Capacity Development Programme on Air Quality Management and Emission Reduction of PM2.5 for Member Countries of ASEAN Haze Agreement and Malé Declaration

19-23 September 2022

Workshop Report

Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for Member Countries of ASEAN Haze Agreement and Malé Declaration

19-23 September 2022

Organized by:

Regional Resource Centre for Asia and the Pacific
Asian Institute of Technology
& Partners

At

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Pathum Thani, Thailand

website: http://www.rrcap.ait.ac.th/apn2022/

Workshop Report

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FOREWORD

Dr. Guilberto Borongan
Director
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Air pollution is a real and severe problem in Asian countries, especially in the countries of South Asia and Southeast Asia. The majority population in these countries is exposed to a high level of air pollution emitted from cause by burgeoning urbanization, industrialization, transport, power generation, and open burning of agricultural residual and municipal solid waste. The high level of air pollution is causing severe impacts on human health, economies, and the environment.

Although countries of South Asia and Southeast Asia are making sincere efforts in addressing air pollution issues including emission reduction of air pollutants, however, most countries are lacking the technical capacities required for efficient management of air quality including knowledge of cost-effective and technical advances in air quality management. In order to assist the countries of South Asia and Southeast Asia in building technical capacities for air quality management, the Regional Resource Centre for Asia and the Pacific at the Asian Institute of Technology (AIT RRC.AP), along with partners, implemented a 2-year project on the "Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for ASEAN Countries" with funding support from the Asia-Pacific Network for Global Change Research (APN). I sincerely appreciate and thank the APN for providing financial support for a capacity-building project on air quality management which countries of the region required the most.

The second workshop of the project on air quality management and $PM_{2.5}$ emission reduction was organized during 19-23 September 2022, physically at the Asian Institute of Technology, Pathum Thani, Thailand. Participants from member countries of the Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia (South Asia) and

the ASEAN Agreement on Transboundary Haze Pollution (Southeast Asia) were invited to the workshop. I am pleased to mention here that 55 participants representing 17 Asian countries, including 8 South Asian (member countries of the Malé Declaration) and 9 Southeast Asian (member countries of the ASEAN Haze Agreement) and partner organizations participated in the 5-day workshop, which covered all aspects of air quality management including air quality monitoring, emission inventory development, air quality modeling, impact assessment, air pollution mitigation policies and action plans through classroom technical presentations, practical sessions, and the field visits.

I extend my sincere thanks to all participants, Air Quality Monitoring Laboratories at AIT and Air Quality Laboratories at the Environmental Research and Training Center (ERTC) and Pollution Control Department (PCD), the Ministry of Natural Resources and Environment, Thailand, for providing practical training on air quality monitoring and emission testing. Also, I extend sincere thanks to all resource persons for their valuable contributions to the workshop.

This was a rare occasion when policymakers, air quality scientists, and technical staff of member countries of the two intergovernmental organizations, namely, the Malé Declaration and the ASEAN Haze Agreement, gathered for a common goal of learning together for improving air quality in the region. I strongly believe that the participants greatly benefited from the workshop as their understanding of air quality management significantly enhanced after the workshop. I am pleased to see the detailed report on the workshop, which summarized the proceedings and evaluation of participants on their enhanced understanding and knowledge of air quality management.

FOREWORD

Mr. Ryuji Tomisaka
Director
Asia-Pacific Network for Global Change Research (APN) Secretariat
Japan

Under its capacity development programme, the Asia-Pacific Network for Global Change Research (APN) granted funds to the Regional Resource Centre for Asia and the Pacific (RRC.AP) located at the Asia Institute of Technology, Thailand, for a project titled "Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for Member Countries of ASEAN Haze Agreement and Malé Declaration," which addresses a critical need identified by APN and aligns closely with the priorities of the APN Southeast Asia Subregional Committee.

This workshop report is the second of two workshops held to strengthen the capacity of the ASEAN countries on air quality management and $PM_{2.5}$ emission reduction, September 19-23, 2022, and organized by the RRC.AP and partners. This report summarizes the results of the session organized by the workshop extended the invitation to the signatories of the Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia, in addition to the ASEAN Agreement on Transboundary Haze Pollution. A total of 55 participants, including 35 representatives from member countries, one from the ASEAN Secretariat, nine resource persons, and other participants from AIT and partner institutions, attended the 5-day Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$.

In many Asian cities and countries, increasing emissions of air pollutants from urbanisation, industry, construction, road traffic, home cooking, open burning of agricultural residues, and municipal waste has resulted in deteriorating health of the population and slow progress in achieving the SDGs. In addition

to human health, this is a major loss to the economic burden on the national health insurance budgets of countries and to agricultural productivity.

As in many countries that have to overcome air pollution, there is a need to monitor and measure the sources of air pollution, develop emission inventories, models/tools to assess impacts and their countermeasures, and ensure effective air pollution mitigation policies. Monitoring technologies have been evolving day by day in recent years, including the development of simultaneous observation and publication techniques due to the advancement of networking, improved satellite observation techniques for air pollutants in line with the observation and measurement of greenhouse gases, and regional model optimization for air quality modeling. We believe that the workshop provided the participants with the best current knowledge and experience in air quality monitoring, emissions inventorying, air quality modeling, air pollution impact assessment, and policy measures for air pollution mitigation during the 5-day workshop. The present report contains information that will be of assistance to everyone who reads it.

We also thank the Air Quality Monitoring Lab at AIT and the Air Quality Labs at ERTC and PCD for understanding the purpose of this workshop and welcoming us to visit their labs. We thank Ms. Dang Espita-Casanova, Mr. J. S. Kamyotra, Dr. Md Firoz Khan, Dr. Johan C.I. Kuylenstierna, Prof. Kim Oanh, Dr. Ittipol Pawarmart, Dr. Didin Agustian Permadi, Dr. Arthit Phosri, Dr. Supat Wangwongwatana, and Dr. Ekbordin Winijkul.

APN, a network focused on promoting collaborative research, capacity development, and science-policy connections in the Asia-Pacific region, is pleased to support and endorse this workshop report, which contributes to the region's efforts to monitor and manage air quality, mitigate climate change, and reduce emissions through action-oriented capacity building, collaborative research, and science-informed policymaking. We, at APN, hope that fellow researchers, the general public and policymakers in the Member Countries of the ASEAN Haze Agreement and the Malé Declaration and other Asian regions will find this workshop report and proceedings useful.

FOREWORD

Mr. Somsak Sappakosonkul
Director-General
Department of Environmental Quality Promotion
Ministry of Natural Resources and Environment
The Royal Thai Government

Air pollution is serious problem in worldwide, especially $PM_{2.5}$ which is transboundary pollutant, impacting human health and is an urgency to address seriously. Thailand has also set the $PM_{2.5}$ problem as a national agenda and all agencies have to implement the National Agenda Action Plan. We would like to express our deepest gratitude to the Asia-Pacific Network for Global Change Research (APN) for funding and generous support, and the Regional Resource Center for Asia and the Pacific (RRC.AP) for hosting the workshop on "Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for Member Countries of ASEAN Haze Agreement and Malé Declaration". The knowledge gained in this capacity development programme will benefit to the member countries of the ASEAN Haze Agreement and the Malé Declaration and also have a good opportunity to share ideas and knowledge to each other in terms of science and air quality management and emission reduction policies.

I recognize the valuable contribution of the capacity development programme can build the capacities of the Asian countries on air quality management and enhance technical capabilities to support their national efforts for addressing air pollution problem i.e., $PM_{2.5}$ in the countries. As a co-benefit the capacity development programme will help in creating awareness and reducing the transboundary impacts of air pollution in the region.

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This publication is an outcome of the project "**Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for ASEAN Countries**" funded by the Asia- Pacific Network for Global Change Research (APN), under their Capacity Development Programme (CAPaBLE), project reference number: CBA2020-01MY-Verma

For support

The authors would like to thank Dr. Guilberto Borongan, Director of the Regional Resource Centre for Asia and Pacific (RRC.AP) for his support and encouragement in the implementation of project activities which include organizing the capacity development workshop. Acknowledgment is also to RRC.AP colleagues who had contributed to the success of the workshop, namely, Mr. Bayasgalan Sanduijav, and Ms. Sengja Jangmaw for providing IT services and support in the development of the project website; Ms. Charina May Lepiten and Ms. Lakshani Gunawardhana for overall support in the organization of the workshop; Mr. Ric Dennis Canullas for the layout design of the report; and Ms. Nawaphorn Supakarn and Natanat Sittichaiyakarn for providing administrative and logistic support to the project.

The authors would like to appreciate and acknowledge the strong support and valuable contributions from the colleagues of the partner organizations, namely, the Asian Institute of Technology (AIT), Environmental Research and Training Center (ERTC), Pollution Control Department (PCD), National Institute of Technology (ITENAS), and the University of Malaya (now at North South University, Dhaka, Bangladesh).

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EXECUTIVE SUMMARY

Air quality in many Asian countries is deteriorating at an alarming rate due to increasing emissions of air pollutants from rapid urbanization, industries, constructions, traffic, residential cooking, open burning of agricultural residuals and municipal waste, and other activities. Most countries are lacking the technical capabilities to manage air quality. Therefore, to build the capacities of the Asian countries on air quality management, a capacity building workshop (*Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for Member Countries of ASEAN Haze Agreement and Malé Declaration*) was organized by the Regional Resource Centre for Asia and the Pacific and partners during 19-23 September 2022 at the Asian Institute of Technology, Pathum Thani, Thailand. This project has been supported by the Asia-Pacific Network for Global Change Research (APN) under its Capacity Development Programme (CAPaBLE).

Participants from member countries of the two Intergovernmental Networks of the Asian region, namely, the ASEAN Agreement on Transboundary Haze Pollution (*Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam*) and the Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia (*Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka*) were invited to the workshop.

A total of 55 participants, including 35 participants representing member countries of the ASEAN Haze Agreement and the Malé Declaration, 1 ASEAN Secretariat, 9 Resource Persons, and the rest from the AIT and partner organizations participated in the 5-day capacity-building workshop on air quality management. Out of 55 participants, 24 participants were women and thus a healthy gender balance was achieved. The participants included policymakers, air quality managers, and scientific and technical staff working with the ministry of environment and pollution control agencies in the countries.

The workshop was divided into 5 Modules, namely, (1) Air Quality Monitoring; (2) Emission Inventory Development; (3) Air Quality Modeling; (4) Impact Assessment; and (5) Policy Measures for Air Pollution Mitigation. To cover various aspects of air quality management of the 5 Modules, a total of 11 lectures/presentations were delivered, conducted 2 hands-on training or practical works, organized 2 visits to air quality monitoring labs of AIT and field visits to air quality labs of ERTC and PCD.

10 well-known resource persons from India, Indonesia, Bangladesh, Philippines, Thailand, and the United Kingdom delivered the lectures, and conducted hands-on trainings and assisted in the field visits.

Evaluation of the participants was made by providing a set of questions for each topic of the lecture, hands-on training, and field visits as well as for the whole workshop to measure the enhancement of knowledge and understanding of participants on the workshop Modules. For the whole workshop, the majority of participants have rated "4" regarding their knowledge and understanding on all aspects of air quality management (i.e., monitoring, emission inventory, modeling, impact assessment, and mitigation policies) before the workshop, on a given scale of 1-10. Their knowledge and understanding of air quality management were increased to "8" after the workshop. On an average, the knowledge and understanding of participants on all aspects of air quality management before the workshop was 4.4±1.8 which increased to 7.7±1.2 after the workshop, with a net increase of 3.3.

The feedback received from the participants showed that they had learned a lot from the workshop and were quite satisfied with the contents of the modules and the topic of lectures delivered, conducted hands-on trainings, and organized field visits during the workshop. The order of liking the Modules by participants are as follows: Emission Inventory, Air Quality Modeling, Impact Assessment, and Mitigation Policies Modules in descending order.

Participants expressed concern that enough time should have been provided to practice emission inventory tools and air quality models. This feedback provided a way forward for organizing separate workshops on emission inventory developments and air quality modeling in the near future. At the end of the workshop, a "Certificate of Participation" was awarded to each participant. A website (http://www.rrcap.ait.ac.th/apn2022/) was developed for the workshop where all details of the workshop, including resource materials, were uploaded.

1. BACKGROUND

Air quality is deteriorating in many Asian countries at an alarming rate due to increasing emissions of air pollutants from urbanization, industries, constructions, road traffic, residential cooking, open burning of agricultural residuals and municipal waste, and other activities. As per air quality data released by the World Health Organization (WHO) in April 2022 from 117 countries, almost the entire global population (99%) is respiring the air that exceeds WHO air quality limits and causing 7-9 million premature deaths every year mostly in developing countries including Asian countries[1,2]. In fact, many Asian cities are among the list of the most polluted cities in the world[3]. Asian countries are mostly lagging behind the timeframe of achieving the Sustainable Development Goals (SDGs) linked to improving air quality, including reducing $PM_{2.5}$ concentration levels to a level of the Interim Target (IT-1) set by the WHO[4]. Increasing air pollution is not only affecting human health and the environment but also causing a large economic burden on the national health budget of the countries and significant losses in agriculture productivity.

Many Asian countries are lacking the technical capabilities to monitor key air quality parameters, including particulate matters (PM_{10} and $PM_{2.5}$) and trace gases (CO, NO_x, O_3, SO_2, etc.). Some countries do not have reliable emission inventories, models/tools to assess the impacts, and effective air pollution mitigation policies. The capacity development programme is necessary to enhance the air quality management capabilities of Asian countries, leading to effective policy formulation and sound decision-making. These include policies and actions for emission reduction of particulate matter (PM) and gaseous pollutants and measures to address air pollution issues in the countries. Many Asian countries need technical capability and policy support for better air quality management to reduce the impacts of air pollution on human health and the environment.

The Asia-Pacific Network for Global Change Research (APN)'s Capacity Development Programme (CAPaBLE) aims to enhance the capacity of scientists, policymakers, and practitioners to assess global change issues. Through the

[1] WHO Air quality Database 2022, https://www.who.int/publications/m/item/who-air-quality-database-2022

[2] Fuller et al. (2022), Pollution and health: a progress update, Lancet Planet Health; 6: e535–47, https://www.sciencedirect.com/science/article/pii/S2542519622000900?via%3Dihub

[3] Air quality and pollution city ranking (IQAir), https://www.iqair.com/th-en/world-air-quality-ranking

[4] HEI, State of Global Air 2020 (Special Report), https://www.stateofglobalair.org/

CAPaBLE programme, APN supports the activities that enhance the capacities of the countries. The APN, under its CAPaBLE programme and priority thematic area of transboundary air pollution and its impact on human health, provided financial support to the Regional Resource Centre for Asia and the Pacific (RRC.AP) of the Asian Institute of Technology for the "**Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for ASEAN Member Countries**" project for a period of 2 years, commencing from January 2021 to December 2022. Under this capacity development programme, the RRC.AP and partners organized 2 capacity-building workshops of a duration of one week each.

The first workshop of the project was organized from 13-17 September 2021 (online) for policymakers and technical staff working with the ministry of environment and pollution control agencies. The workshop was initially designed for the ASEAN member countries and was to be conducted in a physical setting. However, due to the COVID-19 pandemic, the workshop was organized online and therefore its scope was extended and invited participants from other countries of the Asian region. This provided opportunities for more Asian countries to participate in the capacity-building programme and benefited from it. A report on the workshop "**Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for Asian Countries**" (ISBN: e-Book 978-616-8230-13-8) has already been published on the RRC.AP and APN websites.

The second workshop of the project "**Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for Member Countries of ASEAN Haze Agreement and Malé Declaration**" was organized physically during 19-23 September 2022 at the Asian Institute of Technology Conference Center (AITCC), Pathum Thani, Thailand. This report summarized the proceedings of the 5-day workshop.

A backdrop of the Workshop

2. PARTNER ORGANIZATIONS

The following organizations are implementing partners of the RRC.AP lead project "Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for ASEAN Countries":

- School of Environment, Resources and Development of the Asian Institute of Technology (AIT), Thailand;
- Pollution Control Department (PCD), Thailand;
- Environmental Research and Training Center (ERTC), Ministry of Natural Resources and Environment, Thailand;
- National Institute of Technology (ITENAS), Indonesia;
- University of Malaya (UM), Malaysia; and
- UNEP Regional Office for Asia and the Pacific (UNEP/ROAP).

3. OBJECTIVES

The capacity development programme was aimed to build the capacities of the Asian countries on air quality management and enhance technical capabilities to support their national efforts for addressing air pollution problems in the countries. As a co-benefit, this capacity development programme would also help in creating awareness and reducing the transboundary impacts of air pollution in the region.

The major objectives of the project were as follows:

(i) To enhance understanding of air quality monitoring and analysis including satellite data, low-cost sensors, and Continuous Emission Monitoring Systems (CEMS) and their uses in air quality management;
(ii) To enhance understanding of the development of emission inventories of air pollutants through "bottom-up and top-down" approaches and introduction of an Emission Inventory Tool, which countries could use to develop emission inventories of air pollutants at the national level;
(iii) To enhance understanding of air quality modeling, such as chemical transport models, source apportionment models, and secondary pollutants formation models and their applications in air quality management, as well as transboundary estimation of air pollution; and
(iv) To enhance understanding of impact assessment of air pollution on human health and the environment and how the impact assessment tools/models can be used in air quality management including formulations of effective emission reduction policies.
(v) To enhance understanding of the emission reduction policies, action plans incorporating co-benefits approaches, mitigation scenarios, strengthening emissions standards, etc.

4. PARTICIPANTS

Originally, the project was approved by APN for building the capacities of ASEAN member countries on air quality management and emission reduction of $PM_{2.5}$ by organizing two capacity-building workshops each in 2021 and 2022. The first workshop was organized during 13-17 September 2021 online due to the COVID-19 pandemic and some budget was left unused in 2021. Therefore, for the second workshop (which organized during 19-23 September 2022, physically), it was proposed to APN for considering to extend the invitation for the workshop to the member countries of the Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia (*8 South Asian countries*) in addition to the member countries of the ASEAN Agreement on Transboundary Haze Pollution (*ASEAN Haze Agreement, 10 countries of Southeast Asia*). APN approved the request.

Accordingly, participants, including policymakers, air quality managers, and scientific and technical staff working with the ministry of environment, pollution control and agencies, and associated ministries or departments in the member

countries of the two intergovernmental networks, namely, the ASEAN Haze Agreement (*member countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam*) and the Malé Declaration (*member countries: Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka*) were invited to the workshop. The invitation was shared with the National Focal Points (NFPs) of the intergovernmental networks requesting them to nominate two participants from their countries. A few participants from partner organizations, including the ASEAN Secretariat, were also invited.

Group photo of the workshop participants

A total of 55 participants, including 35 participants representing the member countries of the ASEAN Haze Agreement and the Malé Declaration, 1 ASEAN Secretariat, 9 Resource Persons, and the rest from the AIT and partner organizations, participated in the 5-day capacity-building workshop on air quality management. Annex 1 provided a list of participants with their countries and affiliation organizations. Out of 55 participants, 24 participants were women and thus a healthy gender balance was achieved.

5. WORKSHOP

5.1 Agenda

The capacity-building workshop **[Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for Member Countries of ASEAN Haze Agreement and Malé Declaration]** was organized from 19-23 September 2022 at AITCC, physically. Annex 2 illustrates the agenda of the workshop. The agenda was divided into 5 Modules, namely, Air Quality Monitoring,

Emission Inventory, Air Quality Modeling, Impact Assessment, and Air Pollution Mitigation Policies. Well-known resource persons from India, Indonesia, Bangladesh, Philippines, Thailand, and the United Kingdom (UK) delivered the lectures during the 5-day workshop, provided practical sessions to the participants, and organized field visits. Annex 3 provided a short introduction of each resource person. A dedicated website (http://www.rrcap.ait.ac.th/apn2022/) for the workshop was developed which included all details of the workshop including resource materials.

5.2 WORKSHOP PROCEEDINGS

DAY 1

OPENING SESSION

Dr. R. L. Verma, Head of Air Pollution, AIT RRC.AP (Moderating the Session)

The workshop was started with Welcome Remarks by **Dr. Guilberto Borongan**, Director, Regional Resource Centre for Asia and the Pacific, Asian Institute of Technology (RRC.AP), and **Prof. Kazuo Yamamoto**, Interim President, Asian Institute of Technology (AIT); followed by Opening Remarks by **Mr. Yoichi Toyama**, Director, Asia-Pacific Network for Global Change Research (APN) Secretariat (remotely); **Mr. Jatinder Singh Kamyotra**, Former Member Secretary, Central Pollution Control Board, India, and Regional Facilitator, Malé Declaration on Control and Prevention of Air Pollution and its likely Transboundary Effects for South Asia; and **Dr. Ittipol Pawarmart**, Head of Automotive Emission Laboratory, Pollution Control Department (PCD), Ministry of Natural Resources and Environment, Government of Thailand.

Dr. Guilberto Borongan, in his welcome remarks, mentioned that air pollution is a serious global concern and challenge as it is heavily impacting human health and the economies of countries. The countries of Southeast Asia and South Asia are

making their best efforts for addressing air pollution problems by establishing air quality monitoring networks, compiling emissions, assessing impacts, and making emission reduction policies and action plans. Also, countries are cooperating at the regional level for addressing transboundary issues of air pollution. The evidence of the regional cooperation among the countries of the region is that we are hosting the member countries of the ASEAN Haze Agreement and the Malé Declaration. Both intergovernmental Networks are aiming to address transboundary air pollution in the region. RRC.AP, as a technical center of the AIT, is always ready to assist the countries in the region in building technical capabilities and assisting in policy guidance and knowledge support. He was grateful to the Asia-Pacific Network for Global Change Research (APN) for providing financial support through the project "Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for ASEAN Countries" for organizing two workshops in 2021 and 2022. This was the second workshop of the project.

Dr. Guilberto Borongan, Director, AIT RRC.AP

Prof. Kazuo Yamamoto, in his welcome remarks, mentioned that air pollution is a real issue Asian countries are facing. It is impacting human health and economic growth in the region. Air pollution issues are transboundary and therefore there is an urgency to address air pollution issues seriously. More enhanced, collective, and collaborative efforts and actions among all sectors and stakeholders are necessary to improve air quality. Regional cooperation, strengthening institutions and governance, promoting behavioral change, and increasing capacity for integrated air quality management, are among the relevant measures to achieve healthy air. He noted that the member countries of the ASEAN Haze Agreement and the Malé Declaration are participating in the workshop which was a rare opportunity for two intergovernmental networks congregated for capacity building on air quality management and to share ideas, experiences, and

Prof. Kazuo Yamamoto, Interim President, AIT

data, and learn from each other for the shared common goal of improving the air quality. He added that the Asian Institute of Technology is ready to play an important role in building the technical capabilities of the countries in the region.

