BETTER AIR, BETTER INDONESIA

The Economic and Political Case for Urgent and Coordinated Action for Jakarta's Clean Air

SYSTEMIQ

INSTITUT TEKNOLOGI BANDUNG 1920

climateworks FOUNDATION

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FOREWORD

Indonesia is striving to achieve its economic growth target, a vision that must align with green growth through improved infrastructure, green industrialization, and a just transition for a more prosperous and equitable society. Addressing air pollution is essential to sustaining economic growth and ensuring long-term development.

Clean air is not just an environmental issue; it is an economic imperative that requires significant infrastructure improvement. Sustainable development requires a balanced approach—one that ensures economic growth while safeguarding public health and the environment. Poor air quality leads to increased healthcare costs, reduced worker productivity, and constraints on long-term economic competitiveness. To sustain our growth momentum, Indonesia must take decisive action to reduce air pollution through collective action across government, industry, and civil society.

Tackling air pollution and advancing the energy transition are deeply interconnected, offering significant co-benefits for Indonesia's sustainable development. Key strategies enhancing fuel quality, transitioning to cleaner technologies, expanding public transportation, and eliminating open waste burning are among the most impactful levers for achieving immediate and substantial air quality improvements. Long-term, these programs must be coupled with Indonesia's energy transition to maximize impact.

'Better Air, Better Indonesia's' recommended strategies hinges on foundational infrastructure planning and investment. Infrastructure is not just a supporting element—it is a key enabler for cross-sectoral programs for clean air: adopting low-sulfur fuels demands national fuel supply chain upgrades; transitioning coal boilers requires industrial retrofits and energy system planning; expanding public transport hinges on transit infrastructure and fleet procurement; and eliminating waste open burning necessitates improved waste processing infrastructure. These interventions sit squarely within the strategic mandate of the Coordinating Ministry for Infrastructure and Regional Development, whose cross-sectoral authority enables integrated planning, funding alignment, and delivery oversight across regions and ministries. By anchoring clean air goals in infrastructure development, Indonesia not only safeguards public health but also accelerates regional development and green economic growth.

We invite all—government agencies, businesses, and communities—to collaborate in driving cleaner air for Indonesia. Key programs outlined in this report across transport, industry, power, waste, and construction require coordinated action between local and national governments. The private sector plays a key role in mobilizing finance and scaling green technologies, while civil society drives advocacy and public awareness. Only through collective action can we ensure **prosperity and sustainability**, making clean air a lasting resource for future generations.

Jakarta, April 2025

Rachmat Kaimuddin

Deputy for Basic Infrastructure Coordination, Coordinating Ministry for Infrastructure and Regional Development Republic of Indonesia 2025-2030

Former Deputy for Infrastructure and Transporation Coordination, Coordinating Ministry for Maritime Affairs and Investment Republic of Indonesia 2022–2024

FOREWORD

At the Jakarta Provincial Government, we are committed to shaping a future where Jakarta is recognized as a top Global City—a world-class model of a resilient, inclusive, and sustainable society. In realizing this ambition, addressing air pollution must be a central priority. Clean air underpins a resilient society—supporting Jakarta's public health, economic productivity, and long-term development.

Jakarta's transformation, as outlined in UU Nomor 2 Tahun 2024 and the RPJPD Jakarta 2025–2045, provides both the mandate and momentum to act boldly. As a National Economic Center and Global City, Jakarta must demonstrate that economic growth, environmental stewardship, and social equity can advance hand in hand.

Achieving healthier air quality is essential to supporting Jakarta's thriving economy. Poor air quality leads to higher healthcare costs, lost productivity, and reduced competitiveness. Clean air strategies—such as improving fuel quality, expanding public transport, adopting cleaner technologies, and eliminating open waste burning—offer immediate and lasting benefits for both our economy and the well-being of our residents.

This report offers more than just strategies—it presents a call to collective action. By integrating air quality goals into broader urban systems—transportation, industry, energy, waste, and governance—it lays the groundwork for a just and inclusive transition: one that enables green growth while ensuring that no community is left behind.

The path forward requires coordinated and sustained effort across central and regional government, as well as the active participation of business, academia, and civil society. Let this report serve not only as a strategic guide, but also as a guiding compass for all stakeholders—and a bold reminder that **Jakarta's true strength lies in its people, and in the air we all share**.

Jakarta, April 2025

Atika Nur Rahmania
Head of Regional Development Planning Agency (Bappeda) of the Special Capital Region of Jakarta 2025-2030

FOREWORD

Economic growth and rapid urbanization in Jakarta, as a megapolitan city in Indonesia, have led to a rapid increase in energy consumption, resulting in a rise in air pollution sources. Air pollution in Jakarta has become a significant problem, as $PM_{2.5}$ concentrations continue to increase. The current air quality status in Jakarta is a major concern, with pollution levels frequently exceeding both national standards and WHO guidelines. Action plans and better air quality management are needed to control air pollution in the city.

Existing regulations, policies, and best practices initiated in Indonesia are insufficient to curb rising emissions, leading to deteriorating air quality, particularly in Jakarta. Further action is required to enhance current best practices and identify measures with high potential for emissions reduction and economic benefits.

To control air pollution and prioritize effective solutions, it is essential to first understand its main sources. Emission Inventory is a key air quality management tool that helps identify pollution sources, particularly for $PM_{2.5}$. Scientific assessments and robust data are crucial to supporting the government in prioritizing and developing the most effective control options and policies.

This report features a 2023 emission inventory conducted by ITB, based on available government data. It covers multiple anthropogenic sources, including transportation, industry, power plants, residential and commercial sectors, construction, and municipal solid waste. The proposed mitigation measures were developed based on existing policies and regulations set for implementation in Indonesia. The emission inventory results, combined with a cost-benefit analysis of these measures, provide critical insights for policymakers.

The report *Better Air, Better Indonesia*, initiated by Systemiq in collaboration with ITB and other stakeholders, offers a comprehensive analysis of emission sources, the health and economic impacts of air pollution, and potential solutions for improving air quality in Indonesia. A key aspect of this report is the proposed government structure to effectively tackle air pollution in the country. The report presents an in-depth assessment of air pollution issues, solution strategies with cost-benefit analyses, and the economic and health impacts of air pollution. It serves as a valuable resource for policymakers, think tanks, NGOs, professionals, and others interested in improving air quality in cities or countries facing similar challenges.

Jakarta, April 2025

Prof. Ir. Puji Lestari, Ph.D.

Head of Air Quality and Waste Management Research Group

Bandung Institute of Technology

ENDORSEMENTS

"At ClimateWorks Foundation, we believe clean air is not only a public health imperative, but also a catalyst for stronger, more sustainable economies. We are proud to support the Better Air, Better Indonesia report, which highlights the power of collective action and evidence-based policy in driving meaningful change. This work is a testament to Jakarta's leadership potential—and we hope it inspires other cities to take bold, collaborative steps toward a cleaner, healthier, and more equitable future for all.

HUSNI MUBAROK
ClimateWorks Foundation

"As Jakarta transitions from Indonesia's capital to a global city, air quality has become an urgent challenge that demands immediate action. While solutions require a regional approach in collaboration with surrounding areas, Jakarta's role as the national economic hub remains crucial. Better Air, Better Indonesia provides key levers for stakeholders—particularly the government—based on a thorough analysis of air quality and its impact on public health and the economy. This report offers strategic measures for long-term improvements and underscores the need for swift action. By prioritizing key interventions and increasing public awareness through data-driven insights, we can take meaningful steps toward protecting both human well-being and the environment.

SUZANTY SITORUS
Executive Director of ViriyaENB

"Jakarta's escalating air quality crisis poses a significant threat to public health, economic resilience, and environmental sustainability. According to a 2023 study by Vital Strategies, air pollution contributes to an estimated 10,000 premature deaths annually in the city. Meanwhile, Jakarta's average annual PM2.5 concentration frequently exceeds the World Health Organization guideline of 5 µg/m³, highlighting the urgent need for coordinated action.

As a key collaborator in air quality initiatives, WRI Indonesia recognizes that robust data is essential for understanding pollution sources and crafting effective, evidence-based solutions. High quality emissions data underpins targeted interventions and informs policies that drive meaningful change.

The Better Air, Better Indonesia report provides a crucial 2023 baseline emissions inventory for Jakarta, identifying key pollution sources and assessing the projected impacts of twelve strategic intervention levers. Notably, it advocates for a centralized governance model to ensure effective implementation, offering a structured approach to reducing emissions and improving air quality in the city."

NIRATA 'KONI' SAMADHI
Country Director of World Resources Institute (WRI) Indonesia

“

This report provides a critical roadmap for tackling air pollution in Jakarta, offering a clear economic and political case for action. It outlines the costs and benefits for both the public and private sectors, detailing the roles of key government stakeholders and how coordinated efforts can drive real change. As Jakarta aims to compete with world-class cities, this report highlights the investments and policy shifts needed to create a cleaner, more sustainable urban environment. Beyond economic and governance considerations, it also marks a significant step toward protecting public health, as it strengthens the case for action and should encourage more stakeholders to take responsibility in tackling air pollution. Crucially, this report sets a precedent that should be replicated in other Indonesian cities, ensuring that tackling air pollution becomes a national priority.

RATNA KARTADJOEMENA
Co-Founder of Bicara Udara

“

Greater Jakarta’s air quality crisis has gotten worse in recent years and requires immediate, science-based action. Science-based study and practical estimation on the solution are necessary to provide a clearer picture on the solution, and most importantly on the financing. Better Air Better Indonesia provides insights on the solution that needs to be taken as well as an analysis on the benefit and cost of each solution. This report is a valuable reference for policy makers, think tanks, and academia that has concern on air pollution issue and its solution.

RIRIN RADIAWATI KUSUMA
Indonesia Country Director of Clean Air Asia

“

In this publication, Systemiq has done an excellent job analyzing the air pollution issue in Jakarta. The work provides a comprehensive list of economic and political actions for the government to take, including both the central government and the Jakarta provincial government. For those of us who are working closely within the transport sector, this publication offers a comprehensive and well-researched approach, from improving fuel quality to accelerating the electric vehicle transition. With actionable insights, innovative solutions and a clear focus on both policy and practical applications, this work provides a crucial framework for reducing air pollution in Jakarta. We trust that other cities in Indonesia can follow a similar path.

RAY MINJARES
Managing Director of International Council on Clean Transportation (ICCT)

About Better Air, Better Indonesia

"Better Air, Better Indonesia: The Economic and Political Case for Urgent and Coordinated Action for Jakarta's Clean Air" report was produced by Systemiq and Bandung Institute of Technology (ITB), supported by the ClimateWorks Foundation. "Better Air, Better Indonesia" aims to conduct a systemic assessment of the economic and political case for improved air quality in Jakarta, by proposing a multi-action agenda across key sectors (transport, industry, power, waste and construction) and recommending policy and governance reforms for accelerated implementation. This report aims to answer the following exam question: how can the Indonesian government design and implement an air pollution action plan that improves public health, unlocks economic benefits, and establishes an effective governance model across key agencies?

"Better Air, Better Indonesia" aims to contribute to and build on existing literature on Jakarta's air pollution: (1) providing a 2023 baseline emissions inventory of Jakarta's air pollution, conducted by ITB; (2) prioritization of a multi-action agenda and an assessment of its estimated impact to pollution, economy, and health; and (3) and proposed centralized governance model, co-developed with key government stakeholders, to drive implementation. To highlight the 'economic case' of air pollution, this report provides an assessment of investment needs required, from private and public, and projected market potential and government savings. In addition, health benefits are assessed by estimating the economic value of prevented deaths attributed to air pollution. To highlight the 'political case' of air pollution, this report makes a case for developing a centralized Coordinating Team to unify multi-stakeholder and multi-sectoral efforts to drive implementation of key programs. Success in tackling air pollution depends on collective action. Strong political leadership from both national and local governments is crucial, supported by a broad coalition of stakeholders committed to restoring clean air in Indonesia.

The Systemiq team that developed this report is comprised of Batari Saraswati, Dirayati Djaya, Nadhira Ratnasari, Daniel Kurniawan, Nicholas Omar, with significant expertise from Masyita Crystallin, Katherine Stodulka and Widharmika Agung. We would also like to thank Systemiq colleagues Mossele Ambarita, Haykal Ardhanikusumah, Laksmi Satria, Abindra Soemali, Agra Suryadwipa, Mike Webster, and Niklas Niemann for their input and feedback.

The Bandung Institute of Technology (ITB) team that developed this report is led by Professor Puji Lestari, with Bonifasius Mahardhika, Maulana Khafid, and Windy Iriana.

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Noor Arifin and team
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(Vital Strategies)

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Danny Djarum
Hafidz Abdillah
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Novita Natalia
Kristal Amalia
(Yayasan Udara Anak Bangsa, Bicara Udara)

Contributors and their organizations do not necessarily endorse all findings or recommendations of the report.

About Systemiq

Systemiq, the system-change company, was founded in 2016 to accelerate the achievement of the Sustainable Development Goals and the Paris Agreement, by transforming markets and business models in five key systems: nature and food, materials and circularity, energy, urban areas, and sustainable finance. A certified B Corp, Systemiq combines strategic advisory with high-impact, on-the-ground work, and partners with business, finance, policymakers and civil society to deliver system change. Systemiq has offices in Brazil, France, Germany, Indonesia, the Netherlands, and the UK.

Systemiq supported by the ClimateWorks Foundation presents

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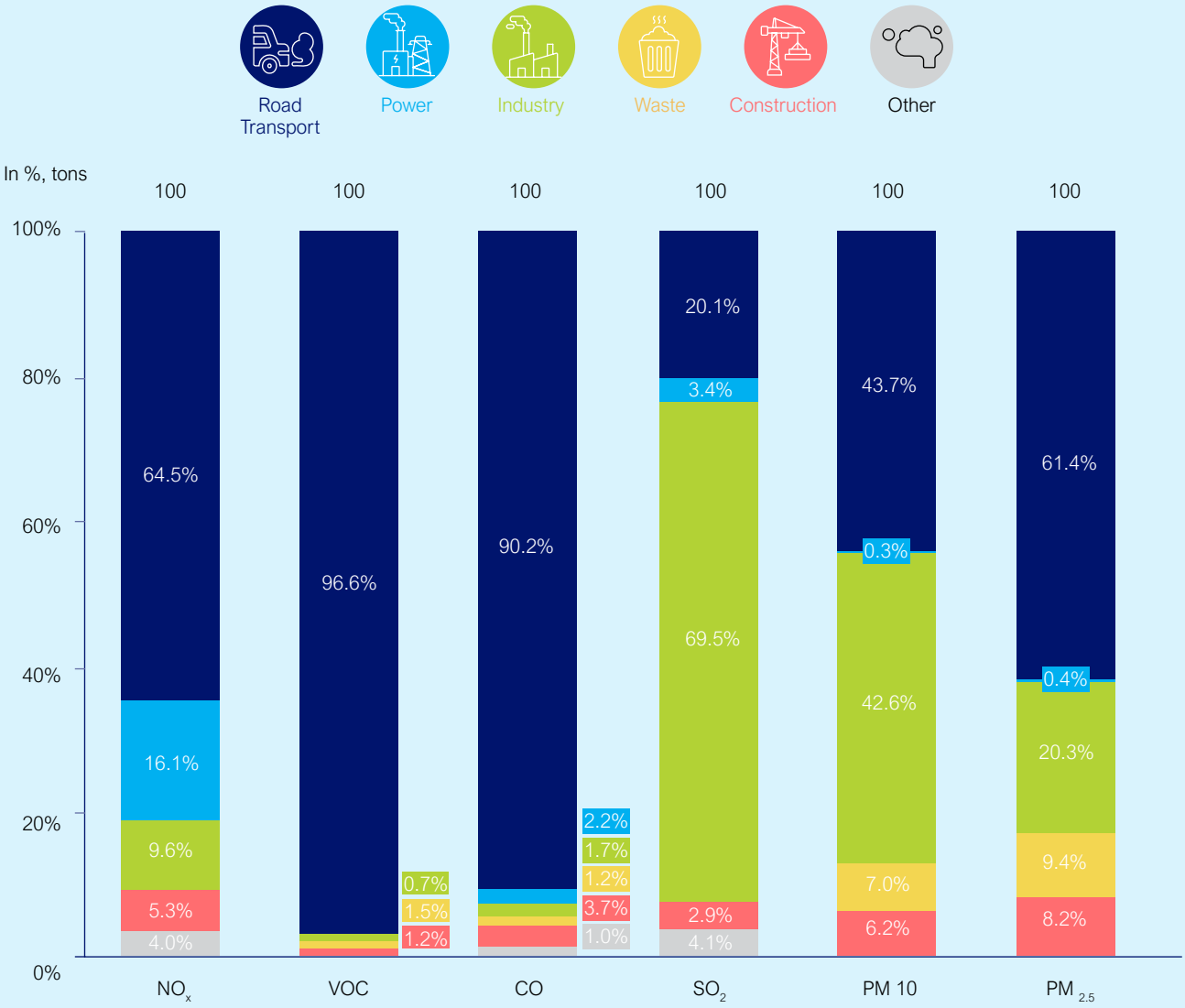
Systemiq, together with the **Bandung Institute of Technology** (ITB) and key stakeholders from **government, think tanks, civil society, NGOs, industry, and business** presents: (1) **2023 emissions inventory of Jakarta** conducted by ITB (2) **multi-action roadmap of key levers** to reduce air pollution, improve health, and unlock economic benefits, and (3) **proposed centralized governance model** to align national efforts for effective implementation.

1 WHAT ARE THE SOURCES OF JAKARTA'S AIR POLLUTION? 2023 EMISSIONS INVENTORY



- **Updated 2023 Emissions Inventory of activities within Jakarta*:** identifies transport, industry, power, waste burning, and construction as major contributing sectors of pollution.
- **Transport as the Largest Contributor:** 65% of NO_x, 90% of CO, and 61% of $PM_{2.5}$ emissions.

Note that Emissions Inventory scope only includes emissions from activities within Jakarta, excluding transboundary pollution from surrounding provinces. Power sector emissions comprised only of power plants located inside Jakarta: Muara Karang, Tanjung Priok, Senayan
Source: ITB. Emissions Inventory calculated using GAINS model

2 12 KEY LEVERS TO MAXIMIZE IMPACT BY 2030: ENVIRONMENTAL, HEALTH AND ECONOMIC CASE

	Levers	2030 Targets
Transport	1 Low-sulfur fuel	100% Euro IV fuel adoption in Jakarta
	2 Electrification of 2W	45% electrification (5.5M E2W) of 2W in Jakarta*
	3 Electrification of 4W	23% electrification (887k E4W) of 4W in Jakarta*
	4 Electrification of trucks	15% electrification (115k E-Trucks) of trucks in Jakarta
	5 Electrification of TransJakarta bus	100% electrification (10k E-Buses) of Transjakarta
	6 Integrated public transport	60% Public Transport ridership
Industry & Power	7 Transition coal boilers to cleaner tech	0% coal usage in industrial boilers
	8 Industry post-combustion controls	50% of highest-emitting industries install NO_x and SO_2 controls
	9 Gas power plant controls	100% NO_x controls at combined-cycle gas turbines (CCGT)
	10 CFPP controls & retirement**	100% CFPPs compliance to post-2019 emission standards
Waste & Construction	11 Eliminate waste open burning	100% waste handling (zero waste open burning)
	12 Controlled construction dust	100% construction dust control

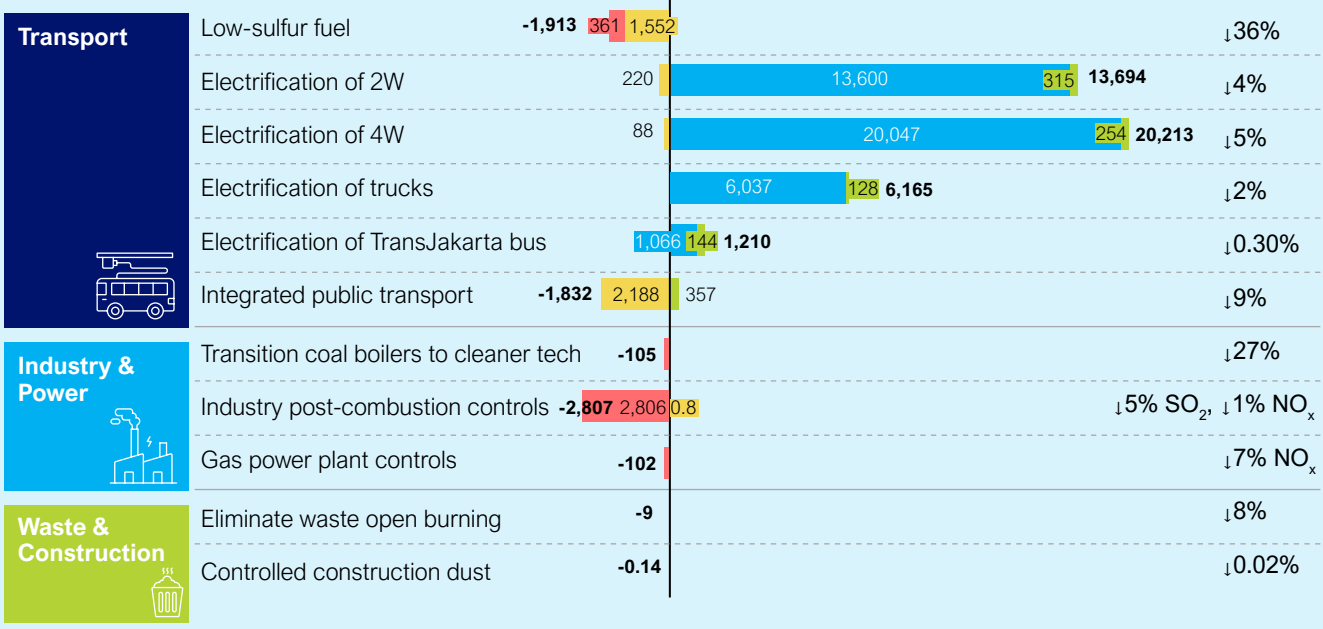
* Electrification targets extrapolated based on national 2030 targets: 13M E2W, 2M E4W
** CFPPs have been included as a notable lever as a key source of transboundary pollution. However, due to data limitations, the emissions inventory of this report is limited to the administrative boundary of Jakarta. As CFPPs are located outside of Jakarta, assessment of CFPP lever impact to air pollution is not included in report.

IMPACT TO AIR POLLUTION, ECONOMY, HEALTH

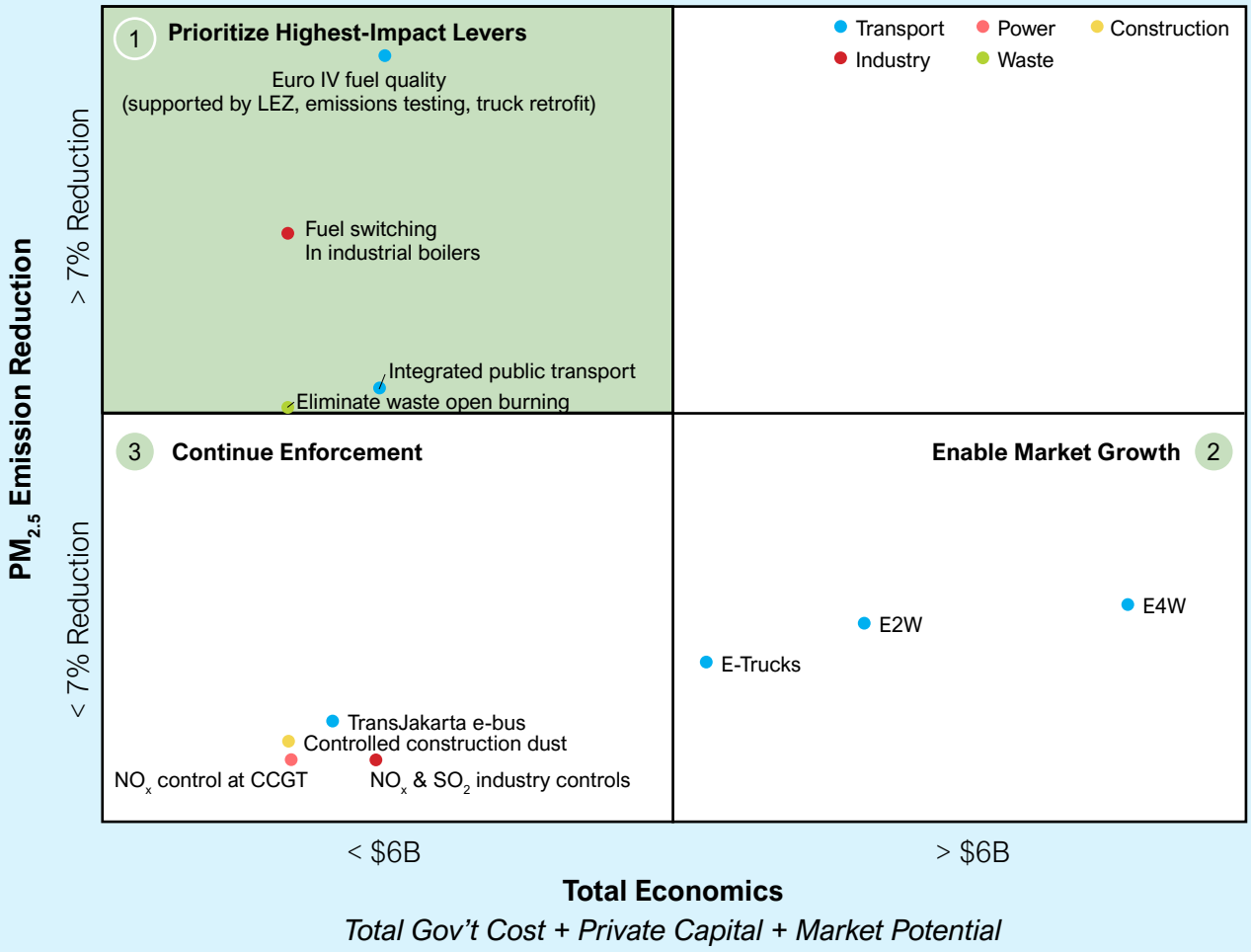
Levers will require **$7.4B (IDR 119T) investment from government and private sector**, support the creation of a **$40.7B (IDR 652T) EV market,** and **$1.2B (IDR 19T) government savings** due to reduction in fuel subsidy needs

↓ 92% **$PM_{2.5}$ emissions** compared to 2030 BAU

Prevent **32,727 pre-mature deaths**, equal to **$27B (IDR 432T) saved**



3 STRATEGIES FOR IMPLEMENTING 12 KEY LEVERS



1

Prioritize Highest-Impact Levers:

Focus on the most impactful and cost-effective levers, including **low-sulfur level, transition coal boilers to cleaner technology, integrated public transport,** and **eliminating waste open burning**, which together can deliver an **80% $PM_{2.5}$ reduction by 2030** while offering the best value for investment.

2

Enable Market Growth:

Accelerate **electric vehicle adoption which encompasses electric two-wheelers, electric four-wheelers, and electric trucks, representing a $40 billion market,** through **subsidies, VAT exemptions**, and other incentives to reduce **CO and VOCs**.

3

Continue Enforcement:

Support levers, **construction dust controls, air pollution controls on industries and power plants and TransJakarta e-bus**, have less significant impact on $PM_{2.5}$ but are essential for comprehensive pollution control of other pollutants.

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3 COORDINATED ACTION PLAN: CENTRALIZED GOVERNANCE BODY TO DRIVE IMPLEMENTATION

Co-developed with key ministries through extensive stakeholder engagement, *Better Air, Better Indonesia* proposes the establishment of a centralized **Coordinating Team for Greater Jakarta Air Pollution** to drive implementation of action plan. The taskforce, led by key ministries and local regional agencies, would elevate **air pollution as a national priority, enhance coordination, enforce accountability, and direct resources effectively.**

EXECUTIVE SUMMARY

The science is clear: air pollution is one of the deadliest environmental health risks in the world, estimated to cause 8.1 million deaths worldwide in 2021.[1] Indonesia is no exception to this risk — Jakarta's air pollution has significantly worsened, ranking among the world's top 10 most polluted cities in the world.[2] In 2023, annual mean $PM_{2.5}$ concentration amounted to 39.6 μg/m^3, which is more than 2 times of the national standard (15 μg/m^3) and more than 6x of the World Health Organization (WHO) guidelines at (5 μg/m^3).[3]

The repercussions on Jakarta's health and economy are substantial, as Jakarta's residents bear the profound toll on their lives and well-being. The World Bank estimated that in 2019, the economic burden of air pollution in Indonesia totalled $220 billion in health costs, equivalent to 6.6% of Indonesia's GDP PPP.[4] University of Chicago's Air Quality Life Index study reported that an average Jakarta resident loses 2.2 years of their life expectancy compared to what it would be if Jakarta pollution level met the WHO guideline.[4]

To dive deeper, this report's 2023 Emissions Inventory of activities within Jakarta reveals that the primary sources of air pollution are road transport, industry, power, waste burning, and construction. Road transport dominates across all pollutants, except for SO_2 whereby the industry sector is the most significant contributor. Open burning of household waste has emerged as a growing source of emissions. If current trends persist, projections for 2035 under a Business-as-Usual (BAU) scenario indicate a sharp rise in emissions across all sectors, driven by increasing vehicle ownership, inadequate public transit, urban expansion, and growing energy demands. Urgent and coordinated action is critical to reverse this trend at the speed and scale needed.

This report's Emissions Inventory was calculated using the Greenhouse Gas - Air Pollution Interactions and Synergies (GAINS) model to quantify emissions load of activities within Jakarta from 2023 to 2035. Notably ambient air pollution in Jakarta is impacted by emissions produced within the Jakarta city limits and outside the city limits from transboundary sources, such as industrial zones, power plants, and road transport exhaust from surrounding regions. Due to the methodology, the scope of the Emissions Inventory provided in the report focuses solely on activities within Jakarta's administrative boundaries, excluding transboundary pollution sources. This underscores the need for further research for a more integrated approach to air quality management that considers the broader airshed affecting the city.[6]

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[1] Health Effects Institute & Global Burden of Disease. (2024). State of Global Air Report 2024. https://www.stateofglobalair.org/resources/report/state-global-air-report-2024

[2] For more information on rankings and their respective methodologies, please see: IQAir, Air Quality Life Index (AQLI).

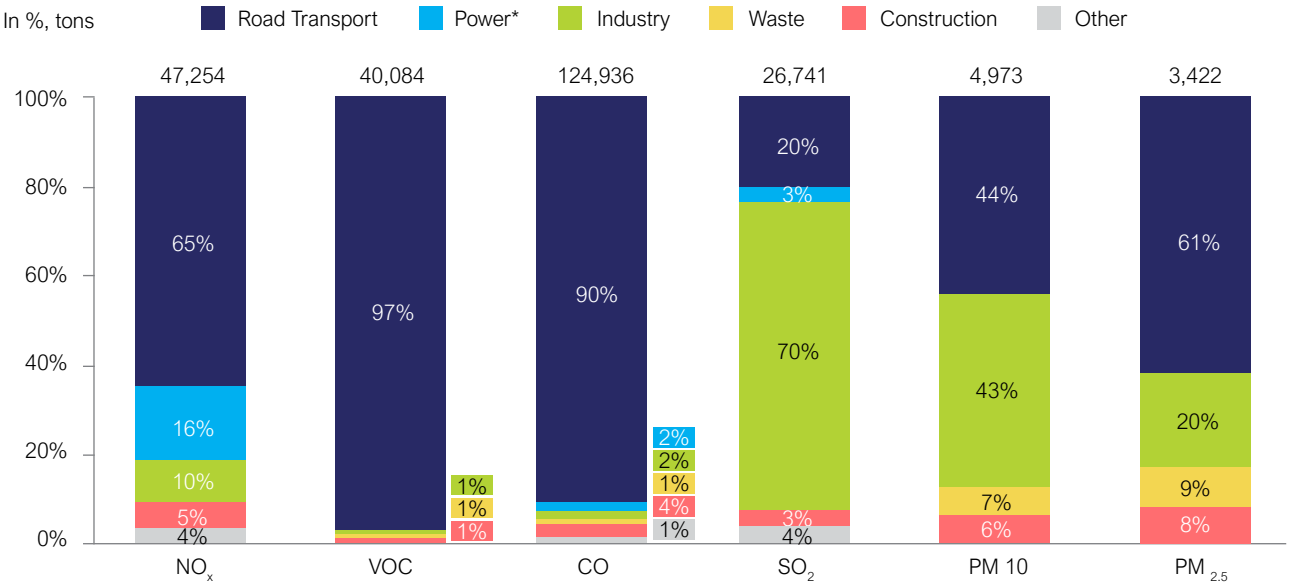
[3] Environmental Agency Jakarta. (2023). Annual report on air quality monitoring activities for the DKI Jakarta Province in 2023. https://lingkunganhidup.jakarta.go.id/files/laporan_udara/LAPORAN_KUALITAS_UDARA_2023.pdf

[4] World Bank. (2022). The global health cost of $PM_{2.5}$ air pollution: A case for action beyond 2021. https://doi.org/10.1596/978-1-4648-1816-5

[5] Air Quality Life Index. (2024). Annual update. https://aqli.epic.uchicago.edu/wp-content/uploads/2024/08/AQLI-2024-Report_English.pdf

[6] For more information on emissions inventory for Greater Jakarta area, see forthcoming report: ITB & ViriyaENB. (forthcoming). Emission inventory in Jabodetabek.

FIGURE ES1: SOURCES OF AIR POLLUTANT EMISSIONS WITHIN JAKARTA



Source: ITB. Emissions Inventory calculated using GAINS model.
Note: (*) Power emissions only cover CCGT power plants in Jakarta: PLTG Tanjung Priok and Muara Karang

***The Better Air, Better Indonesia* report provides a multi-action roadmap for Jakarta to improve air pollution by 2030.** It identifies key levers (see Figure ES2), evaluated based on their impact on air pollution, health costs, economic effects on government and private sectors, and the political feasibility of regulatory reforms and governance models.

Compared to the emissions load of 2030 Business-as-Usual projections, these measures could reduce the emissions of $PM_{2.5}$ by 92%, carbon monoxide (CO) by 64%, nitrogen oxides (NO_x) by 49%, sulfur dioxide (SO_2) by 33%, volatile organic compounds (VOCs) by 64%, and PM_{10} by 89%. Beyond environmental benefits, the levers have potential to contribute to a $40.7 billion electric vehicle (EV) market and save the government $1.2 billion in reduced fuel subsidies.

The health benefits of proposed levers far outweigh the cost to implement levers: from 2025-2030 an estimated 32,747 premature deaths would be prevented, equivalent to $27 billion saved, equivalent to 1–2% of Jakarta's Gross Regional Domestic Product (GRDP).[7,8] The cause-specific diseases included in this study include Chronic Obstructive Pulmonary Disease, Ischemic Heart Disease, Lung Cancer, and Stroke, based on Global Burden of Diseases 2019 methodology. Prolonged exposure to pollutants such as fine particulate matter ($PM_{2.5}$), nitrogen oxides (NO_x), and sulfur dioxide (SO_2) lead to chronic diseases, exacerbating pre-existing conditions, and contributing to thousands of premature deaths nationally each year. Vulnerable populations, such as children, the elderly, and individuals with underlying health issues, bear the brunt of these impacts. In addition to the human toll, the economic consequences—ranging from increased healthcare costs to lost productivity—are staggering.

[7] GDP projection numbers are based on projected nominal GDP with 2015 as the base year, assuming Indonesian GDP is expected to grow at 5% per annum from baseline until 2028 and 8% per annum from 2029 onwards, based on an optimistic scenario aligned with government targets. Jakarta's projected GRDP is calculated assuming a consistent proportion of 16% of nominal GDP, based on historical trends. Sources include Systemiq analysis for Indonesia Climate Growth Dialogue (ICGD), World Bank, CEIC, and BPS.

[8] Health impact is calculated with the Air Quality for Urban Action (AQUA) Model by C40 and AirQ+ model by WHO. The economic value of premature deaths is based on Value of Statistical Life (VSL) calculation. Due to data limitations, the estimated health impact may be undervalued as the analysis does not take into account (1) impact on diabetes and lower respiratory infection (LRI), and (2) the impacts on illness and morbidity, including hospitalization costs, years lived with disability, children's health (e.g. stunting), and adverse birth effects (e.g. pre-term births). For more information, please see appendix on Health Methodology and Assumptions. For more information, please see appendix on Health Methodology and Assumptions.

FIGURE ES2: 12 KEY LEVERS

	Levers	2030 Targets
Transport	1 Low-sulfur fuel	100% Euro IV fuel adoption in Jakarta
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	6 Integrated public transport	60% Public Transport ridership
Industry & Power	7 Transition coal boilers to cleaner tech	0% coal usage in industrial boilers
	8 Industry post-combustion controls	50% of highest-emitting industries install NO_x and SO_2 controls
	9 Gas power plant controls	100% NO_x controls at combined-cycle gas turbines (CCGT)
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*Electrification targets extrapolated based on national 2030 targets: 13M E2W, 2M E4W
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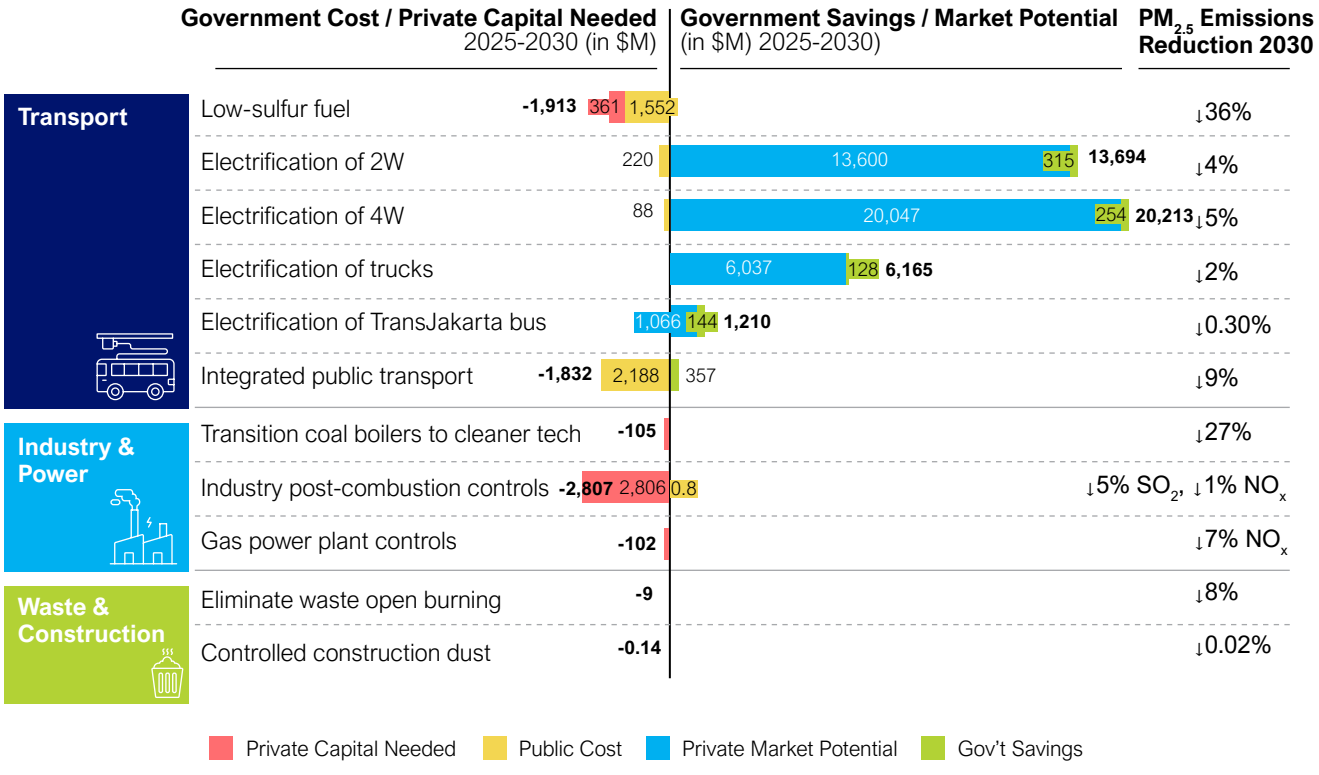
FIGURE ES3: IMPACT SUMMARY



THREE STRATEGIC APPROACHES ARE RECOMMENDED:

1. **Prioritize Highest-Impact Levers:** Focus on the four most effective levers: (1) Low sulfur fuel adoption, (2) Transition coal boilers to cleaner technology, (3) Public transport expansion, and (4) Eliminating waste open burning. Collectively, these four levers alone can deliver an 80% reduction in $PM_{2.5}$ emissions by 2030, providing the greatest immediate impact.

2. **Enable Market Growth:** Leverage the economic potential of emerging electric vehicles (EVs) industry which encompasses E2Ws, E4Ws and e-trucks, representing a $40 billion market. Government incentives, such as subsidies, VAT exemptions, and non-financial incentives, like Low-Emission Zone allowances, can accelerate adoption. Further reduction of CO and VOC can be achieved if EV adoption rates surpass proposed targets.[9]

3. **Strengthen Enforcement:** While their impact on $PM_{2.5}$ is less significant, remaining levers of industrial pollution controls, e-bus and construction dust can be implemented for comprehensive pollution control of other pollutants.

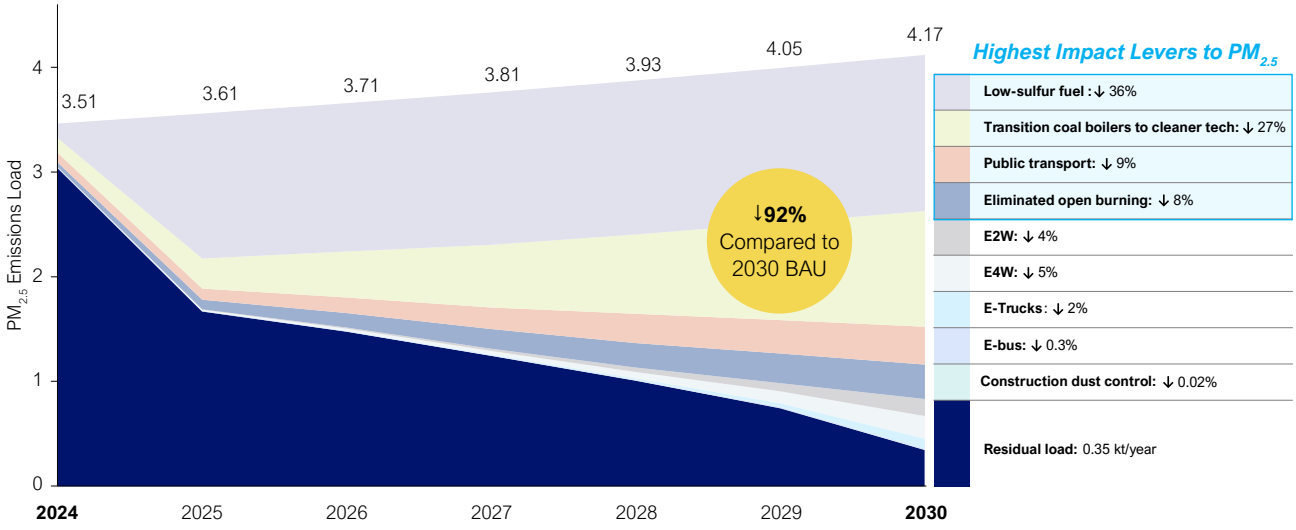
   a. Issuance and continued enforcement of stringent emission standards for industry is crucial to encourage the installation of industrial post-combustion technologies, selective catalytic reduction (SCR) and wet flue gas desulfurization (WFGD) which target pollutants NO_x and SO_2 that pose serious health risks.[10]

   b. The electrification of Transjakarta buses supports long-term national electrification goals. However, with Transjakarta buses making up only 15% of Jakarta's total bus fleet, their impact on $PM_{2.5}$ reduction remains relatively limited compared to other levers. Leveraging this momentum could encourage other bus companies to transition to cleaner public transport for greater impact.

   c. Construction is the 5th largest sectoral contributor to air pollution and will expand with Jakarta's urbanization. Controlling construction dust and issuing standards will become increasingly important – as can be seen in the case of Beijing, which included construction measures as part of its air pollution program.

FIGURE ES4: LEVERS IMPACT TO $PM_{2.5}$

$PM_{2.5}$ Projections: BAU vs. Impact
Kilotons/year



[9] For further research on EV impact with higher targets, please see: ITB & ViriyaENB. (forthcoming). Emission inventory in Jabodetabek.

[10] Note that $PM_{2.5}$ pollution controls, such as Electrostatic Precipitators (ESP) or fabric filters, were not included in the analysis, as cleaner technology for industrial boilers is recommended as it provides a more cost-effective way to reduce particulate matter. For more information on impact of all air pollution controls, see: ITB & ViriyaENB. (forthcoming). Emission inventory in Jabodetabek.

Infrastructure development is critical for the achievement of recommended strategies. Implementing the four highest-impact levers—low-sulfur fuel adoption, coal boiler conversion, public transport expansion, and waste burning elimination—requires major infrastructure planning and investment, including fuel processing and distribution networks, grid upgrades, transport infrastructure systems, and waste processing facilities. The success of emerging sectors like electric vehicles also hinges on supporting infrastructure such as charging stations and urban mobility planning. Strengthening enforcement efforts, including industrial emission controls and construction dust standards, similarly depends on built systems and planning.

TO ACHIEVE PROPOSED LEVERS, CERTAIN ENABLING CONDITIONS ARE CRUCIAL:

- **Improving data infrastructure** is essential for enhancing air quality management.
    - **Air quality monitoring stations:** Jakarta currently has twelve high-quality Air Quality Monitoring Stations (AQMS). Expanding this network is essential for accurately tracking daily and monthly Air Quality Index (AQI) readings.
    - **Regularly conducted emission inventories and source apportionment:** Establishing an official government-owned national emissions inventory, with local Environmental Agencies supplying data to Ministries, would create a reliable data source. Strengthening air quality and health data infrastructure is critical for monitoring, policymaking, responding to high-risk events, and increasing public engagement.
    - **Advanced modeling techniques:** such as source apportionment, atmospheric transport and dispersion modeling, and satellite remote sensing are essential for accurately identifying air pollution sources. Given the significant role of coal-fired power plants, industrial activities, regional transport, agricultural burning, and waste burning in transboundary pollution, further research on pollutants from Jakarta's surrounding regions is crucial to understanding their impact on the city's air quality.
- **Public education and behavior change campaigns** play a critical role in increasing awareness of the health risks associated with air pollution and influencing behavioral shifts, such as increased public transport ridership, promoting EVs over ICE vehicles, discouraging household open burning of waste, and informed consumer choices on cleaner fuel quality.
- **Continuous assessment of air pollution policies and emission standards** aligned with the latest science and global benchmarks is essential to driving and sustaining long-term improvements in air quality. Achieving proposed targets requires embedding them within a broader policy framework of regularly upgrading regulations, ensuring strict monitoring and enforcement, including appropriate penalties to discourage non-compliance.
- **Enabling market conditions** to make cleaner technologies and practices more widely available, accessible and affordable. The government can issue comprehensive financial incentive packages—stimulating market growth on the supply side and alleviating potential financial burden for adoption on the demand side. Once market tipping points are achieved for cleaner technologies, it will be easier for an uptake in adoption.[11]

[11] For more information on tipping points for low-carbon technologies, please see: Systemiq. (2023). The Breakthrough Effect in ASEAN: How to Trigger A Cascade Of Tipping Points to Accelerate ASEAN's Green Growth; Systemiq. (2023). The Breakthrough Effect: How Tipping Points Can Accelerate Net Zero

CENTRALIZED, COLLABORATIVE GOVERNANCE IS KEY TO DRIVE IMPLEMENTATION:

Individual efforts have already been made in many of these levers, but a true step change in action will require collective coordination across national and sub-national governments. Co-developed with and informed by extensive government engagement, a centralized Coordinating Team for Greater Jakarta Air Pollution is proposed to oversee implementation of levers. The taskforce would be led by a Steering Committee comprised of ministries or agencies accountable for achieving specific air pollution targets, supported by a Secretariat responsible for day-to-day coordination with the Implementing Team. Ten workstreams would be assigned to specific ministries or agencies, each responsible for driving policy reforms (e.g., emission standards) and accelerating program implementation (e.g., EV charging infrastructure, low-sulfur fuel roll-out) in collaboration with other stakeholders. The proposed taskforce would elevate air pollution as a national priority, strengthen coordination, enforce accountability, and direct resources more effectively. The Coordinating Minister for Infrastructure and Regional Development could serve as a potential lead for the Steering Committee and house the Secretariat, given the critical role of infrastructure development in achieving the recommended strategies. The proposed governance model remains high-level and flexible, designed to strengthen cross-agency coordination over time.

