Report for 4th Yangtze River Delta Clean Air Forum

Workshop on Ground-level Ozone Pollution Control

CLEAN AIR ASIA

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Contact

Clean Air Asia Center
Unit 3505 Robinsons Equitable Tower
ADB Avenue, Pasig City, 1605 Philippines
Tel +632 6311042
Fax +63 2 6311390
center@cleanairasia.org

Clean Air Asia China Office
11-152, JiangGuoMenWai Diplomatic Residential Compound, No.1 Xiushui Street, Beijing, 100600 China
Tel/Fax: +86 10 8532 6172
china@cleanairasia.org

Clean Air Asia India Office
1st Floor, Building No.4
Thyagraj Nagar Market
Lodhi Colony, 110003, India
Tel +91 11 60120260
Fax +91 11 43850032
india@cleanairasia.org

Country Networks in China, India, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka, Vietnam

About Clean Air Asia

www.cleanairasia.org

Clean Air Initiative for Asian Cities (Clean Air Asia) promotes better air quality and livable cities by translating knowledge to policies and actions that reduce air pollution and greenhouse emissions from transport, energy, and other sectors.

Clean Air Asia was established as the leading air quality management network for Asia by the Asian Development Bank, World Bank and USAID in 2001, and operates since 2007 as an independent non-profit organization. Clean Air Asia has offices in Manila, Beijing and Delhi, networks in eight Asian countries (China, India, Indonesia, Nepal, Pakistan, Philippines, Sri Lanka, and Vietnam) and is a UN recognized partnership of almost 250 organizations in Asia and worldwide.

Clean Air Asia uses knowledge and partnerships to enable Asia's 1,000+ cities and national governments understand the problems and identify effective policies and measures. Our four programs are: Air Quality and Climate Change, Low Emissions Urban Development, Clean Fuels and Vehicles, and Green Freight and Logistics.

The biennial Better Air Quality (BAQ) conference is the flagship event of Clean Air Asia bringing experts, policy and decision makers together to network, learn and share experiences on air quality management. Past BAQs have proven to influence policies, initiate new projects and establish partnerships.

Summary

In order to improve the capacities of controlling ozone pollution and facilitate regional technical collaboration, Clean Air Asia, Yangtze River Delta (YRD) Regional Air Quality Forecast Center, Environmental Science Research and Design Institute of Zhejiang Province, and Zhejiang Environmental Monitoring Center jointly held the *Workshop on Ground-level Ozone Pollution Control* on March 17-18, 2016 in Hangzhou, China. The two-day workshop consisted of 4 major sessions, covering ozone pollution control straregy, policy and management, research methodologies and recent findings, current status and plans of ozone pollution control inYRD, and training of pollution control of coal-fired boilers. The agenda of the meeting is provided in Annex 1.

About 120 representatives from 27 Environmental Monitoring Centers, 9 Environmental Protection Bureaus, and 4 Research Academies of Environmental Science from 15 cities (Shanghai, Hangzhou, Nanjing, Wuxi, Suzhou, etc.) in 5 provinces (Jiangsu, Zhejiang, Anhui, Jiangxi, and Liaoning), experts from well-known domestic and international universities and research institutions participated in the workshop. The participants list is provided in Annex 2.

Photo: Organizers and resource speakers at the workshop.

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1. Introduction

Since the implementation of the national "Action Plan on Air Pollution Prevention and Control" in 2013, the annual mean concentrations of $PM_{2.5}$ and PM_{10} decreased and yet ozone has become an emerging threat in the Yangtze River Delta (YRD) region. The development of more effective ozone-control strategies has been prioritized in air pollution control plans in provinces and cities in the region. In order to improve the capacities of controlling ozone pollution and facilitate regional technical collaboration, Clean Air Asia, YRD Regional Air Quality Forecast Center, Environmental Science Research and Design Institute of Zhejiang Province, and Zhejiang Environmental Monitoring Center jointly organized the *Workshop on Ground-level Ozone Pollution Control* on March 17-18, 2016 in Hangzhou, China. International and domestic experts and practitioners presented and discussed ozone control strategies, policies and management experiences, research methodologies and recent findings, and current status and plans in YRD region. A half-day training on Pollution Control of Coal-fired Boilers was also held back-to-back with the workshop.

2. Agenda and Participants

The two-day workshop consisted of 4 major sessions covering the following topics (See Annex 1 for detailed agenda):

1. Ozone pollution control straregy;
2. Ozone pollution research methodologies and recent findings;
3. Ozone pollution control status and plans in YRD; and
4. Training of pollution control of coal-fired boilers.

