This document aims to identify the potential locations of LEZ, air pollution modeling impact and roadmap of implementation

Jakarta LEZ Roadmap

Clean Mobility for Metropolitan Jakarta

25 April 2024

UK PACT

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Abbreviation

AHP: Analytical Hierarchy Process

AISI: *Asosiasi Industri Sepeda Motor Indonesia* (Indonesian Motorcycle Industry Association)

ANPR: Automatic Number-Plate Recognition

BMUA: *Baku Mutu Udara Ambien* (Ambient Air Quality Standard)

BRT: Bus Rapid Transit

CAGR: Compound Annual Growth Rate

CCTV: Closed-Circuit Television

CMMIA: Coordination Ministry for Maritime and Investment Affairs (Kemenko Bidang Kemaritiman dan Investasi/Kemenkomarves)

CNG: Compressed Natural Gas

CO: Carbon Monoxide

EF: Emission Factors

ERP: Electronic Road Pricing

ETLE: Electronic Traffic Law Enforcement

GHG: Greenhouse Gas

HC: Hydro Carbon

HCV: Heavy Commercial Vehicle

HDV: Heavy Duty Vehicle

HEV: Hybrid Electric Vehicle

ICCT: International Council on Clean Transportation

ICE: Internal Combustion Engine

ISPA: *Infeksi Saluran Pernapasan Atas* (Upper Respiratory Tract Infections)

Jabodetabek: Jakarta, Bogor, Depok, Tangerang, Bekasi

JTMA: Jabodetabek Transportation Management Agency (Badan Pengelola Transportasi Jabodetabek/BPTJ)

JUTPI: Jabodetabek Urban Transportation Policy Integration

KRL: *Kereta Rel Listrik* (Electric Railways)

LCEV: Low Carbon Emission Vehicles

LCV: Light Commercial Vehicle

LEZ: Low Emission Zone

LPG: Liquefied Petroleum Gas

LRT: Light Rapid Transit

LTN: Low Traffic Neighborhood

MAASP/NLA : Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (Kementerian Agraria dan Tata Ruang/ATR)

MEMR : Ministry of Energy and Mineral Resources (Kementerian Energi dan Sumber Daya Mineral/ESDM)

MNDP: Ministry of National Development Planning (Kementerian Perencanaan Pembangunan Nasional/Badan Perencanaan Pembangunan Nasional/Bappenas)

MoEF : Ministry of Environment and Forestry (Kementerian Lingkungan Hidup dan Kehutanan/KLHK)

MoI : Ministry of Industry (Kementerian Perindustrian)

MoT : Ministry of Transportation (Kementerian Perhubungan)

MPW : Ministry of Public Works (Kementerian Pekerjaan Umum dan Perumahan Rakyat/PUPR)

MRT: Mass Rapid Transit

JEA: Jakarta Environmental Agency (Dinas Lingkungan Hidup Jakarta)

JTA: Jakarta Transportation Agency (Dinas Perhubungan Jakarta)

JDPA: Jakarta Development Planning Agency (Badan Perencanaan Pembangunan Daerah/Bappeda Jakarta)

JSPLA : Jakarta Spatial Planning, and Land Agency (Dinas Cipta Karya, Tata Ruang, dan Pertanahan/DCKTRP Jakarta)

JIOSIOA : Jakarta Investment and One Stop Integrated Office Agency (Dinas Penamanan Modal dan Pelayanan Terpadu Satu Pintu/DPMPTSP Jakarta)

JHA: Jakarta Health Agency (Dinas Kesehatan Jakarta)

JCISA : Jakarta Communication, Informatics and Statistics Agency (Dinas Komunikasi, Informasi dan Statistik/Diskominfotik Jakarta)

JITCSMEA : Jakarta Industry, Trade, Cooperatives, Small and Medium Enterprises Agency (Dinas Perindustrian, Perdagangan, Koperasi, Usaha Kecil dan Menengah/DPPKUKM Jakarta)

JPUFA : Jakarta Parks and Urban Forest Agency (Dinas Pertamanan dan Kehutanan Jakarta)

JPWA : Jakarta Public Works Agency (Dinas Bina Marga/DBM Jakarta)

JPHS : Jakarta Public Housing and Settlement (Dinas Perumahan Rakyat dan Permukiman/DPRKP Jakarta)

NMT: Non-Motorized Transport

NOx: Nitrogen Oxide

OCR: Optical Character Recognition

PHEV: Plug in Hybrid Electric Vehicle

PM: Particulate Matter

RDTR: *Rencana Detail Tata Ruang* (Detailed Spatial Plan)

RFID: Radio Frequency Identification

Rp: Rupiah

RPPMU: *Rencana Perlindungan dan Pengelolaan Mutu Udara* (Air Quality Protection and Management Plan)

SOx: Sulphur

SPKUA: Stasiun Pemantau Kualitas Udara Ambien (Air Quality Monitoring System)

TDM: Transport Demand Management

TOD: Transit-Oriented Development

ULEZ: Ultra Low Emission Zone

VKT: Vehicle Kilometer Travelled

WHO: World Health Organization

WPPMU: *Wilayah Perlindungan dan Pengelolaan Mutu Udara* (Air Quality Protection and Management Area)

ZEZ: Zone Emission Zone

1. Introduction of Air Pollution Issues

1.1. Air quality conditions in Jakarta

Jakarta is a city that is home to approximately 10.6 million citizens, with a growth rate that is constantly increasing (BPS, 2023). The rapid growth and urbanisation have caused great advancement in areas such as infrastructure development and economic opportunities. However, In Jakarta, the increase in population was coupled with various car-centric policies, causing a reliance on personal motorised vehicles, which has caused negative externalities in the decreasing air quality level. This trend has several detrimental effects on health and the economy. A 2023 study showed that air pollution in Jakarta had caused more than 10,000 premature deaths and over 5,000 hospitalisations per year, and the health impacts have cost a total of USD 2,943.42 million annually (Syuhada et al., 2023).

Air quality is determined by the concentration of pollutants in the area influenced by meteorological conditions such as humidity, temperature, sunshine, rainfall and wind speed (Handayani, 2023). Pollutants can be broken down into different types of pollutants, all of which have varying effects on one's health. Fuel combustion in vehicles, in both gasoline and diesel fuels, produces, most notably, sulphur dioxide (SO2), nitrogen oxide (NOx), carbon monoxide (CO), black carbon (BC), Non-Methane Volatile Organic Compounds (NMVOCs) and Particulate Matter (PM) 10 and 2.5. This study will mainly focus on PM and NOx as the main indicators of air quality as they have a severe negative impact on human health, and their primary source in the transportation sectors indicates different types of vehicles.

The Provincial Government of Jakarta has five air measuring stations (SPKUA) across five administrative regions. These stations monitored a decreasing trend on average PM 2.5 levels from 2019 to 2021, as illustrated in Figure 1. The decreasing trend might be caused by COVID-19, which reduces the need for mobility and decreases the production of pollutants. However, it must be noted that PM 2.5 levels still exceed national standards (BMUA), especially the WHO standards.

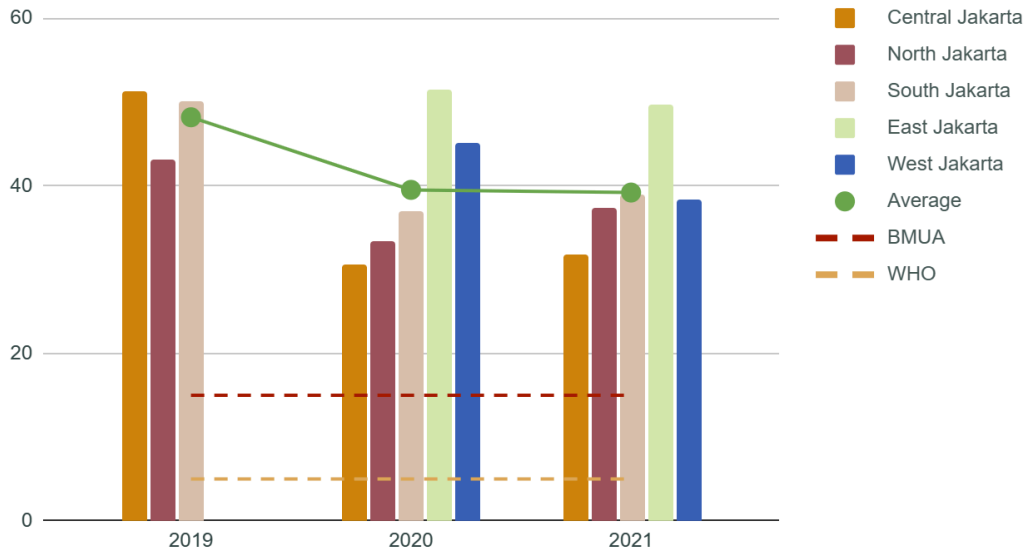


Figure 1. $PM_{2.5}$ Emissions in Jakarta, 2019 - 2021 (Environment Agency, 2021)

On the other hand, NOx also fluctuates with an increasing trend from 2019 to 2021. The average concentration of NOx is lower than the Government Standard; however, the standard is two times higher than the standard set by WHO. The average NOx concentration is lower than WHO Standards in 2020 during COVID-19. NOx levels have been especially high in Central Jakarta in all years.

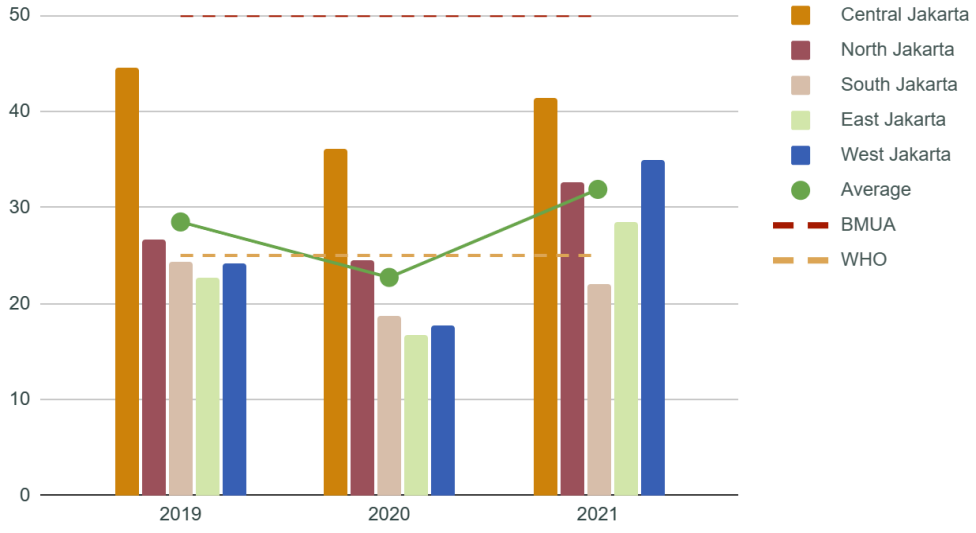


Figure 2. NO_x Emissions in Jakarta, 2019 - 2021 (Environment Agency, 2021)

Each air pollutant will have different negative consequences on human health. When inhaled, PM consists of liquid or solid particles that can lead to severe health issues. Particles with a diameter of less than 10 µm (PM10) have the ability to penetrate the lungs and may even enter the

bloodstream. Smaller particles, known as PM2.5, present an even higher health risk due to their ability to penetrate the human respiratory system to a higher degree. It is important to highlight that individuals with asthma, pneumonia, diabetes, and respiratory and cardiovascular conditions are particularly prone to the impacts of PM and more vulnerable to its effects (Manisalidis et al., 2020). Every increase of 10 μ/m^3 above the health standard could decrease life expectancy by 0.98 years (Greenstone & Fan, 2019).

NOx, one of the primary pollutants produced in fuel combustion, can harm the respiratory system and cause issues such as coughing, wheezing, and trouble breathing. In high concentrations, NOx can also lead to long-term lung damage, affect one's immune system, and cause the loss of sense of smell. Moreover, it is reported to irritate the eyes, throat, and nose (Manisalidis et al., 2020).

The Indonesian Ministry of Health (2023) monitored an increasing trend of respiratory-related illnesses (ISPA) corresponding to the rising concentration of pollutants in Jakarta. Figure 3 visualises the significant increase of ISPA (Respiratory Health Diseases) in Jakarta from 2021 to 2022, which increased six times from 24,015 to 149,607 cases (Arlinta, 2023). By July 2023, the number of cases has surpassed the number of cases in the previous year.

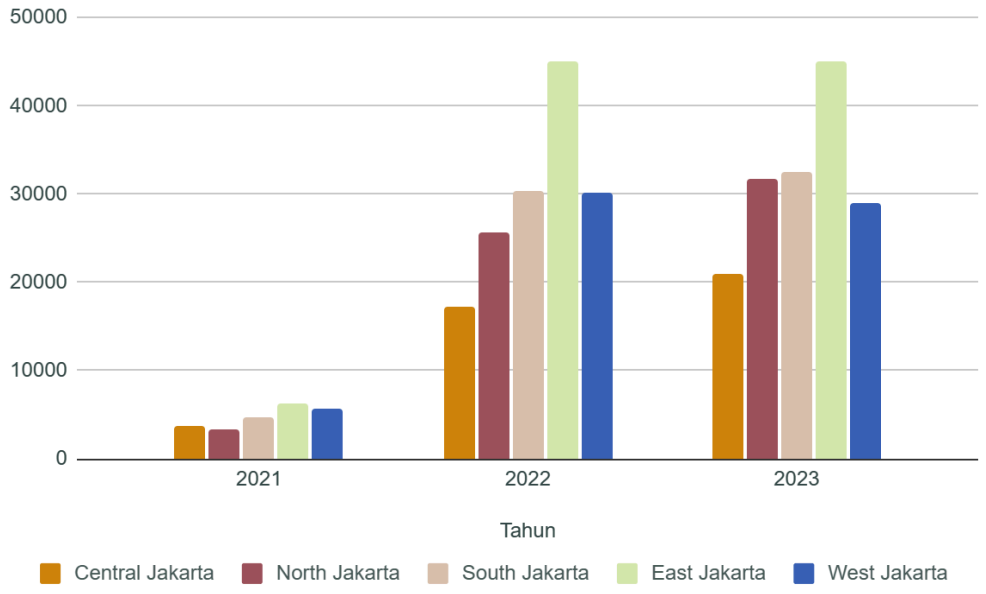


Figure 3. ISPA Data in Jakarta 2021-2023

1.2. Contribution of the transportation sector on air pollution

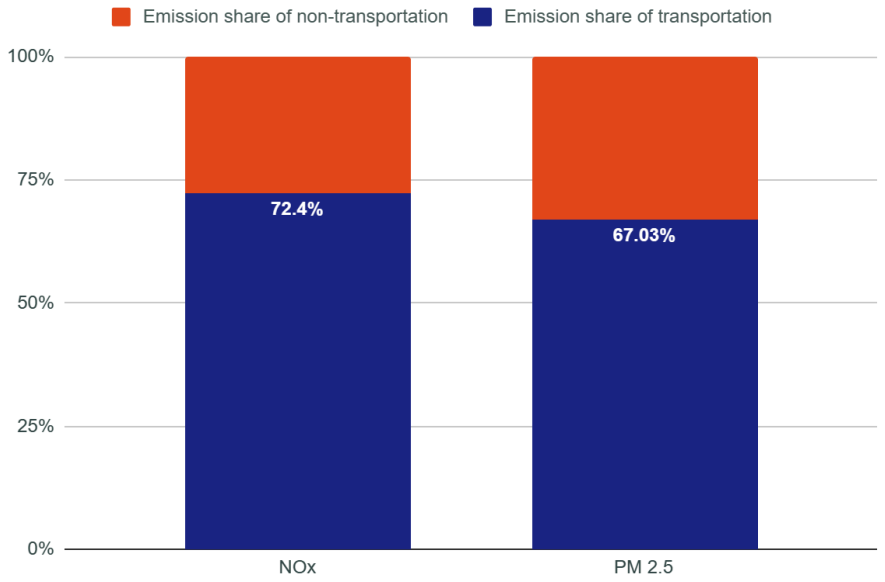


Figure 4. Transportation Emission Share Based on Pollutants Type in Jakarta (Vital Strategies, 2020)

According to the Emission Inventory Report of Jakarta by Vital Strategies (2020), the Transportation sector is Jakarta's main source of air pollutants, as visualised in Figure 4. It is accountable for 72.4% of NOx and 67.3% of PM 2.5 production.

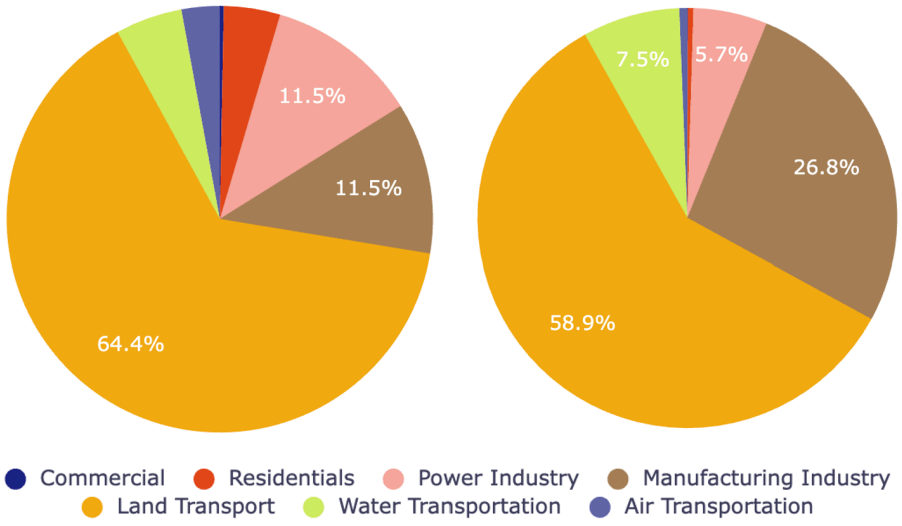


Figure 5. Share of NOx and PM 2.5 Emission in Jakarta by Sectors (Vital Strategies, 2020)

When broken down into subsectors, land transport emits the most air pollution among the three types of transportation in Jakarta. Land transportation has the most significant share of emissions among transportation and all sectors, such as commercial, residential, and industry. Out of 100%, land transportation contributed to 64% and 58.9% of emissions of NOx and PM2.5. It can be

concluded that transportation emits the most significant share of air pollution in Jakarta, and land transportation is the biggest emitter among all types of transportation available. The share of emissions by sectors can be viewed in Figure 5 above.

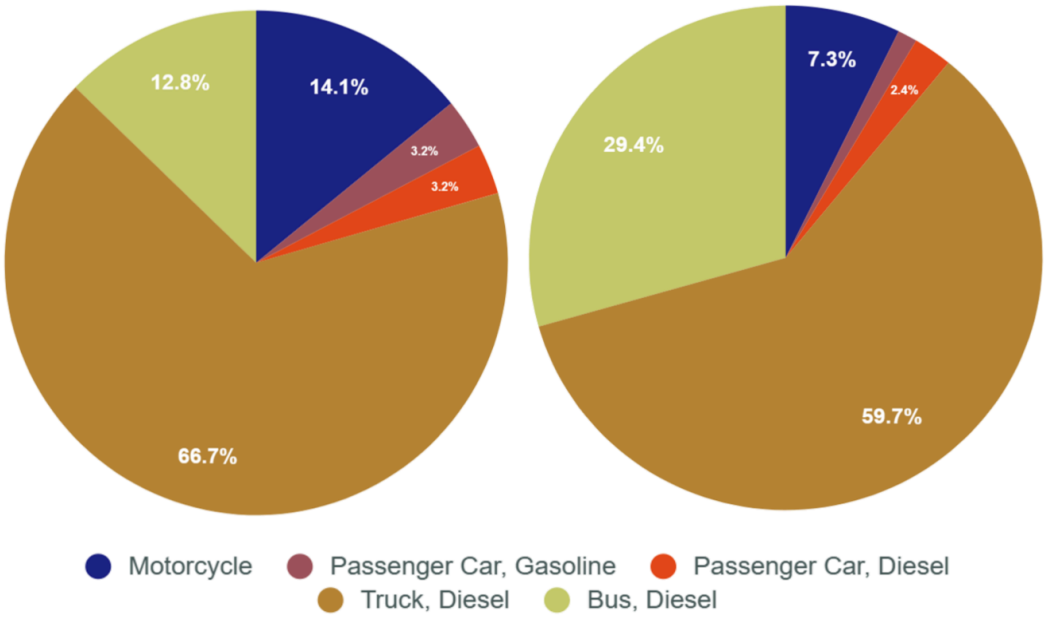


Figure 6. Share of NOx and PM 2.5 emission in Jakarta by type of land transportation vehicle (Vital Strategies, 2020)

Land transportation modes in Jakarta can be split into five categories: motorbikes, gasoline-fuelled passenger cars, diesel-fuelled passenger cars, diesel-fuelled trucks, and diesel-fuelled buses, as illustrated in Figure 6 (Vital Strategies, 2020). The main contributor of NOx comes from diesel trucks, which account for 66.7% of total emissions. It is followed by motorcycles with 14.1%, diesel buses with 12.8%, and diesel and petrol cars with 6.4%. Similar results are also shown from PM 2.5, where diesel trucks amount to 59.7% and diesel buses for 29.4%. Meanwhile, motorcycles accounted for 7.3%, and both diesel and petrol cars accounted for 3.6%. These results show the urgency of improving vehicle emission standards, especially for trucks and buses, to curb air pollution. Personal vehicles such as motorcycles and cars must also be prioritised since they also contribute significantly to emissions from their huge numbers. The Jakarta Environmental Agency, in the draft of the Environmental Protection and Management Plan of Jakarta for 2022 - 2052, stated the number of motorised vehicles has risen by 22.6% from 2016 to the present day, posing a threat to increasing air pollution concentration in Jakarta.

1.3. Urgencies in implementing Low Emission Zone (LEZ)

Current mode share - dominated by private vehicles

Dependencies on private vehicles are one of the main reasons for the high contribution of air pollution from the transportation sector. Figure 7 shows the mode share in Jakarta, with motorcycles as the prominent mode share at 69.9%, followed by cars that account for 9.8%. If added together, private vehicles account for 79.7% of the current vehicle share in Jakarta (BPS, 2019). Mode share for public transportation only accounts for 8.8%, slightly higher than the ride-hailing motorcycle services.

Mobility in Jakarta is not limited to internal mobility since 1.2 million people from the other cities next to Jakarta (Bogor, Depok, Tangerang, and Bekasi or Bodetabek in acronym) commute to the Jakarta area. Bodetabek mode share is essential to determine the dominant modes that ultimately impact air quality. Figure 7 shows dependency on private vehicles, with motorcycles accounting for 71.2% and cars 9.9%. When combined, private vehicle mode share amounted to 81.1%. The number of ride-hailing services is lower since commuters from the Bodetabek area use public transportation more for long-distance commuting.

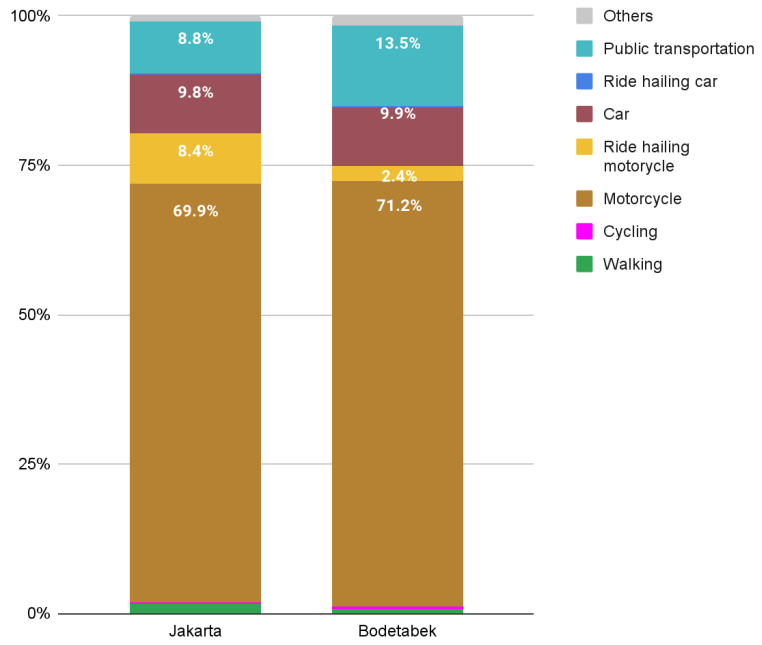


Figure 7. Share of Mode Choices Among Jakarta and Bodetabek-Originated Commuters (BPS, 2019)

Implementing Low Emission Zone (LEZ) strategy

The dependency on private motorised vehicles dominates the Greater Jakarta area, which has significantly contributed to the substantial pollution levels in Jakarta. Shifting to more efficient and sustainable modes of transportation is urgently needed to ensure the reduction of harmful pollutants and emissions. To address this challenge, implementing a Transport Demand Management (TDM) approach is well-suited to encourage and push people to opt for more sustainable modes of transportation. The approach consists of incentives for sustainable transportation, known as 'pull strategies', and disincentives to use private vehicles, known as 'push strategies'. The latter is less implemented in Indonesian cities, including Jakarta, as it might come with resistance from motorised vehicle users and lack public support. Nevertheless, push strategies are important in limiting the use of private vehicles and encouraging the use of more sustainable modes of transportation.

A Low Emission Zone (LEZ) is a form of push policy aimed to regulate vehicle access in a particular area based on their emissions. The main goal is to improve the air quality within the specified area by restricting the most polluting vehicles that do not meet a specified emission standard. Restrictions in place can be in the form of fees, fines, restricted access at certain times, or complete access restrictions on high-emission vehicles. By doing so, people are encouraged to use more sustainable modes of transportation by either shifting to public transportation or adopting a cleaner vehicle.

The Provincial Government of Jakarta applied an LEZ initiative in the Jakarta Old Town (Kota Tua) area in 2021. The implementation is in the pedestrianisation of six road segments surrounding the inner Old Town area with a total area of intervention of 0.14 km^2. Only Transjakarta fleets and vehicles with stickers (people living in the area and business owners) are allowed to pass through the Kota Tua LEZ. However, the limitation falls short since it was not continuously implemented, and private motorised vehicles can still access the area (ITDP, 2022). Furthermore, the implementation of LEZ did not manage to reduce PM 2.5 level below the government standard, and its small-scale intervention does not reduce air pollution contribution from the transportation sector on a citywide scale (Yulinawati, 2021; C40 Cities, 2023).

1.4. LEZ objectives

Main and sub-objectives of LEZ plan in Jakarta

Planning an LEZ initiative in Jakarta needs deliberate and careful consideration to ensure an impactful implementation. The main objective of this report is to provide a comprehensive analysis of the roadmap of implementation for LEZ in Jakarta. The sub-objectives of this report are:

- Analysis of possible LEZ delineation area of implementation

- Scenario and roadmap of implementation for LEZ until 2030
- Emission modelling impact from LEZ roadmap
- LEZ supporting measures

Report structure

This report starts with an introduction to the air quality issues in Jakarta and its trend over the years, which has always surpassed the safe standard and has had a serious impact on human health. Different types of vehicles are responsible for a significant amount of air pollution, which needs to be addressed accordingly. The high dependency on private motorised vehicles is one of the primary reasons for air pollution, and a push policy is required to address this problem. LEZ is explained as one of the most suitable push policies that specifically limit the access of highly emitted vehicles in certain areas.

Chapter 2 explains the situational analysis of the current regulatory framework and evaluation of the existing LEZ initiatives. The regulatory framework will explain the overview conditions of the air quality management approach at the national and provincial levels related to the concept of LEZ. This report chooses the implementation of LEZ Old Town Jakarta as the evaluation area, which is supported by various studies reviewing the implementation.

Chapter 3 explains the existing government stakeholders that are related to the implementation of LEZ in Jakarta at the provincial and national level. Stakeholders are mapped out according to their resources and matrix of interest resulting in high-priority stakeholders for LEZ.

Chapter 4 contains the analysis of possible LEZ delineation in Jakarta. The chapter explains the current characteristics of LEZ as the main guidance to determine the delineation. The method of analysis to determine the LEZ area is with the multi-criteria weighted overlay analysis since there are multiple indicators considered. One of the most important indicators is the pollutant in the area. This study uses the emission factor approach to single out pollution from the transportation sectors.

Chapter 5 continues the explanation of the possible LEZ area with the roadmap of implementation until 2030. There are two phases of implementation: the pilot phase and the expansion phase with Innercity and Citywide implementation. This chapter started with benchmarking studies, which continued with the roadmap of LEZ in Jakarta. The roadmap includes the phasing implementation, possible implementation type, impacted group, stakeholders' role and responsibility, exemption policy, and incentive mechanism.

Chapter 6 models the emission reduction results from Chapter 5. There are two approaches to emission modelling: vehicle model year and vehicle emission design. The model year approach models the results from the assumption of a vehicle phase-out period with older vehicles unable

to enter the area. This approach provides a conservative estimate since the current proportion for vehicle emission standards is still low. As for the vehicle emission standard design, it offers an ideal implementation where limitation is based on the emission standard.

Chapter 7 explains the supporting measures to ensure the significant impact of LEZ implementation. It is categorised into three main categories enabling policy of LEZ, policy to anticipate the harmful effects of LEZ and other additional measures.

The last chapter will summarise all of the previous chapters and provide the overall recommendations of LEZ. The recommendations will cover the roadmap of LEZ with the activity list needed by agencies to plan and implement LEZ.

2. Situation Analysis

2.1. Existing regulatory framework related to LEZ

LEZ is an unfamiliar term in Indonesia since there has been no initiative to control motorised mobility from the emission standard perspective. This subchapter explains three regulatory regimes in Indonesia categorised into air quality, mobility, and air quality management in the transportation sector. Figure 8 explains the relationship between regulation with direct as derivative regulations and indirect as a related regulation.

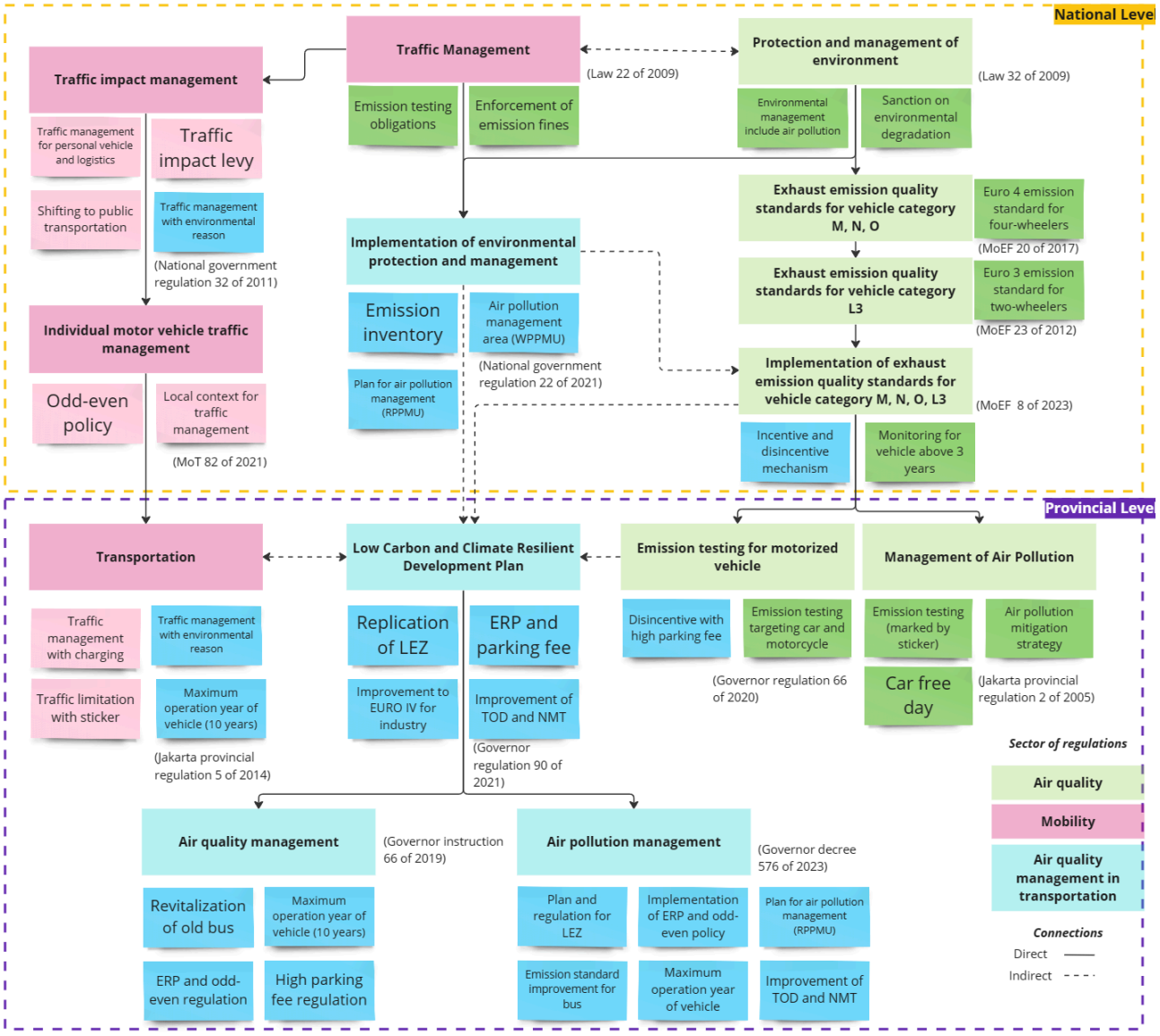


Figure 8. Regulatory framework of LEZ in Jakarta

Air quality sectors

The highest regulation mentioning the importance of ensuring air quality is from Law 32 of 2009 about The Protection and Management of Environment. Air quality is considered to be one of the indicators used to measure environmental quality. Individuals or corporations that violate the air quality standard on purpose or by accident will be subjected to a fine or imprisonment.

The law became a basis for the government to set minimum emission standards for vehicles regulated in the Regulation of the Ministry of Environment and Forestry (MoEF) No. 20 of 2017 and the Regulation of MoEF No. 23 of 2012. The MoEF Regulation No. 20 of 2017 regulates vehicle categories M (passenger vehicles), N (logistics vehicles), and O (heavy-duty logistics vehicles), while the MOEF Regulation No. 23 of 2012 regulates the L3 category, which focuses on two-wheeled vehicles. All four-wheeler vehicles are regulated to have a minimum standard of Euro IV and the two-wheelers to a minimum of Euro III. These two regulations set the standard of emission, which monitors the CO, HC, NOx, and PM according to the type of vehicle. The standard for four-wheeled petrol cars was active in 2018, and diesel was active in April 2022, while the standard for two-wheeled vehicles has been in place since 2015.

Further regulation about the emission standard is regulated with the Regulation of MOEF Regulation No. 8 of 2023, where every new vehicle under the category of M, N, O and L needs to check their emission standard as the requirement to pay their vehicle taxes (article 4). Local governments can also use the emission standard results as a justification to conduct incentive or disincentive mechanisms to control air pollution according to the local context (article 15). The provincial government of Jakarta uses the measurement standard from MoEF Regulation No. 8 of 2023 to measure the CO and HC of vehicles in Jakarta as the basis for emission testing activity.

Law No. 22 of 2009 about Traffic Management regulates the enforcement of the vehicle emission standard, where emission testing becomes the requirement of vehicle operation certificate. Motorcycle owners could get fines up to IDR 250,000 and car owners up to IDR 500,000 if their vehicles do not comply with the emission standards.

