Toward Clean Air Jakarta

English Version

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This White Paper is the result of a collaboration between the Environment Agency of DKI Jakarta and Vital Strategies, with the support of Bloomberg Philanthropies.
http://jakarta.cleanair.id

Cover, Indonesia's capital city Jakarta in the morning on a rare, clear day. Photo: Daxiao Productions - shutterstock, 2019.

Foreword by Environment Agency of DKI Jakarta

Andono Warih
Head of Environment Agency of Jakarta
Dinas Lingkungan Hidup Provinsi DKI Jakarta

Air pollution is the greatest environmental health risk, ranking fifth among all global health risk factors for mortality and accounting for nearly 5 million annual deaths. Most of these deaths are from exposure to fine particles ($PM_{2.5}$). According to epidemiological researchers, the largest contribution to the mortality rate was caused by exposure to $PM_{2.5}$.

Metropolitan cities in rapidly developing countries, such as Jakarta, often experience swift development of infrastructure and an industrial sector. This triggers high urbanization, in which many people will move to cities, and of course, impact air quality.

According to the results of five air quality monitoring stations (ISPU), the average annual concentration of $PM_{2.5}$ in DKI Jakarta has exceeded the Ambient Air Quality Standard (BMUA) which is above 15 µg/m³. Moreover, there are 51% (ISPU 2017) and 48% (ISPU 2019) unhealthy days in terms of air quality in the city, which becomes a challenge for DKI Jakarta provincial government and all stakeholders working to improve air quality. Hence, DKI Jakarta Provincial Government through its Environmental Agency, in collaboration with Bloomberg Philanthropies and Vital Strategies, has prepared these documents on air quality management and Clean Air Actions for DKI Jakarta.

This document aims to describe the challenges that DKI Jakarta is facing in improving air quality in the city, as well as offer solutions that involve participation between DKI Jakarta Provincial government, central government, the public sector, non-government organizations, and also the public.

We believe that by tackling the negative health effects of urban air pollution, a co-benefit will be addressing climate change, as they often share the same emissions sources.

We have outlined solutions and approaches here, as what we hope will be an initial step of formulating a measurable air pollution control policy in DKI Jakarta based on scientific evidence. In addition, this document also provides insights for the public regarding the efforts of DKI Jakarta Provincial Government to control air pollution.

Foreword by Bloomberg Philanthropies

Ailun Yang
Head of International Climate and Environment Programs
Bloomberg Philanthropies

The Global Burden of Diseases study estimates that air pollution is directly responsible for nearly five million premature deaths per year, making air pollution a leading cause of preventable death and disease globally. Bloomberg Philanthropies is working to address this challenge by promoting a data- and science-driven approach to recognizing the problem, identifying its sources, and promoting solutions. At this moment in history, we have a collective responsibility to address the environmental and public health damage caused by air pollution. As the world's urbanization accelerates, cities around the world are already facing a crisis – one which could become worse without rapid action. Now is the time to work together to better measure air pollution, identify its most important and actionable sources, inform the public, and promote lasting solutions to realize the universal right to clean air.

Bloomberg Philanthropies is pleased to be working alongside Governor Anies and Jakarta's city agencies, as well as our implementing partner, Vital Strategies, to support the work to measure air quality and develop effective, long-lasting solutions. We believe data can help inform government and NGO efforts to implement these solutions, whether through initiatives to reduce emissions from vehicles and industry, promote mass transit and active transport, bolster policy initiatives, or raise public awareness. Improving air quality will also help Indonesia make good on its commitment to reduce carbon emissions and help prevent the existential threat of climate change.

Indonesia is a remarkable country – one with an incredibly diverse population, a vibrant culture, and an emerging, rapidly-growing economy. We're excited to expand our work in Indonesia, and we congratulate Jakarta on the publication of this report that describes the city's commitment to a clean air future.

Foreword by Vital Strategies

Daniel Kass
Senior Vice President, Environmental Health Division
Vital Strategies

Jakarta is a remarkable city. Its features, architecture and customs offer a unique blend of antiquity and modernity. It is a place of opportunity, and of course, challenges. Like so many global cities, Jakarta has developed rapidly, and its population growth has strained its natural resources and infrastructure. The impact of its growth on air quality has been substantial. There is a renewed commitment across a wide array of government and non-governmental stakeholders to clean the city's air. The issuance of the Governor's Instruction 66 in 2019, which stipulates seven actions to tackle air pollution, marks an opportunity to rapidly accelerate Jakarta's pathway toward healthier and cleaner air.

Air pollution is one of the leading causes of preventable death and disability around the world. Every improvement in air quality, even small, reduces deaths and improves the health and wellbeing of the population. Investments in clean air solutions return many times their cost to industry, government and the people.

We, at Vital Strategies, as implementing partner of Bloomberg Philanthropies, are so pleased to be working with the administration of DKI Jakarta and Governor Anies Baswedan on efforts to better understand and respond to the leading sources of polluting emissions. Vital Strategies is a global public health organization that partners with governments around the world, providing communication, capacity building and technical expertise that inform public health policies. Last year, we published Accelerating City Progress on Clean Air: Innovation and Action Guide to help cities follow a phased approach for accelerating clean air progress, with a focus on four critical priority areas for action: monitoring air quality; assessing emissions and sources; expanding data access and use; and organizing for action. The organization of this white paper follows this approach—understanding current air pollution levels, assessing air quality monitoring efforts undertaken, examining how DKI Jakarta and clean air stakeholders can identify Jakarta's major sources of air pollution, and identifying the steps toward a cleaner, healthier Jakarta.

With the support of Bloomberg Philanthropies, we look forward to continuing our partnership with the DKI Jakarta government. Sustaining clean air will require investments in clean energy, green infrastructure and better environmental stewardship, and requires continually gathering the best available evidence to address local and regional sources of pollution. This white paper is a starting point, rather than a conclusion. All of us share the mutual goal of Cleaner Air Jakarta.

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Left, Hazy skies in the Sudirman-Thamrin Central Business District, Central Jakarta, Indonesia. Photo: Vital Strategies 2019.

Air Pollution in Jakarta - A Serious Health Risk

The Health and Economic Burden of Air Pollution in Jakarta

Air Pollution and Children's Health

Air Pollution and Noncommunicable Diseases

Left, Masks are a reactive approach to minimizing health risks, and do not address the underlying causes of air pollution. There is limited evidence that masks are effective when living in places with elevated levels of air pollution. Photo: Vital Strategies, 2019.

Right, A doctor examines a respiratory-related patient at Persahabatan hospital, East Jakarta, Indonesia. There are proven links between air pollution and respiratory illnesses, one study has estimated that there are 65 million respiratory symptom days each year that are caused by air pollution. Photo: Vital Strategies, 2019.

"Particulate matter with 2.5 micrometers or less in diameter ($PM_{2.5}$) causes the greatest harm to human health."

Air pollution causes health problems, including stroke, heart disease, diabetes and lung cancer, and both chronic and acute respiratory diseases, including asthma. Air pollution is comprised of particles and gases, each of which causes environmental and health harm. But particulate matter with 2.5 micrometers or less in diameter ($PM_{2.5}$) causes the greatest harm to human health. A single $PM_{2.5}$ particle is 3% the thickness of a human hair and invisible to the naked eye. The small size of the particle enables it to penetrate deep into a person's lungs, from where it can be carried to other body systems (e.g., cardiovascular system and central nervous system), where it can cause oxidative damage and systemic inflammation.

$PM_{2.5}$ is more harmful to health and a better indicator of health risk than PM_{10} (particulate matter with aerodynamic diameter of 10 micrometers or less). The smaller the particles, the deeper they can be deposited deep into the lungs, and travel to other organs (e.g., hearts, brains, placenta), causing the most serious illness and death from cardiovascular and respiratory diseases, cancer and diabetes, which are included in the global burden of disease estimates, as well as adverse birth outcomes and poor child health, potentially impairing well-being and productivity across the life span.[1,2]

[1] World Health Organization, Regional Office for Europe. 2013. Health effects of particulate matter. Policy implications for countries in eastern Europe, Caucasus and central Asia. Retrieved from: https://www.euro.who.int/__data/assets/pdf_file/0006/189051/Health-effects-of-particulate-matter-final-Eng.pdf
[2] Cohen AJ, Brauer M, Burnett R, et al. Estimates and 25-year trends of the global burden of disease attributable to ambient air pollution: an analysis of data from the Global Burden of Diseases Study 2015. Lancet. 2017;389(10082):1907–1918.

1.1 The Health and Economic Burden of Air Pollution in Jakarta

The health burden of air pollution has significant economic and social costs. These include the loss to society from premature deaths, the costs of health care, and the loss of productivity associated with illnesses and caregiving for others. The people most vulnerable to the effects of air pollution are children, elderly and people who suffer from chronic illness.

It was estimated that there were over 5.5 million cases of air pollution-related illness in 2010 in Jakarta; including as much as: 2,450,000 cases of acute respiratory infection; 1,246,000 cases of coronary artery disease; 1,211,000 cases of asthma; 336,000 cases of pneumonia; 154,000 cases of bronchopneumonia; and 154,000 cases of chronic obstructive pulmonary disorder. The associated direct medical cost was as high as IDR 38.5 trillion.[3] Accounting for inflation, this would equate to IDR 60.8 trillion in 2020.[4]

Even so, these sums do not factor in the costs associated with premature death, lifelong disability and decreased workforce productivity, nor worsening air conditions in Jakarta since 2010. Research by Breathe Easy Jakarta[5] also estimated that air pollution caused 260,000 asthma attacks, 85,000 emergency room visits, 65 million respiratory symptom days and 3,420 deaths in the Greater Jakarta region in 2010.[6]

Among all Indonesian provinces, Jakarta residents lose the most number of years due to ill-health, disability or premature death from ambient $PM_{2.5}$ pollution (see Figure 1).

Above, People wearing a mask due to the worsening of the air pollution condition in Jakarta. Photo: Vital Strategies, 2019.

[3] UN Environment, Ministry of Environment Republic of Indonesia. Cost Benefit Analysis for Fuel Quality and Fuel Economy Initiative in Indonesia | UN Environment. https://www.unenvironment.org/resources/report/cost-benefit-analysis-fuel-qualtiy-and-fuel-economy-initiative-indonesia (Accessed January 8, 2019)
[4] https://www.inflationtool.com/indonesian-rupiah/2010-to-present-value?amount=385000000

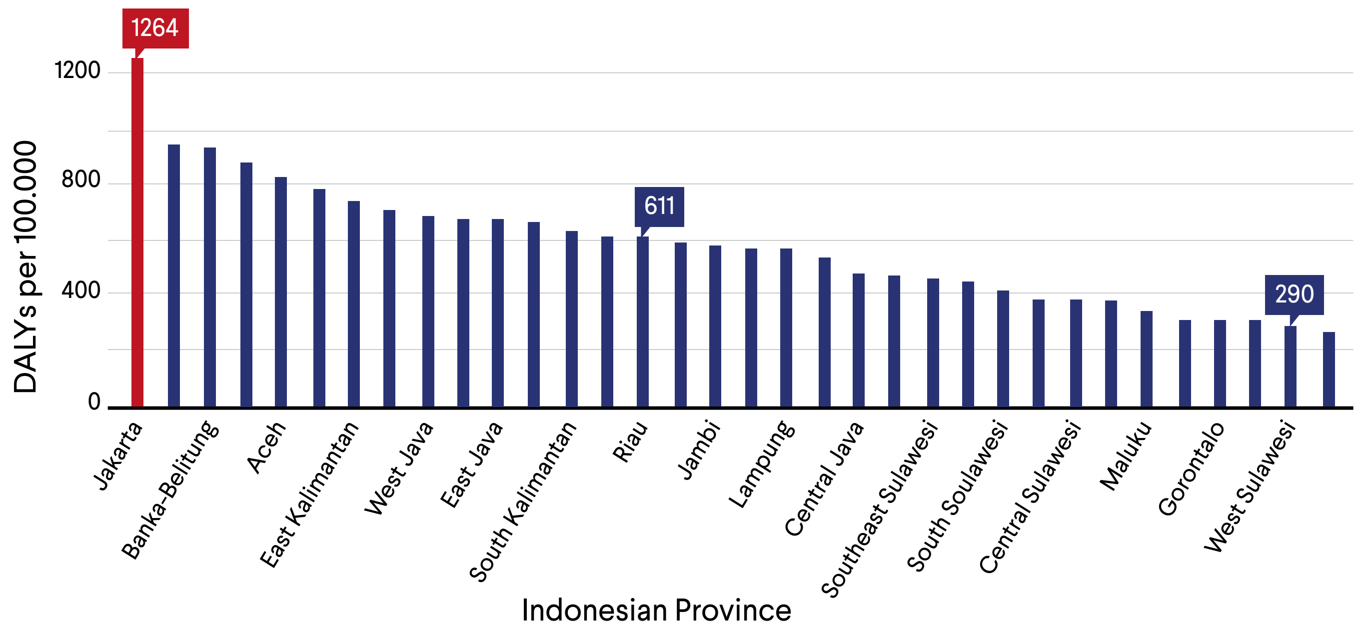


Figure 1:
Severity of Air Quality Health Impacts Among Indonesian Provinces in 2017. Disability-adjusted life years (DALYs) refer to years lost due to premature death, ill-health or disability per 100,000 people.[7]

[5] The Breathe Easy, Jakarta program was supported by the United States Environmental Protection Agency, with implementing partners – Desert Research Institute (DRI), Swisscontact, Clean Air Asia and Komite Penghapusan Bensin Bertimbel (KPBB). The project duration was between August 2012 and February 2016.
[6] Breathe Easy, Jakarta. Factsheet 4: Health Impacts. 2016. Retrieved from http://www.urbanemissions.info/wp-content/uploads/docs/2017-01-Jakarta-Facsheet4-Health-Impacts.pdf.
[7] Analyzed using a platform from Institute for Health Metrics and Evaluation. GBD Comparison by Country. Retrieved from https://vizhub.healthdata.org/gbd-compare/.

1.2 Air pollution and Children's health

Children exposed to high levels of air pollution are especially vulnerable to air pollution, because their lungs and brains are: 1) still developing, 2) absorb toxic materials more efficiently, and 3) inhale more air per unit of body weight than adults. The negative effects of air pollution on a child starts from the time the child is conceived in the womb.

Air pollution in Jakarta is the third leading risk factor for child mortality, after malnutrition and sanitation.[8] There is compelling evidence that air pollution leads to child illnesses and death by increasing the risk of low birth weight, acute lower respiratory infections like pneumonia, and reduced lung function. There is also growing evidence linking long term air pollution exposure to impaired neurological development, obesity, and cancers in children.[8]

Nationally, it was estimated that the air pollution level in 2017 caused over 24,500 Indonesian babies born with birth weights below the 10th percentile for babies of the same gestational age, a prenatal determinant for childhood stunting.[9] The impairments and delays of children's physical and cognitive development associated with air pollution have prolonged impacts throughout the individual's lifetime.

Links between air pollution and COVID-19

A few recent ecological studies have suggested an association between air pollution and COVID-19 infection, though more research is needed to control for confounders (e.g., age, socioeconomic factors) to validate the findings. However, what is certain is that the heart and lung diseases that air pollution causes make people much more likely to become severely ill or die from COVID-19.[13] Because of this shared pathway, improving air quality would likewise improve lung and heart health, and reduce susceptibility to the severe impacts of COVID-19 and potentially other infectious diseases.

1.3 Air Pollution and Noncommunicable Diseases (NCDs)

Noncommunicable diseases (NCDs) — mainly cancer, cardiovascular disease, chronic respiratory diseases and diabetes — are the leading causes of death and disability worldwide.[10]

According to World Health Organization estimates, 25% to 43% of deaths from NCDs are due to air pollution.[11] In Indonesia, NCDs accounted for 1,365,000 deaths or 73% of total deaths in 2016. These top three NCDs — stroke[12], ischemic heart disease and diabetes have all been proven to be linked to air pollution.

[8] UNICEF Indonesia, Vital Strategies. Air Pollution: A Threat to Children's Health in Indonesia. 2018. Retrieved from https://www.vitalstrategies.org/resources/air-pollution-a-threat-to-childrens-health-in-indonesia/
[9] Burden of small for gestational age (SGA) attributable to ambient $PM_{2.5}$ pollution was calculated using SGA prevalence in Indonesia and effect estimates from an unpublished manuscript (currently under review) by Vital Strategies team.
[10] NCD Alliance. Retrieved from https://ncdalliance.org/why-ncds/NCDs. Founded in 2009, the NCD Alliance is a robust global network of more than 2,000 organizations in 170 countries. This includes global and national NGOs, scientific and professional associations, academic and research institutions, private sector entities and dedicated individuals.
[11] World Health Organization. "9 out of 10 people worldwide breathe polluted air, but more countries are taking action." 2018. Retrieved from https://www.who.int/news-room/detail/02-05-2018-9-out-of-10-people-worldwide-breathe-polluted-air-but-more-countries-are-taking-action.
[12] World Health Organization. Indonesia country profile 2018. Retrieved from https://www.who.int/nmh/countries/2018/idn_en.pdf?ua=1.
[13] Stokes, Erin K, et al. 2020. Coronavirus Disease 2019 Surveillance – United States, January 22 – May 30, 2020. Morbidity and Mortality Weekly Report. Retrieved from https://www.cdc.gov/mmwr/volumes/69/wr/mm6924e2.htm?s_cid=mm6924e2_w.