Case studies from other emerging markets that have successfully reduced air pollution, Beijing and Mexico City, show that integrating national and local governance is crucial to drive successful implementation. China launched a 'War on Air Pollution' in 2013 with the launch of Beijing's Coordination Group for Air Pollution Prevention and Control in the Beijing-Tianjin-Hebei Region.[12] Between 2013-2023 when the Group existed, the region achieved a 59% reduction in $PM_{2.5}$, from 106 to 43 μg/m³, respectively.[13] Similarly, Mexico City, once deemed the world's most polluted city by the UN in 1992 and doubly burdened by a valley geography that trap pollutants, launched the Metropolitan Environmental Commission and ProAire program,[14] reducing SO_2 by 89% and PM_{10} by 66%.[15] Key lessons from top-performing cities show that a centralized, coordinated framework across national and local governments, focused on high-polluting sectors like transport, industry, and power, can effectively reduce air pollution, drive economic growth, and improve public health.

[12] UNEP. (2019). A review of 20 years' air pollution control in Beijing.; Wang, J., Zhang, L., & Liu, Y. (2018). Taking action on air pollution control in the Beijing-Tianjin-Hebei (BTH) region: Progress, challenges, and opportunities.

[13] Latest data from Beijing Ecology and Environment Bureau (March 2025).

[14] Center for Public Impact. (2016). Mexico City's ProAire Programme.

[15] The Nature Conservancy. Planting healthy air case study: Mexico City

FIGURE ES5: HIGH-LEVEL PROPOSAL FOR A CENTRALIZED COORDINATING TEAM

	Workstreams	Priority Focus	Main Stakeholders
Pillar 1: Energy Transition-Related	1 **Workstream 1:** Electric Vehicles	Accelerate adoption of electric vehicles (E2W, E4W, E-bus, E-truck) and expand city-wide charging infrastructure	Jakarta Provincial Government, PLN, MEMR
	2 **Workstream 2:** Power	Develop stringent emissions standards aligned with global benchmarks, enforce controls and encourage transition	MEMR, PLN, MSOE, MoE
Pillar 2: Policy Enforcement & Issuance	3 **Workstream 3:** Industry	Develop stringent emission standards and enforce cleaner technologies, inc. PCC, CEMS, and e-heating solutions	MoE, MoF, MoI
	4 **Workstream 4:** Fuel Quality	Accelerate adoption of EURO IV fuel through policy and implementation of timeline	MEMR, Pertamina
	5 **Workstream 5:** Waste Open Burning	Expand waste mgmt. infrastructure and improve monitoring and enforcement against open burning	Jakarta Provincial Government, MoE
	6 **Workstream 6:** Construction	Issue emission standards for construction dust and enforce monitoring	Jakarta Provincial Government, MoE, MoPW
	7 **Workstream 7:** Public Transport & LEZ	Accelerate public transport infrastructure and development of Low Emission Zone	Jakarta Provincial Government, MoT
	8 **Workstream 8:** Financing	Develop financing mechanisms to support air pollution program and policy implementation	MoF
Pillar 3: Data & Health	9 **Workstream 9:** Data & Monitoring	Develop national and regional emissions inventories, enforce AQI aligned with global standard, oversee AQM	MoE
	10 **Workstream 10:** Public Awareness	Develop public awareness and education campaigns on health impact of air pollution	MoH

MoE (Ministry of Environment), MoI (Ministry of Industry, MSOE (Ministry of State-Owned Enterprise), MEMR (Ministry of Energy and Mineral Resources), MoF (Ministry of Finance), MoH (Ministry of Health), MoPW (Ministry of Public Works), MoT (Minisry of Transportation), MoHA (Ministry of Home Affairs), Jabodetabek (Jakarta, Banten, West Java)

Proposed sectoral levers provide significant co-benefits for national climate goals, especially when integrated into a broader energy transition. Electrification technologies, EVs and clean tech for industrial boilers, reduce emissions but are most effective when paired with a greener electrical grid powered by renewable energy sources. Expanding public transport ridership will reduce private vehicle trips and cut per capita carbon emissions. Eliminating open waste burning and improving waste management facilities, such as landfill upgrades and composting, can reduce black carbon and methane emissions—key climate pollutants. Additionally, integrating Nature-Based Solutions (NBS), such as urban greening, reforestation, and green buffers around industrial zones, can complement technological measures by naturally filtering air pollutants and enhancing local resilience. Addressing air pollution and climate mitigation together creates a win-win solution for Jakarta.

Achieving Better Air in Jakarta ensures a Better Indonesia — for our environment, health, and economy.

Table of Contents

List of Abbreviations

CAPEX : Capital Expenditure
CMMIA: Coordinating Ministry for Maritime and Investment Affairs
CMIRD : Coordinating Ministry for Infrastructure and Regional Development
CO : Carbon Monoxide
DG : Directorate General
E2W : Electric 2-Wheeler
E4W : Electric 4-Wheeler
EV : Electric Vehicle
GDP : Gross Domestic Product
GRDP : Gross Regional Domestic Product
GoI : Government of Indonesia
LEZ : Low Emission Zone
MoE : Ministry of Environment
MoEF : Ministry of Environment and Forestry
MEMR : Ministry of Energy and Mineral Resources
MoF : Ministry of Finance
MoH : Ministry of Health
MoHA : Ministry of Home Affairs
MoI : Ministry of Industry
MoPW : Ministry of Public Works
MoT : Ministry of Transportation
MSOE : Ministry of State-Owned Enterprise
NO_x : Nitrogen Oxides
OPEX : Operational Expenditure
$PM_{2.5}$: Particulate Matter with an aerodynamic diameter below 2.5 µm
PM_{10} : Particulate Matter with an aerodynamic diameter below 10 µm
SO_2 : Sulfur Dioxide
TSP : Total Suspended Particulate
VOC : Volatile Organic Compounds

1

INTRODUCTION

THE CASE FOR ACTION

CASE FOR ACTION

The science is clear: air pollution is one of the deadliest environmental health risks in the world, estimated to cause 8.1 million deaths worldwide in 2021.[16] The problem is particularly severe in emerging markets and developing countries, where there is rapid economic growth and increasing urbanization, yet limited regulatory and physical infrastructure for stringent environmental management. This situation often leads to unprecedented harmful levels of air pollution, along with a society and administration that are not yet well-equipped to mitigate it.

Indonesia is no exception, as Jakarta continues to rank among the most polluted cities in the world.[17] In 2023, annual mean $PM_{2.5}$ concentration amounted to 39.6 µg/m^3, which is more than 2 times of the national standard (15 µg/m^3) and more than 6x of the WHO guidelines at (5 µg/m^3).[18] The World Bank estimated that in 2019, the economic burden of air pollution in Indonesia totaled $220 billion in health costs, equivalent to 6.6% of Indonesia's GDP PPP.[19]

Jakarta's air quality has raised public concern globally and locally. In June 2023, IQAir named Jakarta as the #1 most polluted city in the world in their daily rankings, which made global headlines and prompted immediate urgent response from government officials.[20] In 2021, citizens under the umbrella "Coalition of Clean Air Initiative" filed a lawsuit against government officials, including President Jokowi. The court ruled in favor of the citizens-led Coalition, asserting that the Indonesian government had neglected the citizens' rights to clean air.[21]

To tackle Jakarta's air pollution, several government programs have been initiated. Programs include establishing national targets for EVs (Presidential Regulation 55/2019), promoting the roll out of cleaner fuel (MOEF Regulation 17/2020), and installing stringent air pollution controls in industries and power plants. The Governor of Jakarta issued Governor's Decree 576/2023 on Jakarta's Air Pollution Control Strategy (SPPU), a 16-step program to improve local air pollution governance, mobile source emissions and stationary source emissions.

Jakarta's worsening air pollution is largely driven by urbanization and economic development, which currently relies on high-carbon solutions such as internal combustion engines (ICE) and coal energy. This reliance imposes significant health costs, disproportionately affecting Jakarta's residents. However, with low-carbon solutions becoming increasingly cost-competitive, Jakarta has a unique opportunity this decade to transform its core industries. This transformation can pave the way for a healthier, more prosperous society that is green, resilient, and inclusive.

Other cities around the world, including Beijing and Mexico City, show that in emerging economies, it is possible to decouple economic growth from air pollution. China implemented a 'War on Air Pollution' in 2013 and within 5 years, Beijing and its surrounding area across Tianjin and Hebei (BTH region) was able to reduce $PM_{2.5}$ by 30%.[22] Mexico City, once considered the most polluted city by the UN in 1992, doubly

[16] Health Effects Institute & Global Burden of Disease. (2024). State of Global Air Report 2024. https://www.stateofglobalair.org/resources/report/state-global-air-report-2024.

[17] For more information on rankings and their respective methodologies, please see: IQAir, Air Quality Life Index (AQLI).

[18] Environmental Agency Jakarta (2023), "Annual Report on Air Quality Monitoring Activities for the DKI Jakarta Province in 2023".

[19] World Bank (2022), "The Global Health Cost of $PM_{2.5}$ Air Pollution: A Case for Action Beyond 2021".

[20] This ranking is based on IQAir's methodology of calculating daily Air Quality Index. For more information, please see: IQAir; Associated Press. (2023, August 11). Jakarta is the world's most polluted city. Blame the dry season and vehicles for the gray skies. https://apnews.com/article/indonesia-jakarta-air-pollution-dry-season-vehicles-ef97483d1c3de48207619562635710c2.

[21] Greenpeace (19 September 2022), "Champions of clean air: People power in the fight against air pollution", retrieved 17 November 2024, from internet.

[22] UNEP (2019), "A Review of 20 Years' Air Pollution Control in Beijing"; Wang et al (2018), "Taking Action on Air Pollution Control in the Beijing-Tianjin-Hebei (BTH) Region: Progress, Challenges and Opportunities".

challenged with its unique geography and high altitude, was also able to significantly improve air pollution through the ProAire program.[23] For both cities, improvements were achieved through large scale political and legislative reforms, driven by strong collaboration between local and federal governments, the establishment of clear and measurable targets, and widespread public campaigns. Implementing major reforms across cleaner transport, higher fuel standards, industrial restructuring, installing air pollution controls, and improved urban planning, the cities were able to improve its residents' quality of life and city infrastructure.

This report aims to answer the following exam question: how can the Indonesian government design and implement an air pollution action plan that improves public health, unlocks economic benefits, and establishes an effective governance model across key agencies? To answer this question, three key sub-questions are addressed: (1) What is the current 2023 baseline and what are the main sources of air pollution? [Chapter 2] (2) What are the key sectoral levers that can maximize impact to air pollution, health and economy? [Chapter 3] (3) What is the right governance model and who are the accountable agencies to drive implementation? [Chapter 4].

Better Air, Better Indonesia aims to contribute to existing literature of Jakarta air pollution studies: (1) featuring a new 2023 baseline; (2) prioritization of a multi-action agenda of proposed levers and an assessment of their impact to pollution, economy, and health; and (3) co-developed with government, proposing a centralized governance model to drive the implementation of key programs. This report will add to existing literature of air pollution by providing a systemic view of the economic and political case for improved air pollution. There exists a vast literature of studies regarding Jakarta, and broadly Indonesia's, air pollution which this report aims to build upon, including scientific studies measuring Indonesia's ambient air quality, city-wide baseline through Emissions Inventory and Source-Based Apportionment, and evaluating the total health impact based on the Global Burden of Disease 2019 methodology.[24]

The scope of this report is limited to the administrative boundaries of the Special Region of Jakarta. As the nation's largest city and the highest polluted city in Indonesia, tackling Jakarta's air quality first is urgent priority. Based on the scientific literature, it is important to note that as air pollution is inherently trans-boundary, Jakarta's pollution is heavily impacted by source contributors from surrounding regions outside of the city. However, due to limited data availability on emissions inventories in the Greater Jakarta region and in response to the government's priority to focus on Jakarta, this report has narrowed its impact assessment to Jakarta. Further studies on the Greater Jakarta area and other Indonesian regions are crucial for continued research and a deeper understanding of Indonesia's air quality. Notably, the Ministry of Environment (MoE) has ambitions to develop an official national emissions inventory database, that would work together with local and regional governments to submit regional emissions data. This would require establishing a standardized methodology for data collection and calculation and then providing capacity-building for local governments to conduct regional emissions inventories. If achieved, this would strengthen data and monitoring efforts by creating an official, government-based emissions inventory that is consistent and updated annually.

[23] Center for Public Impact (2016), "Mexico City's ProAire Programme".
[24] See appendix for literature review.

REPORT STRUCTURE

Chapter 2 delves into the current state of air quality monitoring and key sources of air pollution in Jakarta, which includes an update on the city's emissions inventory using 2023 data and features Business-as-Usual (BAU) projections to 2035.

Building on the findings, **Chapter 3** outlines twelve key levers targeting both mobile and stationary pollution sources in key sectors (transportation, industry, power, waste, and construction) and quantifies each lever's economic cost and their proposed environmental and health impact.

Chapter 4 reviews the current institutional setup and proposes recommendations on an effective governance model to ensure streamlined implementation of each lever.

Lastly, **Chapter 5** summarizes the proposed recommendations on tackling air pollution issue from a sector-by-sector level as well as a governance model recommendation that requires local-national collaboration.

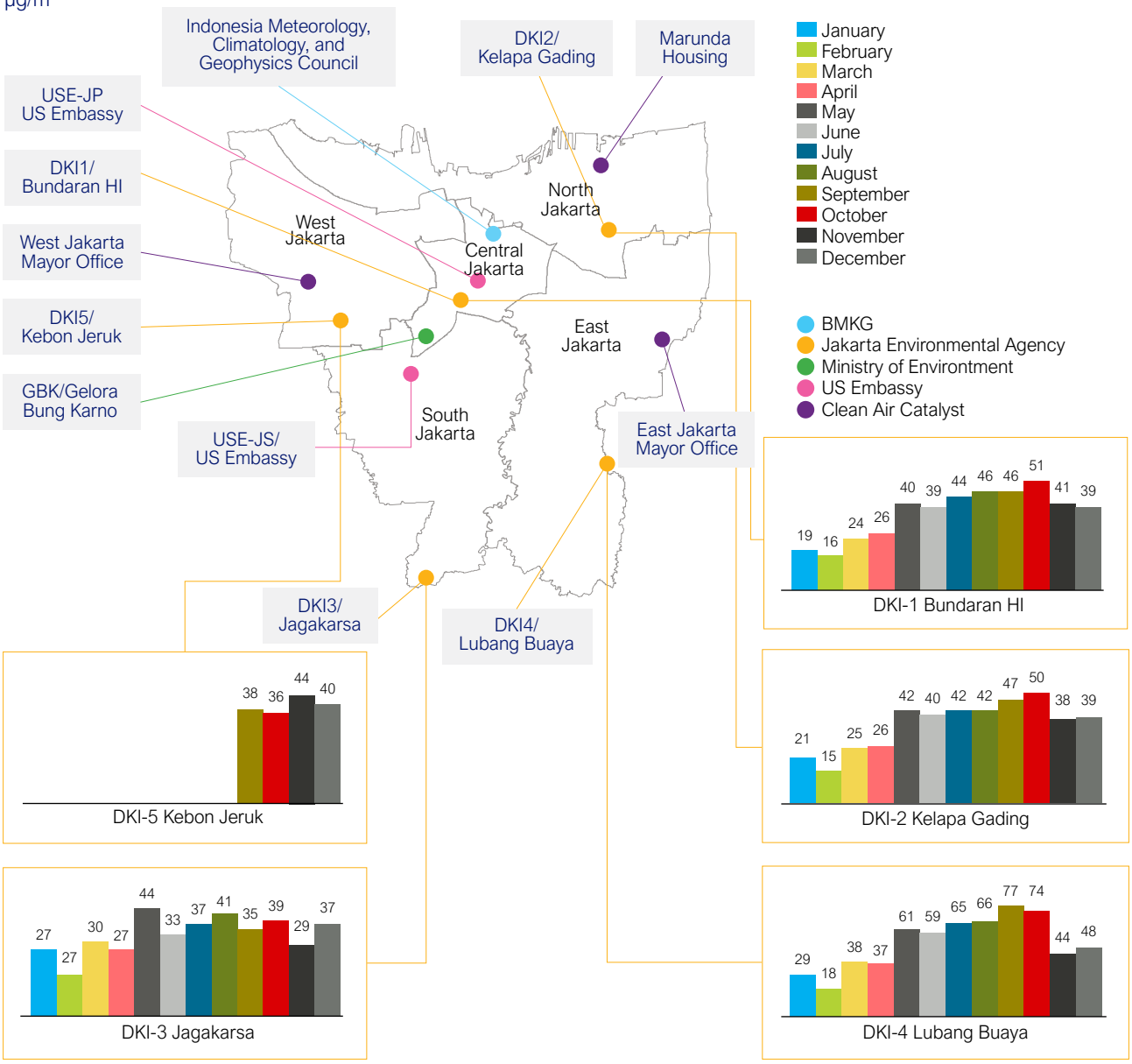
2 WHAT ARE THE SOURCES OF JAKARTA'S AIR POLLUTION IN 2023?

AMBIENT AIR QUALITY MONITORING

There are currently twelve reference-grade air quality monitoring stations (AQMS) in Jakarta managed by the Indonesian Meteorology, Climatology, and Geophysical Agency (BMKG), Jakarta Environmental Agency (DLH), Ministry of Environment (MOE), Clean Air Catalyst (CAC) and the US Embassy. The collected data provides critical input for understanding pollution dynamics and developing effective mitigation strategies. The most recent are three AQMS for $PM_{2.5}$ operated under the Clean Air Catalyst (CAC) project from 2023, which are located at the East Jakarta City Mayor's office, West Jakarta City Mayor's office and Marunda housing in North Jakarta. To strengthen air quality data, it is crucial to increase the number of air quality monitoring stations and develop an integrated database. The spatial distribution and coverage of these monitors, however, may not fully capture localized pollution hotspots, highlighting the need for increased number of AQMS and technologically advanced reference-grade monitoring network that also provide meteorological data.

FIGURE 1. 2023 DAILY AVERAGE CONCENTRATION OF $PM_{2.5}$ PER MONTH

µg/m³



Jakarta's air quality trends indicate a persistent deterioration, with annual average $PM_{2.5}$ concentrations showing an alarming increase over recent years. This pattern underscores the escalating influence of anthropogenic sources on ambient air quality. Data from AirNow and US Embassy AQMS reveal that Jakarta's pollution levels frequently exceed both the daily $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS) of 55 µg/m³ and the more stringent World Health Organization (WHO) Air Quality Guideline of 15 µg/m³. As indicated by the figure below, the daily average $PM_{2.5}$ concentrations fluctuate, notably with mostly high concentration during dry season. evaluated against the National Air Quality Index (ISPU), up to 47.2% of days in 2023 were considered unhealthy, very unhealthy or hazardous depending on the locations.

FIGURE 2. JAKARTA $PM_{2.5}$ DAILY CONCENTRATION

µg/m³

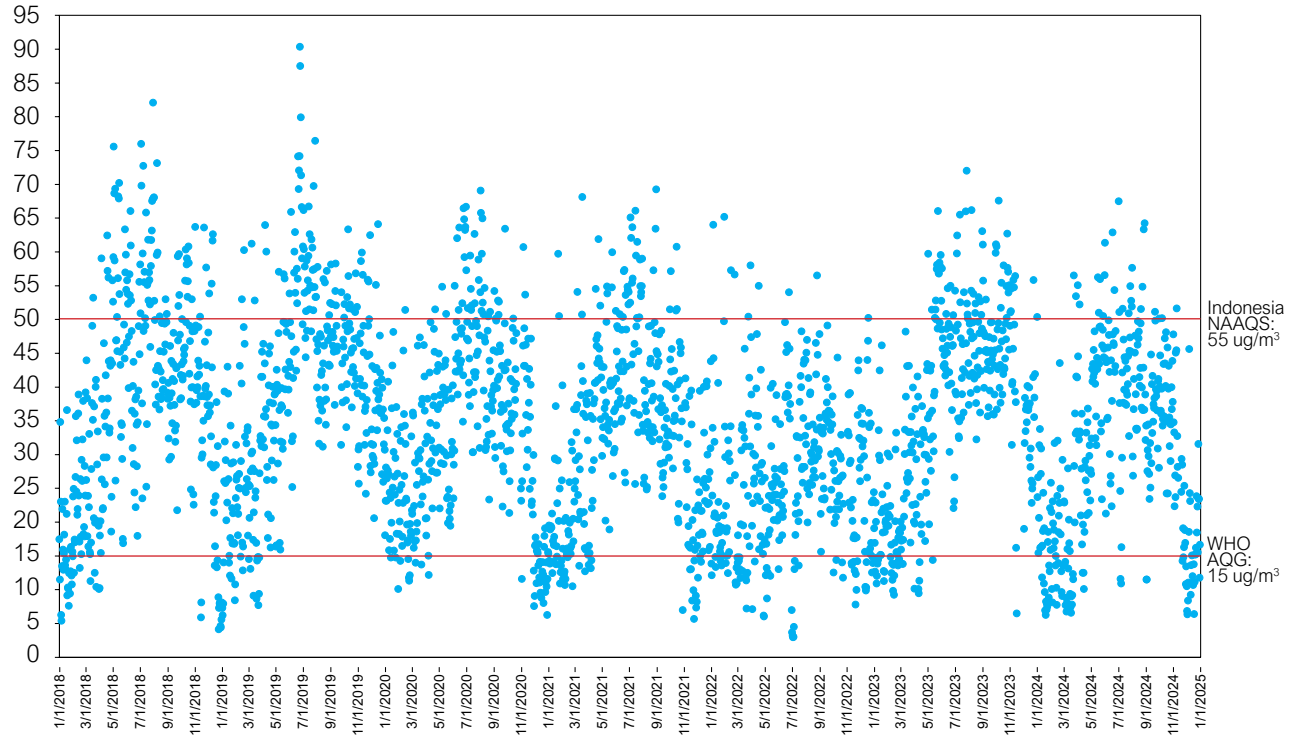


FIGURE 3. JAKARTA $PM_{2.5}$ CONCENTRATION BY MONTH 2018-2024

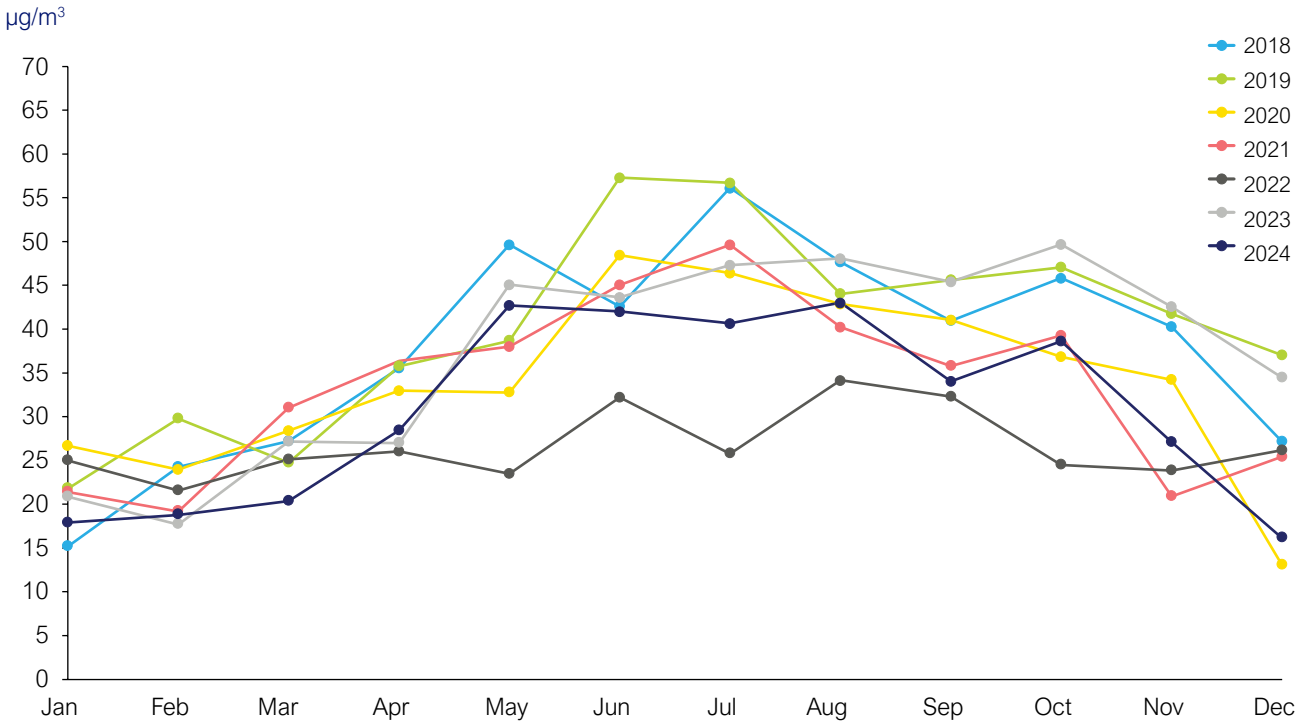
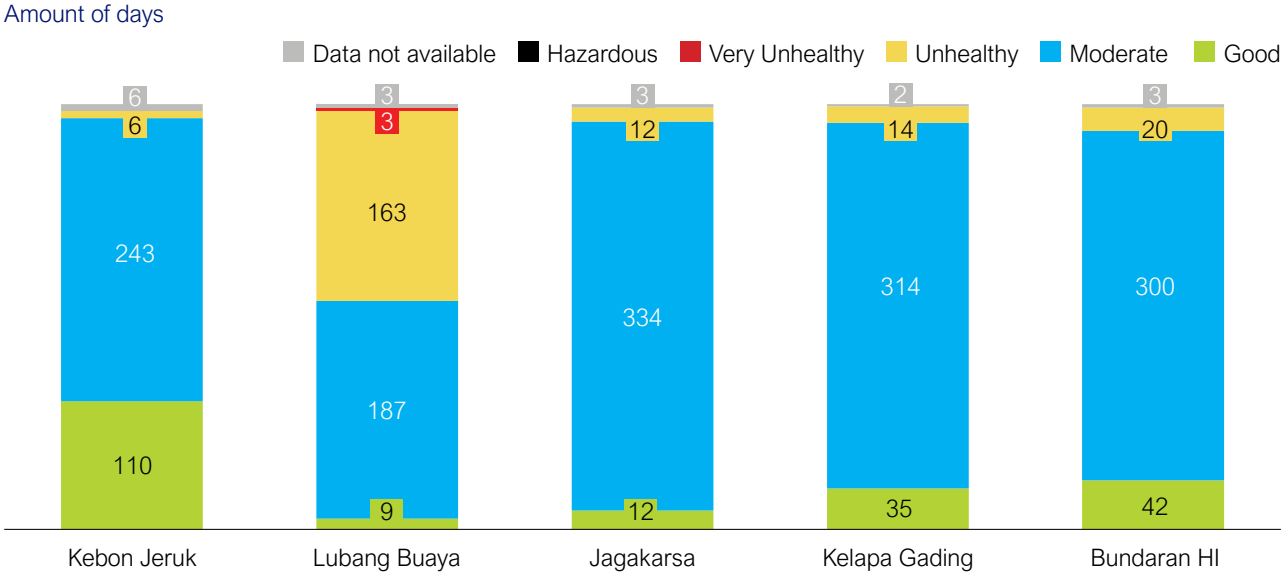


FIGURE 4. JAKARTA AIR POLLUTION INDEX (ISPU) 2023



Source: Environtmental Agency of Jakarta 2023

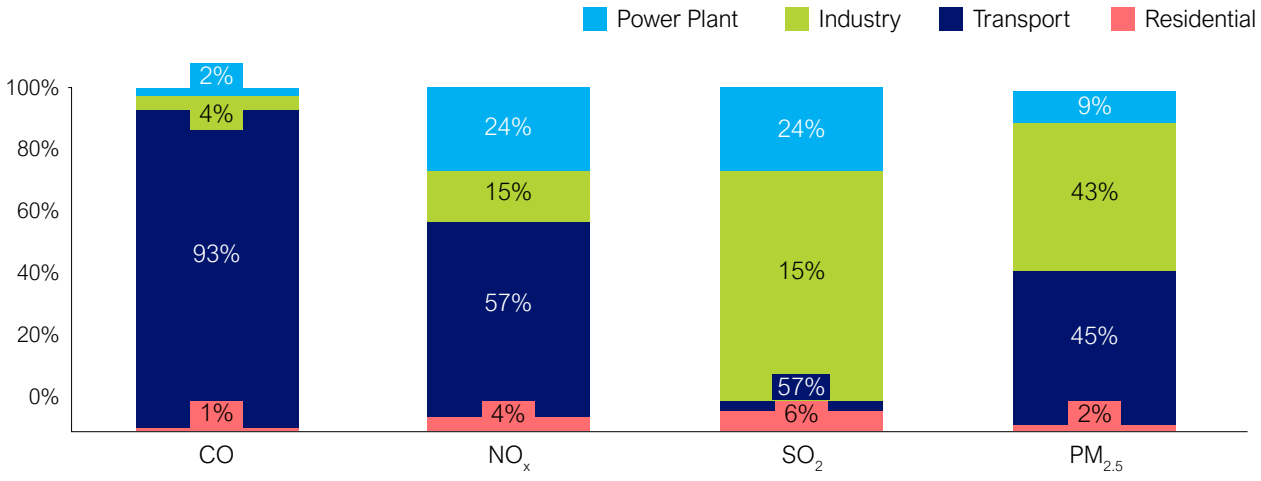
IDENTIFYING SOURCES OF POLLUTION

To understand the key sources of air pollution, there are two methodologies: Emissions Inventory and Receptor-Based Source Apportionment, which offer complementary insights into Jakarta's pollution profile. Emission Inventory is a bottom-up methodology which calculates the emissions load of activities within a defined region, based on activity data, control technology, and local emissions factor. Receptor-Based Source Apportionment is a top-down methodology based on collecting ambient air filter samples from air quality monitoring sites, evaluating the chemical composition of receptors and matching data on specific source fingerprint. The benefit of source apportionment studies, as opposed to emissions inventories, is that it can identify potential transboundary sources coming from outside Jakarta, including from industrial zones, coal-fired power plants (CFPPs), and road transport exhaust in surrounding provinces of Banten and West Java. However, as source apportionment studies require more intensive efforts, there have only one conducted for Jakarta to-date.

To date, there have been 2 emissions inventories and one source apportionment study. The 2015 Emissions Inventory, conducted by ITB, underscores the predominance of the transport sector, followed by industry, power generation, and residential activities.[25] This methodology aggregates emissions based on activity data and emission factors, presenting a macro-level perspective essential for policy design.

FIGURE 5. JAKARTA EMISSIONS INVENTORY 2015 BY ITB

Sources of Air Pollution in Jakarta based on 2015 data



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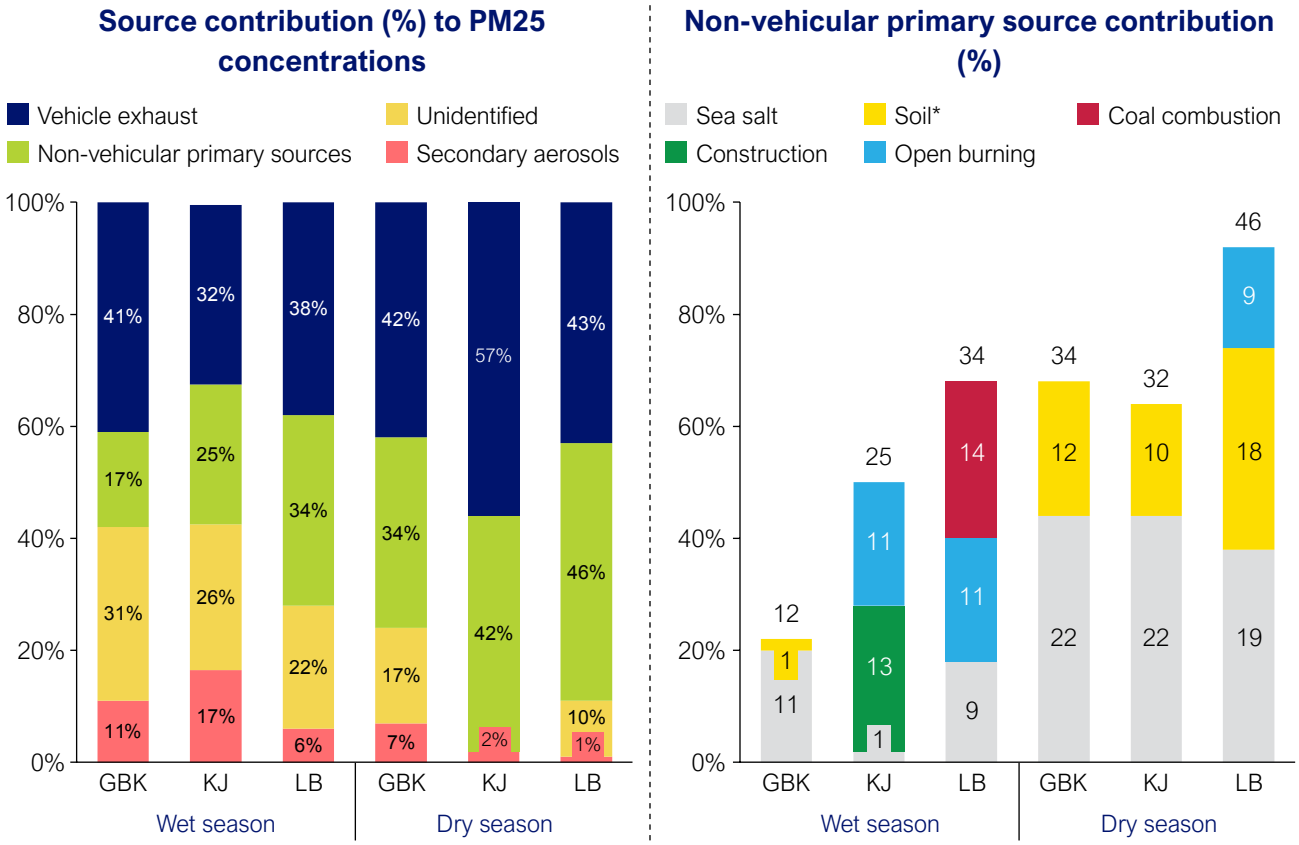
[25] Lestari, P., Santoso, M., & Suyanto, S. (2022). Emissions and spatial distribution of air pollutants from anthropogenic sources in Jakarta. Atmospheric Pollution Research. https://doi.org/10.1016/j.apr.2022.101521

FIGURE 6. RECEPTOR-BASED SOURCE APPORTIONMENT STUDY (VITAL STRATEGIES & ITB)[26]



The Source Apportionment Study led by ITB with Vital Strategies is based on monitoring using Mini Volume Sampler from Air Metric and show the difference between wet season (October 2018-March 2019) and dry season (July-September 2019). In order to understand the $PM_{2.5}$ chemical content (composition) and leading sources, ITB collected 24-hour filter samples of $PM_{2.5}$ at three urban background sampling sites that were interspersed in different districts of Jakarta: Gelora Bung Karno (GBK), Kebon Jeruk (KJ) and Lubang Buaya (LB). These sites were selected based on land use, topography, weather (e.g. wind pattern) and other considerations to capture potential variation in air pollution sources and were co-located with government-owned air quality monitoring stations at the provincial and national level. The study captures the seasonal change which affect $PM_{2.5}$ concentration. $PM_{2.5}$ concentration during dry season has relatively higher concentration than wet season, which may be affected by precipitation rate as one of many meteorological factors. Wind patterns also impact seasonal changes: the prevailing wind for the wet season came from West and Southwest of Jakarta, whereas that for the dry season was from East and Northeast of Jakarta.

The findings are overall aligned with previous emissions inventories with additional highlights of differences between dry and wet season. While transport is the main source of pollution across seasons, non-vehicular emissions vary based on sampling location and season. For non-vehicular primary sources, coal combustion and open burning were the leading anthropogenic pollution sources. The impact of coal combustion on air quality in Jakarta can already be detected, which may come from coal combustion in industries or from coal-fired power plants (CFPPs) which exist

[26] Vital Strategies. (2020). Identifying the main sources of air pollution in Jakarta: A source apportionment study.

outside the city limits in surrounding provinces. There is variation in leading sources to $PM_{2.5}$ concentration across seasons and by location, due to difference in local activities or regional sources of pollution, depending on weather condition (e.g., emissions from surrounding cities).

2023 EMISSIONS INVENTORY AND PROJECTIONS

To determine current baseline and develop long-term projections of BAU versus impact levers, this report features an Emissions Inventory conducted by ITB, using 2023 as baseline year. The analysis in this assessment employs the GAINS (Greenhouse Gas and Air Pollution Interactions and Synergies) model developed at the International Institute for Applied Systems Analysis (IIASA). In this study, the GAINS model was used to calculate air pollutant emissions from 2023 to 2035, with data from 2023 serving as the baseline year. Relevant sectors in the model include power plants, industry, residential, commercial, fishery, road transport, waste, and construction. The model offers robust scenario analysis capabilities to project emissions trends and assess the long-term effectiveness of proposed levers. This inventory integrates updated activity data derived from government agencies including the Jakarta Environmental Agency, PLN Indonesia, Pertamina, MoE, MoH, Central Bureau of Statistics (BPS).[27]

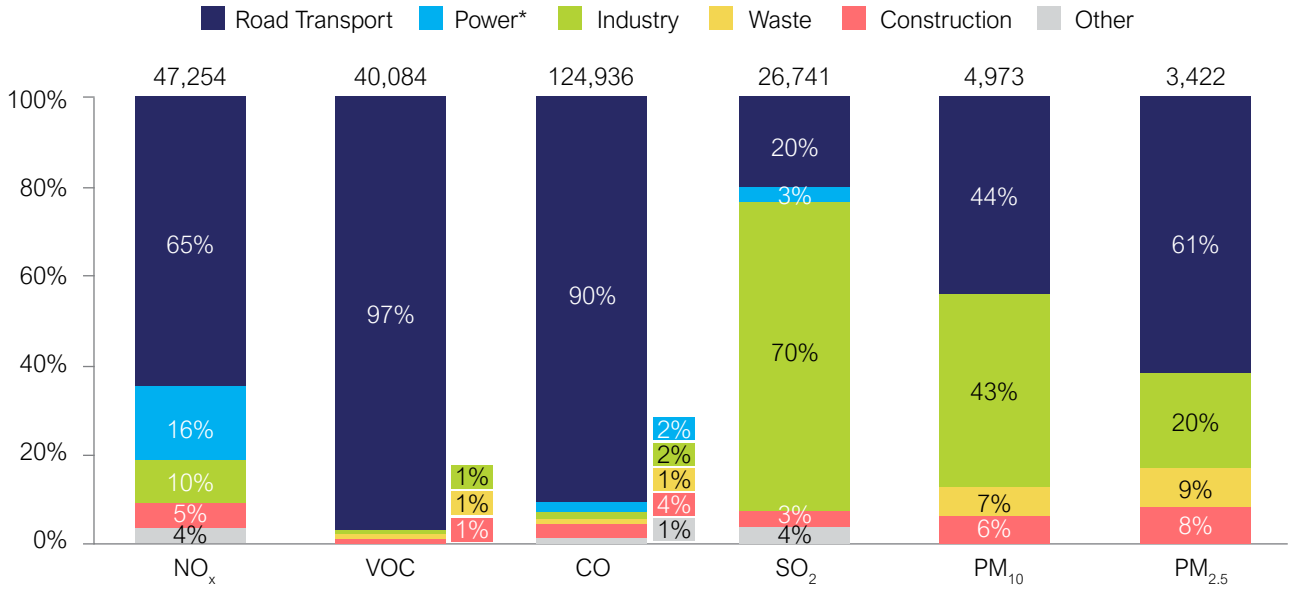
Results from the 2023 baseline emissions inventory show that key sectors contributing to Jakarta air pollution are transport, industry, power, waste and construction. The results show marked contributions from the transport, industry, power, waste and construction sectors. Road transport is by far the largest contributor to air pollution, comprising 61% of $PM_{2.5}$, 97% of VOC, 90% of CO and 65% NO_x emissions. Industry is a significant contributor to SO_2 (70%) and PM_{10} (43%). The power sector, comprised of power plants Combined Cycle Gas Turbine (CCGT) Muara Karang and Tanjung Priok, contributes to 16% of NO_x emissions. Open waste burning further contributes 9% of $PM_{2.5}$ and 7% of PM_{10}. The construction sector, including construction dust particles and emissions of machinery, contribute 8% of $PM_{2.5}$ pollution. Other sectors, including residential, commercial, and fisheries, also feature in the emissions inventory, highlighting the multifaceted nature of air pollution sources. These statistics underscore the need for targeted interventions across all sectors to combat pollution effectively.

Due to the limitations of this emissions inventory, proposed further areas of research include expanding scope to include Greater Jakarta area,[28] additional updated source apportionment to identify transboundary sources, and more detailed primary data, as the current emissions inventory largely utilizes secondary data derived from government agencies. A more detailed industrial emissions inventory, for small-medium enterprises, is needed, given the limitations of industrial emissions reporting to Jakarta Environmental Agency and MoE.

[27] See Annex for more information on input assumptions.
[28] For more information, please see ITB & ViriyaENB. (forthcoming). Emission inventory in Jabodetabek.

FIGURE 7. 2023 JAKARTA EMISSIONS INVENTORY

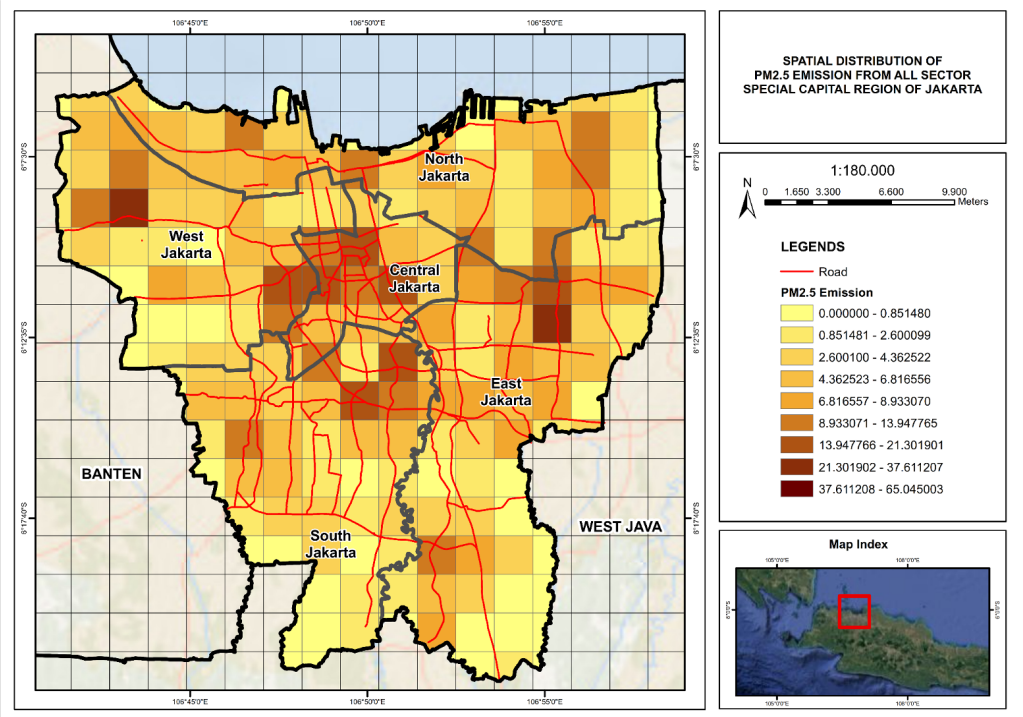
In %, tons



Source: ITB. Emissions Inventory calculated using GAINS model.

Note: (*) Power emissions only cover CCGT power plants in Jakarta: PLTG Tanjung Priok and Muara Karang

FIGURE 8. $PM_{2.5}$ EMISSIONS SPATIAL DISTRIBUTION 2023



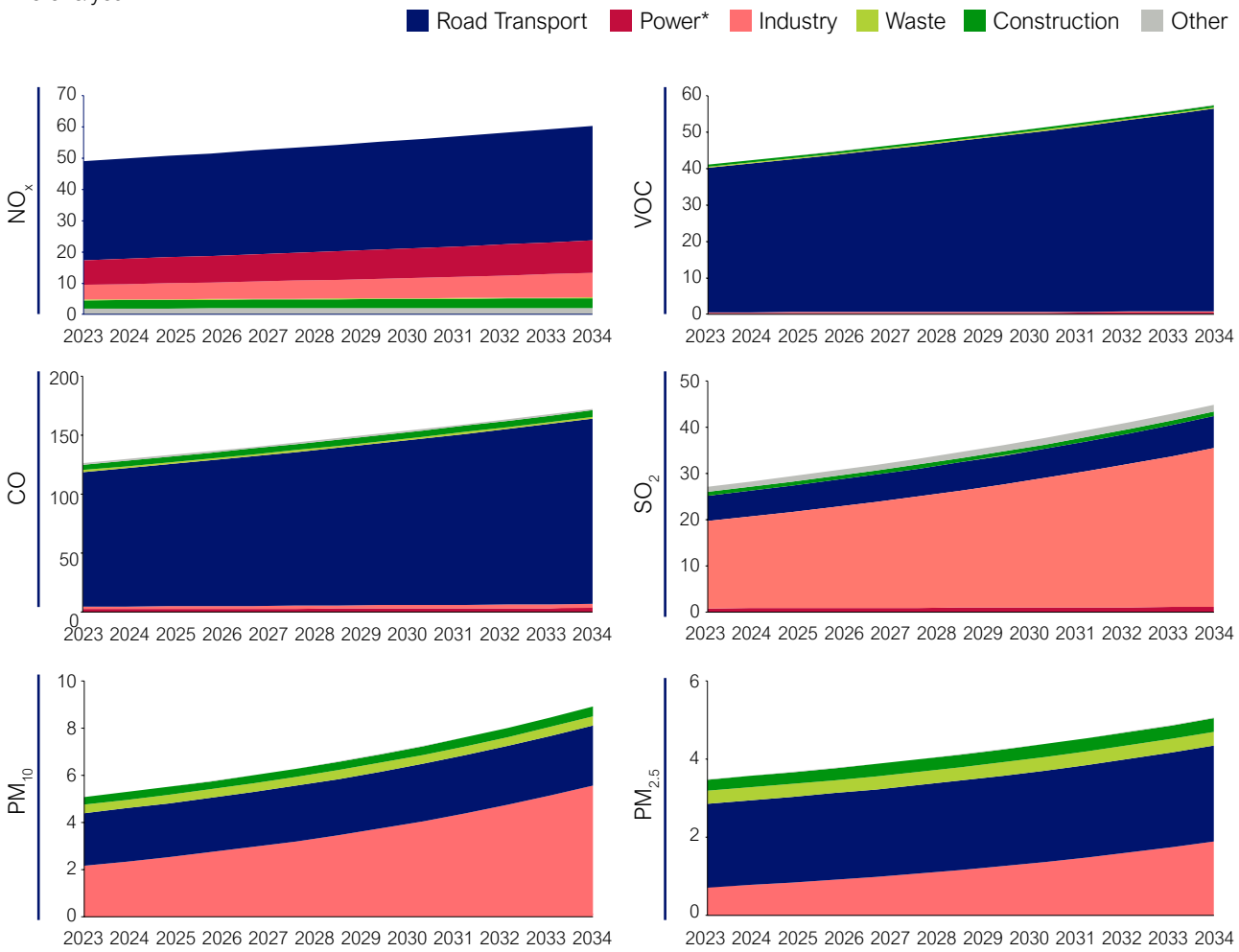
Spatial distribution of $PM_{2.5}$ emissions above show that $PM_{2.5}$ emissions in Jakarta are heavily concentrated along major roadways in Central Jakarta and industrial areas in East and West Jakarta. For transport sector, spatial distribution was developed based on number of vehicles traffic volume on each grid based on traffic counting. Whereas for non-transport sectors were developed based on the number of emission sources (e.g. industries, power plants) within each grid proportionally. Central urban regions with high traffic density show higher concentrations of $PM_{2.5}$, emphasizing the need for targeted interventions in these areas to reduce emissions. Proposed strategies that will be further elaborated in the below sections, including improving public transportation, promoting electric vehicles, and implementing EURO IV emission standards for high-emission zones, could be effective in mitigating the impact of transport-related emissions. Industries in East and West Jakarta, which rely on coal or gas-fired boilers, also contributed significantly to $PM_{2.5}$ emission.