Figure 9. Emission testing in Jakarta, 2023 (source: PMJNews.com)

At the provincial level, Jakarta has Provincial Regulation No. 2 of 2005 about the Management of Air Pollution. The main objective of this regulation is to achieve air quality levels that are healthy for human health. In the event of poor air quality conditions, the governor must take measures to restore air quality. The regulation continues to outline the potential sources of air pollution, with vehicle emission as one of the sources, stating that vehicles must adhere to the emission standards and undergo emission testing every six months. Emission testing would be helpful for the LEZ, as continuous testing of vehicles is important to monitor people's compliance with emission standards as they get tighter and more stringent over time. The provincial government uses the emission testing standard regulated by the MoEF Regulation No. 8 of 2023, which only regulates HC and CO. For the future implementation of LEZ, it requires stringent standards where indicators for NOx and PM are also included as regulated by the MoEF Regulation No. 20 of 2017 and MoEF Regulation No. 23 of 2012.

One of the enforcement of the emission testing program is regulated in Governor Regulation No. 66 of 2020 about the Emission Testing for Motorized Vehicle. This regulation stipulates that the vehicle required to follow emission testing is above three years old. Vehicles that do not comply with the emission standard will receive a disincentive mechanism in the form of high parking fees in specific locations. The high parking fee based on emission standards is in the early stages of implementation, with 33 locations in 2023.

Mobility sectors

At the national level, no specific regulations comprehensively regulate vehicle management based on emissions. One of the closest policies that regulate mobility is in the National Government Regulation No. 32 of 2011 about Traffic Impact Management. This regulation mentioned that environmental quality should be considered when managing traffic in certain areas and times

(article 60). However, the restriction of personal vehicles can only be based on plate number and number of passengers, whereas the regulation still does not mention reasoning based on emission standards (article 66). Regarding freight vehicles, vehicles can be restricted depending on their dimensions, type of vehicle, and cargo. This regulation also sets traffic management enforcement for personal vehicles, and logistics can be implemented with levy. It applies to a road with several congestion criteria, two-way roads with a minimum of two lanes and the availability of mass public transportation. These criteria should also consider environmental quality. The levy collected can only be allocated to improve traffic performance and public transportation services. This decree could provide an enforcement justification for LEZ with the environmental reasoning and levy mechanism to collect the fee from highly polluting vehicles.

Another national regulation specifically regulating traffic management is the Ministry of Transport Regulation No. 82 of 2011 on Individual Motor Vehicle Traffic Management. This regulation sets detailed criteria for the implementation of an odd-even policy. The odd-even policy is implementable for passenger vehicles, including cars, motorcycles, and buses. There is an opportunity for local governments to create their traffic management according to their local context. The traffic management policies can include the traffic regulation of a road segment and traffic regulation in a specific area that generates and/or attracts traffic movements. In essence, it grants local authorities the flexibility to implement traffic management strategies most suitable for their regions' characteristics. In terms of LEZ, air quality issues may be considered as an issue in Jakarta that needs to be addressed, and therefore, the establishment and LEZ could be regarded as part of the traffic management strategy.

In Jakarta province, traffic management regulation is mainly covered in Jakarta Provincial Regulations No. 5 of 2014, which is about Transportation. One of the main objectives of this regulation is to realise a transportation system that preserves and optimises environmental quality. The criteria to determine traffic management is set to be more detailed in this regulation, covering road-traffic volume capacity, availability of public transportation, traffic safety and environmental quality. This regulation also sets the maximum number of years of operation for public road transportation to improve safety and maintain environmental quality. The categories of vehicles are as follows:

1. Big bus, medium, small/micro with operation of 10 years
2. Taxi maximum operation of 7 years
3. Logistic fleet maximum operation of 10 years

Another strategy that might be related to LEZ is stated in article 78 about the limitation of access for passenger vehicles, which are:

- (b) implementation of licence stickers for vehicles to enter an area with the management of traffic
- (c) implementation of the fee-based road on certain corridors or areas within the management of traffic area
- (h) limiting the traffic of two-wheeler vehicles in particular areas or corridors within a certain period
- (l) management of motorised vehicle access from outside the Jakarta area
- (n) implement another method of vehicle limitation strategy

Several of these aspects relate to the establishment of a LEZ in Jakarta, as they share a common objective. Unfortunately, the access limitation of vehicles according to the emission level is not specifically mentioned.

Air quality management in the transportation sector

Although LEZ is still a new initiative in Indonesia, there are already several regulations that have similar concepts that can be used as the baseline regulations, such as the National Government Regulation No. 22 of 2021 about the Implementation of Environmental Protection and Management. This regulation defined certain areas needing air quality management with the concept of ' '*Wilayah Perlindungan dan Pengelolaan Mutu Udara/WPPMU*' (Air Quality Protection and Management Area). It is classified into three classes, where LEZ could fit into class II:

- WPPMU Class I: designated for a pristine area where the natural environment is preserved, and it is allocated as carbon preserving area
- WPPMU Class II: designated for settlement and economic development area
- WPPMU Class III: designated for industrial area and other purposes

The WPPMU is used to formulate *'Rencana Perlindungan dan Pengelolaan Mutu Udara/RPPMU'* (Air Quality Protection and Management Plan) with air pollution management as one of the pre-required objectives. Each Provincial/Regional government is allowed to create their RPPMU according to their local context, and it could include LEZ as one of the strategies.

The regulation to enforce more sustainable transportation to ensure better environmental quality is regulated in more detail at the provincial level. One of the regulations is Governor Regulation No. 90 of 2021 about the Local Low Carbon and Climate Resilient Development Plan. This document recognises the transportation sector as one of the main direct sources of GHG emissions from the energy category. The LEZ initiative is explicitly mentioned in this regulation, although it is still in the context of a pedestrianisation project. Table 1 explains the mitigation strategies in the energy sector related to transportation sectors:

Table 1. Governor Regulation No. 90 of 2021 about Local Low Carbon and Climate Resilient Development Plan

Strategy	Detail explanation
Fuel replacement to become more environmentally friendly	• Electrification for Bus Rapid Transit (BRT) • Electrification for government operational fleet • Improvement of supporting infrastructure for electric vehicle
Shifting to public transportation	• Public transportation integration • Complete rail-based transportation development (MRT and LRT) • Improve MRT, LRT, and BRT network • Develop Transit Oriented Development(TOD) • Regulation for Electronic Road Pricing (ERP) and high parking fee • Reduce emission from the transportation logistic sectors
Mainstreaming pedestrian and cycling infrastructure (NMT)	• Develop bicycle lane integrated with public transportation • Optimise the revitalisation of pedestrian facility • **Replication of Low Emission Zone (LEZ) in Jakarta**

The provincial government of Jakarta has also introduced Governor Instruction No. 66 of 2019 about Air Quality Management, mandating provincial government agencies to manage the air pollution issue in Jakarta. The document does not specifically mention 'Low emission zone' as a term but includes measures to control emissions from various sources, including vehicles. The complete strategy in the governor's instruction is compiled in Table 2.

Table 2. Governor Instruction No. 66 of 2019 about Air Quality Management

Strategy	Detail explanation
Ensure no public transportation above 10 years and that do not pass emission standard operationalize in Jakarta	• Head of Transportation Agency to accelerate the improvement of 10,047 fleet of microbus, medium bus, and big bus under Jaklingko scheme • Head of Transportation Agency to prepare draft of Provincial Regulation for Vehicle Age Limitation of Public Transportation Armada in 2019 • Head of Transportation Agency to strengthen the emission test for public transportation fleet in 2019
Strengthen the emission testing for private vehicle in 2019 and ensure no vehicle above 10 years operationalize in 2025	• Head of Environmental Agency to strengthen the emission testing for private vehicle in 2019 • Head of Investment and One-Stop Integrated Service Office to integrate requirement for vehicle operation with emission testing • Head of Transportation Agency to prepare draft of Provincial Regulation for Maximum Operation 10 Year for Private Vehicle in 2020
Expand the odd-even policy and increase the parking fee in the area covered with public transportation in 2019 and implement congestion pricing in 2021	• Head of Transportation Agency to prepare draft of Governor Regulation for Expansion of Odd-Even Policy • Head of Transportation Agency to prepare revised Governor Regulation of Parking fee in 2019 • Head of Transportation Agency to prepare draft of Provincial Regulation for Congestion Pricing in 2020
Push shifting to public transportation	• Head of Public Works to accelerate the construction of sidewalk

Strategy	Detail explanation
and increase walking infrastructure in arterial roads and public transportation location	• Head of Transportation Agency to prepare traffic management scenario during construction of sidewalk • Head of Transportation Agency to increase law enforcement for possible encroachment on sidewalk

A more recent regulation, the Strategy of Air Pollution Management, was introduced with Governor Decree No. 576 of 2023. This regulation set a more comprehensive action/task to reduce air pollution with a roadmap until 2030 and more concrete action related to the LEZ. The government plans to start a thorough analysis of the criteria of LEZ beginning in 2024 and publish a provincial regulation about LEZ in 2025. The complete activity related to LEZ is explained in Table 3 below.

Table 3. Governor Decree No. 576 of 2023 about Strategy of Air Pollution Management

Program	Action	Agencies
Strategy 1: Improvement of Air Pollution Governance		
Formulation of regulation related to air quality management	Revision of Provincial Regulation No. 2 of 2005 about the Management of Air Pollution	Environmental Agency
	Revision of Provincial Regulations No. 5 of 2014 about Transportation	Transportation Agency
	Development of *'Rencana Perlindungan dan Pengelolaan Mutu Udara/RPPMU'* (Air Quality Protection and Management Plan)	Environmental Agency
Monitoring and enforcement of air pollution	Enforcement of maximum year of operation for public transportation	Transportation Agency
	Enforcement of vehicle emission testing	Environmental Agency
Strategy 2: Emission Reduction from Mobile Sources		
Emission standard improvement for public transportation fleet	Minimum emission standard of Euro IV for microbus and non-Transjakarta flee	Transportation Agency
	Electrification of Transjakarta fleet	Transportation Agency
Emission testing for motorised vehicle	Improve number of emission testing location	Environmental Agency
	Emission testing activity	Environmental Agency
	Data integration from emission	Environmental Agency

Program	Action	Agencies
	testing	
Development of Low Emission Zone	Study on the relevant indicators for LEZ	Transportation and Environmental Agency
	Regulation for the location criteria of LEZ	Transportation and Environmental Agency
	Establishment of a permanent Motorized Vehicle Free Zone	Transportation Agency
	Improvement of bicycle lane network	Transportation Agency
Improvement of Public Transportation Infrastructure	Development of TOD	Transportation Agency Provincial Owned Enterprise
	Pedestrian facility integrated with public transportation	Public Works Agency
	More mode shift with public transportation	Provincial government
	Development and operation of MRT and LRT Jakarta	Transportation Agency
Traffic Management	Operation of Electronic Road Pricing (ERP)	Transportation Agency
	Odd-even policy	Transportation Agency
	Implementation of incentive and disincentive parking mechanism	Transportation Agency

Conclusion of existing regulation related to LEZ in Jakarta

The Low Emission Zone (LEZ) program has been well integrated into regulation at the provincial level but only briefly mentioned at the national level. The provincial government of Jakarta has shown a great interest in the effort to reduce greenhouse gas emissions and air pollution. A specific regulation has set a 2030 goal to reduce air pollution from transportation sectors. LEZ can be seen as one of the priority strategies to be formulated as a regulation in 2024.

The provincial government, already aware of the need to manage high-pollution vehicles with emission testing for private cars, plans to improve the emission standard of Euro IV for industry and the electrification program for public transportation.

A specific regulation to limit vehicle emissions has already been established, ensuring a maximum of 10 years of operation for public road transportation. However, there is still no regulation to limit

the maximum operation for private vehicles as there are no regulations at the national level regulating it. At the same time, the emission testing still uses the standard set by the MoEF Regulation No. 8 of 2023, which only measures CO and HC, whilst PM and NOx should also be considered.

Various supporting policies for LEZ are also mentioned comprehensively, including a plan to improve the public transportation network, NMT infrastructure, electronic road pricing, odd-even regulation, TOD policy, and high parking fee regulation.

At the national level, no regulation specifically mentions LEZ as a program. However, there are a couple of rules that can be correlated with the LEZ. The National Government Regulation No. 22 of 2021 provides a framework for area-based intervention for air pollution mitigation where the provincial government can create their plan according to the local context. LEZ is a suitable strategy since it provides a limitation of access for highly emitting vehicles in certain areas. Another related policy is regulated in MoEF Regulation No. 8 of 2023, where the provincial government can impose incentive or disincentive mechanisms to manage air pollution. Regarding policies focusing on mobility, according to the National Government Regulation No. 32 of 2011 about Traffic Impact Management, the provincial government also has the flexibility to create its own policy to manage the traffic. This flexibility must be made not only for traffic situations but also for environmental reasons. A more detailed conclusion of each regulation's correlation with LEZ is attached in Annex 1.

2.2. LEZ initiatives in Jakarta

The government of Jakarta has acknowledged the need to reduce air pollution in the city due to the various negative externalities and established a low emission zone on the 21st of February 2021. The LEZ was established in Kota Tua, also known as the Old Town, with an area of 0.14 km2. Although the term LEZ was used, the primary intervention that was introduced included the restriction of motorised vehicles in 6 road segments except Transjakarta buses and residents or shop owners within the designated LEZ area. Supporting the restriction of several road segments, the Jakarta government also increased pedestrian and cycling infrastructure, revitalised the plaza and the commercial regions, relocated the bus stops and adjusted bus routes, and provided designated areas for drop off and loading/unloading goods.

Figure 10. Delineation of LEZ in Kota Tua

On top of the several interventions that have been implemented during the establishment of the Kota tua as an LEZ, the area is also served by multiple modes of transportation, which will ensure accessibility of the area.

2.2.1. Evaluation of LEZ Kota Accessibility

ITDP Indonesia produced 'Documentation and Recommendation of LEZ Old Town Jakarta' in December 2022 with a comprehensive review regarding the implementation from the accessibility aspect. At the time of implementation, the main justification for the establishment of the LEZ was the Governor Regulation no 36 of 2014 regarding the master plan of Kota Tua. The regulation stated that transportation within the Old Town area should consider sustainability factors such as maintaining cultural heritage buildings. The master plan elaborated on the need to limit the traffic of motorised vehicles to preserve the buildings and environment and to reduce air pollution. Through this regulation, it can be deduced that the preservation of buildings was the main goal for the reduction of pollution, and the concept of LEZ was not explicitly mentioned within the document. This condition may also cause differences in the objectives of the current LEZ in Kota Tua. A more 'ideal' form of LEZ would usually be implemented on a city-wide scale to increase a city's air quality, while the former aimed at the elimination of through traffic and the conservation of heritage buildings.

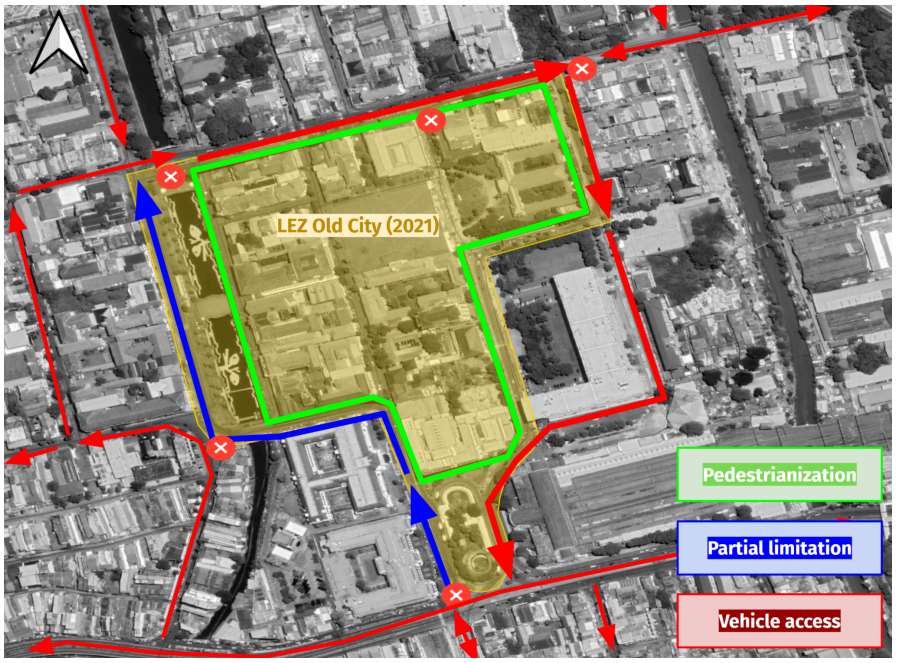


Figure 11. Accessibility in the Old Town Jakarta (ITDP, 2022)

Other than the differences in goals of the LEZ, the interventions that were placed in the Old Town LEZ were not entirely effective. Although the revitalisation efforts improve pedestrian and cycling comfort and safety, there have been reports of violations by motorised vehicles. Since Transjakarta buses are still allowed to enter the area, other motorised vehicles have the opportunity to breach the LEZ via the portal that is made for the buses. This is in contrast to the objective of the Kota Tua LEZ, as through traffic is still present. Moreover, there is also a lack of intermodal connectivity between the Transjakarta Corridor 12 and the KRL commuter rail, causing pedestrian discomfort when transiting.

There has also been a lack of monitoring and evaluation efforts of the LEZ. As mentioned previously, the government aims to reduce pollution within the LEZ to protect several historic buildings in the area. However, there have been no evaluations of improvements in buildings or a decrease in the rate of deterioration.

Current tenants/business owners operating within the Old Town area have also expressed concerns about logistics and the lack of diverse activation efforts. Despite the current mitigation measures for logistic vehicles, people have still mentioned difficulty with their freight vehicles. Moreover, business owners such as street vendors were given a specific spot to sell their goods in Kota Intan, which was unsuccessful as people did not walk to Kota Intan to get their food. The LEZ would then benefit from a more variety of activities within the centre. Visitors to the pedestrianised area also argue that there is a lack of shading in the plaza.

2.2.2. Evaluation of air pollution reduction of LEZ Old Town Jakarta

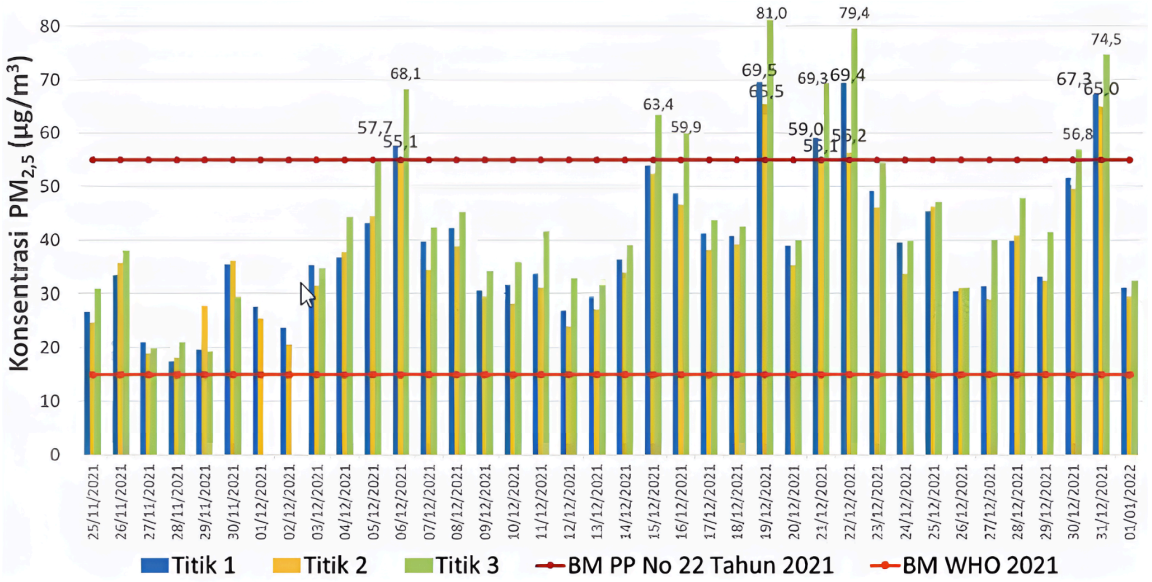


Figure 12. PM 2.5 results in Old Town Jakarta in 2021 (Yulinawati, 2022)

In 2021, the University of Trisakti conducted an analysis of air pollution concentration in Old Town by placing three low-cost sensors to measure the PM 2.5 concentration, as illustrated in Figure 12. They found that a high concentration of PM 2.5 occurred during the nighttime, with the highest concen172 uq/m^3. From 36 sample days, 9 days were above the national average, with the highest PM 2.5 concentration reaching 81 uq/m^3. If the WHO standard was used with the 15 uq/m^3 standard, all of the sample days would have been above the standard. This finding shows the implementation of LEZ Old Town Jakarta was still unable to reduce air pollution because there was still a high volume of highly emitting vehicles, especially logistic vehicles.

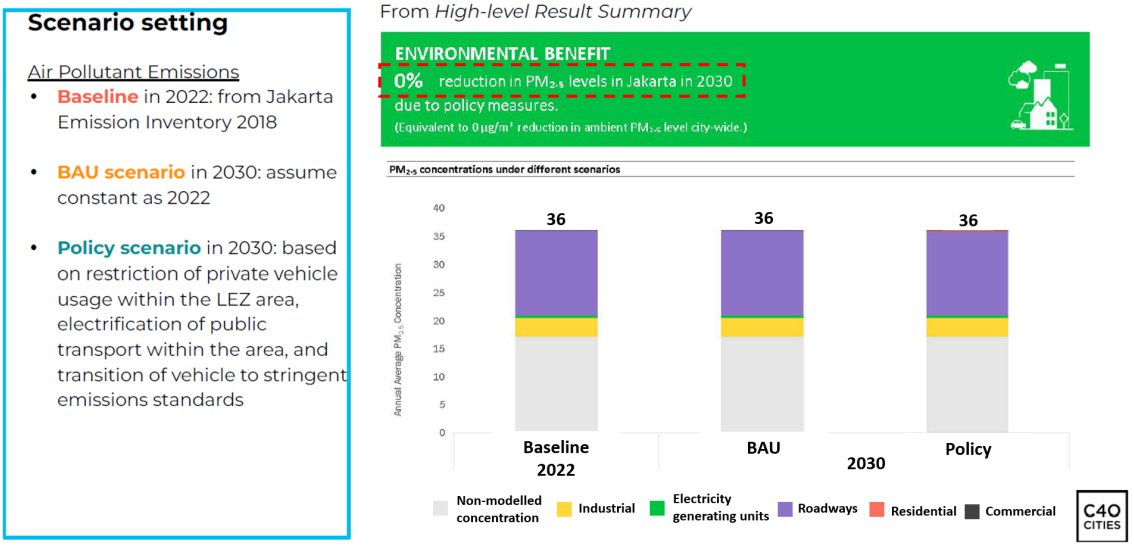


Figure 13. Air pollution reduction of Old Town LEZ Jakarta to the city of Jakarta (C40, 2023)

Another evaluation of the air pollution reduction impact of LEZ Old Town Jakarta to the city of Jakarta is analysed by the C40 using the 'AQUA Transport Models' in 2023. This model uses the assumption of different transport policies and their impact on reducing air pollution. This model uses geographic scale, vehicle setup, fuel context, traffic volume change, vehicle fuel share, and emission standard. Since the geographic scale of LEZ Old Town Jakarta is still on a micro scale, with an area of 0.14 km^2, there is no significant reduction of PM 2.5 concentration in the city scale of Jakarta, as illustrated in Figure 13.

2.2.3. Indicators to determine LEZ and possible LEZ location in Jakarta

WRI Indonesia, in the report 'Alternative Location of LEZ in Jakarta' in December 2022, has disseminated the indicators to identify the potential location of LEZ in Jakarta. They use the Analytical Hierarchy Process (AHP) from various experts to determine the most critical criteria to assess the LEZ location. Table 4 explains the seven criteria for planning LEZ location:

Table 4. Indicators to determine the location of LEZ (WRI, 2022)

Criteria	Weight (%)
Traffic jam	25
Transportation policy (high parking tariff, odd-even, TOD)	25
Pollutant in the area	21
Access to public transport	15
Land use	7
Activity in the area	5
Residential density	2

The analysis from World Resource Institute (WRI) resulted in the location of six potential locations of LEZ, as illustrated in Figure 14. The intervention of LEZ will be located in Senayan, Dukuh Atas, Hotel Indonesia, Harmoni, Trisakti, and Senen. All of the potential LEZ locations are mainly located in the transit area that are separated from each other. There is a proposed plan to connect this different LEZ in the transit area with a corridor or an area, but it is still in a conceptual proposal.

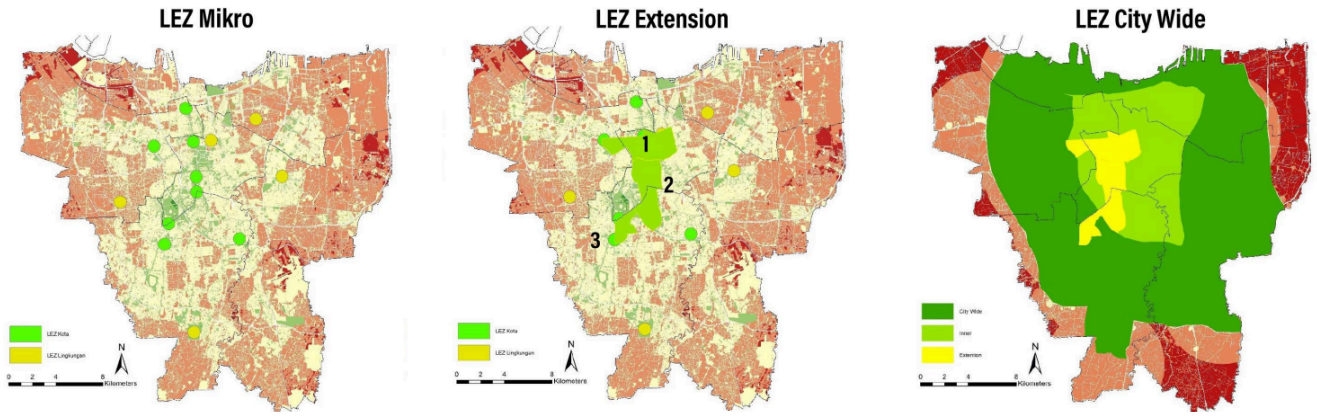


Figure 14. Possible LEZ Delineation (WRI, 2022)

2.2.4. Lesson learned/recommendations

Based on the various evaluation points that were mentioned in the previous section, several recommendations are provided for a successful LEZ implementation.

Table 5. Recommendation from LEZ implementation in the Old Town Area

No	Evaluation Point	Recommendation
1.	There is a lack of law enforcement of vehicles that penetrate the Old Town LEZ, so vehicles pass the borders.	The pedestrianisation of road segments around the area and the design of a transit mall without exceptions. Careful planning and the implementation of adequate policies are needed to address potential conflicts between various modes of transportation and ensure the safety of all road users. This is most relevant with the increased uptake of electric vehicles pardoned from entering LEZs.
2.	Lack of monitoring and evaluation of the success of the LEZ in achieving its initial goals.	The development of indicators of an LEZ, as well as scheduled monitoring and evaluation schemes by the government.
3.	Lack of intermodal connectivity within the LEZ	Increased Transjakarta integration with the commuter rail station with the addition of a bus stop in front of the Mandiri Museum
4.	Not enough access is given for logistic vehicles within the LEZ	Improve the accessibility of logistics vehicles by promoting cargo bikes for freight with government-backed trials. There is also a need for additional loading and unloading points for goods.
5.	Lack of activation within the LEZ, activities are to be segmented, such as the creation of	Activate the area with temporary/semi-permanent public activities.

No	Evaluation Point	Recommendation
	Kota Intan to hold the street vendors	
6.	Through traffic	Reduce direct traffic (through traffic) with filtered permeability
7	Insignificant air pollution reduction: There is a reduction of air pollution concentration in the area, however it is still above the standard set by WHO and the national government (Yulinawati, 2022). The micro-scale implementation of LEZ does not contribute to meaningful pollution reduction at the city level (C40, 2022)	Improve the enforcement of LEZ implementation and expand the geographic scale of LEZ area to achieve a more significant reduction of air pollution. Indicators to determine LEZ have been developed and can be improved to suit the larger implementation of LEZ.

3. Stakeholder Identification

The analysis of different government stakeholders will use the stakeholders' resources approach developed by Klijn & Koppenjan (2016) and the stakeholders' matrix of importance from Johnson & Scholes (1999). The stakeholder resource approach addresses a complex issue where no single government body can solve all the problems because resources to solve the problem are distributed among the actors. Air pollution from the transportation sector is complex and requires collaboration between stakeholders. The stakeholder resources approach covers five categories:

a. Financial: money and budgets to cover the transaction cost of realising solutions

b. Production: means to realise the solutions, policies, or services. In more detail terms, it includes physical needs such as building or personnel.

c. Competencies: formal authority to make decisions, which also included private actors who were given authority from the government.

d. Knowledge: knowledge or expertise to realise the service delivery. If the knowledge is hard to gain/access, the other actors will depend more on them.

e. Legitimacy: relevancy with the issue and support for certain solutions.

Meanwhile, the matrix of importance will provide an overview of stakeholders from the perspective of power and interest to determine the most relevant stakeholders.

3.1. Provincial Level Stakeholders

The collaboration between government agencies for green initiatives in Jakarta is not new and has been implemented for different programs. The provincial government has set up a committee for the Low Carbon Development plan in Jakarta with Governor Regulation No. 90 of 2021. Another regulation has set a committee to tackle air pollution with the Air Pollution Management with Governor Decree No. 576 of 2023. Table 6 explains the different agencies' resources related to the implementation of LEZ, and Figure 15 visualises the stakeholders' interest and influence on LEZ.

Table 6. Provincial Agencies Resources related to LEZ

Stakeholder	Financial	Production	Competencies	Knowledge	Legitimacy
Jakarta Environmental Agency (JEA)		v	v	v	v
Jakarta Transportation Agency (JTA)		v	v	v	v
Jakarta Development Planning Agency (JDPA)	v	v	v		v
DKI Jakarta Provincial Secretariat (including Bureau Heads and Regional Assistants)	v		v		v
Jakarta Spatial Planning, and Land Agency (JSPLA)				v	v
Jakarta Investment and One Stop Integrated Office Agency (JIOSIOA)					v
Metropolitan Jakarta Police		v			v
Jakarta Public Transportation Operators (MRT, LRT, BRT, Commuter Rail)	v	v			v
Jakarta Health Agency (JHA)			v	v	v
Jakarta Communication, Informatics and Statistics Agency (JCISA)		v			v
Jakarta Industry, Trade, Cooperatives, Small and Medium Enterprises Agency (JITCSMEA)		v			v
Jakarta Parks and Urban Forest Agency (JPUFA)		v			v
Jakarta Public Works Agency (JPWA)		v			
Jakarta Public Housing and Settlement (JPHS)		v			

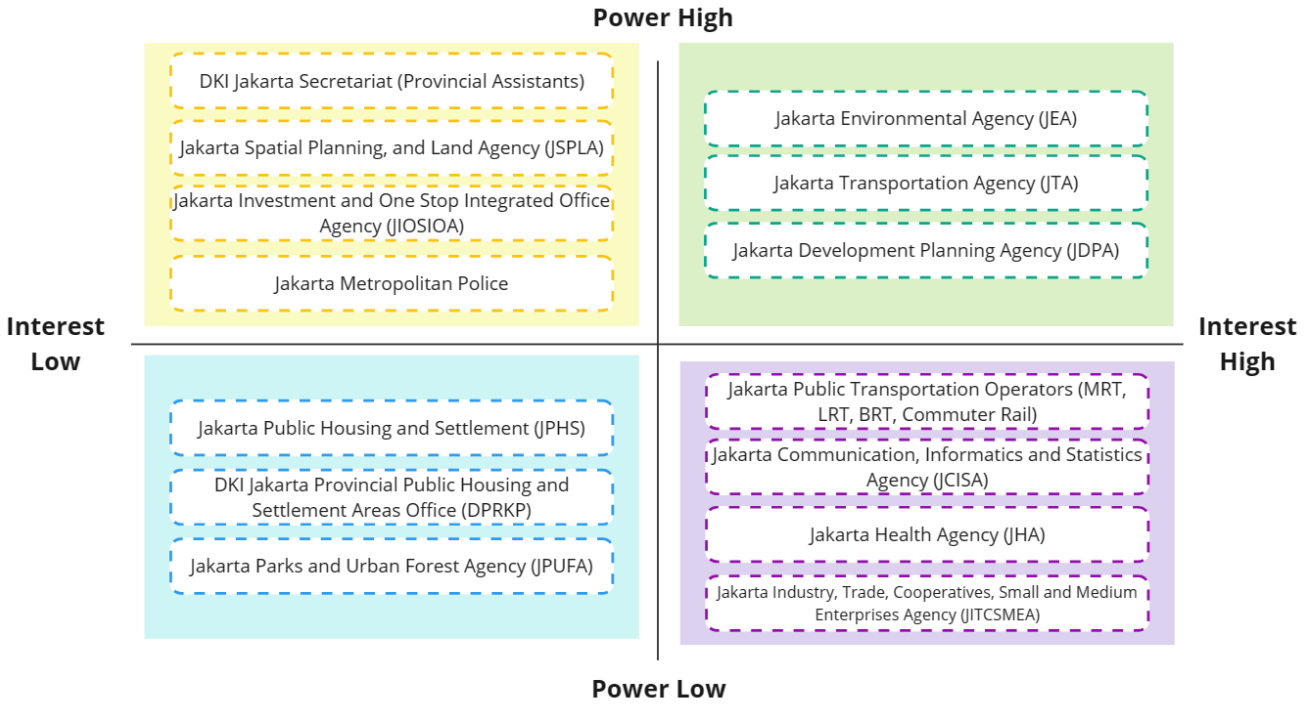


Figure 15. Matrix of interest and power dynamic in the Provincial Level for LEZ

High Interest and High Power

The first category of agencies with high interest and high power are JEA, JTA and JDPA. JEA is tasked with measuring and monitoring air quality conditions, providing emission testing services for motor vehicles, planning the placement of air quality measuring facilities, and leading the Jakarta Air Pollution Management Team. JEA will play an important role in the larger-scale implementation of LEZ to measure air quality and give directions to different agencies to ensure the target to reduce air pollution is achieved.

On the other hand, JTA also has a crucial role in the implementation of LEZ as the agency to plan and manage the traffic circulation in Jakarta. During the pilot project, JTA managed traffic in Old Town, imposed restrictions on vehicle access, and managed parking locations. In a broader scope, JTA is responsible for ensuring good traffic management, parking management, electronic road pricing (ERP), coordinating the operation of public transportation, and prosecuting violators of traffic users. For the implementation of LEZ, they will be responsible for planning the LEZ area from the mobility perspective, preparing the enforcement mechanism, and creating a set of supporting policies to implement LEZ under their authority. The enforcement of LEZ implementation by the Transport Agency will be in collaboration with the Jakarta Metropolitan Police. The current partnership between the Transport Agency and Jakarta Metropolitan Police is in enforcing emission testing activity as dictated by Governor Decree No. 66 of 2020.

The continuity of LEZ cannot be separated from funding and budgeting in its implementation. In this case, JDPA has the authority to formulate regional fiscal policies in the context of preparing regional development planning. In addition, JDPA, as the head of the Mitigation and Adaptation of Climate Change committee, will coordinate different agencies to ensure every activity contributes to the effort to reduce greenhouse gas emissions.

Low Interest and High Power

Agencies with low interest but high power are the agencies with authority to influence the direction of LEZ but do not have a specific focus on the LEZ program. These types of agencies include the DKI Jakarta Secretariat with the Provincial Assistants, JSPLA, and JIOSIOA. The secretariat is directly linked with the governor and has the authority to direct and coordinate the agencies under them. The Economic assistant and development assistant can direct the implementation of LEZ, where the former is responsible for managing JTA and JEA, and the latter is responsible for JSPLA and JEA. The assistant will provide a coordination role to bridge the communication gap between agencies when implementing LEZ.

