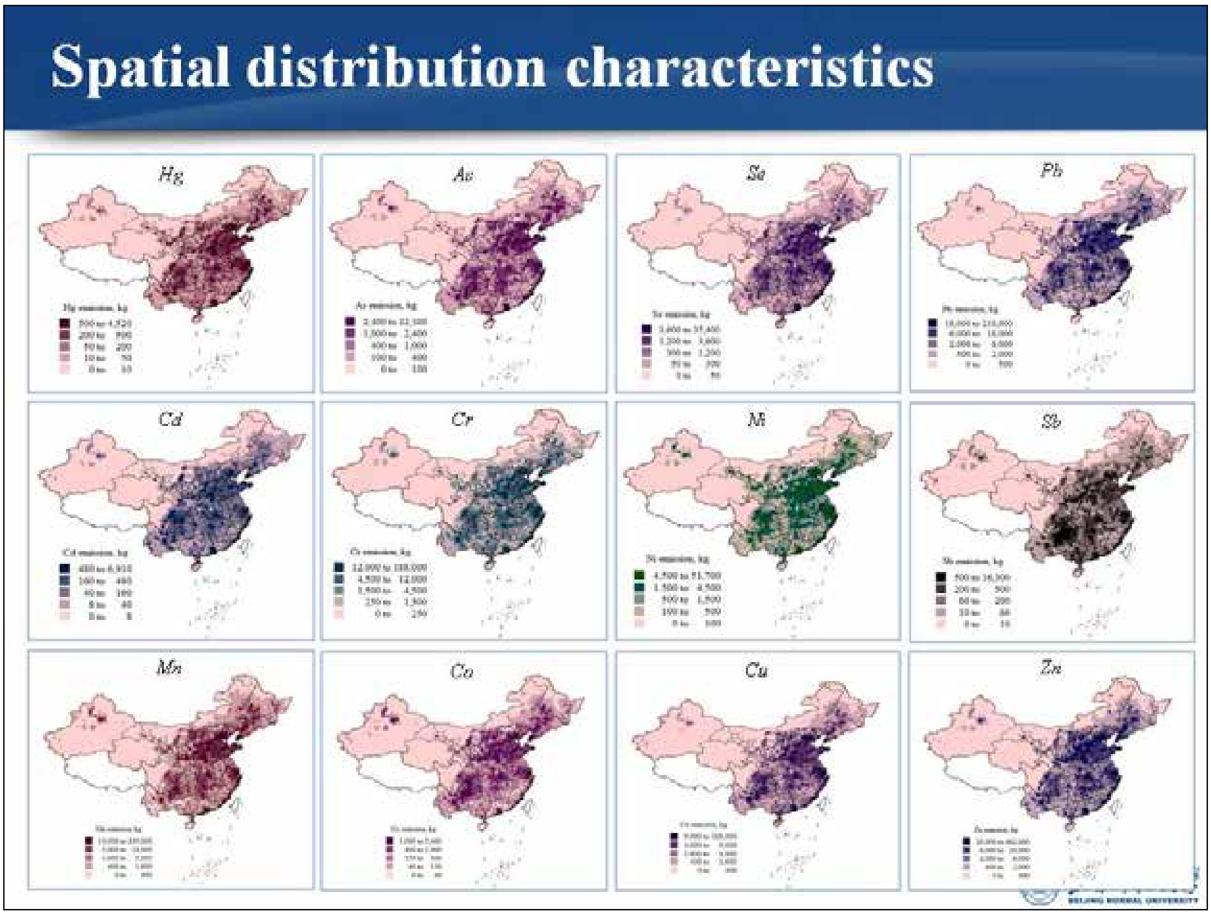
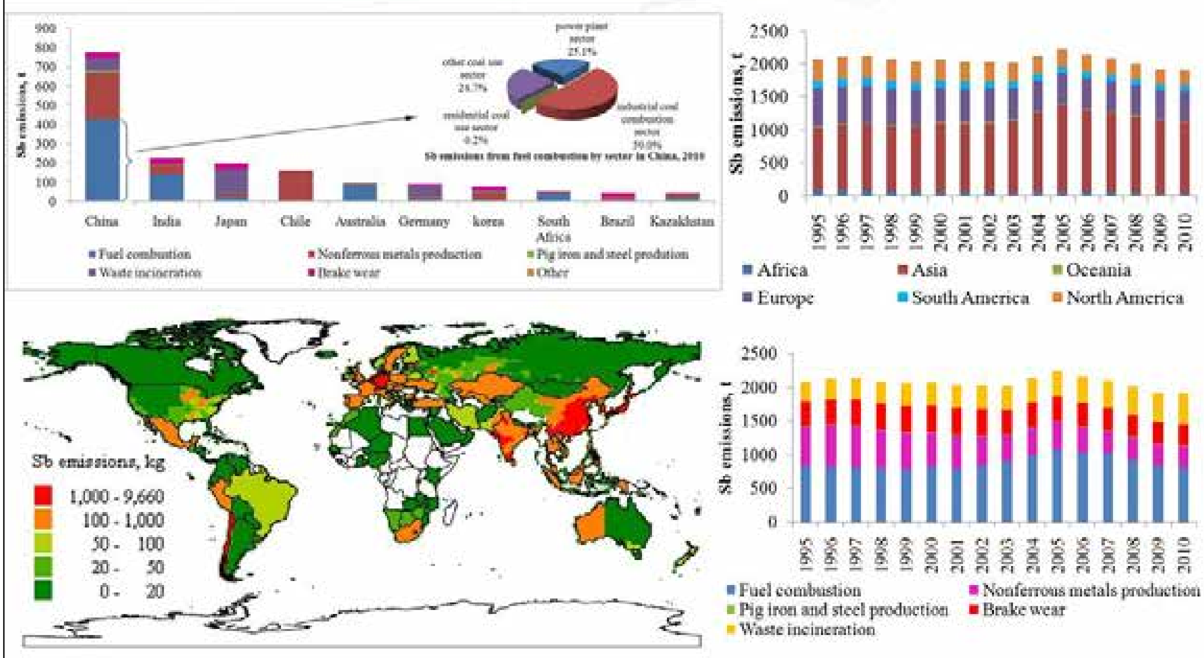