About 120 representatives from 27 Environmental Monitoring Centers, 9 Environmental Protection Bureaus, and 4 Research Academy of Environmental Science in 15 cities (Shanghai, Hangzhou, Nanjing, Wuxi, Suzhou, etc.) from 5 provinces (Jiangsu, Zhejiang, Anhui, Jiangxi, and Liaoning) and, experts from well-known domestic and international universities and research institutions participated in the workshop. Please see Annex 2 for participants list.

3. Proceedings

3.1 Opening Remarks

Representatives from co-organizers delivered the opening remarks: Mr. Jin Jun, Vice Director of Environmental Science Research and Design Institute of Zhejiang Province, Mr. Wang Xiaoquan, Vice Director of Zhejiang Environmental Monitoring Center, Dr. Fu Qingyan, Vice Director of YRD Regional Air Quality Forecast Center, and Dr. Fu Lu, China Director of Clean Air Asia. They expressed gratitude and welcomed all participants and partners for attending the event and emphasized the significance of ozone pollution control in the region. With great efforts on air emission control, the overall air quality of cities in YRD has continuously improved in recent years. However, ozone pollution was worsening, particularly during high ozone concentration season from May to August. The workshop aimed to support ozone pollution control in the YRD region by building the capacities of local decision-makers and technical staff.

Dr. Fu Lu introduced Clean Air Asia and expressed hope that the workshop will be able to help local environmental protection authorities make scientific decisions to tackle ozone pollution. Since 2010, Clean Air Asia has progressively developed the regional collaboration platform for technical and management capacity building in the YRD region, Pearl River Delta (PRD) region, and Northeast region, and plans to initiate such regional platform in the Southwest region in 2016.

3.2 Session 1: Ozone Pollution Control Strategy

Facilitator: Mr. JIN Jun, Vice Director of Environmental Science Research and Design Institute of Zhejiang Province.

- **Overview of California Air Pollution Control: Focusing on Ozone**
  Speaker: Catherine Witherspoon, Former Executive Officer for California Air Resources Board

Successful air pollution control is based on a profound understanding of the source, chemical formation, and transportation process. Balancing the control of nitrogen oxides (NOx) and volatile organic compounds (VOCs) – which are precursors of ozone formation – is essential to control ozone. The State of California in the US started with reducing VOCs emission in 1960s and focused on controlling NOx rather than VOCs due to higher cost-effectiveness of NOx control in recent years. Major NOx control approaches include: 1) targeting the largest remaining sources (off-road vehicles); 2) integrating freight movement system to maximize efficiency, reduce emissions, and deploy cleanest possible fuels; and 3) scrappage/replacement of older combustion equipment. As for VOCs control, major approaches include: 1) prioritizing VOCs with the highest reactivity; 2) extracting VOC co-benefits from other measures; 3) avoiding toxic and high-GWP substitutes to minimize cancer risk and reduce global warming; and 4) promoting pollution prevention at the source by adopting Leak Detective and Repair (LDAR) system.

Q&A

The Q&A discussion focused on why ozone pollution became increasingly prominent in YRD although the pollution control measures on NOx and VOCs were strengthened. Ms. Witherspoon replied that this can be attributed to poor implementation of control measures, so enforcement of control measures should be prioritized.

- **Ozone Control Strategy Development in Taiwan**
  Speaker: Professor TSAI Jiun-Horng, National Cheng Kung University, Taiwan

Taiwan formulated the plan for ozone control in 2001, aiming to reduce ozone emissions. The management strategies and plans for emission reduction are all developed through effective cooperation mechanisms between environmental protection authorities, academia, industries, and technical service suppliers (third party). The ozone control principles include: 1) all emission sources should undertake the obligations of reducing emissions; 2) integrate societal resources to reduce emissions; and 3) set up targets based on best available technologies.

Taiwan prioritizes control strategies for different sources considering economic factors. The sources having the biggest emission reduction potentials will be controlled first. To ensure the effective implementation of control measures, Taiwan periodically updates corresponding laws and regulations.

Q&A

In the Q&A session, questions associated with funding sources and responsibilities of each stakeholder for the cooperation mechanism were raised. Professor Tsai explained that pollution charges are the main funding source for ozone pollution control. The fund is divided into three categories: 1) management expenses; 2) payment for technical services; and 3) subsidies for sources for which owner companies have the willingness to take action in advance. Environmental protection authorities of cities and counties formulate the control plans and commission third parties for implementation under the support of selected experts.

3.3 Session 2: Ozone Pollution Research

Facilitator: Dr. FU Qingyan, Vice Director of YRD Regional Air Quality Forecast Center

- **Modeling for VOCs Source Apportionment**

  Speaker: Professor Philip Hopke, Clarkson University

As an important precursor of ozone and secondary organic aerosol (SOA), VOCs source apportionment is crucial to develop corresponding control strategies. VOCs sampling and analysis is the first key step. In the US, monitoring sites are built to monitor and collect samples of hydrocarbon compounds that are most related to ozone production. Automatic gas chromatographs (Auto-GCs), which provides hourly data and 24 samples per day, are highly preferred for source apportionment studies. All of the apportionment methods work on the basis of a mass balance approach. Major apportionment modeling approaches were introduced, including chemical mass balance (CMB) model, positive matrix factorization (PMF), and non-parametric regression.