As for the technical agencies such as JSPLA are responsible for planning, monitoring, and evaluating spatial planning in the form of Detail Spatial Planning Documents (RDTR). The current spatial planning vision has integrated the TOD concept, contributing to more sustainable mobility in the city. In the context of LEZ, JSPLA could integrate the LEZ concept into the spatial planning product where highly emitting activities from land use and mobility is limited. JIOSIOA will be important in giving development permits if they suit the spatial planning plan.

High Interest and Low Power

Agencies with high interest and low power are agencies that are directly involved or related to LEZ objectives but do not have significant authority with the LEZ program itself, such as public transport operators, JCISA, and JITCSMEA. The main objective of public transport operators is to provide more sustainable transportation with MRT, BRT, LRT, and commuter rail from private vehicles. Special attention needs to be targeted to PT Transjakarta, planning to electrify all of its fleets into electric vehicles by 2030. The electrification program and plan for LEZ should be aligned together to prioritise routes inside the LEZ area. MRT also significantly reduces air pollution in the transportation sector. As TOD Managers, they are responsible for ensuring compact and sustainable mobility development inside the TOD area.

Another relevant agency is JCISA, which has the capacity to disseminate government policies to the public. For the LEZ project, this agency will be responsible for managing all of the technical information and creating more readily accessible information. As for JITCSMEA, they will be responsible for communicating the impact of LEZ to the economic sectors, both formal and informal. During the LEZ pilot project in Kota Tua, they engage directly with the informal economic

sectors. The last agency that will be relevant to LEZ is the JHA since they will provide information related to the impact of air pollution on people. This data is important to evaluate the effectiveness of LEZ intervention and could be used to promote the LEZ program.

Low Interest and Low Power

Low interest and low power agencies are relevant agencies with the LEZ implementation but cannot influence the LEZ program. JPWA is one of the agencies that is slightly related to the LEZ objectives. They provide pedestrian infrastructure, which might be important in reducing dependency on private vehicles. The future pedestrian program should be integrated with the LEZ area. Other agencies, such as JPHS, can carry out evaluations of LEZ in the residential areas. Meanwhile, JPUFA will ensure the management of parks, greenways, and forestry within the LEZ area.

3.2. National Level Stakeholders

In addition to LEZ implementation in Jakarta, LEZ implementation also needs to be applied in metropolitan areas since vehicle mobility is cross-boundary with different administrative authorities. LEZ requires coordination between different cities where national ministries are important. Similar to the previous explanation, Table 7 will provide different agencies' resources, and Figure 16 illustrates the interest and power of relevant stakeholders with the LEZ.

Table 7. National ministry resources related to LEZ

Stakeholder	Financial	Production	Competencies	Knowledge	Legitimacy
Ministry of Environment and Forestry (MoEF)		v	v	v	v
Ministry of Transportation (MoT)		v	v	v	v
Coordinating Ministry for Maritime and Investment Affairs (CMMIA)		v	v		v
Ministry of Industry (MoI)		v	v		v
Ministry of Energy and Mineral Resources (MEMR)		v	v		v
Ministry of National Development Planning (MNDP)	v			v	V
Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (MAASP/NLA)				v	v
Ministry of Public Works (MPW)		v			v

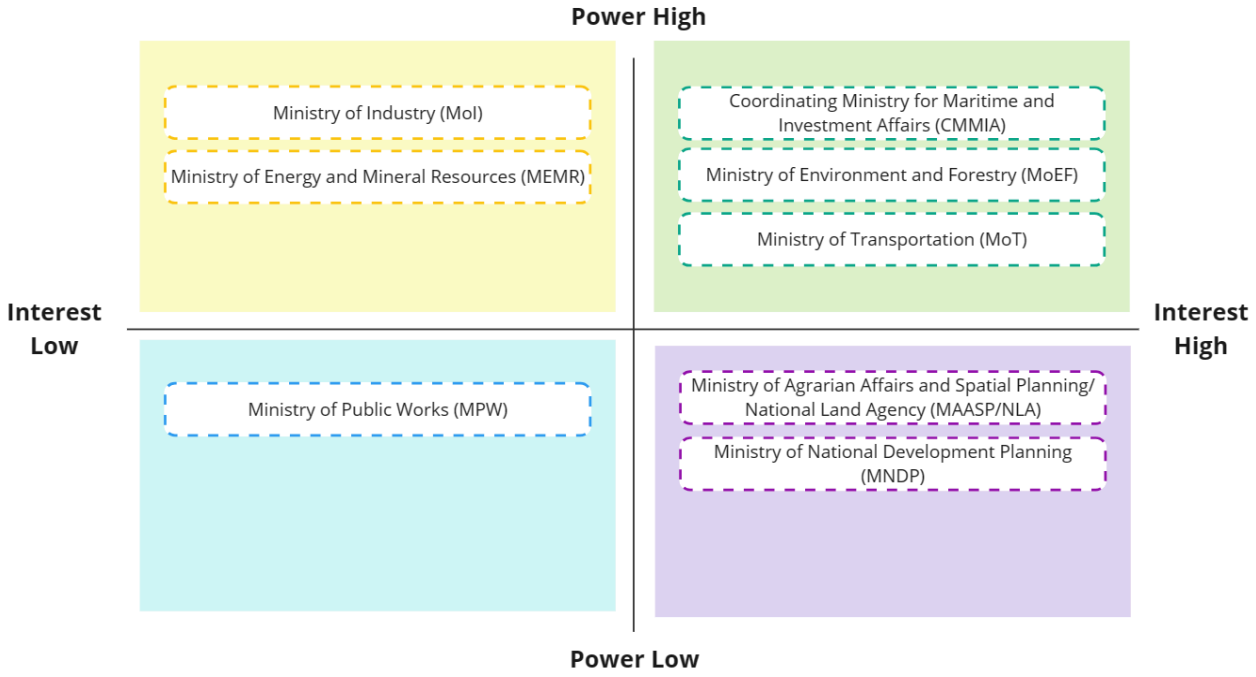


Figure 16. Matrix of interest and power dynamic in the National Level for LEZ

High Interest and High Power

One of the ministries that plays a major role in LEZ implementation is the Indonesian Ministry of Environment and Forestry (MoEF). MoEF has a function to formulate and stipulate policies related to improving the quality of environmental functions, controlling environmental pollution and damage, and controlling the impacts of climate change. This ministry is responsible for setting the emission standards of vehicles which will be influential in the implementation of LEZ. Technically, MoEF has a directorate-general in Environmental Damage Control, with a directorate that specifically manages air pollution with the Directorate of Management of Air Pollution. This directorate is responsible for formulating policy, standards of conduct, coordination, technical assistance, and evaluation related to air quality management.

Apart from the MoEF, there is the Indonesian Ministry of Transportation (MoT), which plays a role in transportation and traffic matters. The LEZ needs to be supported by policies limiting access to motorised vehicles and the improvement of more sustainable modes of transportation. MoT also carries out transportation policy and analysis in the Metropolitan Area of Jakarta through the Jabodetabek Transportation Management Agency (JTMA). They are responsible for developing and managing integrated transportation services on the metropolitan scale following the Jabodetabek Transportation Master Plan (RITJ).

There is also one coordinating ministry, the Coordinating Ministry for Maritime Affairs and Investment (CMMIA), overseeing national priority programs and other policies the President decides. In the middle of 2023, the Government of Indonesia entrusted the leadership to CMMIA

to enhance the air quality in Greater Jakarta. Two relevant deputy ministers might be related to the LEZ, Deputy 3 of Coordinator of Infrastructure and Transportation and Deputy 4 of Coordinator of Environment and Forestry Management. Deputy 3 is responsible for delivering interconnected land transportation infrastructure. As for Deputy 4, they are responsible for monitoring and managing air quality degradation.

Low Interest and High Power

The low-interest and high-power ministries related to LEZ involve the Ministry of Industry (MoI) and the Ministry of Energy and Mineral Resources (MEMR). MoI is responsible for establishing policies in the industrial sector to improve the quality of automotive products. This ministry has created the automotive roadmap until 2030, where Low Carbon Emission Vehicles (LCEV), including electric and hybrid vehicles, are prioritised. MoI is also responsible for communicating the new vehicle standard to the automotive industry only after the emission standard from MoEF is implemented. As for MEMR, they will play a crucial role in delivering fuel standards for vehicles that align with the MoEF emission standards. The current fuel usage is still predominantly dominated by the Octan 90 with Pertalite, where the minimum of Euro IV standard fuel should be fulfilled with Octan 98 with Pertamax Turbo. However, the use of high-octane fuel is still limited due to high prices, and the alternatives for high-quality and affordable fuel are still limited.

High Interest and Low Power

The Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (MAASP/NLA) and Ministry of National Development Planning (MNDP) have a high interest and low power in their influence on LEZ. MAASP/NLA formulates and sets policies in the field of spatial planning where they have an institution to integrate spatial planning in metropolitan Jakarta with the Project Management Office Jabodetabek-Punjur. An LEZ implementation should be supported with a land use planning document that supports low-carbon activity and mobility. Indonesia's current spatial planning regime still focuses on limiting emissions from non-movable emissions, while the focus on moveable emissions from the mobility sector is still non-existent. As for MNDP, they are responsible for initiating, coordinating, and monitoring Indonesia's Low Carbon Development Initiative (LCDI). The LCDI will be incorporated in the Medium Term National Development Plan, where every local government should align their medium-term plan. MNDP will be indirectly involved in the LEZ initiatives on a local scale.

Low Interest and Low Power

The last ministry in the category is the Ministry of Public Works (MPW). This ministry has a national project related to LEZ in several cities, such as Medan and Semarang. However, the main objective of their current LEZ project is still predominantly focused on improving the quality of heritage sites. A high-polluting vehicle can still access the LEZ area since managing traffic is not under the MPW's scope of responsibility. This ministry has the potential to be involved in the physical improvement of LEZ in the future.

4. Planning LEZ location

4.1. Definition of LEZ

LEZ definition and its origin

In general, a low-emission zone (LEZ) could be understood as an access restriction for the most polluting motorised vehicles based on the emission level (e.g., vehicle standard by Euro) or type of vehicle (e.g., heavy-duty vehicle) into a certain area with the main objective to reduce the air pollutant emission from motorised traffic. By urging drivers to shift to public transportation or walking and cycling or to adopt cleaner vehicles, LEZ would improve the city's air quality. It might have a secondary benefit of traffic congestion reduction as well. It has been proven to reduce the harmful air pollutants emissions related to motorised traffic, such as nitrogen oxides (NOx), particulate matter (PM10) and fine particulate matter (PM2.5), thus improving air quality.

Sweden is considered to be the first country to introduce and implement LEZ under the name of Environmental Zone (Ku et al., 2020). Since 1996, three cities in Sweden, Stockholm, Gothenburg, and Malmö, have restricted heavy-duty vehicles over 3.5 tonnes from entering the city centre to improve the air quality. Learning from the success, many cities around the world have implemented LEZ, especially in European cities. As of June 2022, the total number of active LEZs in Europe has reached 320 and is expected to keep increasing to 507 LEZs by 2025 (Clean Cities, 2022).

There are no one-size-fits-all requirements of LEZ as the implementation would be adjusted to the cities' needs. The stringency level of LEZ may vary in terms of the implementation area, allowed emission standard of vehicle types, operational time, and charging or total banning scheme. Nevertheless, most cities have tightened their requirements of the LEZs progressively and are expected to keep upgrading over time, especially regarding the emission standards, vehicle types, and geographical scale.

LEZ application in Indonesia

The implementation of LEZ in Indonesia comes with different justifications compared to the well-established definition in Europe. There are currently three cities that claim their city has implemented LEZ, Jakarta, Medan, and Semarang. These three cities utilise the LEZ concept to support the urban renewal of heritage areas in the city. From the local regulations, air pollution is deemed as a factor that could deter the quality of historic buildings, LEZ is seen as one of the approaches to achieve and preserve the historical building, as explained in Table 8.

Table 8. Perception of LEZ implementation in Jakarta, Semarang and Medan

Jakarta	Semarang	Medan
Governor Regulation No 36 of 2014, Old Town of Jakarta Masterplan	City Regulation 2 of 2020, Urban Design Guideline of Old City Semarang	Plan of Infrastructure and Housing in Old City area of Medan (Public Works Ministry)
Art 24. Plan for mobility in the area - limiting through traffic for motorised vehicles in an effort to realise the preservation of the building and environment of the Kotatua tourist area and reduce vehicle traffic and air pollution level;	Art 29. Mobility circulation - divided into pedestrian-only pathways, combination, one-away, and two-way - all of the road categories prioritised pedestrian	Use of LEZ as one of the main concepts to reduce air pollution by limiting high polluting vehicles

The definition of LEZ that only focuses on urban renewal/pedestrianisation might reduce the number of vehicles entering the area of intervention because the typical intervention is usually a small/micro-scale. It will not significantly impact the main objective of LEZ to reduce air pollution and might create another problem where traffic rerouting to the nearby neighbourhood. This type of intervention is more suitable to be called a Low Traffic Neighborhood (LTN), where the main objective is to reduce through traffic, mainly due to safety concerns and other externalities. Motorised vehicle drivers are forced to travel outside the zone, thus reducing the traffic going through the zone and discouraging travel with motorised vehicles. With less traffic, there are more spaces for travel inside the zone for walking and cycling to become more safe.

Common characteristics of LEZ

While there are no specific criteria for LEZ, there are several characteristics that define a LEZ:

1) Low-emission zone as a tool, not a result
   Although the name reflects a result, the implementation of LEZ refers to a tool or measure of access restriction to high-polluting vehicles from entering a designated area, hence the low air emissions. LEZ is not seen as a goal or result of implementing a series of transport demand management (TDM) measures in the designated area that could have impacts on air quality improvement, such as congestion charges, low-traffic neighbourhoods. pedestrianisation, etc.
2) The primary goal is to reduce air pollution emissions, not traffic congestion
   It is evident that the primary goal of implementing LEZ is to reduce the air pollution emission from motorised vehicles activities. Thus, the type of vehicle that can access LEZ should be based on the vehicle emission standard. LEZ should not be confused with

ERP/congestion charging intervention because the justification is to reduce traffic congestion, not to reduce air pollution. It might be true that ERP could contribute to lowering air pollution and vice versa, but LEZ focus on the emission standard of vehicles and reducing traffic congestion is seen as a side effect.

3) Implemented on the city scale and covers a large or important area of the city
   Being considered as a tool, LEZ practically could be implemented in any scale of the city, be it citywide scale or neighbourhood scale. However, to achieve a significant impact, LEZ is established on the city scale, covering a large part of the city or the central area of the city. Cities such as London, Paris, and Seoul cover the whole city and the metropolitan area. This strategy aims to force drivers to change their travel behaviour and use cleaner vehicles rather than just avoiding the area and driving outside the zone, as this would offset the air pollution outside the zone.
4) The standards get stringent over time
   Limiting motorised vehicles accessed based on the emission level, LEZ usually starts with less demanding standards but with a plan to progressively tighten the criteria. For instance, most cities started with heavy-duty diesel vehicles, then continued to diesel and petrol cars and even motorcycles. As the compliance rate rises over time, the standards should become stringent to reduce the overall air pollution emissions, which might eventually result in zero-emission vehicles. Besides emission standards, stringency could also be improved by expanding geographical areas. Regardless, a clear timetable for the standard increase should be provided to the public, as it would affect the decision on vehicle ownership.

4.2. Analysis of LEZ Indicators

4.2.1. Methodology to determine the LEZ delineation

Multi-criteria weighted overlay analysis is used to determine the delineation of LEZ in Jakarta. This spatial analysis allocates value to areas based on a variety of attributes the selected areas should possess. The different layers are overlaid in the same matrix to compare the different indicators together. This analysis combines the use of QGIS software and Microsoft Excel. There are six main steps for the multi-criteria weighted overlay analysis:

1) Determine the indicators and their weight: indicator is set to determine the expected results from the objective. Each indicator has a set of weighted proportions to determine the most and least impactful indicators to the objective. A detailed description of the indicators is explained in section 4.2.2.
2) Create a matrix: matrix will function as containment to calculate the value from different indicators set in the previous step. A matrix of 500 x 500 metres is set across the administrative boundary of Jakarta.

3) Calculate the matrix value: value from different layers of indicator inside a matrix is counted. All of the indicators will have the same scale of range value, in this case from 0 -1, with a different calculation method for each indicator. The detailed explanation is in section 4.2.3.
4) Calculate the weighted matrix value: all of the value from different indicators in the matrix is then weighted according to their importance. The weighted results are summed together to get the total end value of the matrix.
5) Visualise the total matrix value results: the total matrix value is visualised with the QGIS, with the lowest value in green and the highest value in red. The visualisation will give a spatial distribution of the highest matrix value, which will be an indication of a possible LEZ area.
6) Delineation of the LEZ area: the LEZ area is determined using a polygon shapefile with the consideration of road network.

4.2.2. Indicators for LEZ

The main purpose of LEZ is to reduce the air pollution emitted by vehicles in the most polluted area of the city. The concentration of pollutants in the area is the main parameter to determine LEZ area that is complemented by various indicators. ITDP used the indicators developed by WRI (2022) and expanded the consideration and source of data to measure it. The indicators of LEZ used in this report are as follows:

Table 9. Indicators to determine the possible area of intervention for LEZ

Parameters	Consideration	Source of data	Weight ITDP (%)
Pollutant in the area	Area with high concentration of air pollution using vehicle emission factor criteria	Distribution of air pollution spatial modelling (ICCT)	40
Push policy	Area/road assigned as odd-even policy, limitation for HDV, and parking management (in TOD area)	Policy documents (Government of Jakarta)	10
Access to public transportation	Existing area served by mass public transportation (rail and road-based)	Policy documents: 20 year detail spatial planning (Government of Jakarta)	30
Availability of NMT Infrastructure	Existing walking and cycling infrastructure	Public transport line and transit point (Transport Agency)	5
Land use	Area with land use that attracts movement (commercial, office, mixed use, hotel, tourism, services, health services, education, administrative, public park)	Active land use (Spatial Planning Agency)	5
Residential	Area with lower residential density to determine priority of low resistance area	Demographic land use (Spatial Planning Agency	10

Pollutants in the area have the highest weighted parameters because the main objective of LEZ is to reduce air pollution. The pollutants in the area indicators used the emission factor from the vehicle approach to generate air pollution, specifically from the transportation sector. The 40% weight also considers the previous indicators set by WRI (2022) from their Analytical Hierarchy Process (AHP) analysis, where the pollutant and traffic jam indicators are 20% and 25% respectively. Because this report uses the emission factor approach, ITDP combines the different weight indicators.

The second highest parameter is access to public transportation, which reaches 30%. One of the expected outcomes of LEZ is the shifting travel behaviour from private vehicle users to a more sustainable mode of transportation using public transportation. The LEZ area is prioritised in the area with public transportation networks as the alternative mode from highly emitting private vehicles. Supporting the public transportation services, NMT infrastructure, such as walking and cycling infrastructure, weighted 5%.

LEZ delineation should also be integrated with the parameters of the existing push policy to limit the use of private vehicles to ensure its continuity with the previous policy. Three main policies where LEZ needs to be integrated are limitation of access for Heavy Duty Vehicle (HDV), odd-even, and parking management inside the TOD area, which account for 10% weight of the parameters. Another parameter with the same weight proportion is the residential density. The LEZ is expected to be located in a high concentration of air pollution but at a lower density area to anticipate the resistance from the people living in the area. There will be a temporary exemption policy for people living inside the LEZ area, which will be explained in section 5.2.5.

The last indicator with a proportion of 5% is the type of land use in the area. Land use with an active function is assumed to generate mobility, with a more detailed explanation in the next section. The weight for land use is low because of the indirect effect it causes on mobility.

4.2.3. Analysis of parameters

1. High emission area from transportation
    - Analysis and assumption

As explained in the previous section, LEZ policy specifically focuses on reducing emissions from transportation sectors. The analysis of the spatial distribution of air pollution uses an approach that is based on Emission Factors (EF). The EF represents the amount of pollutant emitted per unit of activity. In this case, it means the pollutants in grams that are emitted per distance travelled by a vehicle, depending on its vehicle type and emission standard (gram emission/kilometres). The fleet-averaged EF is then multiplied with activity data from the total amount of traffic data for each type of vehicle to calculate the total emissions.

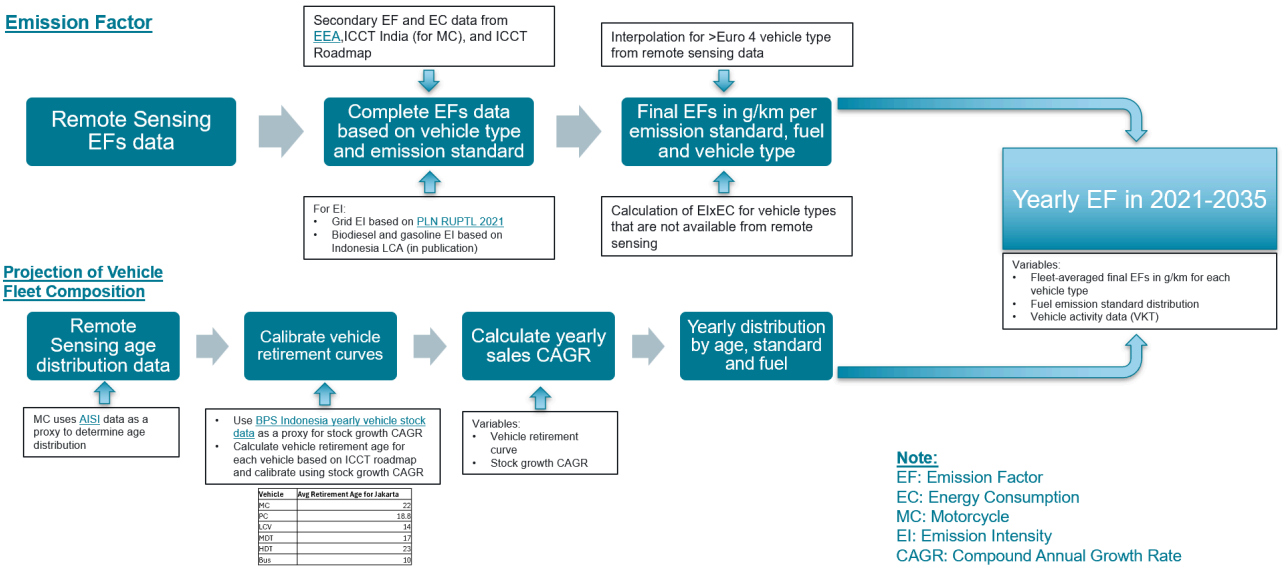


Figure 17. Methodology to determine yearly Emission Factor (EF) 2021 - 2035

Figure 17 visualises the process of determining the yearly fleet-averaged Emission Factor of vehicles in Jakarta from 2021 - 2035 provided by the International Council on Clean Transportation (ICCT). The EF by emission standard and vehicle type are provided by the the remote sensing analysis from the report 'Measurement of Real-World Motor Vehicle Emission in Jakarta' (2022) by The Real Urban Emission (TRUE) Initiative in partnership with ICCT and FIA Foundation (Mahalana et al., 2022). This report provides comprehensive data on all types of four-wheeled vehicle EF in Jakarta. Secondary data from EEA[1] and ICCT Roadmap[2] also used to supplement the emission intensity and energy consumption data that are missing from the remote sensing. As for motorcycles, ICCT uses a benchmarking case from India. The projection of future fleet composition and activity growth is based on the vehicle sales data from BPS Indonesia and AISI. The ICCT used this data to calculate the Compound Annual Growth Rate (CAGR) of past years. The CAGR is assumed to remain constant in future years. The retirement and vehicle sales projections were determined to meet the projected fleet growth. The complete results of vehicle EF are attached in Annex 3.

[1] https://www.eea.europa.eu//publications/emep-eea-guidebook-2023
[2] https://theicct.github.io/roadmap-doc/versions/v2.3/

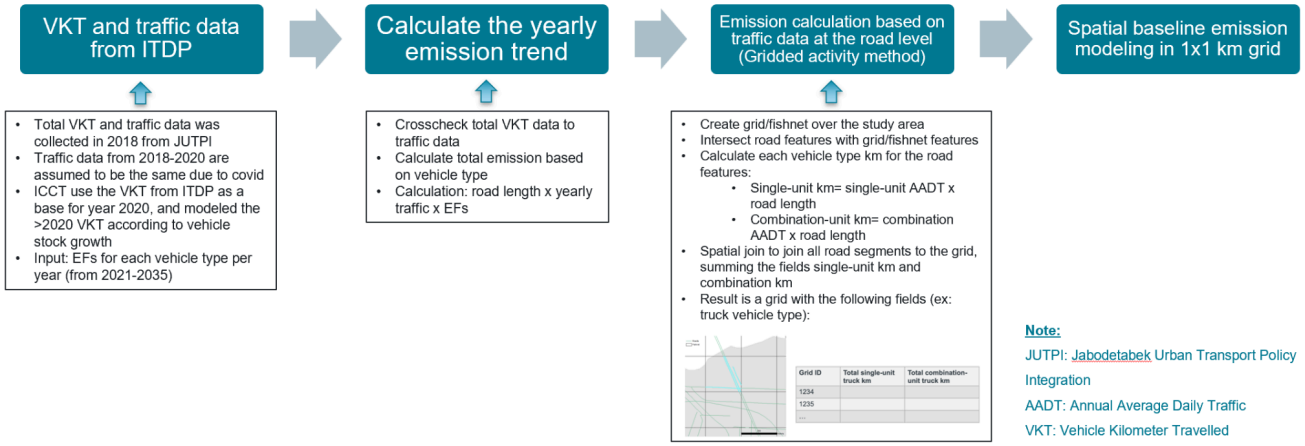


Figure 18. Methodology to visualise the emission results

Figure 18 explains the process of visualising the total emission of each vehicle category using the spatial distribution of vehicle activity on a 1x1 km^2 grid. The traffic sources come from the Jabodetabek Urban Transportation Policy Integration (JUTPI) Phase 2 study in 2019. The base data for calculation used the year 2020 with the assumption vehicle traffic from 2018 - 2020 remains the same. The traffic data generates vehicle activity by calculating road length and EFs. The vehicle activity resembles different categories of vehicles, which are visualised in a grid.

- Spatial emission distribution on a grid

The spatial distribution of total vehicle emission is visualised in Figure 19 with the example of PM and NOx. The emission distribution of PM is concentrated along the inner-toll road of Jakarta since it is mainly generated by logistic vehicles. As for the emission distribution of NOx, it shows more dispersed results on all streets in Jakarta since it is primarily dominated by motorcycles that use arterial, collector, and small roads altogether.

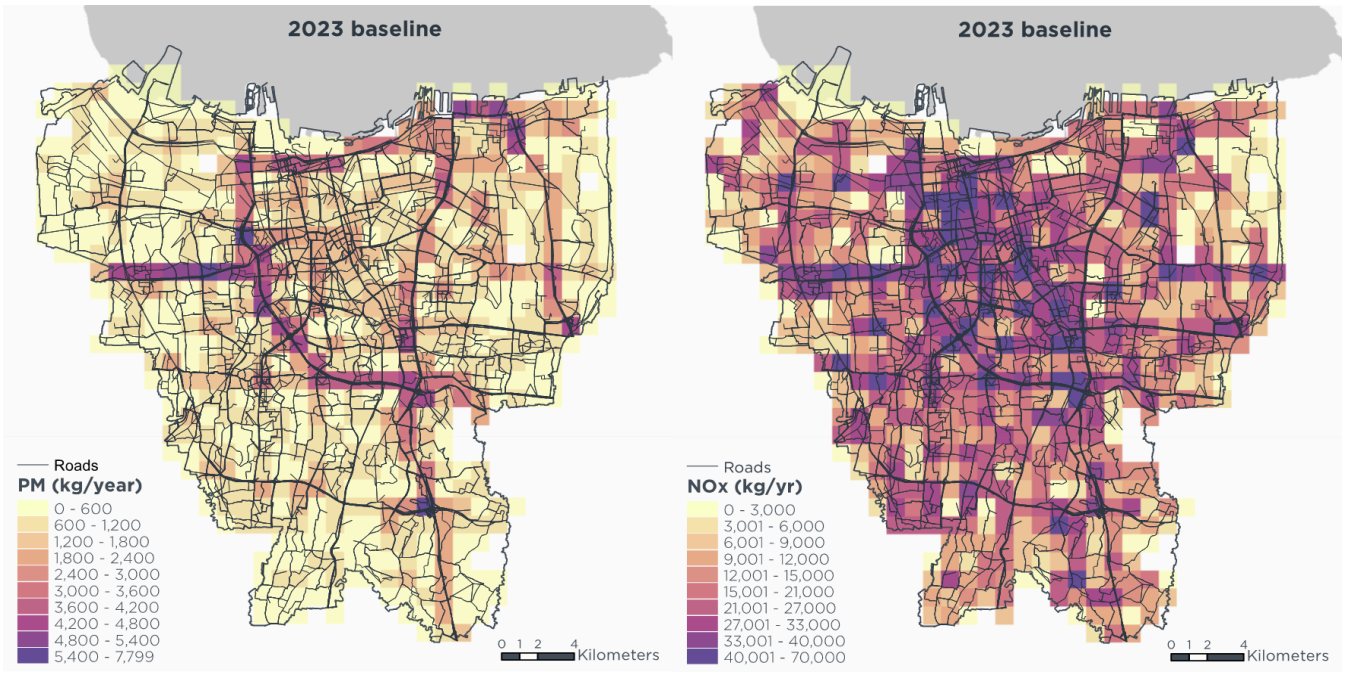


Figure 19. Baseline results of the emission concentration for NOx and PM in Jakarta

The emission sample from PM and NOx from the previous analysis generates an average matrix value based on the ordinal scale of 1 - 10 for each category. Figure 20 shows the matrix results from the value of 0.05 - 1, which is categorised into ten categories. The data distribution from the analysis is not uniform; hence, an equal quantile categorisation is applied.

High emission values are concentrated along the inner toll road from Penjaringan in North Jakarta to Gatot Subroto in the south and the toll road of Merak-Jakarta in the west. High concentration is also situated in the central to south area of Jakarta. The north area is located in Glodok as a commercial economic zone. It extends to central-east Jakarta with a high concentration in Senen, Matraman, and Jatinegara. A separated high concentration value is situated in Tanjung Priok, the main port of Jakarta.

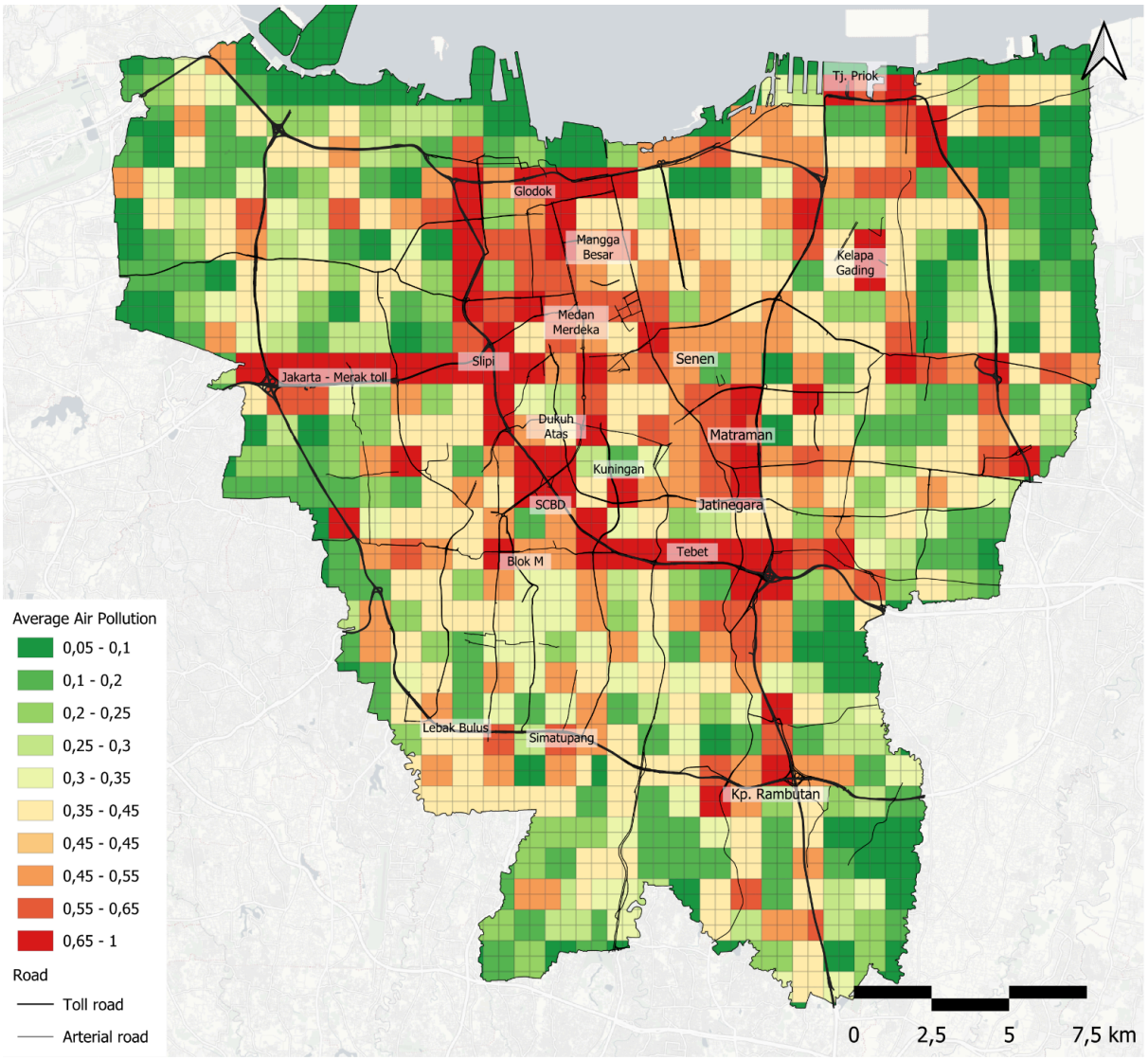


Figure 20. Average baseline results of the emission concentration in Jakarta

2. Access to public transportation
    - Analysis and assumption

Jakarta has a massive public transportation network that is served by rail-based and road-based transportation. Commuter Rail, known as KRL, has served the Jakarta Metropolitan Area since early Indonesian independence. It has 130 stations across the metropolitan area and has served 921,300 passengers daily in 2019 (Commuter KAI, 2020). The next rail-based transportation system is MRT, which has been operating since 2019, with 13 stations serving central and south Jakarta. MRT managed to serve 163,162 passengers daily in 2023 (MRTJ, 2023). The last rail-based transportation is LRT, which has two different operators. The LRT Jakarta stretches 5 kilometres northeast of Jakarta, and the newly operating LRT Metropolitan Jakarta connects central Jakarta to the east and southeast of Jakarta. Figure 21 (left) presents the routes and stations of rail-based transportation in Jakarta.