BAU projections for 2035 forecast a significant increase in emissions across all sectors if current trends continue, with cumulative emissions expected to rise by 39%, from 247 kilotons in 2023 to 343 kilotons in 2035. Transport-related emissions are anticipated to rise sharply due to increasing vehicle ownership. Continued industrial expansion, increasing energy demand, urban development, and expanded waste generation will contribute to projected emissions across all other sectors. The BAU scenario estimation for each sector is carried out using energy consumption trends, utilizing historical and current data.

The transport sector is the most significant contributor to air pollution and will continue to magnify with current trends of rising vehicle population. In 2023, the city has around 12.8 million vehicles, comprising of 21% cars, 75% motorcycles, 0.2% buses, and 4% trucks. By 2035, Jakarta is projected to have 20.8 million vehicles, if annual growth rates continue. Increasing private vehicle ownership, limited road infrastructure and slower adoption of public transport has also resulted in worsening traffic congestion.

FIGURE 9. EMISSIONS INVENTORY BUSINESS-AS-USUAL PROJECTIONS 2023-2035

Kilotons/year



The steady increase in emissions from all pollutants indicates a pressing need for integrated policies targeting vehicle emissions, cleaner fuels, industrial processes, and energy production. Additionally, focusing on expanding public transportation electrification and regulating urban construction activities could mitigate the growing emissions and their adverse health impacts on Jakarta's population. The implications of this trajectory are severe. Without intervention, the continued rise in emissions will lead to increased health cases, with significant economic burden. These projections highlight the urgent need for multi-sectoral interventions across transport, industry, power, waste and construction to curtail emissions.

Below chapters will detail proposed levers in key sectors, with each lever impact assessed against BAU. The chapters will also include an economic and health assessment of each lever.

3 KEY LEVERS FOR BETTER AIR, BETTER INDONESIA

Based on the key sectors identified from the emissions inventory, Better Air, Better Indonesia has identified 12 key levers across transport, industry, power, waste and construction sectors. Of these, impact on air pollution and health has been assessed for 11 levers, as lever #10 regarding CFPPs pertains to plants outside the administrative boundary of Jakarta. Proposed targets have been chosen based on current government targets; feedback based on stakeholder engagement with government, academics, and think tanks; and their high-impact potential based on peer countries' successes and other Jakarta cost-benefit analyses and impact assessment.[29]

Lever #10, focusing on CFPP controls and retirement, has been included as a key intervention due to the transboundary nature of emissions from CFPPs surrounding Jakarta. As this report's impact analysis relies on emissions inventory of emissions produced within administrative boundaries of Jakarta, the report is unable to conclusively report impact of CFPP controls and retirement outside of Jakarta. However, based on other Jakarta source apportionment and other global studies showing CFPP's impact to urban air quality.[30] CFPP air pollution controls and retirement are potential high-impact levers for air pollution, with significant correlation with Indonesia's energy transition plans based on MEMR National Electricity Plan. This report has included in this section a deep dive on air pollution controls and retirement related to CFPPs surrounding Jakarta.

Better Air, Better Indonesia report provides a roadmap for Jakarta to significantly reduce air pollution by 2030. It identifies twelve key levers, evaluated based on their impact on air pollution, health costs, economic effects on government and private sectors, and the political feasibility of regulatory reforms and governance models. Compared to the emissions load of 2030 Business-as-Usual projections, these measures could reduce the emissions of $PM_{2.5}$ by 92%, carbon monoxide (CO) by 64%, nitrogen oxides (NO_x) by 49%, sulfur dioxide (SO_2) by 33%, volatile organic compounds (VOCs) by 64%, and PM_{10} by 89%. Beyond environmental benefits, the levers have potential to contribute to a $40.7 billion electric vehicle (EV) market and save the government $1.2 billion in fuel subsidies. The health benefits are 32,747 avoided premature deaths from 2025 to 2030, resulting in an economic impact of $27 billion, equivalent to 1–2% of Jakarta's Gross Regional Domestic Product (GRDP).

The below sections will present the key insights of overall levers impact to air pollution, economy and health. This will be followed by an in-depth deep dive of each lever, outlining the context, challenges, proposed interventions and policy reforms.

[29] For more information on other proposed impact scenarios for Jakarta, please see: Lestari, P., Santoso, M., & Suyanto, S. (2022). Emissions and spatial distribution of air pollutants from anthropogenic sources in Jakarta. Atmospheric Pollution Research.; IIASA, ITB, MoH, & UNEP. (2023). National assessment of the costs of inaction of tackling air pollution in Indonesia.; Vital Strategies. (2024). Cost-benefit analysis for air pollution control strategies in Jakarta.

[30] Vital Strategies. (2020). Identifying the main sources of air pollution in Jakarta: A source apportionment study.

FIGURE 10. TWELVE KEY LEVERS

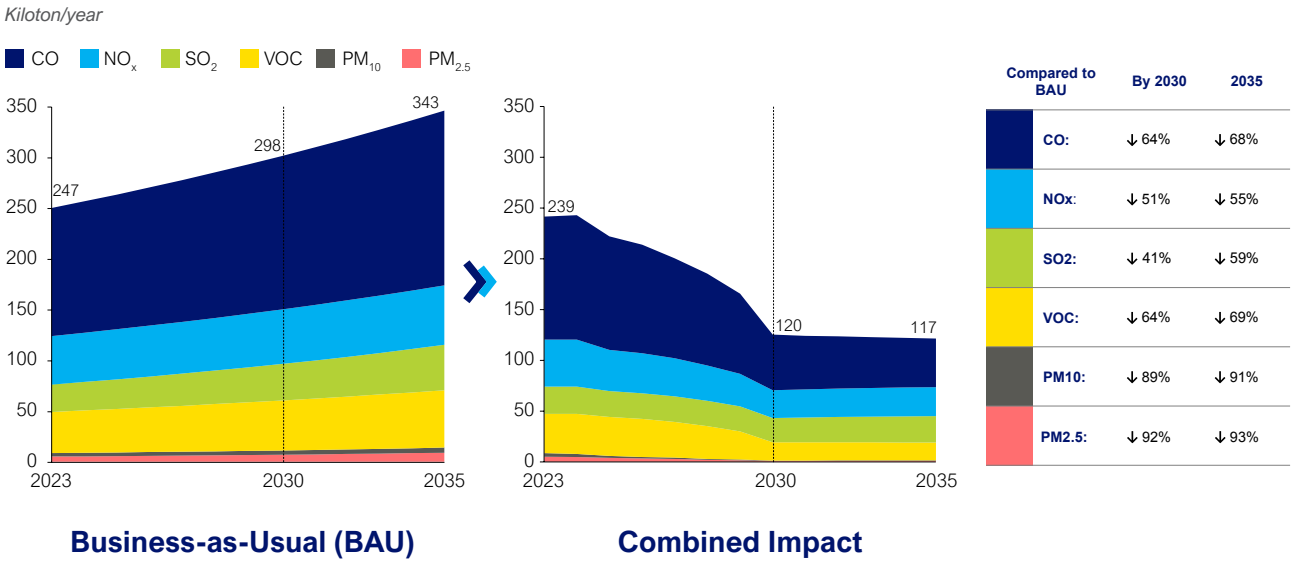
	Levers	2030 Targets
Transport	1 Low-sulfur fuel	100% Euro IV fuel adoption in Jakarta
	2 Electrification of 2W	45% electrification (5.5M E2W) of 2W in Jakarta*
	3 Electrification of 4W	23% electrification (887k E4W) of 4W in Jakarta*
	4 Electrification of trucks	15% electrification (115k E-Trucks) of trucks in Jakarta
	5 Electrification of TransJakarta bus	100% electrification (10k E-Buses) of Transjakarta
	6 Integrated public transport	60% Public Transport ridership
Industry & Power	7 Transition coal boilers to cleaner tech	0% coal usage in industrial boilers
	8 Industry post-combustion controls	50% of highest-emitting industries install NO_x and SO_2 controls
	9 Gas power plant controls	100% NO_x controls at combined-cycle gas turbines (CCGT)
	10 CFPP controls & retirement**	100% CFPPs compliance to post-2019 emission standards
Waste & Construction	11 Eliminate waste open burning	100% waste handling (zero waste open burning)
	12 Controlled construction dust	100% construction dust control

*Electrification targets extrapolated based on national 2030 targets: 13M E2W, 2M E4W
** CFPPs have been included as a notable lever as a key source of transboundary pollution. However, due to data limitations, the emissions inventory of this report is limited to the administrative boundary of Jakarta. As CFPPs are located outside of Jakarta, assessment of CFPP lever impact to air pollution is not included in report.

IMPACT TO AIR POLLUTION

If implemented, the key levers across transport, industry, power, waste and construction have the potential to reduce $PM_{2.5}$ by 92% by 2030. If implemented, these measures could reduce $PM_{2.5}$ by 92%, carbon monoxide (CO) by 64%, nitrogen oxides (NO_x) by 49%, sulfur dioxide (SO_2) by 33%, volatile organic compounds (VOCs) by 64%, and PM_{10} by 89%.

FIGURE 11. EMISSIONS INVENTORY PROJECTIONS 2023-2035: BAU VS. COMBINED IMPACT



Business-as-Usual (BAU) **Combined Impact**

The four highest impact levers to $PM_{2.5}$ are EURO IV (36%), transitioning coal boilers to cleaner technology (27%), expanding integrated public transport (9%) and eliminating open burning (8%).

Transport is the largest contributor to pollutants, and six key levers have been identified to address this issue. The proposed measures align with the Avoid-Shift-Improve (ASI) framework, with a particular emphasis on the "Shift" and "Improve" components: shifting users to more sustainable transport modes such as public transportation (Shift) and improving vehicle technology by adopting cleaner fuels and electrification to reduce emissions (Improve).

These measures are:

- **Low-sulfur fuel**: achieving 100% adoption of EURO IV fuel in Jakarta is the highest-impact lever on $PM_{2.5}$ across all proposed programs. By achieving GoI target of 100% adoption of EURO IV fuel, $PM_{2.5}$ levels can reduce 36% by 2030. The majority of fuel consumption of Indonesia currently uses EURO II fuel, which far lags behind international standards and peer developing countries which have achieved EURO IV and beyond, including Thailand, India and China.
- **Electric Vehicles** make up 4 levers, including electrification of trucks, Transjakarta bus, passenger 2-wheeler

and 4-wheeler. Combined impact of achieving targets for E2W, E4W, E-trucks and E-bus amounts to a total of 11% in $PM_{2.5}$ by 2030. EVs also have a significant impact on CO and VOC emissions: achieving 45% electrification of two-wheelers (2W) in Jakarta can reduce CO emissions by 25% and VOC emissions by 37%. Greater reductions can be achieved if the targets are made more ambitious.

- **Expanding Public Transport** is crucial to reduce transport by private vehicles. Achieving Jakarta target of 60% public transport ridership by 2030 has potential to reduce $PM_{2.5}$ emissions load by 9%.

Industry Sector: Industry is the second largest sector contributor to air pollution, making up 70% of SO_2. Two key levers are proposed to reduce industrial emissions:

- **Transitioning coal boilers to cleaner technology** is the second highest-impact lever to $PM_{2.5}$. In 2023, coal made up 3.8% of total energy consumption in industry but contributes to a significant share of PM_{10} and $PM_{2.5}$ emissions. Eliminating coal-based boilers by 2030 can reduce total $PM_{2.5}$ emissions load by 27% compared to BAU.
- **Industry post-combustion controls:** As cleaner boiler technology can significantly reduce $PM_{2.5}$, NO_x and SO_2 controls are needed to further reduce other pollutants. This report proposes a conservative target for 2030 of 50% of medium and large energy-intensive industries to install controls SCR (Selective Catalytic Reductor) and WFGD (Wet Flue Gas Desulfurization) for medium to large industries. Achieving this target can reduce NO_x by 1% and SO_2 by 5% CEM.

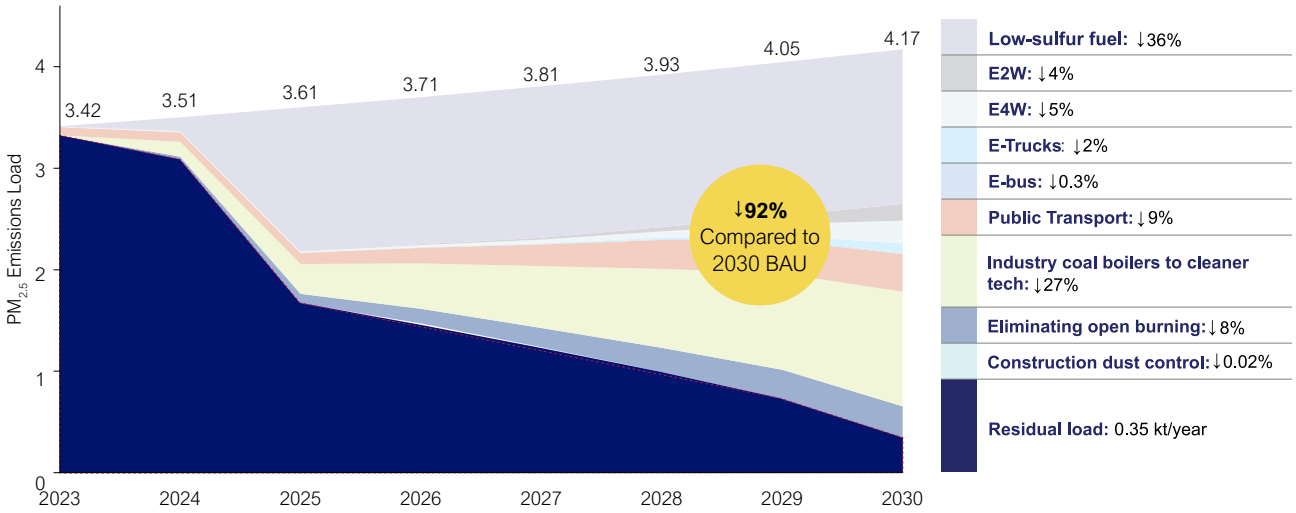
Gas power plant controls: The power sector in Jakarta is comprised of CCGT Tanjung Priok and Muara Karang which contributes to 16% of NO_x. Installing air pollution controls on gas power plants located inside Jakarta will result in 7% reduction of NO_x emissions load by 2030.

Eliminated waste open burning: Based on MOH data, about 1.2% of Jakarta residents report that they regularly burn waste.[31] Households often resort to open burning due to lack of access to proper waste management services, unaware of the dangerous health and environmental impacts. Eliminating open burning in Jakarta by 2030 will achieve 8% reduction in $PM_{2.5}$ emissions load.

Controlled construction dust: Construction contributes to $PM_{2.5}$ concentration in Jakarta, both from dust due to excavation and activity and energy consumption of bulk material transportation and heavy machinery. Currently there are no national emission standards for construction. Controlling construction dust will achieve 0.02% reduction in air pollution. Further reduction can be achieved with improved monitoring and data collection of construction activities.

[31] Ministry of Health. (2024). Riset Kesehatan Dasar (Riskesdas) 2023

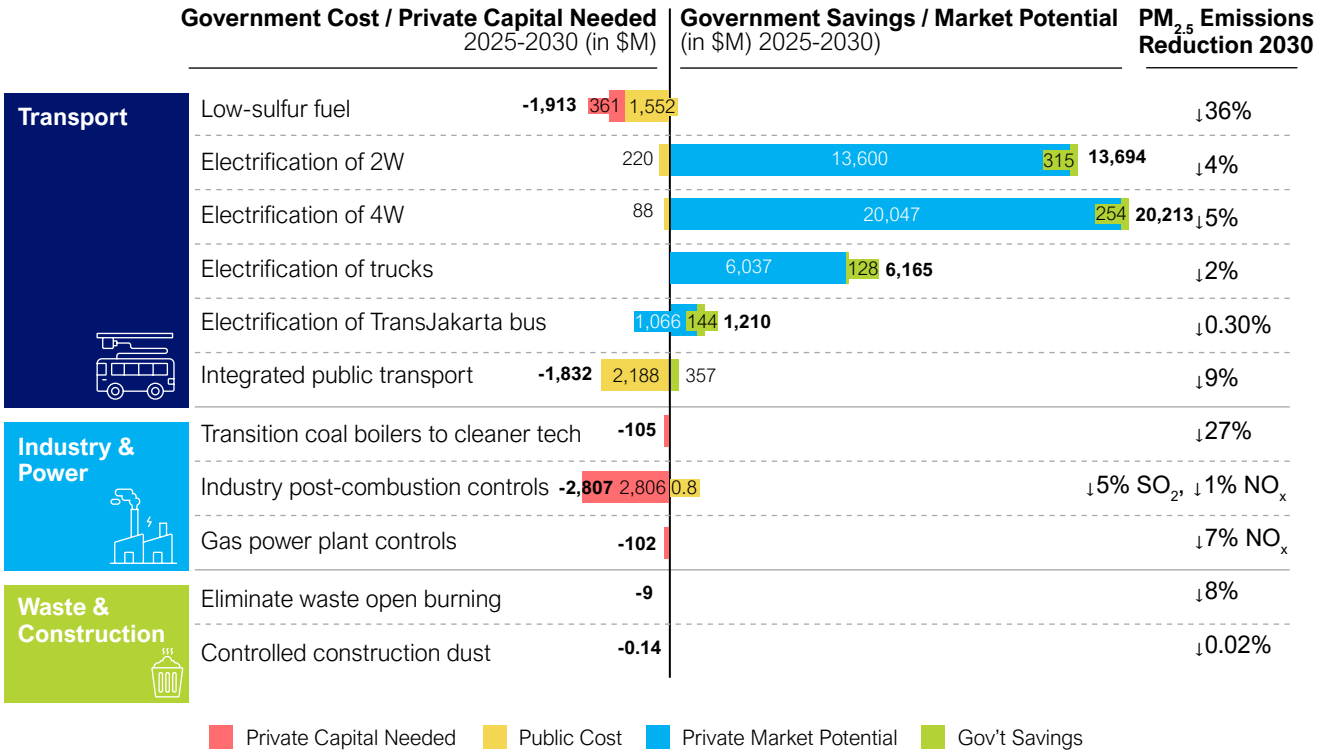
FIGURE 12. $PM_{2.5}$ PROJECTIONS 2023-2030: BAU VS. IMPACT



ECONOMIC IMPACT

This report provides an assessment of investment needs required, from private and public, and projected market potential and government savings.

FIGURE 13. ECONOMIC IMPACT OF LEVERS 2025-2030



An estimated total of $7.4 billion is needed to implement levers: $4.1 billion from government and $3.3 billion from private sector. The EV market, comprised of private and commercial vehicles, can expand up to a $40.7 billion market opportunity, with significant benefits to pollution CO and VOC. $1.2 billion in potential government savings can be realized due to reduced fuel consumption from increased EV adoption and public transport ridership.

Public/Government Capital: Proposed levers will require in total $4.1 billion in government cost, comprised of large-scale infrastructure investment, government financial support (e.g. for EVs and EURO IV), enforcement costs, and database improvements (e.g. industrial emissions inventory). Government spending is necessary for levers EURO IV implementation, public transport expansion, addressing open waste burning, and controlling construction dust.

Private Capital: $3.3 billion is needed in private capital predominantly required for EURO IV processing by Pertamina and other fuel suppliers, transitioning coal boilers to cleaner technology, industrial post-combustion controls and post-combustion controls on power plants. EV markets are reaching tipping points and the combined market share of E-Bus, E2W, E4W, and E-Trucks are projected to create a $40.7 billion market. EVs present a market opportunity both for private vehicle ownership and fleets (e.g. taxis, ride sharing, and municipal trucks).

Government Savings: EV development and public transport could generate $1.2 billion in government savings from reduced need for fuel subsidies.

IDENTIFYING POTENTIAL ADDITIONAL SOURCE OF CAPITAL

Other capital providers—including financial institutions, development banks, and philanthropies—can support the government and private sector in raising the necessary funding to implement proposed levers. Commercial banks and financial institutions (FIs), such as private credit providers, can provide financing for corporate capital expenditures (CAPEX), which can be used for installing pollution controls and upgrading processing refineries to produce EURO IV-compliant fuel. To support Indonesia EV market, FIs can also provide additional capital to market players to expand and scale operations.

Catalytic finance is critical for mobilizing private capital by leveraging finance at below-market rates to de-risk and scale solutions. This is particularly important for levers of less mature technologies in the Indonesian market with high upfront costs. De-risking instruments, including consumer guarantees, can support purchases of EVs, which is critical at this early stage of market adoption. Low-interest loans to support affected industries to install air pollution control technologies or cover additional financing gaps when transitioning to clean technology for industrial boilers. Concessional financing from development banks and international financial institutions can assist governments with CAPEX for public transportation, including for E-buses. Gap funding for municipal waste systems can also be utilized to support initial OPEX, until waste systems achieve financial sustainability through stable revenues for waste retribution and material sales to recycling market, which are major challenges to current waste systems.

Philanthropic funding and grants can be allocated to technical assistance (TA) programs, including policy research and advocacy (e.g., advancing stricter emissions standards or regional emissions inventory guidelines both in stationary and mobile sources), monitoring and data collection (e.g., low-cost sensors, source apportionment and emissions inventories for the Greater Jakarta area), and public education campaigns (e.g., to address open burning and promote public transport).

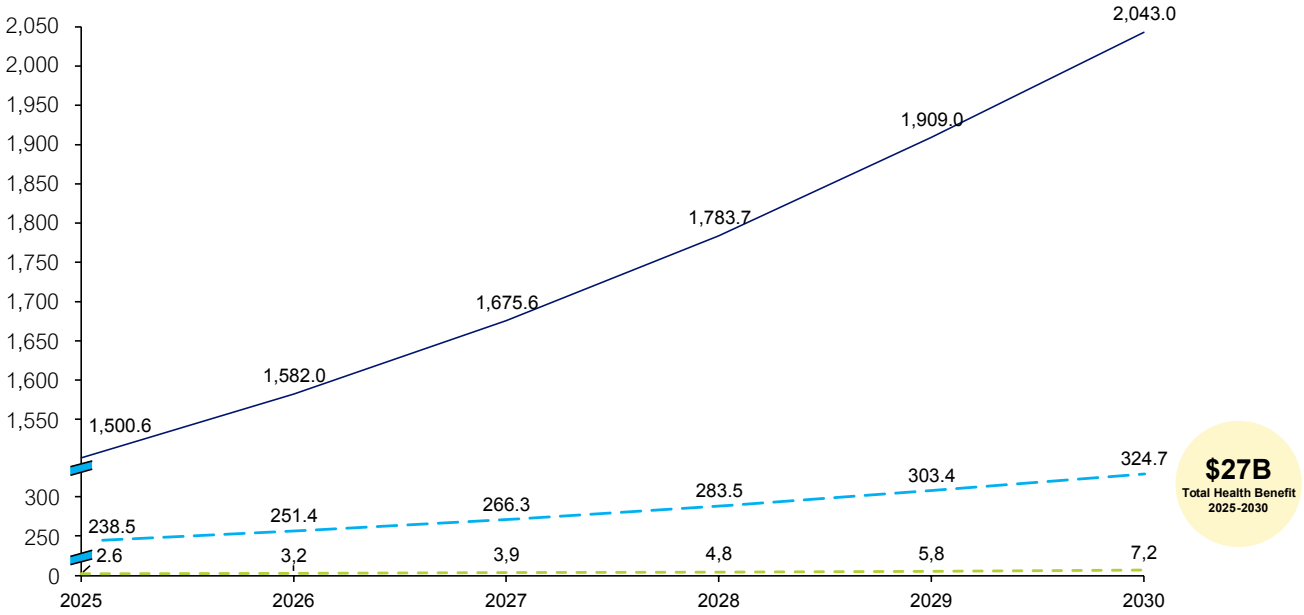
FIGURE 14. POTENTIAL ADDITIONAL SOURCES OF CAPITAL

		Potential Sources of Financing
Transport	Low-sulfur level	**Commercial financing** to cover processing infrastructure CAPEX, distribution OPEX. and other potential investment needs, not already covered by potential gov't financial support
	Electrification of 2W	**Financial support to EV companies** to scale operations (e.g. capital Injection and JVs) **Catalytic finance to lower cost of borrowing** for consumers to support EV early-stage adoption
	Electrification of 4W	**Financial support to EV companies** to scale operations (e.g. capital injection and Ns) **Catalytic finance to lower cost of borrowing** for consumers lo support EV early-stage adoption
	Electrification of trucks	**Concessional finance to support procurement of trucks** for select industries, e.g. municipal trucks, logistics **Innovative leaslng models** to lease e-trucks at more affordable rates
	Electrification of TransJakarta bus	**Catalytic finance to lower cost of capital** to support smaller bus operators **Innovative leasing models** to lease e-buses **Carbon financing,** such as Article 6.2 mechanism, similar to Bangkok E-Bus w/ Swiss KliK Foundation
	Integrated public transport	**Commercial and concessional capital for CAPEX** public transport expansion (MRT and LRT)
Industry & Power	Transition coal boilers to cleaner tech	**Catalytic finance to support e-heating solutions** procurement for industries
	Industry post-combustion controls	**Catalytic finance to lower cost of capital** to procure air pollution controls
	Gas power plant controls	**Commercial and catalytic capital** to support procurement or air pollution controls
	CFPP controls & retirement	**Innovative financing through transition funds or credits** to support early CFPP phase out (e.g. ADB ETM mechanism)
Waste & Construc-tion	Eliminate waste open burning	**Catalytic finance** to support with gap financing (through funds or guarantees) or CAPEX infrastructure (e.g. waste facilities, landfill upgrade, etc.) **Philanthropic funding for technical assistance** on behavioral change / education campaigns
	Controlled construction dust	**Technical assistance** for policy research and advocacy for stringent construction standards **Catalytic finance** to support construction companies to procure dust suppression technologies

IMPACT TO HEALTH

The health benefits of proposed levers far outweigh the cost to implement levers, highlighting the critical need for air pollution improvement to achieve economic growth. From 2025-2030 an estimated 32,747 premature deaths would be prevented, which would translate to $27 billion in health benefit. The economic benefit of preventing premature death is measured by the Value of Statistical Life (VSL), the monetary value associated with an aggregate population's willingness to reduce the risk of disease and mortality. It reflects the economic impact of premature deaths, including the loss of wealth, productivity, and contributions to society. The VSL used in this is $837,781 based on Vital Strategies analysis, following the methodology developed by Robinson et al.[32] To note, the prevention of these deaths and illnesses are significant and not to be taken lightly, as it will have significant implications on individual lives, families and the overall social fabric of Jakarta. For the purposes of this paper, this report has translated the health impact to monetary value, not to minimize the significance of human health, but to enable a macro-level analysis assessing the economic and health impacts of air pollution.

FIGURE 15. HEALTH BENEFIT AGAINST NOMINAL GDP & JAKARTA GRDP 2025-2030



2025-2030 Health Benefit:	32,747	$27B	2%	0.4%
	deaths avoided due to improved air quality	in health benefit equal to	of projected 2030 Jakarta GRDP or	of projected 2030 Indonesia nominal GDP

Notes: GDP projection numbers are projected GDP real with 2015 as the base year, assuming Indonesian GDP is expected to grow 5% each year for baseline and grows at 8% from 2029 onwards for optimistic. Jakarta's projected GRDP with assumption of consistent proportion of 16% of nominal GDP, based on historical trends. Source: World Bank, CEIC, BPS, Systemiq Analysis

[32] See Annex for more information on methodology and input assumptions.

The cause-specific diseases included in this study include Chronic Obstructive Pulmonary Disease, Ischemic Heart Disease, Lung Cancer, and Stroke, based on Global Burden of Diseases 2019 methodology. Prolonged exposure to pollutants such as fine particulate matter ($PM_{2.5}$), nitrogen oxides (NO_x), and sulfur dioxide (SO_2) lead to chronic diseases, exacerbate pre-existing conditions, and contribute to thousands of premature deaths each year. Vulnerable populations, such as children, the elderly, and individuals with underlying health issues, bear the brunt of these impacts. In addition to the human toll, the economic consequences—ranging from increased healthcare costs to lost productivity—are staggering.

To estimate health impact of air pollution, this report utilized two tools: AQUA tool by C40 and AirQ+ model by WHO to estimate premature deaths prevented by improved air quality. The tools use methodology, including mortality rates and relevant Relative Risks, based on Global Burden of Disease 2019 to calculate the health impact of air pollution.[33] This report focused primarily on premature mortality and its economic cost as other studies show that the largest economic impact of health is derived from averted deaths.[34] Due to data limitations, the estimated health impact may be undervalued as the analysis does not take into account (1) impact on diabetes and lower respiratory infection (LRI), and (2) the impacts on illness and morbidity, including hospitalization costs, years lived with disability, children's health (e.g. stunting), and adverse birth effects (e.g. pre-term births). For more information, please see appendix on Health Methodology and Assumptions.

As a reference point, a recent study assessing the impact of air pollution in Jakarta in 2019 estimated total health cost to be USD 2.9 billion.[35] This includes 7,000 adverse health outcomes in children (including stunting, preterm births, and low birth weight), over 10,000 deaths, and more than 5,000 hospitalizations due to cardiorespiratory diseases. To more accurately assess long-term impact, further research will need to be conducted supported by annual monitoring of air quality health impact by government health agencies at national and local level.

[33] Vos, T., et al. (2020). Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019.

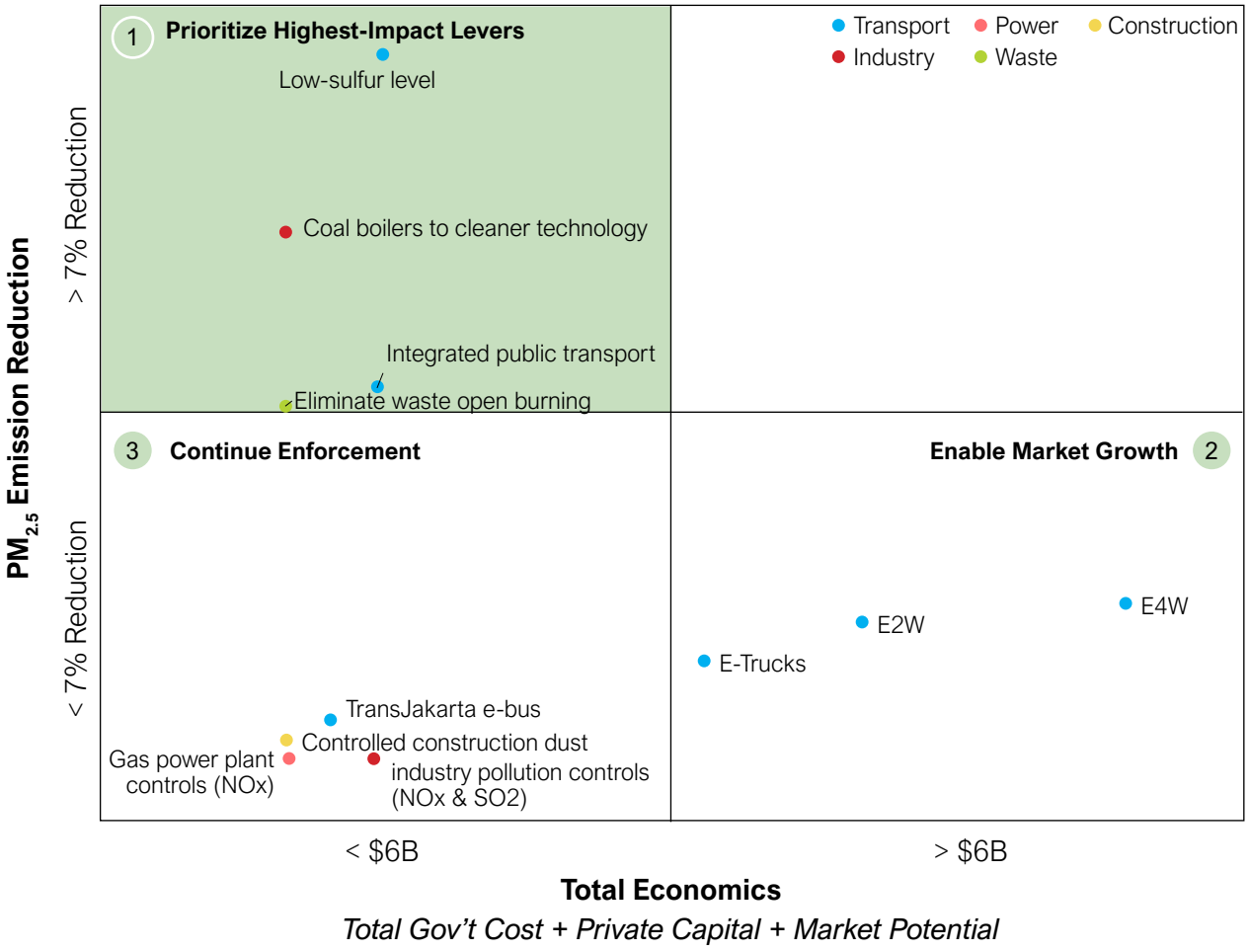
[34] Vital Strategies. (2024). Cost-benefit analysis for air pollution control strategies in Jakarta. ; IIASA (2023) "National Assessment of the Cost of Inaction of Tackling Air Pollution in Indonesia".

[35] This study study quantified the health and economic burden of fine particulate matter ($PM_{2.5}$) and ground-level Ozone (O3). For more information: Syuhada et al. (2023) "Impact of Air Pollution on Health and Cost of Illness in Jakarta, Indonesia." International Journal of Environmental Research and Public Health.

STRATEGIC APPROACHES

Based on the above impact assessment, three strategic approaches are recommended for implementation.

FIGURE 16. PRIORITIZATION



The above matrix assesses the levers based on PM2.5 emission reduction and total economic size. The y-axis is based on ITB's modelling of PM2.5 emissions reductions by 2030. The x-axis is total economic size, the sum of private capital needs, government cost and market potential (assuming market potential are costs borne by consumer).

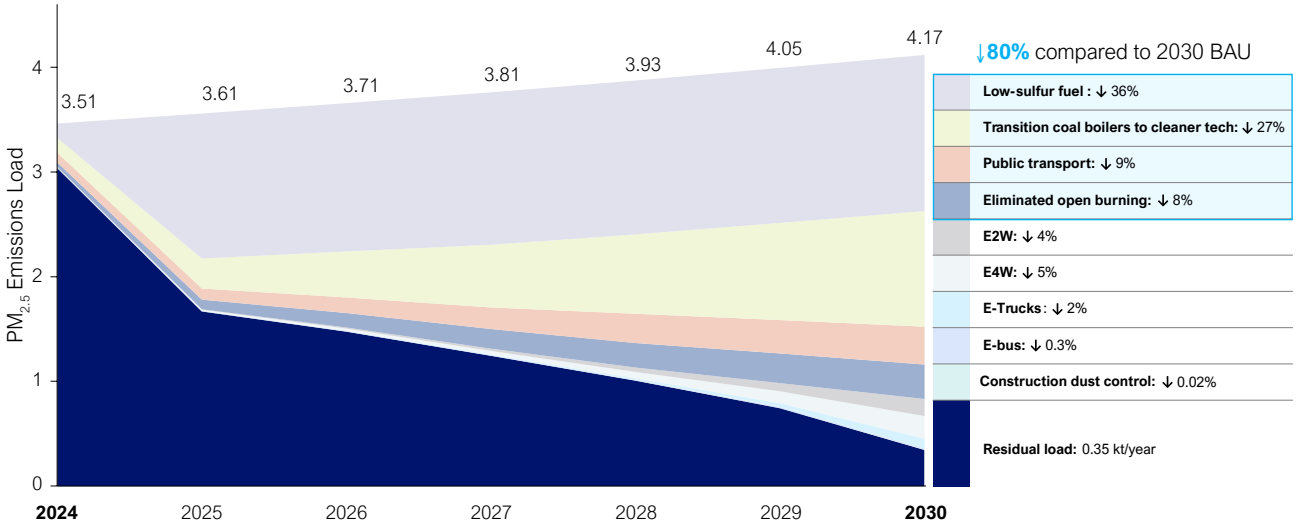
***Better Air, Better Indonesia* proposed three strategic approaches in implementing the levers:**

1. **Prioritize Highest-Impact Levers:** Focus on the four most effective levers: (1) Low sulfur fuel adoption, (2) Transitioning coal boilers to cleaner technology, (3) Integrated public transport, and (4) Eliminating waste open burning. Collectively, these four levers alone can deliver an 80% reduction in PM2.5 emissions by 2030, providing the greatest immediate impact.

FIGURE 17: FOUR HIGHEST IMPACT LEVERS TO $PM_{2.5}$

$PM_{2.5}$ Projections: BAU vs. Impact

Kilotons/year



2. **Enable Market Growth:** Leverage the economic potential of emerging electric vehicles (EVs) industry which encompasses E2Ws, E4Ws and e-trucks, representing a $40.7 billion market. Government incentives, such as subsidies, VAT exemptions, and non-financial incentives, like Low-Emission Zone allowances, can accelerate adoption. Further reduction of CO and VOC can be achieved if EV adoption rates surpass proposed targets.[36]

3. **Strengthen Enforcement:** While their impact on $PM_{2.5}$ is less significant, remaining levers of industrial pollution controls, e-bus and construction dust can be implemented for comprehensive pollution control of other pollutants.

    a. Issuance and continued enforcement of stringent emission standards for industry is crucial to encourage the installation of industrial post-combustion technologies, selective catalytic reduction (SCR) and wet flue gas desulfurization (WFGD) which target pollutants NO_x and SO_2 that pose serious health risks.[37]

    b. The electrification of Transjakarta buses supports long-term national electrification goals. However, with Transjakarta buses making up only 15% of Jakarta's total bus fleet, their impact on $PM_{2.5}$ reduction remains relatively limited compared to other levers. Leveraging this momentum could encourage other bus companies to transition to cleaner public transport for greater impact.

    c. Construction is the 5th largest sectoral contributor to air pollution and will expand with Jakarta's urbanization. Controlling construction dust and issuing standards will become increasingly important – as can be seen in the case of Beijing, which included construction measures as part of its air pollution program.

The following sections will deep dive into each lever, outlining the context, challenges, proposed interventions and policy reforms.

[36] For further research on EV impact with higher targets, please see: ITB & ViriyaENB. (forthcoming). Emission inventory in Jabodetabek.

[37] Note that $PM_{2.5}$ pollution controls, such as Electrostatic Precipitators (ESP) or fabric filters, were not included in the analysis, as cleaner technology for industrial boilers is recommended as it provides a more cost-effective way to reduce particulate matter. For more information on impact of all air pollution controls, see: ITB & ViriyaENB. (forthcoming). Emission inventory in Jabodetabek.

SECTORAL DEEP DIVES

1. TRANSPORT SECTOR

LOW-SULFUR FUEL

Investment needs

$816M (IDR 13T)
Cost of achieving 100% low sulfur gasoline and diesel

Impact to Pollution in 2030

↓ 36%
reduction in **$PM_{2.5}$ emissions load**

- **The GoI has set a target of achieving full adoption of EURO IV in Jakarta, diesel by 2025 and gasoline by 2027.** National target is for 100% adoption of EURO IV fuel by 2028 for both gasoline and diesel.
- **Achieving 100% EURO IV fuel in Jakarta will require $816 million investment –** which would need to be allocated through a combination of government cost, Pertamina and fuel supplier cost, and/or passed through consumers through fuel price and potential subsidy adjustments
- **Additional costs for recommended enablers include:** emissions testing ($713 million), Low Emissions Zone ($24 million) and truck retrofits ($361 million)
- **Adoption of EURO IV fuel is the highest-impact** lever across all levers proposed, resulting in 36% reduction in $PM_{2.5}$ emissions by 2030 compared to BAU.

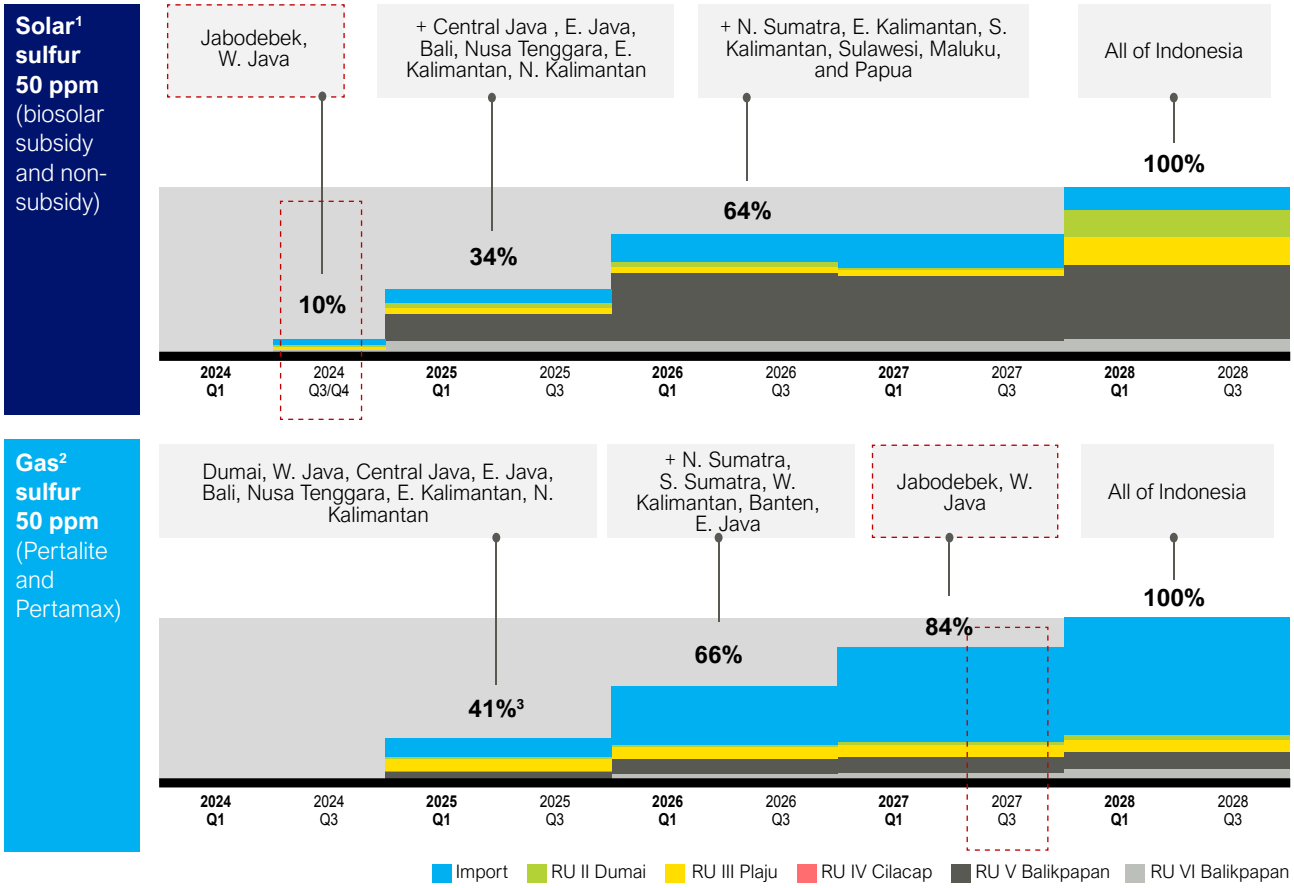
CONTEXT

As the first step towards achieving higher quality fuel, the GoI has set a target for achieving full adoption of EURO IV in Jakarta, diesel by 2025 and gasoline by 2027. The national target is to achieve 100% adoption of EURO IV by 2028. MOEF Regulation 20/2017 was issued mandating that the production of all new vehicles must comply with EURO IV standards, starting with gasoline vehicles in 2018 and diesel vehicles in 2022. Further impact can be achieved if standards are raised to become more stringent towards EURO V or higher, similar to other peer countries.

Low sulfur fuel is the highest impact lever for air pollution, with the potential to reduce 36% of $PM_{2.5}$ by 2030. EURO IV is significantly cleaner than the current fuel standards, as EURO IV contains less than 50 parts per million (ppm) of sulfur compared to over 500 ppm in EURO II fuel, the currently widely used fuel in Indonesia. Based on stakeholder interviews, this report assumes a scenario where EURO IV fuel is produced through additional desulfurization and processing, which is expected to incur additional production costs of approximately IDR 420 / L for gasoline and IDR 350 / L for diesel.[38] Fuel quality could be further improved to reach EURO VI standard with sulfur content lower than 10ppm, which many peer countries have already issued. This needs to be followed by engine improvement from original equipment manufacturers (OEMs).

[38] Numbers sourced from FGD with government stakeholders: MEMR, CMMIA, CMIRD.