Q&A

The questions raised were mainly about sampling methods and how to address the uncertainty caused by chemical reaction activity. Professor Hopke emphasized that the major concerns should be the most active compounds such as polycyclic aromatic hydrocarbons (PAHs), and sensitivity analysis is helpful for correction of results.

- **VOC Monitoring and Identification**

  Speaker: Dr. LAI Qingzhi, former Senior Project Manager, Industrial Technology Research Institute, Taiwan

In Taiwan, VOCs source monitoring and identification technologies are widely used to identify the emission sources in a certain area. The Distribution Probability Method was explained in detail by Dr. Lai. Based on pollutant emissions data and wind information monitored by stations as well as GPS maps, locations of emission sources could be estimated. The tools for VOC pollutants monitoring are shown in Table below.

Pollutants	NMHC	VOCs	VOCs
Analysis method	Flame Ionization Detector (FID)	Fourier Transform Infrared Spectrometer (FTIR)	Gas Chromatograph (GC)
Detection limits	0.1 mg/m^3	0.01 mg/m^3	0.001 mg/m^3
Equipment cost	Low	Medium	High

Dr. Lai also introduced an innovative non-methane hydrocarbon (NMHC) analysis method that uses gas with methane background concentration as chromatography carrier.

Q&A

During the discussion on application conditions of this method, Dr. Lai explained that it is an effective approach to identify fugitive emission sources in an industry park rather than high stationary sources. Road transport emissions with similar height as fugitive sources influence the monitoring data. This phenomenon can be excluded by compounds analysis since road transport pollutant species are different from that of industrial process.

- ## Recent Findings on Ozone Pollution in the Pearl River Delta

  Speaker: Professor YUAN Zibing, South China University of Technology

Professor Yuan's research showed that ozone pollution has not been addressed as successfully as other criteria pollutants in the PRD. Moreover, transboundary air pollution contributes increasingly to the ozone pollution in region. The relationship between ozone (O_3), NOx, and VOCs is driven by complex nonlinear photochemistry, which can be analyzed in Empirical Kinetic Modeling Approach (EKMA). The ozone formation mechanism in the PRD region features VOC-limited in urban areas and NOx-limited in suburb areas. As for developing ozone control strategy, Professor Yuan concluded with 4 key messages : 1) to achieve ozone attainment in VOC-limited area, NOx control is needed in addition to VOC control; 2) transition from VOC-limited to NOx-limited situation is helpful to reduce both ozone and $PM_{2.5}$ pollution; 3) reducing both NOx and VOCs at an equal ratio can be considered as a long-term control strategy for ozone attainment in the PRD region; and 4) localized high-resolution and continuously updated emission inventory plays an important role in ozone modeling and control strategy development.

Q&A

City representatives from YRD and Northeast (NE) requested Professor Yuan to diagnose the photochemical formation characters of their cities. Professor Yuan clarified that an area cannot be simply defined as VOC-limited or NO-limited due to the complexity of ozone-VOC-NOx chemical mechanisms. The profile might change along with the meteorological and local emission factors. He emphasized the importance of co-control of NOx and VOC, because NOx reduction without co-control of VOCs emission in VOC-limited area can increase the concentration of ground level ozone.

- ## Ground Level Ozone Pollution in Shanghai and the Yangtze River Delta

  Speaker: Dr. FU Qingyan, Deputy Director, YRD Regional Air Quality Forecast Center / Shanghai Environmental Monitoring Center

In the YRD region, the air quality of the cities had continuously improved in 2015 in terms of increasing attainment days and decreasing concentrations of criteria pollutants except ozone. Ozone pollution was worsening, particularly from May to August in North and Central areas. Overall, majority of cities in YRD are VOCs-sensitive. Petrochemical industry and mobile sources are primary ozone sources. Moreover, meteorological factors such as high temperature and low humidity in summer also lead to ozone pollution. Dr. Fu provided recommendations on regional ozone monitoring and study: 1) strengthen studies on co-control of $PM_{2.5}$ and O_3, VOCs, and NOx, urban and rural areas, as well as cross-provincial transboundary control; 2) establish regional photochemical air pollution monitoring system; 3) develop monitoring guidelines and regulations for VOCs; 4) set up uniform QA/QC procedures for regional ozone monitoring; and 5) promote YRD regional emission inventory developing and air quality data sharing.