Spatial distribution characteristics
Hg
As
Se
Pb
Cd
Cr
Ni
Sb
Mn
Co
Cu
Zn

全球有毒有害重金属大气排放清单——锑（Sb）

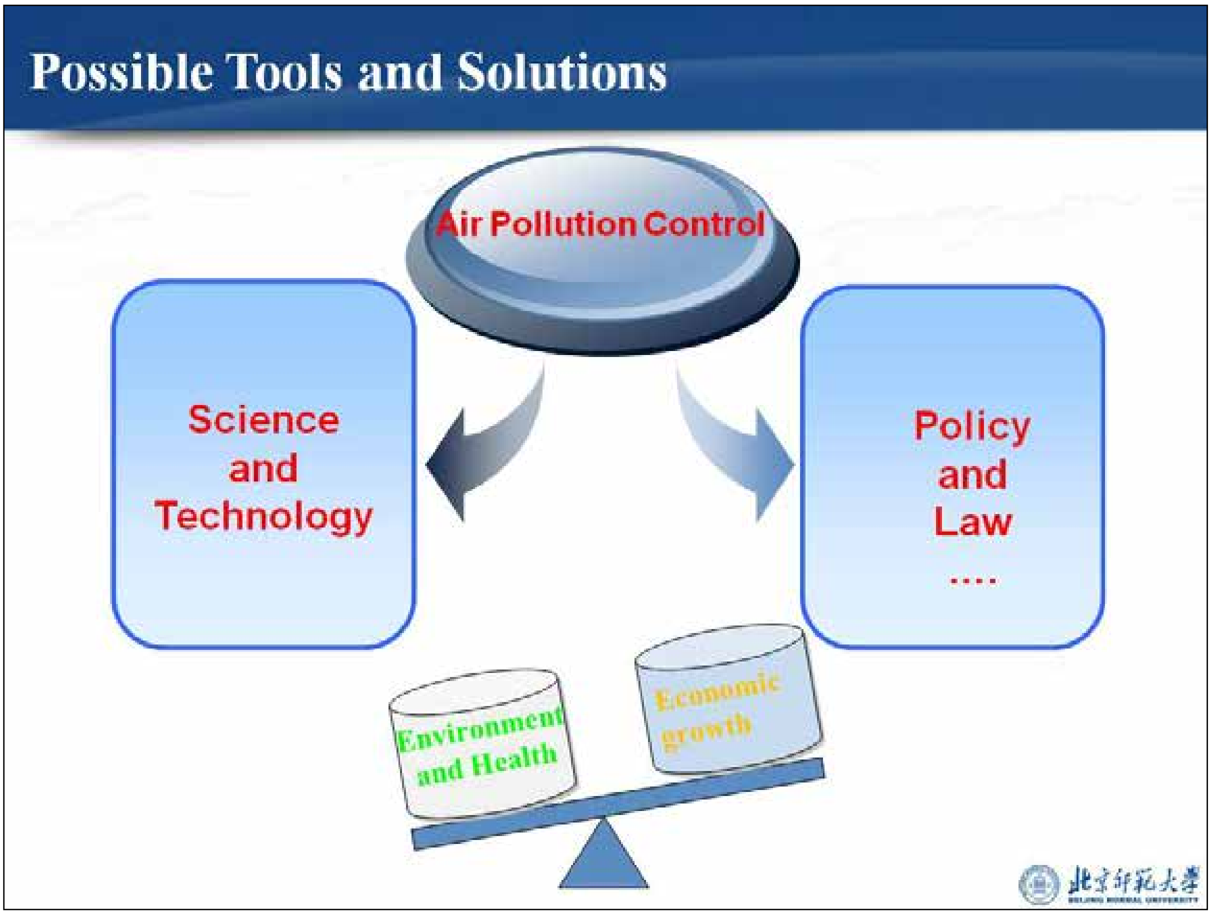
Global Sb emission inventory, 1995-2010

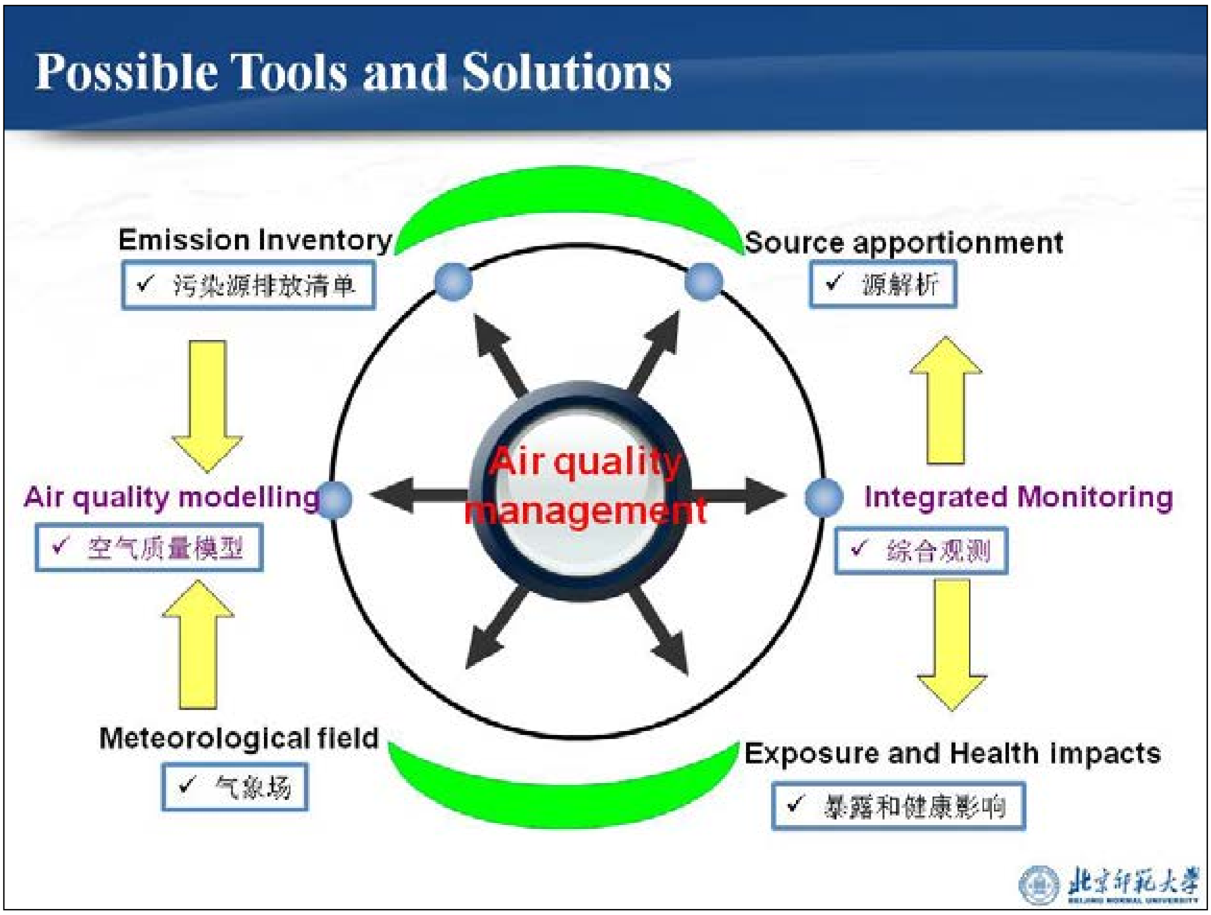


Tian et al., ES&T, 2014

OUTLINE

- Background
- Trend of National Economy in China
- Trend of Energy Output and Consumption
- Trend of Hazardous Air Pollutants Emissions
- Possible Tools and Solutions
- Concluding Remarks


Possible Tools and Solutions
Air Pollution Control
Science and Technology
Policy and Law ....
Environment and Health
Economic growth


Possible Tools and Solutions
Emission Inventory
✓ 污染源排放清单
Source apportionment
✓ 源解析
Air quality modelling
✓ 空气质量模型
Air quality management
Integrated Monitoring
✓ 综合观测
Meteorological field
✓ 气象场
Exposure and Health Impacts
✓ 暴露和健康影响

Possible Tools and Solutions

- Scientific aspect;
- Technical aspect;
- Law, regulation and standard limitation aspect;
- Policy support aspect;
- Economic incentive and penalty aspect;
- NGOs;
- Public awareness;
- Etc.;

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Roles of Partners in Air pollution Control

- Scientific community
  - Knowing what, where, how much and how to do to control regional air pollution?
- Enterprises and Industry
  - Control technologies Implementing for emission reduction
- Central and Local Government
  - Monitoring, Inspection, policymaking and Assessment
- Public and NGO
  - Awareness and participation

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Air Pollution Control from Coal Combustion Sources

Coal Combustion Source Emission Control

燃煤电厂严格排放是短期实现减排首选，但是长期看工业终端燃煤行业是控制重点

Before Combustion 燃烧前	Coal washing and transformation
During Combustion 燃烧中	Fluidized-bed boilers, low NO_X combustion, absorbents injection
Post Combustion 燃烧后	ESP, FF, De-SO_2, and De-NO_X (SCR and SNCR) devices Specialized De-HMs devices, such as ACI for Hg removal.