Mr. Yoichi Toyama,
Director, APN Secretariat

Mr. Yoichi Toyama, who remotely delivered his opening remarks, mentioned that rapid economic growth in the Asian region faces serious environmental problems, especially air pollution, which is compounded by the increase in traffic in several megacities such as Bangkok, Jakarta, Hanoi, etc. He informed that APN has awarded a grant to RRC.AP, for a capacity-building project under its Capacity Development Programme (CAPaBLE), which responded to the high-priority needs of the APN, specifically, the priorities of the APN Southeast Asia Subregional Committee (SEA-SRC). Mr. Toyama acknowledged the representation of intergovernmental networks including the ASEAN Haze Agreement and the Malé Declaration are participating in the workshop which underscores the importance of building capacities of Asian countries on air quality management and emission reduction strategies. He stated that APN was pleased to support this workshop and has seen its contribution to the efforts of air quality monitoring and management in the region.

Dr. Ittipol Pawarmart, Head,
Automotive Emission Laboratory,
PCD, Thailand

Mr. Jatinder Singh Kamyotra, in his opening remarks, highlighted key objectives and achievements of the Malé Declaration since its inception in 1998. He mentioned that the Malé Declaration (an intergovernmental network of South Asian countries for addressing transboundary impacts of air pollution in South Asia), was established when there was not much attention given to air pollution at the national level. Based on the priorities of the member countries, activities of the Malé Declaration were implemented in phases. Over the past 2 decades, Malé Declaration helped the national governments of the member

countries in compiling baseline information and building capacities of the government institutions on air quality monitoring, development of emission inventories, and conducting studies on air pollution impacts. Now we are revising the objectives and activities of the Malé Declaration considering new priorities and challenges in addressing the issues of air pollution in member countries. He further mentioned that this workshop on air quality management and emission reduction of PM2.5 will assist the member countries of the Malé Declaration in building capacities for air quality management.

Dr. Ittipol Pawarmart, in his opening remarks, mentioned that air pollution has become a serious transboundary environmental and health problem globally and air quality and emission reduction of particulate matters, in particular $PM_{2.5}$, are common concerns of our countries to protect human health. Poor ambient air quality, particularly $PM_{2.5}$ remains a significant challenge in Thailand and across countries in Asia. The trans-disciplinary approach to tackling the science and policy issues in terms of monitoring, developing emission inventories, modeling flows, impact assessment, and policies for mitigation are responsive to building capacities and competencies of researchers and policymakers. He appreciated all partners and experts for contributing to the workshop. All speakers emphasized the need for capacity building and regional cooperation in the Asian region on air quality management and air pollution emission reduction strategies for solving air pollution problems in the region.

COUNTRIES' PRESENTATIONS

On day 1, each participating country was invited to make a presentation on available air quality management facilities and infrastructure including air quality monitoring facilities (infrastructure, automatic, manual, online, LCS, country map with monitoring stations, instrumentations, laboratories, manpower, etc.) with monitoring data; status of emission inventory developments (pollutants, sectors, data, if any); studies on air quality modeling and impact assessments (if any); air pollution mitigation plans, actions, and policies; success stories and lessons learned; and any other information/data which countries would like to share during the workshop.

Key points of countries' presentation are summarized below:

BANGLADESH

Bangladesh established 16 Continuous Air Monitoring Stations (CAMS) and 15 Compact Continuous Air Monitoring Stations (C-CAMS) in the country and

measuring criteria pollutants including PM_{10}, $PM_{2.5}$, SO_2, CO, O_3, NO_2, and some meteorological parameters by using respective analyzers and sensors. Policies for addressing air pollution in the country include the Environment Conservation Act 1995, Environment Conservation Rule 1997, Air pollution Control Rules 2022, National Environment Policy 2018, Brick Manufacturing and Kiln Establishment (Control) Act 2013, Gazette Notification for use of Block Brick by 2025, Gazette Notification for Construction dust management, and Air Pollution Guideline 2021. Some of the actions and plans for reducing air pollution are introducing low sulfur diesel (50 ppm), proposal for introducing electric cars, modernization of vehicle fitness, traffic management system (BRTA, MRT), brick emission/industrial emission reduction, enforcement/mobile court for illegal brick fields, and online monitoring for industrial pollution. Bangladesh is facing challenges in air quality management including improper waste management, transboundary impacts, unavailability of modern technologies for industrial pollution, brick field management, open burning, lack of online monitoring system technologies, capacity development, and lack of funds and research studies.

Presentation from delegates of Bangladesh

BHUTAN

Bhutan operates 2 automatic air quality monitoring stations, 3 low-cost sensors stations, and 1 manual monitoring station. Efforts are underway for the development of emission inventories for air pollutants and air quality modeling with international support. Bhutan has developed several policies and action plans for improvement in air quality in the country.

Presentation from delegates of Bhutan

BRUNEI DARUSSALAM

Pressentation from delegates of Brunei Darussalam

Brunei Darussalam is carrying out ambient air quality monitoring since early 2005 through an automatic air quality monitoring network. Brunei Darussalam operates 7 air quality monitoring stations for the measurement of $PM_{2.5}$ and PM_{10}. Generally, ambient air quality in Brunei Darussalam has always been in good condition compared to the WHO Guidelines. To ensure continuous clean air, the country has set targets for clean air with a PM_{10} level of less than 50 $\mu g/m^3$ by 2035. To maintain good air quality, efforts are being made that industries and construction activities should take air quality preventive and mitigation measures, enforcing monitoring of emissions from industries through continuous environmental monitoring systems (CEMs) to ensure compliance with safe emission limits, and regular inspection of industrial sites and activities to ensure compliance and achieve continuous attainment with environmental standards including air quality. The Brunei Darussalam in air quality management includes banning open burning, lack of public participation and industry stakeholders, and unprecedented dry weather conditions.

CAMBODIA

Presentation from delegates of Cambodia

Cambodia started air quality monitoring in 1999 and further strengthened in 2007. At present, Cambodia is operating 10 air quality monitoring stations, 53 ambient air quality monitoring sensors, and 1 mobile air quality monitoring and monitoring 7 key parameters, namely, SO_2, NO_2, CO, O_3, VOC, PM_{10} and $PM_{2.5}$ and meteorological parameters, such as wind speed and direction, temperature, relative humidity, and atmospheric pressure. Air quality monitoring data is recorded daily and broadcast via the Ministry of Environment's Facebook Page and LED Screen in front of the Ministry of Environment building. The Laws, regulations, and standards related to air pollution in Cambodia include "Law on Environmental Protection and Natural

Resource Management (1996)", sub-decree 42 on Air Pollution Control and Noise Disturbance which focused on ambient air quality standards, emission standards for mobile sources, emission standard for stationary sources, and circular 01 (2020) on measures to prevent and reduce ambient air pollution and parkas on the technical guideline to control air pollution from industries. Cambodia has developed an air pollution emission inventory under its clean air plan programme. Cambodia needs assistance in resource mobilization and equipment for air pollution control, source analysis, technical capacity building of monitoring staff, and information and data sharing including cooperation from the factory owners.

INDIA

Presentation from delegates of India

India, under its National Ambient Air Monitoring Programme (NAMP), is operating 1254 ambient air quality monitoring stations including 882 (manual) in 378 cities and 372 Continuous Ambient Air Quality Monitoring Stations (CAAQMS) in 192 cities and monitoring key air quality parameters ($PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3, CO, NH_3, Benzene, and meteorological parameters). India is also monitoring real-time industrial emissions (Continuous Emission Monitoring System (CEMS)) and remote sensing and satellite-based monitoring for aerosol optical depth (AOD). India, in collaboration with NCAR (USA), is forecasting air quality a 3-day advance at 10 km regional scale for the decision support system (DSS) and a 5-day advance at 400 m scale in NCR-Delhi. In addition to this, India, in collaboration with FINISH Meteorological Institute, is forecasting air quality at 5 km regional scale in a 3-day advance and ENFUSER street level forecast for NCR-Delhi in 3-day advance. India launched the National Clean Air Programme (NCAP) in 2019 intending to achieve a 20-30% PM reduction in 131 targeted cities by 2024. For raising awareness and public grievance redressal, India launched SAMEER app to access air quality information and post complaints against air polluting activities in 131 cities. For reducing emissions of air pollutants, India has initiated several sector-specific policies and practices, such as, for emission reduction of air pollutants from the transport sector revised vehicular emission standard to BS VI (equivalent to Euro -VI), phasing out overaged vehicles in NCR (petrol/diesel vehicles 10/15 years), launched EV policy (zero emission), improving road traffic management by developing "Intelligent Traffic Management System"

(ITMS), expanding public transport network (metro rails, RRTS, E-Buses), expanding the use of clean fuels like CNG, CBG and ethanol blending in petrol, LNG. For the industry and power sector, India is implementing stringent emission standards for thermal power plants, installing flue-gas desulphurization (FGD) system, control of NOx and PM, banning the use of coal, pet coke, diesel oil and furnace oil in NCR, installing online Continuous Emission Monitoring Devices in heavily polluting industries, and shifting of brick kilns to zig-zag technology, and several measures in other emission sectors. Success stories of India in regards to improving air quality include improvement in air quality (e.g, PM_{10}) in 75 out of 131 cities, publishing daily Air Quality Index (AQI) in 190 cities, establishing Decision Support System for AQ management in Delhi, 2000+ C&D waste processing facilities in the country, Municipal Solid Waste segregation in 80,000+ wards, integrated control & command centers under the Smart City Programme, launched EV-Policies (sold 5.8 lakh+ electric vehicles and large scale procurements planned), 1 lakh+ PNG connections, and 228 geographical areas with city gas distribution authorization.

INDONESIA

Indonesia is operating over 40 air quality monitoring stations across the country and monitoring key air quality parameters (SO_2, NOx, O_3, CO, HC, PM_{10} and $PM_{2,5}$). Indonesia is also monitoring SO_2 and NO_2 using passive samplers at 2032 locations covering industrial, transportation, residential, and commercial emission sources. Indonesia launched an android based app for knowing air quality (good, medium, unhealthy, very unhealthy, and dangerous represented by green, blue, yellow, red, and black, respectively). Continuous Emission Monitoring Systems (CEM) are also deployed to measure emissions of air pollutants from industrial sources. Indonesia enacted several laws and regulations for the emission reduction of air pollutants including emission standards and ambient air quality standards. Indonesia developed a web-based application for the development of emission inventory and compiled emission inventories in 30 cities. The air pollution abatement plan includes installing monitoring tools in 56 cities and 17 AQMS integrated with MOEF, enforcing the law for forest fires, socializing with business actors in air pollution control activities, implementing EURO 4 standards for vehicles, strengthening ambient air quality standards, installing emission control instruments in industries, developing emission inventories and estimating impacts, and encouraging the use of biofuels and reducing the use of coal fuels in power plants.

IRAN

Presentation from delegates of Iran

Iran is operating over 200 air quality monitoring stations across the country and monitoring PM_{10}, $PM_{2.5}$, CO, NO_X, O_3, and SO_2. In addition to air quality monitoring, Iran is preparing air pollution status zoning maps using the GIS, analysis of management action based on air quality, analysis of concentration trends in the air pollution index, and air quality modeling. Iran has compiled emission inventories from key emission sources for CO, NO_X, SO_X, VOC, and PM and also performed air quality modeling including forecasting of air quality in Tehran. Iran has evaluated the effects of air pollutants on human health using the daily index. Air pollution mitigation plans and actions of Iran include the development of national guidelines for GHG emission inventory and compilations of emissions from various emission sectors, the development of an energy consumption management strategy based on the green economy and low carbon industry, reviewing permissible limits for industries, preparation of a comprehensive plan to reduce air pollution in18 metropolises, performance evaluation of executive bodies responsible for the implementation of the Clean Air Law, upgradation of standards for fuels, studies of $PM_{2.5}$ source apportionment in megacities, and preparation of emission inventory of air pollutants metropolises.

LAO PDR

Lao PDR is operating 6 fixed ambient air quality monitoring stations and 1 mobile van and monitoring SO_2, NO_2, O_3, CO, Benzene, Toluene, Xylene, Styrene, Ethylbenzene, $PM_{2.5}$, and PM_{10}. The air quality data (e.g., $PM_{2.5}$) are published on the ministry of environment website (www.aqm-monre.gov.la) and social media. The air quality (e.g., $PM_{2.5}$) often exceeds the WHO air quality guidelines. Policies of Air pollution Control include Environmental Protection Law (EPL) 2013, Decree on the National Environmental Standard No. 0832/MoNRE 2017, Decision of Pollution Control 2021, Decree on the Protection and Vehicles Facilitation No. 12302/ MPWT 2009. Plans for air quality monitoring include upgrading the existing monitoring stations by installing additional equipment to monitor more parameters, expanding the monitoring network nationwide by installing monitoring stations in air pollution hotspot areas, and improving air quality data management and information system.

MALAYSIA

Presentation from delegates of Malaysia

Malaysia has a well-established air quality monitoring network in the country and operates 72 air quality monitoring stations comprising 68 Continuous Air Quality Monitoring Stations (CAQMS) and 14 Manual Air Quality Monitoring Stations (MAQMS). These monitoring stations are strategically located in industrial, urban, suburban, and rural areas and monitoring SO_2, NO_2, CO, O_3, $PM_{2.5}$, and PM_{10}. On an average, the concentration levels of key air quality parameters are meeting the Malaysian Ambient Air Quality Standard IT-2 Guideline values. Malaysia has estimated air pollution emission loads and published an Environmental Quality Report in 2020. As per the report, power plants contributed the highest SO_2 emission load (63%), followed by other categories (26%), industries (6%), and motor vehicles (5%); whereas in the case of PM, the highest contributors were power plants (39%) followed by industries (29%), motor vehicles (12%), and others (20%); and for NO2, highest contributors were from power plants (62%) followed by motor vehicles (24%), industries (9%), and others (5%); and motor vehicles is the highest contributor of CO (95.7%). Malaysia passed several regulations for air pollution control including the Clean Air Regulations in 2014, the Motor Vehicle Noise Regulations in 1987, the Control of Emission From Diesel Engines Regulations In 2000, the Control of Petrol and Diesel Properties Regulations in 2007, and other rules and regulations and initiated several programmes to mitigate air pollution from various emission sectors.

MALDIVES

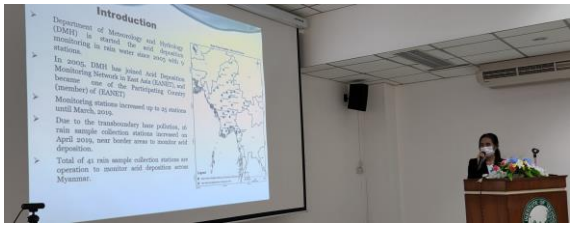
Presentation from delegates of Maldives

Hanimaadhoo island of Maldives has well-established state-of-the-art facilities for air quality monitoring. Maldives has developed an emission inventory for short-lived climate pollutants (SLCPs) which showed that guest houses and hotels contributed a major fraction of $PM_{2.5}$, followed

by transport, fishing, and other sources. Maldives has developed an emission scenario for the next 20 years with the base year 2010. The future plans of Maldives include the development of national standards on fuel quality, Integrated Transport Master Plan, E-Mobility Road Map & Transport Master Plan, the introduction of electric buses, and the installation of air quality monitoring stations. While limitations and challenges of Maldives include the lack of financial resources, technical capacities, public interest, limited data on pollutant sources, emissions, levels of air quality, and lack of technologies.

MYANMAR

Myanmar is operating 25 air quality monitoring stations across the country. Myanmar has conducted emission inventory and found a major portion and PM and trace gases are from vehicular emissions. Myanmar has acted several laws and regulations including air quality guidelines for emission reduction of air pollutants. Myanmar needs systematic long-term assessment of pollutants including laboratory equipment and expertise on air quality management including analysis of the cost-effectiveness of emission control measures and health and ecosystem impacts.



Presentation from delegates of Myanmar

NEPAL

Nepal started establishing an air quality monitoring network in 2002 and presently operates or installed 28 air quality monitoring stations across the country and has further plans to expand the network by increasing the monitoring stations to 56. Real-time air quality data is being acquired and disseminated to the public. In 2020, Nepal started compiling the emissions of air pollutants from various sectors and has compiled emission data from the brick and cement industries. Researchers in Nepal started air quality modeling studies and carried out air pollution impact assessment

for Kathmandu valley. The Constitution of Nepal provided the right to live in a clean and healthy environment and thus Nepal enacted several laws and regulations for air pollution reduction including the National Air Ambient Quality Standards 2012, Environmental Protection Act 2019, Kathmandu Valley Air Quality Management Action Plan 2019, Environment Protection Regulation 2020, National Environment Policy 2020, and drafted Sustainable Development Goals for Nepal 2030.

Presentation from delegates of Nepal

PAKISTAN

Pakistan is operating 2 ambient air quality monitoring stations (1 stationary and 1 mobile) for monitoring of NO_x (NO and NO_2), SO_2, CO, O_3, CH_4, NMHCs, and Total Hydrocarbons (THCs). The legal framework for air pollution reduction includes the National Environmental Quality Standards (NEQS) (S.R.O No. 549(I)/2000 for industrial gaseous emissions, NEQS (S.R.O No. 72(KE)/2009) for motor vehicle exhaust and noise, and Section 11 of PEPA'97 and NEQS for Ambient Air Quality (S.R.O No. 1062(I)/2010) for brick kilns. Pakistan's air pollution mitigation plan includes the implementation of the EV Policy and EURO-V fuel standards for vehicular emissions and the installation of pollution control technologies for Industries emissions. Pakistan's success stories for mitigation of air pollution in the country include the installation of bag house filter technology in steel furnaces and capturing over 150 plus tons of dust monthly, converting many brick kilns to zig-zag, controlling and reducing vehicles emissions through regulation and monitoring, controlling and reducing agriculture waste burning and solid waste burning, and implementation of smog action plan strictly.

Presentation from delegates of Pakistan

PHILIPPINES

Presentation from delegates of the Philippines

The Philippines has a well-established air quality monitoring network and installed 109 (91 operational) air quality monitoring stations in the country. The air quality monitoring include continuous (CAAQMS) and manual. 17 monitoring stations are to be installed soon. Air quality parameters including TSP, PM_{10}, $PM_{2.5}$, SO_2, NO_2, O_3, CO, BTX, and Hg are measured at these stations. The Philippines is also managing 22 airsheds (17 regular and 5 geothermal). The Philippines has started the development of emission inventories from key stationary and mobile sources and maintaining a databank. For monitoring of emissions of air pollutants from stationary sources (e.g., stakes of industries), the Philippines installed CEMS in 39 out of 70 firms and connected to the Data Acquisition and Handling System (DAHS). The Philippines is conducting air quality modeling (dispersion and source apportionment). The policy and plans to combat air pollution in the Philippines include the establishment of an emission charge system, emission averaging of existing sources, updating the Best Available Control Technologies (BACT) and Air Pollution Control Facilities, guidelines for Accreditation of CEMS/COMS Audit Service Providers, updating the National Emission Standards for Source, specific Air Pollutants to Mass Emission Rate Standards, Guidelines on Emissions Averaging of Facilities using the Non-Burn Technologies, Guidelines on Industrial/Commercial Establishment Inspection and Monitoring, and many other measures for mobile sources.

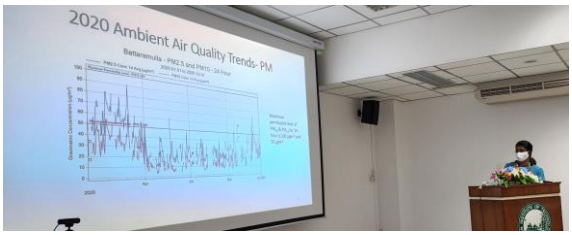
SINGAPORE

Presentation from delegates of Singapore

Singapore started air quality monitoring in 1972 manually. It was automated by commissioning the Telemetric Air Quality Monitoring and Management System (TAQMMS). At present Singapore is operating 23 air quality monitoring stations in the country and monitoring 6 key air quality parameters (PM_{10}, $PM_{2.5}$, SO_2, O_3, CO, NO_2). Singapore

also continuously operates 59 VOC monitors at 11 locations and monitoring VOCs, benzene, toluene, and xylene. For monitoring industrial emissions, Continuous Emission Monitors (CEMs) are installed in 23 industries linked to power and refineries. Singapore has an enhanced air quality reporting system and 24-hr PSI and 1-hr $PM_{2.5}$ concentrations are made available on the NEA website (www.nea.gov.sg), haze microsite (www.haze.gov.sg), and NEA's social media (Facebook, Twitter, MyENV app). The main legislatures for controlling and reducing air pollution include the Environmental Protection and Management Act (EPMA), EPM (Air Impurities) Regulations, EPM (Hazardous Substances) Regulations, EPM (Off-Road Diesel Engine Emissions) Regulations, EPM (Prohibition on the Use of Open Fires) Order, EPM (Vehicular Emissions) Regulations, Transboundary Haze Pollution Act (THPA), and Environmental Public Health Act (EPHA). Singapore is implementing several air pollution control measures in various emission sectors.

SRI LANKA



Presentation from delegates of Sri Lanka

Sri Lanka is operating 2 fully automated Ambient Air Quality Monitoring Stations (AAQMS) at Battaramulla and Kandy and monitoring 6 criteria pollutants ($PM_{2.5}$, PM_{10}, O_3, SO_x, NO_x, CO). Low-cost sensors are also used in many places in the country by different parties. Sri Lanka is making some efforts for developing emission inventories and air quality modeling. Central Environmental Authority (CEA) is the main regulatory body in Sri Lanka. CEA introduced regulations for mobile air emission, fuel and vehicle specification standards for fuel import, permissible ambient air quality standards, and stationary source emission control. Measure to reduce air pollution in Sri Lanka includes phasing out lead in gasoline in 2001, implementing of Vehicle Emission Testing Programme in 2013, introducing low sulfur diesel (10ppm) and 92 RON Gasoline in 2014, a ban on polyethylene and plastic burning in 2017, introducing EURO4 standard premium grade gasoline and Diesel in 2018, introducing EURO 4 Emission Standards for New Vehicle Importation in 2018, and ongoing preparation of Fuel Quality Road Map and indoor air quality guideline.

THAILAND

Thailand presented research and issues related to PM. For Thailand, the major air quality problem is the high PM concentration in many places. Thailand also has issues related to open burning and wildfires. For urban areas such as Bangkok, the level of $PM_{2.5}$ levels often exceed the NAAQs. Thailand studied long-range transport for haze in Northern Thailand using the backward trajectories during 2009-2014 and found that high PM_{10} comes from the west and south and WRF-Chem simulated PM_{10} over Northern Thailand from emission inventory covering the whole domain and only emission in Northern Thailand. Comparison between both results can imply the influence of emissions outside the Northern area on the level of PM_{10} in the northern area. Pollution Control Department (PCD) is operating the WRF-Chem model for PM simulation. According to the revised WHO guideline in 2021, Thailand will soon change the 24-hour $PM_{2.5}$ standard value from 50 to 37.5 $\mu g/m^3$.