Impact of Air Pollution at Different Life Stages

There is no safe level of air pollution. Long-term exposure to air pollutants are linked to decreased growth, disease and early death.

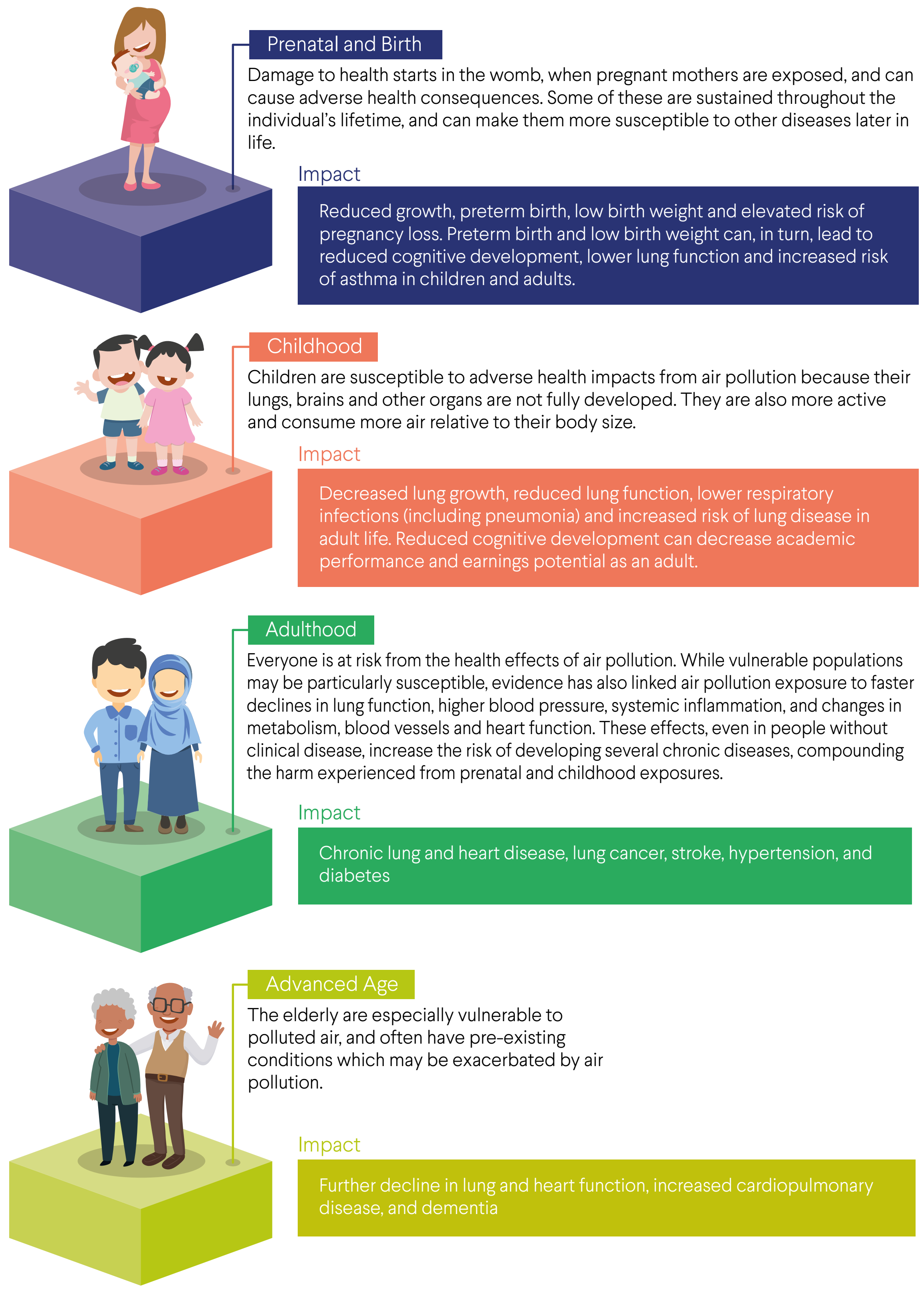


Figure 2: Impact of air pollution in different life stages.
For more information on air pollution and health visit www.vitalstrategies.org/air-pollution-and-health.

Ambient Air Quality Monitoring in Jakarta

Air Quality Monitoring Stations in Jakarta

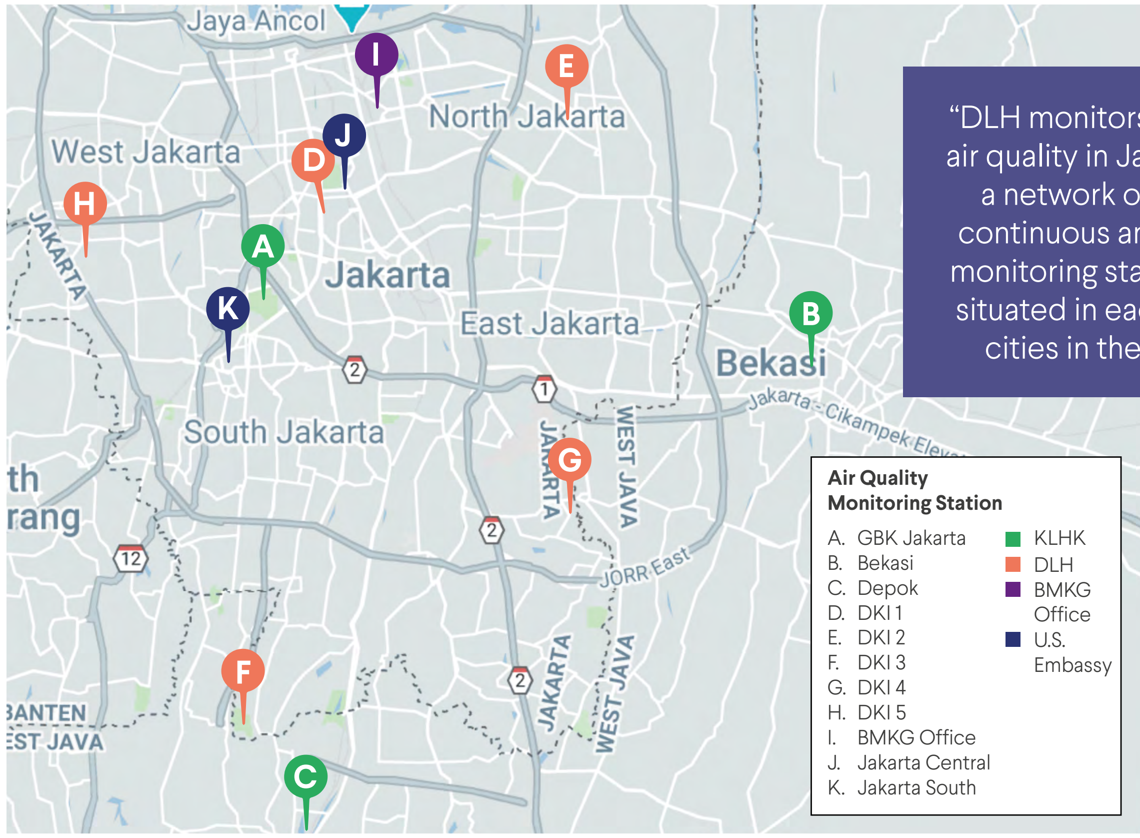
Air Quality in Jakarta

Air Quality Standards in Jakarta

Air Quality Index of Jakarta

Publication of Air Quality Data

Left, A staff person from the Environmental Agency of DKI Jakarta (DLH) carries out routine maintenance on the Air Quality Monitor at Hotel Indonesia Roundabout, Central Jakarta, Indonesia. This tool monitors four gaseous pollutants (SO_2, NO_2, CO, O_3) and two sizes of particulate matter (PM_{10} and $PM_{2.5}$). Photo: Vital Strategies, 2019.



"DLH monitors the ambient air quality in Jakarta through a network of five fixed, continuous and automatic monitoring stations that are situated in each of the five cities in the province."

Figure 3: The Locations of Continuous Ground-Based Air Quality Monitoring Stations in and around DKI Jakarta.

2.1 Air Quality Monitoring Stations in Jakarta

There is a network of continuous ground-based air quality monitoring stations (AQMS) in and around DKI Jakarta. These stations are operated by either local or national governments, or international organizations (Figure 3).

The Environment Agency of Jakarta (DLH Jakarta, Dinas Lingkungan Hidup Provinsi DKI Jakarta in Indonesian) monitors the ambient air quality in Jakarta through a network of five fixed, continuous and automatic monitoring stations that are situated in each of the five cities in the province. In addition, there are three mobile stations used for monitoring air quality before-during-after Car Free Day (CFD). The strong correlation between health and air quality is a priority issue for DKI Jakarta. As such, the city added $PM_{2.5}$ monitoring capacity to three of their stations in January 2019 and fitted their other two stations with $PM_{2.5}$ monitoring capacity in 2020.

Besides the DLH Jakarta stations, the Ministry of Environment and Forestry (KLHK) and the Meteorology, Climatology and Geophysical Agency (BMKG) each has one, and United States Embassy operates two air quality monitoring stations. Table 1 provides more details on the air pollutants measured at each station.

DKI Jakarta conducted a study to add more monitoring stations to monitor the air as the city's economy and population continue to grow. Based on an area of 661.5 square kilometers and a population of 10 million, not including the people who commute from outside the city boundary during the day, the study recommended an additional 31 monitoring stations in the Jakarta area and two other monitoring stations in cities around DKI Jakarta to monitor pollutants stipulated by prevailing regulation[14] to monitor air quality in residential areas, roadsides, and industrial areas.

Table 1. Institutions Reporting Air Quality Data in DKI Jakarta

Agency	Governance	No. of Monitors	Pollutants Measured
Dinas Lingkungan Hidup Provinsi DKI Jakarta (Environmental Agency of Jakarta)	Local	5	PM_{10}, $PM_{2.5}$ (since Jan 2019), CO, O_3, SO_2, NO_2
Badan Meteorologi, Klimatologi, dan Geofisika (Meteorology, Climatology, and Geophysical Agency)	National	1	PM_{10}, SPM, GHG (CO_2, CH_4, N_2O, SF_6), O_3, SO_2, NO_2
Kementerian Lingkungan Hidup dan Kehutanan (Ministry of Environment and Forestry)	National	1	PM_{10}, $PM_{2.5}$, CO, O_3, SO_2, NO_2
U.S. Embassy	Local	2	$PM_{2.5}$ (since 2015)

Air Pollutant Basics

About $PM_{2.5}$, Ozone, Nitrogen Dioxide, Sulphur Dioxide and Carbon Monoxide

$PM_{2.5}$ is the most important pollutant to monitor and reduce, as it causes the most severe and greatest number of diseases and death. In addition to being a proven cause of cardiovascular and respiratory diseases, cancer and diabetes, it also impacts birth outcomes and child health, potentially impairing well-being and productivity across the human life span.

Other important pollutants include ozone (O_3), a secondary, regional pollutant, which currently causes roughly one-sixth as many deaths globally as ambient $PM_{2.5}$ pollution. Nitrogen dioxide (NO_2), a useful indicator of traffic-related air pollution, is a risk factor for asthma development and a pollutant involved in producing ozone. Sulphur dioxide (SO_2) monitoring is especially useful near sources of coal and high-sulphur oil combustion, which also contribute to $PM_{2.5}$ formation. Carbon Monoxide (CO) is a gas that is emitted from combustion that contributes to cardiovascular disease.

Above, Staff from the Environmental Agency of Jakarta carry out routine maintenance on their Air Quality Monitors. Photo: Vital Strategies, 2019.

[14] Laboratorium Lingkungan Hidup Daerah Dinas Lingkungan Hidup, Pemerintah Provinsi DKI Jakarta. 2019. Laporan Rekomendasi Lokasi Alat Pemantau Kualitas Udara Beserta Parameter dan Teknologi Pengukuran.
[15] Dinas Lingkungan Hidup (DLH Jakarta) - Provinsi DKI Jakarta. 2020. Retrieved from https://lingkunganhidup.jakarta.go.id/
[16] The United States Department of State. AirNow. Retrieved from https://airnow.gov/international/us-embassies-and-consulates/#Indonesia$Jakarta_Central

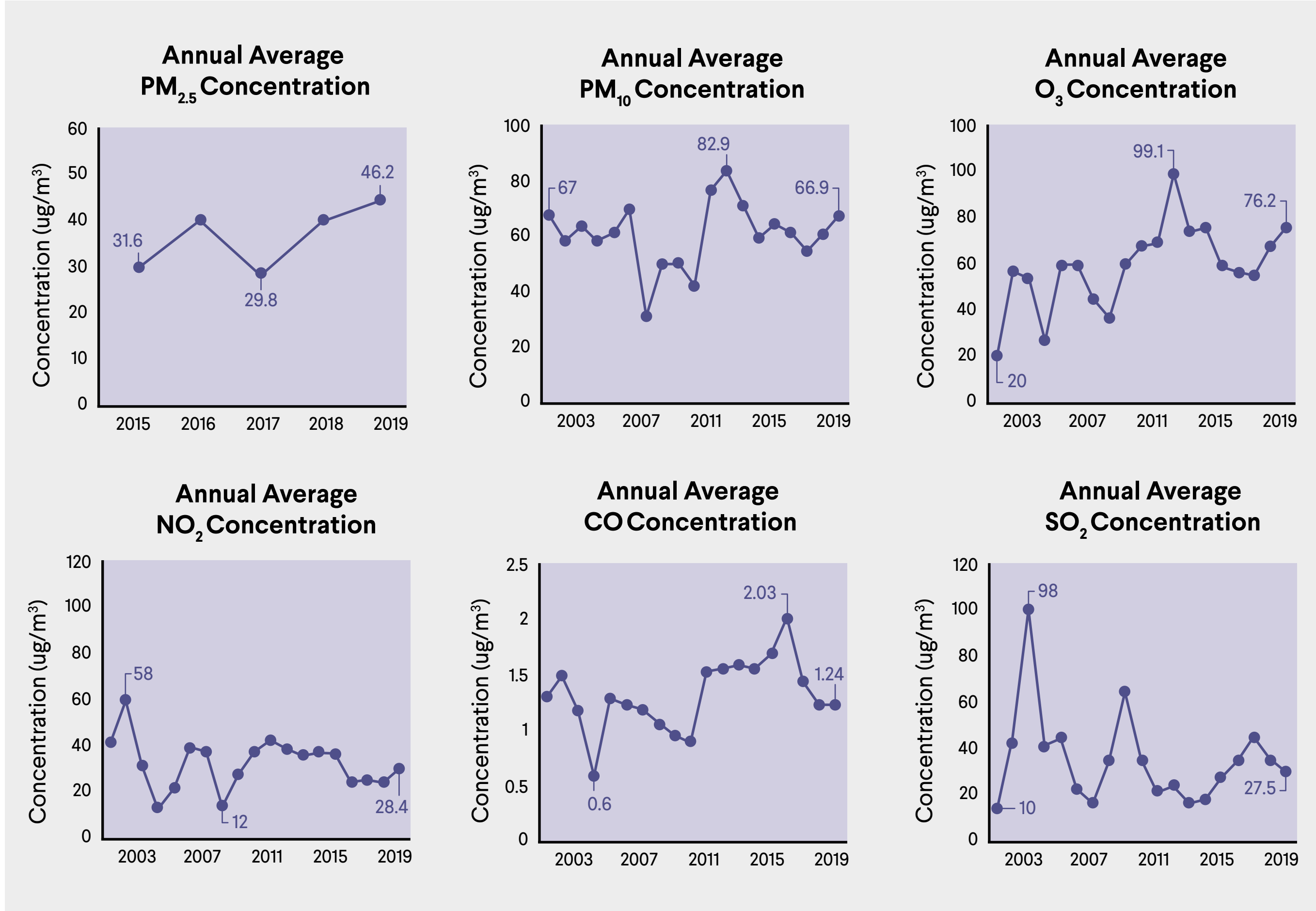


Figure 4:
Annual Average Air Pollution Concentrations Measured in DKI Jakarta, as Compared to the Indonesia Standards and WHO annual Air Quality Guideline (AQG). All pollution measurements, except for $PM_{2.5}$, were taken from DLH Jakarta monitors.[1] $PM_{2.5}$ measurements were taken at either the U.S. embassies in Central and South Jakarta, or DLH Jakarta monitors (for 2019).[3]

2.2 Air Quallity in Jakarta

The annual average concentrations of $PM_{2.5}$ and O_3 in DKI Jakarta from 2001 to 2019 showed an increasing trend. The annual average concentrations of NO_2 remained steady and SO_2 fluctuated, although these levels still meet the national and Jakarta's ambient standard (Figure 4). The amount of pollutants in the air is affected by several factors, such as: development in Jakarta, meteorological conditions, and wind direction.
By the end of 2019, DLH Jakarta reported annual average $PM_{2.5}$ concentrations ranging from 43 to 51 μg/m³ among its monitoring stations.[15] This level is consistent with monitoring data from the two U.S. embassies in Jakarta, which documented the annual $PM_{2.5}$ levels ranging from 39 μg/m³ to 52 μg/m³ in 2019.[16] The annual average of $PM_{2.5}$ in 2019 in all monitoring stations exceeded Indonesia's annual standard of 15 μg/m³ and WHO's AQG of 10 μg/m³ (Figure 5).