FIGURE 18. PROPOSED GOVERNMENT TIMELINE FOR EURO IV

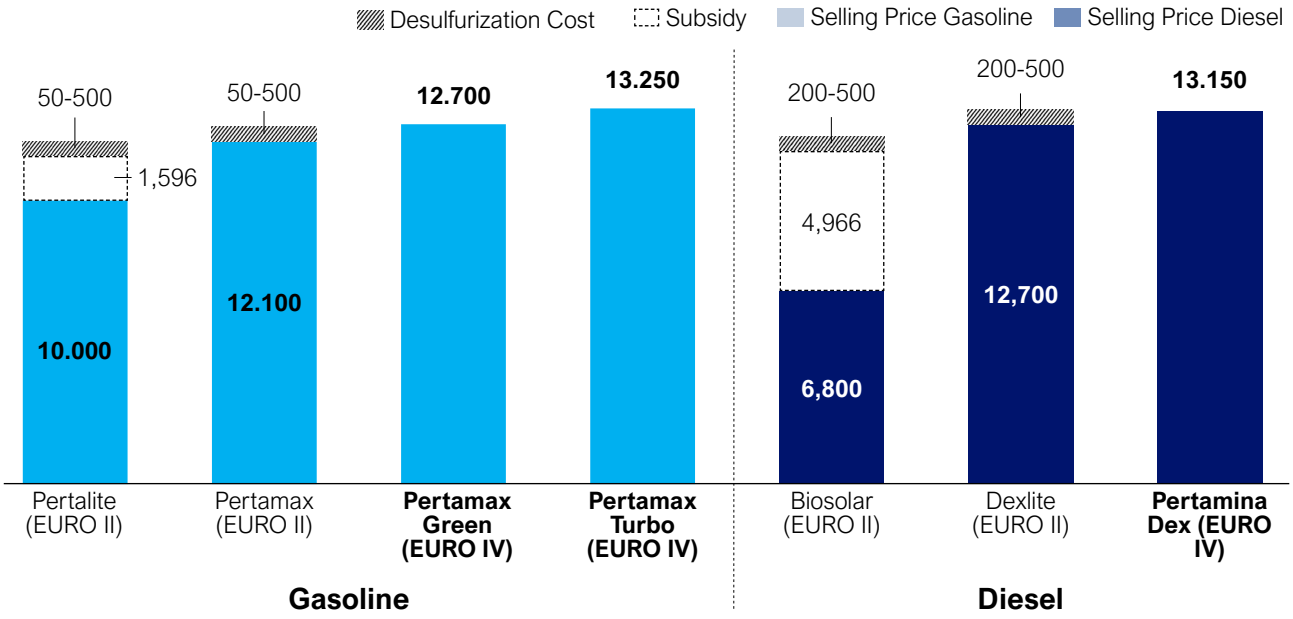


1. Volume of subsidized and non-subsidized B35 diesel including industry; 2. Volume of Pertalite and Pertamax; 3. The ability of import reception facilities in Cilacap in 2025 is still in process; 4. RU = Refinery Unit; . Source: Coordinating Ministry of Infrastructure, Ministry of Energy and Mineral Resources, Pertamina

TABLE 1. KEY REGULATIONS RELATED TO CLEANER FUEL

Regulations	Notes
MoEF Regulation 20/2017	Mandate the production of all new vehicles must comply with EURO IV standards, starting with gasoline vehicles in 2018 and diesel vehicles in 2021
Presidential Regulation 117/2021	Mandate the development for roadmap of cleaner fuel in Indonesia
Jakarta Governor Regulation 576/2023	Mandate emissions testing for all private vehicles, with emissions testing target of 50% by 2025 and 100% by 2030
Director General of Oil and Gas Decree 447.K/2023	Mandate standard and quality of diesel fuel set to maximum sulfur content at 50ppm effective from December 2026
Director General of Oil and Gas Decree 110.K/2022	Mandate standard and quality of gasoline fuel set to maximum sulfur content at 50ppm effective from January 2028

FIGURE 19. CURRENT SELLING PRICE, SUBSIDY OF GASOLINE AND DIESEL FUEL IN INDONESIA (IDR / L)[39]



Fuel subsidy is a key factor in increasing public adoption of cleaner fuel, as the government currently subsidizes Pertalite (gas) and Biosolar (diesel) which are both classified as EURO II. The majority of Pertamina fuel consumption goes to subsidized fuel: 45% of fuel consumption is Pertalite and 26% is subsidized Biosolar. The fuel subsidies were created with the intention of achieving government's goal to ensure fuel affordability and accessibility, in particular to lower-income individuals. However, recent studies indicate these subsidies disproportionately benefit higher-income groups due to the universal accessibility to these fuel types.[40]

Currently, the only EURO IV-compliant fuel options available in Indonesia from Pertamina are Pertamax Green and Pertamax Turbo for gasoline, and Pertamax Dex for diesel.[41] There is currently low adoption of these cleaner fuels due to lack of enforcement, lack of public knowledge on sulfur content, and higher price points compared to subsidized fuel. A synchronized effort and timeline of increasing EURO IV fuel availability from fuel producers and upgrading vehicle engines towards EURO IV-compliance is crucial.

[39] Numbers sourced from FGD with government stakeholders: MEMR, CMMIA, CMIRD.

[40] Subsidized fuel disproportionately benefits higher-income households, with 80-90% consumed by individuals in the top 60% of income earners. Numbers sources from Katadata, CMMIA,

[41] Sourced from FGD with government stakeholders: MoE, MEMR, CMMIA.

FIGURE 20. SULFUR CONTENT IN PERTAMINA FUEL TYPES

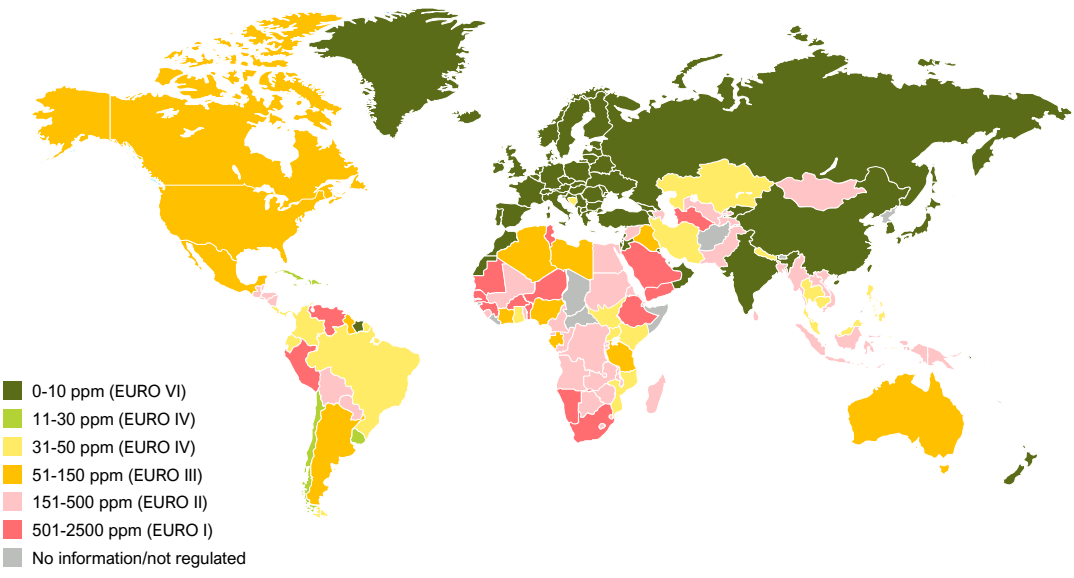
	Pertamina fuel types for vehicles	National volume (mn k. liters)[1]	Pertamina Specifications (max. ppm)	MEMR Standards 2024[2] (max. ppm)	Compliance	
					ESDM	50 ppm
Diesel	Biosolar 48 subsidy	17.3[4] (26%)	2,500	2,500	✓	×
	Biosolar 48 non subsidy	13.0[4] (19%)	2,500	2,500	✓	×
	Dexlite 51	0.7 (1%)	1,200	1,200	✓	×
	Pertadex 53	0.4 (0%)	50	50	✓	✓
Gas	Pertalite 90 subsidy	30.2 (45%)	500	500	✓	×
	Pertamax 92	5.0 (7%)	400	400	✓	×
	Pertamax Green[3] 95	<0.001 (0%)	50	50	✓	✓
	Pertamax Turbo 98	0.2 (0%)	50	50	✓	✓

1. Based on 2023 realization volume, rounded up; 2. Director General of Oil and Gas Decree 110/2022; Director General of Oil and Gas Decree 146/2020; 3. Pertamax Green will only be available in limited quantities in July 2023; 4. Only for subsidized diesel
Source: Coordinating Ministry of Infrastructure, Ministry of Energy and Mineral Resources Transport Policy, Pertamina

CASE STUDY: INDONESIA LAGGING BEHIND OTHER COUNTRIES IN ADOPTING HIGHER QUALITY FUEL

Across countries, maximum gasoline sulfur limits vary significantly, with most Western countries adopting cleaner fuels (below 150 ppm sulfur), whereas countries in the Global South exhibit greater variability in sulfur limits. Indonesia lags behind many of its Asian counterparts, still predominantly using Euro II fuels. Despite recent policy shifts aiming to adopt at least EURO IV standards for both diesel and gasoline, transition remains slower compared to regional peers.

FIGURE 21. MAXIMUM GASOLINE SULFUR LIMITS, 2023[42]



[42] Stratas Advisors. (2023, June 22). Six countries move up in top 100 ranking on gasoline sulfur limits.

This research conducts a deep dive on two Asian countries: Vietnam and India to understand the main driver of switching to cleaner fuel and key interventions to transition to a higher quality fuel. Currently, India adopts EURO VI-equivalent standard whereas Vietnam adopts EURO V fuel for both gasoline and diesel.

Addressing air pollution and greenhouse gas emissions are among the main drivers for governments to issue more stringent fuel standards:

1. **Vietnam also recently strengthened fuel standard from EURO II to EURO IV fuel quality in 2017[43] followed by another transition from EURO IV to EURO V in 2022.[44]** The transition was partly motivated by worsening air pollution which was linked to 60,000 deaths in 2018.[45] Similarly to Vietnam, majority of ASEAN countries have adopted above EURO IV standard: Singapore, Myanmar, Thailand, Malaysia, Philippines, and Brunei.
2. **India, in 2020, adopted EURO VI-equivalent fuel standard (Bharat Stage VI) for 13 cities including Delhi, Mumbai and Kolkata due to air pollution issues and reducing fuel consumption and greenhouse gases also known as Bharat Stage VI[41,46].** It is estimated that, Bharat Stage VI managed to reduce CO by 7%, NMVOC by 9.7%, OC by 20% and BC by 5% in 2021.[47]

There are **three main types of interventions** to impose higher quality fuel standard:

FIGURE 22. FUEL QUALITY STANDARD FOR DIESEL AND GASOLINE IN VIETNAM, INDIA AND INDONESIA

Diesel	2020	2021	2022	2023	2024
Vietnam	Euro II (2500 ppm)	Euro II (2500 ppm)	Euro V (10 ppm)	Euro V (10 ppm)	Euro V (10 ppm)
India	Euro VI (10 ppm)	Euro VI (10 ppm)	Euro VI (10 ppm)	Euro VI (10 ppm)	Euro VI (10 ppm)
Indonesia	**Euro II (2500 ppm)**	**Euro II (2500 ppm)**	**Euro II (2500 ppm)**	**Euro II (2500 ppm)**	**Euro II (2500 ppm)**

Gasoline	2020	2021	2022	2023	2024
Vietnam	Euro II (500 ppm)	Euro II (500 ppm)	Euro V (50 ppm)	Euro V (50 ppm)	Euro V (10 ppm)
India	Euro VI (10 ppm)	Euro VI (10 ppm)	Euro VI (10 ppm)	Euro VI (10 ppm)	Euro VI (10 ppm)
Indonesia	**Euro II (500 ppm)**	**Euro II (500 ppm)**	**Euro II (500 ppm)**	**Euro II (500 ppm)**	**Euro II (500 ppm)**

1. **A clear policy roadmap with strict deadlines for fuel transitions has been a critical intervention in countries like Vietnam and India.** In India, the government set a firm compliance deadline for the adoption of Euro VI, driving private sector urgency to upgrade facilities to meet higher fuel quality standards.
2. **Fiscal support for fuel production companies, either through government fiscal incentives or private investment.** China provided tax benefits and loans to support the investment to upgrade production facilities for state-owned-enterprises. In India, oil companies led the initiative to ensure timely delivery of higher quality fuel.
3. **Fuel pricing adjustments to compensate for higher production cost.** In all three countries, consumer price for higher quality fuel was increased to offset the higher production cost. This may create a wider impact on commodity prices and inflation; hence a thorough analysis is required to adopt this approach.

[43] International Council on Clean Transportation (ICCT). (n.d.). Vietnam: Fuels: Diesel and gasoline. Retrieved November 22, 2024, from https://www.transportpolicy.net/standard/vietnam-fuels-diesel-and-gasoline/

[44] Institute for Essential Services Reform (IESR). (2024). Analisis dampak kebijakan peningkatan standar kualitas bahan bakar minyak pada aspek lingkungan, kesehatan, dan ekonomi.

[45] World Health Organization (WHO). (n.d.). Air pollution. WHO Vietnam. Retrieved November 22, 2024, from https://www.who.int/vietnam/health-topics/air-pollution

[46] International Council on Clean Transportation (ICCT). (n.d.). India: Vehicle emissions standards and policies. Retrieved November 22, 2024, from https://theicct.org/region/india/#:~:text=In%202016%2C%20India%20adopted%20Euro,further%20mitigate%20vehicular%20air%20pollution

[47] Gajbhiye, S., et al. (2022). Effectiveness of India's Bharat Stage mitigation measures in reducing vehicular emissions. Environmental Impact Assessment Review, 94, 106750.

CHALLENGES

To achieve adoption of EURO IV in Jakarta, the priority is to increase the supply of EURO IV fuel which face capital and distribution challenges:

1. **Additional investments are needed throughout the supply chain to make EURO IV fuel supply available.** For processing, additional treating units of Diesel Hydrotreating Unit (DHU) and Gasoline Sulfur Hydrotreater (GSH) are needed in refineries, including all six Pertamina refineries.[48]
2. **Distribution logistics must be adjusted and prepared** including blending process in tanks at Fuel Terminals (TBBM) and pipeline flushing for supply. In addition, there may be an increased need to import EURO IV compliant fuel if fuel supply does not match demand. In 2023, 60% of gasoline (about 20 million KL) and 13% of diesel (about 5.15 million KL) were imported.[49]
3. **Lack of urgency and lack of consumer awareness:** Including low price point of subsidized fuel make it more attractive to the public – resulting in low demand and consumption of existing EUROIV fuel (Pertamax Green and Pertamax Turbo for gasoline, and Pertamax Dex for diesel) available to the market.
4. **Devising policy package and financial mechanism to address additional investment needs –** either through increased government subsidy, passed to consumer through increased fuel costs, and/or increased costs to fuel suppliers. The policy package will need to consider potential changes to national fuel subsidy policy, government financial mechanism to support Pertamina (e.g. through product subsidy, PSO, tax incentives or state capital injection), and long-term macroeconomic impact (e.g. inflation, national budget and deficit)

INTERVENTION

To achieve the roll out of EURO IV according to timeline, the main intervention is government support for Pertamina and other fuel suppliers to account for the additional production costs to desulfurize current fuel, pending discussions with the company. Other interventions include:

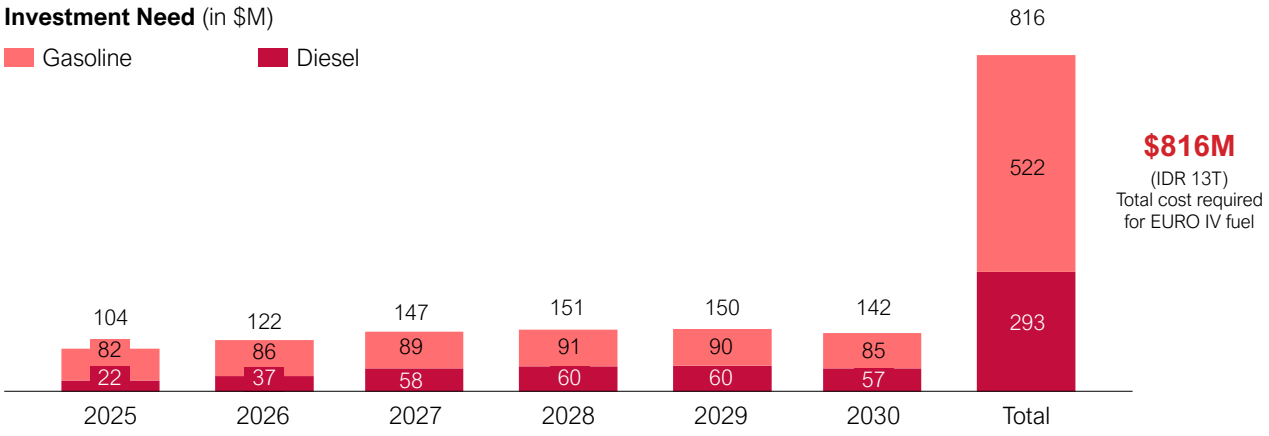
1. **Relevant ministries to coordinate for the harmonization and issuance of key regulations,** to enforce EURO IV. Strong commitment from ministries, through the issuance of a regulation mandating a strict timeline, is crucial to prompt market players to accelerate the necessary capital and infrastructure preparation to provide EURO IV-compliant fuel. Key regulation should also include a comprehensive financial and investment plan outlining potential change to consumer fuel subsidy, costs to state budget and Pertamina financial sustainability.
2. **Increased enforcement of EURO IV usage** through enabling policies including implementation of emissions testing and the establishment of Low Emission Zones.
3. **EURO IV truck retrofitting to make truck engine compliant with EURO IV.** Procurement of new EURO IV compliant trucks or early retirement of fleets could create a big barrier for truck owners to adopt a cleaner fuel. Retrofitting offers a lower cost option with significant benefits to air pollution.

[48] MEMR. (2024, December 19) EURO IV Fuel [FGD Presentation]. MOE FGD on Air Pollution Measures in Transport Sector.
[49] MEMR. (2024, December 19) EURO IV Fuel [FGD Presentation]. MOE FGD on Air Pollution Measures in Transport Sector.

ECONOMIC IMPACT

Achieving 100% adoption of EURO IV fuel could result in $816 million of cost.

FIGURE 23. ESTIMATED ECONOMIC IMPACT (IN $ MILLION)



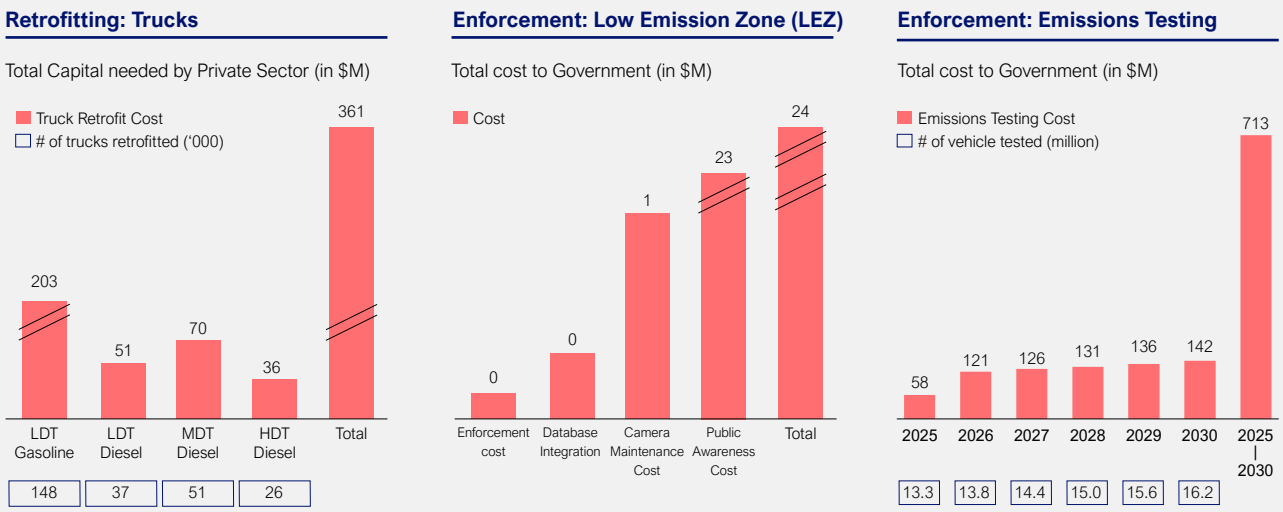
This research estimates $816 million required between 2025-2030 to achieve target of 100% EURO IV fuel adoption in 2028.[50] $522 million is required for EURO IV gasoline, as desulfurizing gasoline will require more complex refinery process. $293 million is needed to desulfurize diesel. Estimated investment needs were calculated based on approximate costs provided by discussions with government stakeholders estimating IDR 420/L for gasoline and IDR 350/L for diesel.

A key challenge in achieving EURO IV fuel is determining how to allocate and distribute the additional processing and distribution costs. These costs can be absorbed by fuel producers, passed on to consumers, or partially/fully offset through government support. In this research, all costs are currently assigned to the government as a placeholder and are subject to further study to assess the implications of subsidies on the government budget, inflation, and other factors.

[50] Cost to government is calculated based on the production subsidy (IDR / L) for gasoline and diesel multiplied by the projected volume of fuel consumed (L). Production subsidy (IDR / L) for gasoline is IDR 420 / L whereas for diesel is IDR 350 / L. Projected volume consumed is based on projected number of vehicles multiplied by national adoption target across all vehicle categories. Numbers sourced from discussions with government stakeholders including CMIRD and MEMR. The production cost is an average of the production costs between 2025-2028.

DEEP DIVE: ACHIEVING 100% EURO IV ADOPTION BY 2028 REQUIRES INCREASED ENFORCEMENT AND VEHICLE RETROFITTING

FIGURE 24. ESTIMATED COST FOR EXAMPLE INITIATIVES TO SUPPORT 2028 EURO IV ADOPTION TARGET



In addition to addressing the urgent supply-side issue of EURO IV, other enabling factors are important to support adoption. This research explores the cost of three potential initiatives that can be considered by provincial government of Jakarta to achieve 2028 adoption target: retrofitting of trucks, implementation of LEZ and emissions testing.

1. Truck Retrofitting

Incompatibility between EURO IV-compliant fuel supply and vehicle engines has the risk of emitting toxic gases and causing damage to the engine. MOEF Regulation 8/2023 was passed regarding emissions standards for current in-use heavy-duty vehicles and mandates periodic emission testing at official inspection centers and certified workshops. Due to the significant impact trucks have on air pollution, this research focuses on the cost of truck retrofitting.

There is an estimated capital requirement of $361 million by the private sector to retrofit truck engines to be EURO IV compliant. Aligned with current discussions with peer organization, this report suggests installing both Diesel Particulate Filter (DPF) and Diesel Oxidation Catalyst (DOC) in the diesel truck engines due to its high-cost efficiency in reducing air pollution.[51] DPF is typically installed in a vehicle exhaust system which captures particulate matter (PM) from exhaust gases. Whereas DOC is installed closer to the engine, before DPF, to oxidize pollutants, reducing the amount of carbon monoxide, hydrocarbons and other pollutants before entering DPF. Other forms of retrofits to support more stringent fuel quality EURO V and beyond, include Selective Catalytic Reduction (SCR) and Ammonia Slip Catalyst (ASC).

Truck retrofitting, though still an investment at an estimated $1,377 per unit,[52] offers a cost-effective alternative to purchasing new trucks. This approach is especially advantageous for trucks with significant remaining operational life prior to 2022, allowing fleet owners to extend usage without premature retirement. To note that, the unit costs here are estimated averages and the actual cost of retrofitting may differ based on control technology, type of vehicle and engine size and intended norm.

2. Enforcement of Low Emission Zone (LEZ)

A Low Emission Zone (LEZ) is a designated area where vehicle access is restricted or subject to charges based on emissions standards, typically to reduce air pollution. Vehicles that do not meet the specified emissions criteria may be banned or required to pay a fee to enter. LEZ has been implemented in Jakarta, in Kota Tua and Tebet Eco Park with ongoing discussion for further expansion and improvement. Establishing a LEZ can support EURO IV adoption.

[51] World Bank. (forthcoming). Clearing the air in Jakarta: Cost-effective solutions for addressing the city's pollution crisis.

[52] World Bank. (forthcoming). Clearing the air in Jakarta: Cost-effective solutions for addressing the city's pollution crisis. Costs may vary based on different norms and engine sizes.

Other than emissions standards, LEZ restrictions could also consider limitations based on vehicle age, as older vehicles typically have less efficient engines and higher levels of incomplete combustion, resulting in increased pollutant emissions. This may be a useful restriction on commercial vehicles, e.g., trucks, given their higher contribution to air pollution, whereas restrictions towards private vehicles may be more difficult to implement and less socially accepted by the public.[53]

This research estimates total government cost of $24 million to implement a LEZ from automatic number plate recognition (ANPR) camera maintenance, public campaign, database integration and enforcement which could be helpful to push adoption when supply of EURO IV is still ramping up. A city-wide LEZ has been explored by the Environmental Agency to ensure stringent compliance for all vehicles coming into Jakarta to meet EURO IV standard. This policy was inspired by the success in London where in 2023, a city-wide Ultra-Low Emission Zone (ULEZ) was implemented mandating that all cars coming in met the designated emission standards. Currently, Jakarta has implemented electronic traffic law enforcement (ETLE) which could be utilized for LEZ implementation. ETLE could be enhanced by integrating Korlantas database with MoE database on emissions testing to enforce EURO IV adoption.

Implementation of a phased approach to gradually achieve a city-wide LEZ could be considered to address some of the key challenges in implementation. Due to its nature as a push policy, implementation of LEZ could face some public resistance, from private vehicle owners and fleets as there needs to be a requirement for all HDV trucks in Jakarta to comply with EURO IV.

LEZ could have a significant impact to reducing air pollution, if implemented alongside emissions testing and supported by database integration between MoE and Korlantas, acting as a push policy to get people to use higher standard fuel.

3. **Enforcement of Emission Testing**

The Jakarta government targets 50% emission testing in 2025 and 100% in 2030 based on Governor Decree No. 576/2023. As of November 2024, 1.5 million cars and 147,065 motorcycles (about 10% of Jakarta vehicles[54]) have undergone emission testing with a compliance rate of 99% for cars and 84% for motorcycles.[55] Currently emission testing is mandatory for all vehicle owners under Government Regulation No. 22/2021 with planned enforcement for tests conducted at authorized vehicle repair shops and is planned to be tied to prerequisite for renewing vehicle registration certificates (STNK).

To reach the 100% emission testing target, this research estimates a government cost of $713 million from 2025-2030. It assumes the current static emission testing but acknowledges the need to shift to dynamic testing for EURO IV compliance, requiring further technological investment. Additionally, to effectively reduce air pollution, emission testing must be extended to the Greater Jakarta area (Bogor, Banten, Bekasi, and Tangerang), given the high number of commuters.

Recommendation – this research recommends a mix of the above interventions to push the adoption of cleaner fuel, i.e., EURO IV and potentially higher standard in the future. It is essential that the increase in supply of EURO IV is also enabled by increased enforcement and readiness of demand through engine retrofitting.

[53] There may be potential challenges with implementing restriction based on model year of vehicles. Sourced from FGD with MOE and stakeholders (2024, November 14).

[54] Number is based on total vehicles that have undergone vehicle testing divided by the projected number of private vehicles in 2024 based on vehicle projection used in the analysis

[55] Uji Emisi Jakarta. (2024, November 24). Dashboard uji emisi Jakarta. Retrieved from https://ujiemisi.jakarta.go.id/dashboard/

NEXT STEPS

Reaching 100% adoption of EURO IV by 2028 requires strong collaboration between the government and fuel suppliers

TABLE 2. ACTION PLAN FOR CLEANER FUEL

Action Plan	Key Stakeholders
Issue MEMR Regulation and following harmonized technical regulations to enforce EURO IV adoption for 4W and 2W and tailpipe technology	MEMR
Ensure sufficient supply of EURO IV fuel and even distribution across areas, including exploring additional processing and/or import needs to respond to market demand	Pertamina, Fuel Suppliers
Explore options for subsidy or other fiscal mechanisms for additional production of EURO IV fuel and other enablers, e.g. truck retrofits	MoF
Increase public awareness of the new EURO IV fuel and importance of adoption before the start of the distribution, including providing information to consumers regarding sulfur content at fuel stations	MEMR, Pertamina, Fuel Suppliers
Develop comprehensive timeline for Low Emission Zones, including consumer education ideally two years before implementation to build awareness	MoH, Provincial Government of Jakarta
Implement emissions testing, including both static and dynamic tests, across identified testing areas and other initiative which support adoption, e.g., Low Emission Zone	Jakarta Transportation Agency, Jakarta Environment Agency, Traffic Corps – Police (Korlantas), MoT - Motor Vehicle Roadworthiness Testing and Certification Agency (BPLJSKB)

Further research is needed to consider the potential reallocation of fuel subsidy with EURO IV target roll out. The government plans to restrict a number of groups to buy subsidized fuel including luxury cars (engine above 1400cc for gasoline and 2000cc for diesel), government vehicles, industrial and mining vehicles, large commercial vehicles, and red-plated vehicles. Further research is needed to address the potential long-term macroeconomic impact of mandating EURO IV and adjusting fuel subsidy mechanisms.[56]

The government recently introduced a QR code system through the MyPertamina app in several districts, requiring consumers to register their vehicles to access subsidized fuel. The program is currently implemented partially in a number of districts for gasoline and mandatory for diesel vehicles. After registration, the app generates a QR code that users must present at gas stations, ensuring subsidized fuel is allocated only to eligible recipients. There is a potential opportunity to explore expanding the QR code system by integrating consumer IDs with taxpayer identification numbers (NPWP), allowing the government to target fuel subsidies based on consumers' tax brackets. Data alignment between national IDs and NPWPs could help the subsidy program more effectively allocate subsidies towards targeted recipients.

[56] For further deep dive, please see: Institute for Essential Services Reform (IESR). (2024). Analisis dampak kebijakan peningkatan standar kualitas bahan bakar minyak pada aspek lingkungan, kesehatan, dan ekonomi.

2. E2W: ACCELERATING INDONESIA E2W ADOPTION TARGET

Government Savings

$94M (IDR 1.5T)

Net savings from fuel subsidy and extending estimated purchase subsidy 2025-2030

Private Sector Benefit

$13.6B (IDR 217T)

From potential sales of 1.2M E2W units 2025-2030

Impact to Pollution in 2030

↓ 4%

reduction in $PM_{2.5}$ emissions load (↓ 25% CO, ↓ 37% VOC)

- **By 2030, Jakarta is projected to reach 5.5 million E2W,** based on GoI national target of 13m units, adjusted for Jakarta.
- **Accelerating E2W adoption could be beneficial for both government and private market;** $94 million government savings from fuel subsidy and unlock $13.6 billion private market potential from EV sales.

CONTEXT

The GoI has set national E2Ws targets, aiming for 2 million units by 2025 and 13 million by 2030 in Indonesia. Though the government has not specified a Jakarta target, this analysis has market sized a realistic Jakarta target to be 5.5 million units by 2030.[57] If E2W adoption rate is increased, impact would be even greater. To promote adoption, the GoI has committed to providing IDR 7 million purchase subsidy for E2Ws with more than 40% local content, up until the end of 2024. As of July 2024, there are more than 130,000 units of E2Ws across Indonesia.

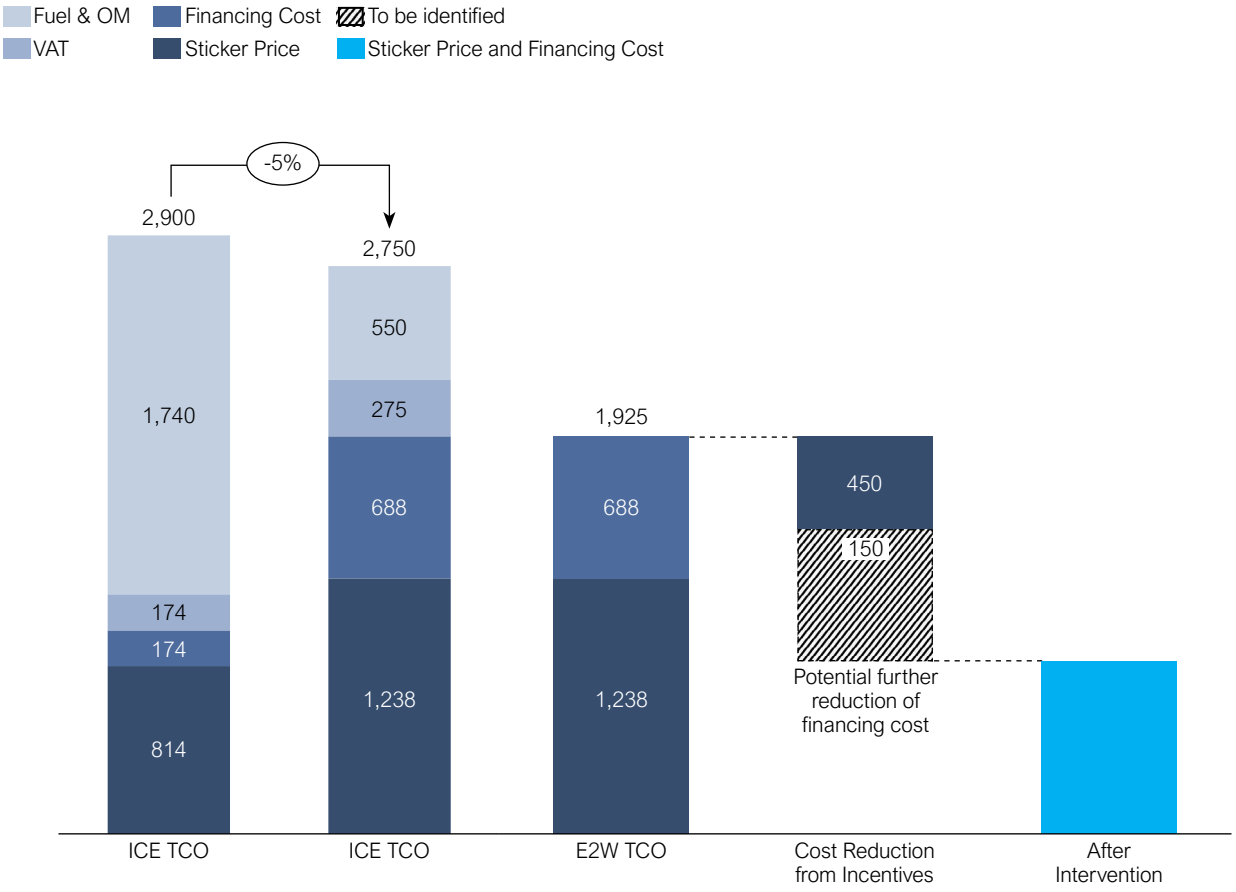
E2Ws have reached cost parity with ICE 2Ws, with a 5-year total cost of ownership (TCO) analysis showing E2Ws to be 5% cheaper. This is largely due to E2Ws' lower energy and maintenance costs, which remain advantageous even when compared to reduced fuel costs from fuel subsidies. For E2Ws, CAPEX makes up nearly half of the TCO, compared to less than 30% for ICE 2Ws. Additionally, it is expected that as the market matures, battery costs will decline due to market learning curves and economies of scale. Government purchase subsidies and tax incentives further reduce CAPEX, widening the TCO gap in favor of E2Ws. Government purchase subsidies and tax incentives further reduce CAPEX, widening the TCO gap in favor of E2Ws.

[57] Based on Korlantas data, Jakarta accounts for approximately 47% of the JADETABEK two-wheelers. ADB projects that by 2030 JADETABEK will reach 10 million electric 2-wheelers. Assuming constant proportion, it is projected that Jakarta will achieve 5.5 million electric 2-wheelers by 2030.

TABLE 3. KEY REGULATIONS RELATED TO E2W

Regulations	Notes
Electrification Target and EV Incentives	
Presidential Regulation 55/2019	Framework legislation for the introduction of electric vehicles: encourages the production and use of electric vehicles, mandates the development of charging infrastructure, introduces fiscal and non-fiscal incentives for electric vehicles, gradually increasing local content for electric vehicles
MoI Regulation 21/2023	Governing purchase subsidy of IDR 7 million for 50k E2W in 2024
MoI Regulation 6/2022	Manufacturing roadmap for electric vehicles, including E2W from 2020 – 2035, provisions for calculating domestic component level (TKDN)

FIGURE 25. 5-YEAR TCO OF ICE TWO-WHEELER AND E2W (IN $)



CHALLENGES

Though 5-year TCO analysis for E2W is already lower compared to ICE two-wheeler due to lower maintenance and charging costs, there are still some challenges which reduce urgency and demand to switch from ICE to EV[58]:

[58] Systemiq. (2023). The breakthrough effect in ASEAN: How to trigger a cascade of tipping points to accelerate ASEAN's green growth.

1. **Higher upfront cost for similar specification between EV and ICE:** When comparing ICE versus EV with desired quality specifications, in terms of power and range, the price of E2W is higher even after applying purchase subsidy.
2. **High financing cost:** Financing cost remains quite significant, currently almost 3 times higher than ICE, as financial institutions are quite hesitant to finance E2W due to the perceived high-risk and lack of resell secondary market. This limits the options of potential consumers to afford E2Ws.
3. **Lack of charging and battery-swapping infrastructure, causing range anxiety:** There are two types of E2W in Indonesia: plug-in charging and battery swapping, both of which have limited infrastructure throughout Jakarta. This shortage is particularly concerning for long-distance riders, such as those in ride-hailing services, who worry about battery range, especially outside Jakarta. Many users also feel less safe on E2Ws, leading to lower confidence in the product.
4. **Lack of consumer education leading to low confidence in product:** There is still low public awareness and consumer education on EVs and its benefits. In addition, there is the absence of E2W offering from well-known household 2W brands, such as Honda or Yamaha.

FIGURE 26. MAPPING OF E2W AND ICE 2W AVAILABLE IN INDONESIA BASED ON POWER AND RETAIL PRICE[59]

INTERVENTIONS

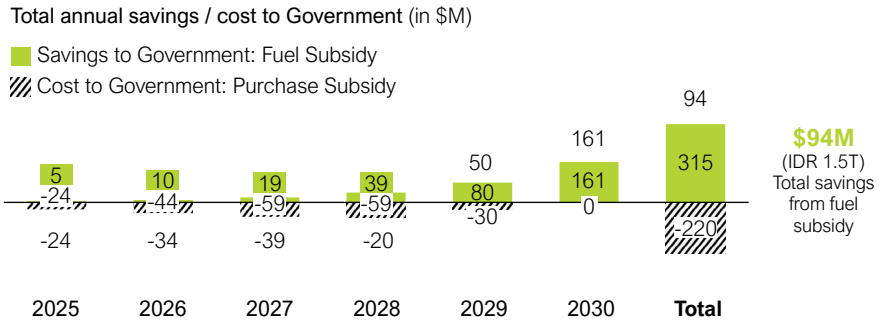
To address these challenges there are three potential interventions:

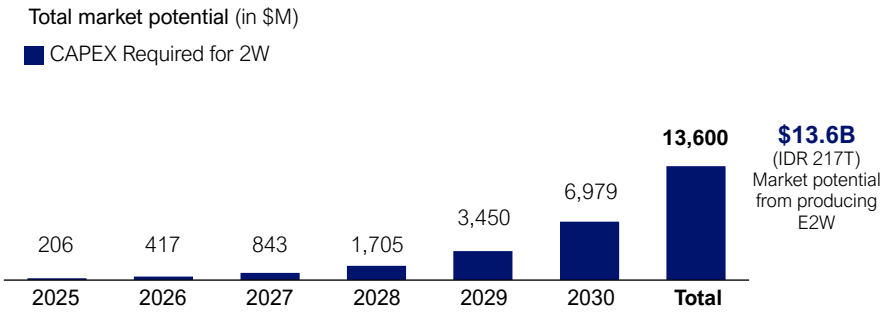
1. **Technology advancement** is required to close the gap between electric and ICE two-wheeler especially for products within the same price ranges. Together with continued government support of purchase subsidy, this could lower the perception of high upfront cost. Additionally, the declining battery learning curve could further lower upfront cost, making E2W more affordable and competitive.
2. **Developing product guarantee –** establishing strong product guarantees, e.g., including buy-back models, warranties, and quality assurance, will also build consumer confidence as it will build a secondary market.
3. **Implementation of de-risking mechanisms** such as guarantee models, can help lower financial barriers leading to lower financing cost for potential consumers.

[59] Document sourced from AISMOLI (22 November 2024)

FIGURE 27. ESTIMATED ECONOMIC IMPACT ON GOVERNMENT AND PRIVATE SECTORS (IN $ MILLION)

Interventions	Impact
Create financing scheme for E2W OEMs to support local manufacturing	**Government Saving**
Implement de-risking mechanism, e.g., guarantee model **Develop product guarantee,** e.g., buy-back model, warranty, quality assurance	**Market Potential**





ECONOMIC IMPACT

Reaching electrification target for two-wheeler is expected to result in $94 million government savings[60] and an estimated $13.6 billion market sales[61] between 2025-2030 period.

Achieving the electric 2-wheelers target has potential to result in a net positive $94 million government savings, from a projected $315 million in fuel subsidy savings and projected $220 million cost if purchase subsidy is extended[62]. Fuel subsidy savings from ICE 2W switching to E2W are projected to reach $315 million. For government cost, the scenario above projects that the IDR 7 million purchase subsidy is extended until 2030 with a 20% reduction every year to ensure continued momentum in E2W adoption, resulting in an estimated $220 million. Considering potential fuel subsidy savings and extended E2W subsidy, government impact is projected to be positive, resulting in $94 million savings.

Market potential could be realised through sales and local production of E2Ws. Manufacturers could prioritize industries with high mileage such as ride-hailing or logistics. When targeting the mass market, it is essential that manufacturers address consumer pain points such as technology gap and secondary market.

[60] The adoption target refers to scenario 2 from the Asian Development Bank Report (2022). The model assumes a split in usage, with 90% of two-wheelers for private use and 10% for commercial, reflecting different travel distances for each group (ADB, 2022).

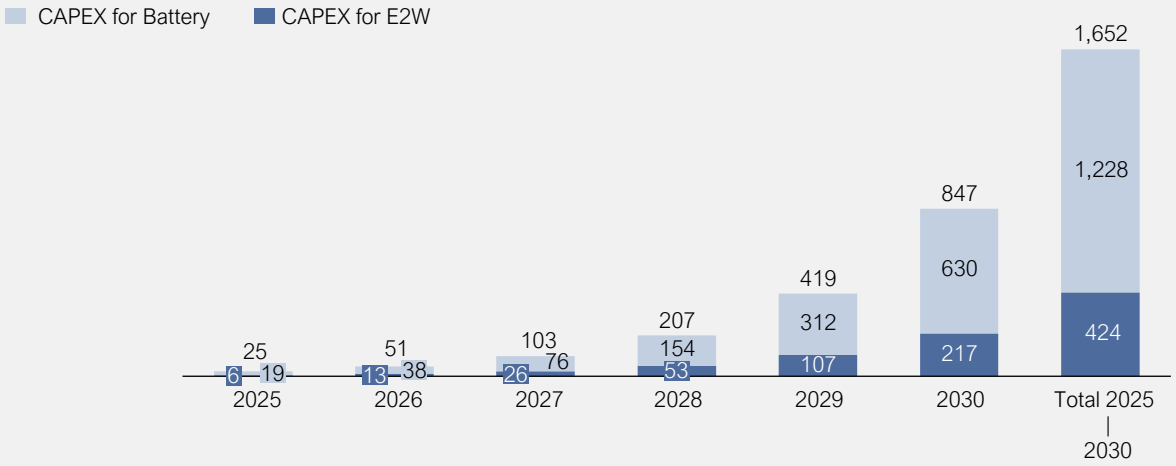
[61] The market potential is calculated based on the estimated retail price multiplied by the number of additional E2W sales per year to reach 5.5 million units by 2030. The estimated retail price per electric two-wheeler (E2W) includes the CAPEX for a single battery, totaling IDR 40.2 million: an average base price of IDR 34.5 million plus a battery cost of IDR 5.7 million (ADB, 2022). It is assumed that the retail price is the same for private and commercial E2W.

[62] This study assumes a continuation of purchase subsidy at a reduced rate to maintain the adoption rate. The purchase subsidy assumption uses a base value of 2024 subsidy of IDR 7,000,000 / unit. It is assumed that the purchase subsidy will be reduced every year following the assumption of: 80% of base value in 2025, 60% of base value in 2026, 40% of base value in 2027, 20% of base value in 2028, 5% of base value in 2029, and 0% in 2030. Scenario discussed based on initial discussions with ministries.

DEEP DIVE: $1.6B MARKET OPPORTUNITY FOR OEMS TO LEASE E2Ws TO GOJEK AND GRAB

There is a $1.6 billion market opportunity to electrify the ride-sharing industry, including Gojek and Grab between 2025 to 2030. OEMs could prioritize B2B sales to drive E2W adoption and expand market penetration more efficiently. Commercial two-wheelers have almost twice higher mileage compared to private two-wheelers.

FIGURE 28. ESTIMATED MARKET POTENTIAL FROM ELECTRIFICATION OF RIDE-HAILING SECTOR (IN $M)



	2025	2026	2027	2028	2029	2030
# of E2W from ride-hailing[2]	573,428	594,666	616,690	639,531	663,217	687,781
# of E2W Target for Jakarta	129,430	222,310	356,470	537,500	811,410	1,233,670

Ride-hailing companies generally operate on an asset-light basis. Therefore, there is an opportunity for OEMs to sell E2Ws to leasing companies, who would then lease them to these platforms. This model lowers the upfront cost for drivers, allowing them to try electric vehicles and providing consumers with firsthand experience, which could help counter negative perceptions around E2Ws.

Currently there are more than 5,000 E2W operating in Jakarta from both Gojek and Grab.[63] Based on stakeholder interviews, current E2W are owned by leasing companies which are then rented to drivers to use daily. Drivers are required to pay monthly rent to the leasing companies, where drivers are unable to do so, ride-hailing company would provide guarantee to the leasing company.

Ride-hailing companies such as GoTo have started to set electrification target as part of their corporate strategy, i.e., 100% electrification by 2030. This provides a positive momentum for OEMs to target the adoption of E2W. This also provides a good opportunity to market E2Ws to potential consumers and increase the confidence in the product.

Opportunity: With their extensive customer base, ride-hailing companies in Indonesia have a unique opportunity to drive E2W adoption by exposing a large audience to EV benefits. These platforms can also address financing challenges by partnering with leasing companies and providing payment guarantees, which would reduce the risk of default for drivers who may struggle with monthly rental costs. This approach could make E2W more accessible for a broader range of drivers, potentially accelerating adoption.

Challenge: Despite these opportunities, the appeal of renting E2Ws is currently limited to a subset of drivers. Typically, these include drivers who do not own a motorcycle or those looking for a secondary vehicle specifically for work. Another challenge is that ride-hailing companies often have limited influence over their drivers, who are independent contractors, and do not directly own or control the motorcycles. This independence limits the ability of ride-hailing companies to enforce or directly incentivize the shift to E2Ws.

Potential Solutions: To overcome these challenges, ride-hailing companies could introduce innovative leasing models, such as allowing drivers to purchase E2Ws at a reduced price after a few years of operation. Additionally, offering exclusive benefits or incentive models, such as reduced service fees, priority dispatch, or visible placement on the app for E2Ws, could attract more drivers to switch. By implementing these strategies, ride-hailing companies can make electric two wheelers a more appealing and viable option, encouraging a broader shift to sustainable transportation.

[63] Based on stakeholder interviews.

NEXT STEPS

Reaching the GoI electrification target for 2W requires collaboration between private sectors, philanthropic funding, and the government required to accelerate adoption of E2Ws:

TABLE 4. ACTION PLAN FOR E2W

Action Plan	Key Stakeholders
Continue purchase subsidy program and explore other financial incentives (e.g. battery subsidy) to support adoption of E2W until economies of scale is able to achieve a lower sticker price to ICE 2W equivalent	MoF
Accelerate domestic E2W market development to achieve national E2W industry targets	MoI
Expand battery swapping and charging infrastructure throughout the city, including in public areas	E2W and battery OEMs, local government
Develop guarantee model to lower high financing cost	Philanthropies, catalytic finance
Incentivize OEM to develop product guarantee, which can spur the creation of a secondary market for E2W	E2W OEM
Commitment from potential key sector, e.g., ride-hailing to set target for electrification	Potential companies, e.g., GoTo, Grab, etc.
Continue providing technical guideline and certification for E2W and retrofitting of ICE two-wheeler, e.g., testing	MoT
Increase consumer education on EV benefits, safety and product specifications of E2W to increase consumer confidence	E2W OEM and user associations, MoH, local government agencies

3. E4W: INCREASING ADOPTION THROUGH WIDER PRODUCT OFFERING AND IMPROVED FINANCING COST

Government Savings

$166M (IDR 2.7T)

Net savings from fuel subsidy and extending VAT exemption incentive 2025-2030

Private Sector Benefit

$20B (IDR 320T)

From potential sales of 887k E4W units 2025-2030

Impact to Pollution in 2030

↓ 5%

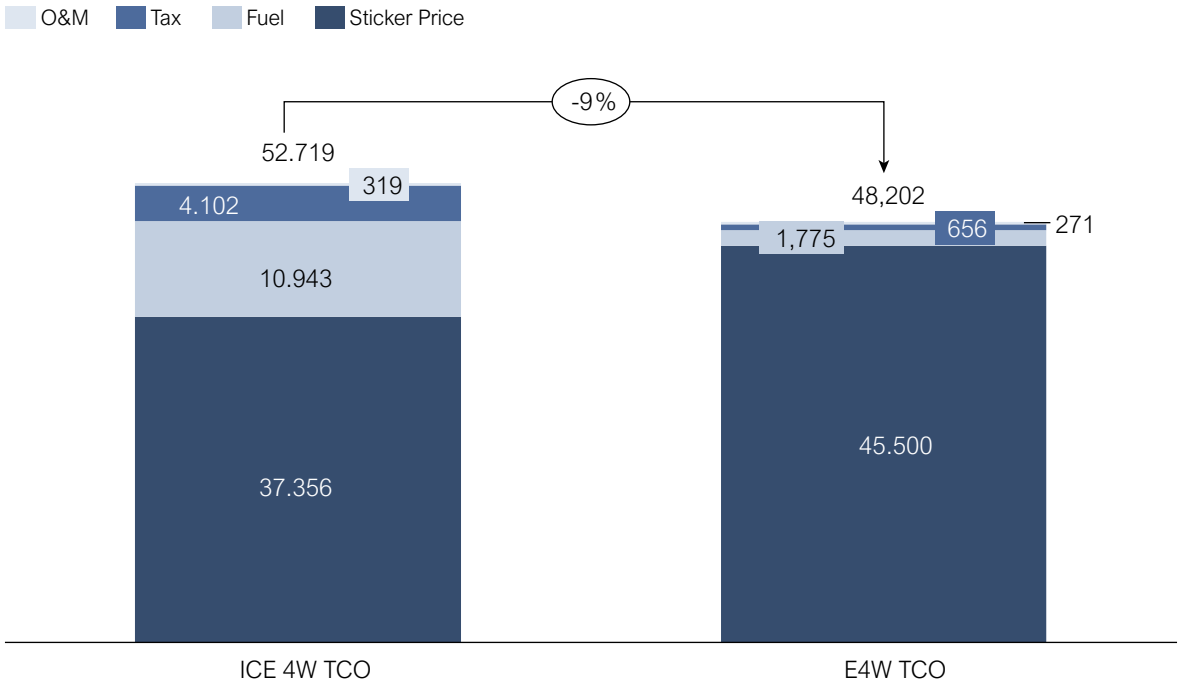
reduction in **$PM_{2.5}$ emissions load** (↓ 6% CO)

- **By 2030, Jakarta is projected to achieve 887,000 units of electric four-wheelers** based on GoI national target of 2.1 million units, adjusted for Jakarta.[64]
- **Accelerating E4W adoption could be beneficial for both government and private market;** $166 million government savings from fuel subsidy and creating a potential $20 billion market.