DAY 2

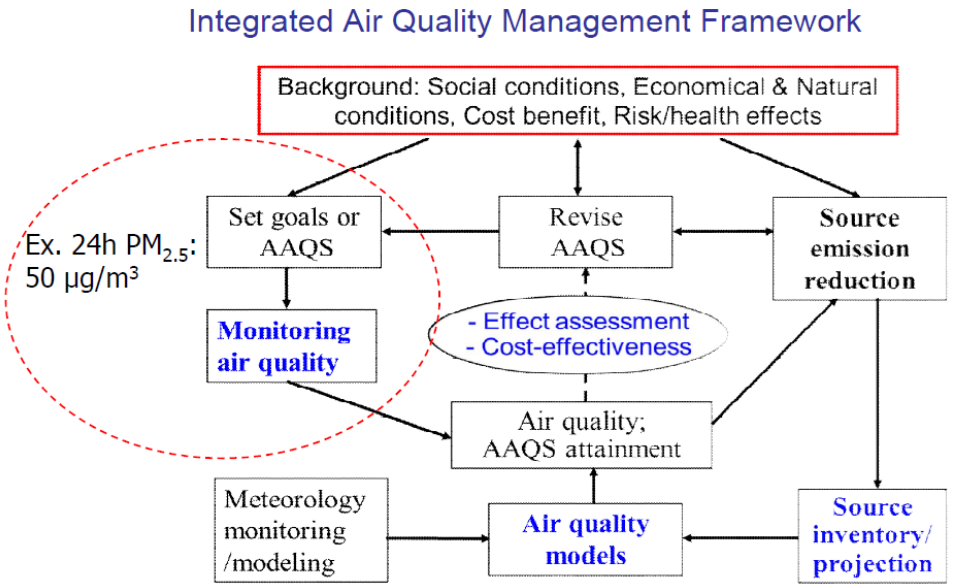
MODULE 1: AIR QUALITY MONITORING

Air Quality Monitoring Module covered details of the air quality monitoring and analysis, monitoring methods, instrumentations, and calibrations including satellite monitoring and air quality monitoring using low-cost sensors. Participants had an opportunity to visit the AIT's Ambient Air Quality Laboratory and the InterLab to learn practical aspects of air quality monitoring and the latest research conducted on Low-Cost Sensors (LCS) for air quality monitoring.

P-01: Overview and importance of air quality monitoring for air quality management

Expert: Prof. Kim Oanh, Asian Institute of Technology, Bangkok, Thailand

Prof. Kim presented highlights of air pollution in Asia, integrated quality management (roles of monitoring tool), and designing an ambient monitoring programme. Major sources of air pollution in the Asian region are traffic, residential combustion, biomass open burning, solid waste open burning, small-medium industries, coal combustion, and others which are causing detrimental impacts on human health, climate, and agriculture. Over 92% population living in the Asia-Pacific region is getting exposed to $PM_{2.5}$ levels higher than the WHO air quality guidelines of 10 $\mu g/m^3$. Globally 6.67 million premature deaths and shorten life expectancy (8 months to 1 year) are attributed to exposure to high levels of $PM_{2.5}$. Following is the Integrated Air Quality Management Framework:



Air quality management requires systematic and reliable information on the status and trend of pollution. Air quality programmes may include ambient air monitoring, source emission monitoring: mobile vs. stationary, personal exposure monitoring, and indoor air quality.

P-02: Air Quality Monitoring Study at AIT

Expert: Dr. Ekbordin Winijkul, Asian Institute of Technology (AIT), Thailand

Dr. Winijkul presented about air quality facilities available at AIT. He introduced types of air quality monitoring which included ambient air quality monitoring for PM (concentration and size) and gaseous pollutants, source monitoring from stationary (stacks) and mobile sources, indoor air quality monitoring for CO, CO_2, organics, and satellite and low-cost Sensors.

Dr. Ekbordin Winijkul, AIT, Thailand

He elaborated PM (TSP and PM10) sampling mechanism of high volume sampler and introduced the air quality monitoring flags programme for showing air quality in the AIT international school. Dry and wet depositions monitoring done in AIT was also presented. He presented a case study of Chiang Mai on air quality monitoring done by remote sensing (AOD by satellite).

PRACTICAL WORKS (PW)

PW-01A: Visit to Ambient Air Laboratory of AIT

Participants visited the Ambient Air Laboratory of AIT and learned about the operation and maintenance of instruments used for ambient air quality monitoring. These included a high-volume sampler for PM monitoring, a gaseous sampler, dry and wet deposition monitoring, and analytical instruments, such as gas chromatography (GC-MS) and analytical instruments.

Visit to Ambient Air Laboratory, AIT

PW-01B: Visit to Internet Education and Research Laboratory, AIT

Participants visited the Internet Education and Research Laboratory of AIT (intERLab) and learned about the latest research and development in Low-Cost Sensors (LCS) for air quality measurements. Dr. Adisorn Lertsinsrubtavee (Director of InterLab) presented the SEA-HAZEMON which is a real-time air pollution monitoring (including forest fires) platform in Southeast Asia using the LCS. Sensors are deployed in various locations in Southeast Asia to measure particulate matter (PM_1/$PM_{2.5}$/PM_{10}), carbon monoxide (CO), carbon dioxide (CO_2), meteorology (temperature, humidity, air pressure, wind direction, wind speed), and GPS. Sensors for NO_2 and VOCs are to be installed soon at some locations in Southeast Asia. The components of the sensors and their functioning were also demonstrated.

Visit to Internet Education and Research Laboratory of AIT

DAY 3

MODULE 2: EMISSION INVENTORY

The emission Inventory Module covered the development of inventories of air pollutants through "bottom-up and top-down" approaches. The Emission Inventory Tools were introduced that countries could use for the compilation of emissions of air pollutants. Classroom lectures on the development of emission inventory and hands-on training were conducted in this Module.

P-03: Overview of emission inventory development process and emission factors

Expert: Dr. Ekbordin Winijkul, Asian Institute of Technology (AIT), Thailand

An emission inventory is a comprehensive listing of emission sources of air pollutants in a geographic area during a specific period. The purpose of development of an emission inventory is to obtain systematic information on the category and distribution of sources, amounts, and types of pollutants to identify major sources, cost-effective control strategies, permitting emission fees, tracking emissions, modeling, design monitoring program, and public awareness. In developing countries, about 60-80% of air pollutants are emitted from mobile sources and other sources including cooking emissions, open burning, and

industries. Two approaches are adopted in developing the emission inventories, namely, bottom-up and top-down, illustrated as follows:

Top-Down VS. Bottom-Up Approaches

Top-Down Approach

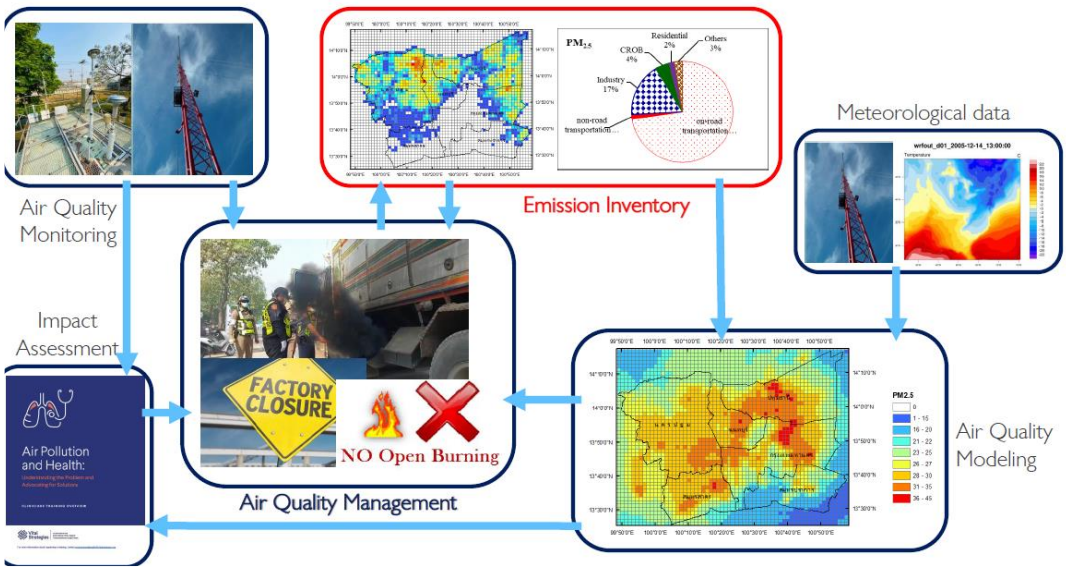
- Methodology
  - Use emission factors and high level (national) activity data (e.g., emission factor x national coal consumption) to estimate emissions
  - National- or regional-level emission estimates scaled to the inventory domain based on surrogate data (geographic, demographic, economic data)
- Typically used when
  - Local data are not available
  - Too high cost to gather local information
- **Advantages:** Requires minimum resources
- **Disadvantages:** Low accuracy, high uncertainty

Bottom-Up Approach

- Methodology
  - Uses source-specific data (for point sources) and category-specific data at the most refined spatial level (for nonpoint and mobile sources)
  - Emission estimates for individual sources (and source categories) are summed up to obtain domain-level inventory
- Typically used when
  - Source/category-specific activity or emissions data are available
  - End-use of EI justifies high cost of collecting site-specific data
- **Advantage:** Produce more accurate emission estimates
- **Disadvantage:** Requires more resources to collect site-specific information than a top-down approach

The role of emission inventory in air quality management is shown below:

Emission Inventory in Air Quality Management

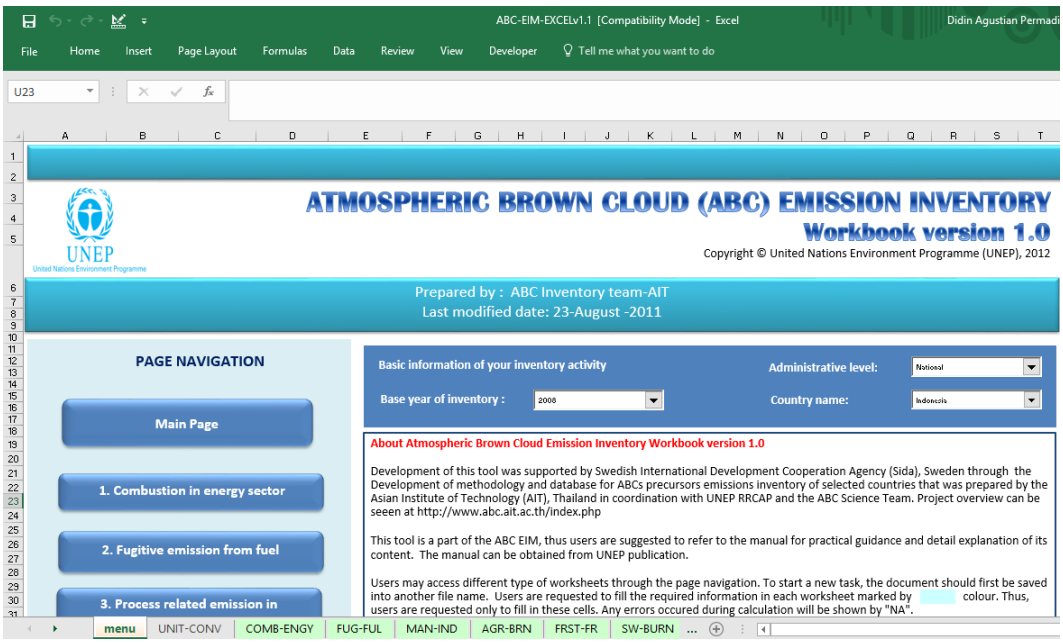


For designing emission inventory needs the identification of the EI manager and EI compiler, identify key air pollution issues, selection of air pollutants and sources, selection of inventory domain and base year, selection of temporal resolution e.g., hourly or daily or annual, and designing reporting document of emission inventory.

PW-02: Emission Inventory Tools

Expert: Dr. Didin Agustian Permadi, National Institute of Technology (ITENAS), Indonesia

Emission inventory concepts and processes, emission inventory tools, emission inventory models, and uncertainty analysis were introduced. There are several tools available for the development of emission inventories, such as the ABC EIM Tool (excel-based), International Vehicle Emission (IVE), Aviation Environmental Design Tool (AEDT), Landfill Gas Emissions Model (LandGEM), and Biogenic emission (GLOBEIS). Among them, ABC EIM Tool is prominently used in the development of emission inventories in many Asian countries. The introduction page of the ABC EIM Tool is shown below:



It is an excel-based tool developed in the Atmospheric Brown Cloud (ABC) project.

For the practice on the development of emission inventory, participants were asked to install the ABC EIM Tool on their computers. An input file of activity data was provided to participants and then participants were allowed to run the tool and

calculate the emission data. Each participant was individually guided to learn the tool. It is expected that the participants will use the tool for calculation of tool in their country.

FIELD VISITS

In order to provide exposure to air quality management practices in Thailand, field visits were organized for the participants. They visited the following 2 places in the Bangkok region.

(1) Automotive Emission Laboratory, Pollution Control Department, Ministry of Natural Resources and Environment, Government of Thailand

Automotive Emission Laboratory of PCD is the ISO/IEC 17025 (International Organization for Standardization/International Electrotechnical Commission) accredited laboratory, well equipped with state-of-the-art facilities for emission testing and calibration of motorcycle, light-duty, and heavy-duty vehicles. Participants at the Emission Testing Laboratory learned about the analysis and evaluation of emissions from vehicles, vehicles' in-use engine qualities in terms of engine performance and durability including the deterioration rate of in-use emission reduction devices, such as catalytic converter and diesel particulate filter (DPF), monitoring of quantities of pollutants emitted from vehicle types, development of the appropriated system, procedure, and suitable method to control and reduce air pollution from vehicles, other techniques for emission testing of vehicles.

Visit to Automotive Emission Laboratory, PCD, Thailand

(2) Environmental Research and Training Center (ERTC), Ministry of Natural Resources and Environment, Government of Thailand

Environmental Research and Training Center (ERTC) is operating under the Department of Environmental Quality Promotion (DEQP) and the Ministry of Natural Resources and Environment (MONRE). The main objective of the ERTC is to carry out research and to provide technical support in the implementation of environmental policies and environmental initiatives. At ERTC participants visited Dioxin Laboratory and VOC Laboratory and learned about sampling and analysis of dioxins and VOCs. Air quality sampling and analysis by the mobile laboratory were also demonstrated.

Visit to Environmental Research and Training Center (ERTC), Thailand

DAY 4

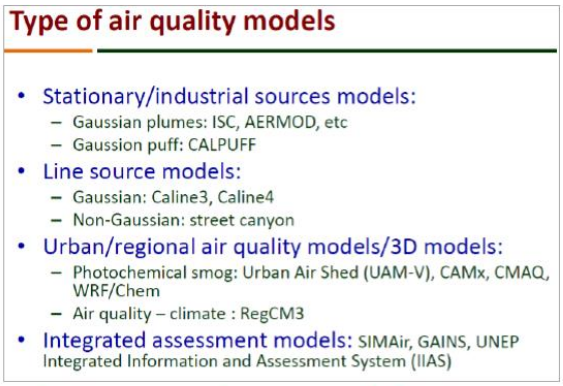
MODULE 3: AIR QUALITY MODELING

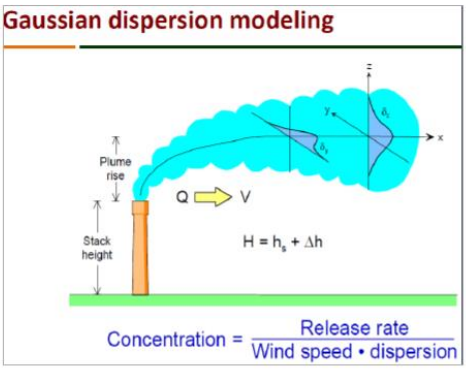
P-04: Overview of air quality modeling

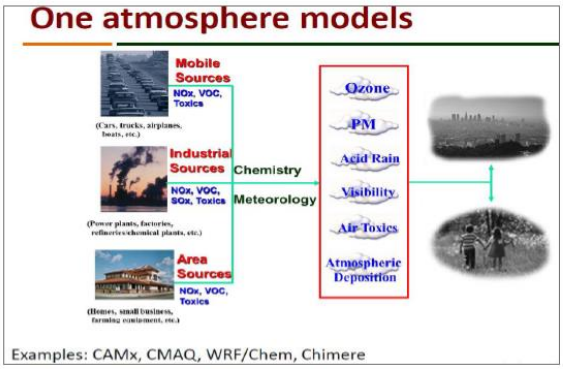
Expert: Dr. Didin Agustian Permadi, National Institute of Technology (ITENAS), Indonesia

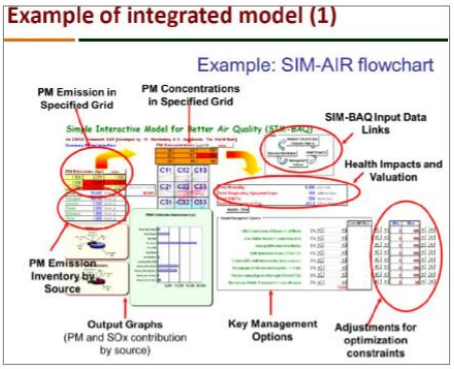
Air quality models use mathematical and numerical techniques to simulate the physical and chemical processes that affect air pollutants as they disperse and react in the atmosphere. In this lecture, basic concepts of air quality modeling including

types of models were introduced. These include stationary or industrial sources models (gaussian plumes: ISC, AERMOD, etc; Gaussian puff: CALPUFF), line source models (gaussian: Caline3, Caline4; non-gaussian: street canyon), urban/regional air quality models/3D models (photochemical smog: Urban Air Shed (UAM-V), CAMx, CMAQ, WRF/Chem; air quality – climate: RegCM3), and integrated assessment models (SIMAir, GAINS, UNEP Integrated Information and Assessment System (IIAS)). US EPA preferred models include AERMOD Modeling System (steady-state new Gaussian plume model, treating both surface and elevated sources, and both simple and complex terrain), CALPUFF Modeling System (non-steady-state puff dispersion model and can be applied for long-range transport and for complex terrain) and other models (BLP, CALINE3, CAL3QHC/CAL3QHCR, CTDMPLUS).





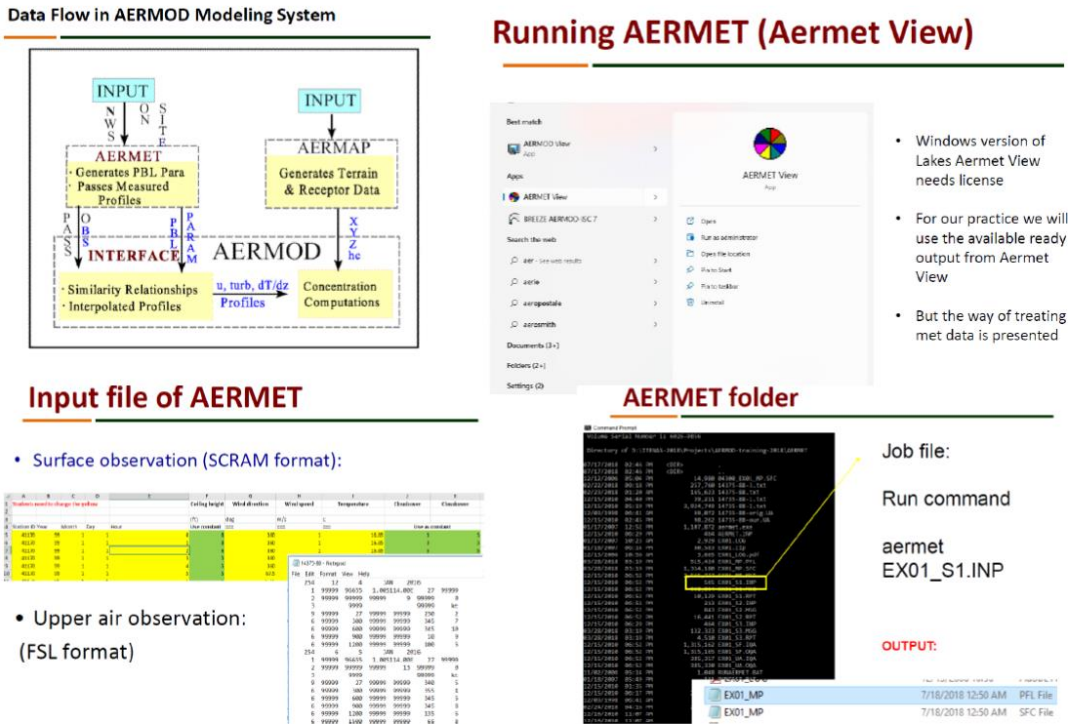




Case studies/research studies using the AERMOD for environmental impact assessment, urban ozone pollution using MM5-CMAx, and Regional PM modeling using WRF-Chimere were also shown to participants.

PW-03: Hands-on training on air quality modeling

Participants were asked to install the AERMOD model (BREEZE-AERMOD-7.2.5-release.msi) in their computer and then instructed or assisted each participant step by step process to simulate the data using the AERMOD model by inputting input file data provided. Participants simulated the air quality modeling data and shared it with other participants.

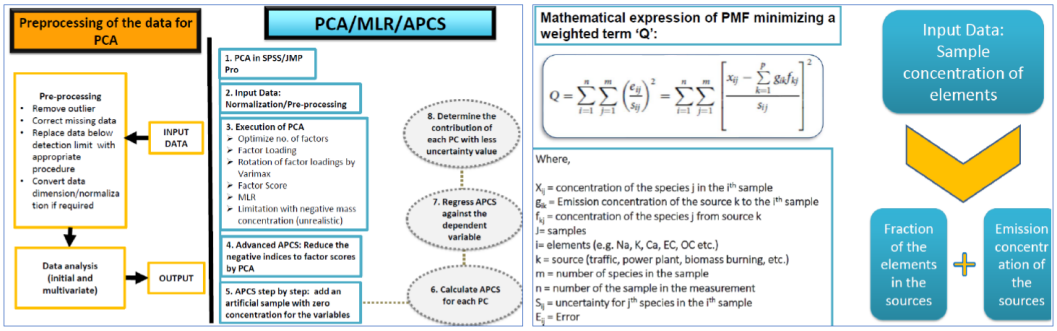


P-05: Source apportionment of emissions of air pollutants

Expert: Dr. Md Firoz Khan, University of Malaya, Kuala Lumpur, Malaysia

Dr. Khan introduced the basics of air pollution, its impacts on health, and concepts of source apportionment of air pollutants. He also introduced chemometrics and its application in air quality management. Chemometrics is a combination of air quality monitoring, chemical analysis, pattern recognition, and source identification. Application of chemometrics includes measurements from the chemical system, real-time decision-making, information extraction, calibration and validation, modeling and prediction, classification, and visualization. For source apportionment, 2 receptor models are normally used, namely, PCA/Absolute Principle component

Score (APCS) and Positive Matrix Factorization (PMF). A framework of both models is given below:



Source apportionment studies conducted in Asian cities using source apportionment models were presented.

PW-04: Hands-on training on source apportionment emissions of air pollutants

Participants are asked to install the PMF-Ver.5 on their computer and then assisted to run the model using step-by-step instructions. All necessary input files were provided to participants.