By comparing daily average data in 2019 between DLH's three monitoring stations and that of the US Embassy's, there is high correlation in the data obtained by these AQ monitors (Figure 6). This suggests that the data produced by these monitoring stations are reliable. Other than measuring air quality,

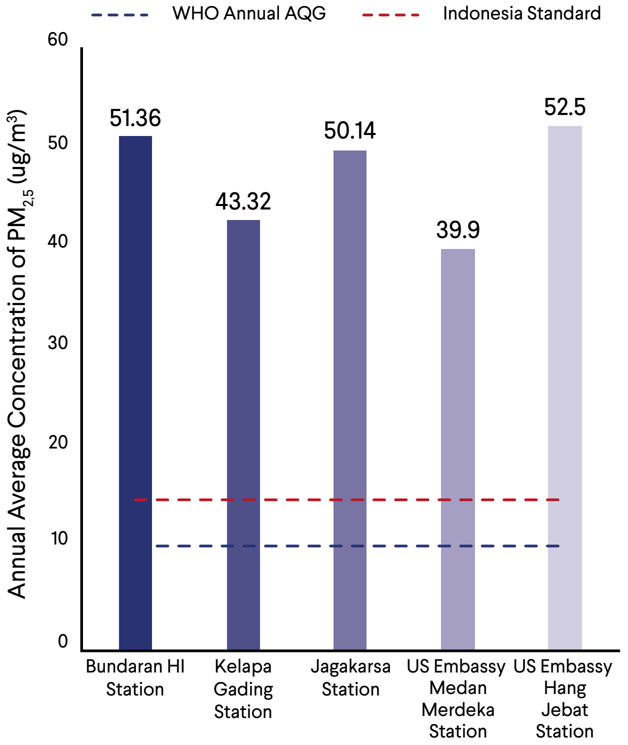


Figure 5:
Annual Average of $PM_{2.5}$ Concentrations from DLH Jakarta Monitoring Stations and U.S. Embassy Stations in DKI Jakarta in 2019 as Compared to the Indonesia $PM_{2.5}$ Standard and WHO

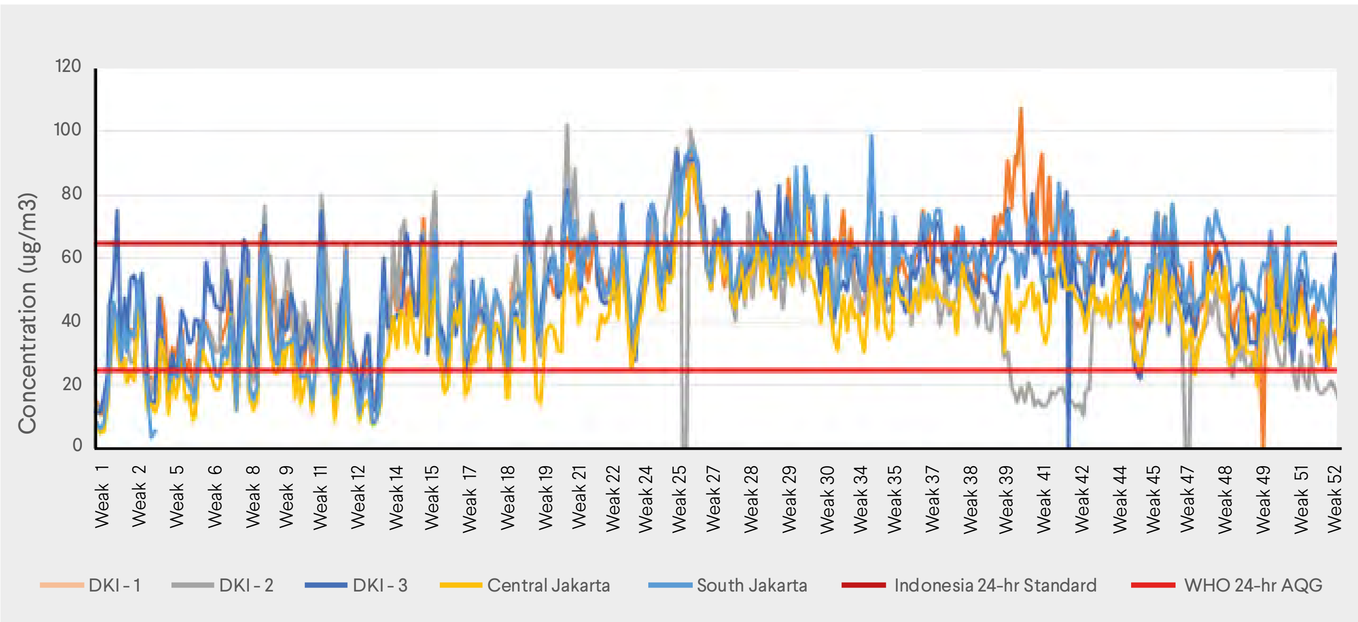


Figure 6:
Daily Average of $PM_{2.5}$ Recorded by Five Jakarta Air Quality Monitoring Stations in 2019, as Compared to the Indonesia $PM_{2.5}$ 24-hour Standard and WHO 24-hour Air Quality Guideline (AQG). DKI 1 to 3 are managed by DLH, whereas Jakarta Central and Jakarta South are managed by U.S. embassies.

these monitoring stations are equipped with tools to measure meteorological data, such as: precipitation, humidity, wind speed, and wind direction. The data may be utilized to analyze pollutants in Jakarta, including contribution from regional sources beyond the city boundary. Nonetheless, additional monitors and monitoring enhancements are needed for more comprehensive monitoring.[17] For example, additional measurements of $PM_{2.5}$ chemical composition and harmful pollutants (e.g., benzene) are needed.

2.3 Air Quality Standards in Jakarta

Under the DKI Jakarta Governor's Decree No. 551 (2001), Jakarta set its own air quality standards. These standards are stricter than the national ambient air quality standards in Indonesia for most air pollutants except for particulate matter, which is the same. Overall, both Jakarta and national air quality standards permit greater pollutant levels than WHO's Air Quality Guidelines (Table 2). From Table 2, we can conclude that the ambient standard for $PM_{2.5}$ in DKI Jakarta falls between Interim 1 (IT-1) and Interim 2 (IT-2) of WHO's air quality guidelines. As the city continues to develop, a study on refining a new ambient standard that is aligned with the city's current air quality is needed.

Table 2. Comparison of ambient air quality standards in DKI Jakarta, Indonesia (nationwide), and World Health Organization Air Quality Standards

Pollutant	Avarage Time	Jakarta (SK Gub. DKI Jakarta No. 55/2001)	Indonesia (PP No. 41/1999)	WHO[18]			
				IT-1	IT-2	IT-3	AQ Guidelines
$PM_{2.5}$ (µg/m3)	24-hour	65	65	75	50	37.5	25
	Annual	15	15	35	25	15	10
PM_{10} (µg/m3)	24-hour	150	150	150	100	75	50
	Annual	-	-	70	50	30	20
SO_2 (µg/m3)	10-minute	-	-	-	-	-	500
	24-hour	260	365	125	50	-	20
	Annual	60	60	-	-	-	-
NO_2 (µg/m3)	1-hour	400	400	-	-	-	200
	Annual	60	100	-	-	-	40
O_3 (µg/m3)	1-hour	200	235	-	-	-	-
	8-hour	-	-	160	-	-	100
	Annual	30	50	-	-	-	-
CO (µg/m3)	1-hour	26,000	30,000	-	-	-	-
	8-hour	-	-	-	-	-	10,000
	24-hour	9,000	10,000	-	-	-	-

Abbreviations: PM_{10}= particulate matter with diameter less than or equal to 10 micrometers; $PM_{2.5}$= particulate matter with diameter less than or equal to 2.5 micrometers. **Note:** The source of Jakarta's $PM_{2.5}$ air quality standard is the Governor of DKI Jakarta Decision No. 551/2001 on Air and Noise Ambient Standard

Left, A new and used filter used in air quality monitors are compared side by side.
Photo : Vital Strategies (2019).

[17] Vital Strategies. 2020. Accelerating City Progress on Clean Air - Innovation and Action Guide. https://www.vitalstrategies.org/cleanairguide.
[18] World Health Organization. "Ambient (outdoor) air pollution". 2018. Retrieved from https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

2.4 Air Quality Index of Jakarta

In addition to air quality standards, many governments, including Indonesia, use an air quality index (AQI) as a simplified tool to communicate daily air quality to the public. In line with the regulation enacted by the Ministry of Environment and Forestry,[19] and based on the Air Quality Index (Indeks Standar Pencemar Udara/ISPU), DKI Jakarta uses a descriptor and color code to reflect the air quality status as per the ranges in Table 3.

The number of days with "Unhealthy" air increased between 2014 and 2018 and showed a slight decline in 2019 as shown in Figure 7.

The ISPU utilizes a useful "warning system" to inform the public on air quality on any particular day, which aims to increase awareness and promote behavior change as exposure to long-term, elevated, but perhaps less extreme air pollution is harmful to human health. To assess public health risks, measuring chronic exposure - as indicated by annual or seasonal average concentrations - is more useful than measuring short-term exposure. Furthermore, different countries have different standards in communicating "good" quality air using their own AQI. See Figure 8.

Global research evidence shows that health harm from $PM_{2.5}$ increases steadily with ambient concentration.[20,21] Therefore, interventions that substantially reduce ambient $PM_{2.5}$ will produce large health benefits for the population. Rough calculations by Vital Strategies,[22] based on the 2020 population estimate, suggest that a reduction in $PM_{2.5}$ concentration from 48 µg/m³ (i.e., $PM_{2.5}$ annual average in 2019) to 31.5 ug/m3 (i.e., halfway to Jakarta $PM_{2.5}$ annual standard) would save at least 4,000 lives annually in the city, and nearly 7,600 lives saved by reducing ambient levels to 15 µg/m³ (i.e., Jakarta $PM_{2.5}$ annual standard). A more comprehensive health impact assessment is needed to evaluate the full benefits of air pollution control action on human health in DKI Jakarta.

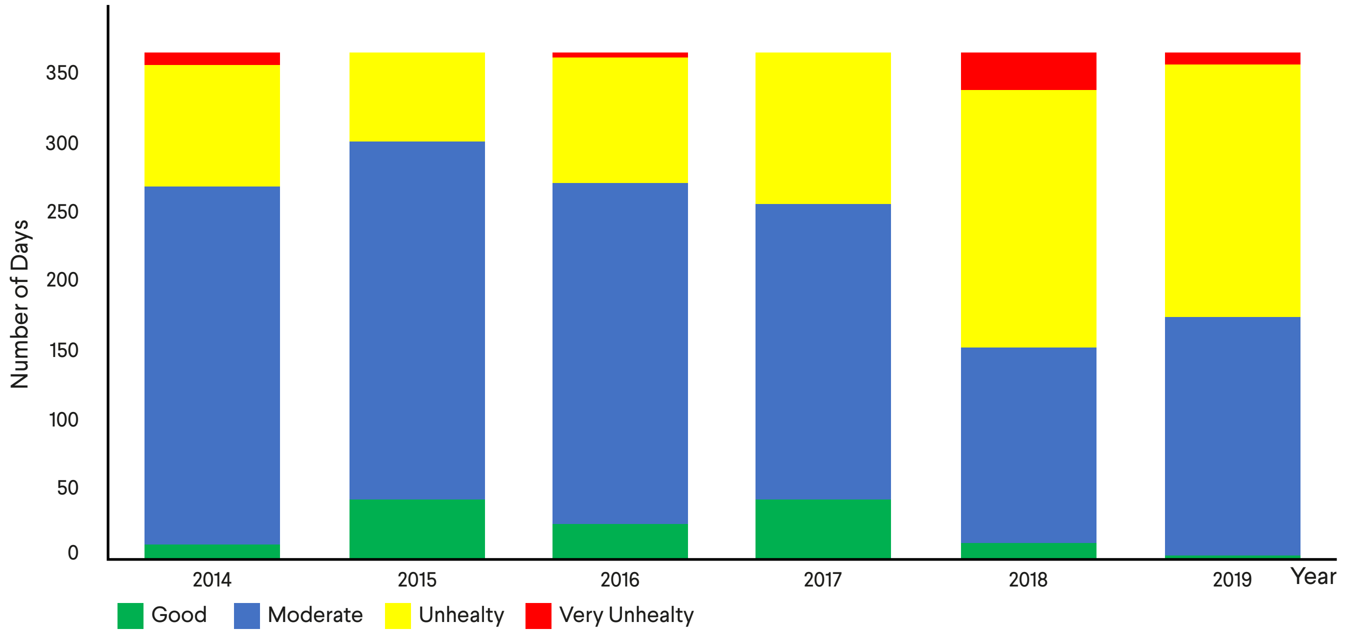


Figure 7:
Number of Days of Air Quality Index (ISPU) by Year in Jakarta.

[19] Peraturan Menteri Lingkungan Hidup dan Kehutanan No. P.14/MENLHK/SETJEN/KUM.1/7/2020 tentang Indeks Standar Pencemar Udara (ISPU)
[20] Adrian G. Barnett. 2014. It's safe to say there is no safe level of air pollution. Aust N Z J Public Health 38:407–408.