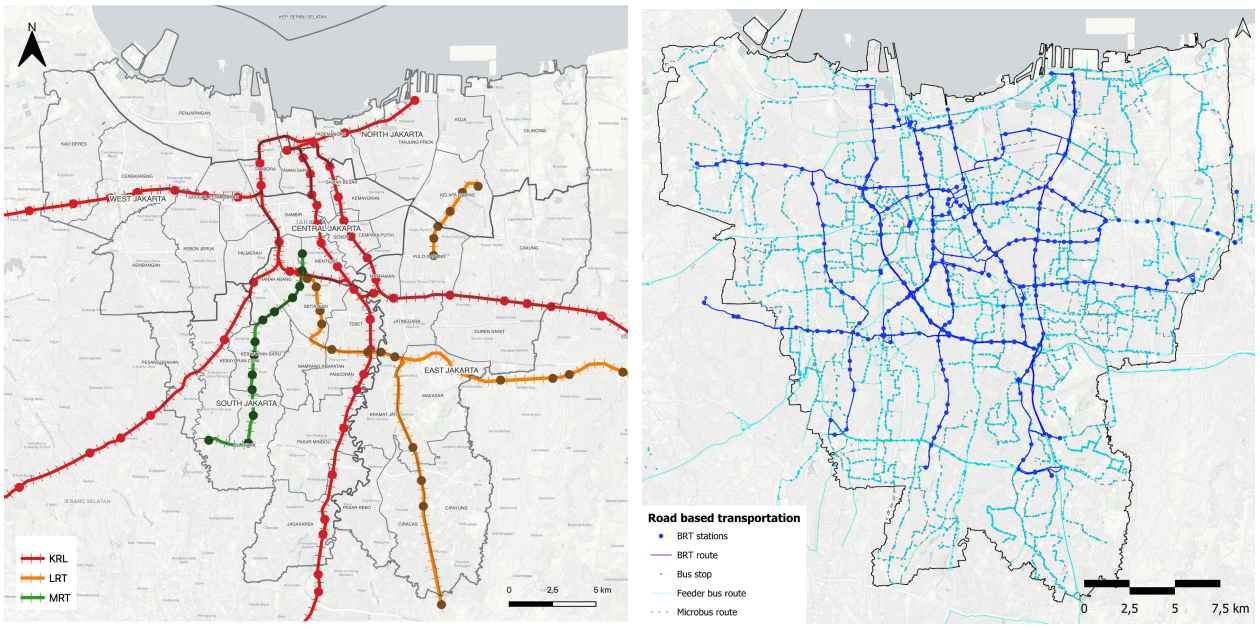


Figure 21. Rail-based (left) and road-based (right) public transportation network in Jakarta

The leading road-based transportation operators are PT Transjakarta, which operates Bus Rapid Transit (BRT), feeder buses, and microbuses. All of these services ensured Transjakarta served 87.1% of the total area of Jakarta and managed to serve 1 million passengers daily in 2023. Figure 21 (right) presents the main corridor of Transjakarta with BRT and its feeder route with feeder bus and microbus.

Calculating access to public transportation into the matrix uses the availability of transit points inside the matrix, represented by the rail and road-based public transportation stations and the bus stop serving the feeder route. The distribution of stations and bus stops is presented in Figure 22.

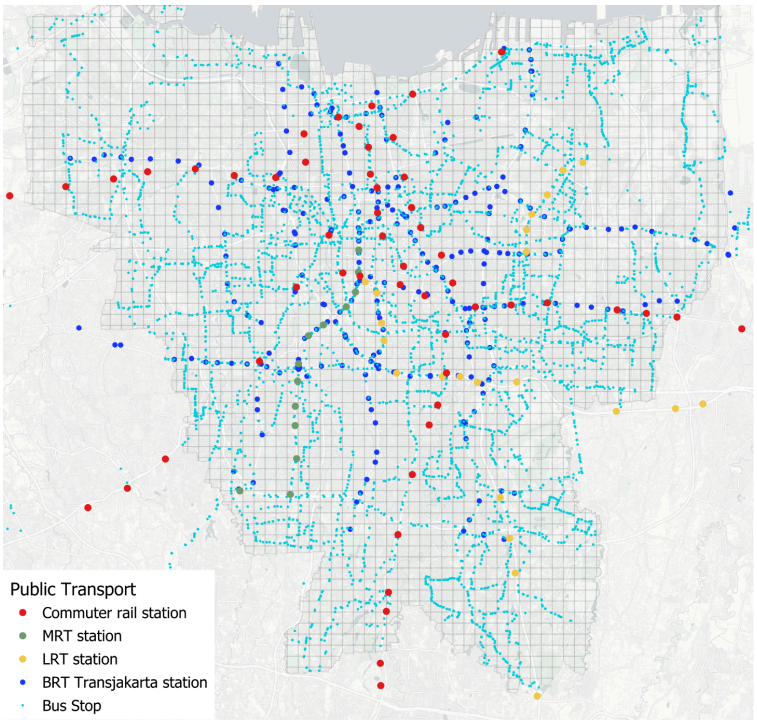


Figure 22. Public transportation nodes in Jakarta

- Analysis and assumption

The assumption used in determining the value of each matrix uses a scale from 0 to 1, with 0 as the lowest and one as the highest matrix served by numerous public transportation services. The maximum amount of value 1 is set for a matrix, which is applied for areas served by four different stations of mass public transportation and a minimum of one bus stop for the feeder services with a value of 0.0625. The complete assumption of access to public transportation is explained in Table 10:

Table 10. Matrix value for access to public transportation

No	Type of transit hub	Value
1	1 bus stop	*0.0625*
2	1 station	0.1875
3	**1 station + 1 bus stop**	**0.25**
4	2 station	0.4375
5	**2 station + 1 bus stop**	**0.5**
6	3 station	0.6875
7	**3 station + 1 bus stop**	**0.75**
8	4 station	0.9375
9	**4 station + 1 bus stop**	**1**

- Matrix of public transportation

The matrix analysis results are visualised in Figure 23, where the highest value of the matrix allgined with LEZ objective is indicated with the colour dark red and the lowest value with the colour dark green (excluding the white matrix with no station or bus stop). The highest matrix value with a score 1 is located in the Dukuh Atas area, where there are MRT, BRT, LRT Metropolitan Jakarta, Commuter Rail, and feeder routes. A high score of 2 for mass public transportation and feeders is located in Jakarta's central to south corridor, where BRT corridor 1 and MRT serve the Sudirman to Blok M area. A similar score is located in Kuningan's central to southeast corridor with the new station of LRT Metropolitan Jakarta integrated with the BRT corridor 6. Another part of Jakarta, which has two mass public transportation connections, is located in the Senen-Matraman corridor between BRT corridor 5 and the commuter rail connecting Jakarta Kota - Bekasi.

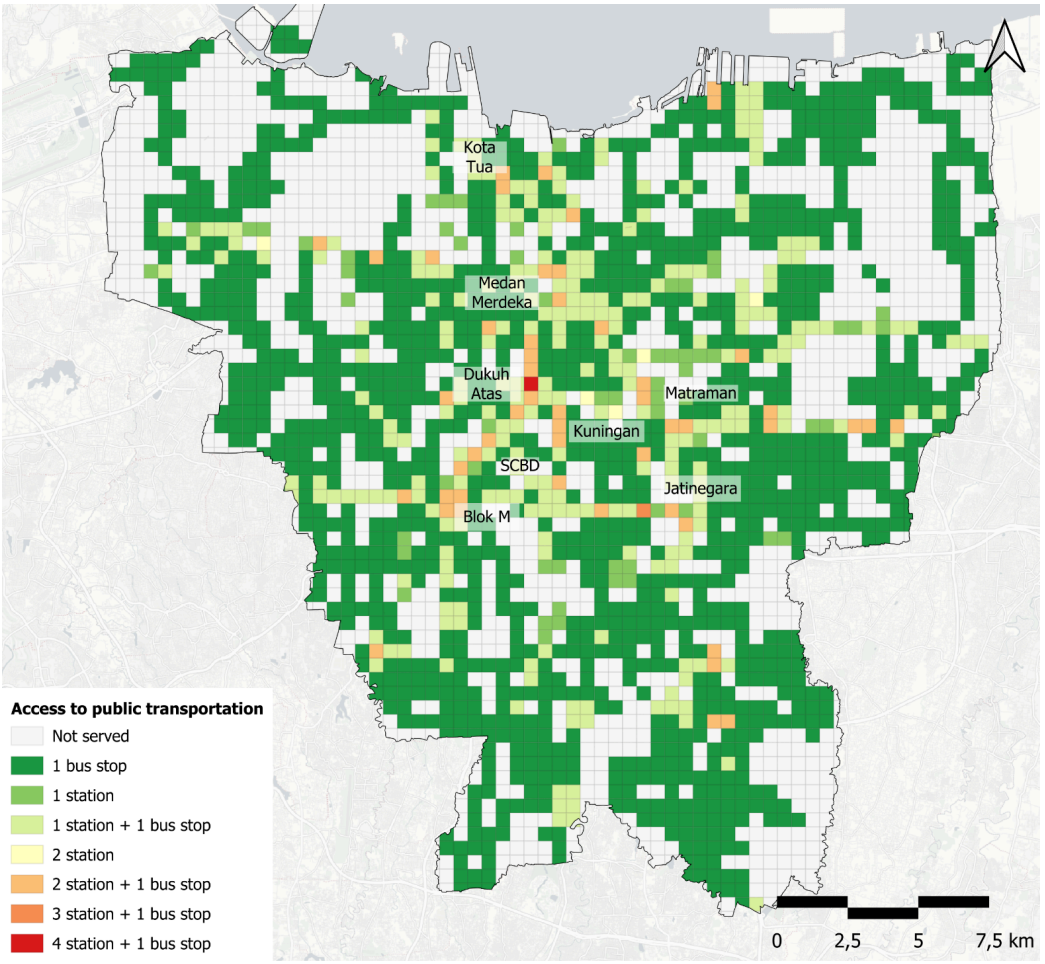


Figure 23. Matrix of public transportation accessibility in Jakarta

3. Availability of walking and cycling infrastructure
    - Analysis and assumption

Low Emission Zone must be supported with an adequate walking and cycling infrastructure for people to access the area or use public transit points. This report uses data on sidewalks between 2016 and 2022, assuming that these sidewalks have already met good standards. By 2022, 214.63 km of sidewalks will be constructed on 198 road segments.

Aside from the sidewalks, Jakarta also promotes the usage of bikes. In 2022, the Jakarta Government planned to activate bike lanes on several major roads totalling around 196.45 km. These bike lanes are classified into 3 types: on the sidewalk, shared, and protected. Shared bike lanes exist alongside the main road, while protected bike lanes have a divider that separates them from the main roads. The existing and planned bike lane network tends to agglomerate in Central Jakarta and relatively extend to East and South Jakarta. The availability of sidewalk and bicycle lane infrastructure is presented in Figure 24.

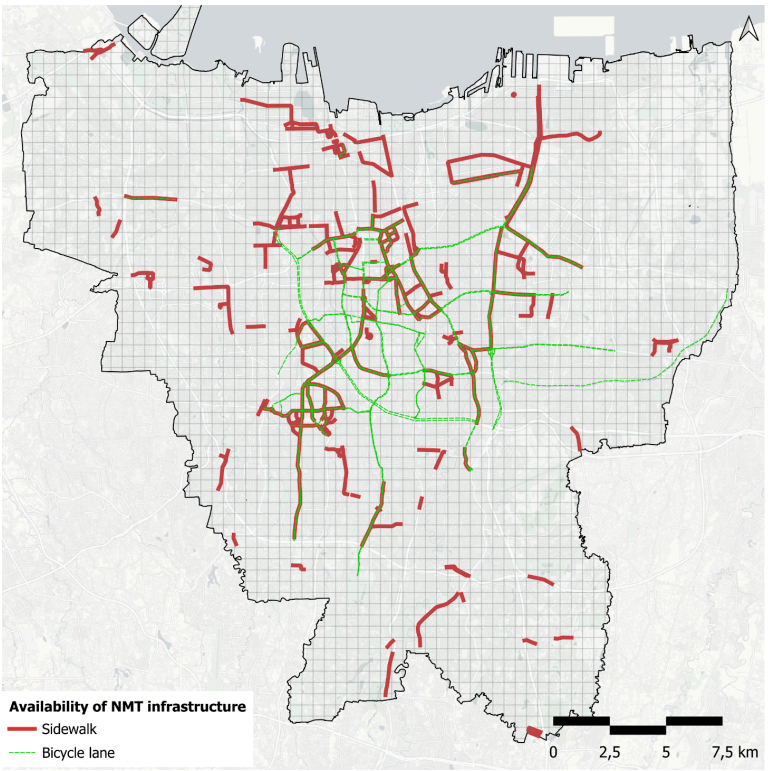


Figure 24. Sidewalk and bicycle lane infrastructure

The assumption to determine the matrix value was to use a scale from 0 to 1, with 0 as the lowest and 1 as the highest value. For every matrix with no sidewalk or bicycle lane, the matrix value will be 0. If there is either a sidewalk or bicycle lane located in the matrix, the value of the matrix is 0.5. The highest value of 1 will be given to a matrix with sidewalk and bicycle lane infrastructure.

- Matrix of walking and cycling infrastructure

Figure 25 illustrates the highest matrix value aligned with the LEZ objective with the colour dark red, where walking and cycling infrastructure exist, and lower matrix values indicated with dark green, where only one infrastructure exists. The highest matrix value is located in the central to south, central to southeast, and east of Jakarta. The BRT and MRT are located in the central to the south corridor of Jakarta. It stretched from the National Monument, Sudirman, Blok M and Fatmawati. A concentration of high-value matrices is also located in the central area of Jakarta in Cikini and Matraman, where economic and services land use is located. On the east side of Jakarta, a high-value matrix is located on the corridor of Ahmad Yani that connects north to east of Jakarta.

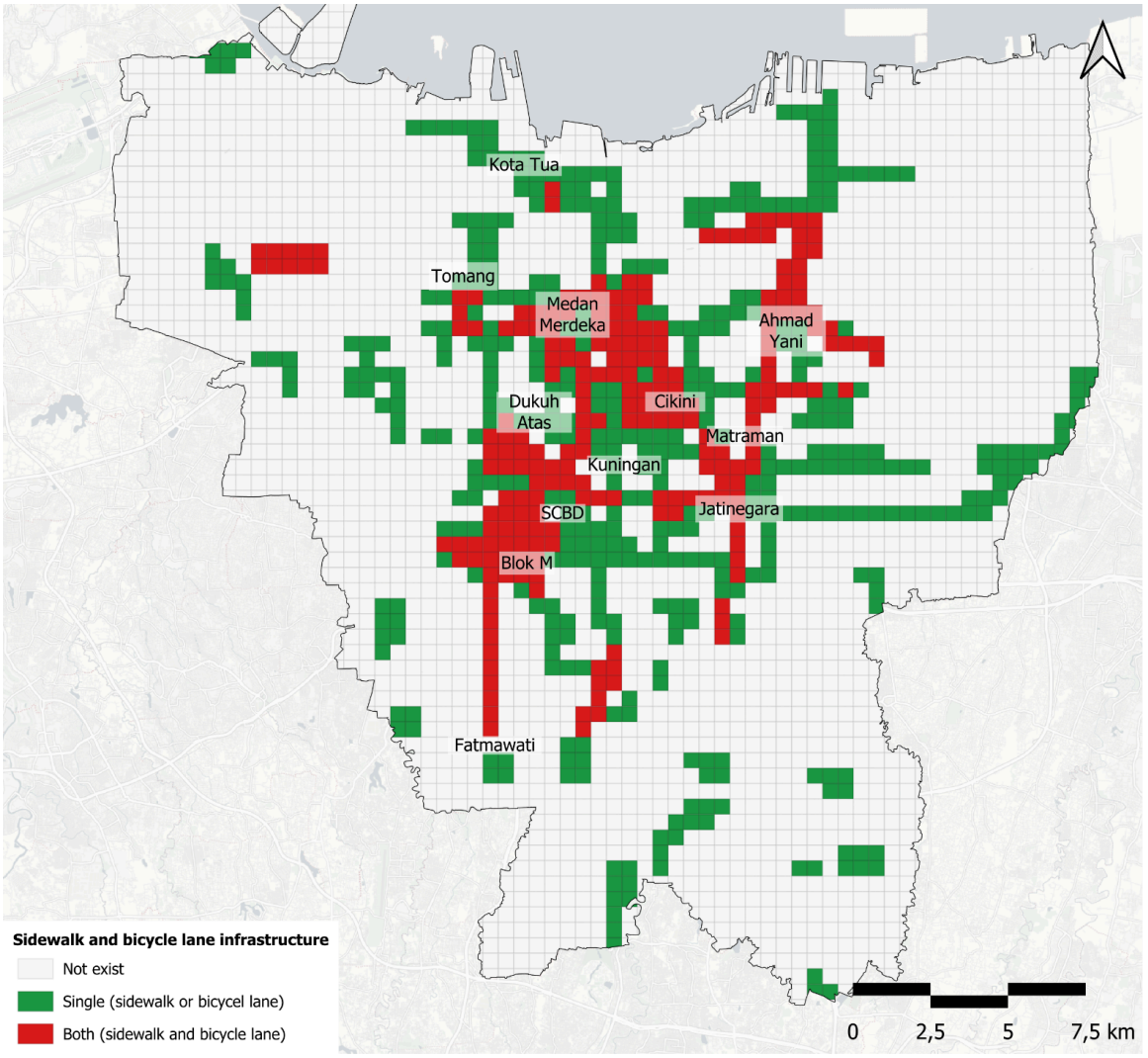


Figure 25. Matrix of walking and cycling infrastructure in Jakarta

4. Push policy implementation
    - Analysis and assumption

Shifting the use of public transportation must be supported by the policy to limit the use of private vehicles, with push policy as the strategy to ensure that objective. There are three main push policies with the consideration of area and corridor based intervention:

Ban on heavy-duty cargo vehicles

According to the Governor's Decree of Jakarta No. 5148 of 1999, access to heavy-duty cargo vehicles is restricted to 36 main roads located in several regions of Jakarta. These roads are classified into two types of restriction, the first being restriction of vehicles carrying cargo weighing 5.5 tonnes and above from 6 AM to 8 PM weekdays, and the second being the same restriction at two time frames: from 6 to 10 AM and from 4 to 8 PM weekdays. They are mainly located on Central Jakarta's busiest roads extending slightly to South, West, North, and East Jakarta. Trucks weighing 5.5 tonnes and above have also been banned from crossing Jakarta's inner ring road toll from 5 AM to 10 PM since 2011.

Odd-even policy

An odd-even vehicle policy was implemented in 2016 to restrict vehicles based on their registered number plate. Only vehicles with an odd-ended plate number are permitted to cross designated roads on odd dates. So, only vehicles with even-ended number plates can cross specific roads on even number dates. The odd-even policy is held in 26 road sections throughout Jakarta from 6 AM to 10 AM and 4 PM to 9 PM on weekdays. This policy is implemented based on Governor Regulation No. 88 of 2019 on Traffic Restriction by Odd-Even System. This regulation does not apply to motorbikes and all sorts of electric vehicles. Special vehicles like public transportation modes, ambulances, fire trucks, and governmental and military vehicles are also exempted from the odd-even policy.

Parking management in the TOD area

Transit Oriented Development (TOD) in Jakarta is defined as urban areas designed to comply with transit functions that are integrated with human activities and supporting buildings to optimise access to public transportation. Governor Regulation No. 31 of 2022 planned seven areas designated for TOD on the MRT corridors. One of the requirements in the TOD area is to limit the number of parking spaces by 50% of the existing capacity. This mandate ensures that more efficient space is used for human activity.

Figure 26 illustrates all of the considered push policies in Jakarta. The assumption to determine the matrix value of push policy is to determine if the matrix contains roads set as odd-even, cargo prohibition, and parking management in the area. As for the last aspect, it assumes all of the area within the radius of 500 metres is impacted by the parking management requirements, as set in the governor's regulation. One push policy will result in 0.35, while two push policies will be 0.7, and the matrix containing all push policies will get 1.

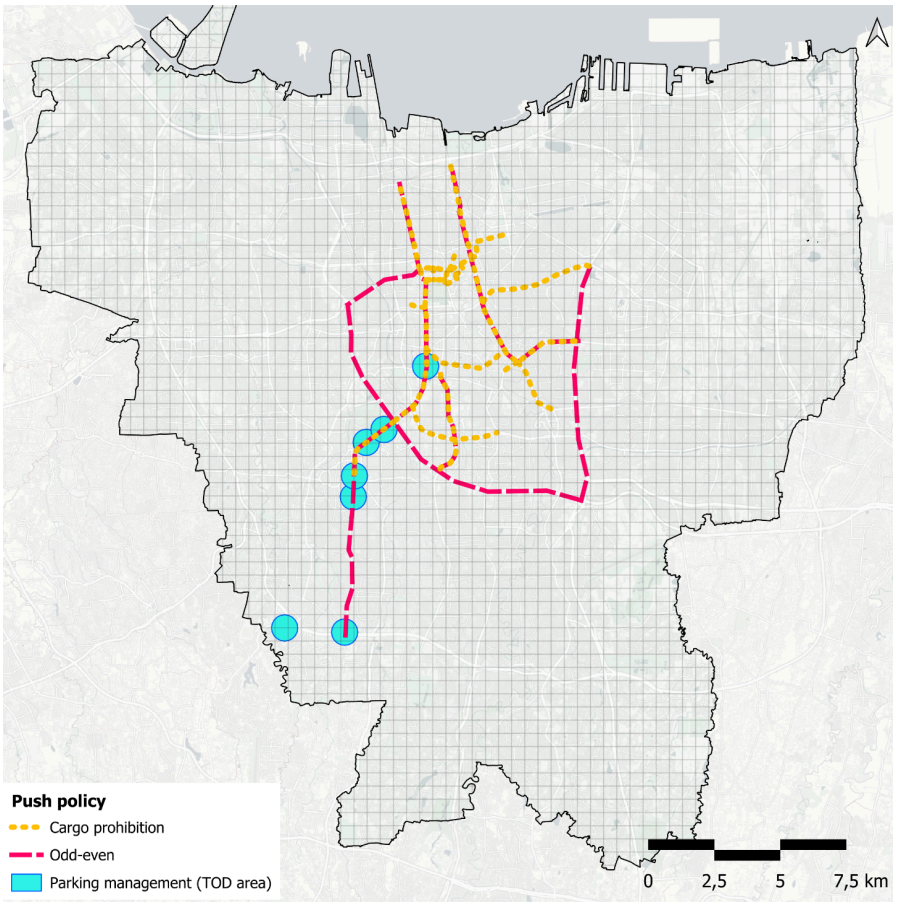


Figure 26. Push Policy in Jakarta

- Matrix of push policy.

Figure 27 illustrates the highest value matrix with the colour dark red, where three push policies were implemented and the opposite to dark green. The highest value matrix is located in Sudirman Street, where odd-even and cargo prohibition policy is supported with TOD area in Dukuh Atas, Istora Mandiri, Senayan and Blok M. Matrix with two policies is located in the corridor from central Jakarta to north Jakarta that reaches Kota Tua and Mangga Dua. The matrix with the single policy is mainly located on the inner toll road corridor.

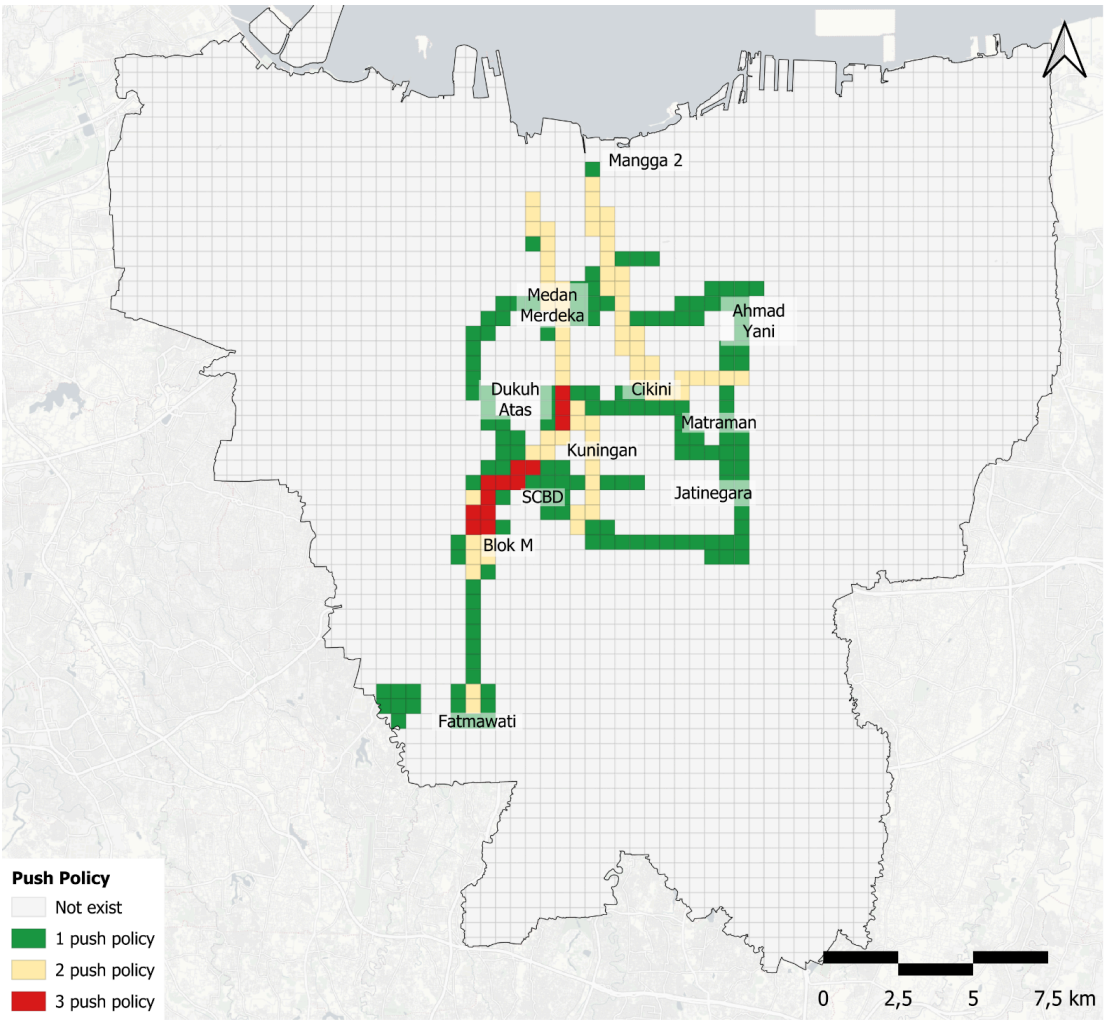


Figure 27. Matrix of push Policy in Jakarta

5. Active land use
    - Analysis and assumption

The active land use term describes the land use that potentially attracts mobility because of its specific function that needs limitations to reduce air pollution. The category of active land use includes the two major categories of economic and public services functions. The economic function covers the office, trade, mix used, hotel, transportation hub and tourism. The active land use with economic function is predominantly located in the north-to-south corridor of Jakarta from Kota Tua to Blok M with Hayam Wuruk, Thamrin and Sudirman Street. It also covers the east side of central Jakarta, from Kramat to Jatinegara.

Meanwhile, public services include education, health, administration, religion, and general facilities. Health facility is used by the vulnerable group of LEZ, which are people diagnosed with respiratory diseases from poor air quality conditions. If economic activity is concentrated in certain areas, the public services do not agglomerate, and it spreads across Jakarta.

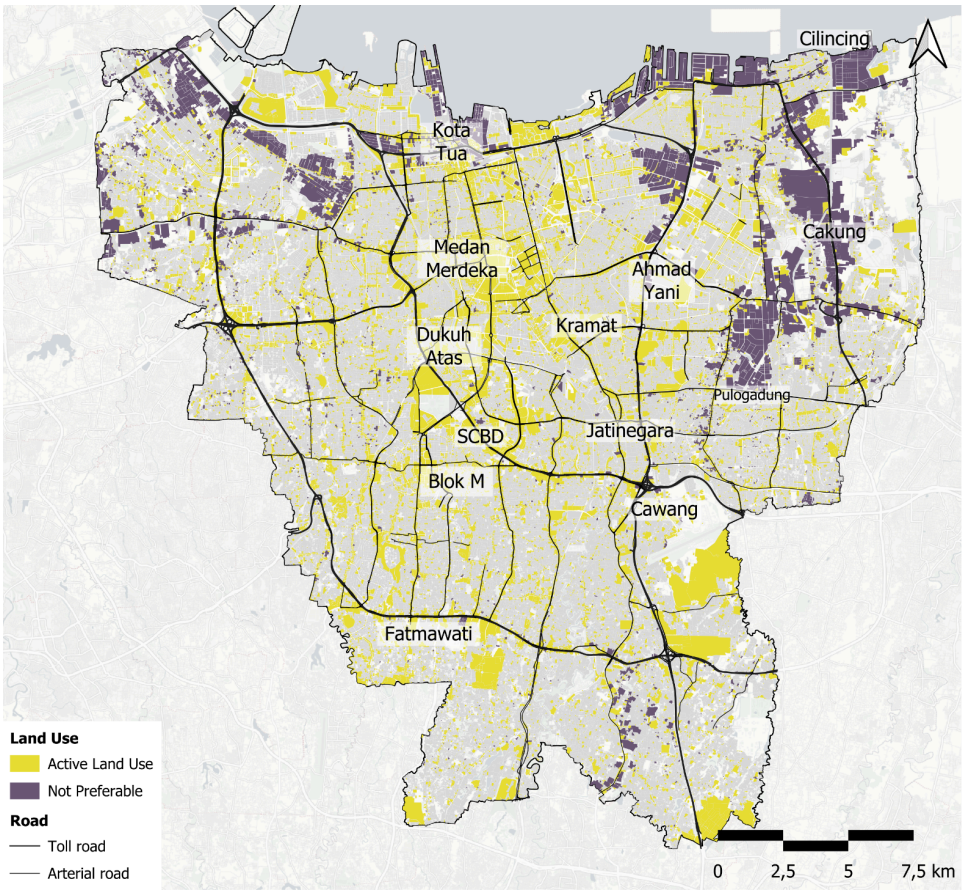


Figure 28. Active land use distribution in Jakarta

Conversely, the delineation of LEZ should avoid land use that generates emissions from their activity, such as industry and warehouse. The industrial and warehouse land use still needs logistic vehicles to mobilise cargo. LEZ in this area could still allow access to logistics by improving the minimum emission standard. This requirement will be explained in the next section. The industrial clusters are located in the eastern part of Jakarta, predominantly in Pulogadung and Cakung and the northern part of Jakarta in Tj. Priok and Cilincing.

The assumption to calculate the matrix value for land use indicators uses the area coverage of the active land use. It will be categorised into five main categories with values ranging from 0 to 1. If there is no active land use coverage, the value will be 0. If active land use coverage is 1 - 20%, it equals 0.25, 20 - 40% equals 0.5, 40 - 59% equals 0.75, and above 59% equals 1.

- Matrix of land use

Figure 29 illustrates the highest value matrix with the colour orange and the lowest value with grey. The concentration of high-value matrix is located in central Jakarta near Medan Merdeka, where most government buildings are located. A high-value matrix is also concentrated in Jakarta's central to the south corridor from Medan Merdeka, Dukuh Atas and Blok M, where the main

economic activity is located. In the south of Jakarta, two main clusters of offices are SCBD and Kuningan. Meanwhile, the northern part of Jakarta has a high matrix value in Glodok as the main area for mass-produced services and products.

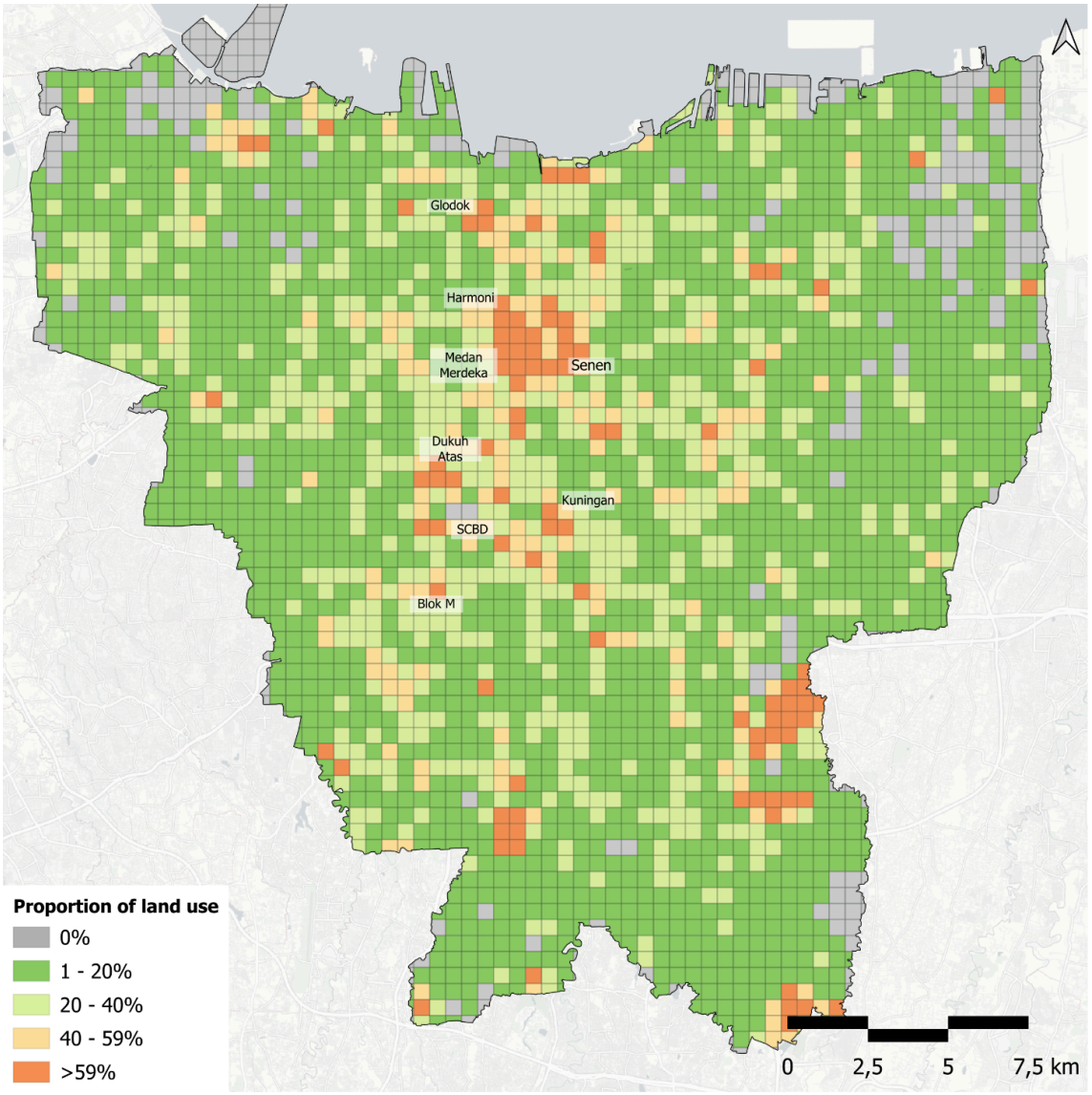


Figure 29. Matrix of active land use distribution in Jakarta

6. Population density
    - Analysis and assumption

The implementation of LEZ will impact the mobility of people living in the planned area. LEZ ideally should be prioritised in the area with low-density levels to ensure more efficient implementation and less resistance from people living in the area. The central to the south corridor of Jakarta has the lowest population density. This condition is caused by the existing land used for economic

activities. However, the population density is high when moved outside the main corridor into the other parts of central Jakarta, such as Senen and more to the east side.