DAY 5

MODULE 4: IMPACT ASSESSMENT

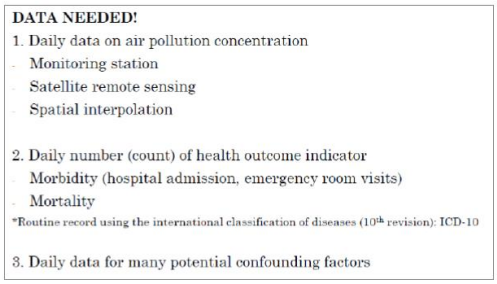
The Impact Assessment Module covered the concepts of impact assessment of air pollution on human health and the environment including models/tools used for impact assessment of air pollution on health and the environment. The focus was made on how the impact assessment tools/models can be used in air quality management including formulations of effective emission reduction policies and co-benefits of air pollution reduction. There were 2 presentations to cover the scope of the impact Assessment Module.

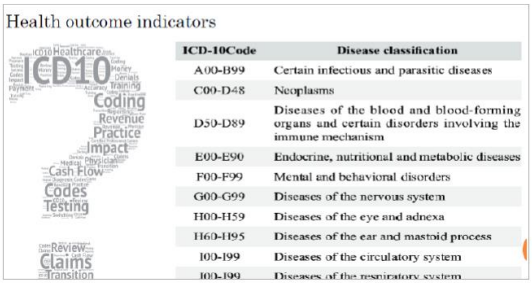
P-06: Air pollution impact assessment on health

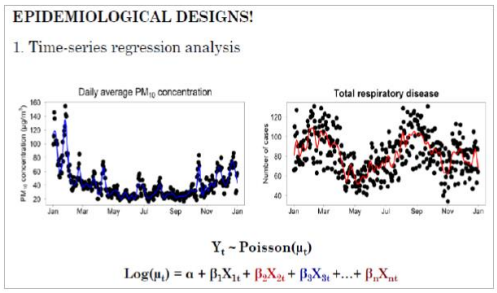
Expert: Dr. Arthit Phosri, Mahidol University, Thailand

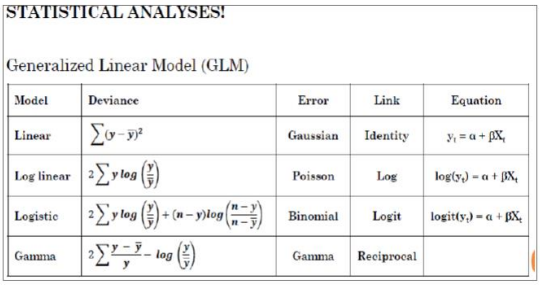
Health impact assessment of air pollution is a method used to estimate the change in the health condition of a population based on a change in air pollution exposure. It estimates the concentration-response function for both short-and long-term effects depending upon available data and overall quantifies disease burden from

air pollution exposure. Health assessment requires data, epidemiological designs, statistical analyses, and risk estimation. Models and methodologies used for the impact assessment of air pollution on health, including recent studies in Asian countries, were presented.







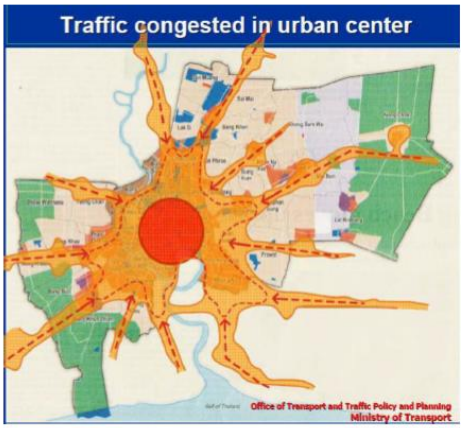


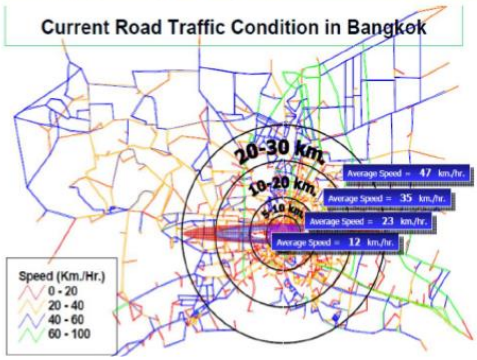
Health impact assessment studies are informative and effective tools of communication with the general public and policymakers in terms of the impact magnitude attributable to air pollution exposure.

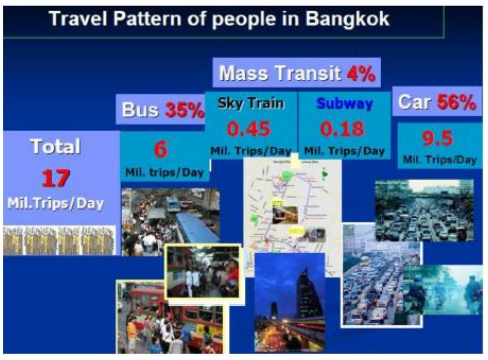
P-07: Overview of mitigation measures implemented in the transport sector in Thailand and air quality in Bangkok.

Expert: Dr. Ittipol Pawarmart, Pollution Control Department, Thailand

The concentrations of TSP, PM_{10}, and CO are decreasing in the Bangkok region during the last 3 decades despite the increasing number of vehicles. Whereas NO_2 remains almost stable but O_3 is showing an increasing trend. Emission inventory showed that biomass burning is contributing the largest portion of $PM_{2.5}$ followed by transport and industries. While NO_2 is being contributed by the transport sector followed by industry and SO_2 is largely contributed by industries. Source apportionment studies showed that diesel vehicles largely contribute to $PM_{2.5}$. Traffic congestion is a big problem in Bangkok.







A comprehensive vehicle pollution control strategy includes the implementation of clean vehicle technologies, clean fuels, transport & land use planning, appropriate maintenance, roadside inspection, building MRT and BTS in Bangkok, conducting research and development, and exhaust emission testing. Ongoing projects in Thailand related to co-benefits include PM and its size Distribution from Diesel vehicles using B7, B10, B20, and B30; the size of PM and respiratory & health impacts, cascade impactor "MOUDI" for PM size classification; installing DPF system with heavy diesel vehicles project; ED-95 Project (Ethanol 95 %) (With KMUTT); DIESEL Project (with World Bank); CNG Bus Project (with BMTA); PM compositions Project (with Ministry of Energy); PM counter for Euro 5 and 6; Emission factors Project; and integrated air pollution and climate change mitigation assessment (with CCAC, SEI, IGES).

MODULE 5: AIR POLLUTION MITIGATION POLICIES

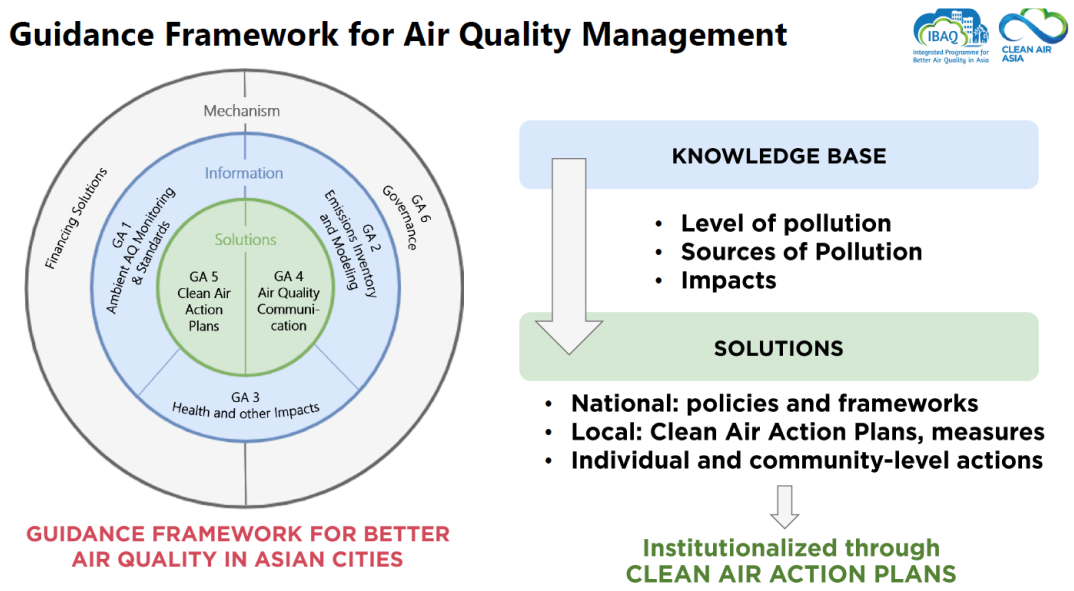
Air Pollution Mitigation Policies Module covered the air pollution emission reduction policies, action plans incorporating mitigation scenarios, strengthening emissions standards, etc. This module provided perspectives on air pollution mitigation strategies and actions in Asia, air pollution and climate change linkages,

models/tools for emission mitigation scenarios, and science-based solutions for emission reduction. Key examples of national mitigation programmes (India and Thailand) were also presented.

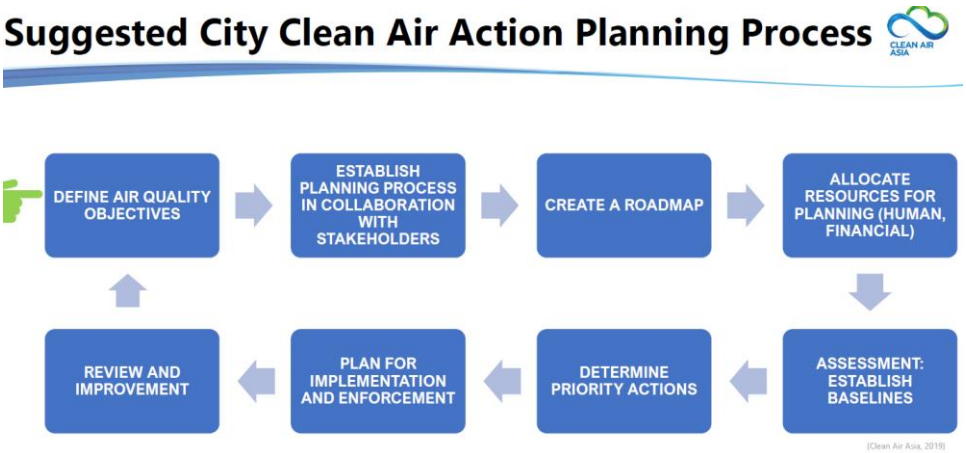
P-08: Air quality solutions and lessons learned in Asia.

Expert: Ms. Dang Espita-Casanova, Clean Air Asia, Manila, Philippines

Ms. Espita-Casanova presented the Clean Air Asia work including the Guidance Framework for strategic air quality management, clean air action plans, cases studies and lessons including Quezon City: air quality monitoring, Bogor: emission inventory development, Manila City: impacts assessment, Can Tho, Marikina: multi-stakeholder participation, and New Delhi: stakeholder and Policy Engagement. Given below is a guidance framework for air quality management:



This framework is guided from developing the knowledge base (pollution level, pollution sources, impacts, etc.) to the solution (policies and frameworks, clean air action plans and measures) and institutionalized clean air action plans and actions. She introduced the basics of the Clean Air Action Plan (CAAP) which must include impacts, costs, governance, technologies, and alignment of CAAP with local, national, regional and international plans.



Good practices in clean air action planning include drawing inputs from assessment of air pollution sources and emissions, ambient air pollution levels, air quality goals, information on source apportionment and exposure assessment; evaluating source mitigation and control options for their efficacy, technical feasibility, and ease of implementation; sets targets and timelines for action; discussion with major stakeholders, and delineates roles and responsibilities; addresses implementation issues such as institutional arrangements and partnerships, infrastructure, and financial resources; considers future activity growth and projected air pollution scenarios; define monitoring and evaluation mechanism, and provides opportunities for mid-term corrections.

P-09: Improving air quality through cleaner fuels and vehicles, and mass transit: a case of Bangkok, Thailand

Expert: Dr. Supat Wangwongwatana, Thammasat University, Thailand

Dr. Wangwongwatana presented the state and trends in the air quality of Bangkok and Thailand, sources of air pollution in Bangkok, strategies for air pollution control from mobile sources, and clean air actions in Thailand. The concentrations of TSP, PM_{10}, $PM_{2.5}$, and CO are decreasing in the Bangkok region during the last 3 decades despite the increasing number of vehicles. Whereas NO_2 remains almost stable but O_3 is showing an increasing trend. The yearly concentration levels of PM_{10} and $PM_{2.5}$ are meeting the standards in recent years. In the Bangkok region, diesel vehicles are the major source of $PM_{2.5}$, followed by biomass burning, secondary particles, industries, and others. A comprehensive vehicle pollution control strategy includes the implementation of clean vehicle technologies, clean fuels, transport and land use planning, appropriate maintenance, roadside inspection, building MRT and BTS in Bangkok, conducting research and development, and exhaust emission testing.

Clean fuels and new vehicles are major factors responsible for today Bangkok's cleaner air. The use of low sulfur fuels, catalytic converters, phase-out 2-stroke motorcycles, and implementation of stringent emission standards helps in improving the air quality in the Bangkok region. Major strategies to control air pollution emissions are increasing the effectiveness of control measures in an area based during the critical period, controlling and minimization of air pollutant emissions at sources, and improving air quality management efficiency.

P-10: Air pollution action plans, mitigation policies & success stories -India

Expert: Mr. J. S. Kamyotra, India

India is facing several challenges in air quality management including 123 cities not meeting NAAQS continuously for the last 5 years, PM_{10} and $PM_{2.5}$ are high in most urban areas, NO_x and O_3 rising, and lack of technologies and management, perceptions based (no science guided) actions, complexity in the development of action plans, implementation of actions and enforcement, participation of stakeholders, and target setting, and others. The national air quality monitoring networks include 882 manual (in 378 cities), and 372 (in 190 cities) real-time air quality monitoring stations. The air quality data is being used for source identification and prioritization, identification of new emission sources, evaluation of interventions, future projections considering development, land-use changes and activity levels, and hotspot identification. Major sources of PM in NCR and other major urban regions are soil and road dust, MSW and biomass burning, coal and fly ash, transport, industry, and secondary particles. Policy initiatives to control the emissions of air pollutants are the implementation of BS-VI (auto fuel and vehicle emission norms), promotion of e-mobility, building metro rails, making non-motorized transport, stringent norms for power plants and industries, real-time tracking of industrial emissions, ujjawala scheme for cleaner cooking fuel (e.g., LPG), use of clean technologies, waste management (swatch Bharat, EPR), creating public awareness, improve governance framework and institutional mechanism, and monitoring and evaluation of policies implementation.

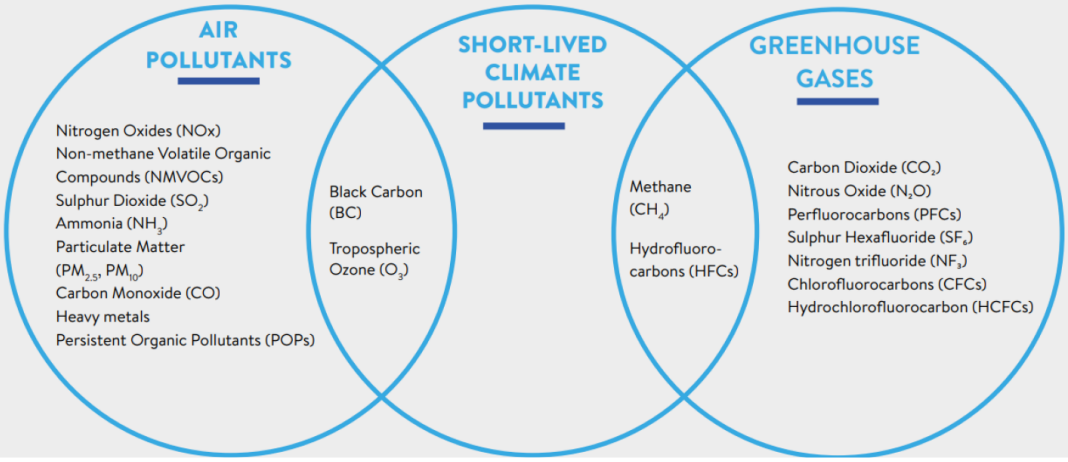
P-11: Co-benefits policy assessment tool, LEAP-IBC (Long-range Energy Alternatives Planning -Integrated Benefits Calculator)

Expert: Dr. Johan C.I. Kuylenstierna, Stockholm Environment Institute (SEI), UK

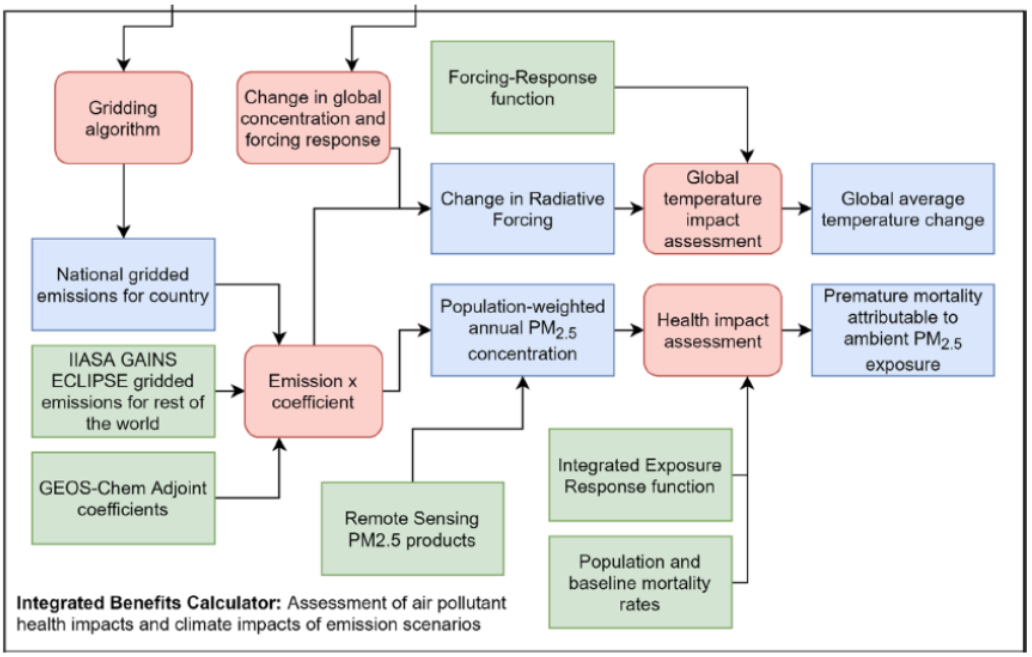
Dr. Kuylenstierna in his presentation mentioned that there is a strong linkage between air quality, SLCP, and climate planning. The same emission source emits GHGs which have long-term warming and climate change, SLCPs have near-term

warming and climate change, while aerosols and trace gases have adverse impacts on health and agriculture productivity.

Air Pollution and Climate Change Linkages



So reducing emissions of GHGs or SLCPs from the same source would help in reducing climate change and air pollution-related impacts. It is estimated that by reducing CO_2 emissions to achieve the Paris Agreement target, over one million premature deaths may be avoided by 2050. There is a need for enhancing the capacity to undertake integrated national planning by supporting national planning, strengthening institutions, and providing training and planning tools. SEI is working with countries in SNAP using the LEAP-IBC for integrated air quality and climate planning by developing emissions scenarios for helping in the planning process. The LEAP, created by SEI, is a software system for quantitative modeling of energy systems, pollutants and GHG emissions from energy and non-energy sources and empowers the developing countries to perform their own analyses well-suited to long and medium-term national planning. Following is a data flowchart for the LEAP-IBC:

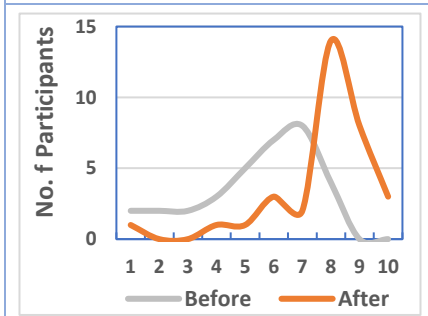
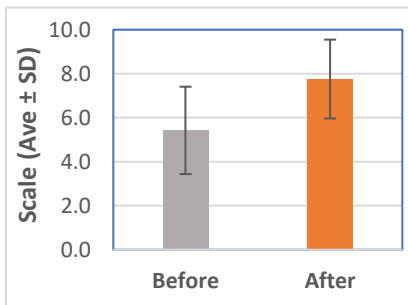
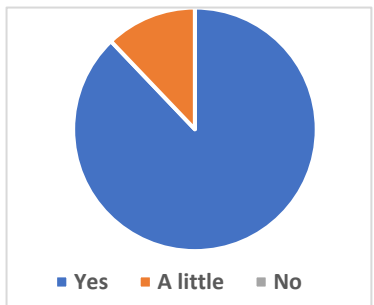
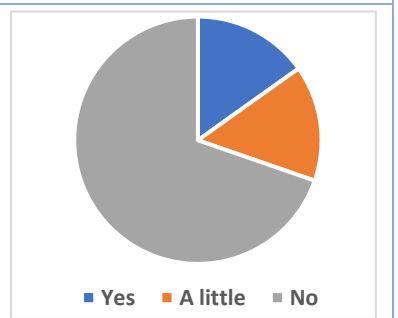


It provides quantitative assessments of emissions, regional transport, exposure, and impacts on climate, health, and agriculture. LEAP website: https://leap.sei.org/

6. EVALUATION OF PARTICIPANTS

The evaluation of participants was made by providing a set of questions for each topic of the presentation and for the whole workshop in order to measure the enhancement of knowledge, understanding, and skills of participants during 5-day of the workshop. The evaluation questionnaire is given in Annex 4. The participants were asked to rate the enhancement of their understanding and knowledge on each topic of the presentation and on the whole workshop on a scale of 1 to 10. All participants have provided their evaluation and feedback. The table below illustrates the evaluation results.

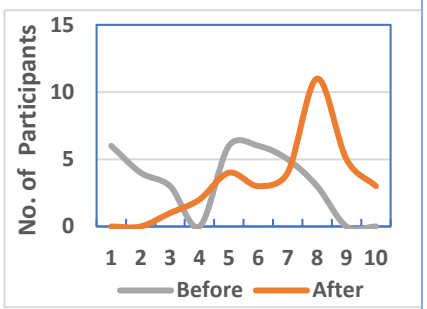
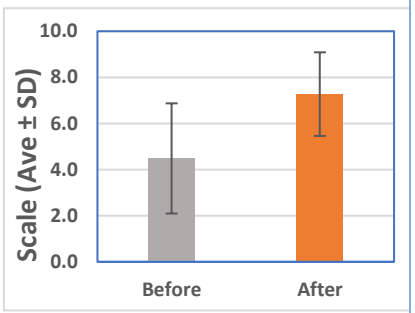
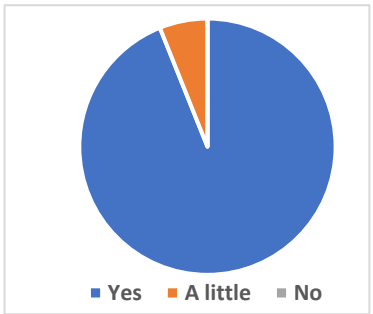
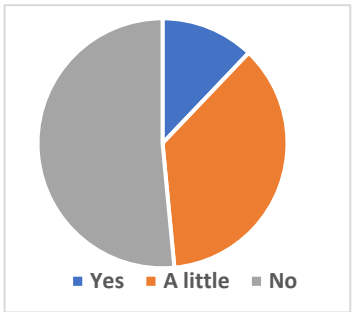
Evaluation results of the participants on their increased understanding and knowledge before and after each lecture and after the whole workshop based on feedback received from the participants using the questionnaire given in Annex 4 (Feedback/Evaluation Form for Participants)

Table 1: Evaluation of participants			
MODULE 1: AIR QUALITY MONITORING			
P-01: Overview and importance of air quality monitoring for air quality management			
How do you rate your understanding (or knowledge increase) of the importance of ambient air quality monitoring for air quality management before and after the lecture? Please rate on a scale of 1 to 10.		Was the content of the lecture interesting to you and has new information which will be useful in your work?	Do you think the lecture was too technical and you could not understand it fully?
			