节能降耗是根本，优化调整能源消费结构是首选，煤炭清洁高效可持续利用是根本

中国巨大的煤炭消耗决定，必须制定世界上最严格的污染物排放标准和空气质量标准，采用最优可用技术（BACT）控制包括重大气污染物排放。

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Concluding remarks

- China is facing up to a great challenge on urban local air quality, regional acid deposition, heavily **PM2.5 and Haze**, and ground-level O_3 pollution.
- **Heavy metals** emissions such as Hg, As, Pb, Cd, and Cr, should also be highlighted owing to their health impacts.
- Advanced **multi-pollutants combined control technologies** as well as effective environmental management experiences are expected.
- **Experiences and Lessons** can be learned by international Exchange and Cooperation network, including **APN**.

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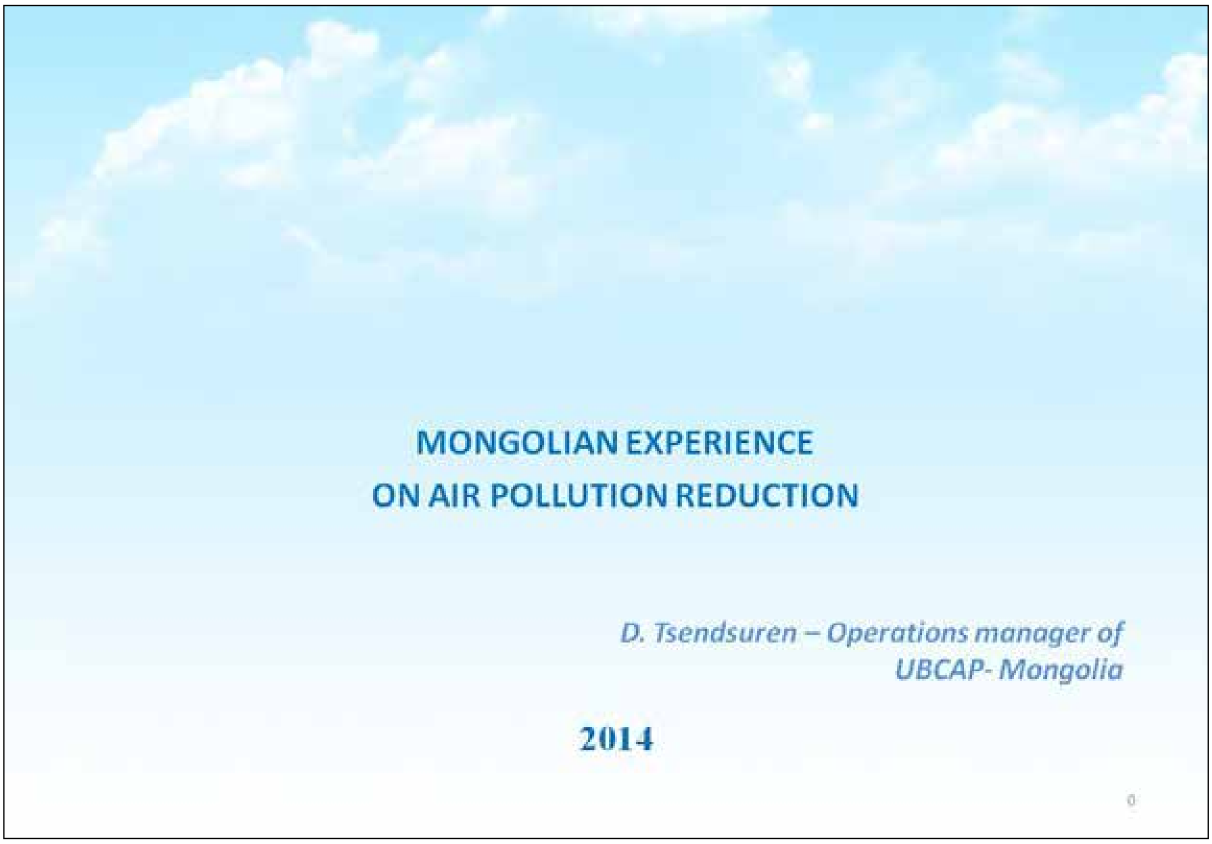
6.17 Mongolian Experience on Air Pollution Reduction (D. Tsendsuren)



CONTENTS

1

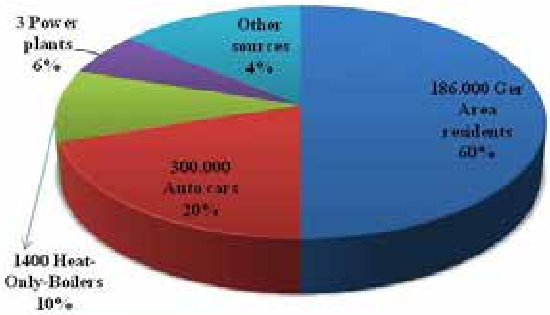
ULAANBAATAR CITY

The coldest capital city in the world ....

Territory :	4,704.4 km^2
Population:	1,278,000
Housing	40%
Ger area	60%
Density	272/km2