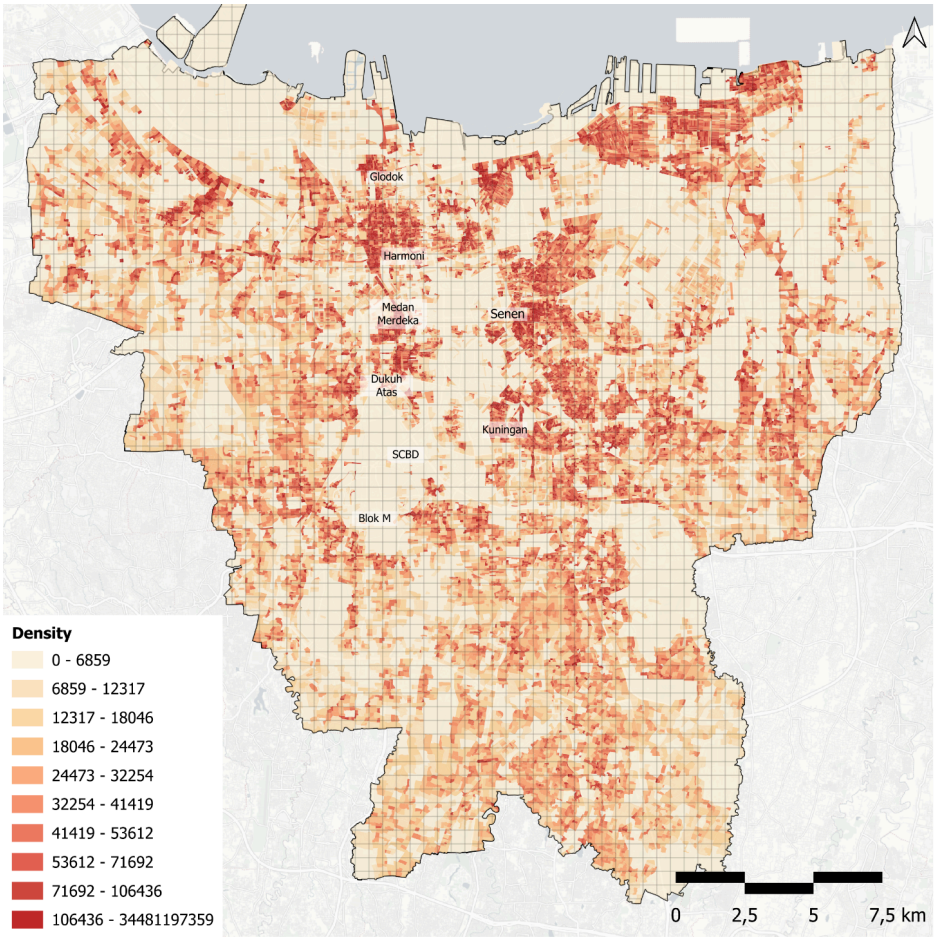


Figure 30. Population density in Jakarta

The assumption to determine the matrix value on a scale from 0 - 1 with ten categories. The lowest value of 0 will have the highest density. In contrast, the highest value will have the lowest density because the matrix value will prioritise the area with the lowest density for more efficient implementation.

- Matrix of residential density

Figure 31 illustrates the highest value matrix with the colour dark red, where lowest density located and the opposite with the colour dark green. The highest matrix value is located in the central to south corridor of Jakarta from Harmoni to Blok M, which is indicated with red colours. Similar results are also found in Papanggo, Pulogadung, Cakung, and Cilincing on the east side of Jakarta, where the industrial cluster is located. The colour green indicates a high density of people, whereas on the east, it is concentrated near Dukuh Atas, and on the east, it is mainly located in Kramat and Jatinegara.

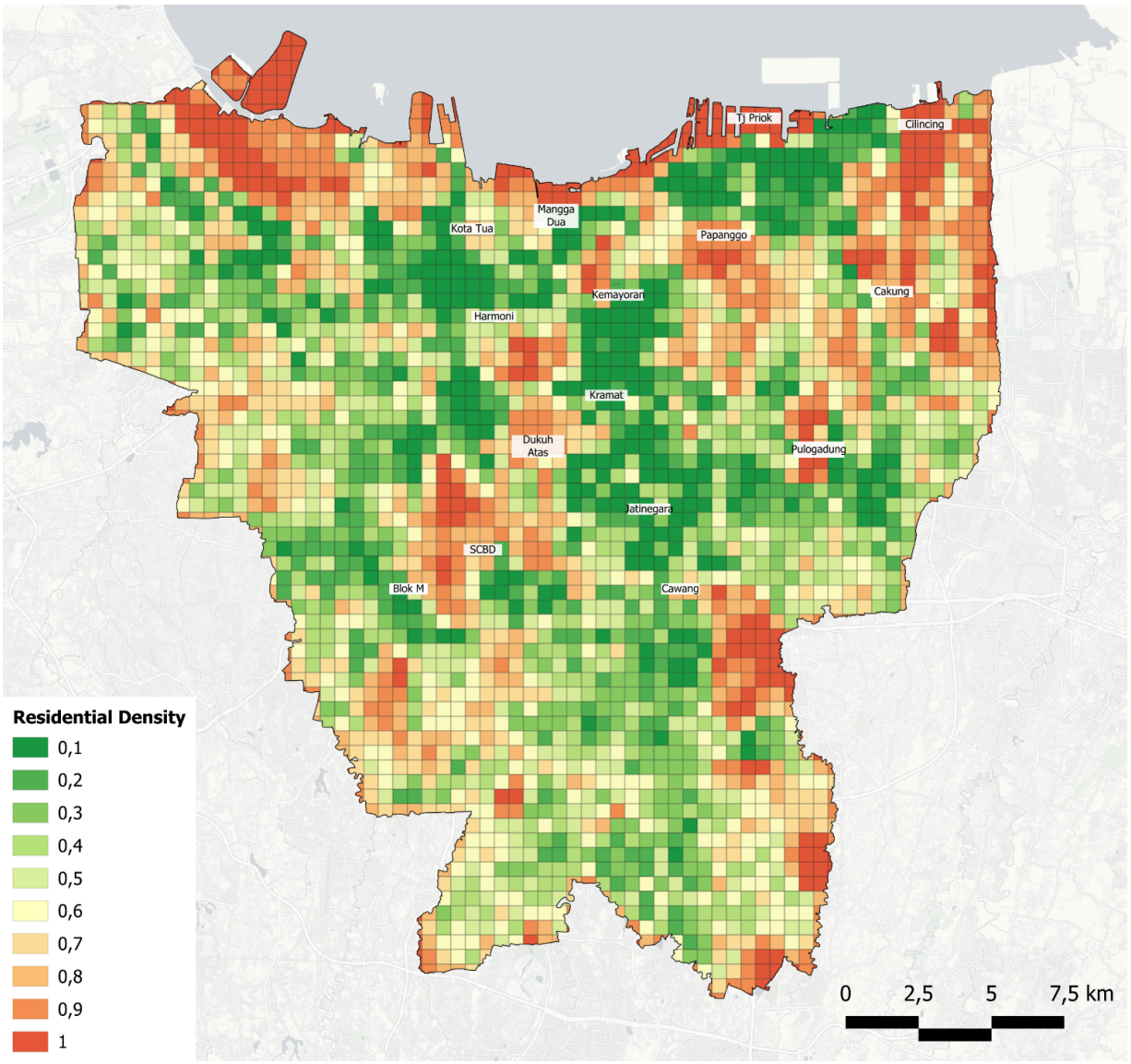


Figure 31. Matrix of population density in Jakarta

4.2.4. Participatory input for LEZ

Figure 32. Participatory engagement to determine the possible LEZ location in Jakarta

On 15th October 2023, ITDP held the Transport Demand Management (TDM) Festival, with one of its main objectives being to introduce the concept of LEZ to the public. ITDP created an installation of LEZ where people could indicate locations where LEZ should be implemented together with the reasons for it. Before putting their answer, an explanation about the concept and best practices of LEZ is explained to provide a better understanding of the concept. ITDP collected 120 qualitative data regarding the location and reasoning for the establishment of an LEZ from respondents who categorised the reasoning of the selected LEZ into seven categories:

- Need to provide accessibility to public transportation
- Availability of public transportation services
- Center of activity (shopping, park, recreation, culinary, exercise)
- High emission from truck
- High pollution area
- Need to limit vehicle traffic in the area
- TOD area

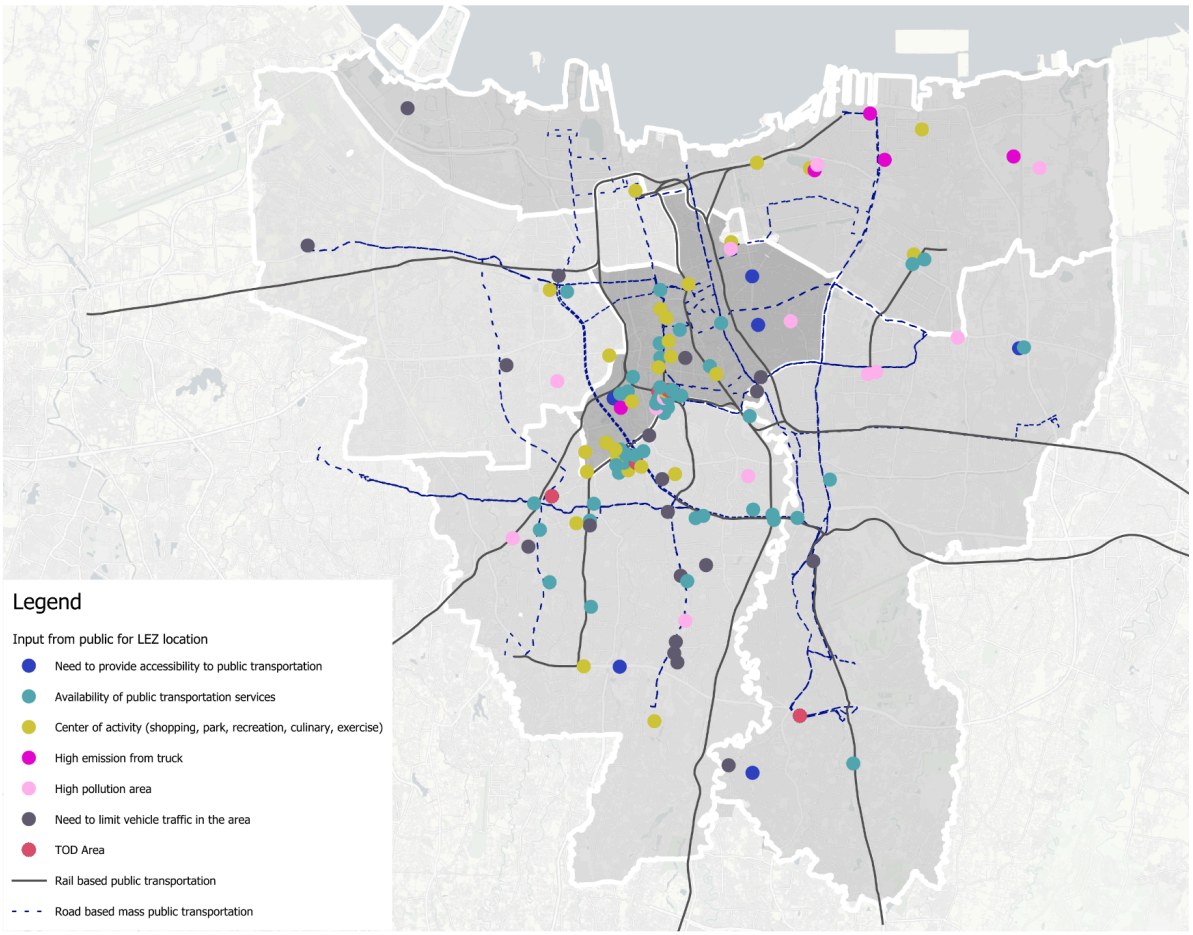


Figure 33. Public input for possible LEZ location in Jakarta

From the public perception, the main location for an LEZ is located in the North-South corridor of Jakarta for various reasons. The availability of public transportation is one of the main reasons for respondents because various public transportation systems, from commuter rail to MRT, LRT, and BRT Transjakarta, serve the area. They consider that people should shift from private vehicles to public transportation since the network is available. The second reason is mainly because the North-South corridor has various types of activity where people can experience cleaner air quality. These activities include shopping, parks, recreation, culinary and exercise.

Another interesting finding is that respondents recognise the LEZ needs to be implemented in the location with a high volume of vehicles. It is mainly located along the arterial road of Jakarta. Respondents also suggest that LEZ is implemented in the area with high mobility of heavy-duty vehicles as they emit a considerable amount of pollution. Respondents consider the north region of Jakarta to be the concentration of heavy-duty vehicle pollution.

4.3. Delineation of LEZ

All of the weighted indicators are summarised to indicate the total value of each matrix. The results are ranging from 0,03 to 0,855. The mean value of the result is 0,2521, with a standard deviation of 0,137 for the lower range and 0,369 for the upper range. The data distribution is not uniform, and applying equal quantile categorisation will be more appropriate to indicate the results of the matrix above the mean value as the priority for LEZ delineation. Matrix with a high possibility to become LEZ is indicated with the colour orange to red. Figure 34 visualises the concentration of high-value matrices in Jakarta and the possible delineation for LEZ location.

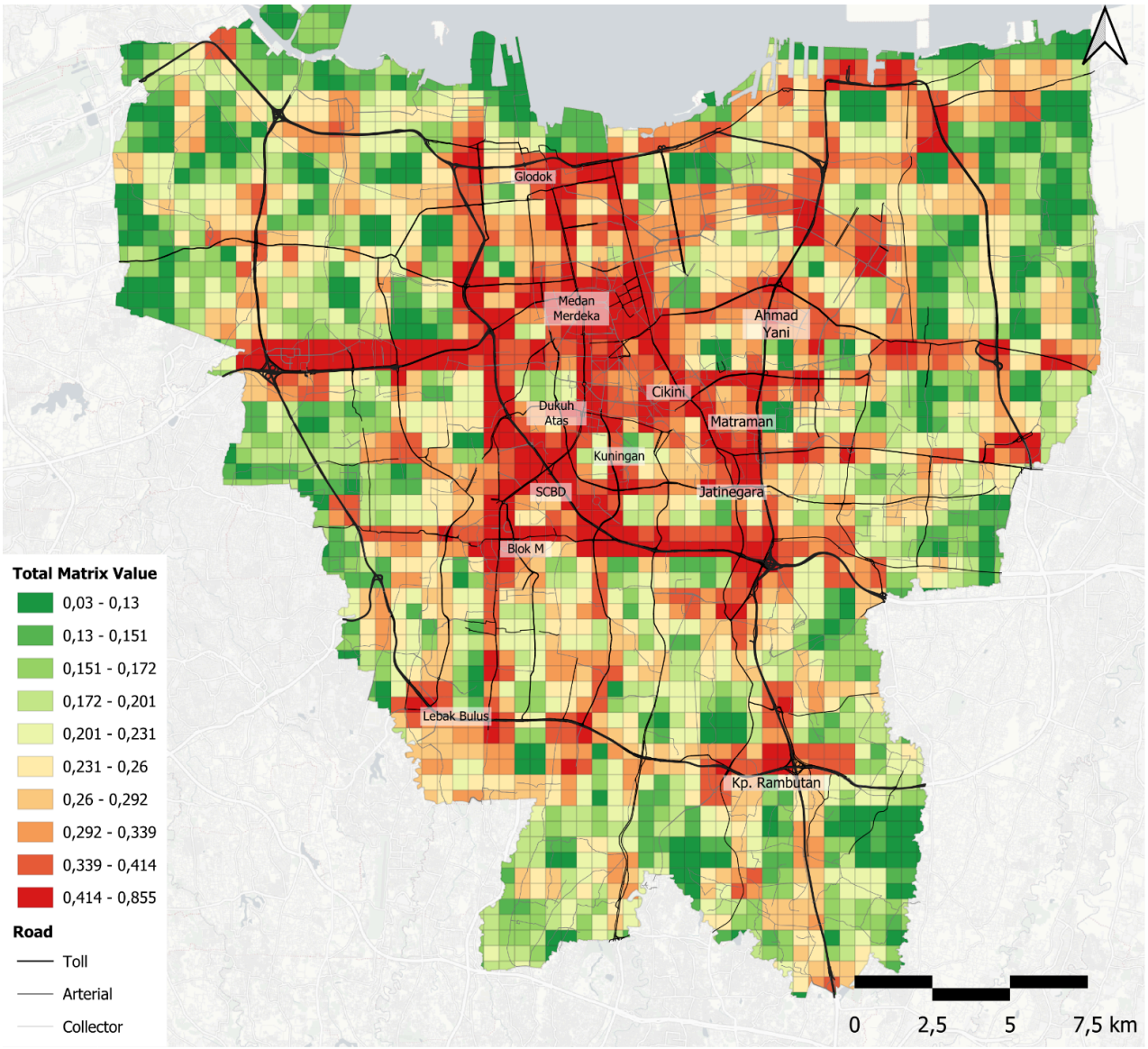


Figure 34. Total value of matrix of LEZ indicators

The delineation of LEZ in Jakarta is visualised in Figure 35 with the blue dashed line. It is based on the existing toll, arterial, and collector road network. The total area for LEZ delineation is 87.8 km2 which covers 13% of the total area of Jakarta. 1.8 million people are estimated to be residing inside the planned LEZ area.

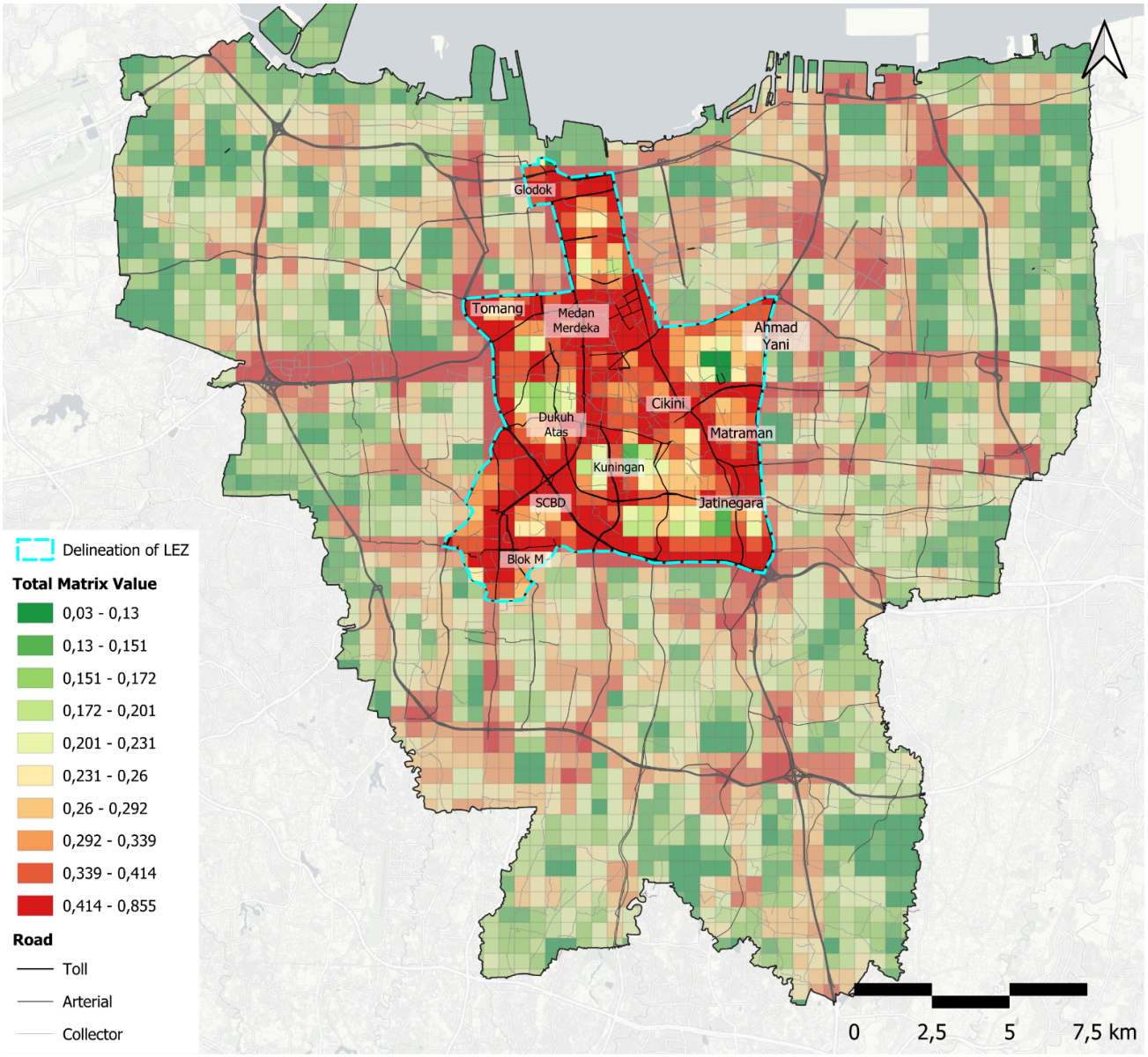


Figure 35. Possible delineation of LEZ in Jakarta

The high-value matrix concentration is located on Jakarta's main economic corridor from the central Jakarta of Medan Merdeka to the south of Jakarta, reaching SCBD and Blok M as the southern delineation. This area has the highest matrix score since the highest concentration of air pollution is situated and has the highest availability of public transportation, NMT infrastructure, and various push policy measures. The southern delineation also covers Gatot Subroto, which

extends to Tomang, as the corridor with the highest pollution from different types of vehicles. LEZ delineation covers other parts of central Jakarta, including Kuningan as the main office district with the newly opened mass public transportation of LRT Metropolitan Jakarta. Delineation covers east Jakarta, including Ahmad Yani, Matraman, and Jatinegara. The delineation of LEZ is integrated with the current LEZ initiative in the northern part of Jakarta in Kota Tua.

Overall, the success of LEZ implementation will be influenced by the availability of more sustainable transportation as the main mode of travel indicated by public transportation. In the LEZ delineation, there are 9 MRT stations, 24 commuter rail stations, 8 LRT stations, and 141 BRT stations which are supported by various feeder services. It is also supported by a massive network of sidewalks and bicycle lanes to ensure end-to-end mobility from the origin to the destination.

5. Roadmap for LEZ Implementation

5.1. Benchmarking of LEZ Implementation

Achieving a significant reduction of air pollution from LEZ implementation requires a long and deliberative planning process. Cities around the world implement LEZ with a step-by-step process to achieve the most ambitious plan. This subchapter will explain the phasing implementation of LEZ from the perspective of emission standard requirements and the area of implementation. Implementing LEZ will also require a deliberative planning process where public consultation needs to be in place before the implementation. This sub-chapter will provide a benchmarking study of planning preparation for LEZ.

5.1.1. Phasing of LEZ Implementation

A. Increasing the emission standard requirements

Explanation

The main objective of LEZ is to limit/reduce the use of highly emitting vehicles and push for more environmentally friendly vehicles. This aim can be achieved by regulating the requirements for LEZ that are usually based on the combination of:

- vehicles emission standard (e.g., Euro 3) or vehicle year (maximum operation of 10 years)
- types of vehicles (e.g., heavy goods vehicle, passenger cars), and
- types of engines (e.g., diesel, petrol, electric vehicle)

The enforcement should aim for the highest emission standard possible to achieve the most meaningful impact. However, it will require a lot of effort and resources to implement it, and there is the possibility of objection from the public. Vehicle requirements could start with less demanding vehicles and increase progressively. Cities need to understand the share of vehicle classes in the city and their impact on air pollution. In the first step, the prohibited vehicle classes should be the ones that give the maximum emission reduction with the least effort. One of the great examples comes from Seoul, South Korea, where the limitation of Heavy Duty Vehicle (HDV) that only accounts for 10% of total vehicles could contribute to the reduction of 53.4% of PM 2.5 in 2012 (Yang et al., 2022).

It is crucial to ensure that the standard for LEZ gets stringent over time because as the vehicle's compliance rate increases, the air pollution reduction will be insignificant over time. Therefore, the requirements should be upgraded until it ultimately reaches the zero-emission vehicle and practically transforms the LEZ into ZEZ.

Limitation with the basis of vehicle emission standards is the ideal approach to limit the emissions for different types of vehicles. However, massive emission testing activity is required for all of the vehicles in the city to be assigned to the specific emission category. If the effort to conduct emission testing activity is limited, officials could limit the vehicle based on the maximum number of years of operation of the vehicle. For example, if a city has a maximum vehicle operation of up to 10 years, the implementation of LEZ in 2025 will only allow for vehicles produced after 2015. This approach uses vehicle operation years as a proxy for the emission standard since older vehicles will have higher emissions.

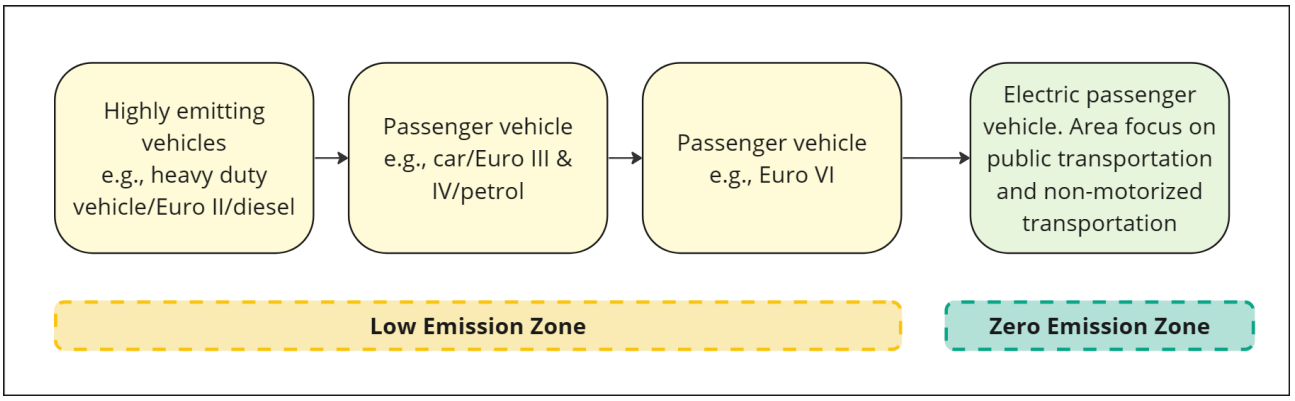


Figure 36. Phasing implementation of a vehicle emission standard for LEZ

Best practice (Brussels, Paris)

Cities around the world have tried to limit the polluting vehicles from entering LEZ progressively. These are several examples of their program.

- Brussels, Belgium

Brussels has developed the phasing plan up to 2025 since the LEZ was established in 2018. For instance, in 2025, only Euro III or above petrol or LPG or CNG cars would be allowed to enter the LEZ area. Table 11 below shows Brussels' LEZ requirement plan up to 2025 for petrol, LPG, and CNG cars (Bruxelles Mobilite, 2018).

Table 11. Brussel's LEZ Requirements Timetable for Petrol/LPG/CNG Vehicles

Petrol/LPG/CNG	2018	2019	2020	2021	2022	2023	2024	2025
Euro 6, 6b, 6d, temp/VI	Access	Access	Access	Access	Access	Access	Access	Access
Euro 5, 5a, 5b/V or EEV	Access	Access	Access	Access	Access	Access	Access	Access
Euro 4/IV	Access	Access	Access	Access	Access	Access	Access	Access
Euro 3/III	Access	Access	Access	Access	Access	Access	Access	Access

Petrol/LPG/CNG	2018	2019	2020	2021	2022	2023	2024	2025
Euro 2/II	Access	Access	Access	Access	Access	Access	Access	No Access
Euro 1/I	Access	No Access	No Access	No Access	No Access	No Access	No Access	No Access
No Euro Standard	Access	No Access	No Access	No Access	No Access	No Access	No Access	No Access

- Paris, France

France developed a national classification of vehicles under the CRIT'Air program in 2016. This certification is based on the vehicle type, fuel type, and emission standard using a number classing and represented by windscreen stickers with different colours. There are six classifications, with 'Green' as the highest or cleanest category while number '5' is considered the worst category represented by the darker colour. Cars registered before January 1997, motorbikes or scooters registered before June 2000, and trucks and buses registered before 2001 are ineligible for this classification and cannot enter the restricted area. Besides, diesel and petrol vehicles with the same 'Euro' standard are not considered equal, while diesel vehicles are considered more dangerous (Bernard et al., 2020). For passenger cars, the CRIT'Air classification is presented below.

Table 12. Passenger Cars CRIT'Air Classification

CRIT'Air Class	Sticker	Eligible Cars
Green		• Battery-electric vehicles • Hydrogen fuel cell vehicles
1		• Gas-powered vehicles • Plug-in hybrid-electric vehicles • Petrol and hybrids Euro 5 and 6
2		• Petrol and hybrids Euro 4 • Diesel Euro 5 and 6
3		• Petrol and hybrids Euro 2 and Euro 3 • Diesel Euro 4
4		• Diesel Euro 3

CRIT'Air Class	Sticker	Eligible Cars
5		• Diesel Euro 2
Unclassified		• Petrol and diesel Euro 1 and earlier

With this classification, the city's government could enforce LEZ according to their local needs. In Paris, they introduced two levels of LEZ in the Central Paris and Greater Paris. For the Greater Paris area, the government initially limited vehicle access under CRIT'Air 4 in 2019 and upgraded it to Crit'Air 3 in 2021. Both of the LEZ implementations in Paris aim to tighten the standard up to green classification by 2030. The detailed phasing of vehicle criteria can be found in Table 13.

Table 13. Paris' LEZ Requirement Time Table

	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
	Min. CRIT'Air 5	Min. CRIT'Air 4	Min. CRIT'Air 3	Min. CRIT'Air 2	Min. CRIT'Air 1	Min. Green CRIT'Air
City of Paris	July 1, 2016	July 1, 2017	July 1, 2019	2022	2024	2030
Greater Paris		July 1, 2019	January 1, 2021	July 2022	January 2024	2030

B. Expanding the LEZ area of intervention

The coverage area for the implementation of LEZ plays a crucial role in determining the impact of reducing air pollution in the city. In principle, the coverage of a LEZ should be large enough and cover a high number of activity centres to force people to shift to cleaner transportation modes, not just merely using the adjacent routes to avoid the LEZ. However, there is no definitive minimum size of LEZ, and a city could also start from a smaller area to allow the residents to experience the benefit, thus gaining better support. Nevertheless, it should be noted that the smaller the area, the less impact it would deliver, as there are more ways to avoid it.

There are two important considerations in determining the phasing for LEZ: start from a high-activity area and a monocentric area. The previous subchapter has explained the overall area for LEZ according to the set indicators. The first phase of LEZ could be started with smaller scale intervention where high mobility of vehicles occurs with the least negative hurdles in the implementation. It could start from the area with the least density and the land uses of commercial, office, and mixed-use since it will not significantly limit people's mobility. Meanwhile, the monocentric and larger LEZ should be preferred compared to multicentric and smaller LEZs as it would be more demanding for drivers. A group of smaller LEZs would likely only offset the traffic and the pollution to the area's perimeter.

In conclusion, two layers of LEZs could be implemented to tackle the city's different issues of motorised traffic. Usually, the outer LEZ would cover all of the city with less demanding standards, while the inner cover the central part with more advanced restrictions, as illustrated in Figure 37. As the number of vehicles adjusting their standard with the LEZ criteria increases, the number of vehicles accessing the LEZ area would also increase, thus increasing the concentration of air pollution to the initial level. This condition will diminish the initial objectives of lowering air pollution as experienced by the city of Milan, which will be covered in the next section. Implementation of LEZ should always strive for further increase of emission standards, and it may also aim for Zero Emission Zone (ZEZ) to solve the issue in long-term planning.

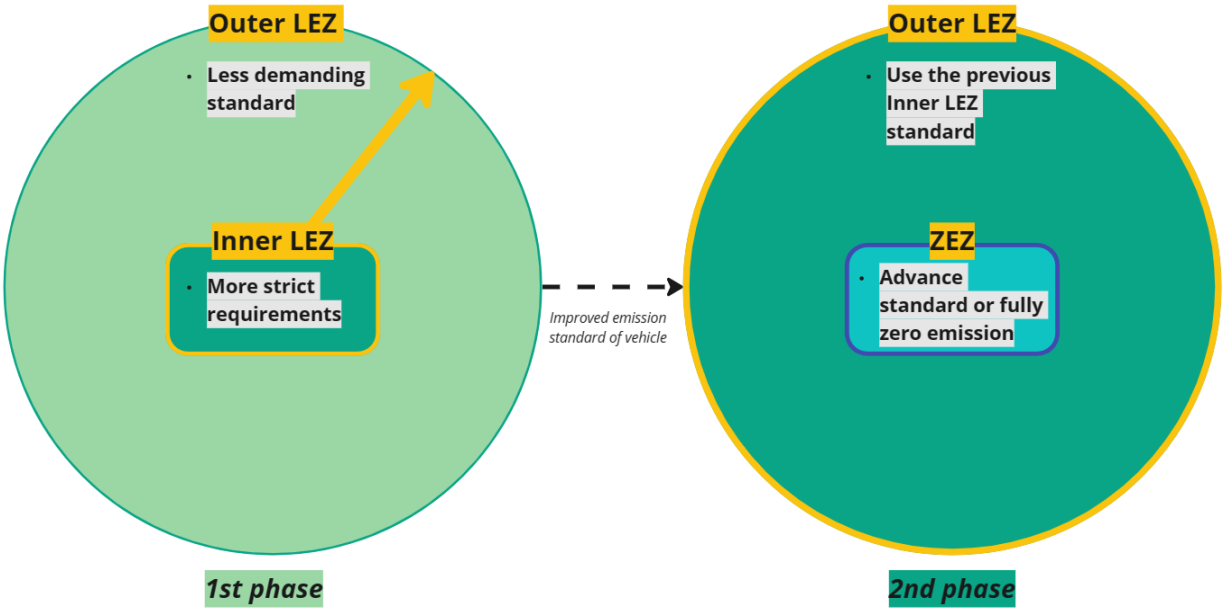


Figure 37. Phasing implementation of LEZ area expansion

Best Practice (London, Milan, Seoul, Amsterdam)

- London, UK

Preparation for the ULEZ implementation in London has been started since 2014 before its initial implementation in 2019. The consultation process of ULEZ started in 2014 and continued until early 2017, involving relevant stakeholders, as mentioned previously.

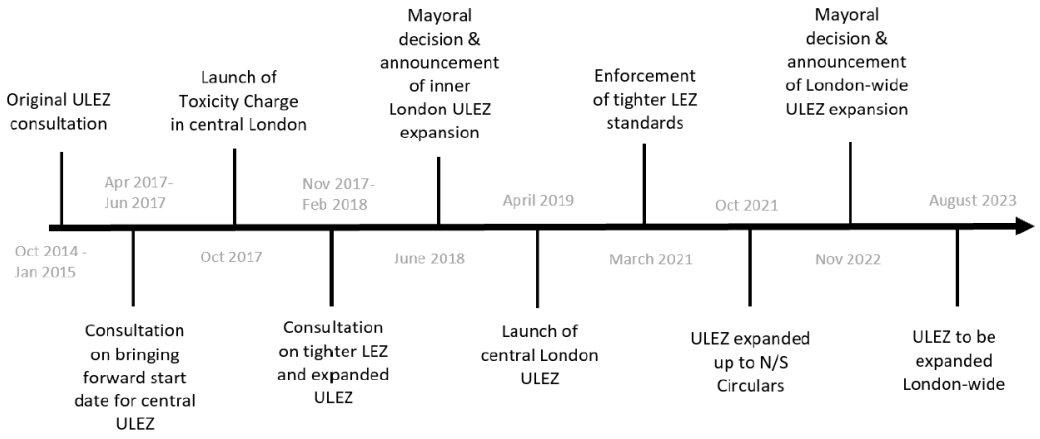


Figure 38. ULEZ implementation planning phase in London (source: london.gov.uk)

Before implementing ULEZ in 2019, the City of London London introduced Toxicity Charges as the transition program. Toxicity Charge (T Charge) was implemented in 2017 in central London, targeting vehicles with a minimum standard of Euro IV for all four-wheeled vehicles. During the implementation, the city still conducted public consultations in preparation for announcing ULEZ in 2018. One year later, in 2019, ULEZ was implemented as more standards were imposed for diesel vehicles from Euro IV to Euro VI.