- The majority of participants rated 7 about their knowledge and understanding on ambient air quality monitoring before the lecture. Their knowledge and understanding were increased to 8 after the lecture.
- On an average, the knowledge and understanding of participants on the ambient air quality monitoring before the lecture was 5.4±2.0 which increased to 7.8±1.8 after the lecture, with a net increase of 2.3.

- About 88% of participants found the contents of the lecture on ambient air quality monitoring interesting and they learned new information which will be useful in their work. However, 12% of participants found the contents of the lecture a little interesting.
- About 70% of participants thought that the lecture was not too technical, and they understood it easily. However, 15% of participants found that the lecture was a little difficult for them, while about 15% of participants found that the lecture was too difficult for them, and they could not understand it fully.

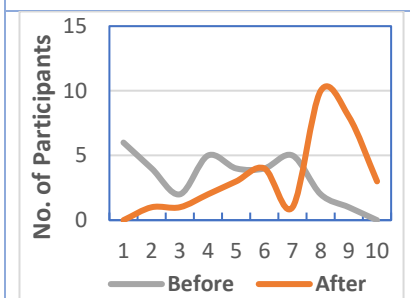
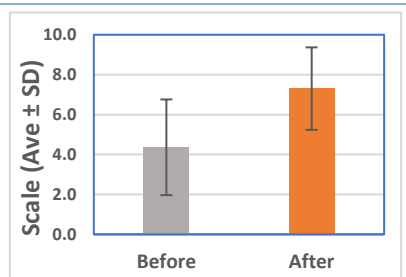
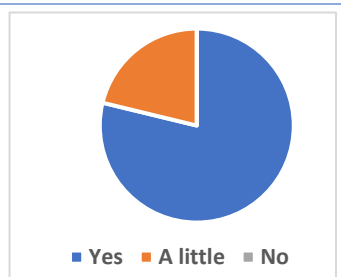
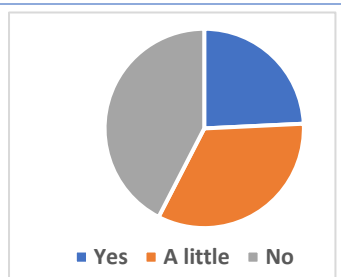
P-02: Air Quality Monitoring Study at AIT

How do you rate your understanding (or increase of knowledge) of the air quality monitoring instrumentation before and after the lecture? Please rate on a scale of 1 to 10.		Was the content of the lecture interesting to you and has new information which will be useful in your work?	Was the content of the lecture too technical and you could not understand it fully?
			

- The majority of participants rated 5 **on** their knowledge and understanding **of** air quality monitoring instrumentation before the lecture. Their knowledge and understanding were increased to 8 after the lecture.

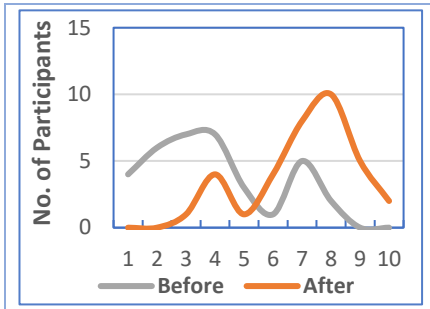
- On an average, the knowledge and understanding of participants on air quality monitoring instrumentation before the lecture w**as** 4.5±2.4 which increased to 7.3±1.8 after the lecture, with a net increase of 2.8.
- About 94% of participants found that the contents of the lecture on air quality monitoring instrumentation were interesting and they gained new information which would be useful in their work. About 6% of participants found that the contents of the lecture were a little interesting.
- About 52% of participants thought that the lecture was not too technical for them, and they understood it easily, while about 36% of participants found that the lecture was a little difficult for them to understand, and about 6 % of participants found that the lecture was too difficult for them, and they could not understand it fully.

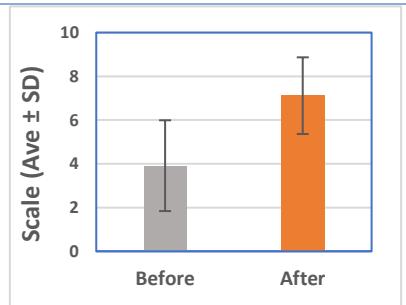
PW-01: Demonstration and hands-on training on air quality monitoring in AIT lab facilities (Ambient Lab and InterLab)

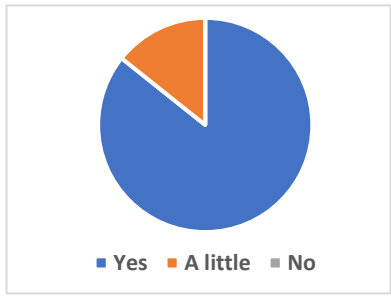
How do you rate your understanding, increase of knowledge, and skill on air quality monitoring instrumentation including low-cost sensors? Please rate on a scale of 1 to 10.		Was the demonstration of lab instruments including LCS of air quality monitoring interesting to you and has new information which will be useful in your work	Was the demonstration too technical and you could not be understood it fully?
			

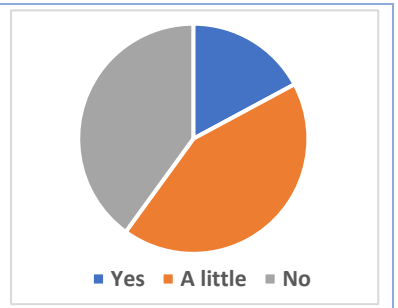
- Knowledge and understanding of air quality monitoring instrumentation including low-cost sensors before the demonstration were quite mixed 4-7. Their knowledge and understanding were increased to 8 after the demonstration.
- On an average, the knowledge and understanding of participants on air quality monitoring instrumentation including low-cost sensors before the demonstration was 4.4±2.4 which increased to 7.3±2.1 after the demonstration, with a net increase of 2.9.
- About 79% of participants found that the demonstration of lab instruments including LCS used for air quality monitoring was interesting and they gained new information which will be useful in their work. About 21% found that the demonstration of lab instruments including LCS of air quality monitoring interesting was a little interesting for them.
- About 42% of participants thought that the demonstration of lab instruments including LCS used for air quality monitoring was not too technical for them, and they understood it easily. About 33% of participants found that the demonstration was a little difficult for them to understand, and about 24% of participants found that the demonstration was too difficult for them and they could not understand it fully.

MODULE 2: EMISSION INVENTORY		
P-03: Overview of emission inventory development process and emission factors		
How do you rate your understanding and increased knowledge of the emission development process and emission factors? Please rate on a scale of 1 to 10.	Was the content of the lecture interesting to you and has new information which will be useful in your work?	Was the content of the lecture too technical and you could not understand it fully?



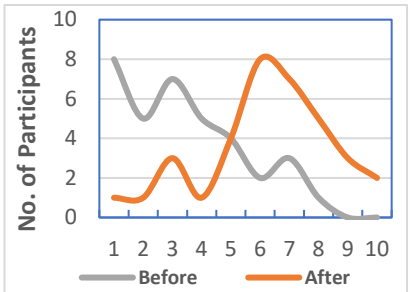
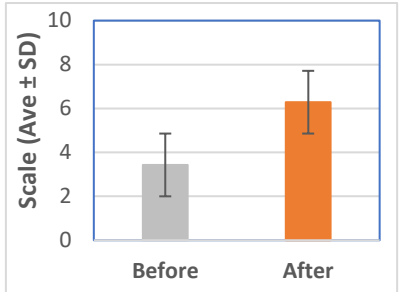
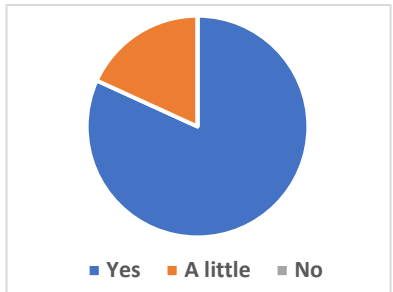
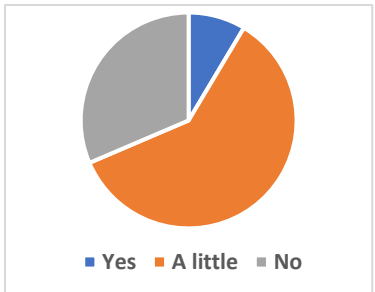






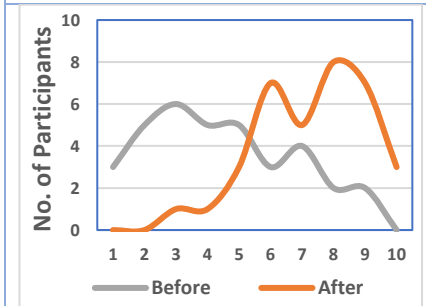
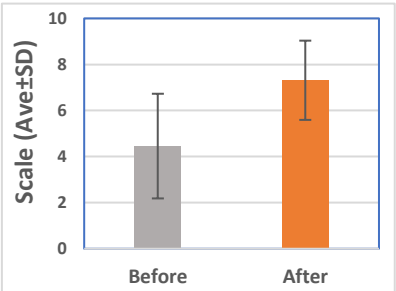
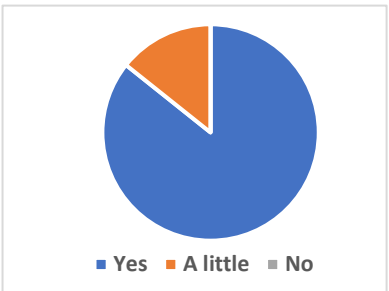
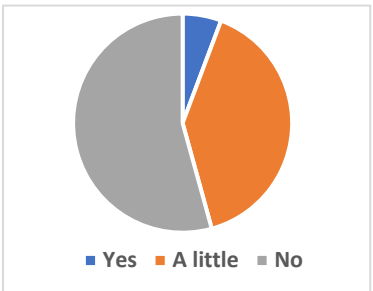
- The majority of participants rated 4 on their knowledge and understanding on the emission inventory development process and emission factors before the lecture. Their knowledge and understanding were increased to 8 after the lecture.
- On an average, the knowledge and understanding of participants on the emission inventory development process and emission factors before the lecture was 3.9±2.1 which increased to 7.1±1.7 after the lecture, with a net increase of 3.2.
- About 86% of participants found that the contents of the lecture on the emission inventory development process and emission factors were interesting and had new information which will be useful in their work. About 14% of participants found that the contents of the lecture were a little interesting.
- About 40% of participants thought that the lecture on the emission inventory development process and emission factors was not too technical for them, and they understood it easily. About 43% of participants found that the lecture was a little difficult for them to understand, and about 17% of participants found that the lecture was too difficult for them and they could not understand it fully.

PW-02: Emission Inventory Tools		
How do you rate your understanding and increased knowledge of Emission Inventory Tools? Please rate on a scale of 1 to 10.	Was the content of the emission inventory tool interesting to you and has new	Was the content of the presentation too technical

		information which will be useful in your work?	and you could not understand it fully?
			

- The majority of participants rated 2 about their knowledge and understanding on the Emission Inventory Tools before the lecture. Their knowledge and understanding were increased to 6 after the lecture.
- On an average, the knowledge and understanding of participants on the Emission Inventory Tools before the lecture was 3.4±2.0 which increased to 6.3±2.1 after the lecture, with a net increase of 2.9.
- About 82% of participants found that the contents of the lecture on the Emission Inventory Tools were interesting and had new information which will be useful in their work. About 18% of participants found that the contents of the lecture on the Emission Inventory Tools were a little interesting.
- About 31% of participants thought that the lecture on the Emission Inventory Tools was not too technical for them, and they understood it easily. About 60% of participants found that the lecture was a little difficult for them to understand, and about 9% of participants found that the lecture was too difficult for them, and they could not understand it fully.

Field Visit: Visit to air quality monitoring facilities operated by PCD and ERTC

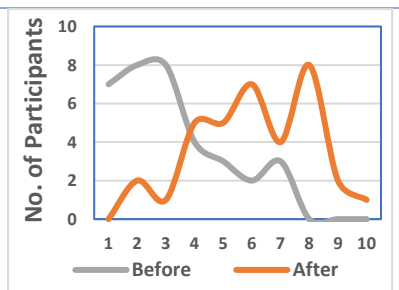
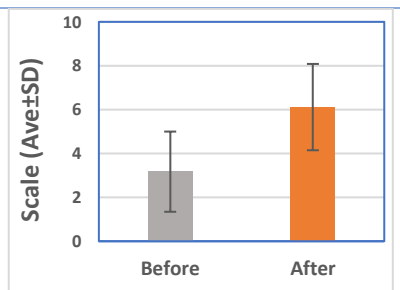
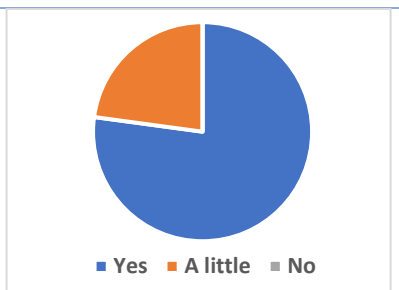
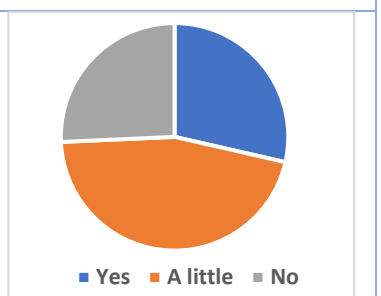
How do you rate your understanding and increased knowledge and skill of air quality monitoring, instrumentation, and facilities? Please rate on a scale of 1 to 10.		Was the demonstration of air quality monitoring instrumentation and facilities interesting to you and has new information which will be useful in your work	Was the demonstration too technical and you could not be understood it fully?
			

- The majority of participants rated 3 about their knowledge and understanding on air quality monitoring instrumentation and facilities during the field visit. Their knowledge and understanding were increased to 8 after the field visit.
- On an average, the knowledge and understanding of participants on air quality monitoring instrumentation and facilities before the field visit was 4.5±2.3 which increased to 7.3±1.7 after the visit, with a net increase of 2.9.
- About 86% of participants found that the demonstration of the air quality monitoring instrumentation and facilities was interesting and has new information which will be useful in their work. About 14% of participants found that the demonstration of air quality monitoring instrumentation and facilities was a little interesting.
- About 54% of participants thought that the demonstration of the air quality monitoring instrumentation and facilities was not too technical for them, and they understood it easily. About 40% of participants found that the demonstration of the air

quality monitoring instrumentation and facilities was a little difficult for them to understand, and about 6% of participants found that the demonstration of the air quality monitoring instrumentation and facilities too difficult for them, and they could not understand it fully.

Module 3: Air Quality Modeling

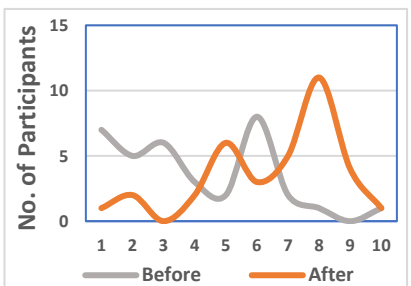
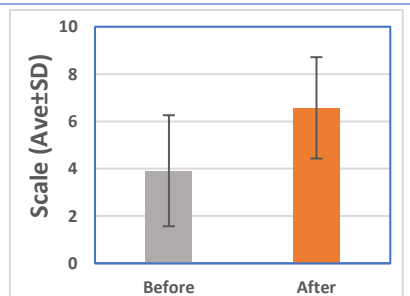
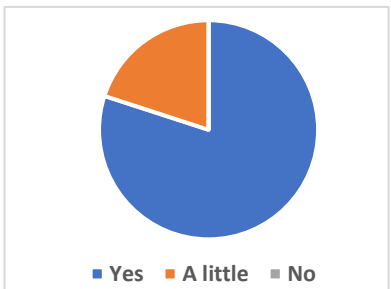
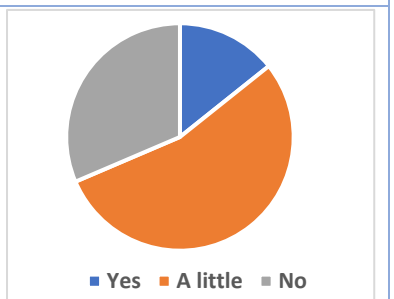
P-04: Introduction of air quality modeling

How do you rate your understanding and increased knowledge of air quality modeling? Please rate on a scale of 1 to 10		Was the content of the lecture on air quality modeling interesting to you and has new information which will be useful in your work?	Was the content of the lecture too technical and you could not understand it fully?
			

- A large number of participants rated 3 about their knowledge and understanding on air quality modeling before the lecture. Their knowledge and understanding were increased to 8 after the lecture.
- On an average, the knowledge and understanding of participants on air quality modeling before the lecture was 3.2±1.8 which increased to 6.2±2.0 after the lecture, with a net increase of 2.9.

- About 77% of participants found that the contents of the lecture on air quality modeling were interesting and had new information which will be useful in their work. About 23% of participants found that the contents of the lecture were a little interesting.
- About 26% of participants thought that the lecture on air quality modeling was not too technical for them, and they understood it easily, while about 46% of participants found that the lecture was a little difficult for them to understand, and about 29% participants found that the lecture was too difficult for them and could not understand fully.

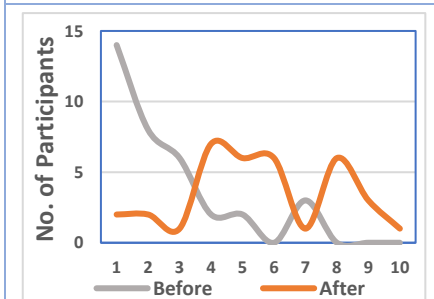
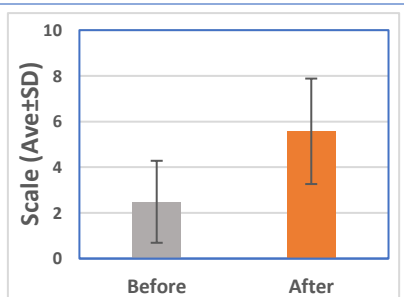
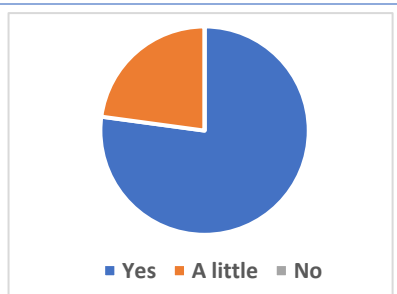
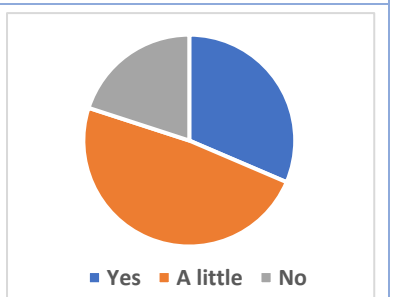
P-05: Source apportionment of emissions of air pollutants

How do you rate your understanding and increased knowledge of source apportionment of emissions of air pollutants? Please rate on a scale of 1 to 10.		Was the content of the lecture on source apportionment of emissions of air pollutants interesting to you and has new information which will be useful in your work?	Was the content of the lecture too technical and you could not understand it fully?
			

- A large number of participants rated 6 about their knowledge and understanding on source apportionment of emissions of air pollutants before the lecture. Their knowledge and understanding were increased to 8 after the lecture.

- On an average, the knowledge and understanding of participants on source apportionment of emissions of air pollutants before the lecture was 3.9±2.3 which increased to 6.8±2.1 after the lecture, with a net increase of 2.7.
- About 80% of participants found that the contents of the lecture on source apportionment of emissions of air pollutants were interesting and had new information which will be useful in their work. About 20% of participants found that the contents of the lecture on source apportionment of emissions of air pollutants were a little interesting.
- About 31% of participants thought that the lecture on source apportionment of emissions of air pollutants was not too technical for them, and they understood it easily, while about 54% of participants found that the lecture was a little difficult for them to understand, and about 14% participants found that the lecture was too difficult for them and could not understand fully.

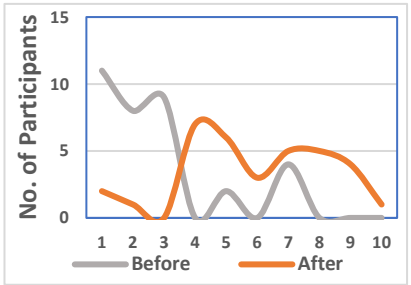
PW-03: Hands-on training on air quality dispersion modeling

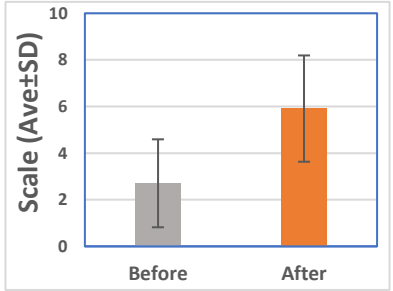
How do you rate your understanding, increased knowledge, and skill of air quality dispersion modeling? Please rate on a scale of 1 to 10.		Was the hands of training on air quality dispersion modeling interesting to you and has new information which will be useful in your work?	Was the hands on training too technical and you could not be understood it fully?
			

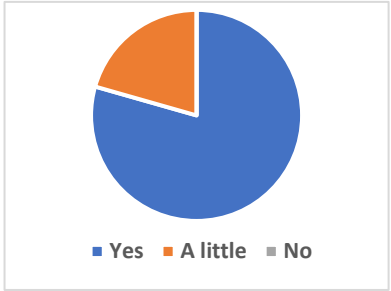
- A large number of participants rated 1 about their knowledge and understanding of air quality dispersion modeling before the practical session. Their knowledge and understanding were increased by 4-8 after the session.
- On an average, the knowledge and understanding of participants on air quality dispersion modeling before the practical session was 2.5±1.8 which increased to 5.6±2.3 after the session, with a net increase of 3.09.
- About 77% of participants found that the contents of the air quality dispersion modeling session were interesting and have new information which will be useful in their work. About 23% of participants found that the contents of the air quality dispersion modeling were a little interesting.
- About 20% of participants thought that the practical session on the air quality dispersion modeling was not too technical for them, and they understood it easily. About 49% of participants found that the practical session on the air quality dispersion modeling was a little difficult for them to understand, and about 31% of participants found that the practical session was too difficult for them and they could not understand it fully.