2

The sources of Air Pollution in Ulaanbaatar

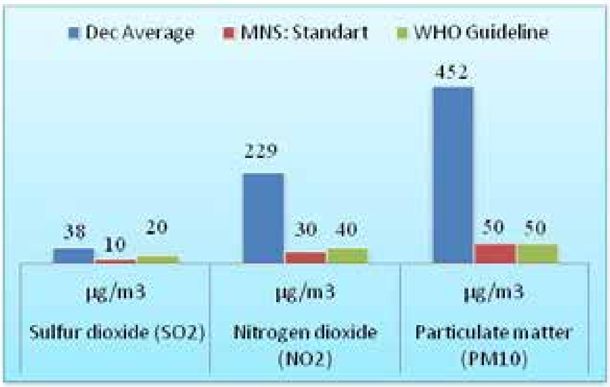


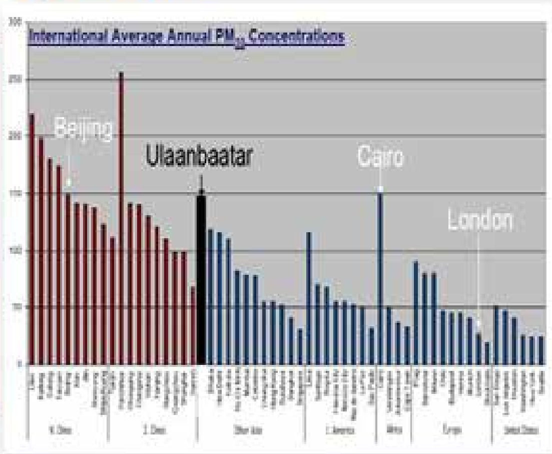
Ger area

Cars

3

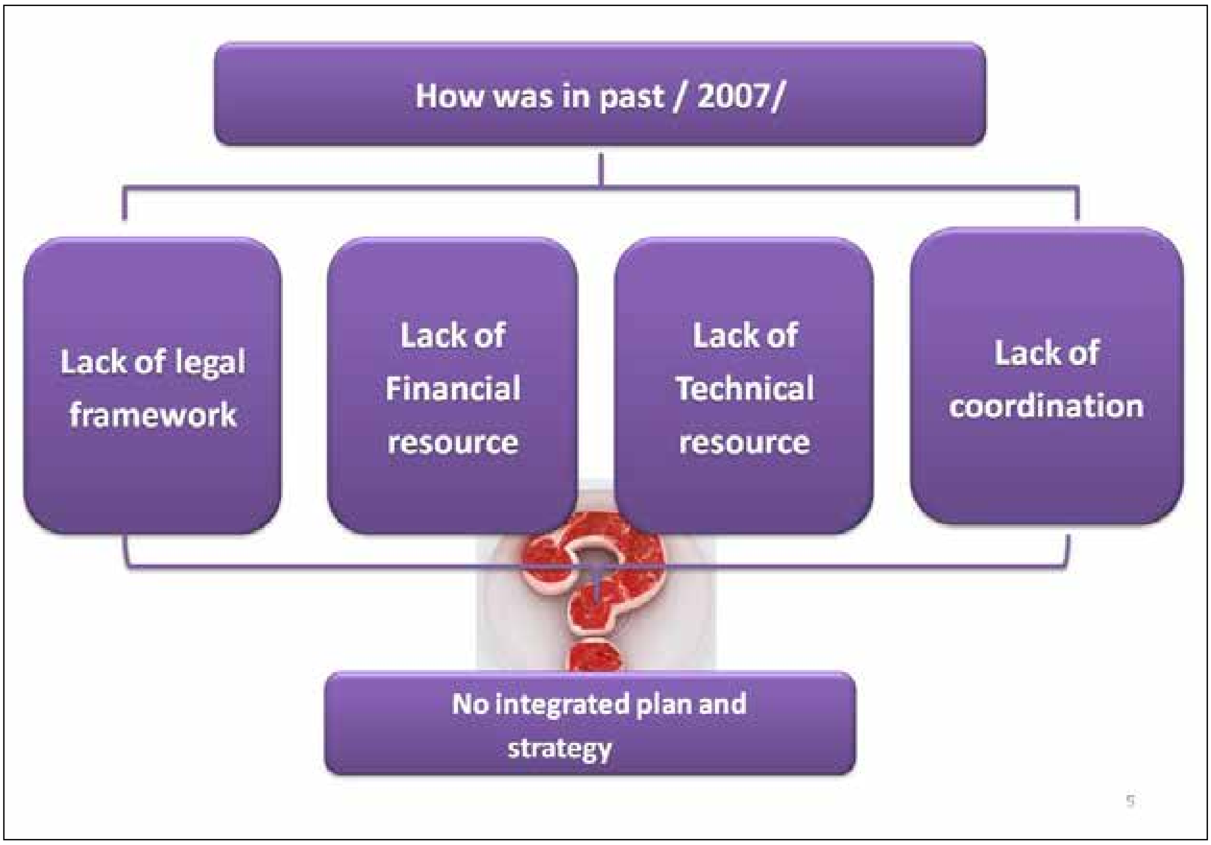
Ulaanbaatar - Air pollution

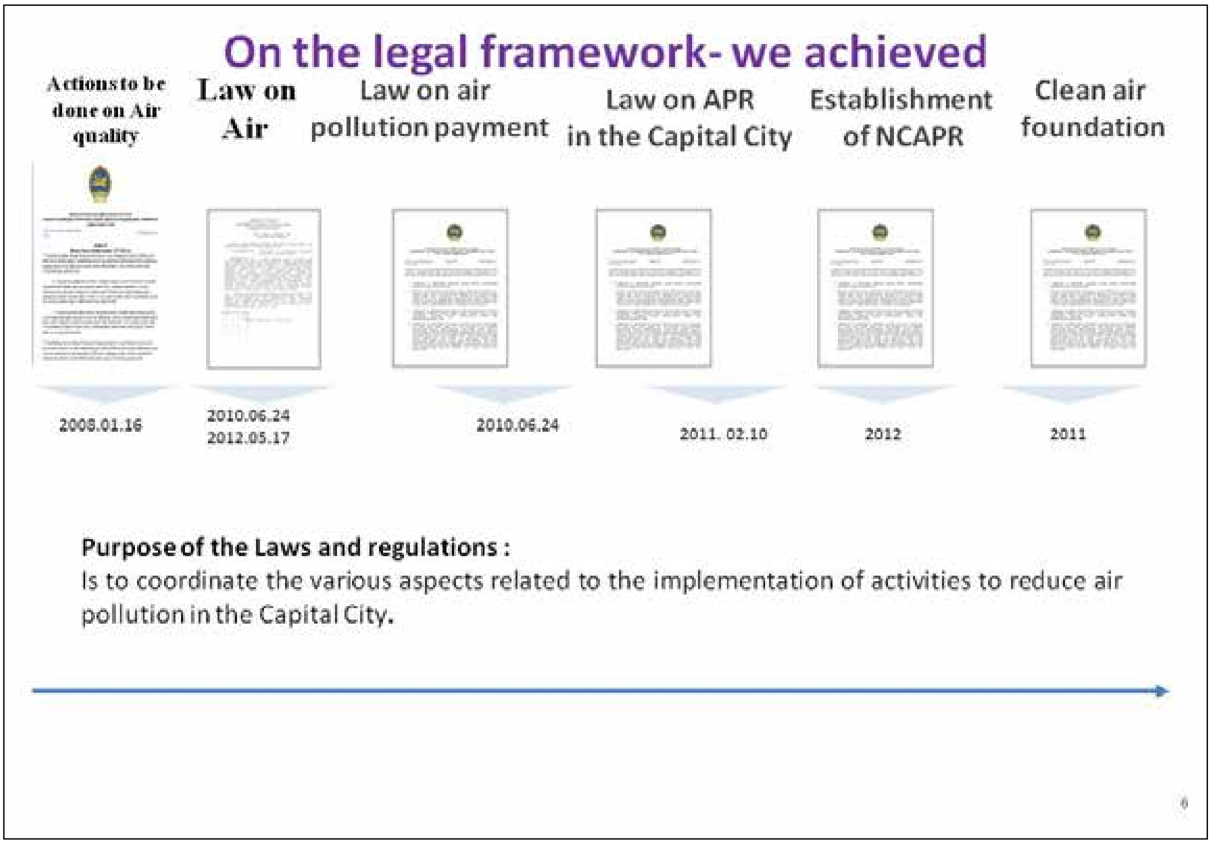


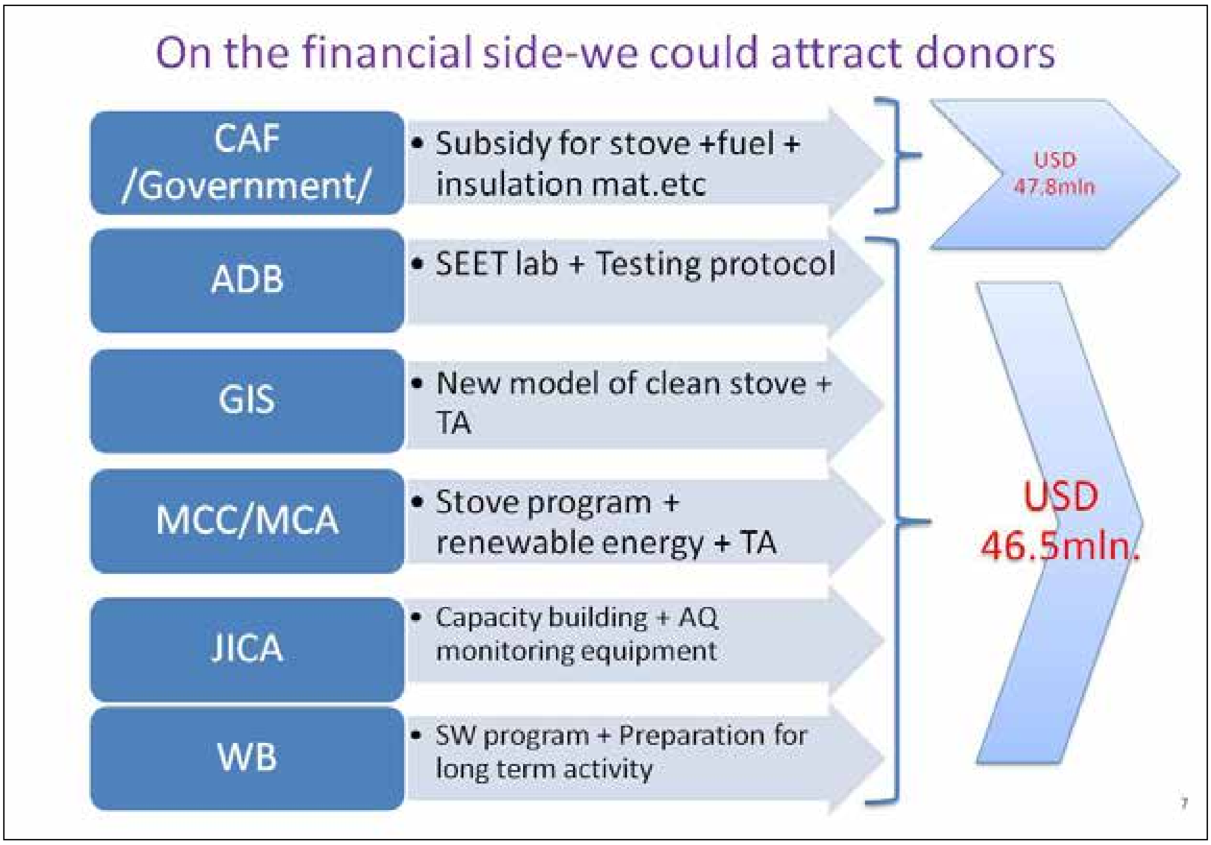