CONTEXT

The GoI has set ambitious targets for electric four-wheelers, aiming for 400,000 units by 2025 and 2.1 million by 2030 nationally. Though the government has not specified a Jakarta target, this analysis has market sized a realistic Jakarta target to be 887,000 units of electric four-wheeler in Jakarta by 2030.[58] However, if adoption rate is increased, impact would be even greater. As of 2024, there are approximately 44,557 electric four-wheelers in Indonesia.[65]

FIGURE 29. 5-YEAR TCO OF ICE 4-WHEELER AND E4W (IN $)



[64] Target is based on national electric four-wheeler target, scaled down to Jakarta assuming similar proportion of Jakarta adoption compared to national target for E2W. This assumes adoption is being prioritized in Jakarta where charging infrastructure is already more advanced.

[65] GAIKINDO, 2024

TABLE 5. KEY REGULATIONS RELATED TO E4W

Regulations	Notes
Electrification Target and EV Incentives	
Presidential Regulation 55/2019	**Framework legislation for the introduction of electric vehicles** encourages the production and use of electric vehicles, mandates the development of charging infrastructure, introduces fiscal and non-fiscal incentives for electric vehicles, gradually increasing local content for electric vehicles
Government Regulation 74/2021 on Luxury Tax Rate for Motorized Vehicles	Exemption of BEV from luxury tax (PPnBM)
Law 1/2022 on Financial Relationship between the National Government and Local Governments	Exemption of BEV from annual vehicle tax (PKB) and title transfer tax (BBNKB)
MoI Regulation 6/2022, MoI Regulation 28/2023	Manufacturing roadmap for electric vehicles, including E2W from 2020 – 2035, provisions for calculating domestic component level (TKDN)
Presidential Regulation 79/2023	Amend earlier Presidential Regulation 55/2019 to extend financial incentives on local content requirements, import duty and tax reductions, and support for domestic EV production

CHALLENGES

TCO for electric four-wheeler is already lower than ICE cars due to lower maintenance and fuel cost. However, sticker price is still significantly higher. With government incentives, adoption is growing but some challenges remain:

1. **High upfront and depreciation costs compared to ICE equivalent** – High upfront cost is the most significant barrier to adopting electric vehicles, deterring many potential buyers. Lack of secondary market and resale value drives up depreciation cost of EVs over ICE. Additionally, battery depreciation costs present a new challenge, as batteries comprise approximately 40% of the initial vehicle cost.
2. **Lack of urgency to switch to electric four-wheelers** – influenced by perceptions that may not prioritize environmental impact or long-term savings.
3. **Lack of charging infrastructure and range anxiety:** Requires a fundamental shift in consumer behavior regarding charging habits. Unlike ICE vehicles, which rely on instant refueling, EV users must adapt to slow charging at home or office, or fast-charging stations for occasional top-ups.

INTERVENTIONS

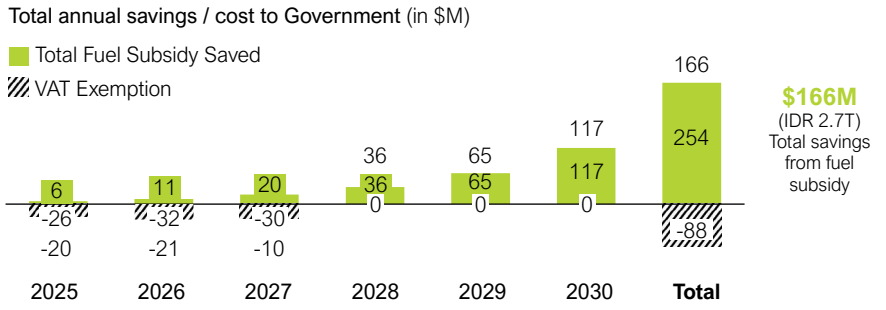
There are several potential interventions:

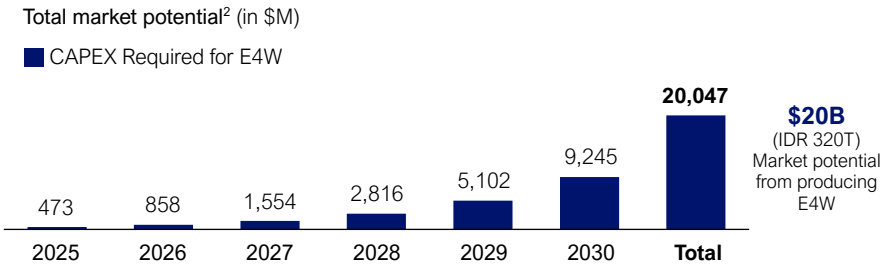
1. **Lower financing cost** through partnerships with banks and lenders could make electric four-wheelers more affordable by reducing interest rates and lease payments.
2. **Continued government incentives such as VAT reduction, as well as potentially extending incentives** to "plug-in taxi grants," rebates, or corporate tax adjustments for ride-hailing and taxi companies, could further encourage adoption within commercial fleets and support broader market growth.
3. **Increased charging infrastructure,** throughout the city including in public facilities, parking lots, retail chains, and residential areas, alongside exclusive designated EV parking spots.

Reaching electrification target of 887,000 units by 2030 could result in an estimated government savings of $166 million[66] and the creation of $20 billion market potential between 2025-2030.[67]

FIGURE 30. ESTIMATED ECONOMIC IMPACT OF ELECTRIFICATION OF 4W TO GOVERNMENT AND PRIVATE SECTOR

Interventions	Impact
Develop product market fit to accelerate demand creation – currently there are limited options for E4W at high price ranges	**Government Saving**
Improved financing costs: Enable banks and lenders to reduce the cost of financing and lease rates	**Market Potential**





Fuel subsidy savings are estimated to reach $254 million in the same period, whereas VAT reduction is estimated to cost the government $88 million.[68] Fiscal incentive in the form of VAT reduction is assumed to be continued to maintain the current adoption of E4W for electric vehicles that comply with local content requirement with yearly reduction of 2.5%.

Market potential is equal to the potential revenue of manufacturing industries, estimated to reach $20 billion between 2025-2030.[69] Similar to E2W, manufacturers could potentially target several sectors such as taxi companies or government vehicles.[70] By 2030, Jakarta's taxi fleet is expected to grow from 17,278 units in 2023 to 25,608 units, creating a market opportunity worth approximately $595 million. With companies striving to meet net-zero commitments, this presents a strategic opportunity for manufacturers to capture demand quickly, positioning electric vehicles as a viable solution for fleet transition.

[66] Fuel subsidy savings are calculated against a business-as-usual (BAU) scenario in which no electrification occurs, cars have a remaining lifetime until 2030 and vehicle growth projections for 4W around 5.8 – 6.1% (ITB). Fuel savings are determined by comparing the production cost to the selling price of fuel (~1,500 IDR/L). The analysis also accounts for differing vehicle kilometers travelled (VKT) per year between private and commercial vehicles: ~14,000-17,000 km/year for private vehicles (depending on gasoline or diesel), and ~50,000-53,000 km/year for commercial vehicles. (Clean Air Catalyst and ITB, 2023).

[67] Projected adoption targets were derived from a number of assumptions aligned with GOI targets: (1) actual number of E4W in 2023 is used as a base assumption to define how many additional E4W needs to be deployed every year, (2) assume 90% of actual E4W adoption in 2023 and 2024 are in Jakarta and (3) compound annual growth rate (CAGR) of 81% to achieve GoI target (MoT, MoI). Price for E4W is assumed constant at $23,250 per unit based on the price of Wuling Binguo EV which is the highest selling model of E4W in 2023 (Otomotif Bisnis, 2024). VAT reduction assumed to be only applicable for electric vehicles with 40% local content, therefore it is assumed that 70% vehicles comply with this requirement based on the 2023 sales number for the models that are compliant, with annual increase of 2.5% to account for a growing manufacturing industry (GAIKINDO, 2024).

[68] Government cost is opportunity cost from PPN reduction from 11% to 1% for every purchase of E4W that meet local content requirement (TKDN). The government cost is based on PPN reduction multiplied by the retail price of E4W and the number of new E4W deployed each year to reach the 2030 E4W projection. 10% PPN reduction is used as a base value in 2024 and will be reduced each year: 7.5% in 2025, 5% in 2026, 2.5% in 2027. Retail price used in analysis is $23,250 / unit or IDR 372,000,000 / unit based on the price of Wuling Air Binguo 2024, as the highest-selling model in 2023 (Otomotif Bisnis, 2023). The proportion of E4W meeting local content requirement is assumed to be 70% in 2024 based on the 2023 EV sales by model, and it assumed to increase 2.5% each year.

[69] The market potential is based on retail price for E4W multiplied by the number of new E4W deployed each year to reach the 2030 E4W projection. Retail price used in analysis is $23,250 / unit or IDR 372,000,000 / unit based on the price of Wuling Air Binguo 2024, as the highest-selling model in 2023 (Otomotif Bisnis, 2023).

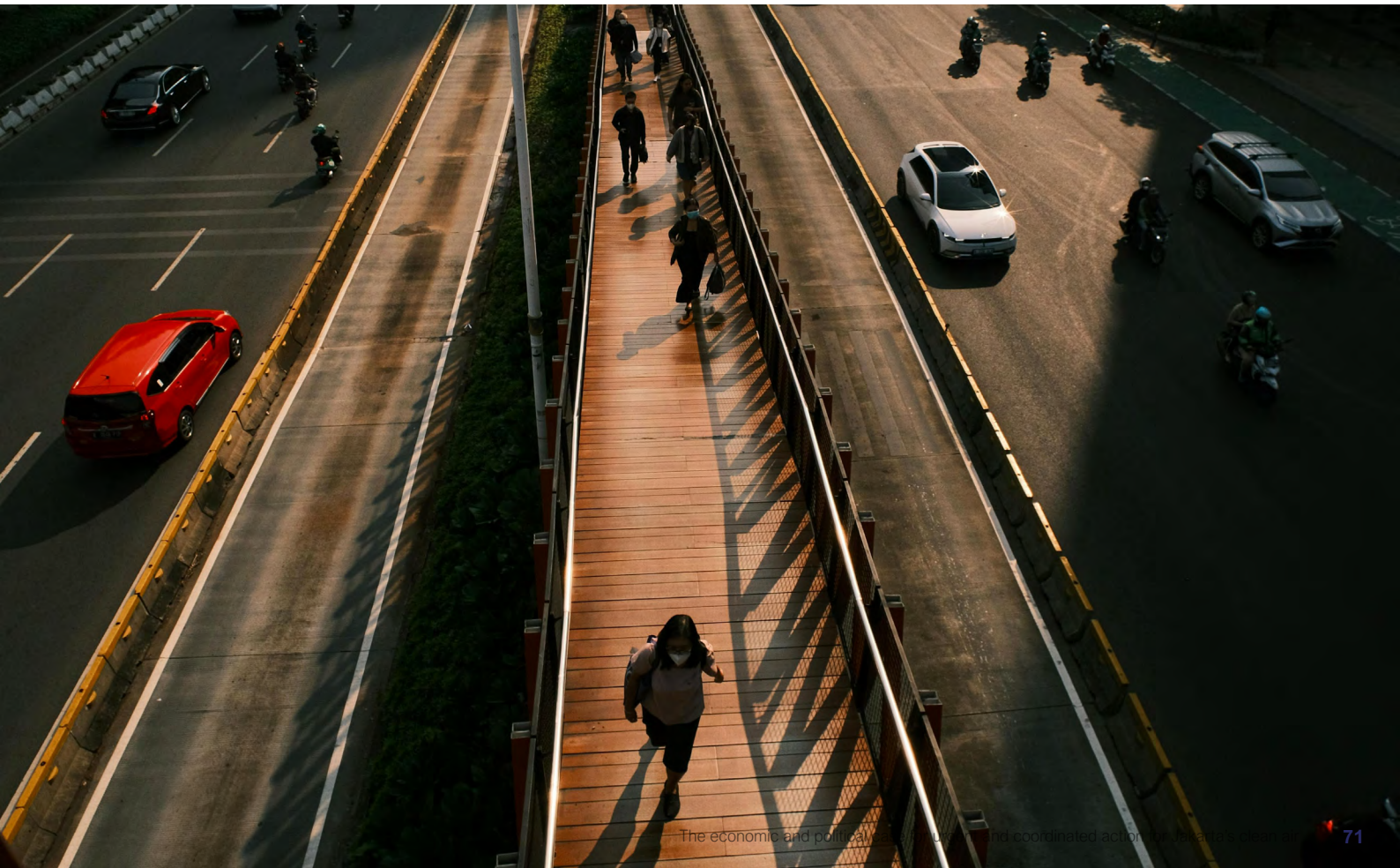
[70] Vital Strategies. (2023). Cost-benefit analysis for air pollution control strategies in Jakarta. Vital Strategies. Retrieved November 24, 2024, from https://www.vitalstrategies.org/resources/cost-benefit-analysis-for-air-pollution-control-strategies-in-jakarta/

NEXT STEPS

Achieving the electrification target requires collaborative effort between ministries, e.g., ministry of finance and ministry of energy and mineral resources, OEMs and user associations:

TABLE 6. ACTION PLAN FOR E4W

Action Plan	Key Stakeholders
Continue fiscal incentives until economies of scale are reached	MoF, MEMR, MoI, Ministry of Investment / Indonesia Investment Coordinating Board
Continue to widen tax gap: exemption of luxury tax (PPNBM), reduction of maximum yearly tax (PKB) and title transfer fee (BBNKB)	MoF
Accelerating government fleet electrification implementation strategies under Presidential Instruction 7/2022 and Jakarta Governor's Decree 576/2023	Central and local government agencies
Increase enforcement e.g., implementation of Low Emission Zones, reduction in fuel subsidy, etc. to push the demand for E4W	MEMR, Provincial Government of Jakarta
Incentivize local OEM to develop product guarantee, which can spur the creation of a secondary market for E4W	E4W OEM
Commitment from potential key sector, e.g., ride-hailing to set target for electrification	Potential companies, e.g., GoTo, Grab, JNE, etc.
Increase awareness of benefits of electrification and market direction to increase confidence in E4W and eliminate anxiety, e.g., range anxiety	E4W user associations



4. E-TRUCKS: TARGET SETTING AND SECTOR PRIORITISATION

Government Savings

$128M (IDR 2T)

Saved from reduced fuel subsidy

Private Sector Benefit

$6B (IDR 96T)

From potential sales of 15% electrification of trucks by 2030

Impact to Pollution in 2030

↓ 2%

reduction in **$PM_{2.5}$ emissions load**

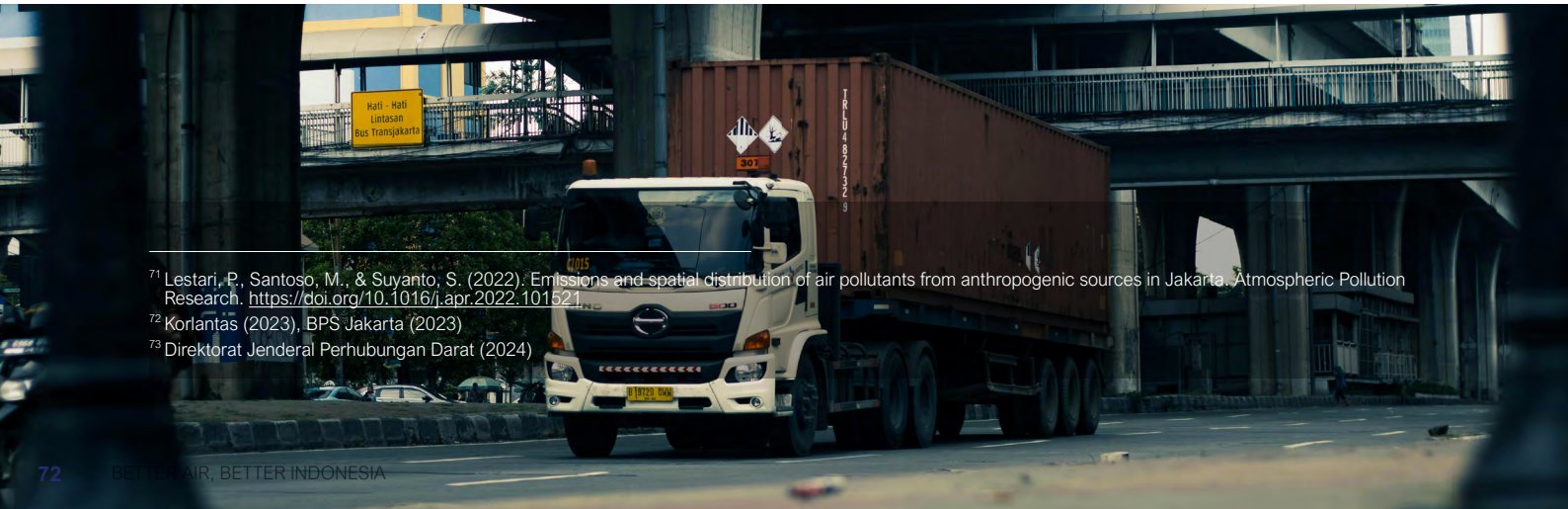
- **This report proposed a conservative 15% electrification target for trucks (relative to global benchmarks),** amounting to 114,985 trucks by 2030. Further impact can be achieved if e-truck target is increased.
- **Reaching this target could lead to government savings and private market benefits:** $128 million government savings from fuel subsidy while unlocking $6 billion of market potential from production of E-Trucks.

CONTEXT

The GoI does not currently have an e-truck target: establishing a conservative 15% electrification target for trucks has potential to reduce air pollution and unlock a new EV market. This report proposes a 15% truck electrification, considering international benchmarks such as China and the US target of 30% electrification of trucks by 2030 and Europe targeting 50% by 2030.

Promoting adoption of e-trucks can be an effective strategy, particularly by targeting large truck fleets with consistent intra-city fixed routes; relevant sectors include municipal services and last-mile logistics. More relevant for other cities with large construction and mining industries, exploring closed-loop non-road trucks e.g., in construction and/or mining sites also present an effective electrification opportunity due to their routine, closed-loop operations and restricted access to unsubsidized fuel.

Trucks are the largest contributors to air pollution in the transportation sector, accounting for 28% of 2015 transport emissions in Jakarta.[71] Currently, over 500,000 trucks operate in Jakarta, with this number growing by 5% annually.[72] Despite the potential benefits, electric truck adoption remains very low, with only 10 registered e-trucks as of July 2024.[73] Currently, there is limited regulatory support for electric trucks, with policies such as Presidential Regulation 55/2019 offering a 0% import duty for Completely Knocked Down (CKD) electric trucks, provided they meet local content requirements.



[71] Lestari, P., Santoso, M., & Suyanto, S. (2022). Emissions and spatial distribution of air pollutants from anthropogenic sources in Jakarta. Atmospheric Pollution Research. https://doi.org/10.1016/j.apr.2022.101521

[72] Korlantas (2023), BPS Jakarta (2023)

[73] Direktorat Jenderal Perhubungan Darat (2024)

CASE STUDY: ZERO EMISSION TRUCKS GAINING MOMENTUM GLOBALLY

Globally, heavy-duty vehicles account for more than 30% of the global CO2 emissions, 40% of on-road NO_x, and 60% of on-road $PM_{2.5}$.[74] Electrification of trucks has been part of many countries air pollution and climate strategy, such as **China, United Kingdom and India.**

Several provinces in China have started to announce zero emission truck (ZET) target, including 100% electrification of new logistics vehicles and 50% of other Light-Duty Vehicles in Hainan by 2025.[75] As of 2022, China sold 52,000 electric medium and heavy-duty trucks, accounting for 18% and 4% of medium and heavy-duty truck sales.[76] Currently, China accounts for 70% of global E-truck sales with Chinese OEMs making up almost 40% of all electric truck models globally.[77]

The United Kingdom pledged for zero emission heavy duty vehicles by 2040 back in 2021.[78] While the 2023 adoption remains quite low with E-Trucks accounting for 5.2% of light duty and 2.8% medium and heavy-duty new vehicles registrations, the number has seen a significant 400% increase since the 2022.[79] E-trucks have been mostly used in logistics sectors where there is high usage and consistent mileage, maximizing the impact of the electrification.

India has announced its national net zero target by 2070, requiring decarbonization of its transport sector including commercial trucks. India government has recently expressed the importance of complete the transition to zero-emission trucks by 2050 to reach the country's net zero target.[80] Almost 60% of total oil consumed in India was used by freight trucks, responsible for 71% of CO_2 emissions, 74% of PM emissions and 55% of NO_x emissions from road vehicles.[81] Electric Freight Accelerator for Sustainable Transport was recently launched as a platform between the government and private sector to collaborate on electrification of large-scale freight trucks, spurring 16 major companies to signal demand for more than 7,000 E-trucks by 2030.

FIGURE 31. GLOBAL CASE STUDY ON GOVERNMENT INTERVENTIONS IMPLEMENTED TO DRIVE THE ADOPTION OF E-TRUCKS

		China	Europe	India
Country Context		Reduce air pollution, reach carbon neutrality by 2060	Reduce GHG emissions by 81% by 2035	Reaching net zero target by 2070
Electrification Target		Varies by provinces, e.g., Hainan 100% electrification for new logistics vehicles	Zero emission vehicle by 2040	No specific target for truck electrification but government has expressed importance of zero emission trucks by 2050
Government Support: Demand	End-User Financial Incentives	**Purchase Subsidy:** A maximum subsidy of 28,000 Yuan for BEV and 18.600 Yuan for PHEB trucks	**Grants:** Plug-in truck grants reduce cost of buying smaller trucks by 20% (up to GBP 16k) and larger trucks (up to GBP 25k)	**Purchase Subsidy:** Subsidies worth 36.79 billion rupees for EV (including electric trucks)
	End-User Tax Incentives	**Tax Exemption:** Exemption of purchase tax up to 30,000 yuan; New EV purchase by end of 2025 are exempt from purchase tax	**Tax Reduction:** EVs pay lower road tax but subject to potential changes in 2025	**Tax Exemption:** Provide road tax exemption to EV owners, Registration fee exemption for EV owners
	Other Incentives	**Free Parking & Tol Rates:** Free parking incentives for EV vehicles, Reduced tol rates for zero-emission trucks	**Congestion Charge Exemption:** E-Trucks are exempt from congestion charge	**Scraping Incentives:** 109B incentive scheme for scrapping old trucks

[74] United Nations Environment Programme (UNEP). (n.d.). Rise in used heavy-duty vehicles: A major contributor to pollution, prompting calls for more stringent regulations. Retrieved from https://www.unep.org/news-and-stories/press-release/rise-used-heavy-duty-vehicles-major-contributor-pollution-prompting

[75] International Council on Clean Transportation (ICCT). (2023, January). China clean diesel III: Progress and challenges in China's diesel vehicle and fuel policies. The ICCT. Retrieved from https://theicct.org/publication/china-clean-diesel-iii-jan23/

[76] International Energy Agency (IEA). (2023). Global EV Outlook 2023: Trends in electric heavy-duty vehicles.

[77] International Energy Agency (IEA). (2024). Global EV Outlook 2024: Trends in heavy electric vehicles.

[78] Department of Transport (2021)

[79] Trans.info. (2023). UK electric HGV registrations up over 400% year-on-year in Q1 2023.

[80] ESG News. (2024, November 21). India targets zero-emission trucks by 2050 with 30 policy interventions to accelerate electrification. Retrieved from https://esgnews.com/india-targets-zero-emission-trucks-by-2050-with-30-policy-interventions-to-accelerate-electrification/

[81] Berkeley Lab, International Energy Analysis. (n.d.). Benefits of electrifying freight trucks.

		China	Europe	India
Government Support: Supply	End-User Financial Incentives	**Manufacturer Grants:** $230 Billion in support to the EV industry, e.g. Chengdu gov't awards up to 50 million yuan to private market that develops EV	**Infrastructure Incentives:** GBP 950 million fund aimed to support the rollout of at least 6,000 rapid charge points	Limited policies
	End-User Tax Incentives	**Consumption Tax Exemption:** China uses exemptions on consumption tax to help lower production cost of EVs	Limited policies	Limited policies

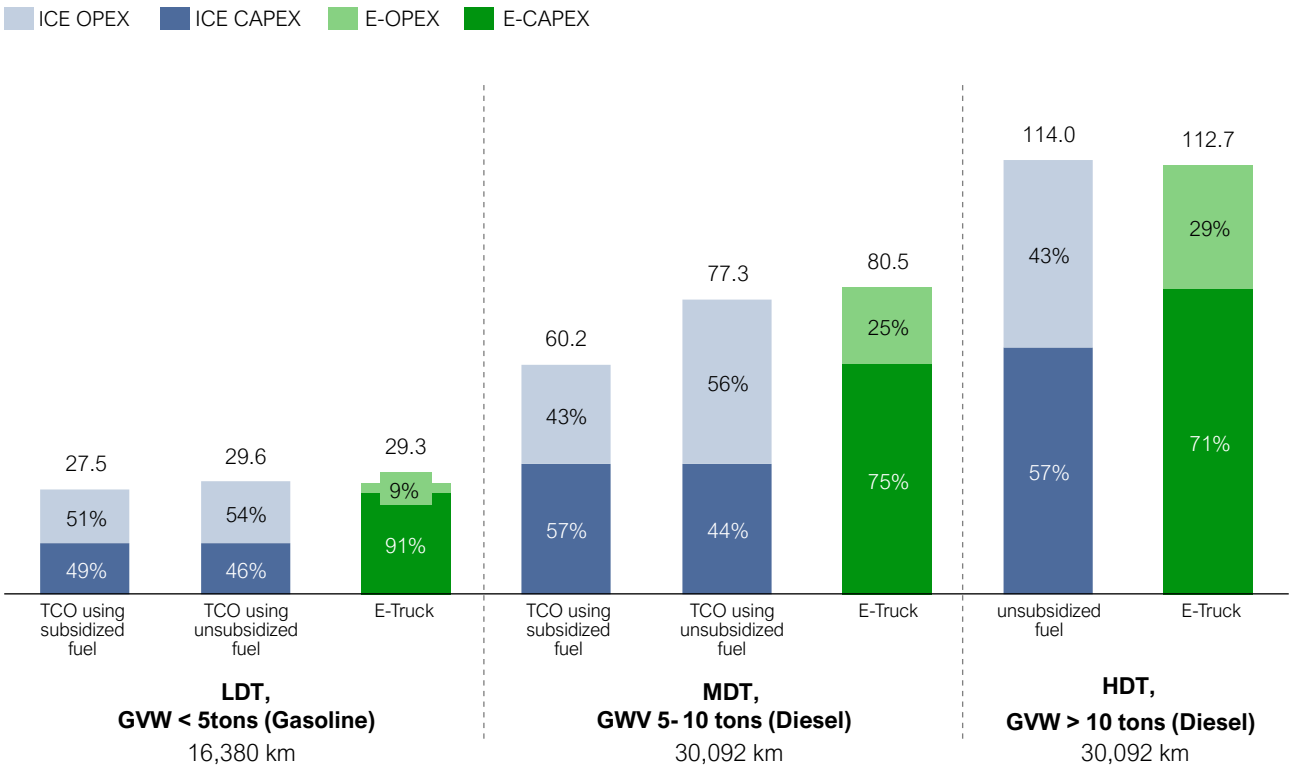
Government support is an essential part in pushing E-truck adoption in China, India and the UK. Support in the form of financial and non-financial incentives is more focused on demand-side incentives compared to supply side.

End-user financial support mainly exists in the form of purchase subsidy and tax exemption or reduction. Purchase subsidies or grants help to lower upfront costs, reducing the barrier to entry in all three countries. This is mainly implemented in the early stage of transition to gain momentum and increase adoption. Tax reduction or exemption provides extra benefits for the vehicle owner to lower its maintenance cost, allowing owners to reach cost parity with ICE trucks sooner. Other financial benefits include free parking, exemption from congestion charge and lower toll rates. All of which contributes to lower operating costs.

End-user non-financial benefits allow owners to have more freedom such as exemption from odd-even number license plate rule and reserved parking. Unlike financial incentives which are aimed at lowering upfront costs or operational costs, non-financial incentives offer convenience and flexibility.

Manufacturer incentives for electric vehicle (EV) adoption are often focused on financial support and import tax reductions. These measures aim to lower the financial barriers for transitioning to EV production and usage. Import tax reductions are particularly impactful in markets with less mature EV industries. For example, India has reduced import duties on electric vehicles to facilitate early adoption and simultaneously nurture the domestic EV manufacturing ecosystem. This approach helps attract global EV makers, accelerates technology transfer, and supports the development of local capabilities, creating a foundation for long-term growth in the EV sector.

FIGURE 32. 15-YEAR TCO CALCULATION FOR COMMERCIAL TRUCKS (IN $'000)



Fifteen-year TCO analysis shows that E-Truck has reached cost parity with ICE trucks across categories if ICE trucks do not use subsidized fuel.[82] The TCO difference for subsidized and non-subsidized fuel is more significant in diesel trucks due to the higher amount of subsidy per liter provided by the government, IDR 4,966 / L compared to IDR 1,596 / L for gasoline. Heavy duty trucks are restricted from using subsidized fuel hence the difference is not too significant. This research focuses on intra-city or closed loop usage of trucks, e.g., logistics and municipalities.

CHALLENGES

There are currently three main challenges in the adoption of electric trucks:

1. **Limited urgency and incentives to convert to electric trucks –** unlike electric two- and four-wheelers, electric trucks lack official adoption targets and receive minimal policy attention. Existing electric trucks are mostly used in closed-loop business models, driven by international pressures for cleaner transportation, such as in the mining sector, where infrastructure is managed by the operating company.
2. **High upfront costs –** while the total cost of ownership (TCO) for electric trucks is projected to be lower over the vehicle's lifetime, the high upfront cost compared to ICE trucks remains a barrier. With similar government incentives applied to completely knocked down (CKD) ICE and electric trucks, the latter become less appealing for OEMs. The high costs are particularly challenging for smaller-scale truck operators which may have limited access to financing.
3. **Lack of charging infrastructure,** both within factories and warehouses as well as for inter-city routes, creating significant logistical challenges to widespread electric truck adoption. While trucks typically have fixed routes, it remains unclear who will bear the cost of building the necessary charging facilities – whether through government in public facilities or in private warehouses. Truck owners may need to finance this infrastructure themselves, further increasing the transition costs for fleet operators.

INTERVENTIONS

To address the challenges, potential interventions that could be explored include:

1. **GoI to set target for E-Trucks –** electrification target builds momentum for truck manufacturers and owners to switch to electric trucks. GoI electrification strategy will require a nuanced approach due to their outsized emissions impact and diverse operational needs across categories (light/medium/heavy duty, varying use cases) and industries.
2. **Identify priority sector to be electrified –** sectors like logistics and municipalities have high usage of trucks and consistent closed loop routes. Targeting these sectors could be a quick win for electric truck leasing companies or manufacturers.
3. **Available charging infrastructure –** at depots and specified routes for prioritized fleets.
4. **Leasing model by trucks operator or OEMs –** similar to leasing model for electric bus, this model allows companies to transition to electric trucks without having to incur the high upfront costs.
5. **Incentivize local manufacturing for CKD –** providing fiscal incentives to manufacturers

[82] TCO assumes intra-city trucks with potentially lower mileage to inter-city trucks. Different truck model is used as a reference for TCO calculation: LDT ICE (Mitsubishi L300), LDT E-Truck (Geely's Radar R6), MDT ICE (Mitsubishi FUSO FE), MDT E-Truck (Mitsubishi FUSO eCanter), HDT ICE (Scania P410-B HT), HDT E-Truck (BYD T9 Truck). Due to lack of data, maintenance cost for Truck is assumed to be the same across categories, $0.03 / km for electric and $0.05 / km for ICE based on ICCT (2023) Total cost of ownership for heavy trucks in china: battery-electric, fuel cell electric, and diesel trucks. Fuel price is adjusted for Indonesia fuel price (As of 1st October 2024) and electricity price is based on PLN industry rate. Annual km travelled have been adjusted for Jakarta, aligned with the assumption used in the research.

could help accelerate electric truck adoption while also strengthening the country's manufacturing sector. Similar to E2Ws and four-wheeler government incentive plays a crucial role in creating momentum for consumers to switch to electric trucks.

ECONOMIC IMPACT

Electrification of 114,985 commercial trucks could lead to $128 million of government savings[83] from fuel subsidy and $6 billion sales potential.[84]

FIGURE 33. ESTIMATED ECONOMIC IMPACT TO GOVERNMENT AND PRIVATE SECTOR BETWEEN 2025-2030 (IN $M)

Interventions	Impact	
Develop product market fit to accelerate demand creation – currently there are limited options for E4W at high price ranges	**Government Saving**	Total annual savings / cost to Government (in $M) Total Fuel Subsidy Saved VAT Exemption 2025: 0 (0, 0) 2026: 1 (1, 0) 2027: 4 (3, 0) 2028: 11 (9, 1) 2029: 29 (3, 26) 2030: 83 (9, 74) Total: 128 (13, 115) **$94M** (IDR 1.5T) Total savings from fuel subsidy
Improved financing costs: Enable banks and lenders to reduce the cost of financing and lease rates	**Market Potential**	Total market potential[2] (in $M) Charging Infrastructure Light Duty Trucks Medium Duty Trucks Heavy Duty Trucks 2025: 22 (7, 8, 5, 2) 2026: 63 (19, 22, 15, 7) 2027: 176 (53, 63, 42, 19) 2028: 495 (148, 175, 118, 53) 2029: 1.388 (417, 492, 330, 149) 2030: 3.893 (1.170, 1.379, 926, 417) Total: 6.037 (1.814, 2.140, 1.436, 647) **$13.6B** (IDR 217T) Market potential from producing E2W

Fuel subsidy savings are mainly realized through electrification of diesel trucks accounting for $115 million, whereas subsidy savings for gasoline account for $13 million between 2025-2030. Subsidy savings are evaluated against a BAU scenario where diesel and gasoline trucks remain operational until 2030. The majority savings come from diesel, as only 30% of light-duty trucks using gasoline[85], and diesel receives a significantly higher subsidy from the government.

Market potential is equal to sales of electric trucks to leasing or truck companies, estimated to reach $6 billion between 2025-2030. Due to the lack of E-Truck manufacturing industry in Indonesia, the market potential could be realized through import from other countries, such as China which currently accounts for 70% of the global sales.[86] Potential sales are highest for light duty trucks followed by medium duty trucks. OEMs could prioritize B2B contracts with companies that use large number of trucks such as logistics companies. Another potential sale could come from building charging stations for commercial trucks, accounting for an estimated 12% of the market potential. Unlike E2W and E4W, charging stations may need to be installed at depots or warehouses.

[83] The proportion of medium-duty trucks (MDT) and heavy-duty trucks (HDT) is derived from the sales distribution of trucks with similar gross vehicle weights used in the TCO analysis. The fuel mix is assumed to be 70% gasoline and 30% diesel for light-duty trucks (LDT), while MDT and HDT rely entirely on diesel. Fuel subsidies are estimated at IDR 1,596/L for gasoline and IDR 4,966/L for diesel. Total savings are calculated cumulatively for the 2025–2030 period, excluding inflation and the time value of money.

[84] The market potential is calculated by multiplying the retail price of an electric truck (E-Truck) by the number of E-Trucks added each year. Price of E-Truck refers to E-Truck model used in TCO analysis.

[85] Sehlleier, F., & Priatama, Y. (2022). Indonesia road freight vehicle market: Analysis of new vehicle sales data 2010–2021. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Retrieved from https://changing-transport.org/wp-content/uploads/2022_GIZ-Truck-Sales-Analysis-Indo-1-1.pdf

[86] International Energy Agency (IEA). (2024). Global EV outlook: Trends in heavy electric vehicles.

NEXT STEPS

A collaborative action between MoI, MoF, industry association and private sectors are required to push the adoption of electric trucks. Key action plans include setting an aggressive target, providing government incentives and commitment from key sectors.

TABLE 7. ACTION PLAN FOR E-TRUCKS

Action Plan	Key Stakeholders
Set a target for electrification of trucks, esp. heavy-duty trucks due to their high contribution to air pollution	Provincial Government of Jakarta, MoI
Provide an economic leasing model for key companies / sectors with large number of trucks to accelerate adoption	OEM, Leasing Companies
Promote adoption of e-trucks for key sectors, with closed-loop operations	Private sector, e.g., logistics, mining
Consider corporate incentives for companies that switch to electric trucks, e.g., corporate tax reduction, incentive to help build charging infrastructure	MoF
Explore potential reduction of import tax for CKD units from all countries to boost local manufacturing of E-Trucks in Indonesia, tied to local production commitment	MoF
Educate truck owners on the benefits of E-Trucks, e.g., lower maintenance cost, higher efficiency, potentially stricter regulations on ICE trucks	Industry Association

FUTURE RESEARCH

This research did not examine the use of hydrogen for electric trucks, as Indonesia's hydrogen market is still nascent, with limited regulatory frameworks supporting its use in transportation. However, the study acknowledges the potential benefits of hydrogen electric vehicles, particularly for long-haul applications in heavy-duty trucks, where hydrogen's high energy density could offer significant advantages.

In addition, this research does not cover the electrification of heavy-duty machinery. However, the demand for electric heavy-duty machinery, in particular in closed loop systems such as mining sites, has increased in the past year which also has positive impact potential to air quality.

5. E-BUS: 10K TRANSJAKARTA E-BUS BY 2030

Government Savings

$144M (IDR 2.3T)

Saved from reduced fuel subsidy

Private Sector Benefit

$1B (IDR 320T)

from E-Bus fleets (Articulated, Single, Medium and Microbus) between 2025 -2030

Impact to Pollution in 2030

↓ 0.3%

reduction in **$PM_{2.5}$ emissions load**

- **TransJakarta has committed to achieving 10,000 electric TransJakarta buses by 2030,** based on Governor's Decree 576/2023
- **100% electrification of TransJakarta buses can** unlock $1 billion private market potential through leasing or local manufacturing of E-Bus and $144m in government savings from fuel subsidy.

CONTEXT

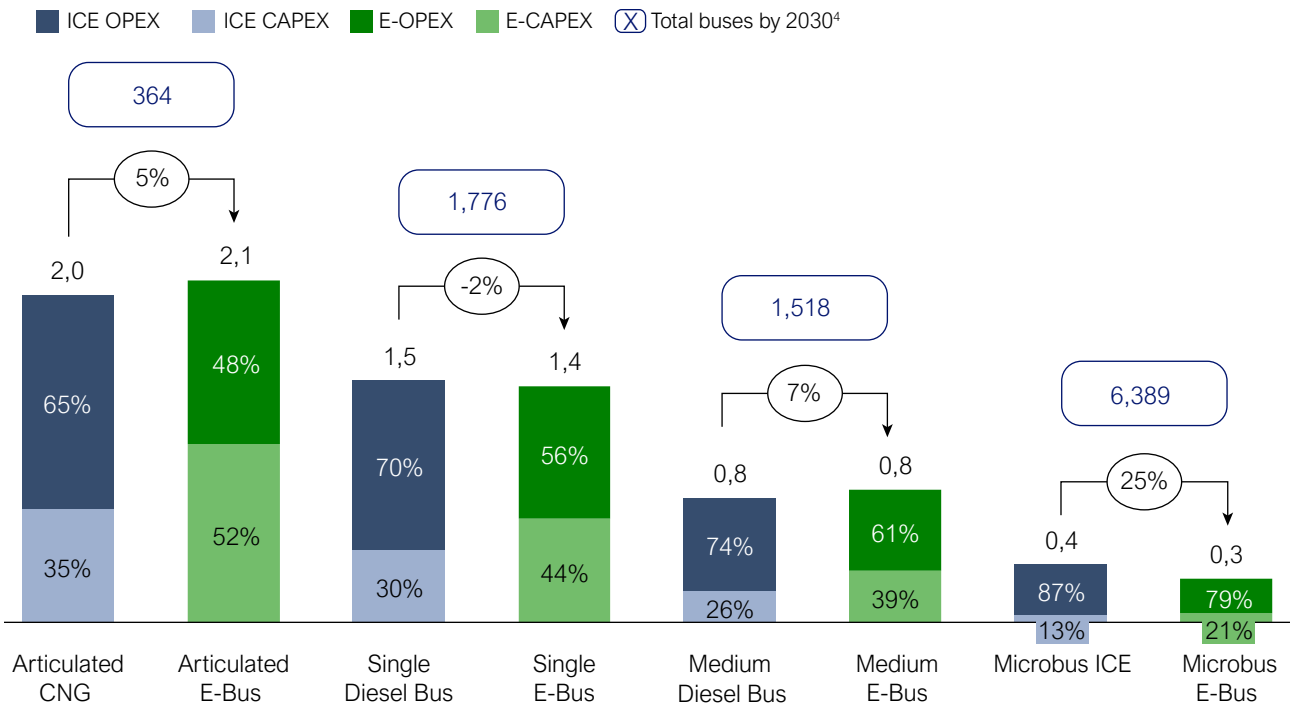
Transjakarta aims to have 10,047 electric buses on the road by 2030, achieving 100% electrification of its bus fleets. Achieving 10,047 e-buses by 2030 will triple the current size of fleet at 37,180 ICE buses in 2024, thus expanding access and route availability to the public. A benefit of bus electrification, as opposed to promoting private EVs, is that it offers an opportunity to modernize public transport, increase ridership of MRT and LRT as bus feeder routes, and reducing private vehicle fuel subsidies.

Several regulations have been implemented to support the adoption of e-buses:

TABLE 8. KEY REGULATIONS RELATED TO E-BUSES

Regulations	Notes
Electrification Target and EV Incentives	
Presidential Regulation 55/2019	Framework legislation for the introduction of electric vehicles: encourages the production and use of electric vehicles, mandates the development of charging infrastructure, introduces fiscal and non-fiscal incentives for electric vehicles, gradually increasing local content for electric vehicles
Governor's Decree 1053/2022	Mandates the use of 100% e-buses for Transjakarta
Jakarta Governor's Regulation 3/2022	EV exemption from the yearly vehicle tax starting in 2024
Jakarta Governor's Regulation 73/2019	Exempts e-buses from the luxury tax (PPnBM) and a temporary VAT reduction depending on local content

FIGURE 34. TCO COMPARISON FOR DIFFERENT TYPES OF E-BUS ($ / KM)



Currently, the 5-year TCO of electric single and microbus buses is already lower than ICE, due to significantly lower cost of charging compared to fuel and lower maintenance cost.[87] In particular for microbuses, which make up more than 60% of e-buses, the TCO per kilometer is 25% lower than the ICE equivalent. Despite this economic benefit, EV's higher upfront CAPEX poses challenges to adoption.

KEY CHALLENGES

Despite lower TCO, there are three challenges remaining:

1. **High upfront cost** – electric buses have high upfront costs, particularly for medium-sized buses that have a higher replacement ratio due to battery requirements.
2. **Lack of charging infrastructure** – Consumer have range anxiety due to lack of charging infrastructure, which is also significant expensive, projecting to $20 million.
3. **Premature retirement of fleets** – many internal combustion engine (ICE) fleets have not yet reached the end of their operational life, making bus operators hesitant to incur the costs associated with retiring these buses prematurely.

INTERVENTIONS

There are two potential interventions to address the challenges:

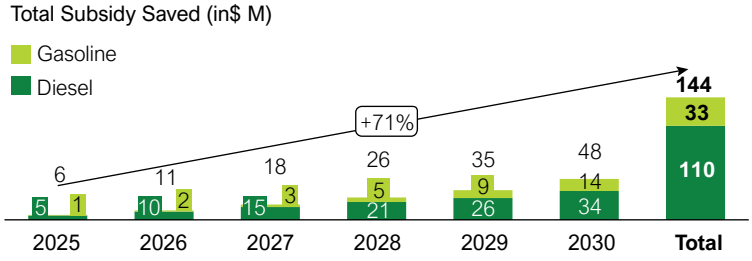
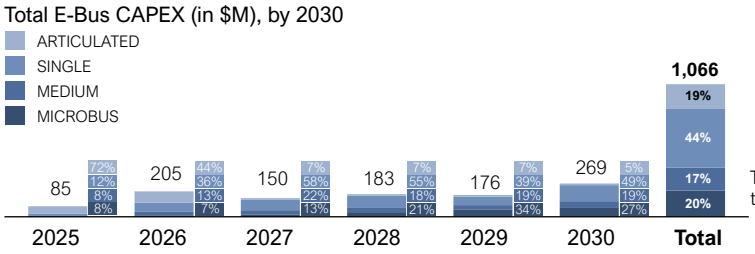
1. **Re-allocation of fuel subsidy savings to support acceleration of electric buses**, e.g., building charging infrastructure
2. **Leasing Model** could address concerns on high upfront costs and premature retirement of fleets. It provides a lower risk option for bus operators while still being able to be part of the transition to electric vehicles.
3. **Innovative financing to address high upfront costs,** including exploring Article 6 carbon financing.

[87] Institute for Transportation and Development Policy (ITDP). (2023). Building a regulatory and financial basis for Transjakarta's first-phase e-bus deployment. TCO number for different types of buses uses the scenario where diesel bus to E-Bus replacement ratio is 1:1.4. Number of buses by 2030 follow E-Bus electrification base case scenario in ITDP report. Medium bus TCO refers to ITDP alternative scenario with battery capacity of 150 kWh and charging at depot and terminals.

ECONOMIC IMPACT

Electrification of 10,047 buses leads to government savings from fuel subsidies (both gasoline and diesel) of $146 million while unlocking $1 billion market potential.

FIGURE 35. ESTIMATED ECONOMIC IMPACT ON GOVERNMENT AND PRIVATE SECTORS (IN $ MILLION)

Interventions	Impact	
Allocate savings from current fuel subsidy to support acceleration of electric buses, e.g., building charging infrastructure	**Government Saving**	 **$144M** (IDR 2.3T) Total savings from 2025-2030 from fuel subsidy
Mobility-as-a-Service (MaaS) Lesaing Model – implement leasing model for Articulated, Medium and Microbuses	**Market Potential**	 **$1B** (IDR 17T) Total CAPEX required to acquire new E-Bus

Market potential is largely dominated by Single buses across the year, accounting for 44% of total market potential between 2025-2030.[88] The market potential could be achieved through either a leasing model or domestic production of E-Bus. Leasing could be facilitated by leasing companies that procure E-Buses and offer cost-effective leasing terms to bus operators. This analysis conservatively estimates market potential as the landed cost of E-Buses, excluding any potential margin added by leasing companies.

