CoP

Community of Practice Technical Brief

Applications of Coal-Fired Power Plants (CFPs) and Industry Emissions Data for Air Quality Management

Knowledge Brief

Clean Air Asia is an international non-governmental organization leading the regional mission for better air quality, and healthier, more livable cities throughout Asia. Clean Air Asia's approach is one of science-based, actionable guidance combined with an ethos of partnerships and collaboration to ensure our work has meaningful and sustainable impact.

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INTRODUCTION

The global power industry has seen an unprecedented rise in the combustion of fossil fuels during the past two decades, and the power generation in Southeast Asia (SEA) during that period has almost tripled *(Tong et al., 2018; IEA, 2022)*. The economic expansion in Southeast Asian countries has been so rapid that it is threatening to exceed the region's capacity to maintain its own energy supplies. According to *IEA's Renewables 2022* report, it is anticipated that renewables will become the leading source of global electricity generation by early 2025, surpassing coal. Southeast Asian governments also have committed to reducing their reliance on fossil fuels and have set goals for achieving carbon neutrality *(World Economic Forum, 2022)*. However, electricity is still currently mainly generated by coal-fired power plants *(IEA, 2022)*.

Air pollution is currently the biggest environmental and public health concern in the world as it harms people's health, the climate, and ecosystems (Kumar et al., 2017). With the increase in fossil fuel use, emissions of greenhouse gases and air pollutants from the power sector have likewise increased *(Tong et al., 2018)*. Emissions from CFPS include sulfur dioxide (SO_2), nitrogen oxides (NO_X), particulate matter (PM), carbon dioxide (CO_2), mercury and other heavy metals, fly ash and bottom ash, and organic compounds *(EIA, n.d.)*. Organic emissions are composed of volatile, semi-volatile, and condensable organic compounds that are either naturally occurring in coal or are produced when combustion is incomplete *(US EPA, n.d)*. In addition, secondary pollutants such as ozone and fine particulate matter ($PM_{2.5}$) are formed through complex chemical reactions from sulfur dioxide (SO_2) and nitrogen oxides (NO_X) produced during the combustion of coal. Ozone formation is a complicated, non-linear process that occurs when nitrogen oxides (NO_X), non-methane volatile organic compounds, carbon monoxide (CO), and sunlight are present *(Shukla, 2019)*. The precursor emissions of ammonia (NH_3), sulfur dioxide (SO_2), nitrogen oxides (NO_X), and volatile organic compounds (VOCs) lead to the secondary formation of $PM_{2.5}$ *(US EPA, n.d.)*.

According to the *Health Effects Institute (2020)*, air pollution is the primary environmental risk factor for early mortality. Only high blood pressure, tobacco use, and dietary hazards have a greater overall influence on early mortality than air pollution. Estimates show that 6.67 million deaths, or approximately 12% of all deaths globally in 2019, were caused by air pollution. Long-term exposure to air pollution contributes significantly to chronic noncommunicable diseases and some of the leading causes of death. Together, $PM_{2.5}$, indoor air pollution from homes, and ozone cause up to 40% of chronic obstructive pulmonary disease fatalities, 30% of lower respiratory infections, and 20% of infant deaths in the first month of life.

Efforts to reduce emissions and promote human health are made more challenging by the inadequate and inconsistent implementation of regulations. Given that industrial emissions cause acute health effects, accurate and high-frequency information on such emissions by the source is important *(Karplus et al., 2018)*. Emissions data can be used to assess emission patterns, evaluate the impact of dispersed emissions, and implement policies and strategies for managing air quality. Progress towards achieving target regulations and objectives can also be monitored using an efficient monitoring system. For instance, if regional and national emissions monitoring data are gathered and published in an emissions inventory, the data can be used to develop a roadmap toward more stringent emissions standards. Ultimately, designing useful standards can be challenging without sufficient monitoring data *(APEC, 2008)*.