Q&A

The Q&A focused on how to use balloon carrying monitoring devices to monitor vertical variation and maximum air pollutants concentration. Ideally, the balloon movement route will be designed based on the air quality modeling observations to maximize the effectiveness of monitoring.

3.4 Section 3: Clean Air Action for YRD

Facilitator: Mr. WANG Xiaoquan, Vice Director of Zhejiang Environmental Monitoring Center

- **Ozone Management Control Program in Bay Area, California, US**
  Speaker: Jack Broadbent, Chief Executive Officer, Bay Area Air Quality Management District (BAAQMD)

The current regulatory program in the Bay Area covers comprehensive abatement measures on all sources, and NOx reduction is prioritized to address the $PM_{2.5}$ problem. Stationary NOx controls are implemented in power plants, boilers, and industrial operations by adopting low NOx burners, selective catalytic reduction (SCR) and Non-SCR equipment, and fuel switching. As for mobile sources controls, California has a local program which complements State Motor Vehicle Control Program. All categories of vehicles (i.e. light duty to heavy duty, on-road and off-road vehicles), are addressed. Although ozone has not attained federal standard or California standard, the NOx concentration continued to decrease in the last 35 years.

Q&A

The questions addressed to Mr. Broadbent were mainly about the basis of policy making as well as the institutional structure of air quality management (AQM) authorities. In the US, AQM policy making is based on the findings of health impact research, such as tightening the ambient ozone limit value. A good example is BAAQMD's great efforts on pollution control for truck and non-road sources, due to findings on diesel particulate matter carcinogenicity. With regards to the institutional structure, BAAQMD is quite different from China's top-down style wherein the BAAQMD was established by state law as the oldest local AQM authority. He explained how BAAQMD, as an independent management organization, cooperates with the federal and state government on finance. Most funds of BAAQMD are from permit fees and penalties; it also receives funds from federal and state government. The amount differs depending on economic conditions. BAAQMD is supervised by state law to make sure it fully performs the function.

- **Ozone Pollution Study and Control Strategy for Zhejiang**
  Speaker: WU Jian, Senior Engineer / Director of Air Department, Environmental Science Research and Design Institute of Zhejiang Province

Based on the ozone pollution characterization and trends of precursor emissions, Mr. Wujiang proposed suggestions for ozone control in Zhejiang in the 13^{th} Five Year Plan period: 1) strengthen management of mobile sources, particularly, focusing on fuel upgrading and promotion of clean fuel vehicles; 2) promote comprehensive control of industrial VOCs throughout the whole production process and develop systematic emission standards; 3) enhance regional collaboration by joint enforcement, regional environmental information sharing, etc.; and 4) provincial government should provide more funding for program implementation.

Q&A

The participants asked the mode of management for VOCs monitoring and control. Mr. Wu explained that Zhejiang started promoting third-party service development. The provincial government covers the cost of VOCs monitoring at the current piloting stage, but enterprises need to invest in their own pollution control devices.

- **Ozone Pollution Study and VOCs Control in Jiangsu**
  Speaker: ZHANG Xiangzhi, Deputy Director, Jiangsu Environmental Monitoring Center

Ms. Zhang Xiangzhi shared approaches and suggestions for VOCs control in Jiangsu Province. 1) compile localized high resolution emission inventory for VOCs; 2) develop more systematic laws, regulations and standards for different industries; 3) enhance VOCs control and LDAR application in more industries and chemical industry zones; 4) construct platform for air quality advisories in industrial parks; and 5) install online monitoring equipment in key polluted enterprises.

Q&A

The questions to Ms. Zhang were mainly on VOCs control policies of chemical industry parks as well as regional transportation of ozone pollution. Ms. Zhang clarified that VOC monitoring for Jiangsu's industry park not only focuses on stationary sources of factories but also concerns fugitive emissions. She also emphasized that the environment management office should take the lead in implementation of control measures. Ozone monitoring and analysis results showed that local emissions are the primary cause of ozone pollution, albeit, the regional pollution also plays an important role under certain meteorological conditions.

- **Establishment and Practice of Regional Air Forecasting and Alerting System in Zhejiang**
  Speaker: TIAN Xudong, Senior Engineer / Director of Automatic Monitoring Department, Zhejiang Environmental Monitoring Center

Zhejiang has set up a monitoring network for complex air pollution and multi-mode forecasting system for regional air quality forecasting and alerting. The monitoring network includes regional stations, urban stations, mobile stations, super stations, background stations, and remote sensing stations. Meanwhile, the forecasting system uses updated emission inventory and various modeling methods to forecast and report air quality.