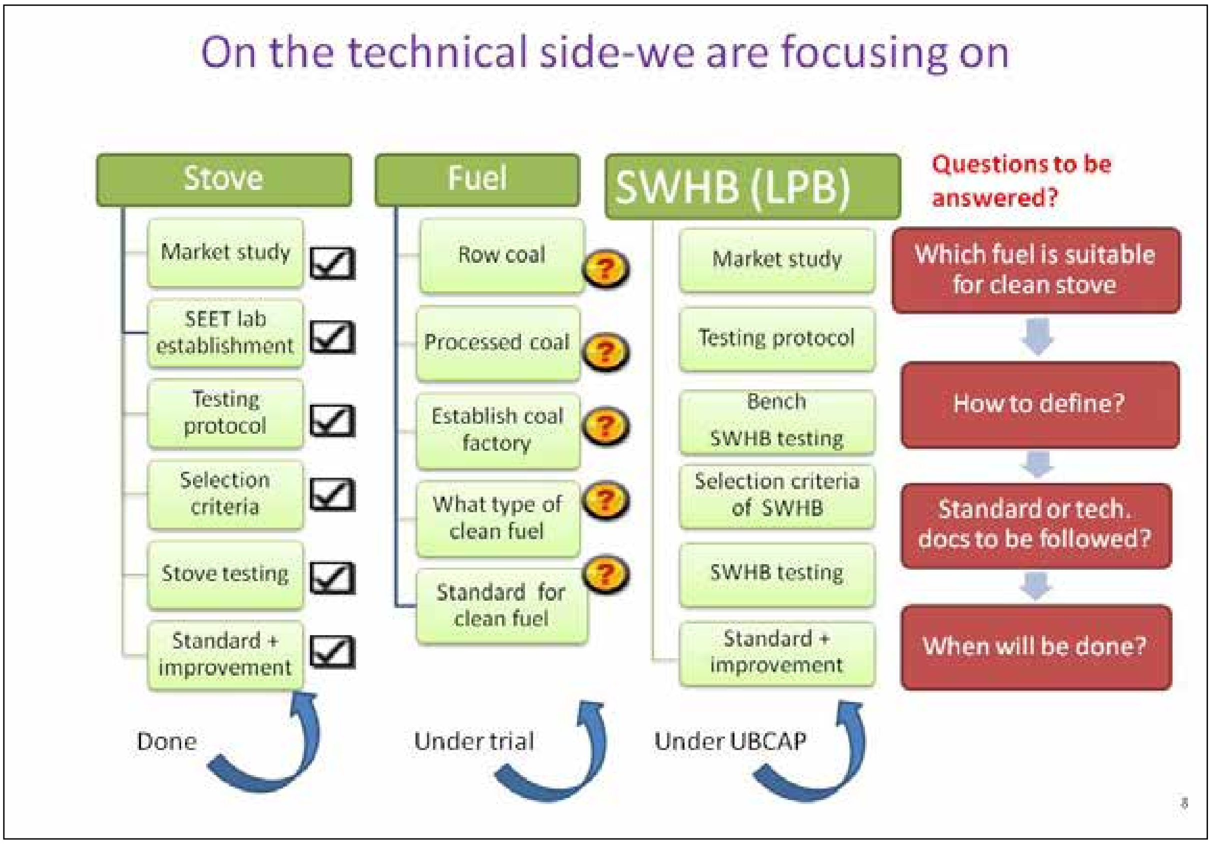
UB is the most air polluted city in the world:
The level of UB air pollution is clearly exceeds all international air pollution standards. The Ger area households' burning of raw coal is the largest contributor to the ground level pollution people inhale, which causes many severe health problems