Table 14. Phasing implementation of LEZ in London (source: london.gov.uk)

Implementation Stage	Start Date	Vehicle Targeted	Minimum Euro Standard
LEZ First Stage (Greater London)	February 2008	/HDV (weight > 12 tonnes)	/Euro III (PM emission)
LEZ Second Stage (Greater London)	July 2008	/HDV and others (weight > 3.5 tonnes) /Bus (weight > 5 tonnes or more than 8 passenger seat)	/Euro III (PM emission)
LEZ Third Stage (Greater London)	January 2012	/HDV /Bus /MDV (weight >1.2 tonnes) /Minibus (weight < 5 tonnes or more than 8 passenger)	/Euro IV (PM emission)
LEZ Fourth Stage (Greater London)	2015		/Euro IV (PM emission) /Euro IV (NOx emission) for HDV and Bus
ULEZ First Stage (Central London)	April 2019	/Petrol cars /Diesel cars /Motorcycles	/Petrol car (Euro IV) /Diesel car (Euro VI)
ULEZ Second Stage (Expanded to N/S Circular)	October 2021		
ULEZ Third Stage (London Area)	August 2023		

One of the best practices of LEZ implementation is in London, with the initial concept of LEZ that later developed into ULEZ. The implementation of LEZ initiatives is implemented in phases for 15 years. The initial conception of LEZ aims to curb emissions from the highest emitter, which are the logistic vehicle in a citywide scale area of Greater London. Stage 1 of the LEZ initiative was implemented in 2008 that specifically targeted Heavy Duty Vehicle (HDV) weighted above 12 tonnes. The implementation moved to the second stage, where more types of vehicles with HDV weighed more than 3 tonnes and buses were included. The third and fourth phases improve the type of vehicles included in the limitations and the minimum emission standard to Euro IV.

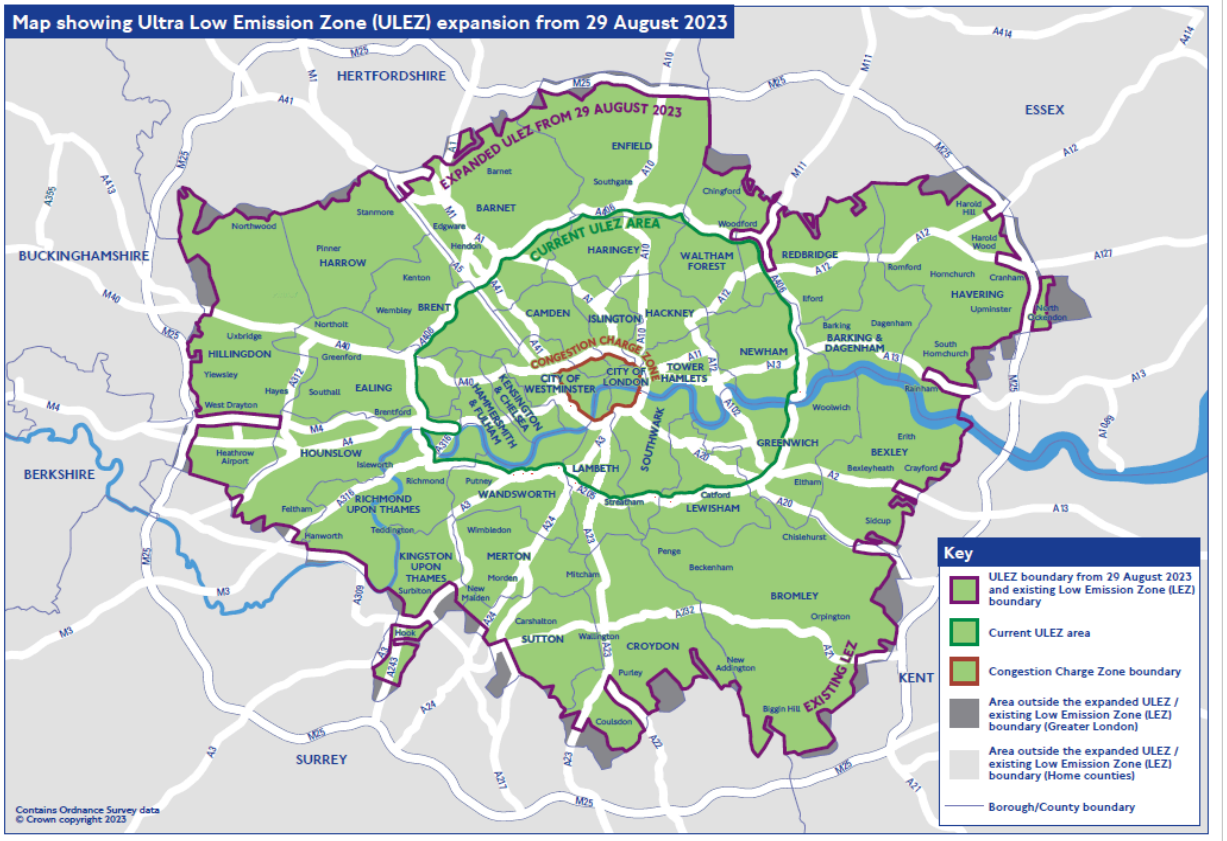


Figure 39. ULEZ implementation area in London (source: tfl.gov.uk)

With the success of limiting emissions from the logistic vehicle in the city scale area, the city of London moves on to the following conception of LEZ, which is the Ultra Low Emission Zone (ULEZ). This concept will expand the vehicle category to include passenger vehicles, including petrol cars, diesel cars, and motorcycles. The first phase of ULEZ was implemented in 2019, with a small-scale area of implementation that covers only Central London (21 km2). The area of implementation was expanded 18 times in 2021, with a total area of 380 km2. The expansion has successfully reduced 20% of the NOx in Inner London. The final expansion has recently been implemented, covering all 32 London boroughs.

- Milan, Italia

To discourage the use of polluting private vehicles inside the central area, in 2008, Milan implemented a LEZ policy with the name of Ecopass. It was a pollution charge for motorised vehicles based on the PM10 emission level, covering 8.2 km^2 or approximately 4.5% of the city. The implementation area was downtown Milan, with land uses for commercial, residential, office, and industrial, estimated to cover 5% of the total population. It was estimated that the reduction of the pollutants reached 20% for PM, 16% for NOx and 15% for CO_2 (Sevino, 2017).

As the exempted vehicle usage rate increased, the traffic was back in the area, diminishing the effect of the Ecopass. Milan then introduced a new scheme in 2012 called Area C, replacing the Ecopass program within the same area. Principally, Area C is a congestion charging scheme as Milan aimed to decrease the overall vehicular traffic to the area, active from Monday to Friday from 7.30 am to 7.30 pm. The charge is flat 5 Euro per day for all vehicles except electric and hybrid vehicles. Gasoline vehicles pre-euro and diesel vehicles Euro 3 or below are forbidden to enter the area (Ku et al., 2020). From 2012 to 2016, the implementation of Area C reduced traffic to 37.7% and polluting emissions to 18% of PM 10, 10% of NOx, and 22% of CO_2 (Sevino, 2017).

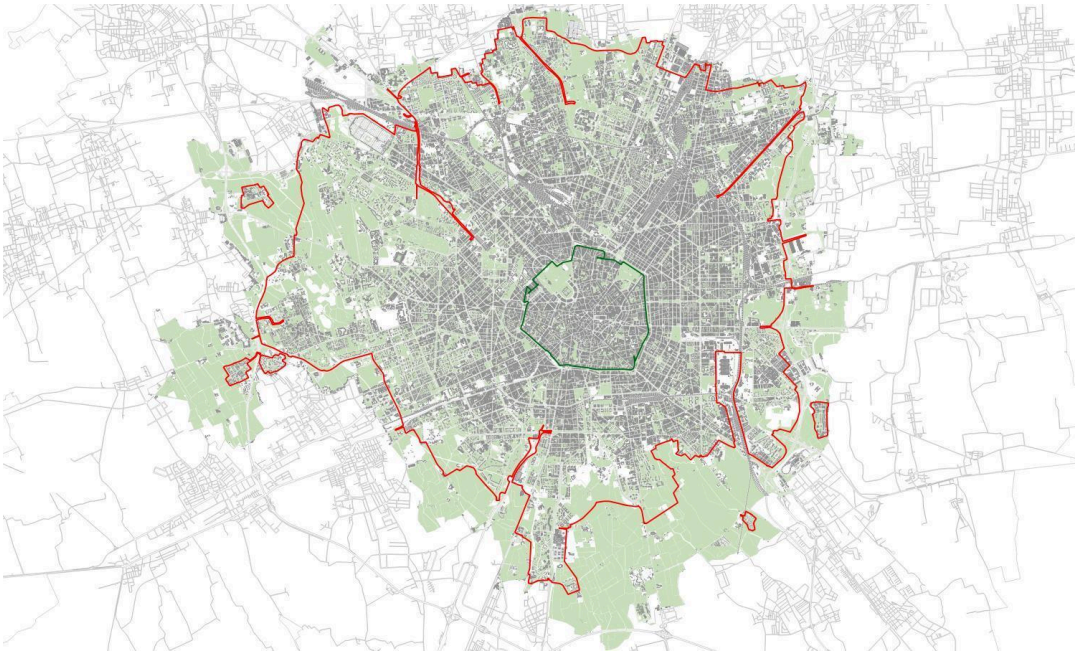


Figure 40. Maps of Milan's Area B (red line) and Area C (green line) (source: comune.milano.it)

Furthermore, since 2019, Milan has also introduced Area B, which acts as the city-wide LEZ. It occupies 132 km^2 or almost 70% of the city area and 97% of the population, making it one of the largest LEZ in Europe. Similar to the Ecopass, this intervention is established to restrict most polluting and heavy vehicles from entering the city, but only from Monday to Friday from 07.30 to 19.30, and exclude the holidays. It initially required petrol LDV to be at least using the Euro 1 standard, while the diesel had to comply with the Euro 4 and would be progressively tightened over time. Milan has developed and published a timetable for the emission standard restriction

and aims by 2030 that all diesel cars be banned from entering Area B and fossil-fuelled vehicles prohibited from entering Area C.

- Seoul, South Korea

The city of Seoul conducts different approaches to implementing LEZ, and they decided to limit the LEZ on the city scale first. Since 2012, Seoul has restricted the grade-five diesel vehicles or diesel cars manufactured before 2002 or 2005 entering the city, and it operates 24 hours a day. In 2019, the Seoul Government permanently introduced the Green Transport Zone after six months of the pilot program as it aims to reach the goal of cutting PM 2.5 concentration to 15 $\mu g/m^3$ by 2025. The restriction occupies 16.7 km^2 of the city centre (within the city walls) and only operates from 6 am to 9 pm. This zone imposes higher standards by limiting grade 5 diesel vehicles and including grade 5 petrol vehicles. Figure 41 explains the area implementation of LEZ in Seoul and the equivalent criteria of grade standard in Seoul with Euro standard. A reduction of 41% of grade-five vehicles entering the zone was seen after the introduction of the Green Transport Zone (C40 Cities, 2020).

Figure 41. Maps of Seoul's Green Transport Zone (source: C40 Cities, 2020)

- Amsterdam, The Netherlands

One of the most ambitious cities to implement the Zero Emission Zone (ZEZ) is the city of Amsterdam, Netherlands. As a well-established city for walking, cycling, and public transportation infrastructure, they plan to implement ZEZ in major areas by 2030 (C40 Cities, 2020). The first important milestone has already been undergone with the prohibition of diesel engine vehicles from entering the city centre area in 2020. The pathway to ZEZ will be in two steps; the first phase will be implemented in 2025, where all vehicles must be emission-free within the A10 ring road, and the second phase, where all traffic within the built-up area must be emission-free. Figure 42 illustrates the phasing of ZEZ in Amsterdam.

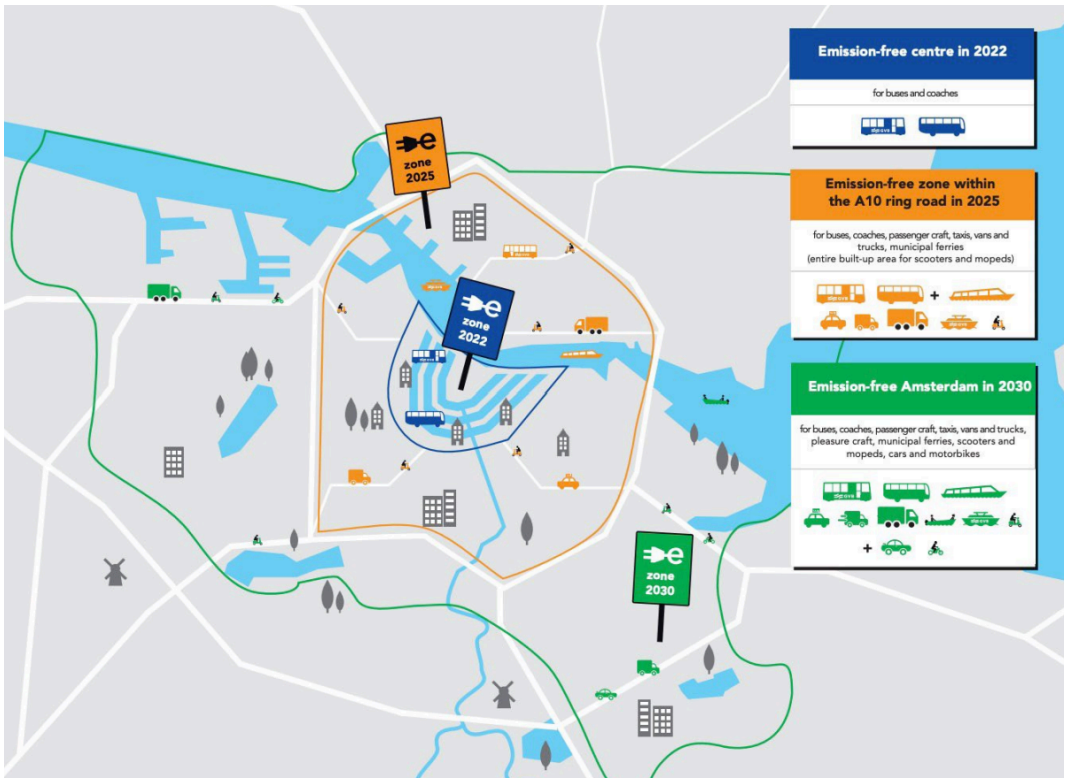


Figure 42. Map of ZEZ plan in Amsterdam (source: C40 Cities, 2020)

5.1.2. Implementation type of LEZ

A. Restriction mechanism

The restriction mechanism of the LEZ could be adjusted mainly through fee-charging and non-price schemes. In addition, the restriction based on the operational hours also determines its stringency.

Price scheme

The price scheme LEZ will charge non-compliance vehicles a certain fee when entering the LEZ area. As a vehicle emits higher emissions, it will receive a charge according to the emission type of the vehicle. Vehicles will be required to pay a fee every time they enter the area if their vehicle emission does not meet the standard and will be subject to a penalty if they do not pay the fee within the stipulated time.

The positive aspect of the price scheme is that it still allows vehicles to travel while discouraging them with disincentive mechanisms. However, this scheme will be politically challenging and require high capacity. Similar to the Electronic Road Pricing (ERP) program, the pricing scheme will require a transparent and accountable financing mechanism because every fee that is being paid must be reinvested for the operation of LEZ system and program that contributed to the objective of LEZ.

Figure 43. ULEZ implementation in London (source: alamy.com)

London has been implementing LEZ under the Ultra Low Emission Zone (ULEZ) mechanism since 2019 in the inner area of its city with the coverage of 21 km2. In the ULEZ area, the minimum standard for motorcycles is Euro III, Euro IV for petrol cars, and Euro VI for diesel cars. Vehicles that do not meet the criteria must pay a sum of GBP 12.5 or IDR 240,000. If the driver does not pay the charge within 14 days, a penalty of GBP 180 or IDR 3.4 million will be given.

Non-price scheme

The non-priced LEZ prohibits high-emission vehicles from entering the LEZ area entirely. Unlike the price scheme that gives leniency for drivers, the non-price scheme will provide a penalty from the beginning for cars that do not comply with the minimum emission standards. They must shift to a cleaner vehicle or upgrade it by installing a particular filter. The advantage of the non-price scheme is that it will achieve the objective of limiting access for high-emission vehicles as the enforcement is more stringent than the price scheme. It is also more politically palatable than priced LEZ, because non-price schemes do not charge per entrance into the zone. Several cities have implemented the fine for entering the LEZ for non-compliant vehicles in Lisbon is USD 120; in Seoul, it is USD 212; in Brussels, it is USD 350.

Operational hours (activity/weekdays only/all day)

The restriction mechanism of LEZ is also supported by the operational hours limitation. LEZs around the world have different operational hours. While some cities operate the LEZ 24 hours per day, other cities only enforce the LEZ for a certain period of time, mainly during people's activity hours. London, for instance, applies the LEZ 24/7 and even includes public holidays, as also done in Brussels. Paris, meanwhile, only enforces the LEZ from 8 am to 8 pm on weekdays, and Seoul

applies the LEZ from 6 am to 9 pm but all days a week, including public holidays. Each city might operate the LEZ differently, adjusting to the characteristics of the city.

Operating LEZ within a certain period of time might maintain accessibility for some, especially for freight delivery which often happens to use polluting vehicles. Outside activities hours mean fewer people would be exposed to air pollution during the non-LEZ hour. However, an LEZ ideally should be operated all days a week to have better impact and not cause air pollutant accumulation during the non-LEZ hour. Implementation of LEZ in Old Town Jakarta shows the concentration of PM2.5 is at its highest during the night to early morning (Yulinawati, 2022). This might be caused by the mobility of HDVs for logistic purposes in the northern part of Jakarta. This example shows the importance of implementing LEZ at all times.

B. Enforcement approach

To achieve the emission reduction target, a robust and effective enforcement strategy is required to ensure public compliance with the policy. There are mainly two approaches to LEZ enforcement which are automatic enforcement and manual enforcement. Both have their benefits and drawbacks, with automatic enforcement offering more robust enforcement although requiring more capital investment.

Automatic: ANPR/RFID/others

Common automatic enforcement for LEZ is using Automatic Number-Plate Recognition (ANPR) technology which uses Optical Character Recognition (OCR) to read vehicles' registration plates. It will then match with vehicle databases, which contain vehicle information such as the emission standard, to identify the eligible and ineligible vehicles where ineligible vehicle owners will be fined accordingly. The benefit of this automatic approach is that the enforcement could be done continuously and will allow better data collection, including the vehicle compliance rate as one of the parameters of LEZ success.

Figure 44. ANPR technology implementation in Seoul (Source: trueinitiative.org)

Seoul is one of the cities that implement the ANPR mechanism to detect and enforce the non-price LEZ scheme. If a non-compliant vehicle enters the Green Transport Zone, the car will be automatically detected, and a penalty will be charged. CCTV will identify the number plate and match it with the database of all vehicle emission criteria. It confirms and notifies the car owners within 5 seconds. The system monitors all of the data in real time and recognises the number plates of vehicles with the help of AI Deep Learning technology. It also uses a Big Data Chatbot to send messages to the drivers to minimise civil administrative service.

ANPR itself is not a new system in Indonesia. In developing electronic traffic law enforcement (ETLE), the Indonesian National Police is utilising the ANPR to capture traffic violations and plate numbers. As of February 2023, all 34 regional policies in Indonesia have implemented the ETLE system with 295 static cameras and 795 hand-held cameras.

Utilising ANPR cameras for LEZ could be aligned with the development of ETLE. Currently, the odd-even policy is already enforced using the ANPR cameras for several points in Jakarta. In principle, the utilisation of ANPR camera for LEZ would be similar to the application for odd-even policy, where the camera would be placed in the entry point of the area to check whether the incoming vehicles are eligible or not based on the vehicles' plate number.

Manual enforcement

Manual enforcement might be a suitable option for enforcing LEZ, especially during the initial phase, where it usually applies in smaller areas and fewer vehicles are affected. For instance, many cities started the LEZ from heavy-good vehicles, which have distinguished features and fewer in number. Cities like Paris and Berlin use this manual approach to enforce their LEZ. Compared to the automatic approach, it is quicker and easier to implement.

Figure 45. Manual enforcement of CRIT'Air policy in Paris

Manual enforcement is indeed less effective than the automatic approach and requires enormous human resources. In order to improve the efficiency, as the plate number does not show the emission standard, windshield stickers that represent the emission standard should be used. Paris could be the leading example with its CRIT'Air stickers that represent the category of emission standards. Figure 45 illustrates the emission standard of vehicles represented by stickers that must be visible from the outside. The LEZ area is indicated by a traffic sign to remind drivers if their vehicle is following the standard. If a vehicle does not conform to the emission standard, police will enforce it by imposing a penalty on the non-compliant vehicle.

5.1.3. Impacted group from LEZ implementation

Planning preparation for LEZ will require the identification of groups that the policy will impact. LEZ implementation in London has provided an overview of the group that raises concerns for the LEZ implementation. Table 15 lists all business organisations and stakeholders, such as bus operators, environmental agencies, freight transport, health agencies, automotive organisations, taxis, and transport campaign groups, with different views on ULEZ implementation in London.

Table 15. Actors affected by LEZ implementation in London

Group	Actors	
Political representatives	• Green Party • Greater London Authority • London Assembly Environment Committee	
Environmental Group	• Air Quality Brentford • Clean Air Merton • Clean Air in London • ClientEarth • Environmental Protection UK	• Friends of the Earth • Greenpeace • London Sustainability Exchange • Chartered Institute of Environmental Health
Health Organizations	• Age UK London • The Association of Directors of Public Health for London	• The British Heart Foundation • The British Lung Foundation • Med act
Transport Campaign Group	• Alliance of British Drivers • Better Streets for Enfield • Campaign for Better Transport & Campaign for Better Transport (London) • Enfield Cycling Campaign	• Living Streets (London) • London Cycling Campaign • Sustrans • Tower Hamlets Wheelers (London Cycle Campaign)
Business Organization	• Baker Street Quarter Partnership • Better Bankside • Brewery Logistic Group • Environmental Industria Commission	• Confederation of British Industry (CBI) • Federation of Small Businesses • Business LDN • Mineral Product Association
Business Entity	• Autogas • Balfour Beatty • Calor Gas • CEMEX • Enterprise Rent-A-Car • Green Flag • John Lewis Partnership	• Royal Mail • Toyota • Tracis Perkins • Uber • UK Power Network • UPS • Veolia
Coach and Bus Operators	• Big Bus Tours • First Group • Harrow Community Transport	• The Original London Sightessing Tour • Wansworth Community Transport
Freight Transportation	• Freight Transport Association (FTA) • Road Haulage Association (RHA)	
Motoring Groups	• Association of Vehicle Recovery Operators • Federation of British Historic Vehicle Clubs	• National Association of Wedding Car Professionals • Routemaster Association • RAC Foundation
Taxi and Private Hire Organizations	• GMB (Professional Drivers Branch) • Licensed Private Hire Car Association	• Licensed Taxi Drivers' Association • Unite the Union (Cab Section)

A. Support group (most impacted neighbourhood)

Political representatives

Most political representatives from London agreed and saw LEZs as an alternative to reducing carbon emissions and improving air quality in London. Only a few were not in favour due to concerns for existing residents and businesses.

Environmental groups

Various environmental groups strongly support the Ultra Low Emission Zone (ULEZ) in London, advocating for its early implementation and expanded coverage to address the city's air quality concerns. Entities like Air Quality Brentford and Clean Air Merton highlight specific areas with high pollution levels, emphasising the necessity of including these regions within the ULEZ framework. Similarly, organisations such as Clean Air in London, Friends of the Earth, and Greenpeace endorse the ULEZ while pushing for more aggressive measures to reduce pollution promptly, advocating for more extensive coverage encompassing all of London. Suggestions for stricter emission standards, aligned with global health guidelines, are echoed by ClientEarth and Environmental Protection UK, emphasising the importance of evidence-based decision-making and robust enforcement.

Health organisations

Health organisations and charities strongly support the Ultra Low Emission Zone (ULEZ) and its early implementation in central London. They emphasise the critical need to promptly address poor air quality to benefit the health of Londoners. A more ambitious standard is also pursued, especially for Particulate Matter to be stricter than EU legal limits. A set of actions to limit air pollution from the transportation sector includes more stringent regulation on Euro 6 for diesel cars and more sustainable modes of transportation.

Transport campaign group

Different transport campaign groups exhibit diverse stances on London's Ultra Low Emission Zone (ULEZ). The Alliance of British Drivers raises objections due to insufficient cost-benefit analysis information. Conversely, groups like Better Streets for Enfield and Enfield Cycling Campaign strongly support the ULEZ, advocating for earlier implementation for residents and broader coverage across London, emphasising cycling infrastructure and reducing car usage. Campaign for Better Transport and its London branch strongly support the ULEZ, highlighting its importance for clean air compliance and alternative transportation methods. Living Streets, London Cycling Campaign, Sustrans, and Tower Hamlets Wheelers advocate for the ULEZ's principles, focusing on real-world driving standards, broader geographic coverage, increased investment in walking and cycling infrastructure and promoting non-polluting transport modes to combat air pollution. Collectively, these groups emphasise the need for diverse transport methods and stringent emission standards to improve London's air quality.

B. *Opposition group*

Coach and bus operators

Coach and bus operators' views on London's Ultra Low Emission Zone (ULEZ) vary widely, reflecting a spectrum of concerns and recommendations. While Big Bus Tours supports the ULEZ principle, it opposes its imminent April 2019 implementation, citing potential adverse effects on London tourism. Harrow Community Transport strongly opposes the ULEZ, foreseeing detrimental impacts on charitable operations and service users due to inadequate fleet upgrade capacity. The Original London Sightseeing Tour highlights concerns about the effect on the open-top bus market, citing technological constraints and lower resale value for non-compliant coaches. Wandsworth Community Transport opposes the ULEZ and its hasty implementation, requesting more time for fleet updates. These operators underscore the complexities and potential adverse impacts of the ULEZ, emphasising the need for more time, exemptions, and considerations to mitigate effects on their operations.

Taxi and private hire organisations

Taxi and private hire organisations express concerns about the impact on drivers' incomes, transition time, access for disabled individuals, and disparities between different types of vehicles in complying with emission standards. A strong opposition comes from GMB (Professional Driver), stating that ULEZ will disproportionately impact poorer motorists. They proposed a guaranteed scrappage scheme to aid the transition. Another concern was raised by the Licensed Taxi Driver's Association, which advocates exemption for taxis since they already have their environmental standard and provide accessibility to the public. Meanwhile, Unite the Union strongly supported ULEZ and the standard of including diesel vehicles. They also support the three-year residents' sunset period as sufficient.

C. *Concerned group*

Business organisation

Business organisations in London exhibit mixed sentiments towards the Ultra Low Emission Zone (ULEZ). While some strongly support its principles and urge an early implementation by April 2019, others express concerns about the timing, costs, and impacts on businesses, especially small and medium-sized enterprises (SMEs). Key points of contention include the need for clarity on emissions standards, challenges in fleet emission phasing, infrastructure development for electric vehicles, and fairness in treating different vehicle types. These entities generally acknowledge the importance of improving air quality but emphasise the necessity for clear communication, support mechanisms, and policy consistency to mitigate potential adverse impacts on businesses during the ULEZ transition.

Business entity

Business entities present a spectrum of perspectives and proposals regarding London's Ultra Low Emission Zone (ULEZ). While Autogas, Calor Gas, and several others support ULEZ principles and some advocate for an earlier April 2019 implementation, UK Power Networks and Veolia express opposition due to significant financial impacts. Discussions vary around the sunset periods, where some business owners agree with earlier implementation, but others ask that the implementation be held during the same period as residents.

Freight transport

Overall, while some entities endorse the ULEZ concept and propose alternative fuel solutions, others raise significant concerns about financial burdens, limited vehicle availability, and the need for more time and support for compliance. There is a collective call for more precise guidelines, exemptions for specific vehicles, and a more extended sunset period for implementation to ensure a smoother transition.

Motoring group

The motoring groups express support for the action to control air pollution from transportation sectors but have different opinions on the form and period of implementation. The Federation of British Historic Vehicle Clubs was asking for an exemption for its historical vehicle fleet. Other groups, such as the RAC Foundation, raised concerns about the government's lack of a scrappage scheme that might hurt businesses and lower-income households.

D. Issue compilation

The public consultation has generated different issues that will be addressed before the implementation of LEZ. In general, all of the group raises various concerns for the grace period of LEZ. One of the concerns comes from the business entity since improving their logistic fleet will take some time compared to the passenger vehicle. The opposition group demands an incentive mechanism from the government as retrofitting will be expensive, and the current technology is still limited. The concerned group demands more detailed information about the guidelines and alternative fuel type availability. As for the support group, they require more progressive measures with the extension of the LEZ area and improvement of the emission standard. Figure 46 summarises all of the issues raised by different stakeholders.

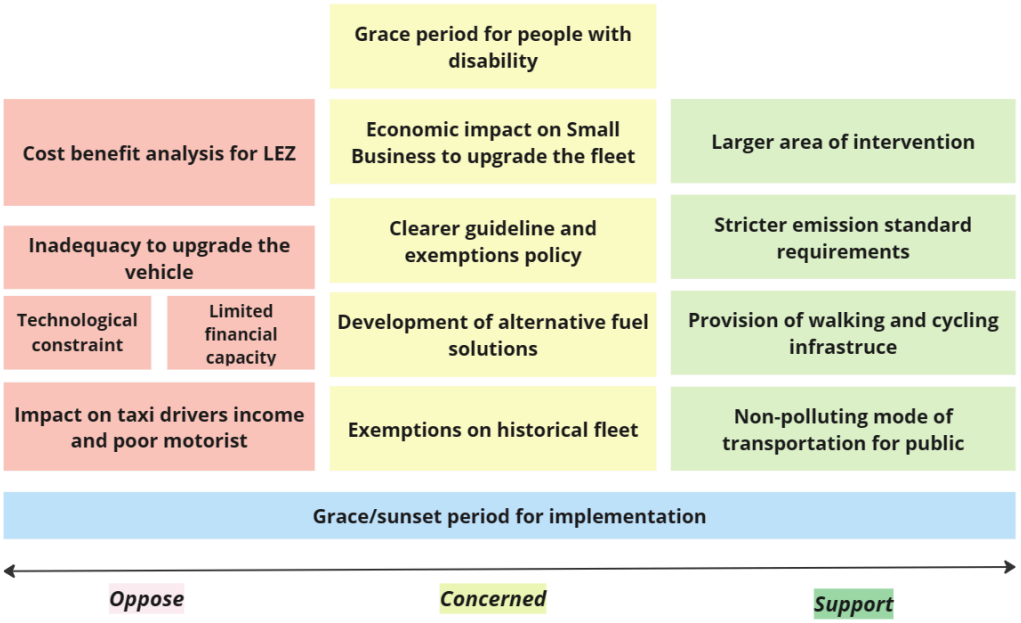


Figure 46. Issues of the ULEZ implementation from public consultation

5.1.4. Exemption policy

Implementing limitations for highly emitted vehicles can discourage specific groups of people as vulnerable groups mostly own older types of vehicles. Officials should consider groups with limited options for mobility to be exempted from LEZ policy. This subchapter provides a benchmarking study case and possible exemption groups in Jakarta.

Edinburgh, Scotland

In Edinburgh, some vehicles are allowed to enter within the low emission zone despite not meeting the emission standards. The exemption is for people with disabilities (blue badge owners), historic vehicles, emergency vehicles, military vehicles, and showman's vehicles. One is automatically eligible for a blue badge if they have a disability or needs mobility support. There are other instances where one may have to apply for a blue badge, and a local council will decide whether or not one will obtain a blue badge. Several factors that the council will consider include high mobility individuals, lasting disabilities, and adults with children requiring medical equipment.

London, United Kingdom

Various categories of vehicles and individuals qualify for exemptions or grace periods from the Ultra Low Emission Zone (ULEZ) charge in London. This includes Blue Badge holders benefiting from a grace period until October 24, 2027, individuals receiving certain disability benefits, and wheelchair-accessible vehicles meeting specific criteria. London-licensed taxis, certain businesses, charities, and sole traders may receive exemptions, and not-for-profit organisations operating minibuses for community transport can obtain a 100% discount.

Brussels, Belgium

Drivers with disabilities in Flanders, Belgium, whose vehicles do not meet the required Euro norm may be eligible for exemptions. This exemption, which can be requested online at no cost, applies to adapted vehicles and covers various categories, including those receiving an increased allowance, vehicles with a wheelchair lift, and vehicles with automatic gear shift (applicable from 27/04/2024). Caregivers' vehicles are also covered from the same date. These exemptions grant access to all low emission zones in Flanders, except for Brussels, which has its own rules. Eligibility for exemption requires a valid parking card for persons with disabilities and vehicle modifications related to the disability. Family members transporting a person with a disability can also apply for exemption, provided they are registered at the same address. A new exception, effective from 27/04/2024, allows an exemption for vehicles registered at the same address as the disabled person.

5.1.5. Incentive mechanism

Improving the vehicle emission standard to comply with the LEZ requirements needs an incentive mechanism from the government. A good example of government support for LEZ implementation comes from London, and they provide several incentive mechanisms to help people upgrade their vehicles and to use more sustainable modes of transport.

A. Scrappage Scheme

The Mayor of London initiated a GBP 160 million scrappage scheme to aid eligible residents in removing vehicles that fail to comply with the Ultra Low Emission Zone (ULEZ) standards. This program aims to improve London's air quality by providing financial support to scrap or modify vehicles that do not meet emission standards, encouraging a transition to cleaner transportation modes. Targeting London residents, small businesses, micro-businesses, sole traders, and registered charities within the city, the scheme assists in eliminating polluting vehicles. Eligibility hinges on owning vehicles that do not meet ULEZ emissions standards.

The application process for the scrappage scheme is divided into two sub-schemes based on vehicle type and applicant:

- The ULEZ car and motorcycle scrappage scheme is for London residents with cars, motorcycles and wheelchair-accessible vehicles that do not meet the ULEZ emissions standards
- The ULEZ van and minibus scrappage scheme is for sole traders, micro-businesses, small businesses or charities with a registered address in London to scrap or retrofit a van or minibus that does not meet the ULEZ emissions standards.

Cars, Motorcycles, and Wheelchair Accessible Vehicles

All London residents can apply for up to GBP 2,000 for scrapping a car or up to GBP 1,000 for scrapping a motorcycle. For wheelchair-accessible vehicles, there is a payment of GBP 10,000 to scrap or GBP 6,000 to retrofit to the ULEZ standards with the condition that mobility experts convert the vehicle to allow a disabled person to access the vehicle as the driver or passenger. If the applicant is a London resident claiming disability benefits with a nominated driver living outside London, it can also apply to scrapping or retrofitting their vehicle.

Vans and Minibuses

Grant payment GBP 6,000 - GBP 11,500. The ULEZ van and minibuses scrappage scheme is open to small businesses (under 50 employees), micro-businesses (up to 10 employees), sole traders, and registered charities. The organisation must operate within the 32 boroughs of London or the City of London.

B. Exemptions and discounts

The city of London provides a 100% discount or exemption for several types of vehicles and drivers, which include:

Vehicle for disabled people

People with Disability (PWD) will receive a grace period or leniency period from the LEZ requirement until 24th October 2027. If the vehicle is registered outside the UK, it can still be exempted from the ULEZ charge, but a registration is needed. Vehicles that have been transformed into Wheelchair Accessible Vehicles (WAV) will also receive a grace period. Different categories of people will receive a similar exemption: parent or guardian of a child under the age of 3 with a medical condition, a terminal illness that resulted in the inability to walk, and war pensioners.

NHS patient reimbursement

If a person is clinically assessed as too ill to travel by public transportation, they can claim back the ULEZ charge from the treating hospital.

Taxis

London taxis are exempt from the ULEZ charges as they will follow the maximum operation age of 15 years. The city of London provides an incentive mechanism of up to GBP 7,500 for taxi drivers to change their petrol/diesel vehicles to Zero Emission Capable (ZEC) taxis in 2018. The proportion of ZEC in London has reached 54.2% of all the fleets in 2023[3].