Majority of government savings come from Diesel subsidy, accounting for $110 million while gasoline accounts for $33 million total savings between 2025 to 2030.[89] This is due to most buses using diesel compared to gasoline, and the subsidy for diesel is significantly higher than gasoline. Government savings are calculated only for single, medium and microbus as articulated bus uses CNG which is non-subsidized.

[88] Market potential calculated based on the landed cost of bus multiplied by the number of new electric buses added in that year based on Transjakarta plans (ITDP 2023)

[89] Government savings taken from ITDP analysis, assumes IDR 4,450 / L gasoline subsidy and IDR 7,150 / L. It is assumed that fuel subsidy saving is realized in the same year of implementation

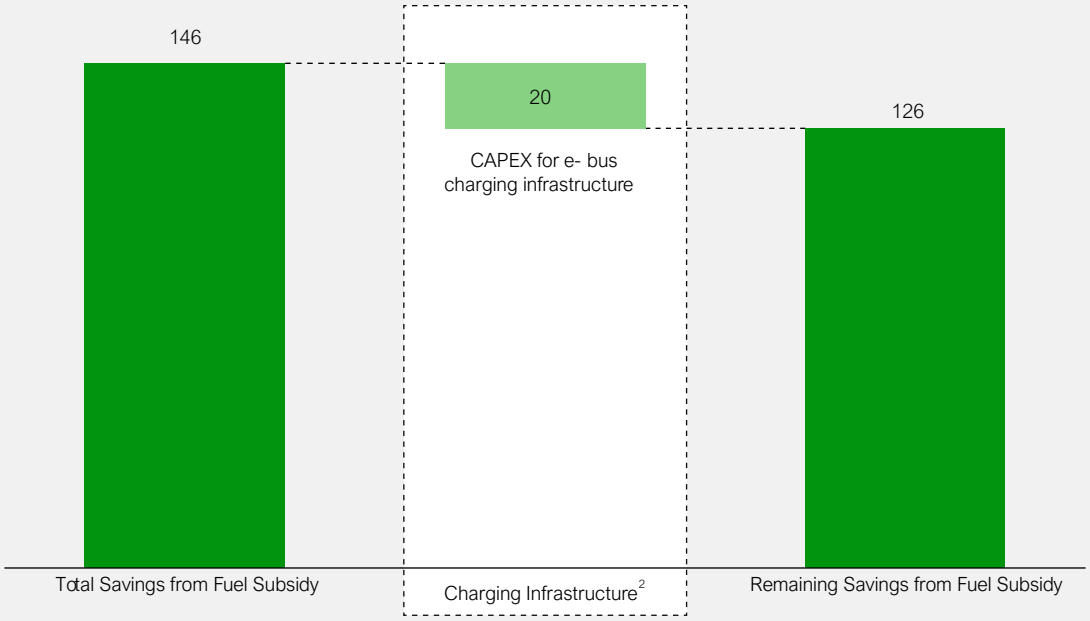
DEEP DIVE: ALLOCATING FUEL SUBSIDY TO BUILDING CHARGING INFRASTRUCTURE COULD STILL RESULT IN $126 MILLION GOVERNMENT SAVINGS

This research suggests reaching Transjakarta electrification target could result in a potential savings of $126 million between 2025-2030. The government could explore the potential allocation of these savings to accelerate E-Bus adoption such as building charging infrastructure.

A key challenge for bus operators transitioning to electric buses is the lack of charging infrastructure, which generally requires costly installations at depots. The high upfront investment makes the shift less appealing. Government support through financing for infrastructure, potentially funded by savings from reduced fuel subsidies, could help offset these costs and encourage adoption.

This research indicates that, even after allocating $20 million from fuel subsidy savings to install charging infrastructure for 10,047 electric buses, the government would still retain about $126 million in net savings. These figures highlight that transitioning to electric buses could present an economically favorable option for the government.

FIGURE 36. ESTIMATED GOVERNMENT SAVINGS AFTER RE-ALLOCATION OF FUEL SUBSIDY FOR BUILDING CHARGING INFRASTRUCTURE



To effectively scale E-Bus adoption, charging infrastructure needs to be built in advance to ensure readiness as demand rises. This approach requires around $20 million CAPEX investment in charging facilities to be made upfront, ahead of fuel subsidy savings.[90]

Therefore, action plans should focus on securing early-stage financing, optimizing infrastructure placement, and setting phased adoption targets to coordinate infrastructure rollout with fleet growth. Potential activities that could support this scenario include:

1. **Strong coordination between the provincial government of DKI Jakarta and MoF** to plan financing of charging infrastructure aligned with Transjakarta target.
2. **Provincial government of Jakarta to maintain close coordination with Transjakarta** to ensure electrification targets are reached.
3. **Engage with financiers to explore early-stage financing support** to accelerate the development of charging infrastructure for E-Bus.

Fuel subsidy savings could be allocated beyond charging infrastructure to further support E-Bus adoption. Key options include funding public awareness campaigns to boost transit use, developing a scrappage scheme for early fleet retirements, and offering fiscal incentives for E-Bus OEMs. Prioritizing these investments requires further assessment to address the most urgent barriers in the transition to electric buses.

[90] Total cost required for charging infrastructure is a high-level estimate based on the investment requirement breakdown calculated in ITDP report, approximately 12% of the total investment in multiplied by the TCO CAPEX for each bus type. CAPEX spending for charging is assumed to follow the bus roll-out timeline under ITDP base case scenario.

NEXT STEPS

Electrification of 10,047 buses requires alignment from multiple stakeholders, including OEM, leasing companies, Provincial Government of Jakarta, MoF, and financiers:

TABLE 9. ACTION PLAN FOR E-BUS

Action Plan	Potential Stakeholders
Enable E-Bus economic leasing model for TransJakarta: OEM / Leasing Companies to develop competitive leasing model to enable TransJakarta to lease E-Buses	OEM, Leasing Companies
Allocate potential financial support e.g., for charging infrastructure and operational costs and explore different financing model including carbon financing	Provincial Government of Jakarta, Ministry of Finance
Enable financing to reach small bus operators: Small bus operators face highest barrier to entry due to high upfront costs. Financial institutions could consider different financing models to increase adoption of electric microbus.	Financial Institutions
Consider amending regulations to support the implementation of E-Bus: (1) Government Regulation 5/2012 – Increasing the maximum weight allowed for buses to operate in DKI Jakarta as E-Bus typically has higher weight due to battery, e.g., Medium bust with battery capacity of 150 kWh would weigh more than 8,000 kg.; **(2) Jakarta Regional Regulation 5/2014** – Increasing the maximum operational year of public transport for E-Bus due to its longer lifetime (typically 15 years).	Provincial Government of Jakarta
Continue initiative to expand BRT route to increase demand for E-Bus and further reduce air pollution and carbon emissions	Provincial Government of Jakarta, Transjakarta
Continue tax incentives for E-Bus to maintain adoption and lower operational cost for E-Bus: 1) Annual vehicle tax exemption for electric vehicles 2) Luxury tax exemption for electric vehicles 3) VAT reduction from 11% to 6%	MoF
Educate asset owners the potential upside of E-bus, e.g., lower operational cost, access to incentives and subsidies, reduced risk of obsolescence	Provincial Government of Jakarta

FURTHER RESEARCH

This research does not consider the population of buses outside the target set by Transjakarta. As of 2023, there are approximately 29,150 buses in Jakarta and have been growing at a CAGR of 7% which means the current target only represents 15% of the overall population.

Moreover, most of the Transjakarta buses are relatively new and compliant with EURO IV standard. Electrification may be more suitable for buses with older models that are not EURO IV compliant as this will have a higher impact.

5. INTEGRATED PUBLIC TRANSPORT

Government Cost

$1.8B (IDR 29T)
Net government cost of fuel subsidy savings and PSO subsidy for MRT and LRT and infrastructure CAPEX

Impact to Pollution in 2030

↓ 9%
reduction in **$PM_{2.5}$ emissions load**
(↓ 15% CO, ↓ 37% VOC)

- **Government of Jakarta targets to increase public transport ridership to 60% by 2030** under Jakarta Governor's Decree 576/2023.
- **$1.8 billion net government cost:** when combined $357 million of fuel subsidy savings offset from $2.2 billion capital required for infrastructure expansion and PSO
- **Public transport is considered a high-priority impact lever as it has the third highest impact potential to $PM_{2.5}$,** with potential to reduce $PM_{2.5}$ emissions load by 9% by 2030

CONTEXT

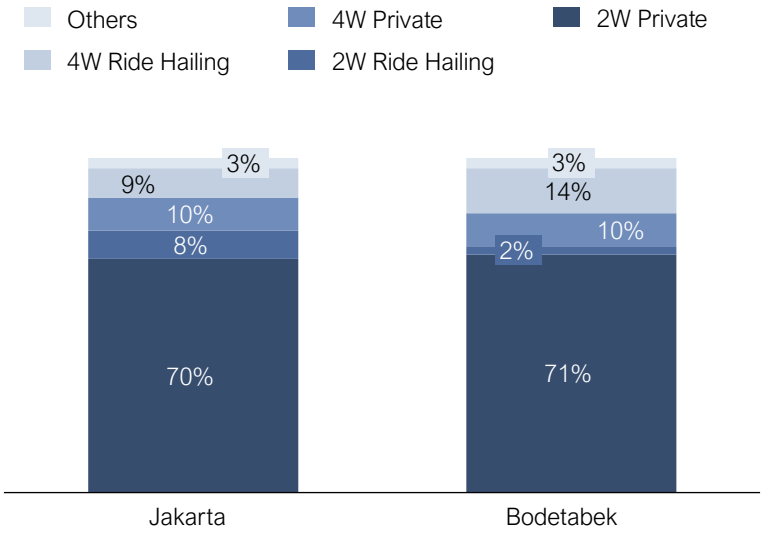
The Government of Jakarta has set a target to increase public transport ridership to 60% by 2030, as established in Governor's Decree 576/2023. Jakarta's public transportation network comprises of four primary modes — Bus Rapid Transit (BRT), Mass Rapid Transit (MRT), Light Rapid Transit (LRT), and the Commuter Line (KRL) — together covering 54% of the city. As of November 2023, public transport ridership stands at 20.7%, with highest share of commuters using KRL (291 million), followed by BRT (285 million), MRT (33.5 million) and LRT (4.6 million).[91] The proposed 60% target will be achieved through the expansion of MRT, LRT, and BRT routes. To note, this section focuses specifically on the MRT and LRT expansions, as the benefits of BRT expansion are addressed separately in the E-Bus section.

This research explores the impact of increasing ridership of public transport on the annual distance travelled by private vehicles following government plans to expand LRT and MRT. Unlike switching to cleaner fuel and transport electrification, integrated public transport aims to reduce the reliance on private vehicles. This research assumes that higher public transport ridership would not necessarily reduce the demand for vehicle ownership but rather reduce the VKT (vehicle kilometer travelled).[92] With increased reliability of public transport and supporting infrastructure, more people will be more drawn to use public transport for day-to-day commute, reducing the amount of distance travelled using private vehicles. In turn, reducing air pollution caused by private 2W and 4W.

[91] United Nations Office for Project Services (UNOPS) & Coordinating Ministry for Maritime Affairs and Investment (CMMIA). (2024). Kajian sosial ekonomi integrasi transportasi umum massal ramah lingkungan di kawasan Jakarta, Bogor, Depok, Tangerang, dan Bekasi (Jabodetabek).

[92] The increase of public transport usage would directly impact total VKT of private vehicles, while reduction in the number of vehicles may happen in the longer term. This aligns with a research based in New Zealand where public transport becomes a key strategy in reducing VKT from private vehicles (Source: Transport Futures Ltd. (2023). Vehicle kilometres travelled (VKT) public transport base and target forecast study. NZ Transport Agency. Retrieved from https://www.nzta.govt.nz/resources/vkt-pt-base-and-target-forecast-study/). Moreover, this research only considers Jakarta, since public transport infrastructure outside Jakarta may not be as advanced, therefore it is still assumed that the number of vehicles still grow linearly due to demand to travel outside of the city.

FIGURE 37. MODE SHARE OF TRANSPORT USED BY COMMUTERS IN JABODETABEK (2019)[93]



Currently, 2W dominate Jakarta's transportation, accounting for 71% of commuters, followed by 4W and ride-hailing services. 2W are popular for their ability to navigate heavy traffic, fast parking, and low costs, offering unmatched flexibility. 4W are often seen as a powerful symbol of an expanding middle class and provide comfort from Jakarta's hot, humid climate. Financing options like instalment plans and subsidized fuel further drive private vehicle use. Ride-hailing services have grown by bridging convenience and affordability, allowing non-owners access to the flexibility of motorcycles and the comfort of cars.

The Jakarta government has actively promoted public transport adoption. In 2023, initiatives included expanding MRT and LRT networks, improving infrastructure, and enhancing safety with CCTV installation. Public transport reliability has also improved, with the MRT achieving a 99.44% on-time performance.[94]

Transit-Oriented Development (TOD) is an approach that could help to increase ridership by designing urban planning that reduce vehicle use by concentrating people, services, and activities around public transportation hubs. It prioritizes accessibility and sustainability by integrating mixed-use zoning, improving proximity to transit, and enhancing pedestrian and cycling infrastructure. TOD not only reduces reliance on private vehicles but also boosts transit ridership by creating environments that encourage walking, cycling, and seamless access to public transportation.

CHALLENGES

Despite the effort by Jakarta government, some challenges remain:

1. **High reliance on private and ride-hailing vehicles** – Private vehicle ownership continues to grow, due to an increasing middle class with higher purchasing power and cars seen as status symbols. In addition, there is high ridership of ride-hailing services (e.g. Gojek, Grab), as opposed to public transport, due to its low prices and accessibility.
2. **Insufficient integrated public transport infrastructure**, such as pedestrian facilities. Limited pedestrian facilities and uneven public transport connectivity hinder accessibility, making private vehicles or ride-hailing necessary for first- and last-mile transit. The current public transport network has limited coverage, with the MRT primarily serving areas from South to Central Jakarta.

[93] United Nations Office for Project Services (UNOPS) & Coordinating Ministry for Maritime Affairs and Investment (CMMIA). (2024). Kajian sosial ekonomi integrasi transportasi umum massal ramah lingkungan di kawasan Jakarta, Bogor, Depok, Tangerang, dan Bekasi (Jabodetabek).

[94] Antara News. (2024, November 15). Jakarta MRT targets passenger traffic of 336 million in 2024. Retrieved from https://en.antaranews.com/news/304152/jakarta-mrt-targets-passenger-traffic-of-336-mln-in-2024

3. **Expanding and enhancing this network requires substantial investment**, as the capital expenditure (CAPEX) for infrastructure development is high.

INTERVENTIONS

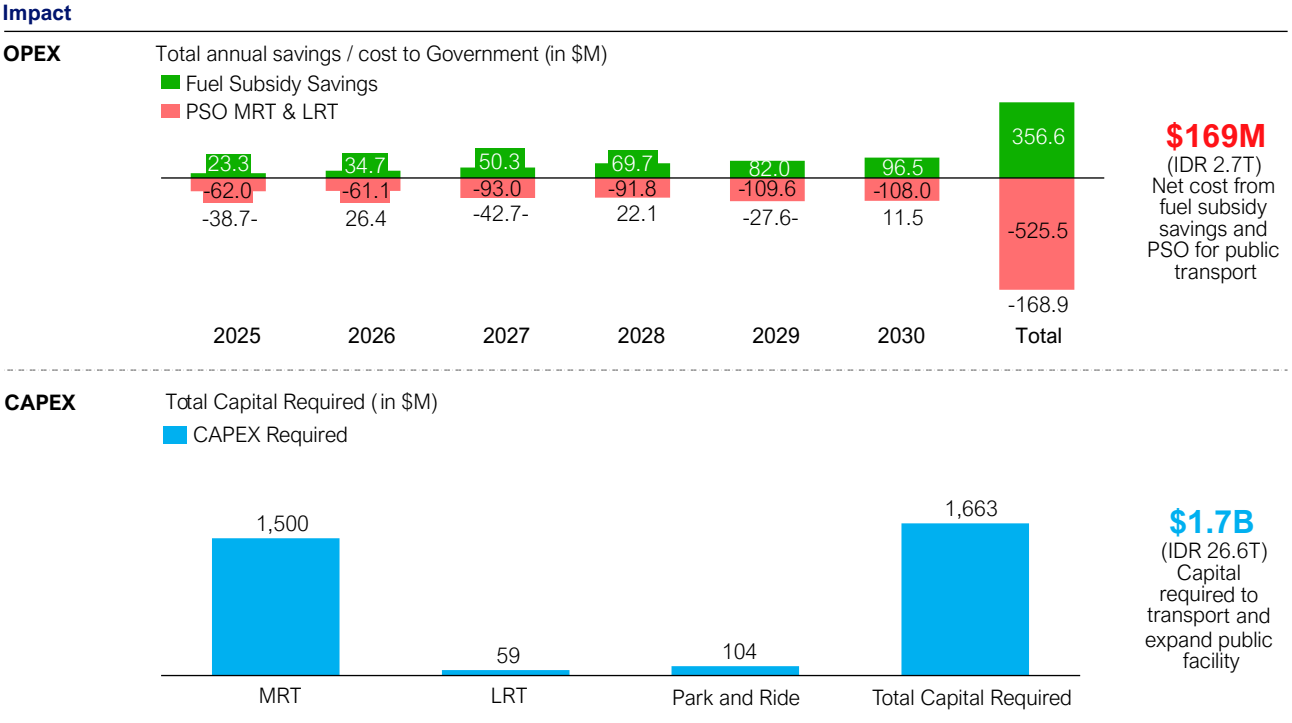
This research proposes several interventions to address the challenges:

1. **The expansion of MRT and LRT routes in Jakarta** including Transjakarta as feeder route, to increase the accessibility and coverage of public transportation across the city.
2. **Complementing these expansions, the development of pedestrian infrastructure**, such as park-and-ride facilities, will further support ease of access to transit stations, encouraging more residents to use public transportation.
3. **Disincentivize the use of private vehicles through push policies**, such as ERP, reducing fuel subsidy, increasing parking fee, and reducing areas for parking.
4. **Complete physical, service and tariff integration to provide integrated option for riders that is cheaper than using private vehicles.** Physical integration could include building sky walks or pedestrian paths between MRT and LRT stations. Whereas service integration includes partnering feeders or buses to expand the coverage of MRT and LRT. Lastly, tariff integration between all public transport could result in a lower commuting cost compared to using private vehicles.
5. **Incentivize MRT and LRT where ridership target is over-achieved** as companies could contribute to reaching government target of 60% ridership by 2030.

ECONOMIC IMPACT

Achieving 60% ridership in 2030 would require net government spend of $1.8 billion, comprised of a total cost of $1.7 billion CAPEX, $525.5 million PSO, and $356.6 million of savings from reduced fuel subsidy usage.

FIGURE 38. ESTIMATED ECONOMIC IMPACT TO GOVERNMENT FROM INCREASING RIDERSHIP OF PUBLIC TRANSPORT



This research estimates a net government OPEX of $169 million from $526 million of PSO subsidy cost to reach 60% ridership and $357 million of fuel subsidy savings from switching to integrated public transport. PSO subsidy is estimated to reach $398 million for MRT and $127 million LRT where subsidy is estimated to increase significantly in 2027 and 2029 where expansion plans are planned to be completed.[95] On the other hand, the Government is also expected to earn savings from fuel subsidy due to reduced km travelled using private vehicles as more people use public transport.[96]

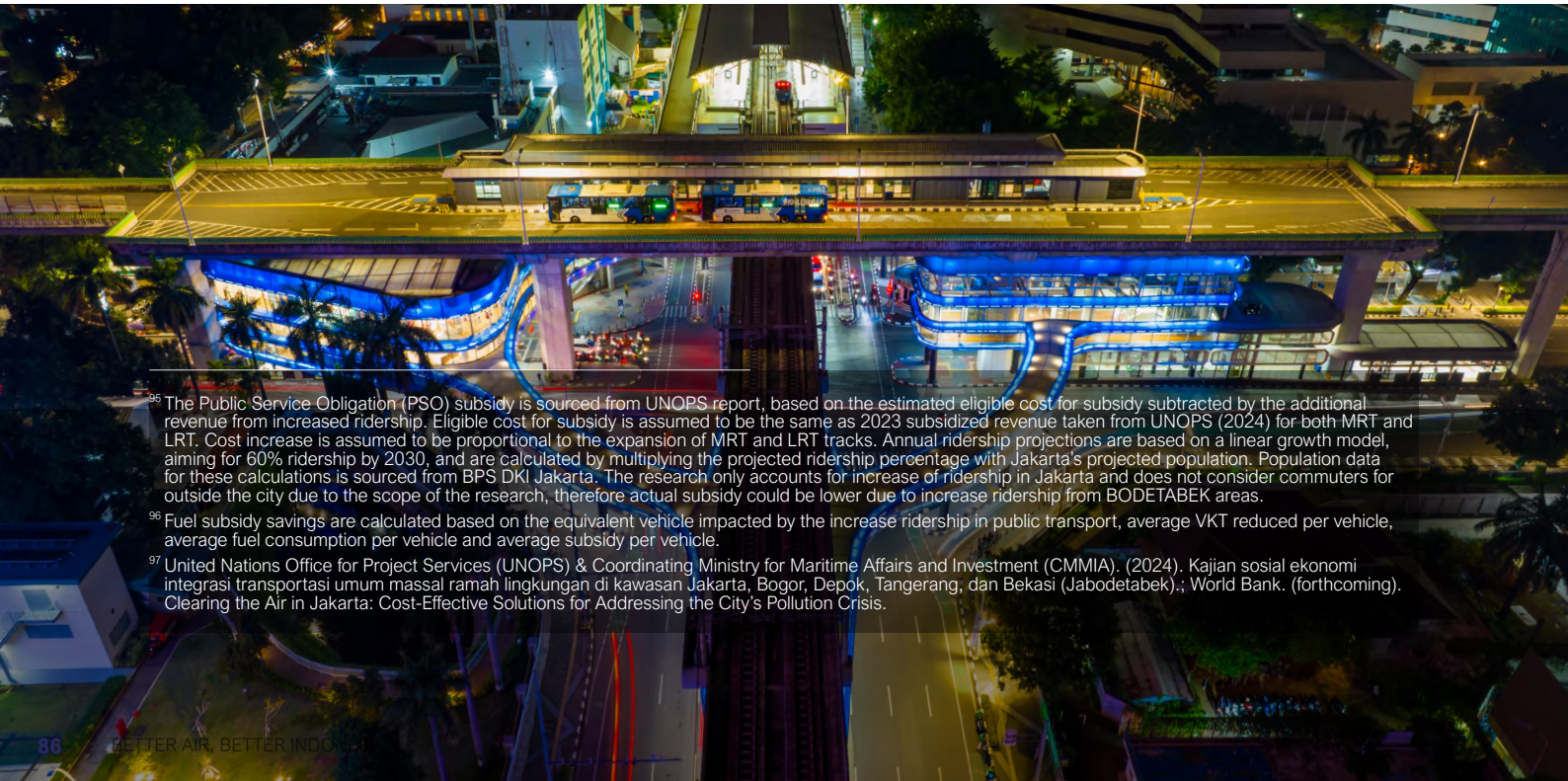
On the other hand, approximately $1.7 billion of CAPEX is required to achieve MRT and LRT expansion plans.[97] MRT expansion is estimated to cost the majority of the investment accounting for almost 90% of the capital requirement. While LRT expansion is estimated to cost $59 million and park and ride facility accounting for $104 million.

NEXT STEPS

In reaching 60% ridership by 2030, securing funding, subsidy allocation and increasing public awareness are crucial. Therefore, there needs to be collaborative actions between ministries, mainly MoT, MoF, financiers as well as private sectors (PT MRT and LRT).

TABLE 10. ACTION PLAN FOR E-BUS

Action Plan	Potential Stakeholders
Allocate funding to MRT and LRT expansion, including Transjakarta routes as feeder	MoT, MoF
Explore options for financing support e.g. PPP for expansion of outer loop MRT and integrated Jabodetabek network	MoF, development banks, Provincial Government of Jakarta
Increase public awareness of public transport ridership through marketing, campaigns, and education.	MRT, LRT
Explore additional incentives for MRT and LRT in achieving above 60% ridership target	Provincial Government of Jakarta
Explore policy to streamline public transport projects across Greater Jakarta Area for easier and faster coordination	MoT, Provincial Government of Jakarta, Provincial Government of Banten, Provincial Government of West Jakarta



[95] The Public Service Obligation (PSO) subsidy is sourced from UNOPS report, based on the estimated eligible cost for subsidy subtracted by the additional revenue from increased ridership. Eligible cost for subsidy is assumed to be the same as 2023 subsidized revenue taken from UNOPS (2024) for both MRT and LRT. Cost increase is assumed to be proportional to the expansion of MRT and LRT tracks. Annual ridership projections are based on a linear growth model, aiming for 60% ridership by 2030, and are calculated by multiplying the projected ridership percentage with Jakarta's projected population. Population data for these calculations is sourced from BPS DKI Jakarta. The research only accounts for increase of ridership in Jakarta and does not consider commuters for outside the city due to the scope of the research, therefore actual subsidy could be lower due to increase ridership from BODETABEK areas.

[96] Fuel subsidy savings are calculated based on the equivalent vehicle impacted by the increase ridership in public transport, average VKT reduced per vehicle, average fuel consumption per vehicle and average subsidy per vehicle.

[97] United Nations Office for Project Services (UNOPS) & Coordinating Ministry for Maritime Affairs and Investment (CMMIA). (2024). Kajian sosial ekonomi integrasi transportasi umum massal ramah lingkungan di kawasan Jakarta, Bogor, Depok, Tangerang, dan Bekasi (Jabodetabek).; World Bank. (forthcoming). Clearing the Air in Jakarta: Cost-Effective Solutions for Addressing the City's Pollution Crisis.

2. INDUSTRY SECTOR

1. TRANSITION COAL-BASED INDUSTRIAL BOILERS TO CLEANER TECHNOLOGY

Private Sector Cost

$57.2M (IDR 915B)
From the cost of transitioning coal boilers to industrial e-heating

Impact to Pollution in 2030

↓ 27%
reduction in **$PM_{2.5}$ emissions load**

- **Switching to cleaner technology for industrial boilers** via e-heating solutions would require $57.2 million investment for CAPEX and OPEX to achieve 0% coal usage in industrial boilers by 2030.
- **Eliminating industrial coal combustion from boilers is the second highest-impact lever towards $PM_{2.5}$ reduction,** as coal combustion has a high emissions factor and emits high amounts of pollutants
- **Industries have the opportunity to leapfrog coal-fired boilers and adopt best-available technology (BAT) for e-heating solutions,** which represent the end-state low-carbon and low-pollutant alternative

CONTEXT

Eliminating coal-based industrial boilers can lead to a significant reduction in PM emissions. In 2023, coal accounted for only 3.8% of total industrial energy consumption but contributes to a significant share of PM_{10} and $PM_{2.5}$ emissions, due to the high emissions factor of coal to particulate matter (0.33 kt/PJ).[98,99]

Industries have the opportunity to leapfrog coal-fired boilers and adopt best-available technology (BAT) for e-heating solutions, which represent the end-state low-carbon and low-pollutant alternative. There are various e-heating solutions available in the market depending on heating temperature and energy needs. This analysis examines the use of heat pumps for industries relying on low temperature processes (<200°C), such as textiles, food & beverage, and pulp & paper, and e-boilers for medium to high-temperature processes (>200°C) in energy-intensive industries like chemicals, steel, and cement.[100] BPS 2021 data on industrial energy consumption indicate an 85:15 split between low (<200°C) and medium to high-temperature (>200°C) heating processes.[101] The design and technical specifications of heating solution will need to be further tailored to type of industry, as they are designed for specific processes and temperature configurations.[102]

[98] Environmental Agency Jakarta. See annex for more information.

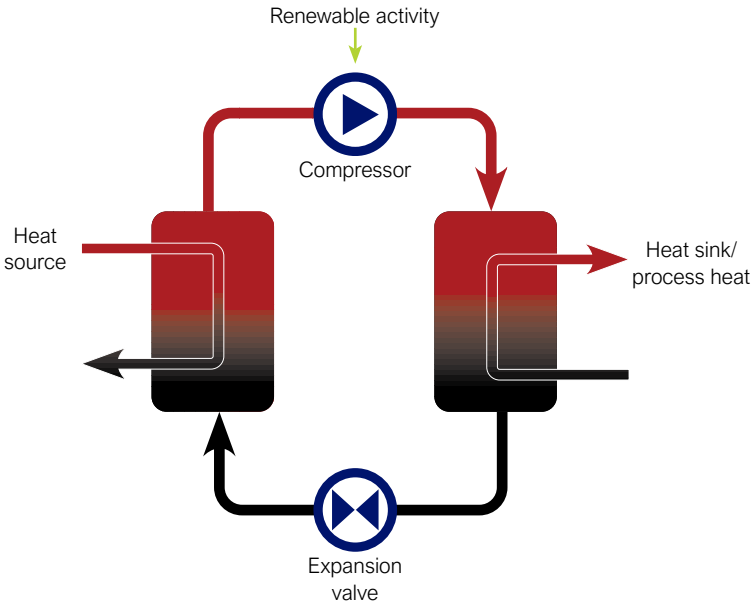
[99] To note, this report does not cover coal used as industrial feedstock or raw material. The government may consider establishing standards for coal feedstock in alignment with global benchmarks. Additionally, this report does not address coal stockpiles in the Jakarta area which may also have an impact air pollution. The government and industry stakeholders could explore implementing measures to manage coal stockpiles, such as utilizing warehouses and avoiding open stockpiles.

[100] For more information regarding electrification of industrial heat, please see: Systemiq. (2023). The Breakthrough Effect in ASEAN: How to Trigger A Cascade Of Tipping Points to Accelerate ASEAN's Green Growth; Systemiq. (2024). Catalysing the Global Opportunity for Electrothermal Energy Storage; Systemiq (2025), A Lightning Moment for Industry: How to Reach Positive Tipping Points in Electrification of Industrial Heat

[101] Badan Pusat Statistik (BPS). (2023). Statistik industri manufaktur produksi Provinsi DKI Jakarta 2021.

[102] International Energy Agency (IEA). (2022). The Future of Heat Pumps.

FIGURE 39. HOW HEAT PUMPS WORK[103]



- **Simple technology. Air-sourced heat pumps** works like air conditioning, only in reverse. It extracts heat from a source (e.g., surrounding air or waste heat), lifts the temperature through compression, and transfers heat to where it is needed.
- **Heat pumps are far more efficient than conventional heating** (e.g., gas steam boilers) because heat is transferred rather than generated. It has the **efficiency of 200-500%** depending on the desired heat output range (up to ~200°C) and source.
- A heat pump typically consists of a compressor, which moves a refrigerant, and heat exchangers. Resulting heat from heat pumps can be delivered via **superheated air, hot water, or steam,** or to directly heat materials.

Upfront cost to switch technologies may be a challenge, but there are also long-term economic benefits of switching to e-heating. The levelized cost of heat (LCOH) of heat pumps are already close to parity with the LCOH of gas steam boiler[104], thus justifying an opportunity for industries to modernize towards direct electrification of industrial heat rather than towards natural gas. Because most of the heat is transferred rather than generated, they are three to five times more efficient than traditional boilers and subsequently may generate long-term savings for industry owners.[105] Additionally, industries utilizing e-heating are more price-secure, as they can also provide protection against fossil fuel price fluctuations and security of supply for primary energy.

Switching from coal-based boilers to industrial e-heating solutions also has significant co-benefits to air quality, climate mitigation, and energy efficiency. Industrial heating accounts for more than 20% of total global CO2 emissions, with the majority (80%) of industrial heat generated by fossil fuel.[106] Industrial heat pumps are a proven technologically feasible low-emission heating solution that is increasingly being adopted globally, including in Latin America and Asia.[107] The transition to industrial e-heating technologies will have significant implications for the power grid, increasing electricity demand further raising the urgency for a cleaner and more efficient energy system. E-heating solutions will be most effective if national renewable energy targets are met, ensuring a lower-carbon grid. Additionally, maintaining and upgrading grid reliability is essential to consistently power heat pumps at a level that meets industrial demand.

[103] Systemiq. (2023). The Breakthrough Effect in ASEAN: How to Trigger a Cascade of Tipping Points to Accelerate ASEAN's Green Growth.; Agora Industry, FutureCamp (2022): Power-2-Heat: Gas savings and emissions reduction in industry; Industrial Thermal Batteries Decarbonizing U.S. Industry While Supporting a High-Renewables Grid (n.d.)

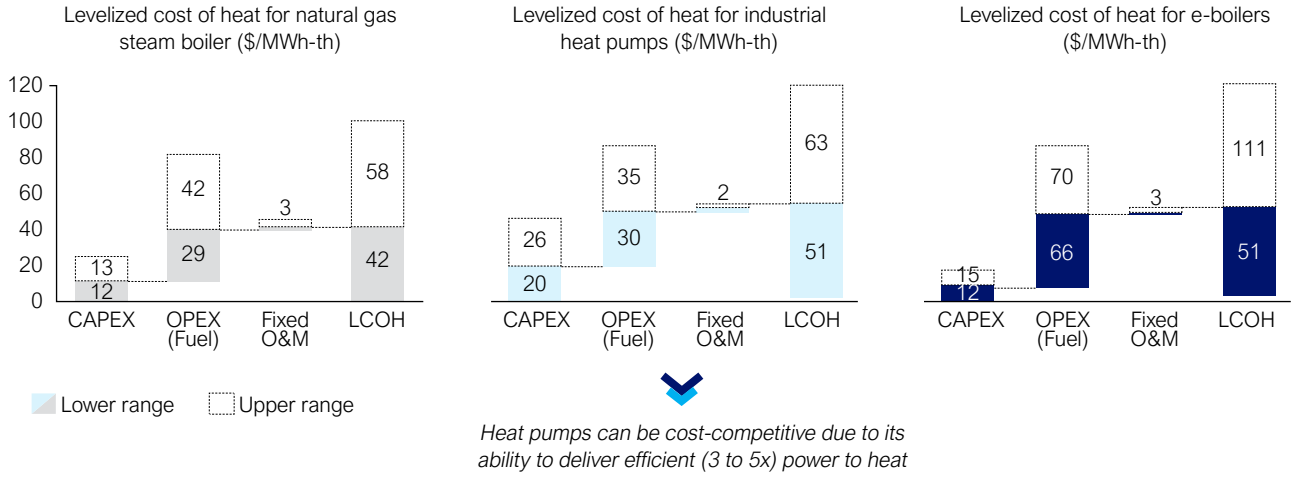
[104] Systemiq. (2023). The Breakthrough Effect in ASEAN: How to Trigger a Cascade of Tipping Points to Accelerate ASEAN's Green Growth.; Levelized cost of heat (LCOH) of gas steam boiler and heat pumps are calculated using Power-2-Heat transformation cost calculator developed by Agora Industry, FutureCamp, and Wuppertal Institute, accessible here: https://www.agora-energiewende.de/en/publications/transformationskostenrechner-power-2-heat/. Agora Industry & FutureCamp. (2022). Power-2-Heat: Gas savings and emissions reduction in industry; Energy Innovation. (2022). Decarbonizing Low-Temperature Industrial Heat in the U.S.

[105] International Energy Agency (IEA). (2022). The Future of Heat Pumps.

[106] International Energy Agency (IEA). (2023). Energy System Overview, Industry.

[107] McKinsey. (2024). Industrial heat pumps: Five considerations for future growth.

FIGURE 40. LEVELIZED COST OF HEAT (LCOH) FOR NATURAL GAS STEAM BOILERS COMPARED TO E-HEATING SOLUTIONS[108]



Heat pumps can be cost-competitive due to its ability to deliver efficient (3 to 5x) power to heat

Industrial heat pumps and e-boilers are already close to a tipping point, due to cost parity and electricity-to-heat conversion efficiency. Current adoption for both technologies is still nascent due to the lack of accessibility, availability and awareness of the technology. Policy support, market advocacy, and mainstreaming of technology through collaborations with OEMs and greening the electricity grid will be key to accelerating the uptake of heat pumps.

CHALLENGES

Switching from coal-fired boilers towards industrial e-heating technologies has various challenges:

1. **High costs compared to existing technologies:** E-heating solutions have a higher CAPEX and OPEX compared to coal. High upfront capital investment is a key barrier for asset owners. When compared to natural gas, the LCOH of heat pumps are comparable, thus potentially generating long-term savings.
2. **Lack of regulation to urge transition:** There is a lack of urgency for industries to seek cleaner technology as existing practices still meet emission standards. A regulatory push to strengthen emission standards and/or eliminate the use of coal-fired boilers is needed to transition.
3. **Site-specific retrofitting and engineering challenges in existing plants:** These include integrating e-heating into existing processes, upgrading electrical grids to meet higher power demands, and addressing space constraints, particularly in older plants.

[108] Systemiq. (2023). The Breakthrough Effect in ASEAN: How to Trigger a Cascade of Tipping Points to Accelerate ASEAN's Green Growth.

INTERVENTIONS

To support the adoption of industrial heat pumps, strong policy and support are required:

1. **Explore policy options to establish more stringent industrial emission standards and timeline to transition down from coal-based boilers,** especially for low-temperature processes that can more easily switch to heat pumps. These regulations are also aligned with government's long-term climate strategy. To achieve compliance, regulations should be supported by strong monitoring and enforcement, including strict punitive measures such as fines and penalties.

2. **Issue financial incentives to support suppliers and industries.** Mainstreaming technology through collaboration with OEM will be key to accelerating the availability of technologies, in line with Indonesia's industrialization strategy. Currently, major industrial heat pump suppliers and manufacturers are based in Japan, Europe, and North America, with China leading the largest share (39%) of heat pump manufacturing globally.[109] Creating market conditions for OEMs to supply the technology in Indonesia market is crucial to make technologies readily available. On the demand side, the government may provide subsidies or corporate tax incentives for factories to incentivize technology adoption of e-heating.

3. **Coupling e-heating buildout with on-site and grid-scale variable renewable energy (VRE):** The emission reduction potential of e-heating solutions is capped if Indonesian grids stay the same. There is a need to balance out the increase in electricity demand with clean electricity generation as well.

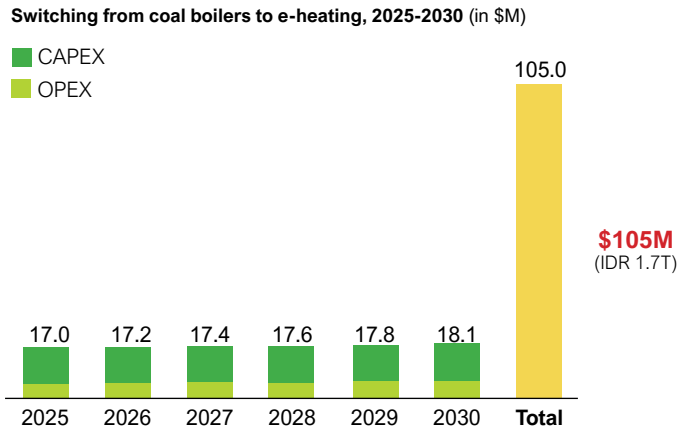
ECONOMIC IMPACT

Transitioning from coal boilers to industrial heat pumps will require an estimated $105 million investment by 2030. This includes the total CAPEX and OPEX needed to phase out coal usage in industrial boilers through the adoption of e-heating, with the goal of achieving 0% reliance on coal-fired boilers by 2030.[110]

FIGURE 41. INTERVENTION COSTS TO TRANSITION COAL BOILERS TO E-HEATING TECHNOLOGIES

Impact

Investment Need



Remarks

- **Economic impact** is calculated by total CAPEX (including estimated increase for retrofits) and OPEX, using levelized cost of heat (LCOH) of $/MWh-th
- **E-heating ramp up timeline** based on phased transition from coal usage, targeting 0% by 2030, aligned with industrial growth projections based on report's ITB Emission Inventory projections
- **Estimated 85:15 ratio** between heat pumps for low temperature processes <200ºC and e-boilers for medium to high-temperature processes >200ºC.

[109] 39% of global heat pump manufacturing (by GW) is in China. European Commission. (2024). The future of European competitiveness.

[110] Cost is calculated by multiplying the additional (converted) coal to e-heating energy consumption between a e-heating scenario against a business-as-usual projection scenario by 2030. In the e-heating scenario, the remaining 3.8% coal energy consumption is phased down so that it reaches 0% by 2030. The business-as-usual scenario assumes a 3% CAGR growth by 2030. Baseline year data is taken from BPS. (2023). Statistik Industri Manufaktur Provinsi DKI Jakarta 2021.

NEXT STEPS

It will require a combination of regulation, financial incentives, and enforcement to encourage switching of coal-based boilers to e-heating solutions. To ensure effective implementation and smooth transition, the government can start by increasing efforts in data collection to identify target industrial boilers and drafting a regulation to eliminate the use of coal in industrial boilers with a transition timeline.

The government can also explore financial incentives to promote market creation for OEMs and subsidies for industry owners. Nearly all European countries offer incentives, in the form of grants, loans or tax rebates for industrial heat pumps, and Brazil has implemented the PotencializEE providing training for industrial energy efficiency experts to help facilities identify technologies, including heat pumps.[111,112]

TABLE 11. ACTION PLAN FOR FUEL SWITCHING IN INDUSTRIAL BOILERS

Action Plan	Potential Stakeholders
Increase efforts in identifying high-emitting industries which do not comply with current emission standards	Provincial Government of Jakarta, MoE, MoI
Propose more stringent emission standards, including regular revaluation of industrial emission standards against peer countries	MoE, MoI
Explore policy to phase out coal in industrial boilers, with a clear target year (e.g., 2030), transition timeline and key priority sectors	MoE, MEMR, MoI, Provincial Government of Jakarta
Explore potential fiscal incentives for both supply-side, to enable market creation for heat pump OEMs, and demand-side, to lessen financial burden for industry owners	MoF, MoI

[111] European Heat Pump Association. (2024). Subsidies for Industrial Heat Pumps in Europe.
[112] International Energy Agency (IEA). (2022). The Future of Heat Pumps.

2. POST-COMBUSTION CONTROLS & CONTINUOUS EMISSIONS MONITORING SYSTEM

Government Cost

$0.8M (IDR 13B)
from improving emissions inventory data & monitoring and strengthening enforcement on industrial emissions standards

Private Sector Cost

$2.8B (IDR 45T)
from the installation of post-combustion controls & CEMS for 20% of the high-emitting industries by 2030

Impact to Pollution in 2030

↓ **5%**
reduction in **SO_2 emissions load**

↓ **1%**
reduction in **NO_x emissions load**

- **Targeting NO_x and SO_2 controls installations** at 20% of the highest-emitting industries by 2030 would require $0.8M of public capital and $2.8B of private investment by 2030

CONTEXT

Industry sector is the largest contributor to SO_2 emissions (70%) and the second largest contributor to $PM_{2.5}$ emissions (21%) in Jakarta. BPS Jakarta recorded around 1,600 medium & large manufacturing facilities within Jakarta administrative boundary in 2021.[113] Industry's contribution to ambient air quality may be even higher, when considering transboundary pollution from surrounding regions outside of Jakarta. To curb industrial air pollution, the installation of post-combustion controls (PCCs) and continuous emissions monitoring systems (CEMS) are one of most important levers.

Enforcement and monitoring of emission standards by the Ministry of Environment (MoE) and the Jakarta Environmental Agency remains challenging. The MoE and Jakarta Environment Agency receive emissions data through self-reporting systems (from SIMPEL regarding environmental permit management[114] and PROPER regarding company performance rating[115]) and direct monitoring (through SISPEK, the MoE's monitoring system of real-time industries' CEMs data[116]) to ensure compliance. Based on PROPER in 2022-2023, the MoE reported that only 372 (65%) out of 573 industries in Greater Jakarta achieved 'Compliant' status.[117] The participation of industries in PROPER in general is limited due to its voluntary nature (only mandatory for certain industries) – only 10% out of the total 1,600 industries in Jakarta participated, and those who participated tend to choose manual measurement of their emissions rather than using CEMS.[118]

Promoting the usage of installation of industry CEMS and registration to SISPEK is crucial for MoE to do real-time monitoring of industrial emissions. SISPEK is the government's integrated continuous emission monitoring information system that receives and manages data from CEMS from the stack emissions of stationary sources (industries & power plants), allowing real-time monitoring of emissions data. The government has mandated 10 industrial sectors to integrate their CEMS

[113] BPS Jakarta . (2023). Statistik Industri Manufaktur Provinsi DKI Jakarta 2021.

[114] SIMPEL (Sistem Pelaporan Elektronik Perizinan Bidang Lingkungan Hidup) is an electronic reporting system mandated for businesses who are required to report their environmental management and monitoring as part of a monitoring & evaluation of holding an Environmental Permit.

[115] PROPER (Program Penilaian Peringkat Kinerja Perusahaan Dalam Pengelolaan Lingkungan) is a company performance rating program on environmental management mandated for certain industries by MoEF.

[116] SISPEK (Sistem Informasi Pemantauan Emisi Industri Kontinyu) is the government's integrated continuous emission monitoring information system that receives and manages data from CEMS from the stack emissions of stationary sources (industries & power plants. The website is accessible at https://ditppu.menlhk.go.id/simpel/gis.

[117] Focus group discussion by MoE, November 14, 2024

[118] World Bank. (forthcoming). Clearing the Air in Jakarta: Cost-Effective Solutions for Addressing the City's Pollution Crisis.

data into SISPEK. These industries include iron and steel, pulp and paper, textile, carbon black, oil and gas mining, thermal waste processing, cement, thermal power plants, and fertilizer & ammonium nitrate. As of February 2025, 254 industries have integrated their CEMS data into MoE's SISPEK database.[119] In the event that an industry is flagged 'Non-compliant' on SISPEK, the MoE (DG of Law Enforcement) also conducted site inspections to monitor high-polluting industries to abide to the emissions standards, with sanctions such as fines and closures of operations.

TABLE 12. KEY REGULATIONS RELATED TO INDUSTRIAL EMISSION STANDARDS AND MONITORING

Regulations	Notes
Emission standards (non-exhaustive)	
MoE 7/2007 on Emissions Standard for Steam Boiler	Sets emissions standard for industrial steam boilers using various types of fuel (e.g., coal, gas, oil, etc.), although only for particulate matter
MoE Decision 13/1995 on Emissions Standard for Stationary Sources	Sets emissions standard for several industries, specifically iron & steel and pulp & paper. Standards for other industries have been updated in separate ministerial regulations
MoEF 19/2017 on Emissions Standard for Cement Industry	Sets emissions standard for cement industry
MoEF 17/2019 on Emissions Standard for Fertilizer Industry	Sets emissions standard for fertilizer industry
Monitoring and reporting	
MoEF 87/2016 on Electronic Reporting System for Environmental Permitting (SIMPEL)	Mandates and details out provisions on electronic reporting for businesses that are required to carry out environmental impact assessment (AMDAL, UKL-UPL)
MoEF 1/2021 on PROPER	Details out provisions on PROPER
MoEF 13/2021 on Continuous Industrial Emissions Monitoring Information System (SISPEK)	Stipulates provisions for CEMS' data integration into SISPEK

This analysis recommends the installation of Selective Catalytic Reduction (SCR) as a NO_x control and Wet Flue Gas Desulfurization (WFGD) as a SO_2 control. There are several industrial control technologies that can target pollutants $PM_{2.5}$, NO_x and SO_2.[120] Particulate matter air pollution controls such as Electrostatic Precipitators (ESP) or fabric filters were not included as the analysis looks at how cleaner technology for industrial boilers were a more cost-effective way to reduce particular matter, as coal has a significantly higher emissions factor. Among the 45 industries in Greater Jakarta that submit to MoE's SIMPEL data, 38 industries have installed particulate matter control (e.g., fabric filters), of which 7 have also installed NO_x and SO_2 controls.[121]

[119] Focus group discussion by MoE, November 14, 2024
[120] For more information on impact of air pollution controls, please see ITB & ViriyaENB. (forthcoming). Emission Inventory in Jabodetabek.
[121] Focus group discussion by MoE, November 14, 2024 (according to data from SIMPEL).