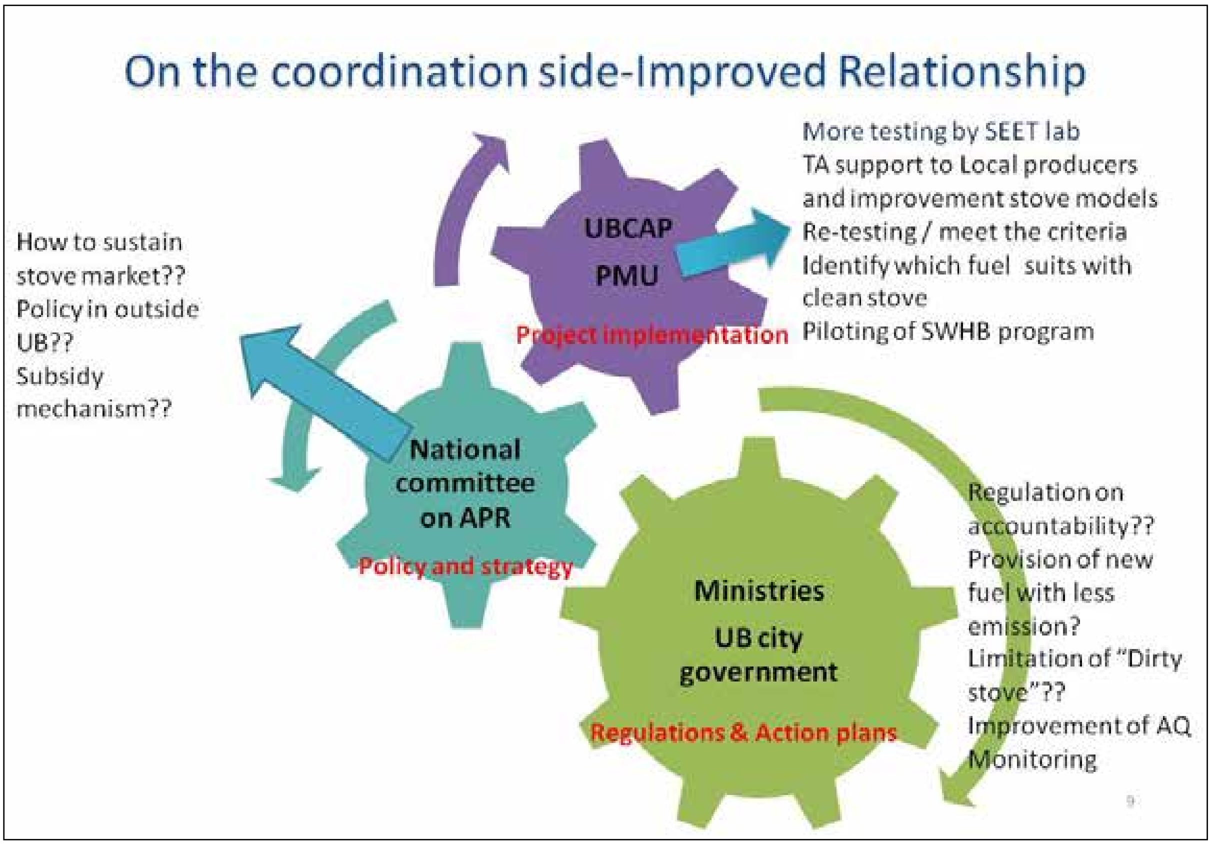
4

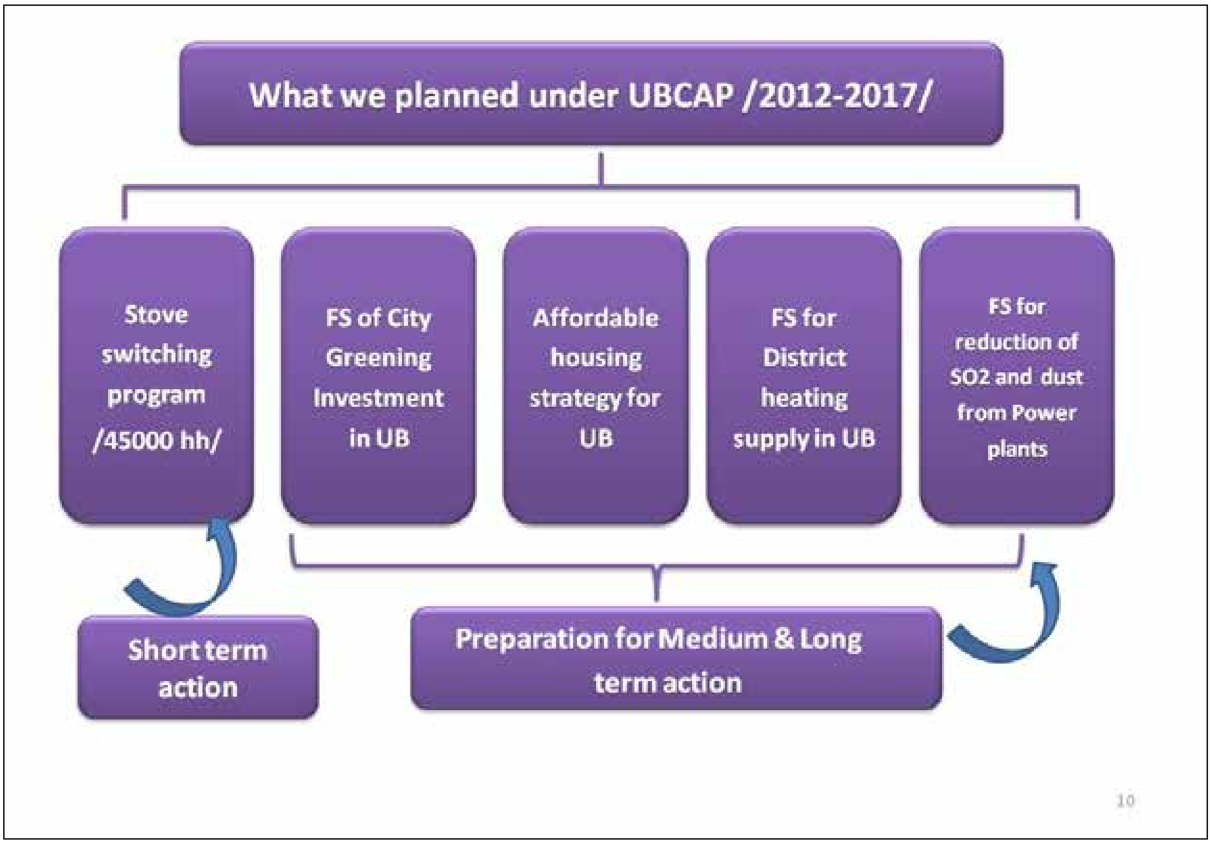

How was in past / 2007/
Lack of legal framework
Lack of Financial resource
Lack of Technical resource
Lack of coordination
No integrated plan and strategy
5


On the legal framework- we achieved
Actions to be done on Air quality
Law on Air
Law on air pollution payment
Law on APR in the Capital City
Establishment of NCAPR
Clean air foundation
2008.01.16
2010.06.24
2012.05.17
2010.06.24
2011. 02.10
2012
2011
Purpose of the Laws and regulations :
Is to coordinate the various aspects related to the implementation of activities to reduce air pollution in the Capital City.
6


On the financial side-we could attract donors
CAF /Government/
• Subsidy for stove +fuel + insulation mat.etc
ADB
• SEET lab + Testing protocol
GIS
• New model of clean stove + TA
MCC/MCA
• Stove program + renewable energy + TA
JICA
• Capacity building + AQ monitoring equipment
WB
• SW program + Preparation for long term activity
USD 47.8mln
USD 46.5mln.
7


On the technical side-we are focusing on
Stove
Market study
SEET lab establishment
Testing protocol
Selection criteria
Stove testing
Standard + improvement
Done
Fuel
Row coal
Processed coal
Establish coal factory
What type of clean fuel
Standard for clean fuel
Under trial
SWHB (LPB)
Market study
Testing protocol
Bench SWHB testing
Selection criteria of SWHB
SWHB testing
Standard + improvement
Under UBCAP
Questions to be answered?
Which fuel is suitable for clean stove
How to define?
Standard or tech. docs to be followed?
When will be done?
8


On the coordination side-Improved Relationship
How to sustain stove market?? Policy in outside UB?? Subsidy mechanism??
UBCAP
PMU
Project implementation
More testing by SEET lab
TA support to Local producers and improvement stove models
Re-testing / meet the criteria
Identify which fuel suits with clean stove
Piloting of SWHB program
National committee on APR
Policy and strategy
Ministries
UB city government
Regulations & Action plans
Regulation on accountability??
Provision of new fuel with less emission?
Limitation of "Dirty stove"??
Improvement of AQ Monitoring
9