Business and charity short-term grace period

ULEZ's short-term grace period is applied to small businesses (under 50 employees),

[3] BBC. (2020). *Majority of London's black cabs now 'zero emission capable'.* Retrieved from https://www.bbc.com/news/uk-england-london-67639496

micro-businesses (up to 10 employees), charities, and sole traders. The grace period until May 2024 targets non-compliant vehicles waiting to be upgraded or changed with a new vehicle. The type of vehicles includes light vans (up to 3.5 tonnes) or minibuses (up to 5 tonnes).

Minibuses used for community transport

Minibuses used by non-profit organisations receive a grace period until 26 October 2025. The type of organisations eligible for this scheme are those related to charity, school, religion, and social welfare.

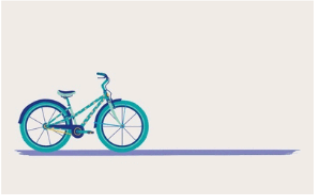
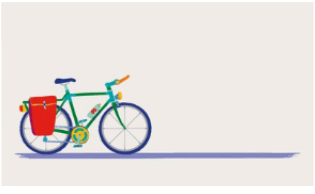
Other exempted vehicles

Different vehicles receive full exemption from ULEZ charges, including emergency vehicles (ambulance, firetruck), historic vehicles (vehicles built before 1973), specialist agricultural vehicles, military vehicles, non-road going vehicles (excavators and mobility cranes), and showman's (circus activity related) vehicles.

C. ULEZ support offers

Transport for London (TfL) has provided internal support offers and secured a range of deals with private companies to persuade people to shift to a more sustainable mode of transport. Several offers include:

Table 16. Various ULEZ support offers in London

Offers	Explanation
Support from TfL	
Free cycle training for people of all abilities	Learn with an instructor You can learn one-to-one or in a group with an instructor. Training is provided by boroughs across London. **Basic Cycle Skills** Practice off-road and learn the basics. Improve your skills to cycle confidently through your local area.  **Urban Cycle Skills** Practice off-road and then move on to quiet roads to refresh your cycling technique. 

<table>
<tr><td>Door-to-door services (dial-a-ride)</td><td> 

<h3>When Dial-a-Ride operates</h3>
Dial-a-Ride currently operates 7 days a week, 07:00-23:00.

Our service hours

Buses operate 07:00-23:00
Telephone enquiry and cancellations are available from 06:00 until midnight
Booking hours are listed on the Bookings page
</td></tr>
<tr><td>Travel mentoring (guide travellers to navigate the public transportation system)</td><td><h3>Mobility aid recognition scheme</h3>
We also assist people who want to use mobility scooters and other mobility aids on London's bus services. Find out about the mobility aid recognition scheme on the Wheelchair access & avoiding stairs page.

Natasha on travel mentoring (2019)

</td></tr>
<tr><td>Free and discounted travel for public transportation</td><td>
Children under 5 travel free
5-10, 11-15, 16-17 free travel for children with Oyster card
Discounted fare for student above 18 years with Oyster card
60+ free travel with Oyster card
Veteran free with Oyster card
Freedom pass: free for People With Disability
Travel package for group of students
Jobcentre plus discount: for unemployed people looking for work
</td></tr>
<tr><td colspan="2">Collaboration with private company</td></tr>
</table>

Bikes, e-bikes and e-scooters hire or subscription	**Santander cycles - Range of membership discounts available if you are a student, NHS employee or your employer is part of Cyclescheme** See offer Get cycle to work, NHS and student discounts on Santander Cycles memberships. **HumanForest - Use an eBike for as little as 3p a minute** See offer Purchase a minutes bundle in the HumanForest app. **Dott - £30 off 30 rides, capped at 5000 users (promo code: TFLSSCHEME30)** See offer Get £1 off each ride for 30 rides on shared e-scooters (£30 worth of credit). See conditions in the app.
Bike and e-bike purchase	**Volt - £50 off and a free chain lock** See offer Get £50 off a Volt e-Bike and a free chain lock worth £30. **Bikeworks - 10% off any purchase of a non-standard bike or e-bike with Bikeworks** See offer Get 10% off any purchase of a non-standard bike or E-bike. For more information, send an enquiry form on Bikeworks website or call on 02089807988. **The Electric Bike shop - Buy a new e-bike up to £2500 and get a free lock and helmet bundle (worth £100)** See offer Get a £100 voucher for a helmet and lock when you purchase any bike priced up to £2500.
Car and van rental	**Enterprise - 10% off Enterprise Rent-A-Car bookings** See offer Get 10% off rent-a-car bookings. **Hiyacar - £10 off your first booking** See offer Use code TFL to get £10 off your first booking as a driver which can be redeemed against the rental fee on any vehicle on the Hiyacar platform.

5.1.6. Engagement strategy

The implementation of LEZ as a push policy will require a careful communication strategy to ensure well-received responses from the public. Local government can increase the likelihood of successful LEZ implementation by providing a well-planned communication strategy. It must be noted that public acceptance is not the objective of LEZ; instead, it is the expected outcome. The main objective is to maximise the awareness of the program, which will lead to a high level of compliance. London, Edin, Milan

Pickford et al. (2017) have compiled international case studies on public communication for LEZ and congestion charging programs. This section will use examples from London, Milan, and Manchester to show different approaches and intensities of public engagement from congestion charging or LEZ, which shares similar engagement strategies as a push policy type example.

London, United Kingdom
As previously mentioned, the planning process for ULEZ in London is already thorough and participative. The engagement strategy for ULEZ in London uses the previous engagement strategy from the congestion charging program in the early 2000s. Transport for London (TfL) was targeting the general public and key stakeholders to be engaged. The general public receives a physical notice in place for every 250 meters of the road with a rolling inspection each week. TfL also engages 500 key stakeholders with consultation meetings from various groups (emergency services, motoring organisations, people with disability, resident's groups, freight industry).

The type of communication conducted by TfL is considered to be two-way communication. Every piece of information shared with the public is accompanied by a communication channel to get further information or to express their concerns. Communication channels using physical mail, emails, and free phone calls were provided. TfL also provided a seven-week public exhibition at two central London venues for people who want to ask questions directly.

TfL also took into account maintaining the credibility and acceptability of the information. They conducted regular large quantitative surveys of thousands of Londoners every six to eight weeks. This activity aims to check which kind of information needs improvement and to be reframed. Special attention was paid to media, where deliberate information was disseminated through interviews. If there is misleading information, TfL actively contacts the media to straighten the information using concrete evidence and statistics.

Milan, Italy

An interesting communication strategy comes from Milan, Italy, where the government has to face shifting objectives of LEZ implementation. Initially, the Agenzia Mobilitia Ambiente e Territori (City of Milan Mobility Agency/AMAT) introduced the EcoPass program in 2008. This program is similar to the concept of LEZ where highly emitting vehicles are subject to charge if they do not comply with the emission standards. Vehicles will be charged according to emission classes, with fees of EUR 2, EUR 5, and EUR 10. However, after two years of implementation, the benefits of EcoPass were offset by the increasing number of exempted vehicles. Area C replaced the existing program in 2012, where all non-compliant vehicles are prohibited from entering the area. In addition, a flat rate charge is implemented for all vehicles. This policy change managed to reduce the number of vehicles entering the area by 34 per cent.

At first, the decision to implement the EcoPass program was made without a proper public consultation process. In 2007, the mayor decided to ban 170,000 cars and motorcycles to pre-Euro requirements from entering the restricted area of Zona a Traffico Limitato (ZTL), the precursor name before EcoPass. The government only relied on media coverage as the main channel for public communication.

After the initial stage, the government decided to conduct a more robust engagement strategy with letter campaigns, press campaigns, and public hearings. The message for EcoPass set a 30 per cent reduction in the particulate matter as the main objective. They adopted the slogan “meno traffico = aria più pulita” (less traffic equals cleaner air). Unfortunately, there was an operational failure during the initial stage of EcoPass implementation. The communication centre failed to respond to the public's questions and created confusion among the general public.

In 2010, when the local government tried to improve the scheme from EcoPass to Area C, they formulated a financial package worth about USD 360 to improve mobility in Milan and address the air pollution issue. The Area C program was bundled with improving metro lines, inner city pedestrian areas, neighbourhood bus services, cycle networks, and nighttime bus services. This policy package received 95 per cent support from the referendum.

Manchester, United Kingdom

The city of Manchester provides a failed example of congestion charging implementation where a significant investment in public engagement is not supported by a good engagement strategy. In 2005, the Association of Greater Manchester Authorities (AGMA), comprised of 10 local authorities, formulated an integrated transportation strategy valued at USD 3.7 billion. It focuses on improving public transportation, parking reform, and bicycle and pedestrian infrastructure. Congestion charging (CC) is one of the components of the strategy. This plan will be financed by the national government and the CC scheme.

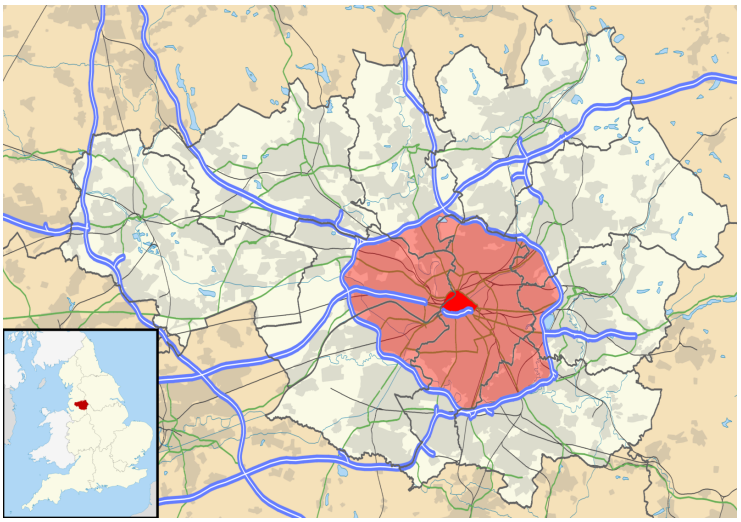


Figure 47. Propose congestion charge area in Greater Manchester

AGMA provided USD 4.0 million for CC consultation, including consultation brochure form to 1.2 million households (in 11 languages), a mobile exhibition for each of 10 authorities, public meetings, telephone inquiry service, updates to 30,000 businesses, curriculum pack for schools, 65 exhibitions, and a website. It started in July 2008 and ran for 14 weeks. The survey showed 15 per cent in favour, 30 per cent opposed, and 55 per cent undecided. One of the main objections came from equity, where the public assumed it would be unfair to the low-income group. Facing this issue, AGMA introduced a low-income worker discount and daily charges limit. They even provided an exemption policy for medical-related trips, recovery vehicles, registered disabled persons, and a 50% discount for the main commercial area.

Despite the adjustment to accommodate public concerns, the referendum resulted in 79 per cent of eligible voters rejecting the package. There are several reasons for the failed congestion pricing policy in Manchester:

- Referendum should not be used to determine the public's acceptability for policies such as congestion charging. The nature of the policy is push policy, which will always have a high opposition from the public. If the city wants to conduct a referendum process, it should do so after a pilot phase after the public reaps the benefit, such as in Stockholm.
- The message of congestion charging is unclear. Messages from AGMA become mixed between the objective of addressing congestion and air pollution. They should have focused on addressing the congestion issue as the main message. If they want to implement LEZ then it should be more about the issue of air pollution.
- The public still did not understand the purpose, and the city failed to address the opposition in time. There was a petition saying congestion charging would track all of the vehicles. It also noted that private vehicle owners already pay the road pricing based on the

high level of taxation on fuel. AGMA was not responsive enough to address this misinformation.

- Lack of trust for the use of funds from congestion charging. AGMA did not provide clear information to the public that congestion charging is one of the more significant policies used to finance public transportation.

5.1.7. Monitoring and evaluation of LEZ

Implementation of LEZ requires constant monitoring and evaluation to evaluate the effectiveness of the policy. City officials in London conduct monthly evaluations of ULEZ, where it is publicly available on london.gov.uk. The monitoring and evaluation components include **compliance rates, changes in fleet composition, traffic flow data, and air quality monitoring results** (NO2 and PM 2.5). All of these evaluation indicators are used to decide if the ULEZ program can be expanded or improved further.

Table 17. Vehicle compliance rate with ULEZ standard in London from 2017 - 2023 (source: london.gov.uk)

Month/Year	Overall ULEZ Compliance Rate
Feb-17’	39%
Apr-19’	73%
Oct-21’	86.9%
Nov-22’	90.5%
Jun-23’	91.6%

The percentage of vehicle compliance is important to determine the readiness of the existing vehicle to comply with the ULEZ standards. Before the implementation of ULEZ in London, the vehicle compliance rate was still 39%, indicating that most vehicles were not ready for ULEZ. However, public consultation managed to improve the emission standard, coupled with incentives from the government, which increased the proportion to 73% before the implementation of the ULEZ in April 2019. For phase 2 of ULEZ in 2021, the compliance rate before the implementation reached 86.9%, indicating that the shift to cleaner vehicles is happening on the ground and that a larger intervention area can be implemented. With the larger implementation area in phase 2, the vehicle compliance rate still increased and reached 91.6%. This high compliance rate prompted the city to expand the ULEZ to all London boroughs in 2023.

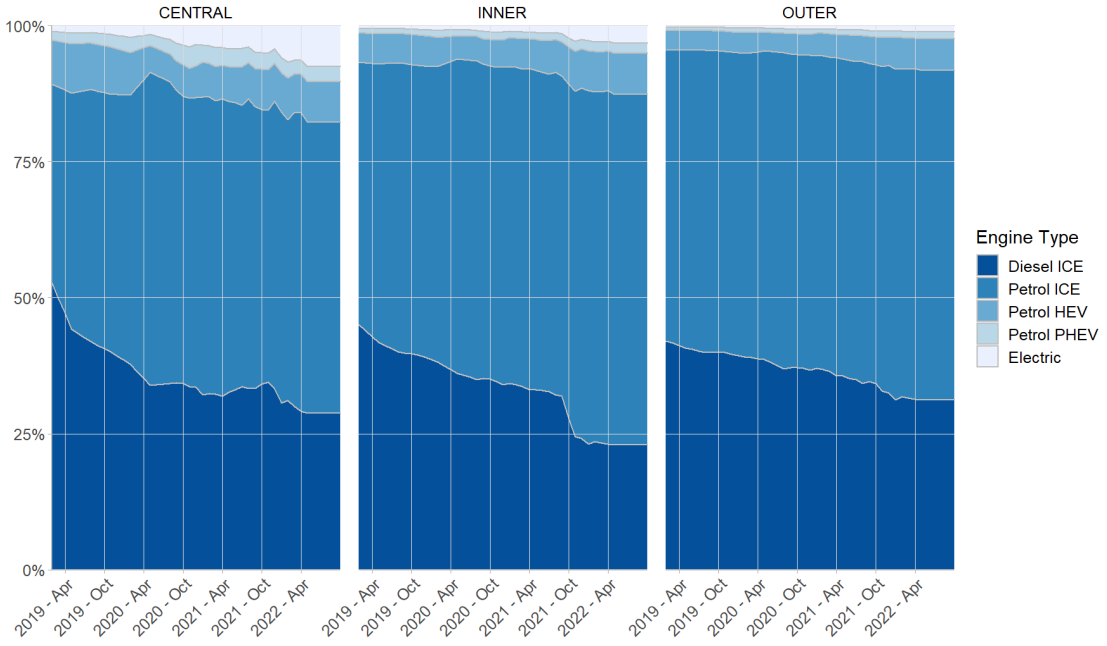


Figure 48. Vehicle kilometres fleet composition by engine and type and London zone (source: london.gov.uk)

The fleet composition data is the category of vehicle that is based on the vehicle type and fuel type travelling in the ULEZ area. This data is useful in determining the success of scrappage incentives because ULEZ is expected to change the fleet composition into greener-type vehicles. Figure 48 shows the change in fleet composition with the different coverage areas of ULEZ. The engines are divided into internal combustion engines (ICE), petrol hybrid electric vehicles (HEV), petrol plug-in hybrid electric vehicles (PHEV), and fully electric. The figure shows a sharp reduction in the proportion of diesel travel distance in the Inner ULEZ between September and November when the ULEZ was expanded to inner London. There was also an increase in the number of cleaner vehicles, with petrol and electric vehicles in general. A significant increase in electric vehicles is apparent in the central ULEZ, where electric cars make up 8% of the car activity. This information provides a successful story in the improvement of vehicle emission standards from the ULEZ implementation.

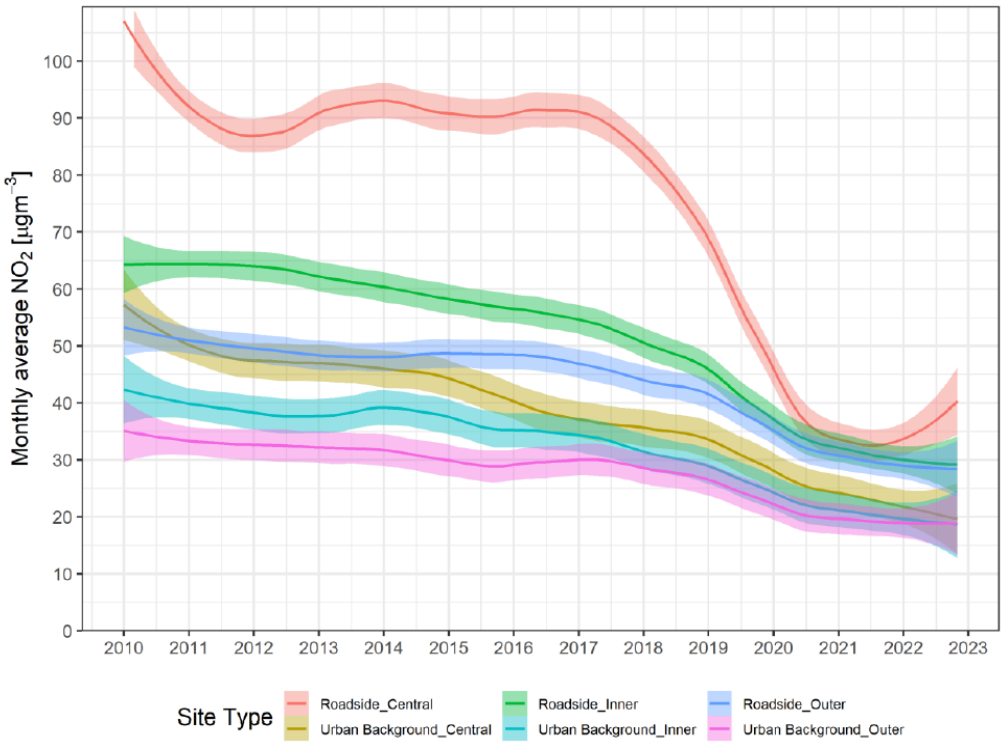


Figure 49. Trends in NO2 in London (source: london.gov.uk)

The main objective of ULEZ is to reduce the concentration of air pollution within the zone. London has one of the world's densest air pollution monitoring devices, enabling comprehensive air quality results across the city. There are 150 monitoring stations with two categories of locations: roadside located one to five metres from the busy road, and urban background sites distanced away from the source and represent the city-wide background conditions. Figure 49 shows the rapid reduction in NO2 at the roadside locations near the implementation of centre ULEZ in 2019. The inner ULEZ also experienced a decreasing trend of NO2 concentrations after the 2021 implementation. Providing an air quality monitoring station is important to gather constant and detailed air quality information on different zones of ULEZ.

5.2. Roadmap of LEZ in Jakarta

5.2.1. Phasing implementation of LEZ in Jakarta

A. Current condition of vehicle emission standard in Jakarta

Most LEZ designs use vehicle emission standards as the criteria for LEZ compliance. In other countries where LEZ has been implemented, vehicle emissions standards are updated every 4 to 6 years to reduce the emissions and health impacts of a growing vehicle fleet. However, emission standards in Indonesia are updated in much longer intervals. Table 18 summarises vehicle emission standards adoption dates for motorcycles and all other gasoline and diesel vehicle types.

Table 18. Vehicle emission standards adoption schedules in Indonesia.

Vehicle Type	Euro II	Euro III	Euro IV
Motorcycles	2006	2013	-
Gasoline vehicles	2007	-	2018
Diesel vehicles	2011	-	2022*

*The Euro IV standard was adopted in the regulation but not implemented up to date.

Motorcycle standards have not been updated from Euro III levels since 2013. Gasoline vehicles, from cars to small trucks, pick-ups, and light commercial vehicles, moved from Euro II, which has been in place since 2007, to Euro IV in 2018 - a measure that substantially improves Indonesian cities' air quality. Diesel vehicles, from cars to heavy-duty trucks and buses, received an essential emission standards requirement in 2011 and were expected to upgrade to Euro IV by 2022. However, this has been delayed due to issues with low sulphur diesel availability.

Based on ICCT remote sensing data, the vehicle population in Jakarta mainly consists of Euro II emission standard vehicles (Mahalana et al., 2022). Table 19 shows each vehicle and fuel type's Euro standard proportion. All vehicle types have 50% of their population under or equal to the Euro II emission standard. A large population of the most polluting Euro 0-1 emission standards are identified in motorcycles (17%) and logistic diesel vehicles (LCV 15% and MDV+HDV 29%).

Table 19. Baseline vehicle Euro standard distribution data (in percentage). Source ICCT remote sensing dataset

Vehicle type	Fuel	Share of fuel in each vehicle category	Emission Standard Share (by fuel)			
			Euro 0-1	Euro II	Euro III	Euro IV
Motorcycles	Petrol	100%	17%	36%	46%	0%
Passenger cars	Petrol	88%	5%	68%	0%	16%
	Diesel	12%	1%	11%	0%	0%

Vehicle type	Fuel	Share of fuel in each vehicle category	Emission Standard Share (by fuel)			
			Euro 0-1	Euro II	Euro III	Euro IV
Small trucks	Petrol	45%	2%	28%	0%	15%
	Diesel	55%	15%	41%	0%	0%
Medium- and Heavy-duty trucks	Diesel	100%	29%	71%	0%	0%
Transjakarta cars	Petrol	100%	0%	82%	0%	18%
Transjakarta buses	Diesel	100%	0%	100%	0%	0%

B. Main implementation approach of LEZ in Jakarta: Emission Standard (ES) Design

Lower emission standards predominantly dominate the current proportion of vehicle emission standards. The number of motorcycles that do not meet current emission standards of Euro II is 53%. As for passenger cars, they are still dominated by petrol cars, with 73% still not meeting the emission standard and the diesel category. Similar proportions are also found with the logistic and public transportation fleets. The low compliance with emission standards shows that emission standard enforcement is needed in Jakarta.

The phasing implementation of LEZ in Jakarta can be implemented in two phases, with the first phase as the pilot implementation and the second phase as the expansion. The first phase will focus on disseminating information about the LEZ policy, which will be implemented in a smaller area. The enforcement for vehicles to comply with the current national standard emission will only be implemented in 2026, 2 years after the grace period in 2024. The emission standard will follow the MoEF regulation, where motorcycles must comply with Euro III and four-wheeled vehicles with Euro IV emission standards.

The second phase starts from 2028 until 2030 with two types of intervention: Innercity LEZ with more types of vehicle limitation and a larger area of implementation, together with Outer LEZ that specifically focus on the logistic fleet. Table 20 explains the phasing implementation for LEZ implementation scene of LEZ in Jakarta based on the vehicle emission standard consideration.

Table 20. Roadmap of implementation for LEZ in Jakarta with vehicle emission standard consideration

Type of Vehicle	Fuel	Share of fuel in each vehicle category	Existing Emission Standard Share (by fuel)				LEZ Scenario Phasing						
							2024	2025	2026	2027	2028	2029	2030
AREA OF INTERVENTION			**Euro 0-1**	**Euro II**	**Euro III**	**Euro IV**	**LEZ Phase 1 (Pilot)**				**LEZ Phase 2 (Innercity)**		
Motorcycle (MC)	Petrol	100%	17%	36%	46%	0%	Euro II		Euro III		Euro III		
Passenger cars (C)	Petrol	88%	5%	68%	0%	16%	Euro II		Euro IV		Euro IV		
	Diesel	12%	1%	11%	0%	0%	Euro II		Euro IV		Euro IV		
Light Commercial Vehicle (LCV)	Petrol	45%	2%	28%	0%	15%	Euro II		Euro IV		Euro IV		
	Diesel	55%	15%	41%	0%	0%	Euro II		Euro IV		Euro IV		
TJ Car (microbus)	Petrol	100%	0%	82%	0%	18%	Euro II + Electric Vehicle			Fully electric fleet	Fully electric fleet LEZ Phase 1 + Euro IV		
TJ Bus	Diesel	100%	0%	100%	0%	0%	Euro II + Electric Vehicle			Fully electric fleet	Fully electric fleet LEZ Phase 1 + Euro IV		
MDV + HDV	Diesel	100%	29%	71%	0%	0%	Euro II MDV & HDV (access restriction based on time for HDV)		Euro IV MDV + HDV (access restriction for HDV based on time		Euro IV MDV (total access restriction for HDV)		
											Outer LEZ		
											Euro IV MDV & HDV		

LEZ Phase 1 (Pilot)

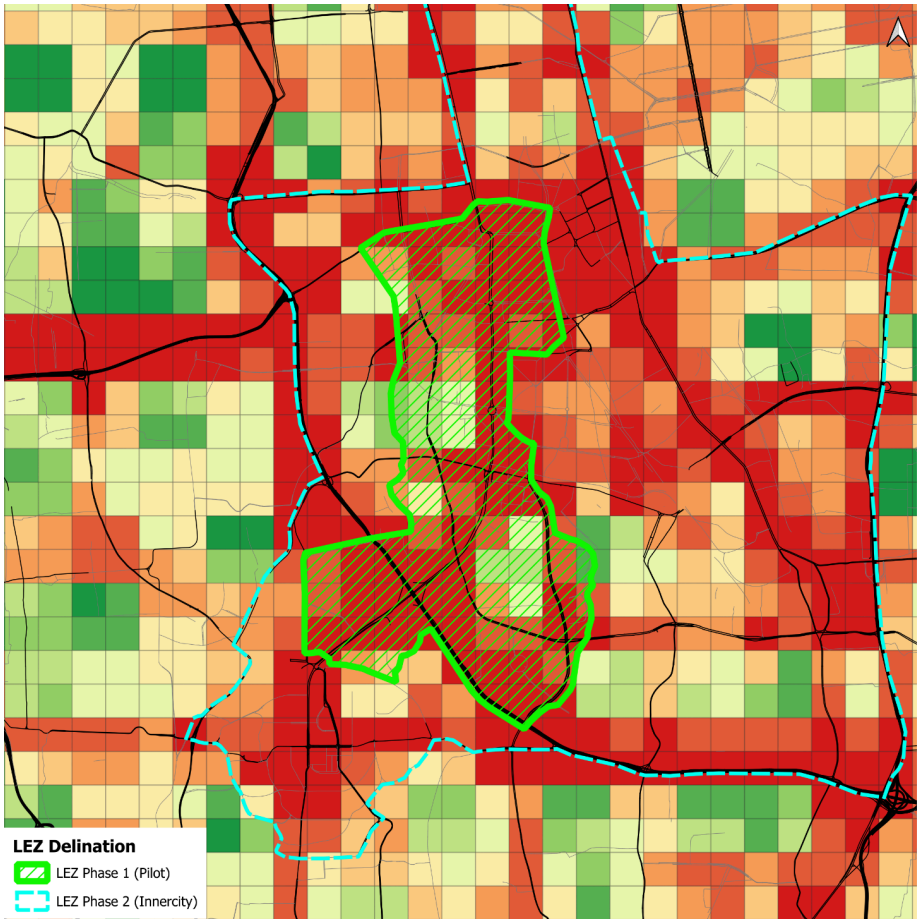


Figure 50. Pilot area for the LEZ Phase 1 implementation

The first phase of LEZ implementation will mainly focus on the smaller scale of the Innercity LEZ, as visualised in Figure 50. The coverage area is five times smaller than the Innercity LEZ, with a total area of 18.77 km2 which only covers 2.9% of the total area of Jakarta. The Pilot delineation is located on the main economic corridor of Jakarta, where the total matrix value is at its highest. This area has also been served by multiple types of mass public transportation, namely MRT with 6 stations, 4 commuter rail stations, 4 LRT Metropolitan Jakarta stations, 36 BRT stations, and multiple feeder routes. Another consideration of this area is the low residential density since most of the land use is dominated by offices, which will reduce the resistance from the people residing there.

The first two years of LEZ Phase 1 will focus on developing the type of LEZ implementation, preparing the public consultation, and gathering the emission standard data of vehicles. The rate of vehicle emission testing in Jakarta is still low, with the rate of cars at 30.8% and motorcycles at 0.64%. This condition shows a need for a grace period phase to collect the emission standard of

vehicles to better equip them for increasing emission standards in 2026. Starting in 2026, the minimum emission standard will follow the regulations of the MoEF, which set all four-wheeler vehicles to Euro IV and two-wheelers to Euro III.

An additional limitation is set for HDV, where they still have to follow Governor Decree 5148 of 1999, where access to HDV is limited by the time period. Different phasing has also been applied to road-based public transportation since PT Transjakarta, as a road-based public transport operator, has plans to electrify all of its fleets. Based on the “Business Case of Transjakarta’s First Phase E-Bus Development'' by ITDP (2023), the proportion of electric vehicles in Transjakarta will reach 51% in 2027. It is expected that all of the vehicles that will be electrified are serving the Pilot LEZ area.

LEZ Phase 2 (Innercity and Outer LEZ)

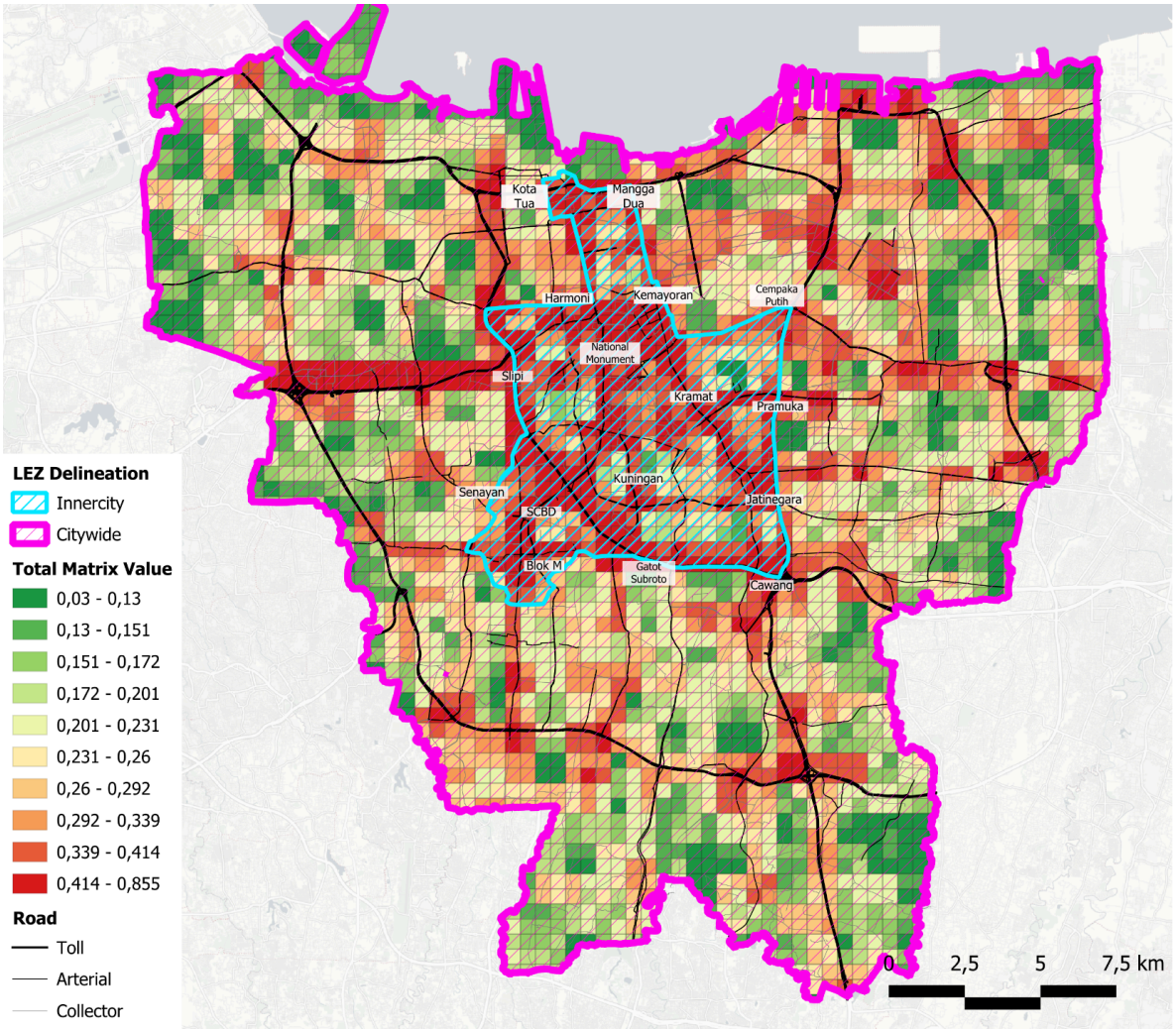


Figure 51. Area for LEZ Phase 2 implementation

The phase of LEZ in phase 2 will be implemented in two scales of implementation with different types of vehicle categories. The Innercity LEZ will have the same emission standard vehicle as the previous Pilot Phase but with more extensive area coverage, as explained in the previous section. The total area for Innercity LEZ is 87.8 km2, or 13% of the total area. The Innercity LEZ is served by multiple types of mass public transportation: MRT with 9 stations, 24 commuter rail stations, 8 LRT Metropolitan Jakarta stations, 141 BRT stations, and multiple feeder routes.

In the Innercity LEZ, highlighted by the blue delineation of Figure 51, access limitation from HDV will be extended from the night period to 24-hour and all-day limitation. This recommendation is supported by the findings from the micro LEZ implementation in Kota Tua Jakarta, where emission from HDV was at its highest level during the night because of HDV volume (Yulinawati, 2022). The future logistics system should be more environmentally friendly where smaller and lower emission vehicles, if possible, even zero-emission logistic systems, are implemented. This plan can be achieved with the concept of micro-logistic consolidation, which will be explained in the next section on supporting TDM measures.

Meanwhile, the emission standard for road-based public transportation will follow the electrification plan of Transjakarta, where the electrified route will be expanded from Pilot to Innercity LEZ area.

As for the Outer LEZ, it specifically targeted HDV with the delineation in all of Jakarta. This limitation for HDV comes from the air pollution distribution of logistic vehicles predominantly located on Jakarta's outskirts, as explained in Figure 52, indicated with a purple circle. The reason behind the activity of logistic vehicles predominantly located on the outskirts of Jakarta is industrial agglomeration in the north and east of Jakarta. Another reason is the current local regulations that limit the access of logistic vehicles to the inner city of Jakarta.

All logistic vehicles operating in Jakarta are expected to meet the emission standard of Euro IV that the national government has set. Monitoring emission standard requirements for logistic fleets is expected to be more efficient because it can be targeted to the location of the HDV industry. The next chapter will explain a more detailed explanation of the enforcement mechanism.