Table 3. Breakdown of the air quality index (ISPU) values, DKI Jakarta.[23] The ISPU for Jakarta is calculated using hourly data per pollutant (e.g. PM_{10}, SO_2) from the previous day. Data from the five DLH Jakarta air quality monitoring stations **are averaged and used as input in the calculation for the ISPU report for the following day. The ISPU is valid for 24 hours** (i.e. from 15:00 of the previous day to 15:00 of the next day). **The daily ISPU is determined by the pollutant with the highest score which is then designated as the "critical parameter."** This ISPU is regulated through Ministry of Environment Decision No. Kep-45/MENLH/10/1997

	Breakpoint							
Range of ISPU values	24-hr HC (µg/m³)	24-hr $PM_{2.5}$ (ug/m³)	24-hr PM_{10} (ug/m³)	24-hr SO_2 (mg/m³)	24-hr CO (ug/m³)	24-hr O_3 (ug/m³)	24-hr NO_2 (ug/m³)	Descriptor and colour code
0-50	45	15.5	50	52	4,000	120	80	Good
51-100	100	55.4	150	180	8,000	235	200	Moderate
101-200	215	150.4	350	400	15,000	400	1,130	Unhealthy
201-300	432	250.4	420	800	30,000	800	2,260	Very Unhealthy
≥301	648	500	500	52	4,000	120	3,000	Hazardous

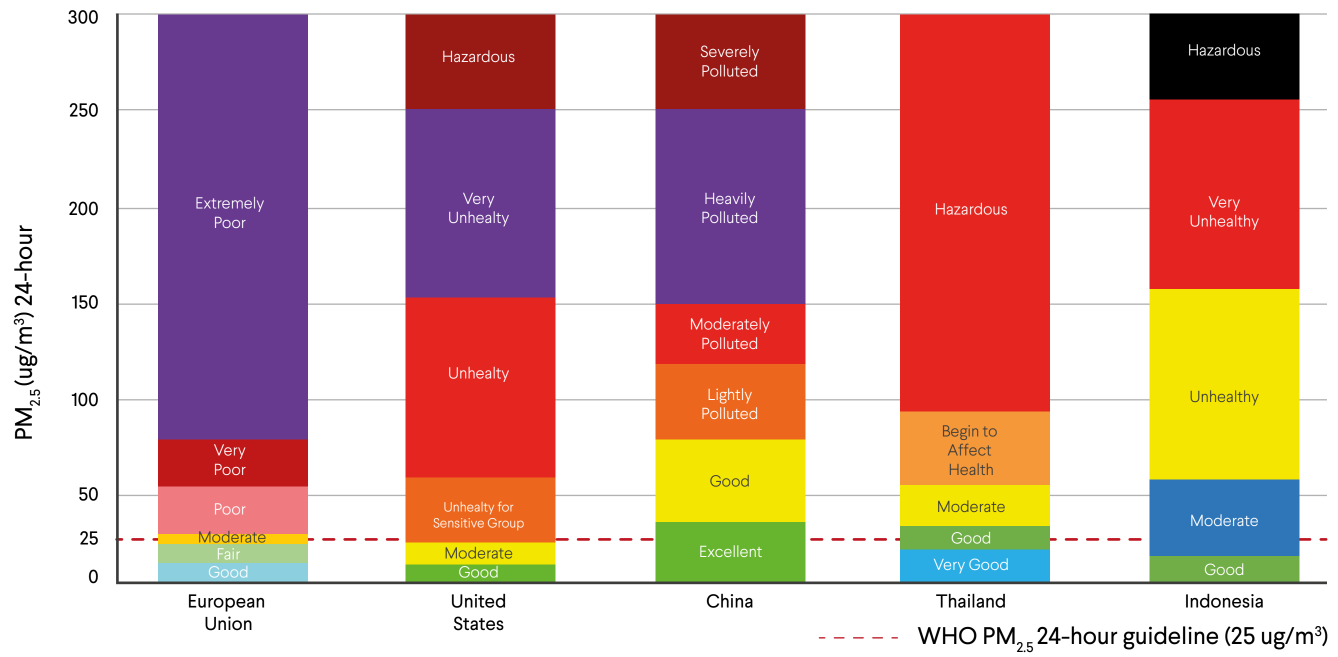
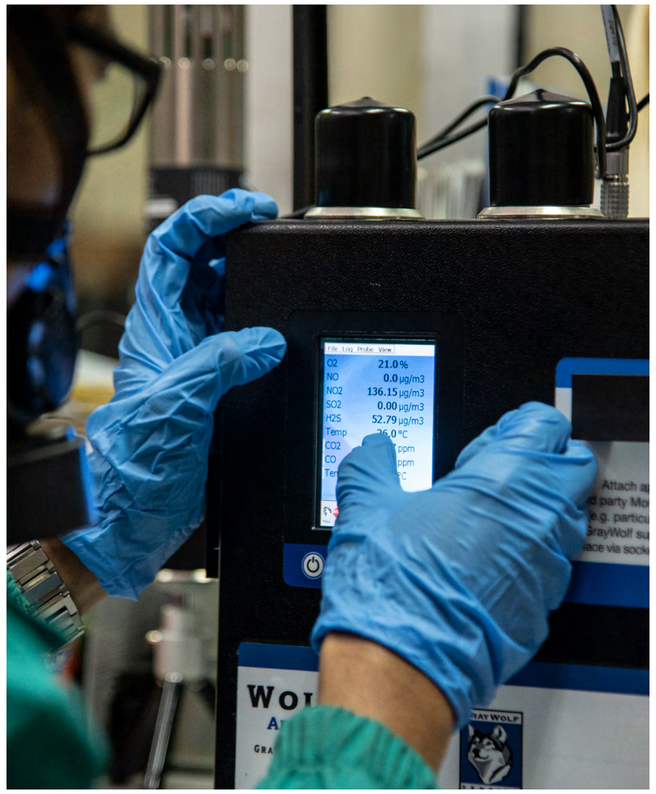
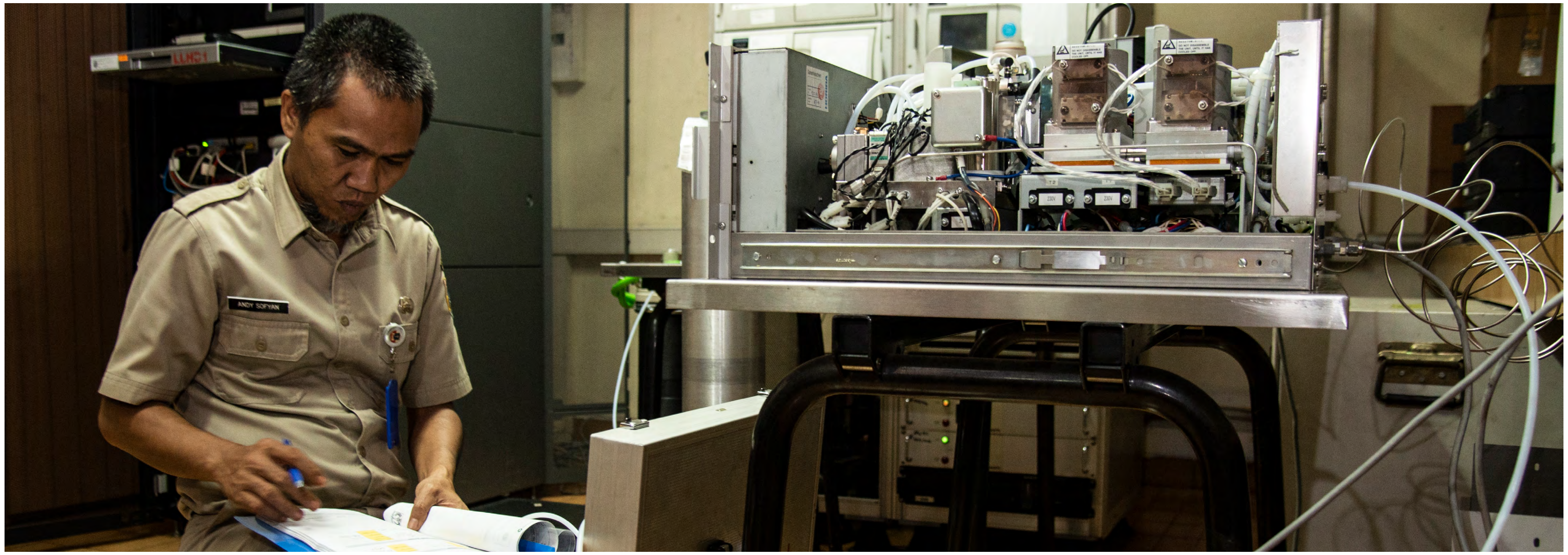


Figure 8:
Comparison of Air Quality Index Designation and Guidelines for $PM_{2.5}$ in Selected Countries. Air quality considered "good" in China is considered "poor" or "very poor" by European Union standards.

[21] World Health Organization. 2018. Ambient (outdoor) air quality and health. Retrieved from: http://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health
[22] Premature deaths attributable to PM2.5 among adults population were calculated using World Health Organization AirQ+ (http://www.euro.who.int/en/health-topics/environment-and-health/air-quality/activities/airq-software-tool-for-health-risk-assessment-of-air-pollution).





2.5 Publication of Air Quality Data

The Ministry of Environment and Forestry mandates local governments[23] to publish air quality data publicly. Air quality data in Jakarta is available to the public through the Jakarta Kini (Jaki) application available on the Google Play store. In addition, DLH Jakarta publishes monthly summaries of air quality data on its website (https://lingkunganhidup.jakarta.go.id/); on the DKI Jakarta website (https://Jakarta.go.id); and collaborating with the Ministry of Environment and Forestry to relay the data on their website. Air quality data from the U.S. embassy air quality monitoring stations is also publicly available on the AirNow International website (https://airnow.gov/international).

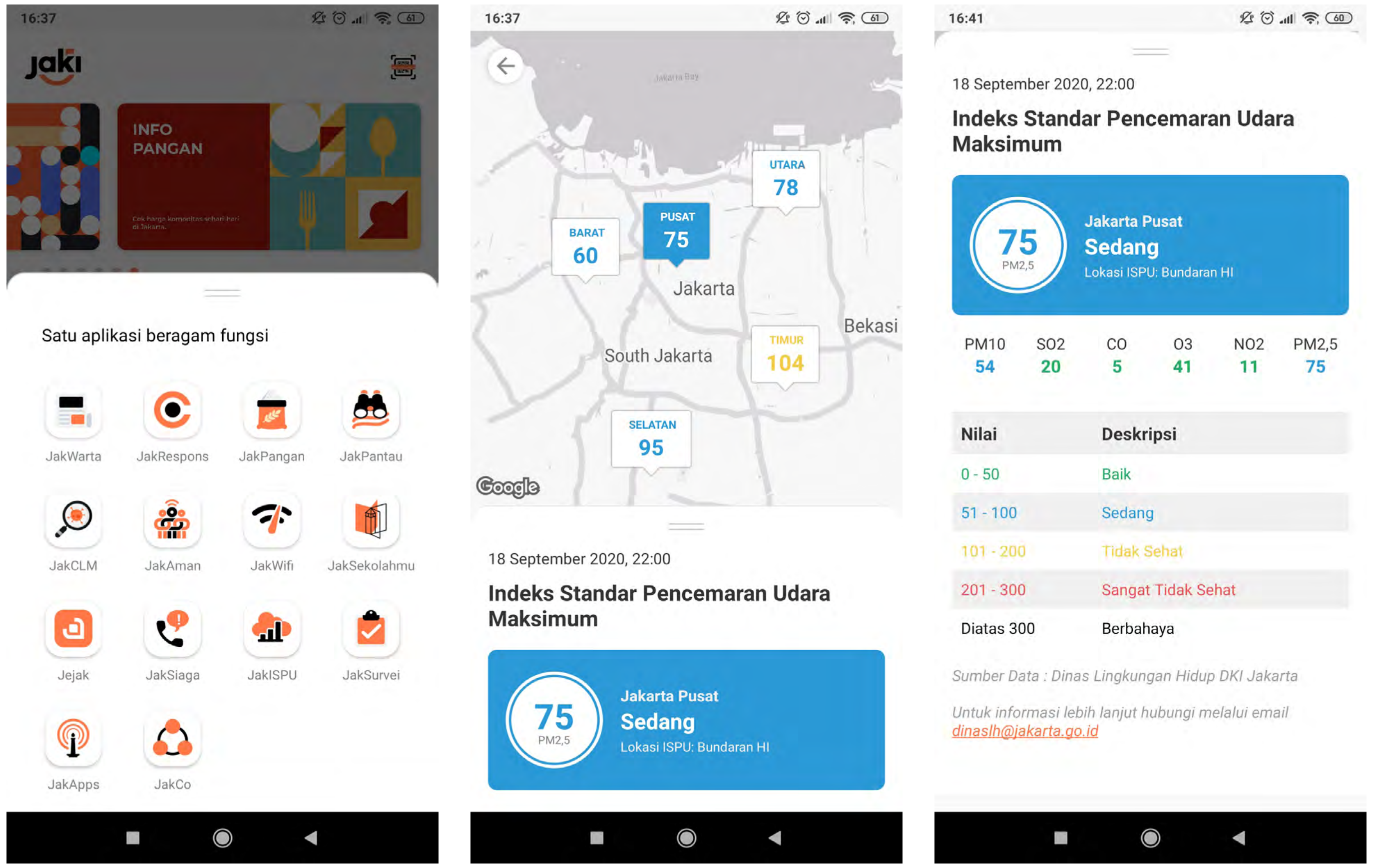
Above left, Staff from Ministry of Environment and Forestry calibrates air quality measurement device in their office in Jakarta, Indonesia. Photo: Vital Strategies, 2019.
Right, Air Quality (ISPU) Display at DLH Office at Casablanca Street, Jakarta, Indonesia. Photo: Vital Strategies, 2019. ISPU on the https://llhd.jakarta.go.id/ website. Photo: Vital Strategies, 2019.

INDEKS STANDAR PENCEMAR UDARA DKI JAKARTA

Last Update 2020-09-18 22:00:00		ISPU	KATEGORI	Parameter Kritikal
DKI 1	BUNDARAN HI	54	SEDANG	PM10
DKI 2	KELAPA GADING	60	SEDANG	PM10
DKI 3	JAGAKARSA	55	SEDANG	PM10
DKI 4	LUBANG BUAYA	70	SEDANG	PM10
DKI 5	KEBON JERUK	60	SEDANG	PM10

Informasi Terkini

[23] Ministry of Environment Regulation No. 12/2010 on Implementation of Air Pollution Control in Local Level.



Above right, Staff from Ministry of Environment and Forestry calibrates air quality measurement device in their office in Jakarta, Indonesia. Photo: Vital Strategies, 2019.
Right below, A screen capture of ISPU from the Jaki application. Photo: Vital Strategies, 2019.

Assessing Emissions and Sources of Air Pollution

Studies on the Sources of Pollution in Jakarta

Major Sources of Air Pollution in Jakarta

Left, Shipping and cargo activities at Tanjung Priok seaport, North Jakarta, Indonesia. Photo: Vital Strategies, 2019.

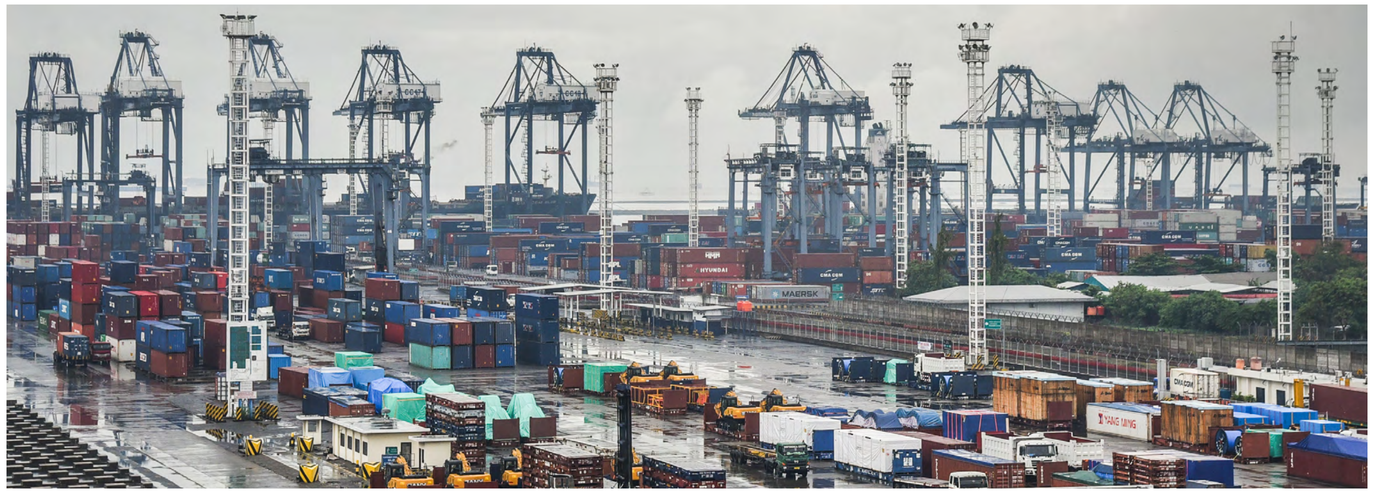
Right, Street vendors grilling food outdoors in Central Jakarta, Indonesia. Photo: Vital Strategies, 2019.

3.1 Studies on the Sources of Pollution in Jakarta

Knowing the sources of air pollution is the most important step to improving air quality. DKI Jakarta is one of a few cities in Indonesia that has adequate, reliable and recent information on the relative contribution of leading sources of air pollution. These data came from studies using two complementary technical approaches to identify sources of pollution: source-based and receptor-based approaches. In brief, these methods make it possible to understand what share of the air pollution problem is attributable to transportation, industry, energy generation, burning, and various commercial activities.

Method 1: Source-Based Approach Using Emissions Data

This approach involves the creation of an air pollution emissions inventory by calculating how much emissions are created by known sources (such as transportation) within DKI Jakarta. An emissions inventory works well when cities have a good system of tracking and monitoring emissions sources both within and beyond the city boundaries. This approach then uses emissions inventory data, meteorological data and chemical transport models to estimate the source contributions to ambient air pollution concentrations. The key limitation of this approach is that a city-scale emissions inventory alone does not consider non-local or regional sources of pollution that could have blown in from elsewhere. They also might not accurately capture pollution from traditional sources like agricultural and household burning.



Currently, DKI Jakarta has a greenhouse gas emissions inventory, which can serve as a basis to create an air pollution emissions inventory. In addition, various ad hoc emissions inventories were developed to provide insight into the leading contributors of air pollution emission within DKI Jakarta's city boundary. However, results from these inventories should be interpreted with caution because they do not capture the regional emission sources that contribute to ambient air pollution levels in the city, and direct comparison between inventories is difficult given the differences in methodology and source categories. For $PM_{2.5}$, two emissions inventories have been developed.[24,25]

The most recent emissions inventory research[24] which utilized data from 2015 concluded that:

a) Transportation (46%) and industrial combustion (43%) are the leading contributors of $PM_{2.5}$ emission
b) Industrial combustion accounted for two-thirds of SO_2 emission
c) Road transport dominated CO emissions (93%); and
d) Fifty-seven percent (57%) of NOx emissions came from road transport, followed by power and heating plants (24%)[26]

Above, Shipping and cargo activities at Tanjung Priok seaport, North Jakarta, Indonesia. Photo: Vital Strategies, 2019.