Q&A

The discussion focused on meteorological data as basis for accuracy of air quality forecasting results. Mr. Tian shared that meteorological data is very important to air quality forecasting, although, the data sharing mechanism between meteorological department and environmental monitoring department has not been established yet in the province. Forecasting accuracy will be improved by refining emission inventory and meteorological data.

- **Clean Air Management of Hangzhou**
  Speaker: LAO Xinxiang, Deputy Director, Hangzhou Environmental Protection Bureau

Mr. Lao introduced Hangzhou's clean air actions to control multiple emission sources, including industrial exhaust, dust, vehicle, cooking exhaust, and industry structure adjustment. As a result, air quality has been improved in terms of increasing attainment days and decreasing $PM_{2.5}$ concentrations; the annual mean of $PM_{2.5}$ decreased 18.7% in 2015 (compared to 2013). Mr. Lao concluded with key factors of AQM success in Hangzhou: 1) Air Office at the city level coordinates all air pollution control-related government authorities such as Environment Protection Bureau and Development and Reform Commission. and 2) monthly air quality ranking system and management performances review is effective, because it is linked with annual bonus of responsible officials.

Q&A

The questions to Mr. Lao were about the details of air quality ranking system and management performances review. Mr. Lao explained that the performance is evaluated based on both air quality and clean air action plan implementation progress.

3.5 Section 4: Training on Coal-fired Boilers Pollution Control

Facilitator: Dr. WAN Wei, China Program Manager, Clean Air Asia

- **CAA Capacity Building Activities**
  Speaker: Dr. WAN Wei, China Program Manager, Clean Air Asia

CAA focuses on providing capacity building opportunities for cities to address their actual needs in air pollution control. CAA has recently launched the document Guidance Framework for Better Air Quality in Asian Cities to implement the long term vision for urban air quality in Asia. The document provides cities with concrete and realistic roadmaps to help them fully develop their AQM capacity, and Clean Air Asia will support cities and countries for the implementation of the Guidance Framework. In China, CAA also provides training courses and technical workshops, city twinning platform, annual report documenting China progress of tackling air pollution, online help-desk, onsite expert guidance and study tours, and global experts resources.

- **Super Clean Techniques Development for Coal-fired Power Plants in China**
  Speaker: Professor GAO Xiang, Zhejiang University

Professor Gao Xiang from Zhejiang Univeristy presented ultra-low emission technologies (ULET) development and application in coal-fired power plants. The coal-dominant energy structure and lack of natural gas drove the ULET development in China. ULET is adopted in coal-fired power plants to control emissions of sulfur oxides (SOx), NOx, dust, mercury (Hg), the emissions of which can be as low as gas combustion. ULETs application methods for desulfurization, dinitration, dedust were introduced.

Q&A

The discusson focused on the cost-effectiveness of ultra-low emission technologies with relatively higher marginal cost comparing to other pollution control measures. Professor Gao suggested that ultra-low emission technologies have been proven to be very effetive and should be the solution not only for power plants but also for other industry emission sources.

- **Clean Boilers Technologies**
  Speakers: Professor LUO Yonghao, Shanghai Jiaotong University and Dr. QIN Hongbo, Shanghai Energy Efficiency Center

A variety of 'coal-to-biomass' technologies such as air staged combustion and selective non-catalytic reduction, and 'coal-to-gas' technologies such as gas distributed energy supply, carbon dioxide (CO_2) heat pump as well as application cases were introduced by the two experts (See more details on clean boilers technologies in the training course material at the link: http://www.allaboutair.cn/a/px/xt/2016/0325/406.html).

- **City Experiences Sharing: Urumqi and Shanghai**
  Speakers: Ms. RUI Lihong, Vice Director, Urumqi Environmental Protection Bureau and Mr. ZHANG Gangfeng, Senior Engineer, Shanghai Research Academy of Environmental Science

Through policy formulation, scientific and rational implementation plan development, and sufficient funding support, Urumqi's 'coal-to-gas' retrofit program resulted in gas/total heating area ratio increasing from 20% to over 80%, 5 million tons of reduction in coal conumption, as well as emission reduction of 35,000 tons of SO_2 and 17,000 tons of dusts. During the heating season, concentration of $PM_{2.5}$ decreased from 202μg/m^3 in 2009 to 147 μg/m^3 in 2015.

Shanghai has successfully completed the coal-to-gas retrofit program by 2015 through establishing cross-sectoral collaboration mechanism, selecting best available technologies, as well as enhancing publicity and strengthening enforcement. Over 2000 coal-fired boilers were retrofitted and 321km^2 became no-coal combustion areas.

Q&A

The questions to Urumuqi and Shanghai presentations were mainly about the air quality improvement and effectiveness of coal-to-gas retrofit program. Both Urumqi and Shanghai have not conducted the program evaluation, but the overall air quality trends and emission reduction estimation have showed the success of retrofit program.