What we planned under UBCAP /2012-2017/
Stove switching program /45000 hh/
FS of City Greening Investment in UB
Affordable housing strategy for UB
FS for District heating supply in UB
FS for reduction of SO2 and dust from Power plants
Short term action
Preparation for Medium & Long term action
10

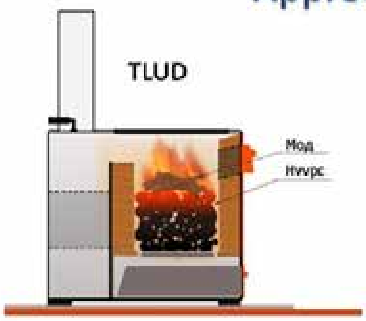
STOVE EMISSIONS AND EFFICIENCY TESTING LABORATORY

- ✓ $PM_{2.5}$ - Max 70 mg/net MJ
- ✓ CO- Max 7 g/net MJ
- ✓ Power capacity-More than 3 kw
- ✓ Thermal Efficiency-More than 70%

UBCAP

11

Approach for testing



Coal
5kg

+

Wood
500gr

- ✓ Base line-Traditional stove performance

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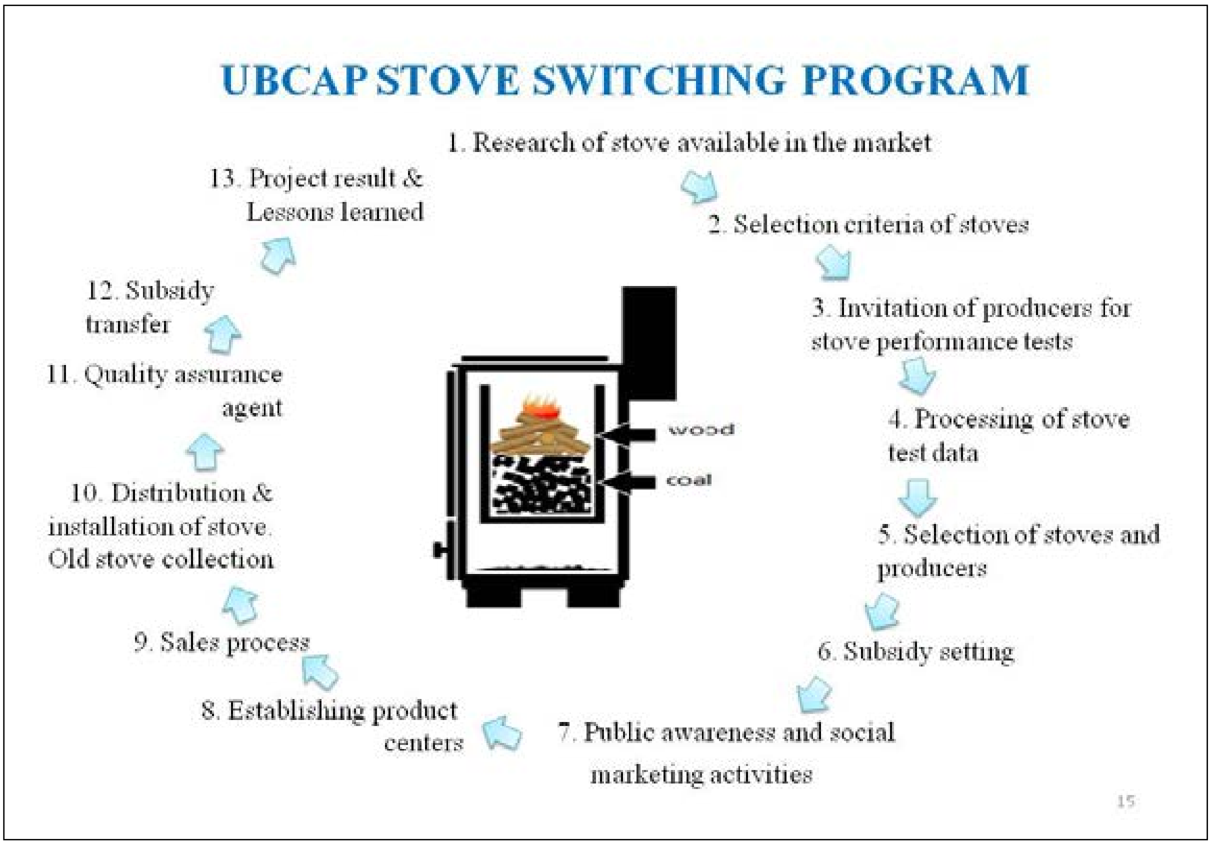
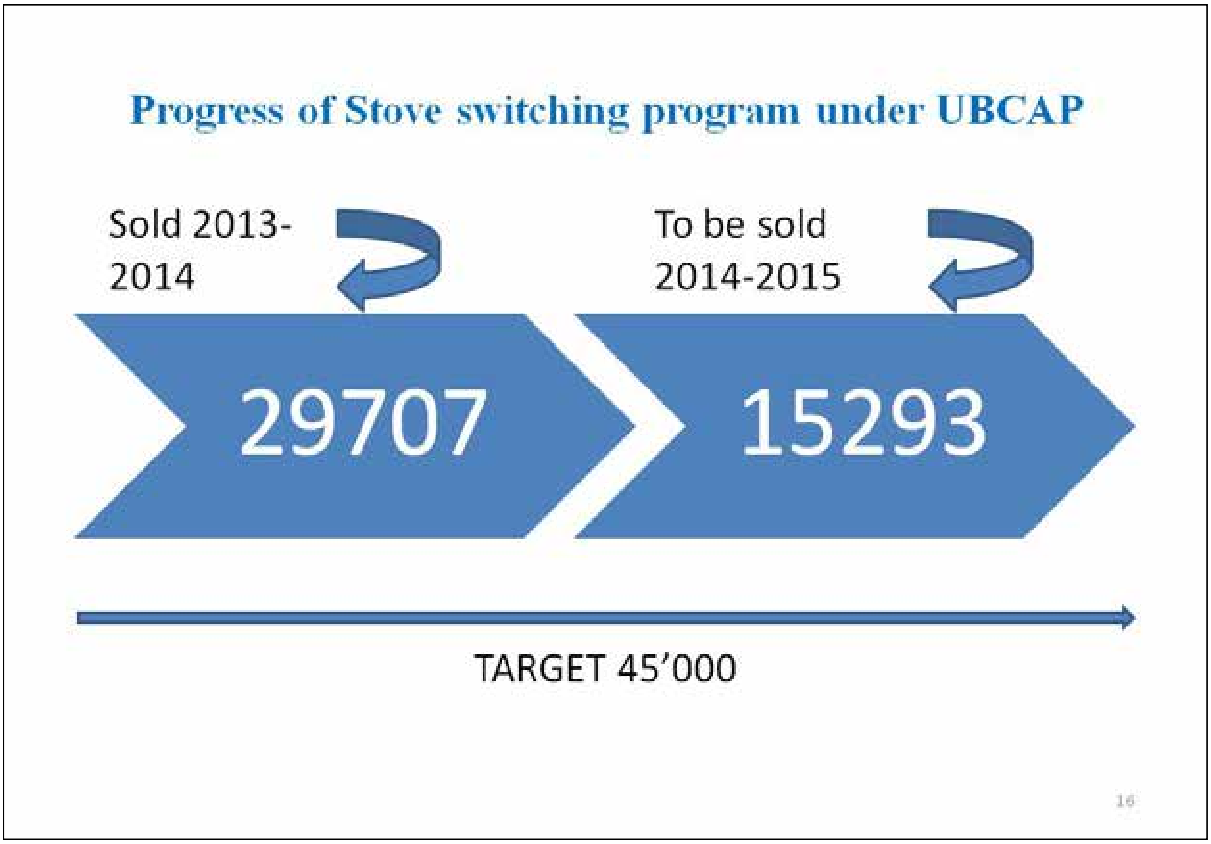
Stoves meet selection criteria in 2013 and 2014
13