CHALLENGES

The main challenge with post-combustion control & CEMS installations is that there is a lack of structural incentives for asset owners, driven by several factors:

1. **High capital requirements to asset owners, without direct monetary return.** The installation of controls is a "full cost" because it has no direct monetary benefits or return – unless there is a structural incentive to turn it into investment instead (e.g., by internalizing environmental cost into penalties when a company fails to meet the emissions standard).
2. **Lack of standardized punitive measures (e.g., sanction, penalty) to discourage non-compliance.** Although there are enforcement measures implemented by MoEF and Jakarta Environment Agency, current punitive measures are not yet standardized to create a structural market incentive to install controls.
3. **Unattractive reward system to encourage participation in voluntary environmental program.** Although PROPER is mandatory for several industries, its voluntary participation is very low due to the lack of attractiveness of the reward system for companies.

INTERVENTIONS

To enforce the installation of post-combustion controls & CEMS, two crucial interventions are proposed:

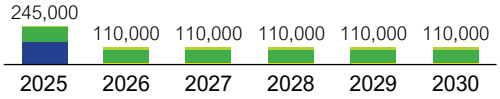
1. **Improve industrial emissions inventory, data monitoring, and emissions standard.** Currently publicly available industrial emissions data from Central Statistics Bureau covers high-level energy use (fuel burning). Emissions from non-energy use, arising from inherent industrial processes, are more difficult to be monitored. It is crucial to have granular data for the industrial sector, including point location, energy consumption by fuel and equipment, and compliance to emissions standards. With improved emissions inventory and data collection, the government can better identify key hot spots and set appropriate climate and clean air measures (including updated emissions standards and developing technology roadmaps for industrial decarbonization).
2. **Issue more stringent emission standards and strengthen enforcement on industries' emissions standards,** with standardized punitive measures such as paying fines or revocation of certain business licenses/permits to internalize the environmental cost of air pollution (at least indirectly). Through stronger enforcement, industries are disincentivized to pollute and install post-combustion controls / CEMS to comply to emission standards regulations. Review of threshold levels and allowance for compliance should be carefully reviewed for each industry and source activity. Policies should be updated periodically, to consider technological advancements, global benchmarks, considering best-available technologies (BAT), as well as commercially available and economically feasible options to appropriate set levels.

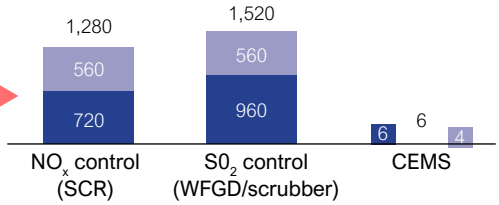
ECONOMIC IMPACT

Enforcing post-combustion controls and CEMS would require $0.8 million of public capital and $2.8 billion of private investment by 2030. The government cost comes from data improvement and enforcement costs, whereas the private sector cost includes investment needs to install post-combustion controls & CEMS at the top four highest energy intensive industries.[122]

[122] Approximated to be 25% of total number of industries in BPS Jakarta (2023). Capital needs are based on total CAPEX for PCC & CEMS installations for the top four most energy-intensive industries in Jakarta (~400). Assumes a technology installation split of 25:37.5:37.5 between PM:NO_x:SO2 control based on BPS Jakarta's emission rates (based on fuel consumption).

FIGURE 42. INTERVENTION COSTS FOR ENFORCING POST-COMBUSTION CONTROLS AND CEMS

Interventions	Impact			Remarks
Stronger enforcement on emissions standard & cont. monitoring, inc. capacity building **Enhancement of** emissions inventory & data monitoring system	**Government Costs**	**Government intervention costs, 2025-2030 (in $)** **Enforcement cost[1]** DLH Jakarta budget MoE budget Capacity building **Data improvement** Digital infra CAPEX Annual maintenance costs 	**$0.8M** (IDR 12B)	• **Enforcement cost for MoE and DLH taskforces** for monitoring and site-visits • **Capacity building workshops** with industry and power plant to raise awareness of emission standards • **Data improvement cost for MoE** to improve SISPEK database

Enforcing post-combustion controls and CEMS at the most polluting (energy-intensive) industries	**Private sector costs**	**Capital needs for post-combustion controls and CEMS by 2030 (in $M)**
		Large industries[3]
		Medium industries
		 
		Controls for highest energy-intensive industries in Jakarta area: **Manufacturing, Minerals, Metals,** and **Chemicals** (BPS Jakarta, 2023)
			$2.8B
			(IDR 45T)
				• **Capital needs based on total CAPEX for PCC & CEMS** installation required for:
				  • **50% of top four most energy-intensive industries** in Jakarta
				  • **Assume 30:70 ratio between large & medium industries** based on BPS Jakarta

NEXT STEPS

A strong, coordinated effort from the government is required to strengthen enforcement of industrial controls. MoE, MoI, Jakarta government, and the Municipal Police are among the primary stakeholders identified in ensuring that industrial controls are effective. Key actions include improved efforts in data collection, monitoring, enforcement, as well as exploring potential fiscal incentives and financing support to support the adoption of controls.

TABLE 13. ACTION PLAN FOR FUEL SWITCHING IN INDUSTRIAL BOILERS

Action Plan	Potential Stakeholders
Increase efforts in data collection (emissions inventory) and monitoring to identify sources of air pollutants from both energy-usage and industrial processes	MoE, MoI, Provincial Government of Jakarta
Strengthen enforcement of emissions standards and continuous monitoring system of industries with sanction (e.g., fines, revocation of certain business permit, to the point of cessation of operations)	MoE, MoI, Satpol PP, Provincial Government of Jakarta
Explore potential fiscal incentives to lessen the financial burden for asset owners, e.g., tax reduction, import duty tax exemption (in the case of importing)	MoF, MoI, MoT
Develop financing support for post-combustion controls & CEMS adoption through grants or results-based finance/funding	Development & commercial banks, Climate philanthropies, MoF
Continue building awareness and capacity for companies to comply with the regulations, especially on emissions standard and continuous monitoring and reporting	MoE, Provincial Government of Jakarta

CASE STUDY ON INDUSTRIAL POLLUTION CONTROL

Seoul Metropolitan Region: Cap-and-trade system for air pollutants

As part of the 1st Basic Plan for Air Quality Management in the Seoul Metropolitan Region (2005-2014), Seoul introduced an Air Pollutant Cap-and-Trade System in 2008.[123] The system set annual emission limits for NO_x and SO_x for large industrial facilities, starting with 117 facilities and expanding to 295 by 2013. Industries were required to stay within the allowances and allowed to trade any surplus allowances. On the other hand, fines are imposed on facilities that exceeded their allocated emissions and have not purchased adequate allowances to cover their excess emissions. To support smaller businesses unable to afford pollution control technologies, the government also provided funding support. The cap-and-trade system was also supported by real-time, continuous emissions monitoring system (CEMS) known as the Smokestack Tele-Monitoring System (TMS), which ensured compliance with emission caps and enables authorities to penalize violators and levy charges.

Although doubt was initially casted on the system's effectiveness in the first year, the system has shown to work. In 2008, allocations of allowance were ~2x higher than actual emissions for both NO_x and SO_x. By 2013, the allocations have been continuously reduced to exceed emissions by only 20%, signifying that genuine reductions were being achieved beyond allowance trading. By the same year, emission trading affected 6% and 23% of NO_x and SO_2 emissions, respectively.[124] Despite significant improvement in air quality over the period, however, the intended concentration targets were not met. This has led to the formulation of the 2nd Basic Plan for Air Quality Management in the SMR (2015-2024), which adds additional target for $PM_{2.5}$ and ozone.

[123] UNEP (2023), Achieving Clean Air for Blue Skies in Seoul, Incheon and Gyeonggi, Republic of Korea.
[124] Trnka, D. (2020), Policies, Regulatory Framework and Enforcement for Air Quality Management: The Case of Korea. OECD Environment Working Papers.

3. POWER SECTOR

EMISSIONS REDUCTION AT GAS POWER PLANTS THROUGH CONTROLS AND REDUCED UTILIZATION

Private Sector Cost

$102M (IDR 1.6T)
from the installation cost of NOx control at CCGT Muara Karang & Tanjung Priok

Impact to Pollution in 2030

↓ 7%
reduction in **NO_x emissions load**

- **Installation of NO_x control at Muara Karang and Tanjung Priok's combined cycle power stations** would require $102 million by 2030.
- **Proposed recommendation to install SNCR (Selective Non-Catalytic Reduction)** has potential to reduce NO_x emissions by 7% by 2030.

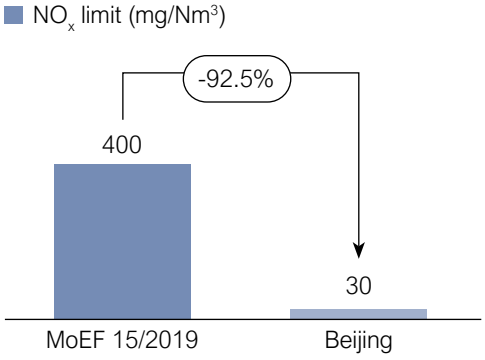
CONTEXT

Jakarta's power generation sector is the second largest contributor of NO_x emissions of the city's emissions in 2023, second only to the transportation sector. The power sector is comprised of two active combined cycle gas power stations (CCGT) in Muara Karang (2.1 GW) and Tanjung Priok (2.7 GW) in North Jakarta. In addition to the two power stations, there is one additional backup diesel power plant (100 MW) located in Senayan, which is rarely activated a couple times per year for backup.

FIGURE 43. POWER PLANTS IN JAKARTA

FIGURE 44. EMISSION LIMIT COMPARISON BETWEEN THE CURRENT EMISSION STANDARD FOR CCGT

Emission limit for NO_x from combined cycle gas power plants



CHALLENGE

There is a need for more stringent emission standards which would mandate the installation of additional NO_x controls. Currently, both power stations have already employed Low NO_x Burners for their gas turbines, outputting emissions below the emission standard's limit set in MoEF 15/2019.[125] However, compared to global standards including Beijing, emissions limit set in MoEF Regulation 15/2019 can still be more stringent to achieve cleaner air. The current NO_x emissions limit set in MoEF Regulation 15/2019 is 400 mg/Nm3, whereas it reaches 30 mg/Nm3 in Beijing.[126]

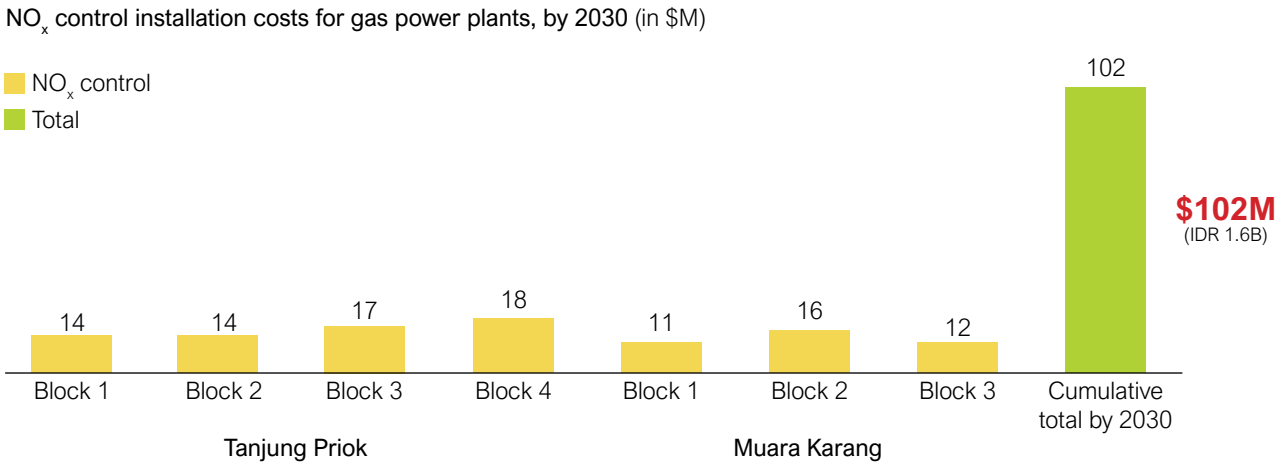
INTERVENTION

Additional installation of post-combustion NO_x controls can be effective in reducing emissions from the city's CCGTs. The CCGT's Low Nox Burners work by modifying the combustion process to reduce the formation of NO_x at the source. Adding post-combustion NO_x controls of Selective Catalytic Reduction (SCR) and Selective Catalytic Non-Reduction (SNCR) which have higher controls efficiency can further reduce NO_x emissions by CCGTs. SCR has higher control efficiency (upwards to ~90%) but is more costly, whereas SNCR has up to 60% efficiency but is less capital intensive and easier to retrofit. Due to its lower cost and feasibility, this report has focused on installation of SNCR as a stronger NO_x control than the currently installed low NO_x burners in CCGTs.

ECONOMIC IMPACT

This will require approximately $102 million by 2030, by installing NO_x control (SNCR) across all the 7 units of the CCGTs in Tanjung Priok and Muara Karang. As it takes time to develop regulation and conduct feasibility studies, the proposed installation target is for 2028.

FIGURE 45. INTERVENTION COST FOR NOX CONTROLS AT COMBINED-CYCLE GAS POWER PLANTS IN JAKARTA



[125] Based on both power stations' respective addendum to environmental impact (ANDAL) documents in 2016 (when both stations plan to add a new unit): PLN (2016), "ANDAL addendum for Muara Karang 500 MW (peaker) combined cycle gas plant development"; PLN (2016), "ANDAL, RKL-RPL addendum for Priok combined cycle gas power plants development". Notes: Despite emissions testing was done in 2014, the standard used remains the same with todays in MoEF 15/2019 for all three parameters: PM (30 mg/Nm3), NOx (400 mg/Nm3), and SO2 (150 mg/Nm3).

[126] Zeng, J., et al. (2018). How best management practices affect emissions in gas turbine power plants—An important factor to consider when strengthening emission standards. Journal of the Air & Water Management Association, 68(9).

To enable this intervention, regulatory update and financing support are required. MoE can work with relevant ministries and power plant owners (PLN subsidiaries) to develop an updated emission limit on NO_x. At the same time, the government can also support the installation by exploring potential incentives and innovating financing to lessen the financial burden to install NO_x control. This could include exploring grants or results-based financing that requires air pollution reduction as a condition to receive the financing.

TABLE 14. KEY ACTIONS FOR NOX CONTROL AT CCGT

Action Plan	Potential Stakeholders
Develop a more stringent emissions standard, especially on NOx emission	MoE, MEMR, PLN
Strengthen enforcement on emissions standards and continuous monitoring system of combined cycle gas power plants	MoE, MEMR, Jakarta Metropolitan Police, Provincial Government of Jakarta
Explore potential financial incentives to install air pollution control technologies	MoF, MEMR, MSOE

TRANSBOUNDARY POLLUTION SOURCE: COAL-FIRED POWER PLANTS

Private Sector Cost

$513M (IDR 8.2T)
from installing relevant air pollution control technology[3] for younger (7-15 years) coal fleets

- **Installing relevant air pollution controls for younger fleets will require $550 million by 2030**
- **Further research and source-apportionment study needed** to measure the full impact of CFPP's to Jakarta's transboundary pollution

Coal-fired power plants (CFPPs) are a major transboundary source of air pollution that affects the air quality of Jakarta and surrounding cities. Though there are no CFPPs located within Jakarta, there are several within the surrounding regions which can affect Jakarta's air quality, depending on seasonal weather patterns and wind. Due to limitations on available data and methodological scope of this report's Emissions Inventory focused on the administrative boundary of Jakarta, this report cannot conclusively provide quantification of the magnitude of CFPP impact to Jakarta's air quality.

Identifying the key highest-pollution coal power plants surrounding Jakarta to be monitored and regulated can be a high-impact lever. The overall adverse impact of coal-fired power plants on air quality and public health have been well studied in the global scientific literature. Coal combustion contributes to $PM_{2.5}$ pollution, both through direct emissions of particulate matter and the formation of secondary $PM_{2.5}$ aerosols, which have significant impact on respiratory and cardiovascular health.[127] Among local studies, Vital and ITB's Receptor-Based Source Apportionment study from 2018-2019 indicate that coal combustion contribute to $PM_{2.5}$ concentrations, in particular during wet season.[128]

There are two different emissions limits for coal-fired power plants depending on whether it is built before or after 2019, the latter imposing a more stringent standard. The post-2019 standard subjects newer plants built after 2019 to lower PM, NO_x, and SO_2 emissions standards than the pre-2019 limit. However, when compared to international benchmarks, even against other emerging markets, the post-2019 emission standards remain relatively lenient (see Box 10).

[127] Amster, E. (2019). Public health impact of coal-fired power plants: A critical systematic review of the epidemiological literature. International Journal of Environmental Health Research, 31(5), 558–580. https://doi.org/10.1080/09603123.2019.1674256

[128] For more information, please see: Vital Strategies. (2020). Identifying the main sources of air pollution in Jakarta: A source apportionment study.; Vital Strategies.; Centre for Research on Energy and Clean Air (CREA). (2020). Transboundary air pollution sources in Jakarta, Banten, and West Java Province.; Greenpeace Indonesia. (2017). Jakarta's silent killer.

TABLE 15. EMISSIONS STANDARDS FOR COAL-FIRED POWER PLANTS BASE ON MOEF REGULATION 15/2019

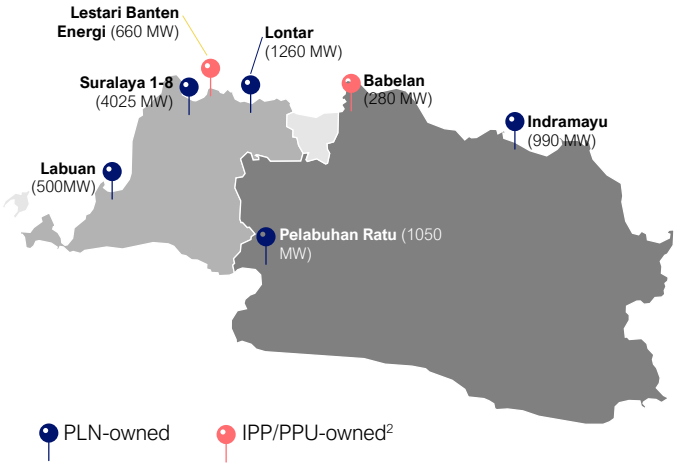
Category	Pollutant	PM	NO_x	SO_2	Hg
Plants built or operated before 2019 (pre-2019)		100	550	550	0.03
Plants built after 2019 (post-2019)	Maximum level (mg/Nm^3)	50	200	200	0.03

The decision to exempt older plants from newer standards can be explained by a combination of economic and technological considerations, implemented through grandfathering provisions. This exemption is usually based on the rationale that older plants were built with less advanced technology, making retrofitting them with modern pollution controls both technically challenging (e.g., due to space constraints) and prohibitively expensive. In addition, there is the assumption that older plants are nearing the end of their lifecycle, thus making it less cost-effective to retrofit if close to retirement. However, there may be benefits to overriding grandfather clauses and subjecting older pre-2019 plants to more stringent standards, especially in cases where rejuvenation efforts could extend the operational lifespans of these plants.

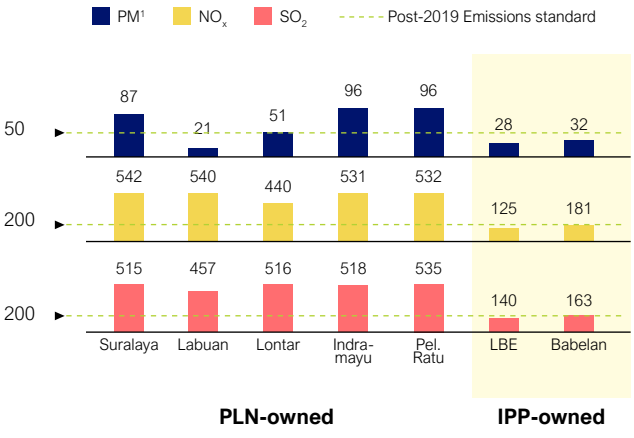
This report focuses on the 7 coal-fired power plants located within 150 km of Jakarta, which were all built before 2019. When assessed against the pre-2019 standards, based on recent emission reports, the plants meet the standards. However, if comparing against the post-2019 stringent standards, 5 out of 7 plants would fail to meet standards, requiring the installation of additional post-combustion controls (see Table 19). This signals the importance of reassessing standards and exploring the issuance of more stringent standards. Additional categorization based on the plants age may be useful to determine which interventions are suitable for each plant: i) **built before 2010** (10-15 years old plants); and ii) **built before 2000** (>25 years old or more).

FIGURE 46. COAL-FIRED POWER PLANTS WITHIN 150 KM RADIUS FROM JAKARTA

Distribution of coal PPs within 150km radius from Jakarta



Plants' pollutant emissions in 2023
(max value)



5 out of the 7 coal plants **do not meet the newer emissions standard if they were subject to it**

Two different interventions are required to control air pollution from coal-fired power plants:

1. **For younger fleets (built after 2010, 10–15-year-old):**

   Subject fleets to stricter emissions standard and enforce post-combustion controls & CEMS.

   As the younger fleets still have 15-20 years of operations, the fleet should be subjected to even stricter emissions standards. This could mean the post-2019 emissions standard, but also a new stricter standard as even the post-2019 one is still relatively weak compared to global standards (see Box 10).

2. **For old fleets (built before 2000, 25–40-year-old):**

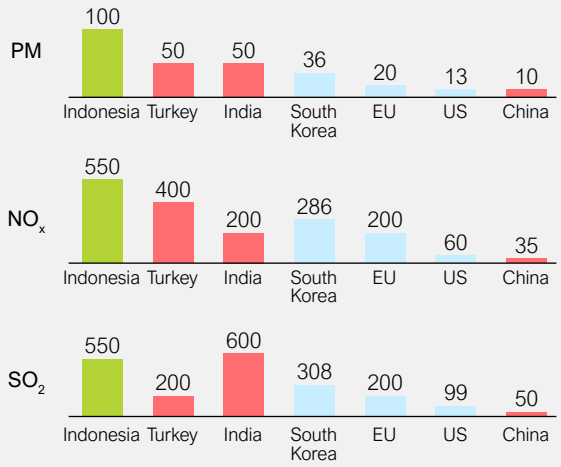
   Explore termination, mothballing, or lower utilization for the old plants.

   Installations of additional post-combustion controls beyond what's already installed (i.e., ESP) do not make economic sense for plants that are already 30-40 years old and are better suited to be retired or mothballed at its end of life. This intervention is specific to Suralaya power plant (Unit #1-7), with a slight variation in its interventions as its unit's ages vary slightly.

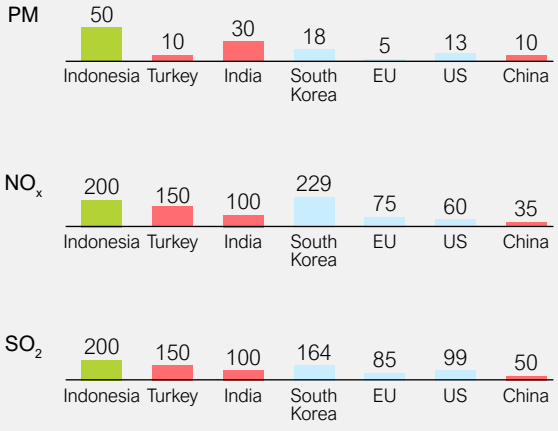
COMPARISON OF COAL-FIRED POWER PLANTS' EMISSIONS STANDARD

Many other countries' emissions limits of coal-fired power plants are more stringent than Indonesia's. Even when compared to other emerging economies (Turkey and India), Indonesia's emission limits are considered less stringent. For example, Indonesia's pre-2019 standard on PM emission limit is 2x higher than Turkey and India, and 10x higher than the US and China, with China being generally stricter due to Beijing's severe air quality in 2000s which leads to stricter emissions standard in the 2010s. For Indonesia's emission standard for coal power plants built after 2019, with Indonesia's limit for NO_x and SO_2 being 3-5x higher than the most stringent standards (e.g., EU, US, and China). Notably, in China, under the Ultra-Low Emissions Policy released in 2015, China has been promoting ultra-low emission retrofitting for existing power units and newly-built units also need to comply with the ultra-low emissions requirements, as per the standards below.

Emissions standard for coal plants built before 2019 (mg/Nm³)



Emissions standard for coal plants built after 2019 (mg/Nm³)



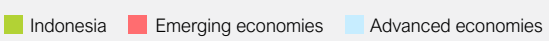


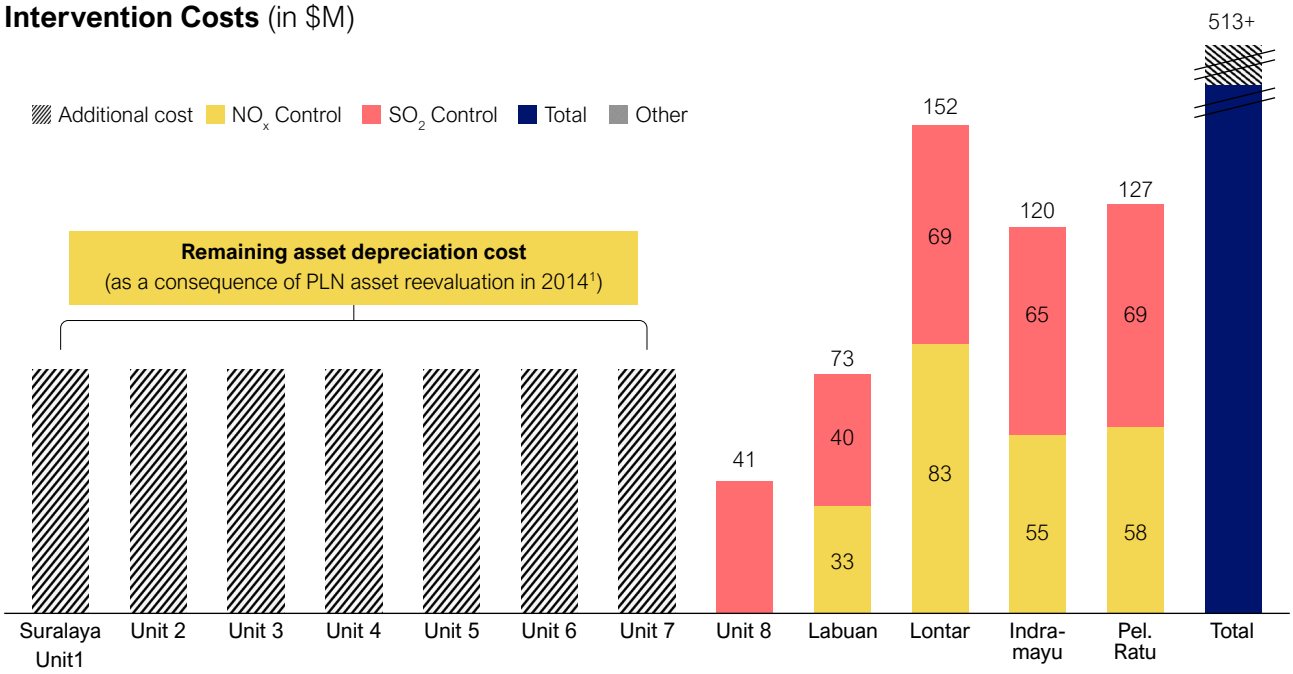
TABLE 16. LIST OF COAL-FIRED POWER PLANTS WITHIN 150 KM RADIUS OF JAKARTA

Plant name	Distance to Jakarta (km radius)	Capacity (MW)	Owner	Year COD	Age (as of 2024)	Emissions			Potential interventions (technical assessment)	Type of cost	Notes
						PM	NO_x	SO_2			
Pre-2019 emissions standard in MoEF 15/2019						100	550	550			
Post-2019 emissions standard in MoEF 15/2019						50	200	200			
CFPP Suralaya	94 km	4025	PLN						• Termination of operation (w/ or w/o decommissioning) • Mothballing* for Unit 1–4 • Lowered utilization rate for Unit 5–7 (for another 3-5 years before mothballed) *Note: Suralaya Unit 1 & 2 are planned to be mothballed after Unit 9 & 10 are operational (expected COD in December 2024)	• No "additional" decommissioning cost – assumed would have happened otherwise • Asset depreciation cost that remains from PLN's asset reevaluation	• PLN had done asset reevaluation2 of Suralaya Unit 1-7 where its asset accounting lifetime are prolonged: » Unit 1-2 (2022 → 2032) » Unit 3-7 (2015 → 2055) • Also need to consider the electricity system impact and cost perspective
- Unit 1		400		1985	39	87	542	515			
- Unit 2		400		1986	38	80	495	510			
- Unit 3		400		1989	35	63	391	525			
- Unit 4		400		1989	35	55	384	496			
- Unit 5		600		1997	27	67	170	467			
- Unit 6		600		1997	27	67	194	461			
- Unit 7		600		1998	26	48	193	423			
- Unit 8		625	PLN	2011	13	36	165	428	Post-combustion controls	PCC installation cost	Could be a potential for early retirement using schemes such as ADB's ETM (e.g., asset spin-off, reinvesting in clean energy, transition credits).[3]
CFPP Labuan	118 km	600	PLN	2009	15	21	540	457			
CFPP Lontar	47 km	1260	PLN	2011	13	51	440	516			
CFPP Indramayu	143 km	990	PLN	2011	13	96	531	518			
CFPP Pel. Ratu[1]	96 km	1050	PLN	2013	11	96	532	535			
CFPP Babelan	32 km	280	PPU	2017	7	32	181	163	No intervention (continued monitoring)	N/A	Proposed to be included in post-2019 emissions standard
CFPP LBE	58 km	660	IPP	2017	7	28	125	140			
CFPP Suralaya											
- Unit 9		1000	PLN	2024 (Expected)		Not yet commissioned			No No intervention (continued monitoring)		Proposed to be included in post-2019 emissions standard
- Unit 10		1000	N/A								

Notes: All the units above have installed ESP and employed Low Nox Burner (Source: UNEP (2017), "Mercury emissions from coal-fired power plants in Indonesia"). In addition, beyond the 150 km radius from Jakarta, out the total 44 CFPPs (13.7 GW) across Jakarta, Banten, and West Java, 100% have installed ESP, 50% have employed Low NOx Burner, 4 (3.7 GW) have installed FGD and another few 4 have employed limestone injection for the combustion process, according to MEMR. Limestone injection and coal input quality monitoring (sulfur content) are some short-term measures that can be done to lower SO2 emissions.

These interventions would cost at least $513 million by 2030, with potential additional costs associated with PLN's asset reevaluation for units of Suralaya power plant.[129] The primary cost comes from the installation cost of relevant air pollution control technology (i.e., NO_x and SO_2 control) for the younger fleets (e.g., Suralaya Unit 8, Labuan, Lontar, Indramayu, and Pelabuhan Ratu). The additional cost's value remains unknown but is expected to be in the form of remaining asset depreciation cost, which could be very restricting since the asset book lifetime is said to be prolonged until 2055 for Unit 3-7.[130] PLN also noted technical feasibility challenges (e.g., lack of space) with installing additional controls.

FIGURE 47. INTERVENTION COSTS FOR AIR POLLUTION CONTROL MEASURES FOR COAL-FIRED POWER PLANTS



CASE STUDY ON COAL-FIRED POWER PLANTS CONTROL

Beijing: Controlling air pollution from coal-fired power plants, a Beijing success story

Beijing successfully controlled air pollution from its 4 coal-fired power plants through various interventions since the 2000s and eventually became coal-free by 2017. Beijing's attempt to reduce air pollution from coal-fired power plants started as early as 1998 through end-of-pipe dedusting and desulfurization retrofitting projects. However, as its air quality worsened, Beijing began the coal-to-gas transformation in power plants in 2005, which was further hastened by Beijing's goal to host the 2008 Summer Olympics.[131]

Efforts further intensified through the implementation of the Beijing Clean Air Action Plan 2013-2017, during which Beijing built 4 major gas-fired thermal power plants to replace the existing 4 coal-fired power plants within its city limits. In 2014, Beijing adopted an Ultra-Low-Emission (ULE) Standard which mandated pollution control in the thermal power industry through upgrading control technologies and increasing regular monitoring. Positive effects of these efforts can be seen in the reduction of SO_2 and NO_x emissions from power plants, which dropped by 59% and 24% respectively in the 2013-2017 period. By 2017, Beijing's power sector became coal-free, with the last of the city's 4 major coal-fired power plants ceasing operations and shifting to using natural gas.

[129] Based on stakeholder interviews, it is assumed that termination and mothballing would not incur additional transition costs since it is considered as natural retirement costs already factored into at end of life. However, there may be asset depreciation cost, that might arise due to PLN's asset reevaluation of Suralaya power plant in 2014/2015 for Units 3-7 and 2022 for Units 1-2.

[130] Based on stakeholder interviews with PLN and CMMIA.

[131] Cheung, K. Y. (2010). Economic analysis of the Beijing Green Olympics: Implications on environmental protection in China. International Journal of Economics and Finance, 2(3), 104–115. https://doi.org/10.5539/ijef.v2n3p104

Enabling interventions for coal-fired power plants will require a mix of regulatory reform and support. The government can start by developing a more stringent emissions standard for coal-fired power plants and strengthening its enforcement. More importantly, the government should explore necessary reforms to enable the interventions to be implemented, especially those related with PLN's asset book value of the coal power plants. Lastly, the government can also further support PLN as an asset owner by exploring potential fiscal incentives and financing support to install post-combustion controls.

TABLE 17. KEY ACTIONS FOR NO_x CONTROL AT CCGT

Action Plan	Potential Stakeholders
Develop more stringent emissions standard that is aligned with global standard to be phased in gradually	MoE, MEMR, PLN, MSoE
Strengthen enforcement of emissions standards and continuous monitoring system of coal power plants with sanctions (e.g., fines, revokement of certain business permit, to the point of cessation of operations)	MoE, MEMR, POLDA, Provincial Govt of Jakarta and surrounding cities
Explore regulatory reforms that can enable the proposed interventions that also mitigate impact to PLN's book value (especially regarding asset re-evaluation), the power system, and state budget	MoF, PLN, MEMR
Explore potential fiscal incentives to lessen the financial burden for asset owners in stopping/lowering utilization or installing air pollution control technologies	MoF, MoI, MoT
Develop financing support for post-combustion controls & CEMS for coal power plants through grants or results-based finance/funding (e.g., Clean Air Fund)	Development & commercial banks, Philanthropies, MoF

COAL-FIRED POWER PLANTS IN THE ENERGY TRANSITION

In addition to the co-benefits for improved air quality, the retirement of coal-fired power plants is a crucial component for Indonesia to achieve a 1.5 °C-aligned net-zero pathway scenario.[132] Previously, Indonesia has committed to reaching net-zero emissions by 2060 or sooner, and recently signaled its ambition to reach net zero by 2050 with plans to retire all coal-fired power plants by 2040.[133,134]

Indonesia has set several milestones toward this coal-to-clean transition in the past few years. In 2022, the government released Presidential Regulation 112/2022 on the Acceleration of Renewable Energy Development which includes mandate to accelerate the early coal retirement and restrict new development for on-grid (main grid) coal-power plants.[135] MEMR is currently developing an early coal retirement roadmap based on this regulation, planning to retire a total of 4.8 GW of 13 coal-fired power plants.[136] During the G20 2022 Summit in Bali, the Just Energy Transition Partnership (JETP) was launched which aims to mobilize $20 billion in public and private financing for Indonesia's just energy transition. It aims to peak on-grid power sector emissions by 2030 and achieve net-zero by 2050 through financing mechanisms such as the ADB's Energy Transition Mechanism.[137]

[132] International Energy Agency (IEA). (2021). Net zero by 2050: A roadmap for the global energy sector.

[133] International Energy Agency (IEA). (2022). An energy sector roadmap to net zero emissions in Indonesia.

[134] Reuters. (2024, November 20). Indonesia can reach net zero emissions before 2050, president says. Retrieved from https://www.reuters.com/business/environment/indonesiacan-reach-net-zero-emissions-before-2050-president-says-2024-11-20/

[135] Except the ones that are already in PLN's pipeline and for captive, integrated downstreaming purposes, with additional criteria such as having emissions reductions plan and operating only until 2050.

[136] Kontan. (2024, August 26). Pensiun dini PLTU, Kementerian ESDM siapkan roadmap. Retrieved from https://industri.kontan.co.id/news/pensiun-dini-pltu-kementerian-esdm-siapkan-roadmap

[137] JETP Indonesia Secretariat. (2023). Comprehensive Investment and Policy Plan (CIPP). https://jetp-id.org/storage/official-jetp-cipp-2023-vshare_f_en-1700532655.pdf

4. WASTE SECTOR

ELIMINATION OF OPEN WASTE BURNING

Government Cost

$9M (IDR 144B)
from expanding municipal waste service, public awareness campaign, monitoring & enforcement cost

Impact to Pollution in 2030

↓ 8%
reduction in **NO_x emissions load**

- **To eliminate waste open burning** estimated cost is $9 million, including expansion of municipal waste collection, campaigns and monitoring & enforcement
- **Waste open burning is considered a priority lever as it is the fourth highest impact lever to $PM_{2.5}$,** with potential to reduce emissions load by 8% by 2030

Open burning of municipal solid waste contributes 8% $PM_{2.5}$ in Jakarta. In 2023, approximately 40,000 tons of solid waste were openly burned, equivalent to 1.2% of Jakarta's total waste generation.[138,139] The open burning of waste is already prohibited under Law 18/2008, and Jakarta Regional Regulation 4/2019 in the context of Jakarta city, but it remains prevalent today. Open burning is harmful to public health: studies show that open burning releases toxic and carcinogenic chemicals and is a leading cause of black carbon.

TABLE 18. KEY REGULATIONS RELATED TO WASTE BURNING

Action Plan	Potential Stakeholders
Law 18/2008 on Waste Management	Outlines foundational law basis regarding waste management and prohibition of waste burning
Law 32/2009 on Environmental Protection and Management	Imposes sanctions for authorized government officials who deliberately fails to enforce compliance regarding environmental protection
Jakarta Regional Regulation 4/2019 on Waste Management	Prohibits open burning of waste on Jakarta-level, including sanctions for violation following Law 32/2009

Open burning is usually done by three types of perpetrators: individuals, informal parties, and business actors for various reasons, including practicality to save space and time especially in areas not covered by waste collection services. Individuals may burn their waste themselves or enlist the help of informal parties in exchange for a fee or "cigarette money", whereas business actors (e.g., waste recyclers, street food hawkers, furniture

[138] Ministry of Health, Riset Kesehatan Dasar (Riskesdas) 2023
[139] Ministry of Environment and Forestry, National Waste Management Information System (SIPSN). https://sipsn.menlhk.go.id/sipsn/

business) typically burn their waste due to the practicality and ease of waste elimination.

Households often conduct open burning either in their own yards or in their neighborhood, viewed as a convenient and cost-free method of managing waste. This practice allows them to avoid paying a monthly waste management fee, which typically ranges from Rp50,000 to Rp100,000.[140] These contributions are usually collected at the community level (e.g., RT/RW-level). However, there is no standardized waste management fee as stipulated by Jakarta Regional Regulation 1/2015. In some neighborhoods, unreliable or poor waste management services further drive households to rely on open burning.

CHALLENGES

There are multiple factors as to why people resort to open burning:

1. **Lack of access to proper waste collection service.**

   At the most upstream, open burning typically occurs because there is a lack of collection, eventually leading to burning due to a limitation on space/disposal site. In some cases, it also leads to utilization of informal waste collectors that burns waste after they recover the recyclable (valuable) materials.

2. **Lack of waste transportation and disposal sites.**

   Even in areas that have a community waste collection, the waste may still end up being burned at the temporary waste disposal site (TPS) if there is no means (and space) to transport it to the landfill.

3. **Lack of awareness and understanding of open burning's negative impacts.**

   Burning of waste is also often done out of norm and convenience to eliminate waste, without proper understanding of its negative health impacts.

4. **Lack of enforcement on open burning activities.**

   When the enforcement is weak, perpetrators will not hesitate to burn their waste as there is no direct consequences. Jakarta Regional Regulation 4/2019 already imposes fine sanctions to open burning perpetrators of up to Rp500,000.

INTERVENTIONS

To eliminate open burning activities, the following interventions are proposed:

1. **Expansion of municipal waste management services,** especially for the unserved households and populated areas. This includes both expansion of waste collection and transportation to temporary shelter (TPS) and eventually to landfill (TPA). In addition, additional sortation and composting at either community-level or at TPS, depending on community needs and organic composition, can reduce waste sent to the landfill. The majority of waste burned will be comprised of non-valuable waste, comprised of residue and organics, that cannot be utilized by waste-pickers to sell to recyclers. To reduce waste sent to the landfill, the TPS workers can conduct additional processing, sortation of organics and composting. This will limit the residual waste transferred to the landfill given that landfill Bantar Gebang is currently in over-capacity.[141,142] Other waste management solutions such as waste-to-energy (WtE) or refuse-derived fuel (RDF) can also be explored.

[140] Systemiq analysis based on Aksara Waste Calculator, https://aksara.duckdns.org/aksara/kalkulator-sampah/

[141] Waste4Change. (2024, January 10). Ketahui fakta tentang TPST Bantar Gebang. https://waste4change.com/blog/ketahui-fakta-tentang-tpst-bantar-gebang/

[142] DPRD Jakarta. (2024, May 21). TPST Bantar Gebang over kapasitas, Pulau Sampah jadi solusi. https://dprd-dkijakartaprov.go.id/tpst-bantar-gebang-over-kapasitas-pulau-sampah-jadi-solusi/

2. **Increasing public awareness & behavior change campaign on open burning.**

   A public campaign on the environmental and health impacts of open burning in hotspot neighborhoods can help shift community behavior. Additionally, implementing a public reporting mechanism can provide a dedicated channel for citizens to report violations or file complaints, enhancing community accountability and applying social pressure to discourage open burning.

3. **Stricter monitoring & enforcement on open burning activities.**

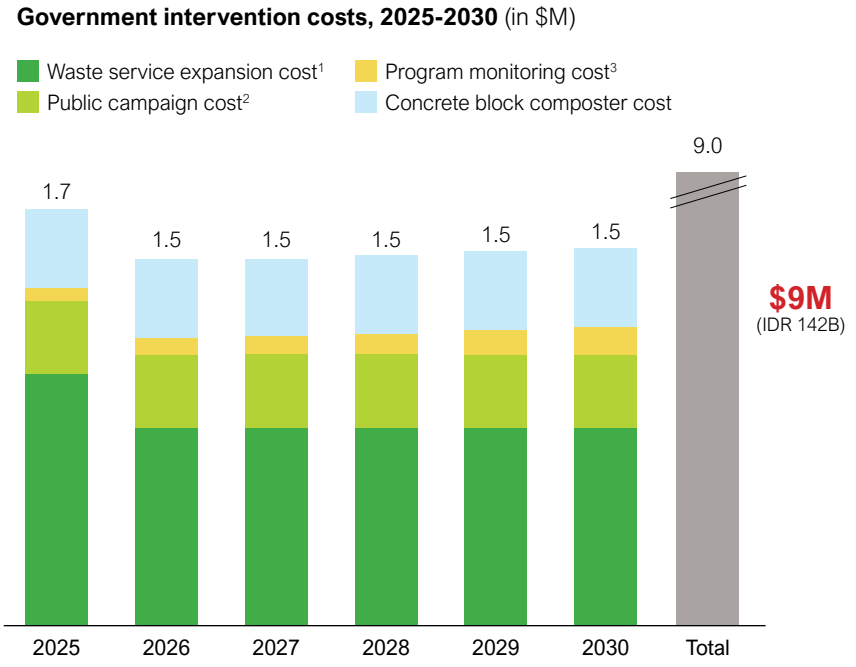
   Along with public campaign and socialization, it must also be followed with strict monitoring and enforcement by the local authorities, administering warnings and fines to prevent open burning.

ECONOMIC IMPACT

Implementing municipal waste service expansion, public awareness campaign, and stricter monitoring & enforcement would require $9 million of public budget by 2030. The cost primarily comes from the expansion of municipal waste services, which comes mostly from the operational cost of the waste service, and additional composter (concrete block) capital expenditure to encourage composting. Public campaign cost[143] comes from door-to-door socialization per household and program monitoring cost[144] comes are based on Jakarta Environment Agency's projected budget by 2030.

FIGURE 48. INTERVENTIONS COSTS FOR OPEN BURNING

Interventions	Impacts
Expansion of municipal waste management services for the unserviced households **Public awareness & behavior change campaign** on waste management and open burning **Monitoring & enforcement program** on open burning activities **Additional concrete block composter** for organic waste composting	**Government costs**



NEXT STEPS

Expanding municipal waste service, public campaigns, and strengthening monitoring & enforcement will require support from Jakarta Environment Agency, Health Agency, and Satpol PP. National support from both Ministry of Environment and Ministry of Health can also be helpful to streamline similar efforts in other cities outside Jakarta.

[143] Based on Systemiq's Project STOP experience in operationalizing local waste systems in East Java and Bali.
[144] Vital Strategies. (2024). Cost-benefit analysis for air pollution control strategies in Jakarta.

TABLE 19. ACTION PLAN FOR OPEN BURNING ELIMINATION

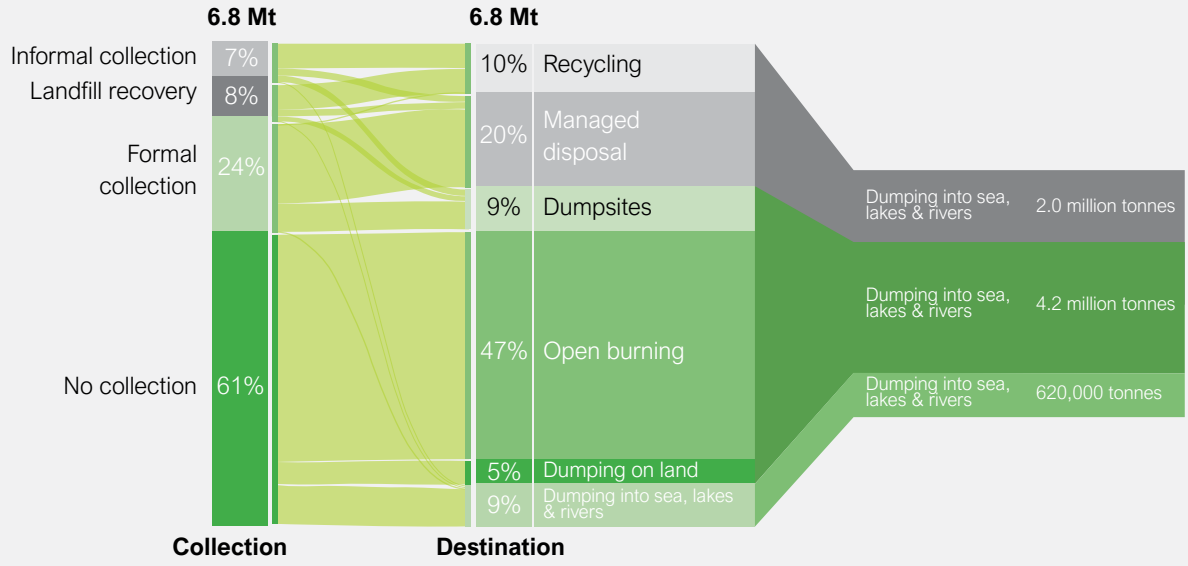
Action Plan	Potential Stakeholders
Improve & expand waste collection and transportation service for remaining households / areas that do not currently have waste service	Jakarta Environmental Agency
Explore other long-term waste management solutions to improve waste system, including waste treatment and energy recovery (e.g. gasification, pyrolysis), upgrade to sanitary landfills, and Extended Producer Responsibility (EPR)	Jakarta Environmental Agency, MoE
Strengthen monitoring & enforcement of open burning activities from household waste	Jakarta Environmental Agency, Municipal Police (Satpol PP)
Create and design public campaigns to raise awareness and promote behavior change on open waste burning for households	Jakarta Environmental Agency, Jakarta Health Agency, MoH, MoE

ANTI-OPEN BURNING INITIATIVE GUIDELINES[145]

Open burning eradication guidelines: A Banyuwangi Hijau case study

Across Indonesia, open waste burning is the most widely used method of disposal.[146] This issue has been getting more attention from national government in recent years. As part of the government's commitment to fulfill Indonesia's Enhanced National Determined Contribution (ENDC), the Government of Indonesia aims to eliminate open burning by 2050.[147]

Lifecycle of Indonesian plastic waste (% of total plastic waste generated)



In response, the regency of Banyuwangi, through Banyuwangi Hijau program, developed an open burning eradication guideline.[148] The guideline employs a five-step approach to eliminate open burning, integrating government policy reforms with grassroots community efforts. This approach could serve as a model for Jabodetabek and other regions in Indonesia with high rates of household open burning.