The goal of collecting emissions data is to inform policymakers, develop strategies, and ensure that sources comply with standards and requirements. Gathering data on all potential sources of pollution is important in estimating pollutant concentrations. Different emissions sources generate air pollution, and factors such as atmospheric lifetime and meteorological conditions affect local, urban, and regional areas differently. As a result, data and information exchanges between nations and local, state, and federal authorities are necessary to regulate air pollution at various geographical levels. Understanding emission sources, the pollutants they release, the amount they emit, and the characteristic of emissions (such as stack parameters for CFPs) are important initial steps in managing air pollution and reducing emissions (notably from CFPs). Point source emissions such as those from CFPs must be accurately characterized; furthermore, the data quality should not be restricted to large emitters since low emitters are a key backup for controls when cutoff thresholds are lowered *(Makar et al., 1999)*.

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EMISSIONS DATA ACQUISITION AND COLLECTION

Identification of pollutant source, type, and amount is essential in controlling air pollution and reducing emissions, particularly from CFPs. Several methods for gathering emissions data from point sources have been established over the years. Data can be acquired from Self-Monitoring Reports, third-party stack tests, and Continuous Emissions Monitoring Systems (CEMS) submitted by the industries or facilities to the regulators *(Clean Air Asia, n.d.)*.

Stack Testing

Prior to the development of CEMS, data is collected through stack emissions sampling, which is often conducted by third-party testing companies with government accreditation. The tests were conducted quarterly, semi-annually, or annually. The facility's stack tests were also performed in front of regulators, and violators were ensured to receive the appropriate penalties.

Continuous Emissions Monitoring System

CEMS is an automated method of monitoring emissions since they broadcast high-resolution real-time pollution data from the CFPs. It provides direct and continuous measurements of the concentration of pollutants by evaluating representative data from flue gas. To ensure compliance, these systems must be appropriately designed, installed, operated, maintained, quality-assured, and inspected. CEMS can deliver the most precise and consistent data necessary to evaluate compliance with emission control requirements, according to experience in the United States *(Zhang et al., 2011)*.

Estimation of Emissions Data

Data from the proximate and ultimate analysis of coal may be used to determine theoretical emissions data in the absence of a CEMS (Clean Air Asia, 2020). The proximate analysis provides information on the moisture content, volatile matter, fixed carbon, sulfur content, and ash content in percentage along with the calorific value, while the ultimate analysis provides the percentage weight of carbon, hydrogen, oxygen, nitrogen, ash, and sulfur in coal.

Emission factors (EFs), which determine the amount of pollutants emitted per mass of coal used, may also be used to produce emissions data. Due to a lack of sufficient onsite monitoring emissions data, EFs from the existing database are often utilized. With thorough knowledge of combustion technology and fuel characteristics, it is possible to select EFs from the existing database that most accurately reflect the conditions. While some are generating their EFs from local data, which is more indicative of local conditions, the majority of countries now utilize EFs from US Environmental Protection Agency's AP-42 and European Environment Agency's EMEP. In addition, EFs from the 2006 Intergovernmental Panel on Climate Change (IPCC) recommendations can be used as input into the GHG emissions inventory.

Although the estimation of emissions and their use in assessing air quality have long been common practices, it is now more important than ever to characterize challenges such as uncertainties and errors in the estimated emissions and to evaluate their impact on air quality *(Makar et al., 1999).*

Policies on Coal-Fired Power Plant Emissions Data Collection and Reporting in Asia

To reduce CFP emissions and their harmful impacts, policies on emissions data collection and reporting are important. In the Philippines, CFP owners are expected to provide a written report every quarter to the Department of Environment and Natural Resources – Environmental Management Bureau (DENR-EMB) Regional Offices according to the rules for the Quarterly Self-Monitoring Report. In Indonesia, reports are given to the regent, mayors, governors, and the Ministry of Environment and Forestry (MoEF) every six months. According to S.R.O. 528 (1)/2001, monthly reports in Pakistan must be forwarded to the Director-General of Pak-EPA, whereas quarterly or annual reports must be submitted to the Bangladesh Department of Environment in Bangladesh. In Vietnam, CFPs are required to conduct routine emissions monitoring and submit monitoring reports to governmental management organizations. Several CFPs post their emissions data and reports on their websites; however, this is not the general practice as it is not required by law *(Clean Air Asia, 2020)*.