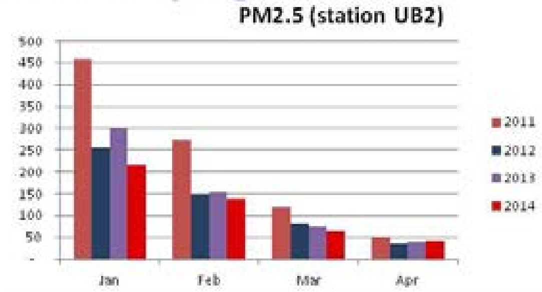

New stoves meet selection criteria in 2014

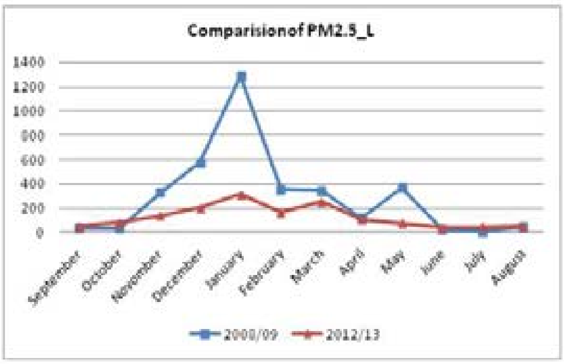

UBCAP STOVE SWITCHING PROGRAM
1. Research of stove available in the market
2. Selection criteria of stoves
3. Invitation of producers for stove performance tests
4. Processing of stove test data
5. Selection of stoves and producers
6. Subsidy setting
7. Public awareness and social marketing activities
8. Establishing product centers
9. Sales process
10. Distribution & installation of stove. Old stove collection
11. Quality assurance agent
12. Subsidy transfer
13. Project result & Lessons learned
wood
coal
15


Progress of Stove switching program under UBCAP
Sold 2013-2014
To be sold 2014-2015
29707
15293
TARGET 45'000
16

Current Results of SW program

- Government policies support a market-based, results-focused approach to stove market transformation.
- Promotes private sector supply and creates private sector jobs
- Transparent producer and product criteria,
- Autonomous testing
- Consumer subsidy (only upon installation) promotes consumer choice and competition
- Stove switching initiative yielded rapid and high penetration of low-e stoves in UB
- Average particulate matter concentrations in winter months decreased in UB /20-50% in some stations/
- Proven and reliable supply chain of low-e stoves established
- Good quality assurance system
- System for removing polluting stoves established
- Good results by any standard internationally





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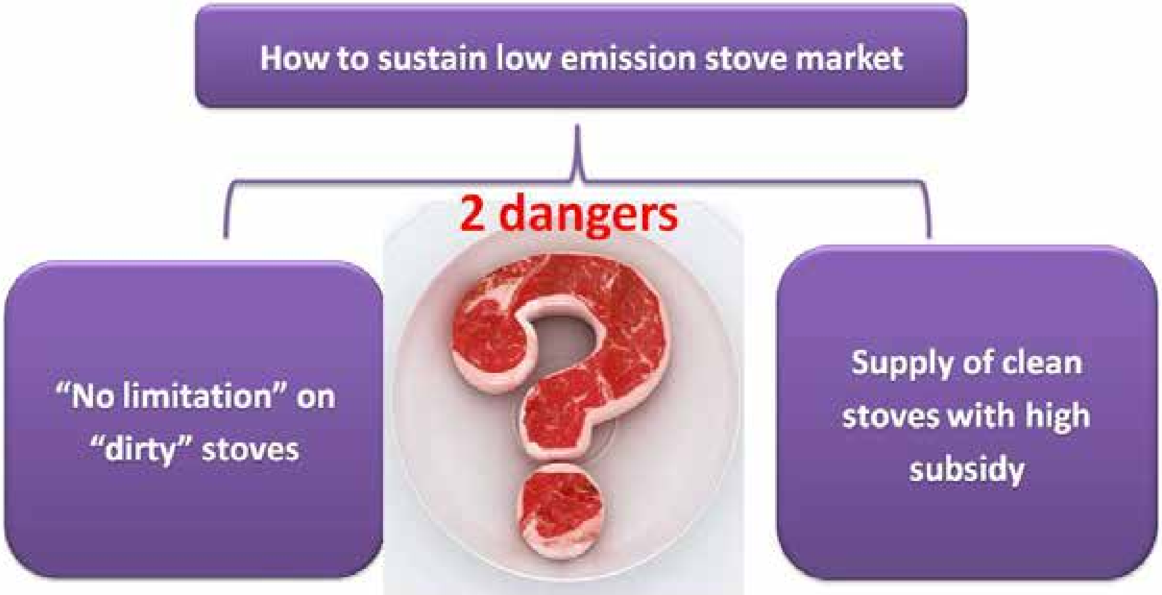

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Threats to Low-e Stove Market Sustainability

- **Parallel existence of dirty stove**
- **No local, large-scale production** of qualified and affordable stove models
- **List prices of imported stoves unaffordable** without high subsidies
- **Threat, If subsidy stops the dirty stove will dominant again**
- **Re-sale** of subsidized stoves
- **Changes in subsidy can be opposed by current low emission stove suppliers and consumers**
- **Difficulties with identifying eligible households due to weak information management system**
- **Lack of technical capacity and materials for maintenance of low-e stoves after warrantee period (some materials not available in Mongolia)**
- **Consumers have hard time breaking with traditional fuelling/cooking habits. Improper use of low-e stoves increases emissions.**
- **Regulatory and policy inconsistencies** (e.g. no penalty on re-sale of stoves)

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National Low Emission Stove Strategy

National Low Emission Stove Strategy - developed in 2014

Strategic Objective

To sustain low emission stove market and extend from UB to provincial towns.

Main principles

- Extend the market and attract the private sector participation
- Minimize government involvement
- Fixed subsidy, gradually decrease up to zero
- Decrease list price of import stoves through promoting local production
- TA Support for Local producers for new ideas

Proposed Target – 120,000 Stoves

	Year 1	Year 2	Year 3
Ulaanbaatar	15,000	15,000	15,000
Aimags	20,000	25,000	30,000

New subsidy mechanism

	Subsidy vs. dirty stove	Remark
Year 1	Lower, Fixed Subsidy No unqualified imports Import incentives for qualified units and spare parts	Subsidy 2013-93%
Year 2	Lower Subsidy No local production of unqualified models	Subsidy 2014- 66%
Year 3	Much Lower Subsidy No local production of unqualified models	Subsidy 2015 will be -33%
Year 4	Subsidy 0 Users disincentive to use traditional stove	Zero subsidy

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The Asia-Pacific Network for Global Change Research (APN) is a network of 22 member country governments that promotes global change research in the region, increases developing country involvement in that research, and strengthens interactions between the science community and policy makers.