[145] For more information on Systemiq's research on waste management in Indonesia, see additional reports: Systemiq. (2021). Building Robust Governance and Securing Sufficient Funding to Achieve Indonesia's Waste Management Targets.; Systemiq (2023), Mobilizing Blended Finance For Circular Waste Collection & Sortation Infrastructure.; Systemiq & World Economic Forum. (2020). Radically Reducing Plastic Pollution In Indonesia: A Multistakeholder Action Plan National Plastic Action Partnership.

[146] Systemiq & World Economic Forum. (2020). Radically Reducing Plastic Pollution In Indonesia: A Multistakeholder Action Plan National Plastic Action Partnership.

[147] Ministry of Environment and Forestry. (2022, November). Speech from Director General of Waste, Waste Water, and Hazardous Waste Management at COP27 UNFCCC. Presented at COP27 UNFCCC, Sharm El-Sheikh, Egypt. https://pslb3.menlhk.go.id/portal/read/talkshow-achieving-national-determined-contribution-ndc-through-waste-management

[148] Banyuwangi Hijau & Project STOP. (2024). Guidelines for the eradication of open burning.

- **Step 1: Policy Set-Up:** involves establishing a robust policy framework that harmonizes national-level policy with local-level movements. For instance, at the national level, Law 18/2008 and Indonesia's Enhanced National Determined Contribution (ENDC), respectively, prohibit the burning of waste and impose a mandate to eliminate open burning by 2050. At the regency-level, the anti-open burning initiative hinges on regency regulations and Regent's mandates to enhance regency-wide waste system. This includes forming a Joint Management Office (JMO) for cross-agency collaboration, and incentivizing villages to improve their waste systems.
- **Step 2: Village Activation:** focuses on fostering community trust and ownership to ensure the sustainability of waste management systems. This involves selecting committed villages, preparing governance structures, triggering behavior change, and formalizing commitments under village regulations.
- **Step 3: Improvement of Waste Collection Service:** launches door-to-door waste collection services, ensuring waste is sorted at the source and transported to Material Recovery Facilities (MRFs) for further processing. This step provides universal access to waste collection, reducing the need for open burning.
- **Step 4: Open Burning Hotspot Selection:** involves mapping and prioritizing open burning hotspots based on impact-effort criteria to prioritize closures. For example, in Singolatren Village, hotspots were identified, and the village government coordinated efforts to plan and mobilize resources for closure.
- **Step 5: Closure of Open Burning Hotspot:** collaborative effort supported by co-funding from partners; planning for post-cleanup initiatives can include installing anti-open burning billboards, repurposing land for beneficial uses, and increasing monitoring to prevent illegal dumping or burning.

This five-step guideline highlights the importance of government buy-in to create scalable and sustainable waste systems. Community participation is crucial for lasting system change, achieved through partnerships with respected leaders and clear community expectations. Lastly, fostering a collaborative culture and building long-term relationships among stakeholders ensures effective implementation and sustainability of the waste management system.

5. CONSTRUCTION SECTOR

CONSTRUCTION DUST CONTROL

Government Cost

$0.14M (IDR 2B) from monitoring & enforcement cost on construction dust control

Impact to Pollution in 2030

↓ 0.02% reduction in **$PM_{2.5}$ emissions load**

- **Targeting 100% construction dust control through** establishing a national standard and continued monitoring & enforcement requires $140,000 of public budget by 2030
- **Proposed measures to control construction dust** can reduce 0.02% of $PM_{2.5}$ emissions load

CONTEXT

Construction dust is also another contributor to particulate emissions, PM_{10}, and $PM_{2.5}$. Based on current emissions inventory, in 2023, construction dust contributed 8% of $PM_{2.5}$ and 6% of PM_{10}. A source apportionment study highlighted that construction activity contributes 13% to $PM_{2.5}$ concentrations in Kebun Jeruk, West Jakarta at a particular dry season in 2019.[149]

Currently, emissions control from construction activity is regulated under compliance to environmental permit. Hence, businesses carrying out construction activities are required to publish two environmental documents: 1) Environmental impact assessment (AMDAL); 2) Environmental management & monitoring plan (RKL-RPL) documents.

TABLE 20. KEY REGULATIONS RELATED TO CONSTRUCTION DUST CONTROL

Action Plan	Potential Stakeholders
Government Regulation 22/2021 on the Implementation of Environmental Protection & Management	Regulates matters involving environmental protection & management, which requires environmental assessment (AMDAL) & permitting for business entities
MoEF 26/2018 on Guidelines for Environmental Documents	Provides guideline for environmental documents (e.g., AMDAL[150], RKL-RPL[151] docs)
Jakarta Governor's Decision 551/2001 on Ambient Air Quality Standard for Jakarta	Sets emissions limit on TSP from construction activity (230 µg/Nm3 for 24-hour limit)

[149] Vital Strategies. (2020). Identifying the main sources of air pollution in Jakarta: A source apportionment study.

[150] AMDAL is Analisis Dampak Lingkungan, a document that assesses environmental impacts of a business activity.

[151] RKL-RPL is Rencana Pengelolaan Lingkungan dan Rencana Pemantauan Lingkungan, two documents to show how a company plans to perform its environmental management and monitoring of its business activity, as part of AMDAL (to receive an environmental permit).

CHALLENGES

Current challenges in managing construction dust include:

1. **Lack of monitoring & enforcement on construction dust control.**
   Although there is already a moderately stringent[152] TSP emission limit under Jakarta's Ambient Air Quality Standard, the current monitoring & evaluation of businesses' environmental protection (RKL) and monitoring (RPL) remains relatively lacking in practice.[153]
2. **Low awareness and voluntary commitment from private sector** to reduce environmental impact of construction dust. There is a lack of awareness of construction dust impact to air pollution and thus rarely seen as a priority environmental issue for construction businesses to mitigate.

CASE STUDY ON CONSTRUCTION DUST CONTROL

Beijing: Six-100% guidelines for construction dust control

Beijing's large-scale infrastructure and housing construction projects made construction dust the third largest contributor (15%) of the city's $PM_{2.5}$ emissions in 2013. As part of *Beijing 2013-2017 Clean Air Action Plan*, the city enacted six-100% guidelines for controlling construction dust:

1. 100% enclosure around the site
2. 100% coverage of demolition waste and stacked materials
3. 100% bare land pavement
4. 100% cleaning of vehicles entering and leaving the site
5. 100% wet excavation; and
6. 100% closed demolition waste transport vehicles

For enforcement and surveillance, video monitoring systems were installed in more than 1,700 construction sites and 155 concrete mixing plants throughout the city. Construction sites and concrete batching plants that fail to comply to the six-100% guidelines were shut down, increasing compliance from construction dust sources in the city. The city also adopted a green construction management model and installed dust suppression technologies, including chemical dust suppressants and spray dust suppression systems. Beijing also developed the Technical Requirements for Marking, Monitoring, and Sealing Construction Waste Transportation Vehicles in 2014 to establish strict control over dust pollution from the transportation of construction and demolition waste.

INTERVENTIONS

Controlling construction dust two require two key interventions:

1. **Develop a stricter dust emissions standard for construction activities.**
   This could include developing a national emissions standard for dust-generating construction activities, including the machinery and transportation of construction materials, aligned with global benchmarks.
2. **Enforce compliance of construction dust mitigation plans outlined in current environmental documents** (e.g., RKL-RPL docs) **through stricter monitoring & enforcement.** Monitoring efforts can be enhanced through video surveillance systems and site inspections at construction sites and mixing plants within the city, whereas enforcement efforts

[152] Jakarta's TSP limit under Jakarta Governor's Decision 551/2001 is 230 µg/Nm3 (24-hour limit). For comparison, China's TSP limit in its ambient air quality standard is 300 µg/Nm3 (24-hour limit) for Class 2 area (which includes residential areas, mixed-use areas, cultural areas, industrial zones, and rural regions), based on China's GB 3095-2012; https://www.fao.org/faolex/results/details/en/c/LEX-FAOC136756/

[153] For an example on construction dust mitigation plan, please refer to this ANDAL, RKL-RPL addendum of MRT Jakarta Phase 2A Project: https://jakartamrt.co.id/sites/default/files/2021-12/3.%C2%A0Addendum%C2%A0ANDAL%2C%C2%A0RKL-RPL%20MRT%20Fase%202A.pdf.

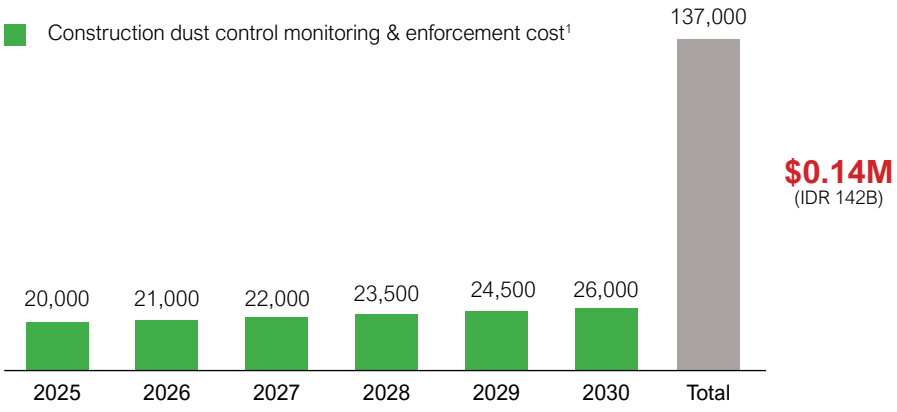
should be directed toward dust suppression measures, such as water spraying, applying dust suppressants, installing barriers, and avoiding dust-generating activities on windy days. Non-compliance should result in penalties or fees.

ECONOMIC IMPACT

Implementing stricter monitoring & enforcement on construction dust control would require $140,000 of government cost by 2030. This cost is primarily for monitoring and enforcement to implement the construction dust control activities (e.g., payroll budget, site inspections).

FIGURE 49. INTERVENTION COSTS FOR CONSTRUCTION DUST CONTROL

Interventions	Impacts	
Monitoring & enforcement cost for implementation of construction dust control	**Government costs**	Government intervention costs, 2025-2030 (in $M)



NEXT STEPS

Controlling construction dust requires strong government collaboration to monitor & enforce dust suppression activities at both the construction sites and the mixing plants throughout the city. Designing an online monitoring system can also help navigate hotspots early and save costs from manual inspections.

TABLE 21. ACTION PLAN ON CONSTRUCTION DUST CONTROL

Action Plan	Potential Stakeholders
Implement more comprehensive emissions standard for construction dust, including from machinery and transport of construction materials	MoE, MPW
Increase efforts in better online dust monitoring system for construction and road dust	Jakarta Environmental Agency, Public Works Agency
Strengthen enforcement and inspections on dust level infringement	Municipal Police (Satpol PP), Jakarta Environmental Agency, Public Works Agency

4 INSTITUTIONAL ARRANGEMENT & GOVERNANCE

CURRENT LEGISLATIVE FRAMEWORK

Enshrined in the 1945 Constitution of the Republic of Indonesia is the right of all Indonesians to a 'good and healthy environment', of which clean air is no exception to[154]. Law No. 32 of 2009 on Environmental Protection and Management reinforces this right, highlighting the responsibility of the state to maintain and protect the environment. It provides the legal framework for comprehensive environmental protection, outlining obligations for pollution control and prevention.

Both the national and local government have defined roles in overseeing air quality, with the central government leading a larger role by establishing national standards. Government Regulation 23/2014 outlines the division of responsibilities between central and local government: the central government sets national air quality standards and regulations which local governments must enforce. The central government oversees environmental issues that affect multiple regions or have national significance, including air pollution control regulations, transboundary pollution issues, and long-term national sectoral strategies, such as energy transition and fuel quality. The local government is responsible for enforcing national standards and implementing programs to achieve air quality standards. Strengthening national and local government coordination is crucial to develop a cohesive, uniform approach to air quality management.

At the national level, MoE is the primary ministry responsible for overseeing air pollution. MoE establishes national-level policies on National Ambient Air Quality Standards, manage air quality monitoring stations, air pollution controls, emissions limits and fuel standards.[155] The relevant directorate within MoE is Directorate General of Environmental Pollution and Degradation Control (DG-PPKL).

To strengthen governance, MoE launched the Air Pollution Control Task Force for the Greater Jakarta area to monitor and take action against non-stationary sources of pollution such as coal-fired power plants, industries, open burning of waste, and others[156]. Led by DG of Environmental and Forestry Law Enforcement (GAKKUM), it has mobilized more than 100 environmental impact supervisors and controllers for oversight operations. The task force works with DG-PPKL to identify air pollution hotspots for site visits. Any detected violations during monitoring can be subject to strict action, including fines, halting operations, revocation of business permits, or administrative sanctions. To date, the task force has suspended business activity of 11 companies, 3 are recommended for legal action, and 44 will face administrative sanctions[157]. MoEF Decree 8/2023 outlines a seven-step work plan to control air pollution, which includes identifying pollution sources, monitoring vehicle emissions, promoting tree planting, supervising compliance, enforcing the law, applying weather modification technology, and providing guidance and coordination.

At the local level, there also currently exists a Jakarta-level multi-agency taskforce, but no cross-ministerial taskforce at the national level, which limits coordination across key technical ministries. The Provincial Government of Jakarta through Governor's Decree 576/2023 launched a multi-sectoral taskforce to lead implementation of the Jakarta's Air Pollution Control Strategy (SPPU). The air pollution taskforce is led by the Regional Secretariat of DKI Jakarta and key

[154] Article 28H, 1945 Constitution of the Republic of Indonesia

[155] UNEP. (2019). Air pollution in Asia and the Pacific: Science-based solutions.

[156] MOEF Decree Number SK.929/MENLHK/SETJEN/KUM.1/8/2023

[157] MOEF. (2024, December 20). KLHK laksanakan operasi inspeksi lapangan Satgas Pengendalian Polusi Udara Jabodetabek. Retrieved from https://ppid.menlhk.go.id/berita/siaran-pers/7322/klhk-laksanakan-operasi-inspeksi-lapangan-satgas-pengendalian-polusi-udara-jabodetabek

agencies involved include: the Environmental Agency, Transportation Agency, Health Agency, Industry and Energy Agency, Regional Coordination Bureau, and Municipal Police. The central ministries are not currently included and have a minimal role in the Jakarta Air Pollution Taskforce. The taskforce's remit is restricted to Jakarta's administrative area, leaving coordination with the surrounding Greater Jakarta local governments (at provincial, regency or city level) to more ad-hoc arrangements.

TABLE 22. KEY REGULATIONS RELATED TO AIR QUALITY MANAGEMENT

Regulations	Notes
Emission standards	
Law 32/2009 on Environmental Protection and Management	Sets legal framework for comprehensive environmental protection, including outlining government obligations for pollution control and prevention
Law 23/2014 on Regional Government	Outlines the division of environmental management responsibilities between Indonesia's national and regional government • Central government oversees environmental issues across multiple regions and/or have national significance, whereas local government is responsible for environmental issues within its jurisdiction's boundaries • Mandates that local governments coordinate with national and provincial administration to align environmental policies, e.g. air quality standards Central government has authority to intervene if local government fails to enforce national environmental standards, ensuring that minimum environmental standards upheld nationwide
MOEF Regulation 14/2020 on Air Pollutant Standard Index (ISPU)	Indonesia's official metric for assessing ambient air quality. The regulation specifies the monitoring of pollutants including Particulate Matter (PM_{10} and $PM_{2.5}$), Carbon Monoxide (CO), Sulfur Dioxide (SO_2), Nitrogen Dioxide (NO_2), Ozone (O_3), and Hydrocarbons (HC) The ISPU categorizes air quality into five levels: • **Good (0-50):** Air quality poses little to no risk. • **Moderate (51-100):** Acceptable air quality; however, some pollutants may pose a moderate health concern for a small number of individuals. • **Unhealthy (101-200):** Everyone may begin to experience health effects; sensitive groups may experience more serious effects. • **Very Unhealthy (201-300):** Health warnings of emergency conditions; the entire population is more likely to be affected. • **Hazardous (>300):** Health alert: everyone may experience more serious health effects.
Government Regulation 22/2021 on the Implementation of Environmental Protection and Management	Replaced earlier law Government Regulation 41/1999 on Air Pollution Control. Part of Indonesia's 'Omnibus Law' reforms and introduces more stringer air quality standards and emission thresholds for pollutants

CURRENT GOVERNANCE CHALLENGES

Effective governance is crucial to drive progress, yet in the past, air pollution governance has been fragmented between local and national governments and across sectoral ministries. Stakeholders highlighted several challenges to governance which hindered implementation of air pollution levers. First, there is a lack of clear governance and coordination between local Jakarta provincial government and national ministries. Jakarta provincial government has been actively leading efforts to tackle air pollution, through the Air Pollution Taskforce established through Governor's Decree 576/2023 Jakarta's Air Pollution Control Strategy (SPPU). SPPU includes local-led programs such as promoting emissions testing and electrification of Transjakarta buses. However, several of the key levers identified, such as EURO IV fuel, national EV targets, sectoral emission standards and energy transition matters, have national strategic implications which require ministerial-level intervention. In addition, Jakarta Environmental Agency has faced difficulties in cross-regional coordination with other local governments in the Greater Jakarta area — stronger involvement from MoE or MoHA could help support coordination.

At the central level, there is a need to strengthen cross-ministerial coordination and develop accountability mechanisms between MoE and relevant technical ministries. For example, regarding adoption of EUROIV fuel, MoEF Regulation 20/2017 was issued to promote EUROIV, but the responsibility of overseeing and implementing the roll out of EUROIV fuel is led by MEMR, Pertamina and other fuel companies. Similarly, MoE is responsible for establishing sectoral emission standards, but enforcement and oversight involves the coordination with MoI for industries and MEMR for power plants. There is an opportunity to better streamline policy and governance for air pollution mitigation and national climate and energy transition strategy. Integrating these efforts under a unified governance model could further strengthen coordination on key programs such as electric vehicle adoption and power plant emissions monitoring and retirement.

There has been precedence on successful cross-ministerial taskforces to accelerate action for certain issues. In the previous administration 2019-2024, there were two similar taskforces related to environmental protection led by the Coordinating Ministry of Maritime and Investment Affairs (CMMIA): National Energy Transition (also known as Satgas TEN) or the National Coordinating Team for Marine Debris Handling (also known as TKN-PSL). Notably, the National Coordinating Team for Marine Debris Handling was launched with the Presidential Regulation 83/2018 as the leading governance body to achieve national targets of reducing marine plastic debris by 70% in 2025[158]. The Team had two key governance bodies: a Steering Committee and Implementing team. The Steering Committee oversaw the overall strategy and direction, whereby the Chairman was the Coordinating Minister of CMMIA and the Daily Chair was the Minister of MoEF, with members of the Steering Committee comprised of 18 various ministries, including MoHA, MoI, and MoF[159]. The Implementing Team was responsible for carrying out the day-to-day coordination, whereby specific Directorates were assigned to 5 different workstreams related to marine or land-based waste management. The Team's targets were integrated within the assigned Directorates KPIs and were allocated budget and full-time staff in MoEF. This report proposes a similar inter-agency model, with the addition of including Provincial governments, to set national ambition and accelerate resources towards air quality improvements in Jakarta.

[158] TKN-PSL. (2022). Laporan pencapaian Rencana Aksi Nasional penanganan sampah laut 2021.
[159] For more information, please see TKN-PSL website: https://sampahlaut.id/.

PROPOSED GOVERNANCE MODEL

Co-developed and informed by extensive engagement with government, this report proposes the establishment of a centralized Coordinating Team for Greater Jakarta Air Pollution to lead the strategy and implementation of air pollution measures. The taskforce would be comprised of ten key workstreams, led by relevant ministries and provincial governments. A national taskforce has the potential to catalyze progress by raising priority of air pollution to national scale, promote coordination to overcome siloed efforts across ministries, enforce accountability and channel increasing resources to the implementation of levers. In the long term, to ensure continuity, it is recommended that the targets, responsibilities, and capabilities of the task force be incorporated and institutionalized within the functions of relevant ministries and directorates.

FIGURE 50. HIGH-LEVEL PROPOSAL FOR A CENTRALIZED COORDINATING TEAM

	Workstreams	Priority Focus	Main Stakeholders
Pillar 1: Energy Transition-Related	1 **Workstream 1:** Electric Vehicles	Accelerate adoption of electric vehicles (E2W, E4W, E-bus, E-truck) and expand city-wide charging infrastructure	Jakarta Provincial Government, PLN, MEMR
	2 **Workstream 2:** Power	Develop stringent emissions standards aligned with global benchmarks, enforce controls and encourage transition	MEMR, PLN, MSOE, MoE
Pillar 2: Policy Enforcement & Issuance	3 **Workstream 3:** Industry	Develop stringent emission standards and enforce cleaner technologies, inc. PCC, CEMS, and e-heating solutions	MoE, MoF, MoI
	4 **Workstream 4:** Fuel Quality	Accelerate adoption of EURO IV fuel through policy and implementation of timeline	MEMR, Pertamina
	5 **Workstream 5:** Waste Open Burning	Expand waste mgmt. infrastructure and improve monitoring and enforcement against open burning	Jakarta Provincial Government, MoE
	6 **Workstream 6:** Construction	Issue emission standards for construction dust and enforce monitoring	Jakarta Provincial Government, MoE, MoPW
	7 **Workstream 7:** Public Transport & LEZ	Accelerate public transport infrastructure and development of Low Emission Zone	Jakarta Provincial Government, MoT
	8 **Workstream 8:** Financing	Develop financing mechanisms to support air pollution program and policy implementation	MoF
Pillar 3: Data & Health	9 **Workstream 9:** Data & Monitoring	Develop national and regional emissions inventories, enforce AQI aligned with global standard, oversee AQM	MoE
	10 **Workstream 10:** Public Awareness	Develop public awareness and education campaigns on health impact of air pollution	MoH

MoE (Ministry of Environment), MoI (Ministry of Industry, MSOE (Ministry of State-Owned Enterprise), MEMR (Ministry of Energy and Mineral Resources), MoF (Ministry of Finance), MoH (Ministry of Health), MoPW (Ministry of Public Works), MoT (Minisry of Transportation), MoHA (Ministry of Home Affairs), Jabodetabek (Jakarta, Banten, West Java)

The figure above outlines a high-level structure of a centralized Coordinating Team for Greater Jakarta, comprised of a Steering Committee, Implementing Team and Expert Body. We propose recommendations for Steering Committee members and workstream leads based on roles and responsibilities, though these can be further adapted by the government.

The task force can be led by a Steering Committee, comprised of relevant ministries and provincial governments, which will determine the overall strategy and priorities of the task force. Relevant ministries include MoE, MoI, MSOE, MEMR, MoH, MoT, MoPW, representing key sectors linked to air pollution and will ensure alignment of efforts with broader national strategic priorities. The three provincial governments—Jakarta, West Java, and Banten—can also be included to ensure implementation throughout the Greater Jakarta area and lead coordination with their respective city and regency governments. In addition to key technical ministries, MoHA and MoF is recommended to be included in Steering Committee. MoHA is included to support interregional collaboration, ensuring consistent program implementation. Meanwhile, MoF would advise on financial matters such as budget allocation, subsidies, trade and import regulations, and capital financing or debt management for infrastructure projects related to public transport, energy, and industry. The Coordinating Minister for Infrastructure and Regional Development could serve as a potential lead for the Steering Committee and house the Secretariat, given the critical role of infrastructure development in achieving the recommended strategies.

The Implementing Team is tasked with driving the implementation of workstreams, comprised of ten workstreams across three pillars. Below is a potential high-level model with proposed workstreams:

Pillar 1: Energy Transition-Related – Given EV development and power sector is closely linked with and has broader implications to national climate strategy, these workstreams will be embedded within and/or closely coordinate with the existing national energy transition taskforce. This recommendation was advised in various stakeholder engagements.

Workstream 1: Electric Vehicles – proposed workstream lead is Provincial Government of Jakarta to ensure targeted, localized efforts for increased adoption of EVs in Jakarta. Key activities include coordinating with Environmental and Transport Agencies to develop transport and traffic-related incentives, supporting the electrification of Transjakarta buses, and expansion of public charging infrastructure for private EVs, which will require coordination with PLN and MEMR.

Workstream 2: Power – proposed workstream lead is MEMR, in coordination with PLN and MSOE, tasked with monitoring emissions to ensure compliance to standards, installation of post-combustion technologies, and exploring reduced utilization or mothballing and retirement coal-fired power plants in the surrounding areas of Jakarta. MoE is also critical in the issuance of stringent emission standards of power plants, and strict oversight and monitoring of emissions data.

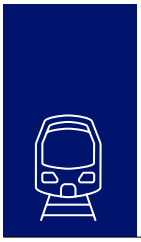
Pillar 2: Policy Enforcement and Issuance – This pillar will focus on strengthening and enforcing implementation of key policies.

Workstream 3: Industry – proposed workstream lead is MoE, in collaboration with MoI, for the issuance of stringent industrial emission standards, monitoring of emissions data, and enforcement of air pollution controls and cleaner boiler technology for industries. MoF is critical in the exploration of financial incentives, e.g. through corporate tax benefits or subsidies, to support industry owners in the procurement and adoption of controls or e-heating technologies.

Workstream 4: Fuel quality – proposed workstream lead is MEMR, responsible for coordinating with Pertamina and other fuel suppliers for the roll out of EURO IV fuel in the Greater Jakarta Area, as the first stage towards achieving government target of 100% EURO IV nationally by 2028.

Workstream 5: Waste open burning – proposed workstream lead is Jakarta Provincial Government, namely the Jakarta Environmental Agency, with support from MoE. This workstreams is tasked with optimizing waste systems, improving and expanding waste processing infrastructure and strengthening local enforcement of bans against open burning.

Workstream 6: Construction dust – proposed workstream lead is the Jakarta Provincial Government, primarily the Environmental Agency and the Public Works Agency. MoE is also critical for issuance of construction emission standards and enforcement of Environmental Impact Assessments (AMDAL) to minimize pollution from construction site, with oversight and support from MoPW.



Workstream 7: Public Transport and Low Emission Zones – proposed workstream lead is the Jakarta Provincial Government, primarily the Transportation Agency. This workstream will coordinate with MoT and MoF, and public transport companies (MRT, LRT, KRL) to streamline financing, infrastructure development and promote ridership of public transport. In addition, this workstream will work on developing a clear roadmap and enforcing the development of Low Emission Zones in Jakarta.

Workstream 8: Financing – will be led the MoF, responsible for designing financial incentives and funding mechanisms to support the implementation of key air quality levers. MoF will coordinate with relevant sectoral ministries and local governments to assess national and regional budget allocations, identify fiscal instruments, and mobilize financing to accelerate clean air programs and achieve targeted outcomes.

Pillar 3: Data and Health – This pillar will focus on overseeing data and health campaigns as key enablers.

Workstream 9: Data & Monitoring – will be led the MoE, overseeing monitoring stations, data collection and analysis, and determining Air Pollution Index (ISPU). This includes developing an Emission Inventory Guideline to ensure standardized data collection methodology to establish regional emissions inventory.

Workstream 10: Public Awareness – will be led the MoH, responsible for designing behavior change and social campaigns related to air pollution, including promoting low-emission transport, educating the public on the dangers of air pollution, staying indoors on days with hazardous or unhealthy levels, and prohibiting open burning.

An expert body comprised of academics and think tanks is proposed to provide strategic guidance and support on monitoring and evaluation. Research will play a critical role in conducting scenario modelling analyses to ensure that policies remain evidence-based and aligned with the latest scientific developments. This approach will foster transparency and accountability through objective, third-party assessments of progress, reinforcing the credibility and effectiveness of program implementation.

GLOBAL CASE STUDIES ON GOVERNANCE

Numerous countries have adopted various governance models to tackle air pollution, showing the benefits of both centralized and collaborative frameworks in improving air quality. Here's a closer look at three distinctive models from London, Mexico City, and Beijing.

London: Mayor-Led Model

London's air pollution control efforts are driven by a centralized, Mayor-led model. The National Air Pollution Control Programme sets the overarching targets for air quality. The Mayor of London takes charge of developing and implementing a localized strategy for Greater London.[160] This approach has enabled the Mayor to take an active role in global initiatives, including leading organization C40, a network of cities committed to addressing climate change. The Mayor also establishes ambitious policies at the beginning of each term, laid out in key documents such as the London Environment Strategy, Mayor's Transport Strategy, London Health Inequality Strategy, and London Plan. From 2019 to 2023, London introduced Ultra Low-Emission Zones (ULEZ), which resulted in a 13% reduction in nitrogen oxides (NO_x) and a 30% reduction in $PM_{2.5}$ levels.

Mexico City: Metropolitan Environmental Commission

In 1992, Mexico City was named the most polluted megacity in the world by UNEP and WHO.[161] Local urban myth say that the pollution was so severe that birds were reportedly falling dead from the sky.[162] Mexico City sits at over 7,000 feet in elevation in a valley surrounded by mountains, which ends up trapping the pollution inside the city. To accelerate efforts, the Mexican government created a national inter-agency body, the Metropolitan Environmental Commission (MEC), led by the Ministry of Environment and Mexico City government, also involving the Ministry of Health and National Institute of Ecology. In 1995, the MEC launched the National Program to Improve Air Quality in the Valley of Mexico (ProAire), a stricter program from previous Comprehensive Program Against Air Pollution (PICCA). Key ProAire policies included stricter fuel standards, emissions inspections and testing, substituting natural gas for coal and oil in industrial facilities, and relocating high-polluting industries outside the city. By 2013, Mexico City received the C40 Air Quality Award for the success of the ProAire program, which was able to reduce 89% of SO_2 and 66% of PM_{10}.[163] The MEC and ProAire programs still exists to date leading air pollution programs nationally.

Beijing: Coordination Group for Air Pollution Prevention and Control in the Beijing-Tianjin-Hebei Region

In 2013, China's central government declared a "War Against Pollution" and launched the National Air Quality Action Plan.[164] The Beijing Municipal Government, with the support of the China's State Council, launched the Coordination Group for Air Pollution Prevention and Control in Beijing-Tianjin-Hebei and Surrounding Areas in 2012. The Coordination Group is comprised of eight ministries and seven provinces which aims to target air pollution in Beijing and its surrounding areas, through five-year plans with unified regional requirements for air quality improvements. The group also established a special joint mechanism to address mobile source pollution, involving joint inspections, penalties, and a shared data platform among the regions. The BTH region's most impactful policies include controlling and phasing out coal-fired boilers, promoting clean residential fuel, restructuring industrial sectors, and managing fugitive dust. Between 2013 and 2017, the region achieved a 35% reduction in fine particulate matter ($PM_{2.5}$), demonstrating the effectiveness of a collaborative, region-wide approach.[165]

[160] London School of Economics (LSE). (n.d.). Contested powers in City Hall.; Greater London Authority. (2024). Air quality in London 2016–2024.

[161] Center for Public Impact. (2016). Mexico City's ProAire Programme.

[162] Air Quality Life Index. (2023). Mexico City: ProAire (1990).

[163] The Nature Conservancy. (n.d.). Planting healthy air case study: Mexico City.

[164] UNEP. (2019). A review of 20 years' air pollution control in Beijing.; Wang, J., Zhang, L., & Liu, Y. (2018). Taking action on air pollution control in the Beijing-Tianjin-Hebei (BTH) region: Progress, challenges, and opportunities.

[165] Stakeholder interviews with Clean Air Asia China.

5 RECOMMENDATIONS

Indonesia's development goals cannot be achieved without addressing Jakarta's air pollution. *The Better Air, Better Indonesia* report provides a multi-action roadmap for Jakarta to significantly reduce air pollution by 2030. Twelve key levers have been identified and evaluated based on their impact on air pollution, health costs, economic effects on government and private sectors, and the political feasibility of regulatory reforms and governance models. If implemented, these measures could reduce $PM_{2.5}$ by 92%, carbon monoxide (CO) by 64%, nitrogen oxides (NO_x) by 49%, sulfur dioxide (SO_2) by 33%, volatile organic compounds (VOCs) by 64%, and PM_{10} by 89%.

Beyond environmental benefits, the levers have potential to contribute to a $40.7 billion electric vehicle (EV) market and save the government $1.2 billion in reduced fuel subsidies. The health benefits are 32,747 avoided premature deaths from 2025 to 2030, resulting in an economic impact of $27 billion, equivalent to 1–2% of Jakarta's Gross Regional Domestic Product (GRDP).

This report outlines a comprehensive case for developing a coordinated action plan to unify national, multistakeholder, and multi-sectoral efforts aimed at systematically reducing air pollution in Jakarta. This report makes for the recommendations below:

1. Proposed Levers to Reduce Air Pollution.

The report identifies twelve key levers that can significantly reduce air pollution, achieving a projected 92% reduction in $PM_{2.5}$ emissions by 2030.

Three strategic approaches are recommended for implementing the twelve levers:

- **Prioritize Highest-Impact Levers:** Focus on the four most effective levers—EURO IV fuel adoption, transitioning coal boilers to cleaner technology, public transport expansion, and eliminating waste open burning. Collectively, these four levers alone can deliver an 80% reduction in $PM_{2.5}$ emissions by 2030, providing the greatest immediate impact.
- **Enable Market Growth:** Leverage the economic potential of the burgeoning industry of electric vehicles (EVs), which represent a $40 billion market. Government incentives, such as subsidies, VAT exemptions, and Low-Emission Zone allowances, can accelerate adoption, aligning with national targets and reducing pollutants like CO and VOCs.
- **Continued Enforcement:** Strengthen enforcement for remaining levers, including construction dust controls and industrial post-combustion technologies such as selective catalytic reduction (SCR) and wet flue gas desulfurization (WFGD), which target pollutants like NO_x and SO_2 that pose serious health risks. While their impact on $PM_{2.5}$ is less significant, these measures are essential for comprehensive pollution control of other pollutants. The electrification of Transjakarta buses is also included in this category, contributing to long-term electrification goals despite its relatively limited immediate impact on $PM_{2.5}$, as Transjakarta buses account for only 15% of the total buses in Jakarta.

2. Centralized Governance for Accountability.

Establishing a centralized governance body, including both ministries and local governments, is critical to raising the urgency of addressing air pollution, ensuring accountability across agencies, and better monitoring of established targets. This governance body would also play a pivotal role in supporting the Greater Jakarta area governments by coordinating efforts and resources efficiently.

As significant sources of transboundary pollution, further research on CFPPs, industrial activities, and waste burning from the regions surrounding Jakarta is crucial in further understanding its impact to Jakarta's air pollution. Enhancing data collection and monitoring will provide more comprehensive insights into the transboundary effects of emissions.

Jakarta's air pollution crisis demands an urgent, coordinated response. The proposed action plan, grounded in robust governance, impactful levers, and strategic investments, offers a pathway to achieving cleaner air. By reducing emissions, fostering market growth, and ensuring policy enforcement, Jakarta can unlock significant health, economic, and environmental benefits, paving the way for a healthier and more sustainable future.

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TECHNICAL APPENDIX

EMISSIONS INVENTORY ASSUMPTIONS

Action Plan	Activity Data	2023	Unit	Data Source
Industrial	Middle Fuel Oil	4.445	PJ	Jakarta Provincial Environmental Agency
	Diesel	27.768	PJ	
	Kerosene	0.095	PJ	
	LPG	2.149	PJ	
	Natural Gas	13.880	PJ	
	Hard Coal	1.886	PJ	
Power Generation	Middle Fuel Oil	0.042	PJ	PLN Indonesia Power & PLN Nusantara Power
	Diesel	0.108	PJ	
	Natural Gas	144.488	PJ	
Residential	Diesel	0.0000	PJ	Downstream Oil and Gas Regulatory Agency (BPH Migas) & Pertamina
	Kerosene	0.0000	PJ	
	LPG	20.378	PJ	
Commercial	Gasoline	0.001	PJ	Downstream Oil and Gas Regulatory Agency (BPH Migas)
	Diesel	0.320	PJ	
	Natural Gas	10.009	PJ	
Fishery	Diesel	2.436	PJ	Downstream Oil and Gas Regulatory Agency (BPH Migas)
Waste Management	Waste Generation	3.142	Mt waste	SIPSN by Ministry of Environment and Forestry
	Waste to Landfill	3.10	Mt waste	
	%Open Burning	1.20%		Riskesdas by Ministry of Health
	Open Burning	0.04	Mt waste	
Waste Composition	Paper	0.1724		BPS
	Glass	0.0148		
	Metal	0.0108		
	Textile	0.009		
	Food	0.4987		
	Wood	0.0318		
	Others	0.033		
	Plastic	0.2295		
Construction	Total area of activity	148731.06	m2	Jakarta Provincial Public Works Agency for Highways (Bina Marga), Jakarta Provincial Spatial Planning, Urban Development, and Land Affairs Agency
		0.14873106	M m2	
	Construction machinery	2.20	PJ	Greenhouse Gas - Air Pollution INteractions and Synergies (GAINS) Asia
Transportation	Gasoline	66.346	PJ	Pertamina
	Diesel	28.470	PJ	

KEY TARGET BY 2030

Sector	Lever	Adoption Parameter	2025	2026	2027	2028	2029	2030
Transport	**Low sulfur fuel**	% Roll out of EURO IV diesel in Jakarta	100%	100%	100%	100%	100%	100%
		% Roll out of EURO IV gasoline in Jakarta	41%	66%	100%	100%	100%	100%
	E2W	% Electrification of trucks in Jakarta	2%	3%	6%	12%	23%	45%
	E4W	% Electrification of trucks in Jakarta	2%	3%	5%	8%	13%	23%
	E-trucks	% Electrification of trucks in Jakarta	0.1%	0.3%	0.8%	2.1%	5.6%	15%
	E-bus	% Electrification of Transjakarta	9%	19%	31%	48%	70%	100%
	Integrated public transport	% Ridership of Daily Trips	28%	33%	38%	44%	52%	60%
Industry	**Post-combustion controls & CEMS**	% High-polluting medium & large industries install controls	0	10%	20%	30%	40%	50%
	Cleaner tech for industrial boilers	% Coal usage in industry boilers	1.6%	1.3%	1%	0.7%	0.3%	0%
Power	**NO_x control at combined cycle gas turbine power plants**	% Combined cycle gas turbine with NO_x control installations	0%	0%	0%	100%	100%	100%
Waste	**Eliminating open burning**	% Waste open burned	0.86%	0.69%	0.51%	0.34%	0.17%	0%
Construc-tion	**Construction dust control**	% Construction dust controlled	100%	100%	100%	100%	100%	100%

DEMAND PROJECTION OF ELECTRIC VEHICLES AND ICE VEHICLES

Projected number of vehicles used in the analysis between 2025 – 2030

Vehicle Type		2025	2026	2027	2028	2029	2030	Assumptions
Commercial Trucks	Total Trucks	609,783	638,335	668,225	699,515	732,273	766,566	Assumes 4.6% growth for diesel LDT, MDT and HDT, and 4.9% growth for gasoline LDT
	E-Trucks	**661**	**1,855**	**5,206**	**14,606**	**40,981**	**114,985 (15%)**	Assumes a conservative target of 15% electrification, comparing to global benchmarks[1]
	Trucks (ICE)	609,300	637,176	665,446	692,851	716,291	728,238	Total Trucks – E-Trucks
Passenger Vehicles	Total 2W	10,351,123	10,713,728	11,089,035	11,477,489	11,879,551	12,295,697	Assumes 3.5% growth
	E2W	**162,114**	**327,956**	**663,456**	**1,342,174**	**2,715,222**	**5,492,900 (43%)**	Aligns with ADB JADETABEK target, adjusted for Jakarta (approx. 42% of national target)
	2W (ICE)	10,221,693	10,491,418	10,732,565	10,939,989	11,068,141	11,062,027	Total 2W – E2W
	Total 4W	2,930,959	3,101,425	3,281,808	3,472,686	3,674,668	3,888,401	Assumes 5.8% growth for gasoline cars and taxis, and 6.1% for diesel cars
	E4W	**45,427**	**82,313**	**149,149**	**270,254**	**489,694**	**887,315 (23%)**	Assumes the same proportion as E2W to national target (approx. 42% of national target)
	4W (ICE)	2,885,028	3,037,431	3,192,647	3,348,463	3,501,592	3,647,260	Total 4W – E4W
Public Transport	Total Bus	30,942	31,942	33,019	34,178	35,426	36,771	Assumes 7.8% growth for diesel bus and 0.1% growth for microbus; includes non-TransJakarta buses
	E-Bus	**942**	**1,935**	**3,068**	**4,775**	**7,066**	**10,047**	Aligns with TransJakarta target
	Bus (ICE)	30,000	30,007	29,951	29,403	28,360	26,724	Total Bus – EBus
	Ridership	28%	33%	38%	44%	52%	60%	Aligns with government target; assumes linear growth of ridership

Source: BPS, KORLANTAS, ITDP and UK PACT (2023) 'Building a Regulatory and Financial Basis for Transjakarta's First Phase Ebus Deployment' Notes:
1. Conservative target compared to global benchmark of electrification of trucks 2. BPS 3. KORLANTAS 4. ITDP

HEALTH METHODOLOGY AND ASSUMPTIONS

Methodology

The methodology recommended by the Global Burden of Disease (GBD) Study 2019 was used to estimate cause-specific deaths attributable to PM2.5. The health benefit of combined levers is measured from estimated economic value of premature mortality avoided due to cause-specific diseases attributed to changes in PM2.5 concentration. Cause-specific diseases included in this study include Chronic Obstructive Pulmonary Disease, Ischemic Heart Disease, Lung Cancer, and Stroke for ages 25+. These diseases were chosen based on the Global Burden of Disease 2019 methodology.[166] Due to data limitations, the estimated health impact may be undervalued as the analysis does not take into account (1) impact on diabetes and lower respiratory infection (LRI), and (2) the impacts on illness and morbidity, including hospitalization costs, years lived with disability, children's health (e.g. stunting), and adverse birth effects (e.g. pre-term births).

$$Health\ Benefit = VSL \times Deaths\ Prevented$$

Two models were used to develop this analysis: AQUA (Air Quality through Urban Actions) model from C40 and AirQ+ version 2.2 from the World Health Organization (WHO).

The Air Quality through Urban Actions (AQUA) tool is a scoping level tool designed by C40, with the purpose of delivering fast and accessible analysis of city-level air quality, the associated health and economic burdens, as well as benefits from reducing air pollution[167]. AQUA helps cities estimate $PM_{2.5}$ concentrations and associated health outcomes, facilitating informed decision-making to enhance urban air quality.

AirQ+ is a software tool developed by the WHOd for quantifying the health burden and impact of air pollution. AirQ+ includes methodologies to assess the impacts of short- and long-term exposure to ambient air pollution. The main methodologies use evidence generated by epidemiological cohort studies showing a relationship between average long-term air pollution concentration levels and the mortality risks in exposed populations.

First step of the health analysis is to calculate the projected $PM_{2.5}$ concentration for BAU and Impact Scenario, using the model's emission methodology which utilizes spatial analysis of InMAP-Global model. The AQUA model was utilized to calculate projected $PM_{2.5}$ concentrations for BAU and Policy Scenario by inputting projected sectoral emissions load. AQUA's emissions to concentration modelling uses chemical transport modelling from the Intervention Model for Air Pollution (InMAP-Global), to convert emissions of $PM_{2.5}$ and other precursor pollutants into an annual average $PM_{2.5}$ concentration within the city's boundary.

$$PMConc_{t,y} = \sum_p Em_{p,t,y} \times I_{p,ss}$$

$PMConc_{t,y}$: Annual average $PM_{2.5}$ concentration from sector, i, in year y [µg/m3]
$Em_{p,t,y}$: Annual emissions of pollutant p, from sector i, in year y [tonnes]
$I_{p,ss}$: InMap sensitivity (source-receptor relationship) for pollutant p, and spatial surrogate ss

[166] Vos, T., et al. (2020). Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019.
[167] To access the AQUA model by C40, please see: https://www.c40knowledgehub.org/s/article/AQUA-Air-Quality-through-Urban-Actions-tool?language=en_US

Second, calculated $PM_{2.5}$ concentrations were inputted in AirQ+ model to calculate projected deaths in BAU and Policy Scenarios. Projected $PM_{2.5}$ concentration results, population data from BPS, and mortality rates of relevant diseases from the Global Burden of Disease Study 2019 were inputted into AirQ+ to calculate projected attributable deaths due to long-term exposure to air pollution. Calculation method utilized Global Burden of Disease 2020 methodology, with Relative Risks based on Integrated Exposure-Response (IER)[168].

$$\Delta AD = pop \times M \times PAF_{\beta}(PM_{2.5}, cf)$$

Population Attributable Fraction (PAF) formula:

$$PAF = \frac{\sum_i P_i \times (RR_i - 1)}{\sum_i P_i \times (RR_i - 1) + 1}$$

P_i = proportion of the population exposed to pollutant concentration i
RR_i = relative risk for a specific health outcome at exposure level i

Or,

$$PAF = 1 - \frac{1}{WRRIER}$$

$$WRRIER = \frac{\sum_{i=1} RR(z_i) \times p_i}{\sum_{i=1}^{n} p_i}$$

$RR(z_i)$ = relative risk at exposure level z_i
p_i = population in grid cell $_i$

The AirQ+ version 2.2 model utilizes RR based on the IER methodology:

$$RRIER(z) = \{1, \text{if } z < z_{cf};\ 1 + \alpha \times (1 - \exp[-\gamma \times (z - z_{cf})^{\delta}], \text{if } z \geq z_{cf}\}$$

z = exposure concentration of $PM_{2.5}$ (μg/m^3)
z_{cf} = counterfactual exposure of $PM_{2.5}$ below which no additional risk is assumed (typically 5.8-8.8 μg/m^3)
α = maximum relative risk (RR) at very high $PM_{2.5}$ levels
γ = shape parameter determining how quickly the RR increases at low-to-moderate exposure
δ = parameters influencing the curve's steepness and whether it flattens at high exposures

Third, the economic benefit is estimated from multiplying the number of prevented premature deaths attributed to pollution by the Value of Statistical Life (VSL). The VSL is the monetary value associated with reducing the risk of death in an aggregate population.[169] The VSL is a common formula in cost-benefit analysis of public policy. The VSL used in the analysis is $837,781 based on Vital Strategies analysis, following the methodology developed by Robinson et al.[170]

$$\text{Economic Benefit} = \sum_t VSL \times \Delta Deaths(BAU\ Scenario_t - Impact\ Scenario_t)$$

Where t = years from 2025-2030

[168] Vos, T., et al. (2020). Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: A systematic analysis for the Global Burden of Disease Study 2019.

[169] Robinson, L. A., Hammitt, J. K., & O'Keeffe, L. (2019). Valuing mortality risk reductions in global benefit-cost analysis. Journal of Benefit-Cost Analysis, 10(S1), 15-50. https://doi.org/10.1017/bca.2018.26

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