Method 2: Receptor-Based Approach Using Air Filter Samples

The second method of determining the sources of pollution in a city is collecting ambient air filter samples, analyzing the chemical composition in the samples, and matching the chemical profiles with those of emissions from different fuels. This highly technical approach depends on the skills of researchers and complex laboratory analysis. It can be difficult to tell apart different sources that may be burning the same fuel. For example, coal is burned both in electrical generation and in other industries.

The benefit of this approach is that it helps to identify the sources of air pollution that originate from both inside the city boundary and from regional sources outside the city. Cities and countries around the world, such as Taiwan[27], Hong Kong,[28] and India[29], have used this approach to identify significant contributions of local and regional or cross-boundary sources to ambient air pollution concentrations.

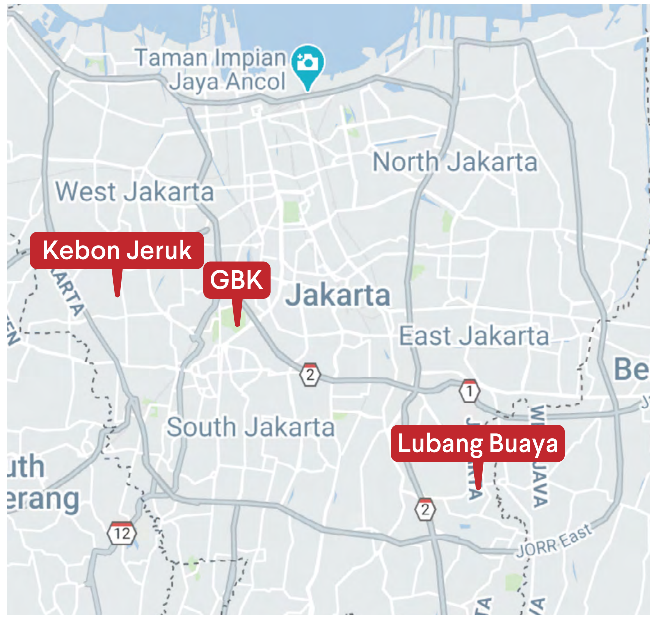
In DKI Jakarta, two receptor-based studies were conducted in early 2010 to identify potential source contribution to $PM_{2.5}$ in the city and in the greater Jakarta area, respectively.[30,31]

Latest Receptor-based Source Apportionment Study on Sources of Air Pollution in Jakarta

In 2019, we worked with the Bandung Institute of Technology (ITB) to expand an ongoing receptor-based source apportionment to collect $PM_{2.5}$ filter samples from urban background sampling sites at Gelora Bung Karno (GBK), Kebon Jeruk (KJ) and Lubang Buaya (LB) within Jakarta city boundary during the wet and dry seasons.[32] The samples were then analyzed for their chemical composition to identify contributing sources.

Findings from this study and the associated policy recommendation will be available at: www.vitalstrategies.org/source-apportionment-report.[32] This study found that transportation is one of the leading sources of ambient $PM_{2.5}$ pollution in Jakarta, similar to the in the source-based method. The study provided insight into the different types of sources that were not well known previously, such as open burning, construction and soil dusts, coal combustion and secondary aerosols. This study was conducted within the Jakarta city boundary, and the exact origins of the pollution sources are unclear. Yet, there is an indication that some of the sources (e.g., coal combustion, secondary aerosols) identified may be regionally transported into the city. This contributes to the regional emissions of sulfur oxide (one of the precursor gaseous pollutants of secondary aerosol). Overall, the study findings indicated the effects of a troubling trend—the reliance upon private vehicles, which grow in number each year due to the city's rising population and wealth.

Ultimately, using and comparing results from both methods—emissions data (source-based) and air filter samples (receptor-based)—allows us to identify consistencies and discrepancies between results and provides greater confidence in the resulting data on some of the leading sources and priorities for control. More information and examples can be found elsewhere.[17]



[24] Breathe Easy, Jakarta. Factsheet 3: Emission Inventory. 2016. Retrieved from http://www.urbanemissions.info/wp-content/uploads/docs/2017-01-Jakarta-Facsheet3-Emissions-Inventory.pdf
[25] Lestari P, Damayanti S & Arrohman MK. 2020. Emission Inventory of Pollutants (CO, SO2, PM2.5, and NOx) In Jakarta Indonesia. IOP Conf. Series: Earth and Environmental Science 489.
[26] NOx refers to Nitrogen oxides, which is a group of seven gases and compounds composed of nitrogen and oxygen, sometimes collectively known NOx gases. The two most common and hazardous oxides of nitrogen are nitric oxide and nitrogen dioxide.
[27] Chang CC, Yuan C shin, Li TC, Su YL, Tong C, Wu SP. 2018. Chemical characteristics, source apportionment, and regional transport of marine fine particles toward offshore islands near the coastline of northwestern Taiwan Strait. Environ Sci Pollut Res 25:32332–32345; doi:10.1007/s11356-018-3093-9.
[28] Pun VC, Yu IT, Ho K, Qiu H, Sun Z, Tian L. 2014. Differential effects of source-specific particulate matter on emergency hospitalizations for ischemic heart disease in Hong Kong. Environ Health Perspect 122:391–6; doi:10.1289/ehp.1307213.
[29] Guo H, Kota SH, Sahu SK, Hu J, Ying Q, Gao A, et al. 2017. Source apportionment of PM2.5 in North India using source-oriented air quality models. Environ Pollut 231:426–436; doi:10.1016/j.envpol.2017.08.016.
[30] Santoso M, Lestiani DD, Mukhtar R, Hamonangan E, Syafrul H, Markwitz A, et al. 2011. Preliminary study of the sources of ambient air pollution in Serpong, Indonesia. Atmos Pollut Res 2:190–196.
[31] Santoso M, Lestiani DD, Markwitz A. 2013. Characterization of airborne particulate matter collected at Jakarta roadside of an arterial road. J Radioanal Nucl Chem 297:165–169
[32] Vital Strategies. Main Sources of Air Pollution in DKI Jakarta - A source apportionment study. Available from www.vitalstrategies.org/source-apportionment-report.

3.2 Major Sources of Air Pollution in Jakarta

Based on the studies discussed in the aforementioned section, the three main sources of pollution that affect the air quality in Jakarta are land transportation, industrial combustion, and power plants. pollution.

A. Land Transportation-Related Air Pollution

DKI Jakarta's economy grew at an average rate of 6.1% for each of the past five years, exceeding the national economic growth rate of 5.1%. The city accounted for 17% of Indonesia's gross domestic product (GDP) in 2018. With the fast-growing economy, Jakarta's citizens are increasingly able to afford personal cars and motorcycles. Between 2012 and 2016, the number of cars and motorcycles operating in Jakarta grew 7.1% and 5.5%, respectively. Between 2017 to 2019, the number of cars and motorcycles operating in Jakarta grew more slowly, at about 2.5% annually (see Figure 9). The number of buses (the most efficient of vehicles) fell by more than 20,000 between 2012 and 2016 and remained steady from 2017 to 2019.

Private vehicles are the least efficient way to transport people in terms of fuel use and street space. DLH Jakarta estimates that motorcycles and cars together consume 25.9 million liters of fuel each day (approximately 9.45 billion liters a year). In the greater metropolitan area of DKI Jakarta, private vehicles consume nearly 34 million liters per day. The fuel used has a very high sulfur content (500 ppm) and contributes substantially to particulate matter and SO_2 pollution.

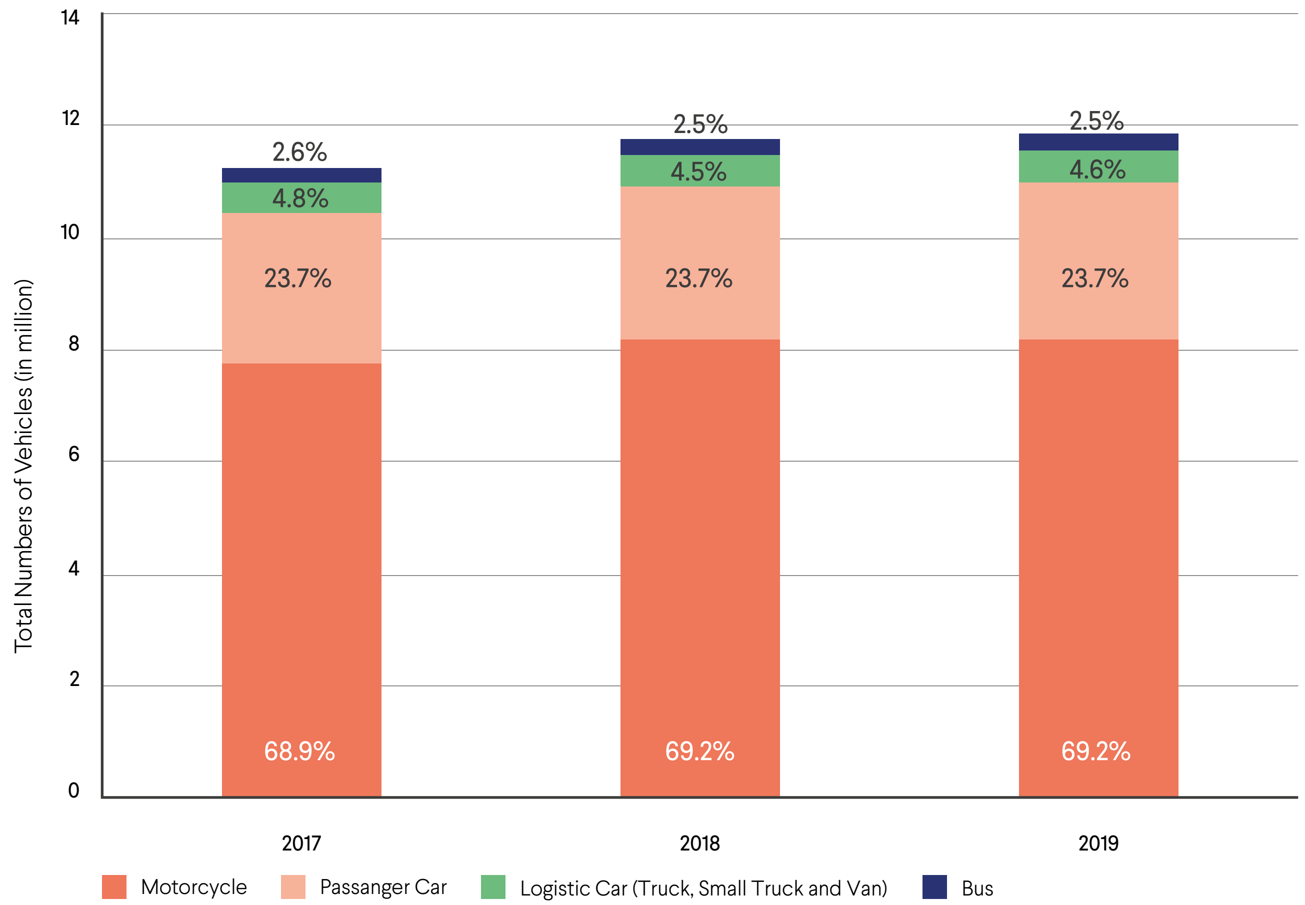
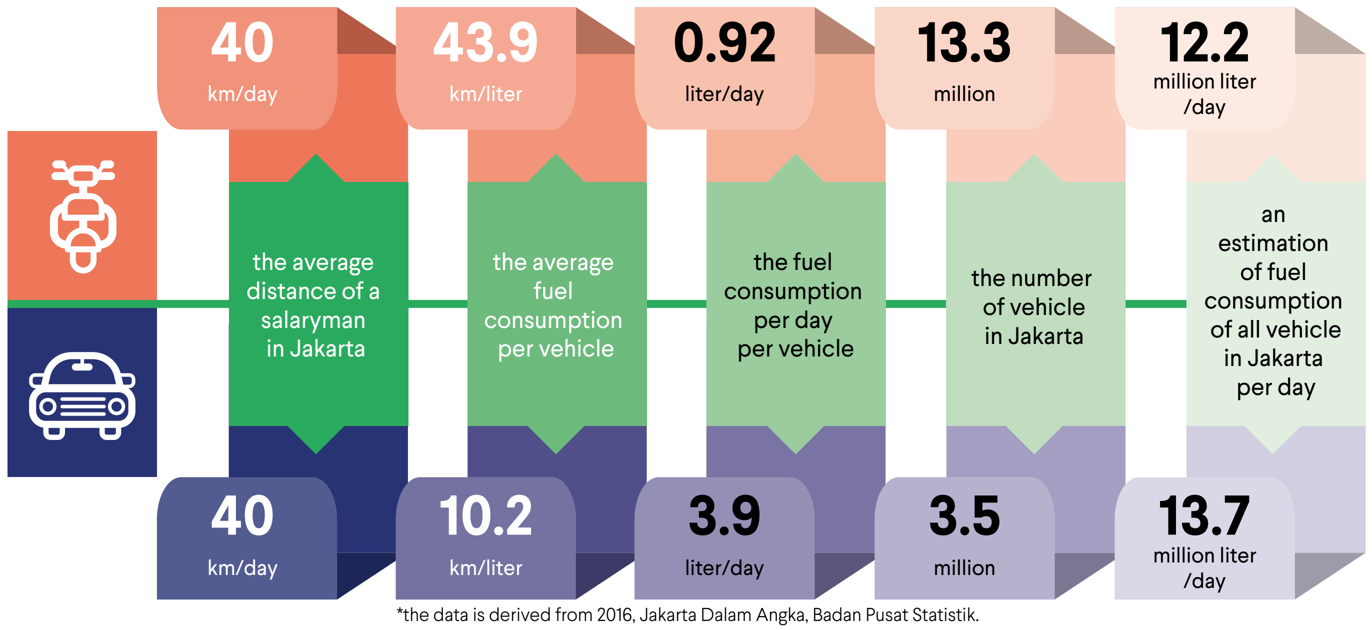


Figure 9: Numbers of Vehicles (by type) Operating in DKI Jakarta.[33]



Left, Jakarta's peak hour, where traffic congestion can cause hours of delays. Photo : Vital Strategies, 2019.

[33] Statistik Transportasi Jakarta. 2018. BPS DKI Jakarta.

B. Smelting, Manufacturing, and Chemical Industrial Pollution

Industry is the second largest contributor to air pollution. As of 2017, there are 92 textile factories, 143 chemical factories, 64 smelters and 42 ceramic factories located in DKI Jakarta.[34] Many of these factories rely on gasoline and diesel fuel to generate their own electrical power, heat and hot water. In 2017, industries in Jakarta used 32.2 million liters of gasoline and 73.79 million liters of diesel fuel.[34]

C. Air Pollution from Power Plants

Air quality in a city is affected not only by local emissions but also by regional transport of anthropogenic emissions outside of city boundary. In DKI Jakarta, evidence has suggested that regional sources outside of the city have contributed to air pollution.[32] DKI Jakarta is surrounded by industrial smaller satellite cities, such as Bekasi and Tangerang, where big manufacturing industries and coal-fired power plants and other polluting sources are located. This adds to regional air pollution, especially during the wet season when prevailing winds come from the west.[32] Therefore, strong regional collaboration is required to tackle these sources of air pollution and complement local efforts in controlling air pollution.

D. Other Factors Affecting Ambient Air Quality

In addition to emission activities from known pollution sources, other factors can play a role in ambient air pollution concentration in a city. These factors include, but are not limited to:

- pollution from unidentified sources (e.g., waste burning, road-side cooking);
- meteorological conditions (e.g., temperature, cloudiness, humidity precipitation, wind patterns);
- topography, chemical transformations that change air pollutants in the air (e.g., secondary aerosols); and
- regional transport of air pollutants.

Household air pollution (e.g., the use of solid fuels for cooking) also contributes to ambient air pollution.

Above, Babelan Power Plant, a coal-powered power plant located in Bekasi. Photo: Vital Strategies, 2019.
Right, Jakarta's citizen burning waste. Photo: Vital Strategies, 2019.

[34] BPS Jakarta. 2017. Manufacturing Industrial Statistics DKI Jakarta.

Clean Air Actions for Jakarta

Regulations for Air Pollution Control in Jakarta

Successful Experiences from Other Cities

Actions Toward Clean Air Jakarta

- Innovation and Action for Clean Air
- Toward Clean Air Jakarta Workshops
- Action Plan for Air Pollution Control in Jakarta

Left, Bicycle lanes in the Sudirman-Thamrin Central Business District in Central Jakarta, Indonesia. Photo: Vital Strategies, 2019.