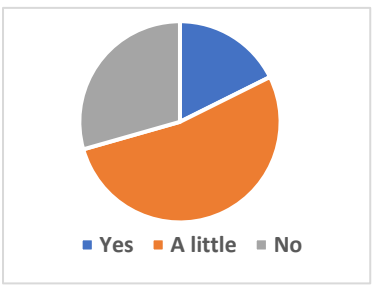
PW-04: Hands-on training on source apportionment emissions of air pollutants

How do you rate your understanding, increased knowledge, and skill of source apportionment emissions of air pollutants? Please rate on a scale of 1 to 10.	Was the hands of training on source apportionment of air pollutants interesting to you and has new information which will be useful in your work?	Was the hands on training too technical and you could not be understood it fully?





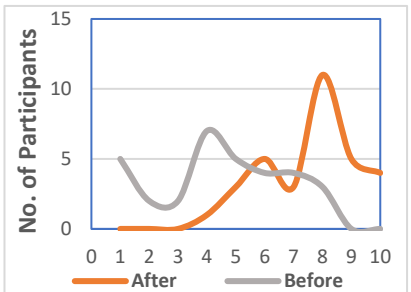
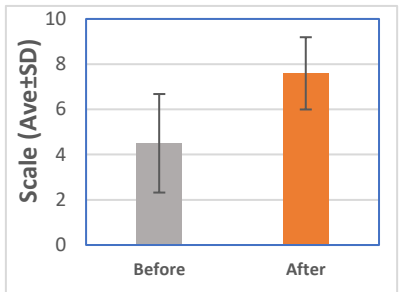
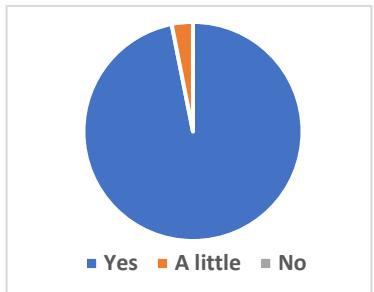
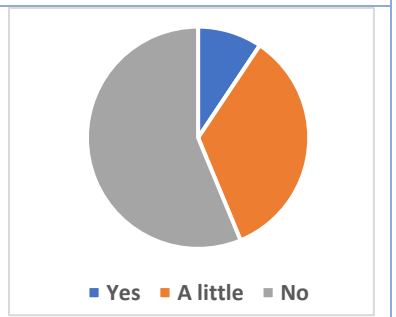




- The majority of participants rated 1 about their knowledge and understanding of source apportionment emissions of air pollutants before the practical session. Their knowledge and understanding were increased to 4-7 after the session.
- On average, the knowledge and understanding of participants on source apportionment emissions of air pollutants before the practical session were 2.7±1.8 which increased to 5.9±2.3 after the practical session, with a net increase of 3.2.
- About 79% of participants found that the contents of the practical session on the source apportionment emissions of air pollutants were interesting and had new information which will be useful in their work. About 21% of participants found that the contents of the session were a little interesting.
- About 29% of participants thought that the practical session on the source apportionment emissions of air pollutants was not too technical for them, and they understood it easily, while about 53% of participants found that the session was a little difficult for them to understand. About 18% of participants found that the lecture was too difficult for them and they could not understand it fully.

Module 4: Air Pollution Impact Assessment

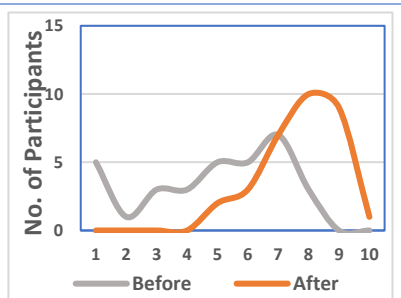
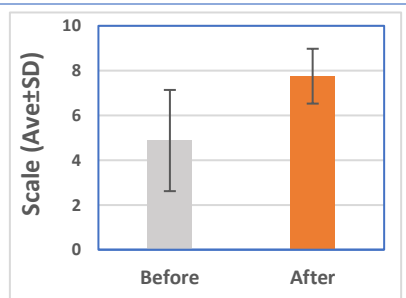
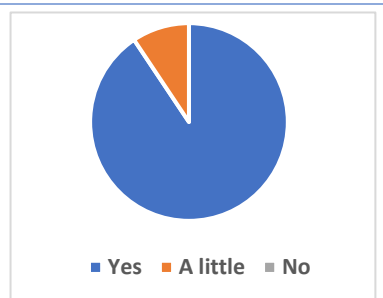
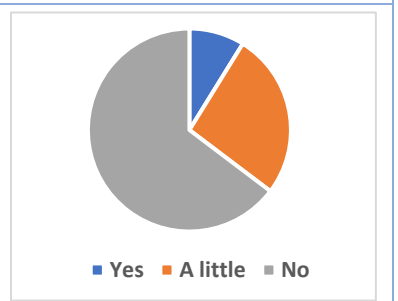
P-06: Air pollution impact assessment on health

How do you rate your understanding and increased knowledge of air pollution impact assessment on health? Please rate on a scale of 1 to 10.		Was the content of the lecture on air pollution impact assessment on health interesting to you and has new information which will be useful in your work?	Was the content of the lecture too technical and you could not understand it fully?
			

- A large number of participants rated 4 about their knowledge and understanding on air pollution impact assessment on health before the lecture. Their knowledge and understanding were increased to 8 after the lecture.
- On an average, the knowledge and understanding of the air pollution impact assessment on health before the lecture was 4.5±2.2 which increased to 7.6±1.6 after the lecture, with a net increase of 3.1.
- About 97% of participants found that the contents of the lecture on the impact assessment of air pollution on health were interesting and had new information which will be useful in their work. Only 3% of participants found that the contents of the lecture were a little interesting to them.

- About 56% of participants thought that the lecture on the impact assessment of air pollution on health was not too technical for them, and they understood it easily, while about 34% of participants found that the lecture was a little difficult for them to understand. About 9% of participants found that the lecture was too difficult for them and could not understand it fully.

P-07: Overview of mitigation measures implemented in the transport sector in Thailand and air quality in Bangkok

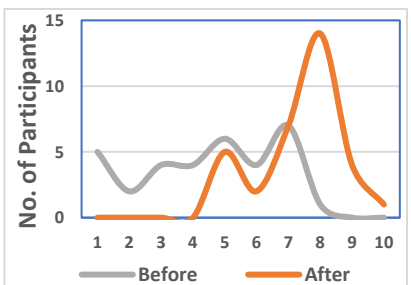
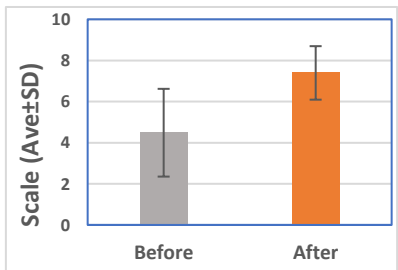
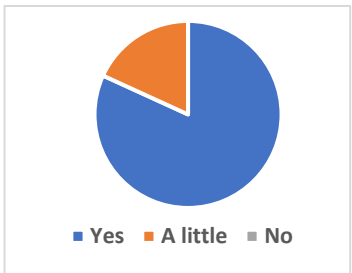
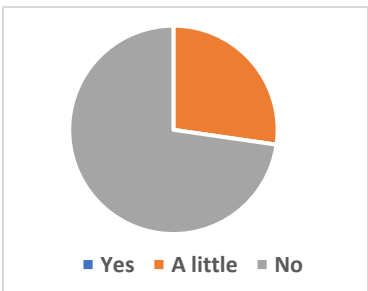
How do you rate your understanding and increased knowledge about mitigation measures implemented in the transport sector in Thailand and air quality in Bangkok? Please rate on a scale of 1 to 10.		Was the content of the lecture on co-benefits of air pollution emission reduction interesting to you and has new information which will be useful in your work?	Was the content of the lecture too technical and you could not understand it fully?
			

- A large number of participants rated 7 about their knowledge and understanding of the mitigation measures implemented in the transport sector in Thailand and air quality in Bangkok before the lecture. Their knowledge and understanding were increased to 9 after the lecture.
- On an average, the knowledge and understanding of participants on the air pollution impact assessment before the lecture was 4.9±2.3 which increased to 7.8±1.2 after the lecture, with a net increase of 2.9.

- About 91% of participants found that the contents of the lecture on the mitigation measures implemented in the transport sector in Thailand and air quality in Bangkok were interesting and have new information which will be useful in their work. However, about 9% of participants found that the contents of the lecture were a little interesting.
- About 65% of participants thought that the lecture on the mitigation measures implemented in the transport sector in Thailand and air quality in Bangkok was not too technical for them, and they understood it easily, while about 26% of participants found that the lecture was a little difficult for them to understand, and about 9% participants found that the lecture was too difficult for them and they could not understand it fully.

Module 5: Air Pollution Mitigation Policies

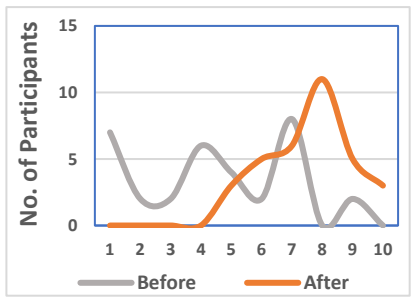
P-08: Air quality solutions and lessons learned in Asia

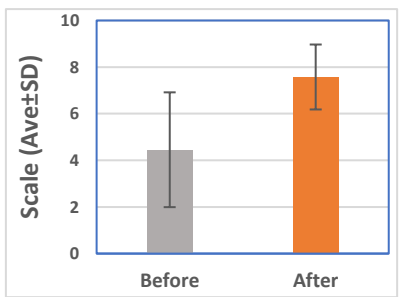
How do you rate your understanding and increased knowledge of air pollution solutions and lessons learned in Asia? Please rate on a scale of 1 to 10.		Was the content of the lecture on air pollution solutions and lessons learned in Asia interesting to you and has new information which will be useful in your work	Was the content of the lecture too technical and you could not understand it fully?
			

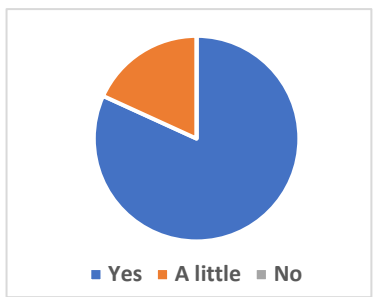
- A large number of participants rated 7 about their knowledge and understanding on the air pollution solutions and lessons learned in Asia before the lecture. Their knowledge and understanding were increased to 8 after the lecture.
- On an average, the knowledge and understanding of the air pollution solutions and lessons learned in Asia before the lecture was 4.5±2.1 which increased to 7.4±1.3 after the lecture, with a net increase of 2.9.
- About 73% of participants found that the contents of the lecture on air pollution solutions and lessons learned in Asia were interesting and had new information which will be useful in their work. About 18% of participants found that the contents of the lecture were a little interesting.
- About 73% of participants thought that the lecture on air pollution solutions and lessons learned in Asia was not too technical for them, and they understood it easily, while about 27% of participants found that the lecture was a little difficult for them to understand.

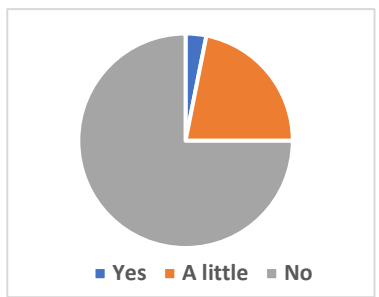
P-09: Improving air quality through cleaner fuels and vehicles, and mass transit: a case of Bangkok, Thailand

How do you rate your understanding and increase knowledge on improving air quality through cleaner fuels and vehicles, and mass transit: a case of Bangkok, Thailand? Please rate on a scale of 1 to 10.	Was the content of the lecture on Improving air quality through cleaner fuels and vehicles, and mass transit: a case of Bangkok Thailand interesting to you and has new information which will be useful in your work?	Was the content of the lecture too technical and you could not understand it fully?



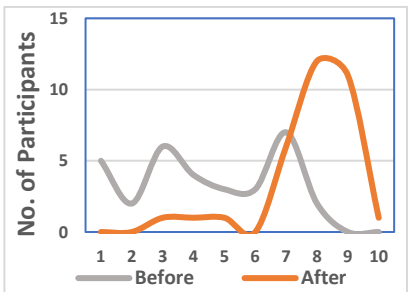
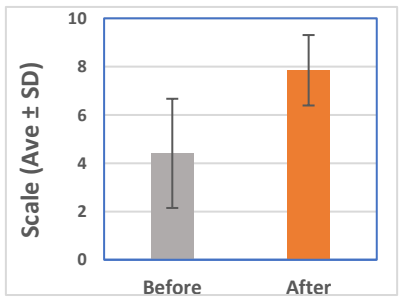
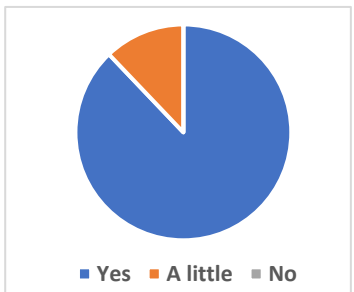
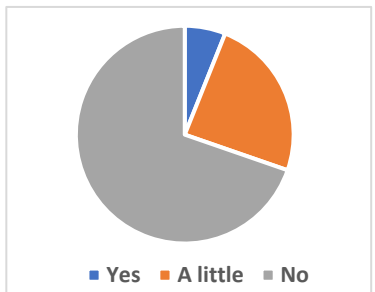






- The majority of participants rated 4-6 about their knowledge and understanding on improving air quality through cleaner fuels and vehicles, and mass transit: a case of Bangkok, Thailand before the lecture. Their knowledge and understanding were increased to 8 after the lecture.
- On an average, the knowledge and understanding of improving air quality through cleaner fuels and vehicles, and mass transit: a case of Bangkok, Thailand before the lecture was 4.5±2.5 which increased to 7.6±1.4 after the lecture, with a net increase of 3.1.
- About 82% of participants found that the contents of the lecture on improving air quality through cleaner fuels and vehicles, and mass transit: a case of Bangkok, Thailand was interesting and has new information which will be useful in their work. About 18% of participants found that the contents of the lecture were a little interesting to them.
- About 75% of participants thought that the lecture on improving air quality through cleaner fuels and vehicles, and mass transit: a case of Bangkok, Thailand was not too technical for them, and they understood it easily, while about 22% of participants found that the lecture was a little difficult for them to understand. About 3% of participants found that the lecture was too difficult for them and could not understand it fully.

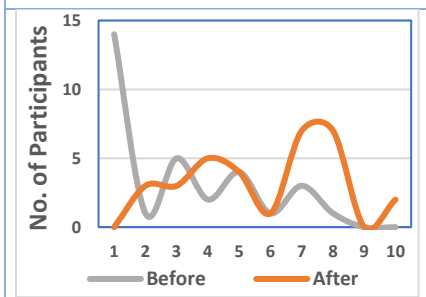
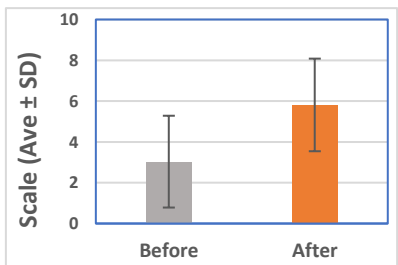
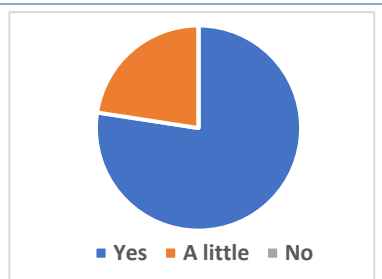
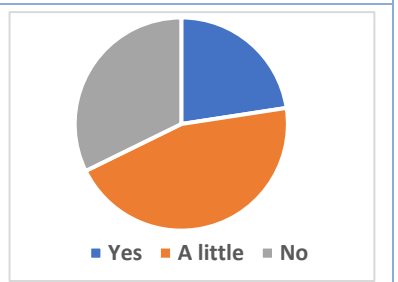
P-10: Air pollution action plans, mitigation policies & success stories -India

How do you rate your understanding and increased knowledge of air pollution mitigation policies and action plans and success stories of India? Please rate on a scale of 1 to 10.		Was the lecture on air pollution mitigation policies and action plans and success stories of India interesting to you and has new information which will be useful in your work?	Was the lecture too technical and you could not be understood it fully?
			

- The majority of participants rated 3-7 about their knowledge and understanding on the air pollution mitigation policies and action plans and success stories of India before the lecture. Their knowledge and understanding were increased to 8 after the lecture.
- On an average, the knowledge and understanding of the air pollution mitigation policies and action plans, and success stories of India before the lecture was 4.4±2.3 which increased to 7.9±1.5 after the lecture, with a net increase of 3.4.
- About 88% of participants found that the contents of the lecture on the air pollution mitigation policies and action plans and success stories of India were interesting and had new information which will be useful in their work. About 12% of participants found that the contents of the lecture were a little interesting.

- About 70% of participants thought that the lecture on the air pollution mitigation policies and action plans and success stories of India was not too technical for them, and they understood it easily, while about 24% of participants found that the lecture was a little difficult for them to understand, and about 6% participants found that the lecture was too difficult for them and could not understand it fully.

P-11: Co-benefits policy assessment tool - LEAP-IBC (Long-range Energy Alternatives Planning -Integrated Benefits Calculator)

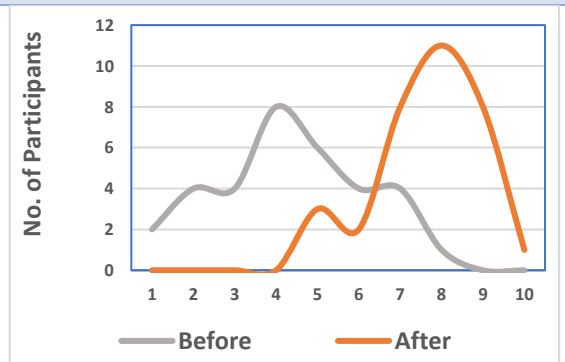
How do you rate your understanding and increased knowledge of LEAP-IBC? Please rate on a scale of 1 to 10.		Was the lecture on LEAP-IBC interesting to you and has new information which will be useful in your work?	Was the demonstration too technical and you could not be understood it fully?
			

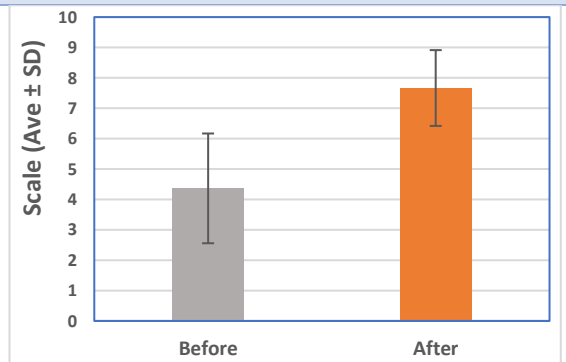
- The majority of participants rated 1 about their knowledge and understanding on the LEAP-IBC before the lecture, however. Their knowledge and understanding were increased to 8 after the lecture.
- On an average, the knowledge and understanding of the LEAP-IBC before the lecture was 3.0±2.3 which increased to 5.8±2.3 after the lecture, with a net increase of 2.85

- About 77% of participants found that the contents of the lecture on the LEAP-IBC were interesting to them and has new information which will be useful in their work. About 23% of participants found that the contents of the lecture were a little interesting to them.
- About 32% of participants thought that the lecture on the LEAP-IBC was not too technical for them, and they understood it easily, while about 45% of participants found that the lecture was a little difficult for them to understand, and about 23% of participants found that the lecture was too difficult for them and could not understand it fully.

Table 2: Evaluation of the Whole Workshop

How do you rate your understanding and increased knowledge and skills on all aspects of air quality management (i. e., monitoring, emission inventory, modeling, impact assessment, and mitigation policies? Please rate your response on a scale from 1 to 10.

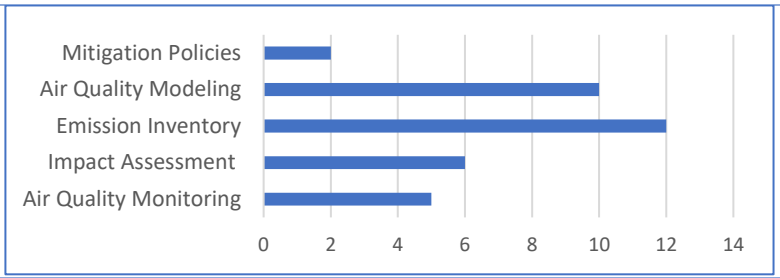




- The majority of participants rated 4 about their knowledge and understanding on all aspects of air quality management (i.e., monitoring, emission inventory, modeling, impact assessment, and mitigation policies) before the workshop. Their knowledge and understanding of all aspects of air quality management increased to 8 after the workshop.

- On an average, the knowledge and understanding of participants on all aspects of air quality management before the workshop was 4.4±1.8 which increased to 7.7±1.2 after the workshop, with a net increase of 3.3.

Which module of the AQM workshop (1-5) do you like the most and have further interest to learn more about the module?



The majority of participants liked the Emission Inventory module, followed by the Air Quality Modeling and then Impact Assessment, Air Quality Monitoring. Mitigation Policies modules were liked less.

Which lecture/hands-on training do you like the most?

Participants liked all workshop proceedings. In particular, participants liked the overview and importance of ambient air quality monitoring for air quality management, the introduction of air quality monitoring instrumentation at AIT Lab, emission Inventory tools, air quality modeling, visit PCD and ERTC AQM facilities, co-benefits of air pollution emission reduction, air pollution mitigation strategies and clean measures and actions and lessons learned in Asia including Thailand and India.

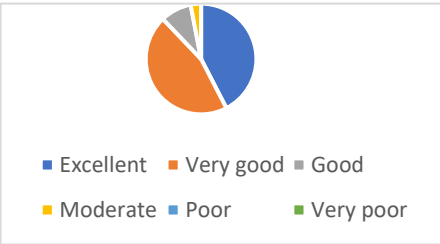
Would you like to have further interaction with us (RRC.AP and resource persons) for knowledge sharing and learning on air quality management or any particular module or an individual topic?

All said “Yes”, except 1 who said “Maybe”

Would you be interested in developing joint project proposals with us (RRC.AP and resource persons) on air pollution issues of your country or regional level?

All said “Yes”, except 5 who said “Maybe”

What is your overall experience of participating in the AQM workshop organized by AIT RRC.AP



- 42% of participants rate “excellent” the overall experience of participating in the AQM workshop organized by AIT RRC.AP
- 45% as very good
- 9% as good
- 3% as moderate
- No participants rate their experience as poor or very poor.

Overall impressions, recommendations, and suggestions by participants for the workshop is given in Annex 5.

7. CERTIFICATE OF PARTICIPATION

At the end of the workshop, a “Certificate of Participation” was awarded to each participant by the AIT President Prof. Yamamoto.






8. LESSONS LEARNED

Opportunities

- The workshop on air quality management successfully gathered participants from 17 member countries of the ASEAN Haze Agreement on Transboundary (9 Southeast Asian countries) and the Male' Declaration (8 South Asian countries) which was a rare opportunity of meeting participants from 2 intergovernmental networks.