3.6 Closing

The closing session was chaired by Dr. Fu Lu, China Director of Clean Air Asia. She gave a presentation to summarize the workshop. She highlighted the key points raised by the audience as well as suggestions from experts. Based on participants' feedback, Clean Air Asia will continue providing tailored technical support in the YRD region in the future.

4. Conclusion

The workshop served as a platform for capacity building and information exchange among cities and different stakeholders in the YRD region. Clean Air Asia conducted a survey to collect the workshop feedback, as well as management and technical needs to better understand the detailed support that should be provided to the YRD region in the next year. 36 valid questionnaires were collected and amongst 36 respondents, 100% regarded the workshop as highly helpful to their daily work. As for the half-day coal pollution control training, 100% respondents assessed that the workshop meets their needs for coal-fired boilers retrofit management. The evaluation scores for clean boilers technology and Urumqi and Shanghai experiences sharing were all above 4 (i.e. scored as 1 to 5, 5 as the highest). Seventy-two percent of respondents identified VOCs control while 50% of respondents identified source apportionment for suggested future technical training deliveries.

Experts and participants provided the following suggestions to address the ozone pollution issue in term of control strategy and research in the YRD region:

- Successful air pollution control is based on a profound understanding of the source, chemical formation, and transportation process. Balancing the control of NOx and VOCs, which are precursors of ozone formation, is essential to control ozone. NOx reduction without co-control of VOCs emission in VOC-limited area can increase the concentration of ground-level ozone. VOC control can be effective to decrease the high values of ozone concentration in short term, but attainment of ozone standards will need NOx control in the long term, which is more cost-effective and feasible .
- The management strategies and plans for emission reduction should be developed through effective cooperation mechanisms between environmental protection authorities, academia, industries, and technical service suppliers (third party). It is also important to develop ozone control policies based on health impact research findings.
- Regional collaboration is very essential to address the ozone issue considering the chemical reaction complexity and transportation of ozone pollution. It is recommended to establish regional photochemical monitoring network, conduct regional zone modeling, and share emission inventories and monitoring data. Compiling localized high resolution emission inventory and monitoring data is needed for ozone modeling and control strategy development.

Annex 1: Agenda

(Day 1)	
08:30–9:00	Sign in
09:00–09:40	**Opening Remarks** By organizers
Part I: Ozone Pollution Control Strategy	
09:40–10:20	**Overview of California Air Pollution Control: Focusing on Ozone** By Catherine Witherspoon, Former Executive Officer for California Air Resources Board
10:20 –10:40	Q&A
10:40–11:00	Group Photo & Tea Break
11:15–11:45	**The Experience on Ozone Control Strategy Development in Taiwan** By Professor TSAI Jiun-Horng, National Cheng Kung University, Taiwan
11:45–12:00	Q&A
12:00-13:00	Lunch
Part II: Ozone Pollution Research	
13:00–13:45	**Modeling for VOCs Source Apportionment** By Professor Philip Hopke, Clarkson University
13:45–14:00	Q&A
14:00–14:45	**VOC Monitoring and Source Analyzing** By Dr. LAI Qingzhi, former Senior Project Manager, Industrial Technology Research Institute, Taiwan
14:45–15:00	Q&A
15:00–15: 15	Tea Break
15:15–16:00	**Recent Findings on Ozone Pollution in the Pearl River Delta** By Professor YUAN Zibing, South China University of Technology
16:00–16:15	Q&A
16:15–17:00	**Ground Level Ozone Pollution in Shanghai and the Yangtze River Delta** By Dr. FU Qingyan, Deputy Director, YRD Regional Air Quality Forecast Center / Shanghai Environmental Monitoring Center

17:00–17:15	Q&A
17:15–17:30	**Closing of the day**
17:30	Dinner
(Day 2)	
Part I: Clean Air Action for YRD	
08:30-09:00	**Ozone Management Control Program in Bay Area, California, US** By Jack Broadbent, Chief Executive Officer/Air Pollution Control Officer for the Bay Area Air Quality Management District
09:00-09:10	Q&A
09:10-09:40	**Ozone Pollution Study and Control Strategy for Zhejiang** By WU Jian, Senior Engineer / Director of Air Department, Environmental Science Research & Design Institute of Zhejiang Province
09:40-09:50	Q&A
09:50-10:20	**Ozone Pollution Study and VOCs Control in Jiangsu** By ZHANG Xiangzhi, Deputy Director, Jiangsu Environmental Monitoring Center
10:20-10:30	Q&A
10:30-10:45	Tea Break
10:45-11:15	**Establishment and Practice of Regional Air Forecasting and Alerting System in Zhejiang** By TIAN Xudong, Senior Engineer / Director of Automatic Monitoring Department, Zhejiang Environmental Monitoring Center
11:15-11:25	Q&A
11:25-11:55	**Clean Air for Hangzhou** By LAO Xinxiang, Deputy Director, Hangzhou Environmental Protection Bureau
11:55-12:05	Q&A
12:05-13:00	Lunch
Part II: Training on Coal-fired Boilers Pollution Control	
13:00-13:30	**Launch CAA Capacity Building Activities**