Right, Commuters wait for their buses during the afternoon rush hour in the Sudirman Central Business District Area. Jakarta has not been successful in switching from diesel to natural gas fuel for their public buses. Photo: Vital Strategies, 2019.

4.1 Regulations for Air Pollution Control in Jakarta

The Provincial Government of DKI Jakarta has issued several regulations to control air pollution, mainly to tackle these three main sources of pollution: transportation sector, manufacturing industry, and power generation. Some of these policies, apart from reducing air pollution, also aim to obtain other benefits (co-benefits), such as improving health, reducing congestion, mitigating climate change, increasing energy use, and energy efficiency. These regulations issued by the Provincial Government of DKI Jakarta are sorted according to the hierarchy of the legal system in Indonesia.

1. DKI Jakarta Government Regulation No. 2/2005 on Air Pollution Control

This regulation stipulates the emission standards for stationary and mobile sources, regulates the use and the sharing of information on air quality monitoring indexes, the prohibition of open waste burning, and the mandatory conversion of BBM (gasoline) to BBG (natural gas) for government operational vehicles and public transportation. Also, this regulation also regulates the development of green open spaces, the implementation of Car Free Days, the emission permits for industries with routine evaluation, and emission taxes.

2. **DKI Jakarta Government Regulation No. 5/2014 on Transportation**

    This regulation calls for the expansion and integration of public transportation and the development of a pedestrian-friendly environment to support an integrated public transportation system. In addition, it also regulates the periodic revitalization of public buses, the use of clean energy for public transportation, emission testing, and the application of congestion pricing.

3. **Governor of DKI Jakarta Regulation No. 141/2007 on the Use of Natural Gas for Public Transportation and Operational Vehicles of the Regional Government**

    This regulation mandates the conversion from gasoline to natural gas for public transportation and government operational vehicles.

4. **Governor of DKI Jakarta Regulation No. 71/2019 on Plan to Accelerate Regional Strategic Activities in DKI Jakarta**

    This regulation contains 73 Regional Strategic Activities that are priority activities of the Provincial Government of DKI Jakarta, one of which stipulates Air Pollution Control on Action Plan No. 71.

5. **Governor of DKI Jakarta Regulation No. 66/2020 on Vehicle Emission Testing**

    This regulation mandates emission testing for all vehicles - both private and public vehicles - to conduct emission tests once a year. This regulation also regulates the requirements for workshops to conduct emission tests and integrate emission test reports with the local tax payment system. In addition, it also regulates penalties in the form of higher parking fees for vehicles that violate the rules.

Above, Currantly, DKI Jakarta strives to integrate its public transport system to provide better mobility and reduce the gas emission. Photo: Communication, Informatics and Statistics Agency of Jakarta, 2019.

6. **The Decree of DKI Jakarta Governor No.670/2000 on the Determination of Emission Standard for Stationary Sources in DKI Jakarta**

    This regulation sets the quality standards for stationary sources including the processing industry and power plants.

7. **Governor of DKI Jakarta Instruction No. 66.2019 on Air Pollution Control**

    This regulation details seven activities to reduce air pollution including: revitalizing old buses, the implementation of odd-even policies and ERP, emission testing, use of new vehicles, improving pedestrian accessibility, controlling industrial emissions, and increasing urban green area development.

4.2 Successful Experiences from Other Cities

There are many tried and proven strategies for controlling air pollution from various sources. This section summarizes the experiences from other cities that have successfully improved air quality by addressing their leading sources of pollution. While not all of these solutions are directly transferable to Jakarta, as their successful implementation depends on many other factors for success, there is merit to studying how similar approaches may be applied in Jakarta.

1. New York City, USA

The challenge: New York City's (NYC) regulatory air monitoring was too sparse to identify local hot spots and sources to help bring it into compliance with national air quality standards.

The measure(s): Under NYC's long-term sustainability plan, the mayor and health department launched the New York City Community Air Survey (NYCCAS) in 2008 to assess spatial variation in air pollution across neighbourhoods, identify important local sources and inform local clean air measures. NYCCAS found high-sulphur content heating fuels used in some 10,000 buildings to be a major source of neighbourhood air pollution. These building's boilers generated as much $PM_{2.5}$ emissions as all on-road vehicles citywide. A subsequent health impact assessment using the refined emissions data found a complete phase-out of high-sulphur heating oil could avoid annual health impacts of 290 premature deaths, 180 hospital admissions for respiratory and cardiovascular emissions and 550 emergency department visits for asthma.

The impact: Findings from NYCCAS helped spur local and state laws and regulations that required phase-out and conversion of heating systems to cleaner, zero- or ultra-low sulphur fuels. NYC's effort highlights the importance of political leadership, convening and coordination across multiple agencies; data-driven policy and implementation follow-through; and open data access that engaged stakeholders to support continued air quality monitoring.

2. London, UK

The challenge: Air pollution is a huge challenge for London, because all of London's boroughs fail the city's annual targets and exceed WHO's air quality guidance.[35] London's toxic air has resulted in an economic cost of £3.7 billion (IDR 70.9 trillion) every year from lost years of life, hospital admissions and deaths due to $PM_{2.5}$ and NO_2 exposure.

The measure(s): In response to the ambitious air quality targets set out in the London

Environment Strategy, the Mayor of London launched, in 2019, Breathe London, a cutting-edge, 'hyperlocal' air quality monitoring project which maps and monitors air pollution across London.[36] The project created a network of 100 fixed sensor pods, Google Street View cars equipped with mobile pollutant sensors, and sensors worn by public volunteers. In the first few months of operation, 40% of the Breathe London sensors detected high levels of air pollution, and identified locations that exceed standards.[37,38]

Breathe London complemented other air quality initiatives such as the Ultra Low Emission Zone (ULEZ), Low Emission Zone and Congestion Charge Zone. The ULEZ, launched in April 2019, has the strictest vehicle standards of any Low Emission Zone globally. Vehicles not meeting these standards must pay a charge, in addition to the Congestion Charge and the Low Emission Zone charge.[39]

The impact: Within the first six months of its launch, the ULEZ led to a 36% reduction in NO_2, 4% reduction in CO_2, reduced traffic, and increase in the presence of emission-compliant vehicles. London's experience in hyperlocal air quality data mapping fills the important data gaps regarding localized pollution hot spots and enables targeted pollution reduction and control measures.

3. Hong Kong, China

The challenge: The Port of Hong Kong, a world-class international maritime hub, allowed vessels to use high-sulphur bunker fuels in Hong Kong waters, which contributed to extremely high levels of ambient SO_2 and particulates. Given that the port is located near 3.8 million Hong Kong residents, shipping emissions significantly impacted public health.

The measure(s): Hong Kong's primary effort to address its air pollution from shipping emissions was to refine its local marine vessels' emissions inventory, after local receptor-based source apportionment studies suggested that an earlier official emission inventory severely underestimated shipping's contribution to air pollution. Another critical strategy was the strategic partnership and active engagement among key stakeholders to develop strategies to mitigate shipping emissions. One of the most notable initiatives was the Fair Winds Charter, an industry-led voluntary initiative to switch fuels. Fair Winds led the government to roll out an incentive scheme and regulations to reduce shipping related emissions.

The impact: The review of data and exchange of knowledge and experiences among local government, civil society, industry and regional policymakers prompted a quick and smooth legislative process for local and regional policy actions. Implementation of cleaner marine fuel and fuel-switch measures resulted in immediate reduction of SO_2 and PM emissions from marine vessels, and a drop in the ambient concentrations of SO_2 and PM_{10} near the port in the following years.

4. Beijing, China

The challenge: In 2013, the Beijing-Tianjin-Hebei region was among the most polluted regions in China, with annual $PM_{2.5}$ levels of over 90 μg/m^3. Prior emission reduction programs focused mainly on coal use in industry and electric power generation, whereas mitigation in the residential sector (i.e., household solid biomass and coal for cooking and heating) had been overlooked. As a result, severe haze events caused by $PM_{2.5}$, especially during the wintertime periods, continued to occur.

The measure(s): Source apportionment studies found that while both industrial and residential sectors are the dominant contributors to $PM_{2.5}$ in the region, residential emissions accounted

Left, Cyclists enjoying car free day in Jakarta. Photo: Communication, Informatics and Statistics Agency of Jakarta, 2019.
Right, A happy old man riding his bicycle with Indonesian Flag in car free day Jakarta. Photo: Communication, Informatics and Statistics Agency of Jakarta, 2019.

[35] Breathe London. Understanding air pollution. Retrieved from https://www.breathelondon.org/understanding-air-pollution/
[36] C40. Breathe London. Retrieved from https://www.c40knowledgehub.org/s/article/Breathe-London?language=en_US
[37] Mayor of London. Press release. Retrieved from https://www.london.gov.uk/press-releases/mayoral/first-breathe-london-data-published
[38] C40. London's Ultra Low Emission Zone website: Retrieved from https://www.c40knowledgehub.org/s/article/London-s-Ultra-Low-Emission-Zone-website-centre?language=en_US
[39] Mayor of London. Central London Ultra Low Emission Zoom – six month report. Oct 2019. Retrieved from https://www.london.gov.uk/sites/default/files/ulez_six_month_evaluation_report_final_oct.pdf

for nearly 50% of $PM_{2.5}$ levels during the winter heating season. The Chinese government created an action plan and launched a public campaign to address residential emissions, including redirecting natural gas from power generation units towards households, replacing biomass for cooking with LPG and electricity for over 3 million households, and substituting coal with briquettes for over 6 million households.

The impact: These efforts will eventually reduce residential $PM_{2.5}$ emissions by 91%, and mean population exposure by 13%. Beijing's experience demonstrates the value of using source apportionment with a regional airshed analysis along with identifying available, scalable interventions to prioritize clean air actions where they will have the greatest effect.

5. Bangkok, Thailand

The challenge: Air quality has deteriorated in Bangkok over the past several decades, with levels of air pollution often 2-4 times the WHO recommended limits. Rapid urbanization and limited public transportation capacity in Bangkok led to explosive growth of on-road private motor vehicles and motorcycles in the city, from 2 million in 1992 to 9.8 million in 2017. Motor vehicles using dirty fuels, coupled with highly polluting vehicles, were found to be the largest air pollution source in Bangkok, accounting for nearly 54% of PM_{10} levels.

The measure(s): Upon identifying mobile sources to be the largest source of air pollutants, the Royal Thai Government implemented a number of vehicle pollution control measures. These measures include 1) the adoption of cleaner vehicle technologies (from pre-Euro to Euro IV) and low sulphur fuel; 2) enhanced vehicle inspection and maintenance programs; 3) better transport and land use planning, including the development of the Mass Rapid Transit network; and 4) restrictions on the use of personal vehicles in Bangkok Metropolitan Area.

The impact: The annual average of PM_{10} concentrations dropped from 90 μg/m^3 in 1997 to 49 μg/m^3 in 2016. However, data suggests that gains in tackling air pollution have stagnated or even reversed in the city in recent years. This highlights the importance for sustained clean air progress on all leading sources.

A summary of the abovementioned case studies is showed in the Table 4. Additional case studies can be found in Vital Strategies' "Accelerating City Progress on Clean Air: Innovation and Action Guide".[18]

Table 4. Lessons Learned form Other Countries

City	Source of Air Pollution	Innovation
New York, U.S.	High-sulphur heating oil	• Enhance local monitoring • Improve emissions and modeling • Organize for clean air actions
London, U.K.[40]	Vehicular	• Congestion fee for all vehicles • Ultra-Low Emission Zone (ULEZ) policy
Hong Kong, China	Shipping	• Incentive scheme for cleaner fuel switch in shipping • Regulations for shipping emissions mitigation
Beijing, China	Residential, industrial	• Replace household fuel to LPG and electricity • Convert coal-fuel power plants to natural gas
Bangkok, Thailand	Vehicular	• Clean vehicle technology • Enhance inspection and maintenance program • Phase down sulphur content on fuel • Improve transport and land use planning • Restrictions on use of motor vehicles

Above and Below, Citizens lining up to enter a Transjakarta bus. Photo: Communication, Informatics and Statistics Agency of Jakarta, 2019.

[40] Congestion Charge and ULEZ charge. The London City Government. Retrieved from https://tfl.gov.uk/modes/driving/congestion-charge/congestion-charge-zone

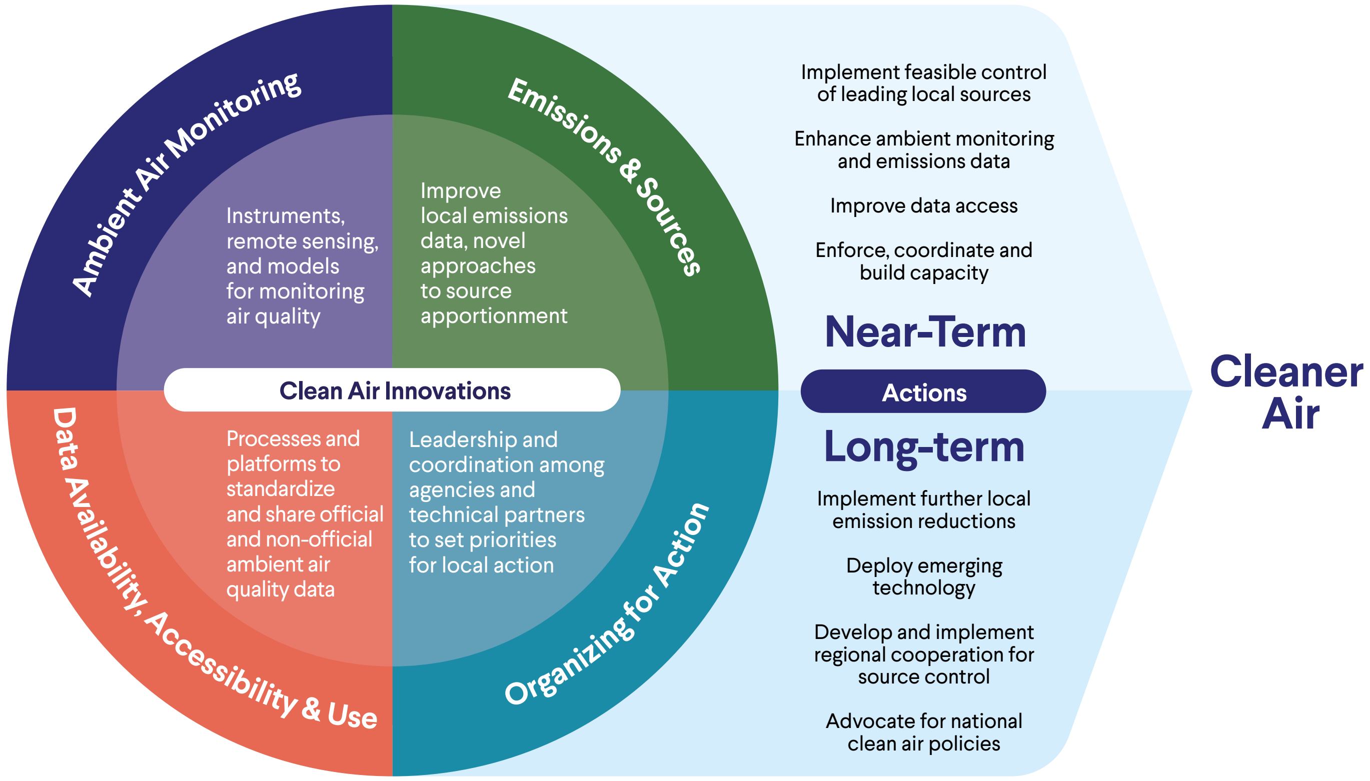


Figure 10:
Innovations to Promote Air Quality Action

4.3 Actions Toward Clean Air Jakarta

4.3.1 Innovation and Action for Clean Air

Practical Guidance to Prioritizing Action

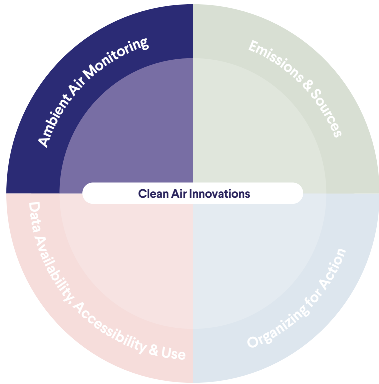
Successful development and implementation of effective air quality management requires having good air quality data, technical and policy analysis, political will, multisector cooperation, and effective enforcement. Vital Strategies, a partner of DKI Jakarta, recently developed "Accelerating City Progress to Clean Air: Innovation and Action Guide" for cities to fast-track proven approaches and innovations to accelerate progress on clean air.[17] The guide provides a stepwise (phased) approach for city governments, outlining four critical priority areas for action: 1) monitoring air quality; 2) assessing emissions and sources; 3) expanding data access and use; and 4) engaging governments and partners to develop and implement action plans (see Figure 10). The following provides a brief description of the four main priority areas of the guide.