- Participating countries shared the status of air quality management in their countries with data. By using the information shared by countries, new projects could be developed to fulfilling the needs of the countries in the areas of air quality management.

- The feedback from participants showed that they learned a lot from the workshop which is an important output and an indication of a successful workshop organization.

- Feedback from the countries reveals improvement needed in organizing the workshops on air quality management in the near future.

Challenges

- Post COVID-19 era created a lot of challenges in the logistic arrangement. Few resource persons delivered their lectures online as they could not come to Thailand due to the COVID-19-related restrictions in their countries.

- Also, airfare was high which disturbed the overall workshop budget.

9. CONCLUSION AND WAY FORWARD

A Capacity Development Programme on Air Quality Management and Emission Reduction of $PM_{2.5}$ for the Member Countries of the ASEAN Haze Agreement and the Malé Declaration was organized by the Regional Resource Centre for Asia and the Pacific and Partners during 19-23 September 2022 at the Asian Institute of Technology, Pathum Thani, Thailand.

Participants from the member countries of the two Intergovernmental Networks of the Asian region, namely, the ASEAN Agreement on Transboundary Haze Pollution and the Malé Declaration on Control and Prevention of Air Pollution and its Likely Transboundary Effects for South Asia were invited to the workshop. A total of 55 participants, including 35 participants representing the member countries of the ASEAN Haze Agreement and the Malé Declaration, 1 ASEAN Secretariat, 9 Resource Persons, and the rest from the AIT and partner organizations participated in the 5-day capacity-building workshop on air quality management.

The participants included policymakers, air quality managers, and scientific and technical staff working with the ministry of environment and pollution control agencies. The workshop was divided into five Modules, namely, Air Quality Monitoring; Emission Inventory; Air Quality Modeling; Impact Assessment; and Air Pollution Mitigation Policies. A total of 11 lectures/presentations were delivered, 2 hands-on training or practical works conducted, organized 2 visits to air quality monitoring labs of AIT and filed visits to air quality labs of ERTC and PCD.

Evaluation of participants was made by providing a set of questions for each topic of the lecture, hands-on training, and field visits as well as for the whole workshop in order to measure the enhancement of knowledge and understanding of participants on the workshop Modules. For the whole workshop, the majority of participants have rated “4” regarding their knowledge and understanding on all aspects of air quality management (i.e., monitoring, emission inventory, modeling, impact assessment, and mitigation policies) before the workshop, on a given scale of 1-10. Their knowledge and understanding of air quality management were increased to “8” after the workshop. On an average, the knowledge and understanding of participants on

all aspects of air quality management before the workshop was 4.4±1.8 which increased to 7.7±1.2 after the workshop, with a net increase of 3.3.

The feedback received from participants showed that they had learned a lot from the workshop and were quite satisfied with the contents of the modules. The order of liking the Modules by the participants as follows: Emission Inventory, Air Quality Modeling, Impact Assessment, and Mitigation Policies Modules in descending order.

Participants expressed concern that enough time should be provided to practice emission inventory tools and air quality models. It provided a way forward for organizing separate workshops on emission inventory developments and air quality modeling in the near future. At the end of the workshop, a "Certificate of Participation" was awarded to each participant.

Annex 1: List of Participants

No.	Country	Name	Designation	Organization
1.	Bangladesh	Dr. Syed Shahjahan Ahmed	Deputy Secretary	Ministry of Environment, Forest and Climate Change
2.	Bangladesh	Mr. Nazim Hossain Sheikh	Deputy Director	Department of Environment, Ministry of Environment, Forest and Climate Change
3.	Bhutan	Mr. Sonam Chophel	Assistant Environment Officer	Environment Assessment and Compliance Division, National Environment Commission
4.	Bhutan	Dr. Jas Raj Subba	Lecturer	Royal University of Bhutan
5.	Brunei	Ms. Masridah Hj Mahmud	Special Duties Officer Grade 1	Pollution Control Unit, Department of Environment, Ministry of Development
6.	Brunei	Ms. Juraidah Binti Baidi	Environment Officer	Pollution Control Unit, Department of Environment, Ministry of Development
7.	Cambodia	Mr. Ing Chhay Por	Vice Chief of Office	National Ozone Unit, Department of Air Quality, Noise and Vibration Management, Ministry of Environment
8.	Cambodia	Ms. Eang Phallis	Vice Chief of Office	Department of Freshwater Wetland Conservation, Ministry of Environment
9.	India	Mr. Arvind Kumar Nautiyal	Member Secretary	Commission for Air Quality Management in National Capital Region & Adjoining Areas (CAQM)

10.	India	Ms. Sakshi Batra	Scientist	Central Pollution Control Board (CPCB)
11.	Indonesia	Ms. Noor Rachmaniah	Deputy Director	Ministry of Environment and Forestry
12.	Indonesia	Ms. Nevy Rinda Nugraini	Environmental Impact Control Expert	Ministry of Environment and Forestry
13.	Iran	Dr. Fatemeh Hassani	Group Head	Dust Storm Group, National Air and Climate Change Center, Department of Environment
14.	Iran	Ms. Maryam Izadpanah	Group Head	Air Pollution Monitoring, National Air and Climate Change Center, Department of Environment
15.	Lao PDR	Mr. Lonkham ATSANAVONG	Director General	Natural Resource and Environment Research Institute (NRERI), Ministry of Natural Resource and Environment (MoNRE)
16.	Lao PDR	Mr. Vanhna PHANPHONGSA	Deputy Director	Environmental Laboratory, Natural Resource and Environment Research Institute, Ministry of Natural Resource and Environment
17.	Malaysia	Mr. Halmy Bin Sirat	Senior Environmental Control Officer	Air Division, Department of Environment, Ministry of Environment and Water

18.	Malaysia	Ms. Ezahtul Shahreen Ab Rahman	Senior Environmental Control Officer	Air Division, Department of Environment, Ministry of Environment and Water
19.	Maldives	Ms. Nashwa Ahmed Manik	Assistant Director	Environment Protection, Environmental Compliance and Assessment, Environmental Protection Agency
20.	Maldives	Ms. Fathimath Nashwa	Chemicals Management Officer	Environmental Management Section, Environmental Management and Conservation Department, Ministry of Environment, Climate Change and Technology
21.	Myanmar	Ms. Witt Yi Soe	Assistant Director	Hydrological Division, Department of Meteorology and Hydrology, Ministry of Transport and Communications
22.	Myanmar	Ms. Wai Lwin Than	Staff Officer	Hydrological Division, Department of Meteorology and Hydrology, Ministry of Transport and Communications
23.	Nepal	Mr. Rajeshor Paudel	Environment Inspector	Pollution Control and Monitoring section, Department of Environment, Ministry of Forests and Environment
24.	Pakistan	Ms. Nausheen Mohyuddin	Deputy Secretary (B&C)	Ministry of Climate Change

25.	Pakistan	Mr. Khalid Mehmood Chadhar	Deputy Director (EE/TT)	Environmental Impact Assessment/ Monitoring Directorate, Pakistan Environmental Protection Agency, Ministry Of Climate Change
26.	Philippines	Mr. Paul Nathan Vallar	Engineer 11	Environmental Quality Division, department of Environment and Natural Resources, Environmental Management Bureau
27.	Singapore	Ms. Ng Zhao Ying	Manager, Policy Division	Policy Division, Environmental Protection Policy Department, National Environment Agency
28.	Singapore	Ms. Yogeswari Raju	Executive Scientific Officer	Environmental Monitoring and Modelling Division, Environmental Quality Monitoring Department, National Environment Agency
29.	Singapore	Mr. ANG Yuen Kai, Lincoln (self-funded)	Assistant Director	Environmental Policy, Environmental Protection Policy, Ministry of Sustainability and the Environment
30.	Sri Lanka	Mr. M.P.N. L. Senarathne	Development Officer-Environment	Air Resource Management and National Ozone Unit , Ministry of Environment
31.	Sri Lanka	Ms. S.M.A.I Sangakkara	Senior Environmental Officer	Air Resource Management and Monitoring Division, Central Environmental Authority

32.	Thailand	Dr. Wanna Laowagul	Director	Environmental Research and Training Center (ERTC)
33.	Thailand	Dr. Sirapong Sooktawee	Environmentalist	Environmental Research and Training Center (ERTC)
34.	Thailand	Dr. Preeya Unwiset	Environmentalist	Environmental Research and Training Center (ERTC)
35.	Thailand	Dr. Ittipol Pawarmart	Head of Automotive Emission Laboratory	Automotive Emission Laboratory, Pollution Control Department (PCD)
-	Viet Nam	*No nomination*	-	-
36.	ASEAN Secretariat	Mr. Wiraditma Prananta	Officer - Environment Division	ASEAN Secretariat
Resource Persons				
37.	India	Mr. J. S. Kamyotra	Former Member Secretary of CPCB,	Regional Facilitator of the Malé Declaration
38.	Indonesia	Dr. Didin Agustian Permadi	Assistant Professor	National Institute of Technology (ITENAS), Bandung
39.	Bangladesh	Dr. Md Firoz Khan	Associate Professor	North South University Dhaka
40.	UK (Remotely Join)	Dr. Johan C.I. Kuylenstierna	Research Leader	Stockholm Environment Institute (SEI)
41.	Thailand	Dr. Supat Wangwongwatana	Former Director General of PCD (now Faculty of Public Health)	Thammasat University
42.	Thailand	Dr. Arthit Phosri	Assistant Professor	Mahidol University
43.	Thailand	Prof. Nguyen Thi Kim Oanh	Emeritus Professor	Asian Institute of Technology
44.	Thailand	Dr. Ekbordin Winijkul	Associate Professor	Asian Institute of Technology

45.	Thailand	Dr. Lai Nguyen Huy	Research Specialist	Asian Institute of Technology
Regional Resource Centre for Asia and the Pacific (RRC.AP)/Asian Institute of Technology				
46.	-	Prof. Kazuo Yamamoto	Interim President	AIT
47.	Organizer	Dr. Guilberto Borongan	Director	RRC.AP
48.	Organizer	Dr. Ram Lal Verma	Head, Air Pollution Cluster	RRC.AP
49.	Organizer	Ms. Naharuethai Supakarn	Senior Programme Specialist	RRC.AP
50.	Organizer	Mr. Bayasgalan Sanduijav	Senior IT Specialist	RRC.AP
51.	Organizer	Charina B. Lepiten	Programm Specialist	RRC.AP
52.	Organizer	Ms. Natanat Sittichaiyakarn	Administrative Officer	RRC.AP
53.	Organizer	Ms. Lakshani Gunawardhana	Programme Officer	RRC.AP
54.	Organizer	Ms. Kristine Perez	Administrative Officer	RRC.AP
55.	Organizer	Mr. Ric Dennis A. Canullas	Programme Specialist	RRC.AP

Annex 2: Workshop Agenda

Day 1 (19 September 2022)	
Time	**Agenda item description**
8:30 – 9:00	Registration
Opening Session Moderator: R. L. Verma	
9:00 – 10:00	- Welcome remarks from **Dr. Guilberto Borongan**, Director, Regional Resource Centre for Asia and the Pacific, Asian Institute of Technology (AIT RRC.AP) - Welcome remarks from **Prof. Kazuo Yamamoto**, Interim President, Asian Institute of Technology (AIT) - Opening remarks from **Mr. Yoichi Toyama**, Director, Asia-Pacific Network for Global Change Research (APN) Secretariat (*participating in the workshop remotely from Japan*) - Opening remarks from **Mr. Jatinder Singh Kamyotra,** Former Member Secretary, Central Pollution Control Board, India, and Regional Facilitator**,** Malé Declaration on Control and Prevention of Air Pollution and its likely Transboundary Effects for South Asia - Opening remarks from **Dr. Ittipol Pawarmart**, Head of Automotive Emission Laboratory, Pollution Control Department (PCD), Ministry of Natural Resources and Environment, Government of Thailand
10:00 – 10:30	*Group photo and coffee break*
10:30 – 10:45	**Introduction of participants and workshop agenda** Moderator: Dr. Ittipol Pawarmart
	- Introduction of participants - Introduction of workshop agenda (R. L. Verma)
10:45 – 12:00	**Country presentations** (15 min. presentations + 5 min. Q&A) Moderator: Dr. Ittipol Pawarmart
	- Bangladesh - Bhutan - Brunei - Cambodia
12:00 – 13:00	*Lunch break*
13:00 – 15:00	**Country presentations** (continue)

	Moderator: Mr. Wiraditma Prananta, ASEAN Secretariat
	- India - Indonesia - Iran - Lao PDR - Malaysia - Maldives
15:00 – 15:20	*Coffee break*
15:20 – 17:20	**Country presentations** (continue) Moderator: Mr. J S Kamyotra, Regional Facilitator for Malé Declaration
	- Myanmar - Nepal - Pakistan - Philippines - Singapore - Sri Lanka - Thailand - Vietnam
End of the Day 1	
Day 2 (20 September 2022)	
Module 1: Air Quality Monitoring Moderator: R. L. Verma	
9:00 – 10:30	**Lecture 1: Overview and importance of ambient air quality monitoring for air quality management** The expert resource person will provide details of air quality monitoring including air quality parameters, monitoring methods and analysis. The resource person will explain the importance of air quality monitoring for air quality management. **Expert: Prof. Nguyen Thi Kim Oanh,** Asian Institute of Technology (AIT), Thailand
10:30 – 10:45	*Coffee break*
10:45 – 12:00	**Lecture 2: Introduction of air quality monitoring instrumentation at AIT Lab** The expert resource person will introduce air quality monitoring instruments installed and operated in the AIT Lab including their basic theories, operations, calibrations, etc. **Expert: Dr. Ekbordin Winijkul,** Asian Institute of Technology (AIT), Thailand

12:00 – 13:00	*Lunch break*
13:00 – 17:20	**Practical work 1:** Hands-on training on air quality monitoring in AIT Lab The participants will have the opportunity to learn hands-on training on air quality management instruments (sampling, analysis, calibration, etc.). **Expert: Prof. Nguyen Thi Kim Oanh/ Dr. Ekbordin/ Dr. Huy,** AIT
17:20 – 17:30	Evaluation feedback from Participants on Day 2 proceedings
End of day 2	
Day 3 (21 September 2022)	
Module 2: Emission Inventory Moderator: R. L. Verma	
9:00 – 10:00	**Lecture 3: Overview of emission inventory development process and emission factors** The expert resource person will present an overview of the emission inventory development process including bottom-up and top-down approaches, emission factors, emission calculation from mobile and stationary sources, etc. **Expert: Dr. Ekbordin Winijkul**, Asian Institute of Technology (AIT), Thailand
10:00 – 10:15	*Coffee break*
10:15 – 12:00	**Emission Inventory Tools** **Practical work 2:** Expert resource person will demonstrate Emission Inventory Tools such as ABC Emission Inventory Tool or any other tool and explain how the Tool can be used for the compilation of emissions of air pollutants. The participants will have an opportunity to practice on the tool with a set of activity data either provided by the resource person or participants can use activity data from their country. **Expert: Dr. Didin Agustian Permadi**, National Institute of Technology (ITENAS), Bandung, Indonesia
12:00 – 13:00	*Lunch break*
Field Visit	
13:00 – 17:00	**Field visit: Participants will visit the PCD Lab or Air Quality Monitoring site operated by PCD/ERTC** Participants will have an opportunity to learn about air quality

	monitoring and analysis in Thailand including the Continuous Emission Monitoring System (CEMS) **Experts: PCD/ERTC**
17:00 – 17:15	Evaluation feedback from Participants on Day 3 proceedings
End of day 3	
Day 4 (22 September 2022)	
Module 3: Air Quality Modeling Moderator: R. L. Verma	
9:00 – 10:30	**Lecture 4: Introduction of air quality modeling** The Expert resource person will present an overview of air quality modeling including the types of models used in air quality modeling and the application of air quality modeling in air quality management **Expert: Dr. Didin Agustian Permadi**, National Institute of Technology (ITENAS), Bandung, Indonesia
10:30 – 10:45	*Coffee break*
10:45 – 12:00	**Lecture 5: Source apportionment of emissions of air pollutants** The expert resource person will present source apportionment of emission of air pollutants using receptor models, such as PMF or CMB models including open-source models, and explain how these models can be used for validation of emission inventories of air pollutants. **Expert: Dr. Md Firoz Khan**, Department of Environmental Science and Management, North South University, Dhaka, Bangladesh
12:00 – 13:00	*Lunch break*
13:00 – 15:00	**Practical work 3: Hands-on training on air quality modeling** The expert will provide hands-on training on an important AQ Model. Participants will run the models on their computer. **Expert: Dr. Didin Agustian Permadi**, National Institute of Technology (ITENAS), Bandung, Indonesia
15:00 – 15:15	*Coffee break*
15:00 – 17:15	**Practical work 4: Hands-on training on source apportionment emissions of air pollutants** The expert will provide hands-on training on source

	apportionment of emissions of air pollutants. Participants will run the model on their computer. **Expert: Dr. Md Firoz Khan**, Department of Environmental Science and Management, North South University, Dhaka, Bangladesh
17:15 – 17:30	Evaluation feedback from Participants on Day 4 proceedings
End of day 4	
Day 5 (23 September 2022)	
Module 4: Air Pollution Impact Assessment Moderator: R. L. Verma	
9:00 – 10:00	**Lecture 6: Air pollution impact assessment on health** The expert resource person will present an overview including basic concepts (theories and models) of air pollution impact assessment including methods and estimation of impacts of air pollution on human health. **Expert: Dr. Arthit Phosri,** Mahidol University, Thailand
	Coffee without break
10:00 – 11:00	**Lecture 7: Co-benefits of air pollution emission reduction** The expert resource person will present the co-benefit of air pollution reduction. **Expert: Dr. Ittipol Pawarmart,** Pollution Control Department, Thailand
Module 5: Air Pollution Mitigation Policies Moderator: R. L. Verma	
11:00 – 12:00	**Lecture 8: Air pollution mitigation strategies and clean measures and actions and lessons learned in Asia** The expert experts resource person will present Air pollution mitigation strategies and clean measures and actions in Asia **Expert: TBC**
12:00 – 13:00	*Lunch break*
13:00 – 14:00	**Lecture 9: Air pollution mitigation policies and action plans and success stories of Thailand (Southeast Asia)** The expert will present air pollution mitigation policies and action plans and success stories of a key country in Southeast Asia (e.g., Thailand)

	Expert: Dr. Supat Wangwongwatana, Thammasat University
14:00 – 15:00	**Lecture 10: Air pollution mitigation policies and action plans and success stories of India (South Asia)** The expert will present air pollution mitigation policies and action plans and success stories of a key country in Southeast Asia (e.g., India) **Expert: Mr. J. S. Kamyotra,** India
	Coffee without break
15:00 – 16:00	**Lecture 11: The Long-range Energy Alternatives Planning - Integrated Benefits Calculator (LEAP-IBC)** The expert will present LEAP-IBC, which is an integrated planning tool for assessing GHG, SLCPs, other air pollutants, build mitigation scenarios, and associated co-benefits **Expert: Dr. Johan C.I. Kuylenstierna**, Stockholm Environment Institute (SEI), UK
16:00 – 16:30	Open discussion among participants on sharing air pollution policies and actions and lessons learned in their country (Moderator: Mr. J. S. Kamyotra, India)
16:30 – 17:00	Awarding of certificates to Participants
17:00-17:15	Evaluation feedback from Participants on Day 5 proceedings and the whole of the workshop
17:00 – 17:30	**Closing Remarks** - RRC.AP/AIT
End of workshop	

Annex 2: Brief description of resource persons

	**1. Prof. Nguyen Thi Kim Oanh** is a Professor at the Asian Institute of Technology (AIT), Thailand, and a member of the science panel of the Asia Pacific Clean Air Partnership (APCAP). She has 35 years of experience in research, education, consultancy, and capacity building and is internationally recognized for her work on air pollution and climate in Asia. She provided a better characterization of air pollution issues in Asian developing countries through field measurements, emission inventory, and modeling studies at urban, national, and regional scales. She has published 2 books, 110 scientific papers and 50 book chapters, and over 50 development reports. She has conducted, as PI or Co-PI, over 50 regional collaboration research projects and supervised 190 Master's and 16 PhD students.
	**2. Dr. Ekbordin Winijkul** is an Assistant Professor at the Asian Institute of Technology (AIT), Thailand. Dr. Winijkul's research areas are emission inventory, air pollution modeling and monitoring, air quality management, and environmental system dynamic. His recent research is focusing on emission inventory development, air quality management and cost-benefit analysis of introducing cleaner fuels and vehicles. He got his Ph.D. in Environmental Engineering from the University of Illinois at Urbana-Champaign, USA. Before joining AIT, Dr. Ekbordin worked at Argonne National Laboratory (USA), International Institute for Applied System Analysis (Austria) and Atmospheric and Environmental Research, Inc. (USA).
	**3. Dr. Didin Agustian Permadi** is an Assistant Professor at the National Institute of Technology (ITENAS), Bandung, Indonesia. Dr. Permadi's research is mainly focused on the application of 3-dimensional chemistry-transport models, emission inventory, environmental impact assessment and monitoring, and air pollution-climate change linkages. He published many research papers in highly reputed journals including 16 book chapters. He has served as a trainer in many international trainings in the fields of emission inventory and air quality monitoring and modeling. Professionally, he is engaged with the international scientific

	communities as a reputed scientist and a member of the International Global Atmospheric Chemistry (IGAC) and the Asian Network on Climate Science and Technology (ANCST).
	**4. Dr. Md Firoz Khan** is a Senior Lecturer at the Faculty of Science, University of Malaya, Kuala Lumpur, Malaysia. He is also a visiting professor at the China University of Mining and Technology, China for the period of 2019-2022. His research interests cover a wide variety of topics in air pollution, source apportionment, environmental analytical chemistry, and human health risk factors of pollutants. He received his Ph.D. degree in Risk Management and Environmental Sciences from the Yokohama National University, Japan in 2010. He published more than 100 journal papers, book chapters, and a book. Dr. Khan is serving as an Associate Editor to Elementa: Science of the Anthropocene and Arabian Journal of Geosciences.
	**5. Dr. Johan C.I. Kuylenstierna** is a Research Leader at Stockholm Environment Institute (SEI), a member of SEI's Global Research Committee, and Reader at the University of York, UK. He is a member of the Scientific Advisory Panel (SAP) of the Climate and Clean Air Coalition (CCAC). Key areas of interest related to the integration of strategies to address climate change and air quality, in particular, associated with strategies to reduce Short-Lived Climate Pollutants (SLCPs). He is part of a team developing an SLCP strategy support tool – LEAP-IBC – being used by many governments to develop national integrated air pollution and climate change mitigation strategies. He also contributed to assessing the impacts of air pollution on human health such as on pre-term births and asthma. He coordinated a UNEP/WMO integrated assessment on Black Carbon and Tropospheric Ozone and is an author of the CCAC/UNEP Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions.