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USES AND APPLICATIONS OF EMISSIONS DATA FROM COAL-FIRED POWER PLANTS AND INDUSTRIES

Emissions data collection is not done merely for the purpose of acquiring information. As stated in the first section, the ultimate goal of collecting emissions data is to inform policies, establish strategies, and ensure that sources are complying with standards and requirements. To achieve these goals, agencies must be capable of using and analyzing the collected data for the development of emissions inventory (EI) and air quality dispersion models. Furthermore, the use of emissions data in policy implementation can open opportunities for the adoption of new and more stringent emissions standards.

Emissions Inventory (EI)

An EI is an extensive list of the estimated amount of major air pollutants emitted from various sources; therefore, ample preparation is necessary when determining data availability, as well as in organizing and carrying out the process of data collection. It is a vital tool for managing air quality since it can be used to identify sources of air pollution, establish baseline conditions for future planning, develop plans and strategies to reduce air pollution, as well as set rules and permits for industries *(Clean Air Asia, n.d.).*

For point sources such as CFPs, a bottom-up approach is commonly used to build the EI. This method uses precise emission estimates from each point source to provide an accurate representation of emissions.

Air Quality Dispersion Modelling

As part of air quality management, air quality modeling provides a different computational method for estimating the quantity of pollutants in the atmosphere. The data required for collection and input into the model must be prepared in consideration of the tool that is most suited and effective for usage in the area of interest. Every air quality model has useful features and calls for a certain set of data *(Clean Air Asia, n.d.).*

The air quality models may require the speciation of the emissions data into chemical classes. To give the air quality model hourly data, they may alternatively be distributed on a daily basis or according to a temporal distribution. The speciation and temporal allocation procedures are independent operations that frequently use default profiles depending on the nature and type of the source *(Makar et al., 1999).*

Enforcement and Updating of Standards

CFPs are required to adhere to emission regulations set by environmental ministries or departments in order to operate. Emission standards specify the maximum allowed limits for hazardous pollutants that CFPs should not exceed. The three main pollutants that are controlled by CFP emission standards in several Asian countries are SO_X, NO_X, and PM. These pollutants are the primary combustion byproducts and have major adverse impacts on human health and the environment.

Monitoring emissions data is a key component of managing air quality, making it a valuable source of information for updating emissions standards. Data from stack tests and CEMS can be used as a basis for determining the capacity of the facilities to comply with the proposed standards. EI and simulated concentration from air quality dispersion modeling can serve as a basis for science-based information during the development of strategies to mitigate emissions from CFPs.

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SYNTHESIS

The urgent need to reduce emissions from CFPs is already recognized worldwide. The accurate collection and effective use of emissions data are necessary for achieving such reductions. CFPs are classified as a point source, which is described as a single source that generates a substantial amount of emissions. Despite having fewer units than there are in mobile or area sources, the impact of each individual source from this category is substantially greater. Furthermore, although initiatives and technologies to reduce CFP emissions are being developed and recognized throughout Asia, a lack of proper data management makes it difficult to understand the emissions characteristics of CFPs. Guidelines on data transparency and correctness are important for air quality management, particularly in Asia, where electricity generation still relies on CFPs.

There is a need to further link different types of collected data with actual policy development and implementation. The effectiveness of government regulations, as well as changes in activity levels, are reflected in changes in emissions levels throughout time. Thus, the accuracy and completeness of emissions databases are important. To achieve science-based policy development and implementation, countries must ensure data quality and enhance and link the level of understanding from field personnel to ministry leaders.

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