These four priority areas aim to answer questions about their key role in urban air quality management, and to lay out a pragmatic, phased approach to launching and building clean air activities, with methods and activities suited to local objectives and capacity (Table 5).

Right, Developing an integrated public transportation system is an innovative approach toward cleaning the air in Jakarta. Photo: Army firmansyah-unsplash, 2019.

Table 5. Practical Questions About Urban Air Quality Management To Be Addressed.[18]

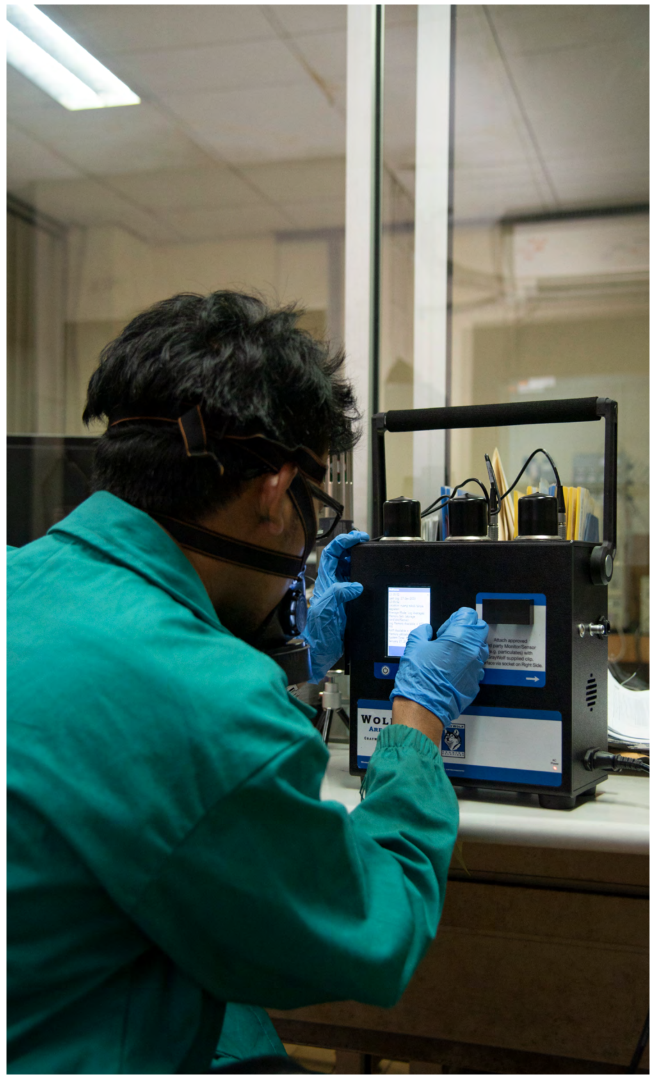
Ambient Air Quality Monitoring	• Why is urban air quality monitoring needed to inform clean air action? • What data on air pollution levels are already available to fill gaps in official monitoring? • What types of information can different types of monitoring innovations provide? • What are the advantages and disadvantages of different monitoring approaches? • How can monitoring approaches and innovations be in phases to provide initial actionable data and build an integrated system of complementary approaches?
Source and Emissions Characterization	• Why is characterization of leading air pollution sources and emissions essential for clean air action planning? • What data on sources and emissions influencing air quality are already available? • What information can different source characterization methods provide? • How can innovative and lower-cost approaches be used to improve local air pollution emissions and source data? • How can different air pollution source assessment methods be used together to evaluate and improve data? • How can emissions and source data help identify local "hot spot" areas, inform air pollution monitor placement and set source control priorities in the near term?
Data Availability and Accessibility	• Why should air pollution data be made open and accessible? • What defines open, accessible air pollution data? • What are barriers to achieving open, accessible data and strategies for overcoming them? • How can reliable air pollution data collected by government and non-governmental institutions be integrated and organized to inform clean air programs? • How can integrated and open-air pollution data benefit a city's clean air program, researchers and other local data users? • How can air quality data be effectively shared with different stakeholder groups?
Organization for Action	• How can a city organize to develop, implement and sustain clean air actions? • How can strategic policy analyses be used to inform the planning process? • What are key elements of successful clean air action plans in both the near term and the long term?



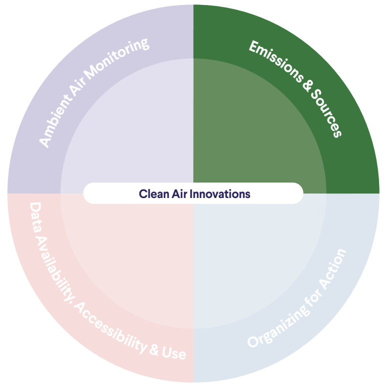
Monitoring air quality

To inform clean air action, urban air quality monitoring is needed to compare air pollution levels against national or international health-based standards, assess variation in pollution levels by space and time, prioritize locations of concern, help identify major sources of air pollution and priorities for control, advise the public and stakeholders, and evaluate control measures and progress. Innovations in monitoring technology, remote sensing and modelling can help support these objectives more rapidly and at lower cost than conventional regulatory monitoring approaches.

The Guide provides a stepwise phased approach to prioritize innovations and monitoring that fit the city's policy-relevant objective and technical capacity, and help reduce complexity and avoid monitoring pitfalls, combining conventional regulatory monitoring approaches with innovations. For instance, for urban areas without reliable official group-based monitoring, a planned low-cost $PM_{2.5}$ sensor campaign and/or satellite-based estimates can be used to estimate annual $PM_{2.5}$ exposures, while establishing one or a few well-placed, high quality $PM_{2.5}$ monitors. Subsequently, more comprehensive monitoring is needed to assess $PM_{2.5}$ sources, space and time variation, and to measure other harmful pollutants; and advance surface particle monitoring stations and receptor-based source apportionment analysis may be considered.



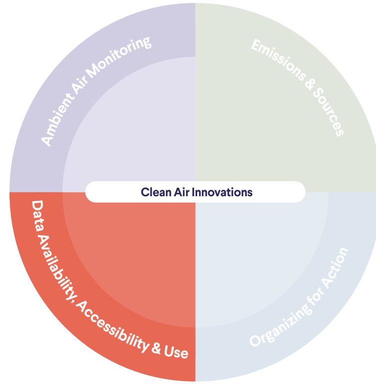
Having established a reliable urban-scale air quality monitoring system that can track progress on clean air measures that address multiple pollutants, a useful next step is to use periodic deployment of reliable low-cost sensors, mobile monitoring campaigns and/or land use regression or dispersion models to produce high-resolution spatiotemporal air pollution estimates and identify local neighbourhood hotspots and sources. A combination of innovative and phased approaches can inform a robust air quality management program, support the needs of local, regional and national air quality management, and provide data for research and public information. The case studies in the previous section offer examples of how cities utilize different monitoring approaches to fill air quality data gaps.



Characterizing emissions and leading local and regional sources of air pollution

While air pollution monitoring can point to the need for action, understanding of emissions and sources contributing to air pollution in a city is central to identifying appropriate control measures for the local context. For cities with limited baseline capacity, they should emphasize on the use of available data and tools to set priorities and take actions to reduce emissions. As technical capacity grows, all cities should establish an official emissions tracking and source assessment process, and develop procedures for data use; sustain routine collection, improvement and use of emissions and source data; and eventually build advanced, highly space- and time-resolved emissions, source and forecasting capabilities.

To identify leading sources of air pollution, there are two complementary source assessment or apportionment approaches: the source-based (or bottom-up) approach, and receptor-based (or top-down) approach. Innovative application of both source-based and receptor-based approaches to characterize leading sources of pollution allows assessors to identify consistencies and discrepancies in the data and provides a strong foundation for strategic clean air interventions. The case studies in the previous section offer examples of how cities use various source apportionment approaches to identify air pollution sources of that most impact population exposure and health.

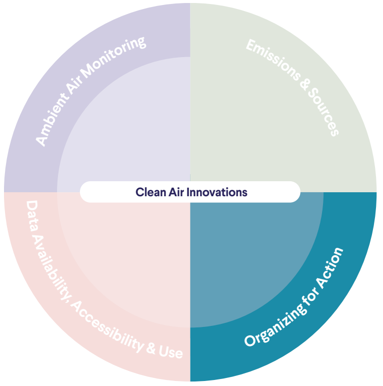


Data transparency and accountability

A government commitment to collecting reliable official air monitoring data with clearly documented quality assurance and quality control measures in place is an obvious first step and should be paired with a commitment to creating open and accessible data. Innovative solutions are available to help cities overcome common technical, social, political, and financial barriers to a publicly accessible air quality data system. Through routine communication, expanded access and integration of air quality data, and an eventual advanced, open air quality ecosystem, all cities can maximize the utility of reliable data for both official and nonofficial end users to keep a broad group of air quality stakeholders (including civil society) informed, and cultivate public support for government action.

Left, A staff from Ministry of Environment and Forestry calibrates air quality measurement device in their office in Jakarta, Indonesia. Photo: Vital Strategies, 2019.

Organizing for action



Successful development and implementation of effective air quality management requires more than just having the right data and technical knowledge. Political will, government leadership, an intersectoral approach, and coordination of partners are all essential to build and sustain systems to monitor air quality and assess sources, use data to establish priorities and plan control measures, implement and assure clean air actions; and communicate progress, health risks, and benefits of controls to sustain public support.

City governments often have substantial authority to promote clean air. They may control sources within their jurisdiction, leverage their authority to convene often siloed agencies to align relevant initiatives and policies, convene key local stakeholders to advance voluntary actions in energy conservation, transit mode-shifting, drive use of corporate social responsibility spending and climate mitigation, and coordinate and engage technical assistance from relevant experts. Moreover, cities can use their influence to help shape broader regional and national clean air policies. In addition to being hubs for civil society mobilization, cities can promote and participate in the establishment of regional air quality management planning and organizations or collaborate in advocacy with city partnership organizations. The case studies in the previous section offer examples of how cities at various stages of air quality understanding and political commitment took specific initial actions to move forward.

Left, Emissions inventory of $PM_{2.5}$, CO, NO_2, SO_2, BC, and GHG discussion at an Air Quality Forum held last year. Photo: Rendy Primrizqi, 2019.
Right, Air pollution monitoring system discussion at an Air Quality Forum held last year. Photo: Rendy Primrizqi, 2019.

4.3.2 Toward Clean Air Jakarta Workshops

In 2019, Vital Strategies together with DKI Jakarta organized multi-stakeholder workshops and forums to share knowledge and gather feedback on existing and potential air pollution control strategies.

These meetings allowed groups representing academia, non-governmental organizations, local and regional governments, civil society and the private sector to propose ideas on curbing air pollution for consideration by the government and other clean-air stakeholders.

2019	March	April	May	June	July
Event Summary	Forum: Air Quality Management Programs by DLH Jakarta, DKI Jakarta and BMKG's Plan to Construct Air Quality Monitoring Tower in Jakarta	1st Workshop on Air Quality Management and Grand Design Formulation Emissions Inventory for Jakarta Forum, Air Quality Monitoring and Hazy Perceptions	2nd Workshop on Air Quality Management and Grand Design Formulation	Forum: The Impact of Pollution from Coal Fired Power Plant and Increasing Renewal Energy	2-day Workshop on Innovations to Strengthen Air Quality Improvement in Jakarta (Conducted by Vital Strategies) 3rd Workshop on Air Quality Management and Grand Design Formulation

Figure 11: A brief summary of stakeholder workshops and events in 2019, organised by the Jakarta city government and Vital Strategies

Table 6. Organizations Participated in Vital Strategies events

Sector	Organisation
Academia	Bandung Institute of Technology, University of Indonesia
Central Government	Center of Meteorology, Climatology, and Geophysics (BMKG), National Institute of Aeronautics and Space (Lapan), the Ministry of Environment and Forestry, National Development Planning Agency (Bappenas), and Badan Pusat Statitsik (BPS)
Provincial Government of DKI Jakarta	Environment Agency, Transportation Agency, Energy and Industrial Agency, Health Agency, Bureau for Spatial Planning and Environment, Housing and Population Agency, Regional Development Planning Agency, Public Works Agency, City Planning Agency (Bappeda), Jakarta Smart City, Communication and Informatics Agency, Forestry Agency, five DKI Jakarta district representations and TGUPP.
Neighbouring Cities	Environment Agency Tangerang, Environment Agency South Tangerang, Environment Agency Bekasi
Non-Government Organizations (NGO)	Vital Strategies, Jakarta Resilient Secretariat, International Council on Clean Transportation (ICCT), Center for Energy Research Asia (CERA), C40, KPBB, WWF, Greenpeace Indonesia, International Institute for Sustainable Development (IISD), United Cities and Local Government (UCLG), Indonesia's Ulema Council (MUI), CIMSA, ITDP, US Embassy in Indonesia, USAID, UNICEF Indonesia, Agence Française de Développement (AFD).
Private Sector	PT Jakarta Utilitas Propertindo (JUP), PT TransJakarta, PT MRT Jakarta, PT PGN, PT PLN.

*This may not be an exhaustive list. We would like to sincerely thank all other organizations who have participated in any of the above events but were not listed within.

4.3.3 Action Plan for Air Pollution Control in Jakarta

As air pollution worsens in DKI Jakarta, the Provincial Government of DKI Jakarta formulated an action plan that has been discussed with stakeholders through workshops described above to work towards cleaner air in Jakarta by 2030. In addition, the Provincial Government of DKI Jakarta through Governor Instruction No. 66/2019 has determined seven action plans to tackle air pollution by improving data collection and addressing the three main pollution sources (transportation, industry, and power generation) as depicted in Figure 11.

The action plans are: 1) improving air quality monitoring; 2) action plans for the transportation sector; 3) action plans for the industrial sector and power generation; 4) provision of green space areas; and 5) increasing public participation and creating public awareness.

- **Improving Air Quality Monitoring**

Adding air quality monitoring devices

As explained above, DKI Jakarta already has five monitors equipped with the capabilities to monitor NO_2, SO_2, CO, O_3, PM_{10}, and $PM_{2.5}$ levels. However, there is a need to add monitoring devices across the city to help improve the accuracy of air quality monitoring data and find hot spots. DKI Jakarta plans to add additional monitoring devices within the city boundary and two permanent monitoring devices outside DKI Jakarta.

Air quality monitoring data integration

With the addition of monitoring tools, integrating the data into one data platform would boost transparency and aid communication to the public. Furthermore, internally, the integrated information system can be developed to identify air quality trends. Integrating DKI Jakarta's monitors

with monitoring devices managed by other institutions will also increase the coverage of monitored areas. However, the challenge is ensuring quality control and uniformity of measurement methods to generate reliable data.

Conduct studies to support air quality monitoring

To support air quality monitoring, several studies can be carried out including periodic emission inventories, research on sources of pollution using the source apportionment approach, and studies on the impact of air pollution on health. The government can engage partners to conduct such studies that will help find the main sources of pollution, measure the health impacts and economic burden of air pollution on Jakarta residents. Partners can also be involved to describe the potential cost savings in health and economic burdens if solutions are successfully implemented.