	**6. J. S. Kamyotra** is an Environment Expert. He served the Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, Government of India for over 30 years at various positions including the Member Secretary of the Central Pollution Control Board as his last position. Mr. Kamyotra has wide experience in policy formulation, development of environmental standards, and establishment of real-time air quality monitoring networks in the country. He played an important role in developing India's first indigenously mobile laboratory for environmental monitoring. Mr. Kamyotra has been a member of various National Policy Planning Committees and various environmental committees constituted by the Supreme Court and the National Green Tribunal. He authored several publications and has represented India in various international conferences and committees focusing on sustainable development in developing countries of the ASEAN and SAARC region. He is a member of the Asia Pacific Clean Air Programme and OECD's Committee on Best Available Technologies (BAT). He is serving as the Regional Facilitator for the Male' Declaration - a voluntary contribution to the region for addressing air pollution problems.
	**7. Dr. Supat Wangwongwatana** has widely credited for improving the air quality of Thailand while serving with the Thai Government for more than 30 years holding various positions including the Director General of the Pollution Control Department (PCD) and the Secretary General of the Office of Natural Resources and Environmental Quality Policy and Planning. Has been involved in climate change talks since Thailand's negotiations with the UNFCCC in early 1990. He was declared as the Asian Air Quality Management Champion by the Clean Air Asia for his efforts in institutionalizing air quality management in Thailand and Asia. He was the first recipient of an honorary degree from the USEPA's Air Pollution Training Institute for training young people in the field of air pollution. He was also member of the Scientific Advisory Panel of the Climate Clean Air Coalition (CCAC). He is also the Co-Chairperson of the Asian Co-benefit Partnership (ACP). Currently, he is a Faculty of Public Health at the Thammasat University, Rangsit, Thailand

	**8. Ms. Dang Espita-Casanova** oversees programme development and strategic planning for Clean Air Asia's impact initiatives on transport, energy, and urban air quality. She worked for government, private, and non-profit organizations in the early years of her professional career, with training and experience on environmental pollution chemistry and management for more than 10 years. Her career with Clean Air Asia on air quality management started in 2014 when she led a team of about 15 international and regional experts in the development of the Guidance Framework for Better Air Quality in Asian Cities (Guidance Framework). She has led projects focusing on capacity building of governments for air quality management through policy guidance and direct technical assistance on air quality monitoring, emissions inventory and modeling, health impact assessment, air quality communication, and development of clean air action plans.
	**9. Dr. Arthit Phosri** is currently working as an Assistant Professor at the Department of Environmental Health Sciences, Faculty of Public Health, Mahidol University, Thailand. He is doing research mainly on environmental epidemiology, which is investigating the health effects of environmental factors using epidemiological methods.
	**10. Dr. Ittipol Pawarmart** is a Head of Automotive Emission Laboratory, Pollution Control Department, Thailand. He is involving in exhaust emission standards development such as in-used vehicles emission standards, new vehicles emission standards, improving inspection program for in-used vehicles in Thailand including various mitigation measures for emission reduction of transport sector. He has been conducting research focusing PM source profiles, PM size distribution and its chemical composition for identifying sources in study areas. He is also involving in emission factors development and emission inventory in Bangkok and Thailand. He has been working on collaboration projects with international organizations regarding PM2.5 Mitigation measures strategies including co-benefits approaches to integrate between air pollution and climate change management.

Annex 4: Feedback/Evaluation Form for Participants

<table>
<tr><td colspan="2">Basic Information</td></tr>
<tr><td>Country:</td><td></td></tr>
<tr><td>Name of Participant:</td><td></td></tr>
<tr><td>Your major role in current your job:</td><td>(1) Policy making
(2) Policy implementation
(3) Scientific and technical</td></tr>
<tr><td colspan="2">Module 1: Air Quality Monitoring</td></tr>
<tr><td colspan="2">P-01: Overview and importance of ambient air quality monitoring for air quality management</td></tr>
<tr><td colspan="2">Q1: How do you rate your understanding (or increase of knowledge) of the importance of ambient air quality monitoring for air quality management?</td></tr>
<tr><td>Before the lecture (on a 1 to 10 scale)
(a) 1
(b) 2
(c) 3
(d) 4
(e) 5
(f) 6
(g) 7
(h) 8
(i) 9
(j) 10</td><td>After the lecture (on a 1 to 10 scale)
(a) 1
(b) 2
(c) 3
(d) 4
(e) 5
(f) 6
(g) 7
(h) 8
(i) 9
(j) 10</td></tr>
<tr><td colspan="2">Q2: Was the content of the lecture interesting to you and has new information which will be useful in your work?
(a) Yes absolutely, very interesting
(b) A little
(c) Not</td></tr>
<tr><td colspan="2">Q3: Was the content of the lecture too technical and you could not understand it fully?
(a) Yes
(b) A little
(c) No</td></tr>
<tr><td colspan="2">P-02: Air Quality Monitoring Study at AIT</td></tr>
<tr><td colspan="2">Q4. How do you rate your understanding (or increase of knowledge) of the air quality monitoring instrumentation?</td></tr>
<tr><td>Before the lecture (on a 1 to 10 scale)
(a) 1
(b) 2
(c) 3
(d) 4
(e) 5</td><td>After the lecture (on a 1 to 10 scale)
(a) 1
(b) 2
(c) 3
(d) 4
(e) 5</td></tr>
</table>

(f) 6 (g) 7 (h) 8 (i) 9 (j) 10	(f) 6 (g) 7 (h) 8 (i) 9 (j) 10
Q5: Was the content of the lecture interesting to you and has new information which will be useful in your work (a) Yes absolutely, very interesting (b) A little (c) No	
Q6: Was the content of the lecture too technical and you could not understand it fully? (a) Yes (b) A little (c) No	
PW-1: Demonstration and hands-on training on air quality monitoring in AIT lab facilities (Ambient Lab and InterLab)	
Q7: How do you rate your understanding (or increase of knowledge) and skill of air quality monitoring and instrumentation including low-cost sensors?	
Before the lab visit (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10	After the lab visit (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10
Q8: Was the demonstration of lab instruments of air quality monitoring interesting to you and has new information which will be useful in your work (a) Yes absolutely, very interesting (b) A little (c) No	
Q9: Was the demonstration too technical and you could not be understood it fully? (a) Yes (b) A little (c) No	
Q10: Do you have any suggestions or topics to be included in Air Quality Monitoring Model in future workshops? Please write in brief.	

<table>
<tr><th colspan="2">Module 2: Emission Inventory</th></tr>
<tr><td colspan="2">P-03: Overview of emission inventory development process and emission factors</td></tr>
<tr><td colspan="2">Q1: How do you rate your understanding and increased knowledge of the emission development process and emission factors?</td></tr>
<tr><td>Before the lecture (on a to 10 scale)
(a) 1
(b) 2
(c) 3
(d) 4
(e) 5
(f) 6
(g) 7
(h) 8
(i) 9
(j) 10</td><td>After the lecture (on a 1 to 10 scale)
(a) 1
(b) 2
(c) 3
(d) 4
(e) 5
(f) 6
(g) 7
(h) 8
(i) 9
(j) 10</td></tr>
<tr><td colspan="2">Q2: Was the content of the lecture interesting to you and has new information which will be useful in your work?
(a) Yes absolutely, very interesting
(b) A little
(c) No</td></tr>
<tr><td colspan="2">Q3: Was the content of the lecture too technical and you could not understand it fully?
(a) Yes
(b) A little
(c) No</td></tr>
<tr><td colspan="2">PW-02: Emission Inventory Tools</td></tr>
<tr><td colspan="2">Q4: How do you rate your understanding and increased knowledge of Emission Inventory Tools?</td></tr>
<tr><td>Before the practical work (on a 1 to 10 scale)
(a) 1
(b) 2
(c) 3
(d) 4
(e) 5
(f) 6
(g) 7
(h) 8
(i) 9
(j) 10</td><td>After the practical work (on a 1 to 10 scale)
(a) 1
(b) 2
(c) 3
(d) 4
(e) 5
(f) 6
(g) 7
(h) 8
(i) 9
(j) 10</td></tr>
</table>

Q5: Was the content of the emission inventory tool interesting to you and has new information which will be useful in your work (a) Yes absolutely, very interesting (b) A little (c) No
Q6: Was the content of the presentation too technical and you could not understand it fully? (a) Yes (b) A little (c) No
Field Visit: Visit to air quality monitoring facilities operated by PCD and ERTC
Q7: How do you rate your understanding and increased knowledge and skill of air quality monitoring, instrumentation, and facilities?

Before the field visit (on a 1 to 10 scale)	After the field visit (on a 1 to 10 scale)
(a) 1	(a) 1
(b) 2	(b) 2
(c) 3	(c) 3
(d) 4	(d) 4
(e) 5	(e) 5
(f) 6	(f) 6
(g) 7	(g) 7
(h) 8	(h) 8
(i) 9	(i) 9
(j) 10	(j) 10

Q8: Was the demonstration of quality monitoring, instrumentation, and facilities interesting to you and has new information which will be useful in your work (a) Yes absolutely, very interesting (b) A little (c) No
Q9: Was the demonstration too technical and you could not be understood it fully? (a) Yes (b) A little (c) No
Q10: Do you have any suggestions or topics to be included in Emission Inventory Module in future workshops? Please write in brief.

Module 3: Air Quality Modeling
P-04: Introduction of air quality modeling
Q1: How do you rate your understanding and increased knowledge of air quality dispersion modeling?

Before the lecture (on a 1 to 10 scale)	After the lecture (on a 1 to 10 scale)
(a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10	(a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10
Q2: Was the content of the lecture on air quality dispersion modeling interesting to you and has new information which will be useful in your work? (a) Yes absolutely, very interesting (b) A little (c) No	
Q3: Was the content of the lecture too technical and you could not understand it fully? (a) Yes (b) A little (c) No	
P-05: Source apportionment of emissions of air pollutants	
Q4. How do you rate your understanding and increased knowledge of source apportionment of emissions of air pollutants?	
Before the lecture (on a 1 to 10 scale)	After the lecture (on a 1 to 10 scale)
(a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10	(a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10
Q5: Was the content of the lecture on source apportionment of emissions of air pollutants interesting to you and has new information which will be useful in your work (a) Yes absolutely, very interesting (b) A little (c) No	
Q6: Was the content of the lecture too technical and you could not understand it fully? (a) Yes (b) A little	

(c) No

PW-03: Hands-on training on air quality dispersion modeling

Q7: How do you rate your understanding, increased knowledge, and skill of air quality dispersion modeling?

Before the training (on a 1 to 10 scale)	After the training (on a 1 to 10 scale)
(a) 1	(a) 1
(b) 2	(b) 2
(c) 3	(c) 3
(d) 4	(d) 4
(e) 5	(e) 5
(f) 6	(f) 6
(g) 7	(g) 7
(h) 8	(h) 8
(i) 9	(i) 9
(j) 10	(j) 10

Q8: Was the hands of training on air quality dispersion modeling interesting to you and has new information which will be useful in your work?

(a) Yes absolutely, very interesting
(b) A little
(c) No

Q9: Was the hands on training too technical and you could not be understood it fully?

(a) Yes
(b) A little
(c) No

PW-04: Hands-on training on source apportionment emissions of air pollutants

Q10: How do you rate your understanding, increased knowledge, and skill of source apportionment emissions of air pollutants?

Before the training (on a 1 to 10 scale)	After the training (on a 1 to 10 scale)
(a) 1	(a) 1
(b) 2	(b) 2
(c) 3	(c) 3
(d) 4	(d) 4
(e) 5	(e) 5
(f) 6	(f) 6
(g) 7	(g) 7
(h) 8	(h) 8
(i) 9	(i) 9
(j) 10	(j) 10

Q11: Was the hands of training on source apportionment of air pollutants interesting to you and has new information which will be useful in your work?

(a) Yes absolutely, very interesting
(b) A little

(c) No
Q12: Was the hands on training too technical and you could not be understood it fully? (a) Yes (b) A little (c) No
Q13: Do you have any suggestions or topics to be included in Air Quality Modeling in future workshops? Please write in brief.

Module 4: Air Pollution Impact Assessment	
P-06: Air pollution impact assessment on health	
Q1: How do you rate your understanding and increased knowledge of air pollution impact assessment on health?	
Before the lecture (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10	After the lecture (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10
Q2: Was the content of the lecture on air pollution impact assessment on health interesting to you and has new information which will be useful in your work? (a) Yes absolutely, very interesting (b) A little (c) No	
Q3: Was the content of the lecture too technical and you could not understand it fully? (a) Yes (b) A little (c) No	
P-07: Overview of mitigation measures implemented in the transport sector in Thailand and air quality in Bangkok	
Q4. How do you rate your understanding and increased knowledge about co-benefits of air pollution emission reduction?	
Before the lecture (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5	After the lecture (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5

(f) 6 (g) 7 (h) 8 (i) 9 (j) 10	(f) 6 (g) 7 (h) 8 (i) 9 (j) 10
Q5: Was the content of the lecture co-benefits of air pollution emission reduction interesting to you and has new information which will be useful in your work (a) Yes absolutely, very interesting (b) A little (c) No	
Q6: Was the content of the lecture too technical and you could not understand it fully? (a) Yes (b) A little (c) No	
Q7. Do you have any suggestions or topics to be included in Air Pollution Impact Assessment Module future workshops? Please write in brief.	

Module 5: Air Pollution Mitigation Policies	
P-08: Air pollution mitigation strategies and clean measures and actions and lessons learned in Asia	
Q1: How do you rate your understanding and increased knowledge of air pollution mitigation strategies and clean measures and actions and lessons learned in Asia?	
Before the lecture (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10	After the lecture (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10
Q2: Was the content of the lecture on air pollution mitigation strategies and clean measures and actions and lessons learned in Asia interesting to you and has new information which will be useful in your work (a) Yes absolutely, very interesting (b) A little (c) No	
Q3: Was the content of the lecture too technical and you could not understand it fully? (a) Yes	

(b) A little (c) No	
P-09: Air pollution mitigation policies and action plans and success stories of Thailand	
Q4. How do you rate your understanding and increase knowledge on air pollution mitigation policies and action plans and success stories of Thailand	
Before the lecture (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10	After the lecture (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10
Q5: Was the content of the lecture on air pollution mitigation policies and action plans and success stories of Thailand interesting to you and has new information which will be useful in your work? (a) Yes absolutely, very interesting (b) A little (c) No	
Q6: Was the content of the lecture too technical and you could not understand it fully? (a) Yes (b) A little (c) No	
P-10: Air pollution mitigation policies and action plans and success stories of India	
Q7: How do you rate your understanding and increased knowledge on air pollution mitigation policies and action plans and success stories of India?	
Before the presentation (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10	After the presentation (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10

Q8: Was the lecture on air pollution mitigation policies and action plans and success stories of India interesting to you and has new information which will be useful in your work

(a) Yes absolutely, very interesting
(b) A little
(c) No

Q9: Was the lecture too technical and you could not be understood it fully?

(a) Yes
(b) A little
(c) No

P-11: The Long-range Energy Alternatives Planning -Integrated Benefits Calculator (LEAP-IBC)

Q7: How do you rate your understanding and increased knowledge on LEAP-IBC?

Before the presentation (on a 1 to 10 scale)	After the presentation (on a 1 to 10 scale)
(a) 1	(a) 1
(b) 2	(b) 2
(c) 3	(c) 3
(d) 4	(d) 4
(e) 5	(e) 5
(f) 6	(f) 6
(g) 7	(g) 7
(h) 8	(h) 8
(i) 9	(i) 9
(j) 10	(j) 10

Q8: Was the lecture on LEAP-IBC interesting to you and has new information which will be useful in your work

(a) Yes absolutely, very interesting
(b) A little
(c) No

Q9: Was the demonstration too technical and you could not be understood it fully?

(a) Yes
(b) A little
(c) No

Q10: Do you have any suggestions or topics to be included in air pollution mitigation policy module in future workshops? Please write in brief.

Summary Evaluation and Way Forward

Q1: How do you rate your understanding and increased knowledge and skills on all aspects of air quality management (i. e., monitoring, emission inventory, modeling, impact assessment, and mitigation policies

Before the workshop (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10	After the workshop (on a 1 to 10 scale) (a) 1 (b) 2 (c) 3 (d) 4 (e) 5 (f) 6 (g) 7 (h) 8 (i) 9 (j) 10
Q2: Which module of the AQM workshop (1-5) you like the most and have further interest to learn more about the module? (a) Air Quality Monitoring (b) Emission Inventory Development (c) Air Quality Modeling (d) Impact Assessment (e) Mitigation Policies	
Q3: Which module of the AQM workshop (1-5) need improvement in terms of contents? (a) Air Quality Monitoring (b) Emission Inventory Development (c) Air Quality Modeling (d) Impact Assessment (e) Mitigation Policies	
Q4. Which lecture/hands on training you like the most? ▪ Overview and importance of ambient air quality monitoring for air quality management ▪ Introduction of air quality monitoring instrumentation at AIT Lab ▪ Hands-on training on air quality monitoring in AIT Lab ▪ Overview of emission inventory development process and emission factors ▪ Emission Inventory Tools ▪ Visit to PCD and ERTC AQM facilities ▪ Introduction of air quality modeling ▪ Source apportionment of emissions of air pollutants ▪ Hands-on training on air quality modeling ▪ Hands-on training on source apportionment emissions of air pollutants ▪ Air pollution impact assessment on health ▪ Co-benefits of air pollution emission reduction ▪ Air pollution mitigation strategies and clean measures and actions and lessons learned in Asia ▪ Air pollution mitigation policies and action plans and success stories of Thailand	

- Air pollution mitigation policies and action plans and success stories of India
- The Long-range Energy Alternatives Planning -Integrated Benefits Calculator

Q5: Which lecture/hands on training need improvement in terms of content?

- Overview and importance of ambient air quality monitoring for air quality management
- Introduction of air quality monitoring instrumentation at AIT Lab
- Hands-on training on air quality monitoring in AIT Lab
- Overview of emission inventory development process and emission factors
- Emission Inventory Tools
- Visit to PCD and ERTC AQM facilities
- Introduction of air quality modeling
- Source apportionment of emissions of air pollutants
- Hands-on training on air quality modeling
- Hands-on training on source apportionment emissions of air pollutants
- Air pollution impact assessment on health
- Co-benefits of air pollution emission reduction
- Air pollution mitigation strategies and clean measures and actions and lessons learned in Asia
- Air pollution mitigation policies and action plans and success stories of Thailand
- Air pollution mitigation policies and action plans and success stories of India
- The Long-range Energy Alternatives Planning -Integrated Benefits Calculator

Q6: Would you like to have further interaction with us (RRC.AP and resource persons) for knowledge sharing and learning on air quality management or any particular module or an individual topic?

(a) Yes
(b) May be
(c) No

Q7: Would you be interested in developing joint project proposals with us (RRC.AP and resource persons) on air pollution issues of your country or regional level?

(a) Yes
(b) May be
(c) No

Q8: Would you be interested in contributing to technical report with us (RRC.AP and resource persons) on the status of air quality management in your country or regional level?

Q9: Would you be interested to involving RRC.AP (as an individual consultant) for capacity building or any other projects related to air pollution in your country? (a) Yes (b) May be (c) No
Q10: What is your ovell experience of participating the AQM workshop organized by by AIT RRC.AP (a) Excellent (b) Very good (c) Good (d) Moderate (e) Poor (f) Very poor
Q11: What is overall your overall impression, recommendations, suggestions for the workshop?

Annex 5: Some overall impressions, recommendations, and suggestions by participants for the workshop?

1. The classroom is good if room accommodation is single for every participant is very good. The food is good.
2. Well-organized programme. Should organize programs for other member states venues and help in taking projects support both technical and funding.
3. Overall good experience with a lot of knowledge gained from the workshop. However, time constraint has limited us from clarifying our doubts. Discussion on the technology stack for industrial emission control and transport of air pollutants would be appreciated. My thanks to the organizers and resource person for the knowledge and opportunity.
4. Overall very good, the logistics were fantastic, food was marvelous. Need more time, especially for the modeling module. Need to space a bit more since lots of hands-on practice is required for modeling. Better if the resource person is present in-person. Better if participants were asked to listen to each module more seriously since many I found were not so serious.
5. Perhaps providing evaluation electronic forms may help to reduce papers.
6. For all the hands-on training (on individual laptops) I can't run the application as it requires an admin username and password. It would be good if a computer lab is available to create such training.
7. The organization of the workshop is very good in general.
8. The training is well organized and the organizers are very helpful and friendly, Some lecturers should slow down their lectures and simplify their lessons, I hope this kind of training will happen annually with the expansion of further knowledge regarding AQ management. Should have a separate session on training for modeling sessions due to it requires more time to understand, To sum up, all lectures are really useful and I gain a lot of knowledge regarding AQ which I can bring

home to share with my colleagues to improve AQ management in my country.

9. I think better make one case study to implement all of the topics in the workshop.
10. Some of the lectures were very interesting to me and I hope in the future we can improve this practice and improve knowledge in our country. Thanks with best wishes.
11. It is better to participate in PCD ERTC AQM labs than see the empty lab, For future improvement to the hands-on training on air quality modeling in each tool.
12. Needs more hands-on training.
13. Need more information on success stories from many countries with default plans to implement in the country.
14. The workshop should take far more than one week for the participants to fully understand.
15. I enjoyed and learned a lot regarding the emission inventory, air pollution issues, and challenges in different countries, and has helped the networking. The workshop is well organized. Thank you.
16. To include more interactive sessions
17. We have learned a lot of knowledge, technologies, and experiences from this workshop in terms of air quality management and related modules. We are very impressed with the lectures on EI and air quality modeling which are very useful for us to develop these.
18. The good teaching/hands-on experience that I received from this course is beneficial to the department in my country. Thanks for everything.
19. More hands-on training on air quality modeling and emission inventory, more sessions on emission reduction strategies and policies, and mitigation measures.
20. The virtual session somewhat lose understanding of the issues.
21. 5 days are short considering some topics can be explained further or Q&A can be accommodated. Create a short drive wherein speakers

must upload their resource materials prior to the workshop. Inform participants if they need to install the software before because some laptops need admin username/ password permission.

22. There should be more interactive learning for air quality modeling and source apportionment study. Since it is quite technical, there would be more step-by-step guidance for participants. It appears that participants are from different levels of seniority with different years of experience. It will be useful for the organizers to state in advance the level of seniority of the workshop so that all countries are aligned and can be on the same page in terms of learning pace,
23. Lectures conducted via zoom could have allowed wearing to dial in, send course materials in advance, provide guidebook/articles on software such as modeling, inventory tool, source apportionment.
24. Well organized and very important to improve our knowledge of air quality-related policies, action, and mitigation measure. We hope to participate in the further program also about developing emission inventory and air quality modeling.
25. This platform is very much beneficial to us as implementors of air quality regulation. Glad for your effort taken to empower us with knowledge within a very short period of time. Though some aspects are not properly understood looking forward to contacting resource persons while we start practicing in the modeling aspect. If you can share the recording of Dr. Didin ppt on modeling that will be helpful
26. It would be better to provide a dormitory for Thai participants to have more activity with others.
27. On the occasion of the physical workshop, it would be good for the lectures to be held face to face, to participate in the hand on training (i.e, air quality modeling). Suggestion for the organizer to make more time modules on the impact of policies (health, economic, etc.).

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