	By Clean Air Asia
13:30-14:00	**Super Clean Techniques Development for Coal-fired Power Plants in China** By Professor GAO Xiang, Zhejiang University
14:00-14:20	Q&A
14:20-14:50	**Coal Boiler to Biomass Boiler** By Professor LUO Yonghao, Shanghai Jiao Tong University
14:50-15:10	Q&A
15:10-15:30	Tea Break
15:30-16:00	**Coal Boiler to Gas/Oil Boiler** By Dr. QIN Hongbo, Senior Engineer / Director of Strategy Development Department, Shanghai Energy Saving Centre
16:00-16:20	Q&A
16:20-16:50	**City Experiences on Coal Boiler Pollution Control: Urumqi** By RUI Lihong, Deputy Director, Urumqi Environmental Protection Bureau
16:50-17:00	Q&A
17:00-17:30	**City Experiences on Coal Boiler Pollution Control: Shanghai** By ZHANG Gangfeng, Senior Engineer, Shanghai Research Academy of Environmental Science
17:30-17:40	Q&A
17:40-18:00	**Closing**
18:00	Dinner

Annex 2: Participants List

Name	Organization
Jack Broadbent	Bay Area Air Quality Management District
Catherine Witherspoon	Climate Works Foundation
Philip K. Hopke	Clarkson University
TSAI Jiun-Horng	National Cheng Kung University, Taiwan
LAI Qingzhi	Industrial Technology Research Institute, Taiwan
YUAN Zibing	South China University of Technology
GAO Xiao	Zhejiang University
LUO Ronghao	Shanghai Jiao Tong University
QIN Hongbo	Shanghai Energy Efficiency Center
RUI Lihong	Urumqi Environmental Protection Bureau
ZHANG Gangfeng	Shanghai Academy of Environmental Sciences
FU Qingyan	Shanghai Environmental Monitoring Center
DUAN Yusen	Shanghai Environmental Monitoring Center
WANG qian	Shanghai Environmental Monitoring Center
ZHANG Yihua	Shanghai Environmental Monitoring Center
LIN yanfen	Shanghai Environmental Monitoring Center
HUANG Ruizhu	Shanghai Environmental Monitoring Center
SHENG Tao	Shanghai Environmental Monitoring Center
ZHAO Qiaobiao	Shanghai Environmental Monitoring Center
WU Shijian	Shanghai Environmental Monitoring Center
SHA Fei	Shanghai Environmental Monitoring Center (Pudong District)
ZHOU Zhong	Shanghai Environmental Monitoring Center (Pudong District)
ZHANG Feifang	Shanghai Environmental Monitoring Center(Hongkou District)
FENG Ruijun	Shanghai Environmental Monitoring Center(Hongkou District)
MA Hui	Shanghai Environmental Monitoring Center (Minxing District)
LUO Jianting	Shanghai Environmental Monitoring Center (Qingpu District)
CHEN Donghong	Shanghai Environmental Monitoring Center (Qingpu District)

Name	Organization
SONG Qiang	Shanghai Environmental Monitoring Center (Songjiang District)
MAO Jie	Shanghai Environmental Monitoring Center (Songjiang District)
YE Feng	Shanghai Environmental Monitoring Center (Changning District)
ZHANG Qiaojun	Shanghai Environmental Monitoring Center(Changning District)
YI Xuewen	Shanghai Environmental Monitoring Center(Jinshan District)
NI Chaoqiong	Shanghai Environmental Monitoring Center(Jinshan District)
LIU Li	Shanghai Environmental Monitoring Center(Baoshan District)
LI Ming	Shanghai Environmental Monitoring Center(Baoshan District)
GUAN Qingyu	Shanghai Environmental Monitoring Center(Jiading District)
WANG Xiao	Shanghai Environmental Monitoring Center(Jiading District)
GU Yinqi	Shanghai Environmental Monitoring Center(Fengxian District)
LU Xiaoyi	Shanghai Environmental Monitoring Center(Fengxian District)
JIN Jun	Environmental Science Research & Design Institute of Zhejiang Province
WU Jian	Environmental Science Research & Design Institute of Zhejiang Province
WANG Qiongzhen	Environmental Science Research & Design Institute of Zhejiang Province
ZHOU Yanyi	Environmental Science Research & Design Institute of Zhejiang Province
ZHOU Lei	Environmental Science Research & Design Institute of Zhejiang Province
WU Dian	Environmental Science Research & Design Institute of Zhejiang Province
JIN Jun	Environmental Science Research & Design Institute of Zhejiang Province
WANG Xiaoquan	Zhejiang Provincial Environmental Monitoring Center
TIAN Xundong	Zhejiang Provincial Environmental Monitoring Center
LAI Yinzhi	Zhejiang Provincial Environmental Monitoring Center
ZOU Qiaoli	Zhejiang Provincial Environmental Monitoring Center
XU Shengchen	Zhejiang Provincial Environmental Monitoring Center
LAO Xinxiang	Hangzhou Environmental Protection Bureau
ZHEN Xianyu	Hangzhou Environmental Monitoring Center
CHEN Chao	Hangzhou Environmental Monitoring Center
SHEN Jiandong	Hangzhou Environmental Monitoring Center
YIN Fang	Hangzhou Environmental Monitoring Center
YE Hui	Hangzhou Environmental Monitoring Center