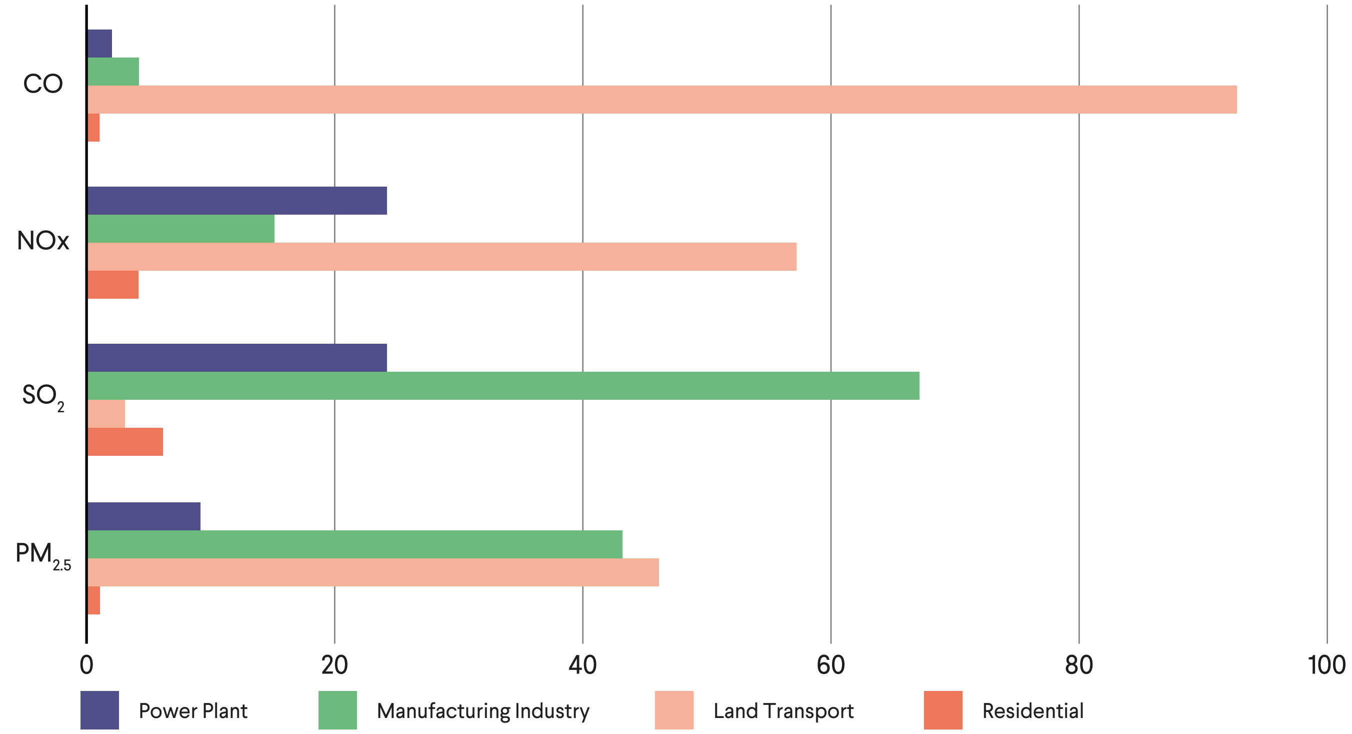


Figure 12: Sources of Air Pollution in Jakarta based on 2015 data[25]

- **Action Plan for Transportation Sector**

Improve the quality of integrated public transportation system

Since 2007, DKI Jakarta has made progress by building an integrated mass transportation and cross-rail system as well as convenient pedestrian areas that attract more public transport users. Currently, there are several modes of public transportation in the city, including the TransJakarta BRT system, MRT, and micro transportation which are connected to Jaklingko. In the future, DKI Jakarta will build the LRT, another mode of mass transportation.

Some of the action plans included in this activity are the improvement of connecting infrastructure of public transportation facilities, development of Transit Oriented Development, and construction of housing near to public transportation facilities.

Use of cleaner energy on public transportation

DKI Jakarta has also made efforts to use cleaner energy for public transportation, such Compressed Natural Gas (CNG) for TransJakarta buses which contain lower PM and NOx per mile.[41]

To boost the use of cleaner fuels for public transportation, there are two core efforts: promoting the use of CNG for public buses and increasing the use of electric buses and micro-powered electric transportation. The addition of the electric-powered bus fleet has been stated in the DKI Jakarta Governor Instruction No. 66/2019. However, the electricity generated for transportation will have the greatest benefit for air quality if it is electricity generated with renewable energy.

[41] Qiu, Z., Li, X., Hao, Y. et al. Potential of diesel emissions reduction strategies in Xi'an, China. Clean Techn Environ Policy. 2016. 18, 2717–2724.

Left, Air pollution monitoring equipment near Sudirman-Thamrin street, Jakarta, Indonesia. Photo: Vital Strategies, 2019.

Table 7. Data on Number of Public Transport Vehicles Licensed by the DKI Jakarta Transportation Agency as of February 2020, According to Fuel Type[42]

Vehicle category	No. of Vehicles	No. of Vehicles by Fuel Type			
		Diesel	Gasoline	CNG	Electricity
Transjakarta buses	3,076	1,830	847	340	3
Large City Buses	980	980	-	-	-
Medium City Buses	7	7	-	-	-
Small City Buses	7,785	-	7,785	27	-
Intercity buses	5,218	5,218	-	-	-
Taxis	12,681	-	9,351	3,300	30
Residential Transportation	266	266	-	-	-
City Trasnportation (shuttle bus)	70	70	-	-	-
Environment Transportation (e.g., garbage truck)	11,041	-	88	10,953	-
Ride-sharing transportation (e.g., Grab-Car, Go-Car)	12,208	-	12,208	-	-
Tourist Bus	2,805	2,805	-	-	-
Intercity Shuttle Bus	61	61	-	-	-
Logistic Truck	33,505	33,505	-	-	-
Total Vehicles	86,663	44,758	30,252	14,620	33
Percentage of Total Vehicles	100%	49.9%	33.7%	16.3%	0.04%

[42] Transportation Agency of DKI Jakarta.
[43] Febriyan. 2019. Tempo.co. Baru 5 Persen Kendaraan di DKI Jakarta yang Melakukan Uji Emisi. Retrieved on13 April 2020 from https://metro.tempo.co/read/1235437/baru-5-persen-kendaraan-di-dki-jakarta-yang-melakukan-uji-emisi
[44] According to Government Regulation No. 41/1999 on Air Pollution Control and Environment Ministerial Decree No. 141/2003 on Vehicle Emissions Standard, new vehicles produced and operated in Indonesia should be using the Euro 2 standard starting Jan. 1, 2007.
[45] The fuel is based on the product sold by state-owned oil and gas company Pertamina as the biggest fuel distributor in Indonesia.
[46] Utami SS. Fuel sales in 2018 Reach 67.35 Million KL. 2019. Retrieved from: https://www.medcom.id/ekonomi/energi/dN6nxDGN-penjualan-bbm-di-2018-capai-67-35-juta-kl
[47] This product is subsidized by the government
[48] Although Pertalite has octane level minimum of 90, the regulation only requires this product to have sulphur level max 500ppm (Director General Oil dan Gas Decree No. 0486.K/10/DJM.S/2017 on Standard and Quality (Specification) of Fuel with Octane 90 Sold within the Country.
[49] Pertamina is no longer selling this product anymore as of the end of 2018
[50] This product is subsidized by the government.

Promote low emission private vehicles

Routine emission testing is required to maintain the emission standards for private vehicles. Emissions testing for private vehicles in Jakarta was introduced in 2005 under the DKI Jakarta Local Government Regulation on Air Pollution Control. To improve the participation of emission testing, DKI Jakarta has enacted a new regulation, Governor Regulation No. 66/2020 on Emission Test, where emission testing is required once a year and there are penalties for violating vehicles, as only 5% of all vehicles in DKI Jakarta participated in 2019.[43] Also, action plans for efforts to retrofit private vehicles older than 10 years old will be implemented gradually from 2019 to 2025.

Upgrading vehicle fuel quality

One of the reasons the transportation sector is responsible for a large proportion of air pollution is because of the type of fuel available and used in Jakarta. Most of the vehicles in Indonesia use low-grade gasoline and diesel (Euro 2 standard) with high sulphur content.[44] Most of the fuel sold in Indonesia currently falls within the Euro 2 standard (see Table 8). In addition, higher fuel subsidies for fuel at Euro 2 standards compared to Euro 4 can contribute to hinder the modernization of vehicles using clean fuels.

A significant investment is needed to build refineries that can produce cleaner fuels. In 2015, the state-owned fuel oil producer, Pertamina, invested USD392 million to build a refinery, with a production capacity of 1.6 million barrels per month.

To increase the use of fuels with low sulphur content in DKI Jakarta, the Government formulated an action plan to promote the supply of fuel with a minimum Euro-IV standard. This supports a regulation issued by the Ministry of Environment and Forestry in 2017 which requires the provision of low-emission vehicle technology.[51]

Table 8. Fuel Sold in Jakarta

Type of Fuel[45]	Price (IDR/litre; as of 24 Jan 2020 in Jabodetabek)	Sulphur content (max-ppm)	Equal to standards of Euro	Volume sold in 2018 in Indonesia (million litres)[46]
Gasoline	-	-	-	-
Premium[47]	6,450	500 (Director General of Oil and Gas 2006)	Euro 2	9,600
Pertalite	7,650	500[48]	Euro 2	16,100
Pertamax	9,200	500	Euro 2	5,300
Pertamax Plus[49]	-	500	Euro 2	118.4
Pertamax Turbo	9,900	50 (Director General of Oil and Gas 2018)	Euro 4	243.2
Diesel	-	-	-	-
Regular Diesel[50]	-	2,500 (Pertamina)	Euro 1	13,200
Biodiesel	5,150	100 (Director General of Oil and Gas)	Euro 3	1,670
Dexlite	9,500	1,200	Euro 1	616.9
Dex	10,200	300	Euro 3	177.9

Above, Jakarta ready to test 100 electric buses before replacing its existing fleet. Photo : Communication, Informatics and Statistics Agency of Jakarta, 2019.
Below, Governor of DKI Jakarta, Anies Baswedan launched the first electric buses used for public transport in the city. Photo : Communication, Informatics and Statistics Agency of Jakarta, 2019.

Traffic management to reduce air pollution

The DKI Jakarta Government has implemented an odd-even policy on several roads and enforced a Car Free Day policy in several areas, even at the city level. To increase these efforts, in the future, the expansion of odd-even policies will be carried out. Furthermore, initiatives such as the development of Low Emission Zones will be also executed. In addition, according to Governor Instruction No. 66/2019, the implementation of Electric Road Pricing (ERP) will be conducted in several areas with severe congestion and the plan will take effect from 2021.

- **Action plan for the industrial sector and power generation**

Although Jakarta is moving toward a less industrial economy, the city continues to host many factories. Most of these factories are in East Jakarta at the industrial complex of Jakarta Industrial Estate Pulogadung (JIEP), where there are approximately 400 factories. Currently, DKI Jakarta relies on a mix of indirect (self-reporting), direct monitoring and continuous emission monitoring systems (CEMS) to ensure that factories do not exceed emissions standards. In 2018, DLH Jakarta conducted direct monitoring for 25 chimneys and indirect monitoring for 124 chimneys. While all the direct monitoring met the ambient standard, 48% of the self-reported results did not.[52] DKI Jakarta has eight factories in the power plant and steel smelting industries that require CEMS. Currently four of these factories have already installed CEMS, while the other four are scheduled to have their CEMS installed.

In addition to CEMS, there needs to be stringent emission standards for industries to install the best available air pollution control devices, such as scrubbers or air filters. Meanwhile, to increase the use of clean energy for industry, the government of DKI Jakarta should start to encourage industries that use high sulfur fuels, such as diesel and coal for their boilers, to shift to natural gas. It can be developed through incentives scheme, regulation, sanction, to promote the use of natural gas and renewable energy. The government needs to collaborate with PGN to build infrastructure for gas distribution to ensure sufficient natural gas availability.

- **Expansion of green space areas**

Adding green spaces can contribute indirectly to emissions reduction. Green spaces can benefit air pollution control, as several plants can absorb harmful pollutants. Based on discussions in previous workshops, a study of the role of plants that can absorb harmful pollutants needs to be conducted. Green spaces also encourage more physical activity and people moving out of vehicles. This is a small effort to control air pollution in general.

- **Increase community participation to create public awareness**

Currently, public awareness of the importance of clean air for health is still low. Awareness of the role communities can play to drive emissions reductions should be strengthened. For this reason, the next action plan will be focused on increasing community-targeted air quality improvement campaigns. Various forms of campaigns can take the form of individual-level competitions as well as citizen-level competitions involving citizen efforts to reduce emissions in their daily lives.

Left, Jakarta has implemented an odd-event policy to reduce traffic congestion. Photo: Vital Strategies, 2019.
Right, Staff from the Jakarta Environment Agency test the emissions from an apartment block. Photo : Vital Strategies (2019). Industrial chimneys emit pollutants into the air in Jakarta, Indonesia, Photo : Vital Strategies (2019). Citizens enjoying public (green) spaces in Jakarta, Indonesia. Photo : Communication, Informatics and Statistics Agency of Jakarta, 2019.

[51] In 2017, the Ministry of Environment and Forestry issued a regulation stating that new vehicles produced and sold in Indonesia from 2017 must fulfill the Euro 4 standard for two-wheeled motorbikes, cars and logistics vehicles such as trucks, small trucks and vans. Gasoline-fueled vehicles (BBM) must comply with regulations no later than 10 October 2018, while for diesel-fueled vehicles no later than 10 March 2021 (Ministry of Environment and Forestry (KLHK). Decree No.P.20 / MENLHK / SETJEN / KUM. 1/3/2017 on Ambient Emission Standards for New Vehicles (Category M, N and O).
[52] Dinas Lingkungan Hidup DKI Jakarta. Presentation slide. Personal communication. 2019.

Collaborative Actions

Supporting studies for air quality monitoring

Reduction of emissions from the transportation sector

Reduction of emission from the industrial sector

Increasing public awareness

Left, A family plays outdoors in their neighbourhood in South of Jakarta, Indonesia. Photo : Vital Strategies, 2019.

Right, A family taking a walk in their neighbourhood in South Jakarta, Indonesia. Photo: Vital Strategies, 2019.

Collaboration between the provincial government and stakeholders is important to tackle the air pollution problem. Case studies in cities of other countries have proven that this simultaneous collaboration in policy making and policy implementation will lead to successful output. Therefore, this section will present several action plans that require stakeholder collaboration related to air quality management both at the local, national, and international level.

5.1 Supporting studies for air quality monitoring

To improve accuracy and create effective policies, supporting studies such as the impact of air pollution on health, Cost Benefit Analysis for policy planning, targeting, and studies of air pollution sources can assist in policy planning and evaluation of policies that have been carried out by the DKI Jakarta Government. Collaboration with other stakeholders is needed to fill the gaps in the knowledge and resources of the DKI Jakarta Provincial Government.

5.2 Reduction of emissions from the transportation sector

Collaboration for action planning to reduce emission from the transportation sector can be carried out on these activities: providing clean energy for vehicles, increasing public transport passengers, and using private low emission vehicles. For clean energy supply, cooperation is needed with the central government which has more authority to increase the availability of fuel with low sulfur content, given the limited authority of the provincial government.

Meanwhile, to increase the number of public transportation passengers, campaigns should be conducted to promote its use. Collaboration is also needed to encourage private vehicles to do emissions tests. An intensive campaign can be executed in cooperation with community organizations, companies, or workshops.

5.3 Reduction of emission from the industrial sector

The case study of the city of Hong Kong, where the shipping industry association took the initiative to convert to cleaner fuel, is an example of how collaboration among institutions can accelerate efforts to reduce emissions in the industrial sector. In addition, collaboration on studies will be useful for efforts to tighten exhaust emissions in the industrial sector. One example is the collaboration between DLH and Vital Strategies to study the tightening of emissions standards for stationary source emissions.

5.4 Increasing public awareness

Collaboration to increase public awareness of having clean air should include government, NGOs, community groups and individuals to expand the reach of information to all levels of society and age groups. This information will play a significant role in changing people's behavior to develop concern for air quality.

CONCLUSION

DKI Jakarta, as the capital city of Indonesia, and the largest contributor by province for Indonesia's economy, is facing a massive challenge: maintaining steady economic growth while making the city liveable to its citizens. Air pollution is one of the prominent issues that Jakarta needs to tackle, as it affects the health and productivity of its citizens. Air pollution, particularly $PM_{2.5}$ pollution, has long-term health impacts that lead to premature mortality and affect the well-being of future generations.

Over the last few years, air quality in Jakarta has worsened with the rapid development in the city. However, it is possible for Jakarta to maintain its growth while simultaneously improving their air quality. The DKI Jakarta government has formulated an action plan for improving air quality in the city with the support of various stakeholders, to tackle the major source of pollution—transportation and industry.

Accurately identifying leading sources of air pollution is an important step to formulate robust policies, followed by data-driven and evidence-based policy evaluation to attain the best possible results in air pollution control and reduction. Calculating the cost and benefit of future policies can assist the policymakers to prioritize and strategize on the implementation of the policies.

Of course, the government of DKI Jakarta cannot be alone in finding the solution for improving air quality. The city should collaborate with other stakeholders, such as academia, civil society, international experts, the central government, and local government in adjacent cities. Collaboration with stakeholders can fill the gaps that Jakarta cannot provide alone. The central government and local government in adjacent cities, for example, could assist the solutions that the government of DKI Jakarta is unable to provide due to its limited legal authority.

This document can be a start to create further long-term action plans that carefully assess and assemble evidence to provide better and robust policy solutions for Jakarta. Cleaner air for DKI Jakarta is more than a single goal. It will also improve the city's future economy and the wellbeing of its citizens. Cleaner air will make the city a more attractive place for residents and visitors to live, work and play, and influence how others may view Jakarta favorably as a city to invest in and host international events such as the Olympics. Improving air quality in the city could help achieve our long-term vision in 2030 to become the capital city that is secure, comfortable, productive, sustainable, comparable to other major cities, and a home for citizens to prosper.

Above, An Ondel-ondel Played at Monumen Nasional (Monas), Jakarta-Indonesia. Photo : Wira Adhyatma, flickr (2012).

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