Name	Organization
WANG Xiaoyuan	Hangzhou Environmental Monitoring Center
HONG Shenmao	Hangzhou Environmental Monitoring Center
CHEN Zhijiang	Hangzhou Environmental Monitoring Center (Yuhang District)
DU Zheng	Hangzhou Environmental Monitoring Center(Yuhang District)
ZHANG Xingmao	Yiwu Environmental Protection Bureau
LUO Yang	Yiwu Environmental Protection Bureau
GAO Xunfeng	Jinhua Environmental Monitoring Center
QIU Yiyan	Jinhua Environmental Protection Bureau
ZHANG Jie	Jiaxing Environmental Protection Bureau
SUN Dalin	Jiaxing Environmental Protection Bureau
ZHANG Lin	Taizhou Environmental Science Institute
SHEN Ji	Huzhou Environmental Protection Bureau
JI Wenjin	Wenzhou Environmental Science Institute
ZHAO Shu	Zhoushan Environmental Bureau
YAO Ye	Zhoushan Environmental Bureau
ZHANG Xiangzhi	Jiangsu Provincial Environmental Monitoring Center
ZHANG Lin	Jiangsu Provincial Environmental Monitoring Center
QIN Wei	Jiangsu Provincial Environmental Monitoring Center
TANG Chengbo	Jiangsu Provincial Environmental Monitoring Center
TANG Lili	Jiangsu Provincial Environmental Monitoring Center
YANG Xue	Jiangsu Provincial Environmental Monitoring Center
LU Weiqin	Jiangsu Provincial Environmental Monitoring Center
DU Yuanxin	Wuxi Environmental Monitoring Center
DONG Mei	Wuxi Environmental Monitoring Center
XIA Jin	Changzhou Environmental Monitoring Center
LI Chunyu	Changzhou Environmental Monitoring Center
LIU Zhiqiang	Changzhou Environmental Science Institute
SUN Kai	Changzhou Environmental Science Institute
ZHOU Meichun	Changzhou Environmental Science Institute
YANG Lili	Nanjing Environmental Monitoring Center

Name	Organization
LIU Xiaobo	Nanjing Environmental Monitoring Center
RUAN Xiaojie	Suzhou Environmental Monitoring Center (Wuzhong District)
ZOU Qiang	Suzhou Environmental Monitoring Center
WU Yezheng	Suzhou Environmental Monitoring Center
JIANG Rong	Nantong Environmental Monitoring Center
WANG Qianming	Kunshan Environmental Protection Bureau
WAN Zhiyong	Jiangxi Provincial Environmental Monitoring Center
XU Changren	Jiangxi Provincial Environmental Monitoring Center
LI Xiufeng	Jiangxi Provincial Environmental Monitoring Center
XIAO Nanjiao	Jiangxi Provincial Environmental Monitoring Center
LIU Hui	Jiangxi Provincial Environmental Monitoring Center
DONG Hao	Anhui Provincial Environmental Monitoring Center
WEI Zhen	Anhui Provincial Environmental Monitoring Center
YANG Yonghong	Urumqi Environmental Monitoring Center
LIN Chao	Dalian Environmental Protection Bureau
YANG Song	Dalian Environmental Protection Bureau
BAO Yanying	Dalian Environmental Monitoring Center
XU Jie	Dalian Environmental Monitoring Center
LIU Bing	China National Environmental Monitoring Center
WANG Xiaoyuan	China National Environmental Monitoring Center
FU Lu	Clean Air Asia
Kaye Patdu	Clean Air Asia
WAN Wei	Clean Air Asia
ZHANG Weihao	Clean Air Asia
WANG Qiuxia	Clean Air Asia
LIU Mingming	Clean Air Asia
WANG Sihang	Clean Air Asia