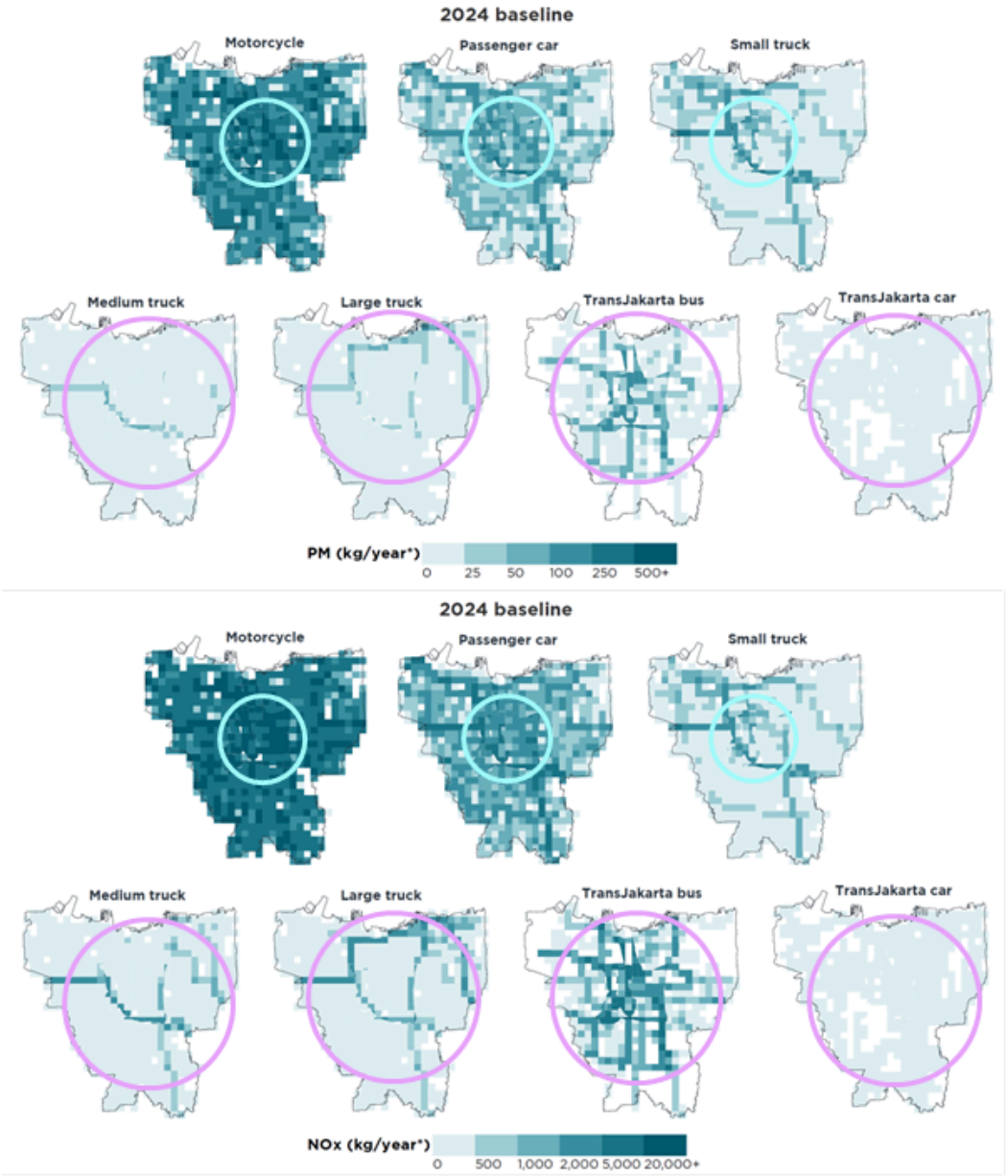


Figure 52. Distribution of vehicle emission based on vehicle category for PM and NOx

C. Alternative implementation approach of LEZ in Jakarta: Model Year (MY) Design

The limited number of emission standard options makes it very difficult to balance implementing a LEZ design in Indonesia under Emission Standard criteria while aiming to reduce the impacted population. The alternative solution, which also facilitates implementation, is to use vehicle Model Year (MY) as the requirement for LEZ compliance.

The LEZ implementation design proposed here is based on a vehicle model year of 10 years of age maximum. The estimation of air pollution reduction will use the assumption of a model year scheme where vehicles with more than 10 years of operation will be restricted from entering the LEZ area, which is in line with the Governor Instruction 66 of 2019 to limit vehicles more than ten years. The impact on vehicle activity for those vehicles covered under the LEZ is estimated by calculating the share vehicles that would be impacted based on each LEZ phase-in condition. This analysis does not consider modal shift or route shift for the vehicle activity impacted by the LEZ implementation.

The MY approach applies the same restrictions phase as the ES design with two implementation phases. The first two years of LEZ implementation, from 2024 to 2025, will be the grace period, where there is no restriction on vehicles based on the model year. It will focus on planning consultation, formulating regulations, and preparing the system and infrastructure. In 2026, the MY design will be implemented where motorcycles and cars produced before 2017 are restricted to run inside the LEZ Phase 1 area.

The minimum MY standard will increase again in Phase 2 with the Inner City and Citywide implementation. In 2028, vehicle MY below 2019 will be prohibited from entering the Phase 2 area, with an additional restriction for HDV, similar to the ES design. The increase MY standard will only occur every two or three years to avoid public confusion. Table 21 explains the MY approach implementation roadmap in Jakarta.

Table 21. Roadmap of implementation for LEZ in Jakarta with vehicle model year consideration

Type of Vehicle		Fuel	Share of fuel in each vehicle category	Existing Emission Standard Share (by fuel)				LEZ Scenario Phasing						
								2024	2025	2026	2027	2028	2029	2030
AREA OF INTERVENTION				**Euro 0-1**	**Euro II**	**Euro III**	**Euro IV**	**LEZ Phase 1 (Pilot)**				**LEZ Phase 2 (Innercity)**		
Motorcycle (MC)		Petrol	100%	17%	36%	46%	0%	*Grace period*		MY2017		MY2019		
Passenger cars (C)		Petrol	88%	5%	68%	0%	16%			MY2017		MY2019		
		Diesel	12%	1%	11%	0%	0%							
Light Commercial Vehicle (LCV)		Petrol	45%	2%	28%	0%	15%			MY2017		MY2019		
		Diesel	55%	15%	41%	0%	0%							
TJ Car (microbus)		Petrol	100%	0%	82%	0%	18%			MY 2018 + BEB	BEB	MY 2022 + BEB		
TJ Bus		Diesel	100%	0%	100%	0%	0%			MY 2018 + BEB	BEB	MY 2022 + BEB		
MDV + HDV	Medium Duty Vehicle (MDV)	Diesel	100%	29%	71%	0%	0%			MY2017		MY2019		
	Heavy Duty Vehicle (HDV)									MY2017		No access		
	MDV + HDV											**Outer LEZ**		
												MY2019		

D. Comparison between ES and MY design

The implementation of LEZ will impact vehicle activity since it will limit a certain category of vehicles to enter the LEZ area. Table 22 provides a summary of the impact of vehicle activity on private and commercial vehicles, comparing the Emission Standard and Model Year Approach.

The design aims for vehicle activity impacts to be below 10% for the Phase 2 implementation. This assumption comes from different LEZ implementations in several cities in Europe. Vehicle activity impacts are reduced over time within each phase as older vehicles are retired, and new ones enter the fleet already in compliance with the LEZ requirements. More information regarding the vehicle retirement assumption is explained in Chapter 6.

Table 22. Vehicle activity impact from the LEZ Model Year and Emission Standard Approach

Vehicle type	Phase 1 - Pilot		Phase 2 - Innner LEZ	
	2024	2027	2028	2030
Emission Standard (ES) Approach				
Motorycle	0.36%	0.99%	2.62%	1.46%
Passenger car	0.11%	2.46%	7.21%	5.43%
Small truck	0.13%	2.82%	6.66%	4.35%
Medium trucks	0.58%	3.19%	10.56%	8.86%
Large trucks	0.25%	1.19%	6.76%	100.00%
TJ cars	0.00%	1.61%	0.32%	0.00%
TJ buses	0.00%	5.24%	4.76%	0.00%
Model Year (MY) Approach				
Motorcycle	0.00%	1.86%	6.59%	4.67%
Passenger car	0.00%	1.78%	8.30%	6.36%
Small truck	0.00%	1.27%	4.30%	2.29%
Medium trucks	0.00%	1.56%	7.21%	5.78%
Large trucks	0.00%	0.63%	4.86%	100.00%
TJ cars	0.00%	1.61%	0.32%	0.00%
TJ buses	0.00%	5.24%	4.76%	0.00%

As can be seen in Table 22, in general, the MY approach offers a lower Vehicle activity impact percentage if compared to the ES approach. This condition is caused by the higher volume of vehicles that still do not meet the emission standards requirement. During the grace period implementation from 2024-2025, Vehicle activity impact will be 0%. During the LEZ

implementation, the number of Vehicle activity changes is higher in the MY approach since the number of vehicles already aligned with the Euro III standard of motorcycles is already high. The rest of the vehicle types show higher Vehicle activity impact in the ES approach, especially the medium trucks, which reached 10.56%. A 100 per cent Vehicle activity impact will occur to the HDV in the Inner City area since they will be prohibited from entering the LEZ area. As for the Transjakarta fleet, both approach vehicles are impacted very little given that their fleets are periodically renewed, the vehicles operate under 7-year contracts that help retain a cleaner fleet, and the electrification plan is underway and aims for 50% electrification by 2025 and 100% by 2030.

The ideal implementation design for LEZ should follow the ES approach since it can be upgraded in the future with the introduction of higher emission standards. The current national government plans to introduce Euro V or Euro VI soon, and the ES approach can respond to that vision. In the long-term planning vision, the ES approach also aligns with the plan to implement Zero Emission Zone (ZEZ) where only zero emission vehicles, such as electric vehicles, can enter the area. However, as explained in Chapter 2, the government needs to provide a supporting regulation that limits vehicle access based on emission standards, which is still non-existent in the regulatory framework. The government is also required to conduct more robust emission testing where the level of implementation is still not significant.

The MY approach offers an alternative with more practical requirements since it can limit vehicles based on the existing data on vehicle age. The regulation to limit vehicles based on the model year is already in place with the Jakarta Provincial Regulation 5 of 2014 about Transportation, where road public transportation has a maximum year of operation. The current government of Jakarta has also been mandated to create similar regulations for private vehicles. The MY approach might also efficiently bypass the need to gather emission standard data of vehicles, since model year data is already available. However, the MY approach will not be able to separate older vehicles being retrofitted with high emission standards. This approach is also not responsive to the government's vision to introduce more sustainable vehicles since the limitation is on vehicle age.

5.2.2. Implementation type recommendation in Jakarta

A. Pros and cons of different types of LEZ implementation

The main objective of LEZ is ideally to reduce the number of air pollution by the transportation sector in the area. There are mainly four categories of LEZ implementation considering the restriction mechanism and the enforcement type. This subsection explains the pros and cons of different LEZ implementation with Table 23 summarises the assumption (ITDP, 2023).

Table 23. Scenario for LEZ implementation type in Jakarta

Restriction Mechanism	Non-priced		Priced	
Enforcement Type	**Automatic**	**Manual**	**Automatic**	**Manual**
Accessibility of vehicles	restrict	restrict	limit	limit
Environmental impact	high	medium	high	low
Revenue generation	medium	low	high	low
Compliance rate	high	low	high	low
Monitoring consistency	high	low	high	low
Investment needs	high	medium	high	medium
Complexity	high	medium	high	medium
	Example: Seoul, South Rome, Italy Brussels, Belgium	*Example:* Paris, France Shenzhen, China Lisbon, Portugal	*Example:* London, UK Milan, Italy Antwerp, Belgium	*Example:* -

Non-priced and Automatic

The combination of non-priced and automatic enforcement will theoretically result in the highest environmental impact to reduce air pollution. This is caused by the prohibition scheme, which fines trespassers a high penalty. In addition, the automatic enforcement consistently monitors vehicle access in the LEZ area, which can cover large areas of intervention. LEZ in Brussels cover 161 km2 or 100 per cent coverage area, which operates 24/7 with the ANPR cameras technology. This intervention resulted in a 38% reduction in PM 2.5 and a 9% reduction in NOx in 2020 since its implementation in 2018.

It must be noted that implementing this type of LEZ requires a substantial upfront investment, mainly for the procurement and operation of the automatic enforcement technologies. This scheme will also face complexity in integrating the emission standard data with the ANPR technology under one system. Usually, different agencies are responsible for different datasets, which requires good collaboration.

Non-priced and Manual

This scheme provides more conservative enforcement since it only relies on manual enforcement by the on-ground officers. It does not depend on the high investment requirements for the infrastructure since it can use stickers as a sign to detect vehicles for certain emission standard categories. Lisbon, Portugal, is one of the cities that have implemented non-priced and manual types since 2011 until now. The last phase of LEZ implementation in Lisbon began in 2015 with the

limitation of below the Euro III standard from entering the LEZ area. This resulted in a decreased tendency in pre-Euro II vehicles and an increase in Euro 4 and Euro 5 vehicles.

This scheme offers more efficient implementation since it is conducted manually but suffers from consistent monitoring. The LEZ implementation in Lisbon is only in operation from 7 am - 9 pm on weekdays. The monitoring by police focuses on giving shock therapy to drivers instead of consistent monitoring. Another critique of manual enforcement is the small area of intervention for LEZ since it requires numerous on-ground officers for larger areas. The City of Shenzhen faced difficulty enforcing the mechanism due to drivers circumventing the regulation.

Priced and Automatic

The benefits and challenges of this scheme are similar to the non-priced and automatic scheme; it differs in vehicle accessibility and its impact on the environment. The priced and automatic scheme still allows highly polluting vehicles to enter the LEZ area with a certain fee. However, it can still result in a significant reduction of air pollution if coupled with automatic enforcement. The first 10 months of ULEZ implementation in Central London resulted in 44% NO2 reduction and 27% PM 2.5 reduction in the area. It decreases the number of highly polluting vehicles accessing the area by 13,500.

Priced and Manual

Until now, no city has implemented price and manual enforcement for LEZ. In theory, this scheme will result in the least benefit of LEZ intervention since it does not offer consistent monitoring and limitation of vehicles. Singapore implemented a policy similar to the 'Area Licensing Scheme' (ALS) from 1975 to 1998. The objective is not to limit the vehicle based on emissions but to charge every vehicle a fee for entering a specific area. Drivers need to buy a license manually in the post office or other public spaces. This license will be paid monthly, and the daily fee to enter ALS is SGD 3. ALS coverage is still limited to a small intervention area with only 7.25 km2. The Singaporean government decided to expand the program by implementing automatic enforcement under the ERP program.

B. The recommended scenario

The most ideal scheme to be implemented, considering the main objective of LEZ and the context of Jakarta is the **non-priced with the automatic system**. The non-priced scheme is already aligned with the current regulatory framework in Indonesia, especially in Jakarta. The Provincial Regulation 2 of 2005 about the Management of Air Pollution dictates that every vehicle in Jakarta must follow the emission standard requirement set by the government. In a more detailed regulation, Governor Regulation 66 of 2020 about Emission Testing for Motorised Vehicles stipulates that vehicle owners must independently check the compliance every six months. Metropolitan police and Transport agencies have the authority to enforce the standard by conducting random

inspections on the road. If the vehicle owners do not comply with the emission standards, they will be charged a penalty according to Law 22 of 2009 about Traffic Management. It states that every vehicle that does not meet the emission standards will be subjected to a penalty of IDR 250,000 and IDR 500,000 for motorcycles and four-wheelers, respectively. This condition shows the LEZ implementation in Jakarta should follow the non-priced scheme because there is still no regulation for vehicle charges based on the emission unless the government decides to formulate it.

Figure 53. Existing ETLE hardware in Jakarta

In terms of enforcement type, the Metropolitan Police is now shifting its enforcement type from a manual to an automatic system to solve the issue of illegal fee collection. Jakarta has already implemented an automatic system to monitor vehicle traffic violations with Automatic Number Plate Recognition (ANPR), more known as ETLE (Electronic Traffic Law Enforcement). This system has been functioning since 2018 and can identify the number plates of motorcycles and cars. There are 98 stationary locations and 11 mobile ANPR cameras. 70 more units of ANPR cameras will be installed by the end of 2023 (Syahrial & Carina, 2023).

The current system allows ANPR cameras to capture vehicles' violations of traffic laws according to Traffic and Road Transports Law No 22 of 2009 and then integrate it into the database. The violator will later be notified for confirmation, and a week later, officers will indirectly notify them to pay violation fees through banks. Currently, 10 forms of violation could be recognised from the ETLE system, such as violating road marks and signs, mobile phone usage while driving, driving above velocity standards, usage of a fake number plate, violation of one-way traffic, and violation of traffic lights for cars. Some of these ANPR cameras are installed on Transjakarta bus lanes,

targeting vehicles that violate the rules of using them. Motorbikes can also be imposed by not using helmets, riding with more than three persons, and not using motorbike lights.

It should be noted that the fine deployment has not been optimal in Indonesia. Until December 2022, a total of 42,852,990 vehicles have been captured with the ETLE cameras, but only 1,716,453 (4.01%) vehicles have been validated, and confirmation letters have been sent. From those numbers, 636,239 vehicles have been confirmed, and only 268,216 vehicles have paid the fine (Rahmatul, 2023). According to Irjen Dedi Prasetyo (Head of the Public Relations Division of the Indonesian Police Force), the current major difficulties of ETLE implementation are a limited budget for confirmation letter shipment, a manual mechanism for ETLE unblocking, and limited resources for ETLE development. Due to these reasons, the application of ETLE for LEZ might face the same conditions.

Another issue must be addressed is the data integration between the ETLE system and the vehicle emission standard data from the Jakarta Environmental Agency (JEA). JEA already created an online platform called 'Si Elang Biru Jaya', which stands for Emission Testing System for Blue Sky of Jakarta. JEA is currently in the process of integrating its platform's backend data with the Metropolitan police. A pilot program to implement ETLE based on the emission testing data will be implemented soon (Sutriasna, 2023).

C. Alternative scenario

The **manual and non-price scenarios can soon become the substitute for automatic and non-price enforcement scenarios**. The existing police forces have the authority to enforce the emission standard and can conduct random checking inside the proposed LEZ area. In September 2023, the Environment Agency and the Metropolitan Police of Jakarta started to conduct emission testing for vehicles in Jakarta to check if they have complied with the regulations. It is planned to be performed in 5 locations in Jakarta 51 times until the end of 2023. However, one day after implementation, it was stopped due to a lack of socialisation from the government (Hamasy, 2023). This event shows the need to increase collecting the data on vehicle emissions standards from the government before the penalty of LEZ implementation starts.

Until August 2023, the percentage of vehicles participating in emission testing reached only 5% of 21 million vehicles (CNN Indonesia, 2023). The government of Jakarta needs to intensify the vehicle emission inventory. This inventory will determine which vehicle emission category is allowed to enter the area. The intervention to indicate vehicle emission category can be in the form of a sticker that is visible to ground enforcers with a specific code (QR) to verify the authenticity of the sticker. An online platform must be prepared to verify the information, which will also be helpful as a database for the automatic approach in the future.

5.2.3. Stakeholders' role and responsibilities in Jakarta

A. Government collaboration

The implementation of LEZ requires a collaborative effort amongst the government stakeholders, especially in the Province of Jakarta. The recommendation for government coordination will use the existing collaboration from several regulations.

Existing collaboration

There is already an organisation scheme to manage the air pollution issue in Jakarta with Governor Decree 209 of 2023 about Mitigation and Adaptation Team for Climate Crisis and Governor Decree 576 of 2023 about Strategy to Control Air Pollution; Figure 54 and Figure 55 explain it, respectively.

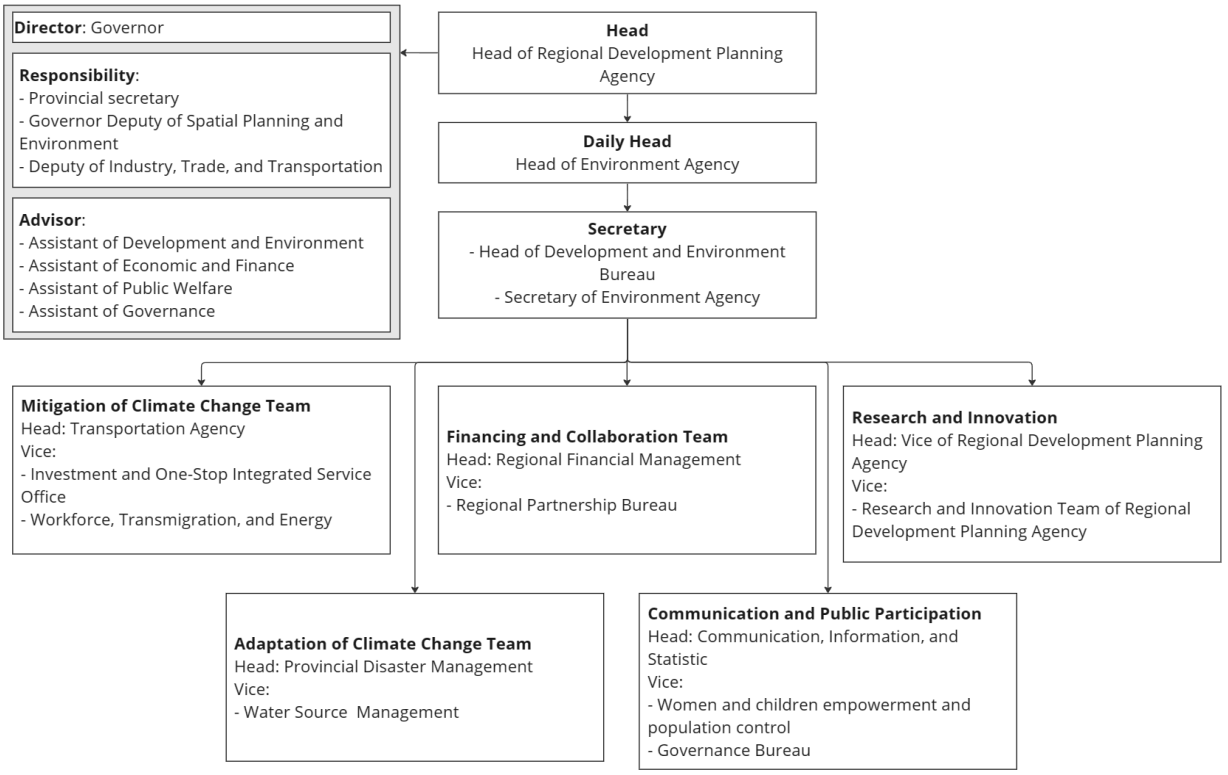


Figure 54. Government organisation scheme of Mitigation and Adaptation Team for Climate Crisis, Governor Regulation 209 of 2023

The Mitigation and Adaptation Team for Climate Crisis has a main objective to formulate policy related to the Action Plan to Manage the Impact of Climate Change in the Province of Jakarta. They will create:

- Actionable strategy from Low Carbon Development Plan in the medium and short term with a target in 2030

- Updated baseline data every two years
- Yearly program

Each team needs to conduct at least one coordination meeting every three months to update the current progress of their team objectives in preparation for the Plenary Meeting. Every six months, every team will update their progress on the Plenary Meeting to bridge collaboration needs between teams. All of the results are then reported to the Advisor every six months.

The Head of the Regional Development Planning Agency is responsible for directing and coordinating all of the team to comply with the Plan of Action for Climate Disaster Management and Adaptation. They will be the ones who report all of the progress to the advisor for further direction. The Daily Head, the Environment Agency, held a crucial role in determining the target and output of the plan. They will also coordinate all the data and achievements of all the teams under them. All of the technicalities related to the results of work from each team will be coordinated by the Environment Agency. Related to the mitigation aspect, which might be related to air quality, the Mitigation of Climate Change team is headed by the Transport Agency. They will create a medium and short-term climate mitigation plan according to the target set by the Daily Head. Furthermore, the Transport Agency will also formulate a list of actions derived from the strategy

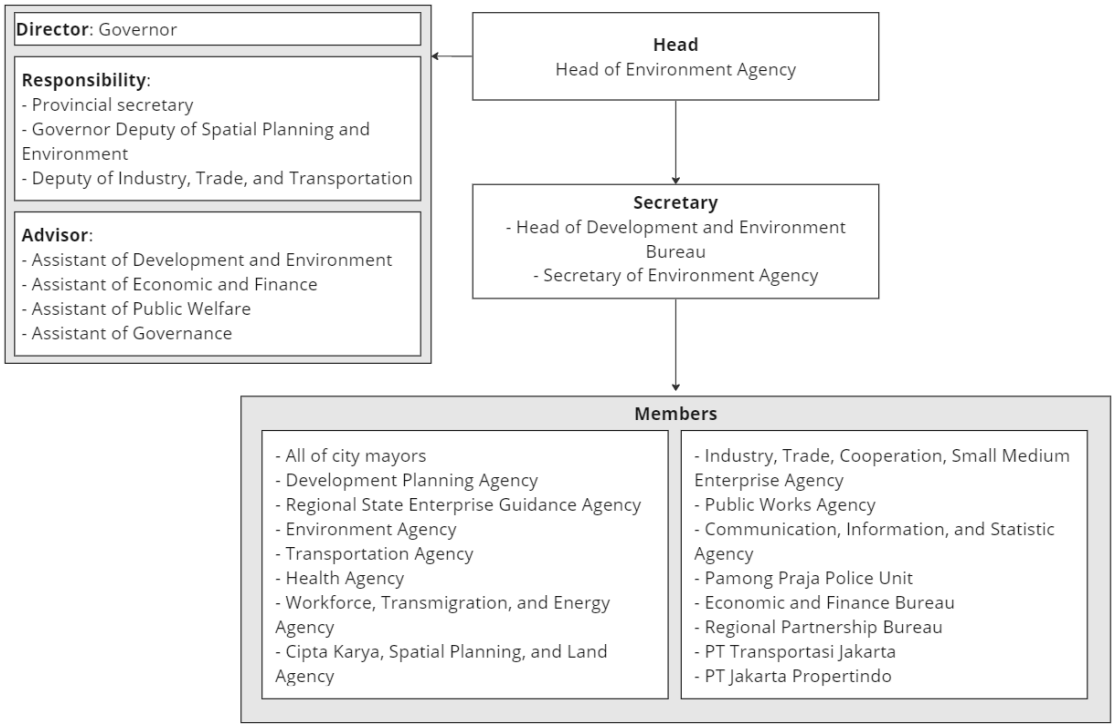


Figure 55. Government organisation for Air Pollution Management Team, Governor Decree 576 of 2023

If the previous team focuses on reducing carbon emissions, the Province of Jakarta already has a team specifically to tackle the issue of air pollution. Governor Decree 576 of 2023 chose the Environment Agency to manage the air pollution issue in Jakarta. They are responsible for:

- Coordinate all of the activities related to the target to reduce air pollution
- Led every internal meeting and public consultation
- Led the evaluation of the Air Pollution Management plan every two years
- Monitor and evaluating all of the members' activity
- Formulate report related with all of the activity related with Air Pollution Management

All of the members under the Environment Agency will be responsible for creating their own 5 year strategy to reduce air pollution according to their sectors. A list of actions follows the strategy according to the set objectives. Every team member will conduct multi-stakeholder meetings with strategic partners every six months.

Proposed government collaboration

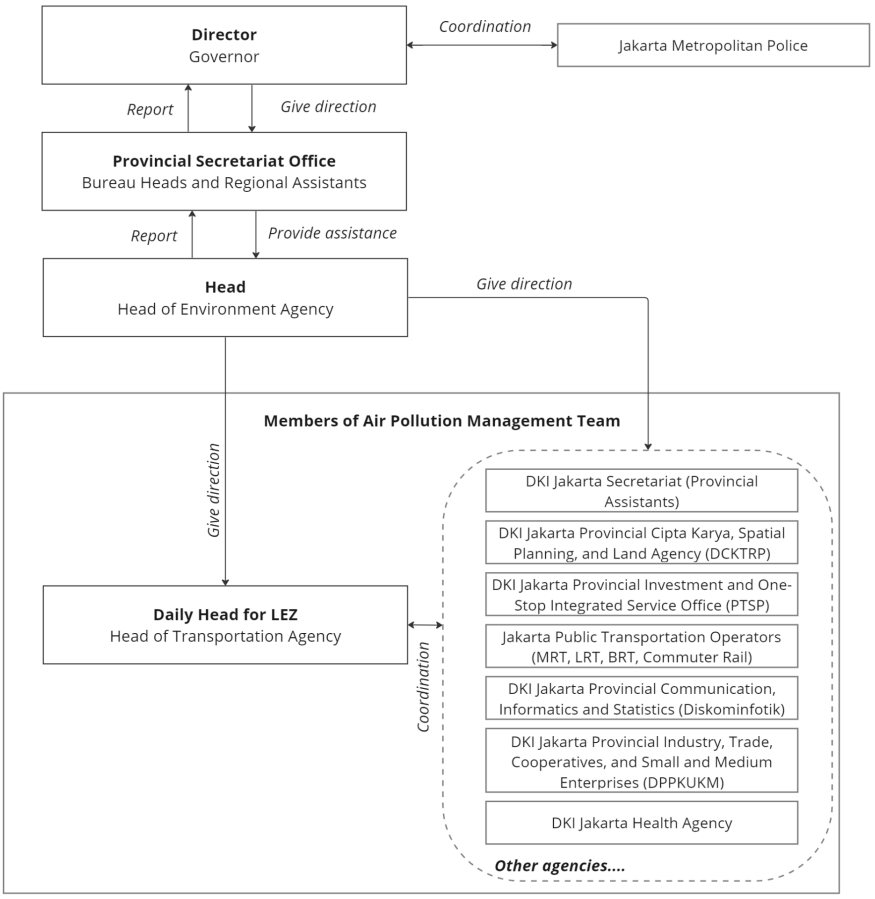


Figure 56. Proposed stakeholders coordination for LEZ program in Jakarta

The LEZ program could utilise the existing government organisation scheme from the Climate Crisis and Air Pollution team. Since LEZ directly relates to the issue of air pollution, the collaboration between stakeholders could use the organisation scheme set by the Governor Decree 576 of 2023. The Environment Agency will lead all of the efforts related to the air pollution reduction objectives, including the LEZ program. In contrast, the Transport Agency will lead all of the technicalities related to the mobility aspect of LEZ. The intervention of LEZ should be seen as an effort to minimise the access of traffic based on the standard; hence Transport Agency will be the most relevant agency to lead the implementation. Other agencies will follow their roles and responsibilities and contribute to the LEZ program accordingly, as explained in Chapter 2. An overview of potential government collaboration for LEZ is visualised in Figure 56.

The Environment Agency will help to direct and coordinate the support needed to ensure the successful implementation of LEZ. As the main Head of LEZ, they will provide the proposed delineation area of LEZ and the roadmap of implementation. It will become the consideration by the Transport Agency to provide all of the necessary implementation needs. The Environment Agency will receive coordination assistance from the Provincial Secretariat Office.

The Transportation Agency will lead the implementation and consistent monitoring and evaluation of LEZ, focusing on the mobility aspect, and supported by different agencies according to their responsibilities. As the Daily Head, Transport Agency and Jakarta Metropolitan Police will be responsible for enforcing the LEZ implementation, the coordination with the Jakarta Metropolitan Office will be connected by the Governor.

B. Public groups

Implementing LEZ requires collaboration with the organisation outside the government agencies. The Governor Regulation 209 of 2023 lists all potential collaborators related to Climate Mitigation and Adaptation. Table 24 lists all of the collaborators from the regulation which might be useful with the LEZ program.

Table 24. Organisations outside government bodies involved in climate mitigation and adaptation program

Climate Mitigation	Climate Adaptation	Financing and Collaboration	Communication and Public Participation	Research and Innovation
/Public transport operators (Transjakarta, KCI, MRT, LRT KAI, LRT Jakarta) /Sarana Jaya State Enterprise /PAL State Enterprise	/Society of Disaster Management /Red Cross Indonesia /PAM State Enterprise /PAL State	/Indonesia Climate Change Trust Fund (ICCTF) /International Council for Local /Environmental Initiatives (ICLEI) /C40 Cities /Citynet /World Resource Institute	/Jakarta Smart City International Council for Local Environment Initiatives (ICLEI) /CityNet /KARINA-Caritas	/Research and Innovation Body (BRIN) /Research Center for /Climate Change /University of Indonesia (RCCC-UI) /Bandung Institute

Climate Mitigation	Climate Adaptation	Financing and Collaboration	Communication and Public Participation	Research and Innovation
/PT Pertamina /PT PGN /Jakarta Transportation Council (DTKJ) /Green Building Council Indonesia /Indonesia Transportation Society (MTI) /World Resource Institute (WRI) /Institute for Transportation and Development Policy (ITDP) /PT PLN /PT Indonesia Power /PT PJB Muara Karang	Enterprise /Meteorological, Climate, and Geophysic Body (BMKG)	(WRI) /Vital Strategies /United Cities and Local Governments Asia Pacific (UCLG-ASPAC) /International Finance Corporation /Institute for Transportation and Development Policy (ITDP) /Jakarta CSR Forum Government /Association of Indonesia (APPSI) /Company Community Partnership for Health in Indonesia (CCPHI) /Environment Fund from Ministry of Finance /Fiscal Body of Ministry of Finance /World Bank /Indonesia Business Council for Sustainable Development (IBCSD) Indonesian Chamber of Commerce and Industry	Indonesia /Committee of Gasoline Phase Out /Majelis Ulama Indonesia (MUI) /Disability organisation	of Technology /Center for Climate Risk and Opportunity Management in Southeast Asia (CCRROM-SEAP) /University of Trisakti /Thamrin School /Data Center from various ministry /Climate, and Geophysic Body (BMKG) /Low Carbon Development Initiateve by Ministry of National Planning

The LEZ program is highly related to the Climate Mitigation group, which is being led by the Jakarta Transport Agency (JTA). Outside the government body, there are several provincial state-owned enterprises that are crucial for LEZ. Transjakarta (Transportasi Jakarta) is responsible for public road-based transportation in Jakarta, and they are planning to electrify all of the fleets by 2030. The electrification program by Transjakarta needs to be integrated with the LEZ implementation phase. Other non-government organisations such as ITDP (Institute for Transportation and Development Policy, WRI (World Research Institute), and MTI (Masyarakat Transportasi Indonesia/ Indonesia Transport Society) should be incorporated to formulate the plan for LEZ. Currently, ITDP and WRI have assisted the Jakarta government in evaluating the existing implementation in Kota Tua and the future plan for expansion in Jakarta.

The involvement of other public groups could also utilise other groups, such as communication and public groups, as well as research and innovation. The communication and public group will take part in creating a communication strategy and formulate content that relevant stakeholders use. Jakarta Communication, Informatics and Statistics Agency (JCISA) will lead the efforts, and the JTA

and JEA will create the content of information. JCISA also needs to collaborate with the city mayor to help disseminate the information to the neighbourhood level. As for the research and innovation group, they will support the relevant agencies in developing the technical analysis related to LEZ. The JEA is currently collaborating with the Bandung Institute of Technology to formulate the indicators and potential locations for LEZ in Jakarta.

5.2.4. Public perception towards LEZ implementation in Jakarta

The implementation of LEZ requires the identification of the group impacted and benefited by the LEZ implementation. LEZ will limit the use of highly emitting vehicles and might create an inconvenience which will result in resistance to the implementation. Regulators should be aware of the group that has perceived LEZ as a limitation and address their concerns carefully.

Public acceptability of LEZ

Public understanding of the LEZ concept comes from the pilot implementation in the LEZ Old Town, which was implemented in February 2021. Vital Strategies (2024) conducts a public survey identifying perceptions towards the concept of LEZ. The majority of respondents (54%) are already aware and understand the concept of LEZ, 41% are aware but do not understand, and 5% are unaware and do not understand. Furthermore, the majority of respondents from the aware group already understand the LEZ concept as the limitation of highly emitting vehicles in certain areas with 56%, 26% perceive it as a limitation of access to certain areas, 16% perceive it as prohibition and 2% perceive it as pedestrianisation projects. This survey indicated although the current LEZ implementation in Old Town focuses on pedestrianisation, the public understanding of LEZ already aligns with the ideal LEZ definition of access limitation for highly emitting vehicles.

Identifying public perception of the LEZ is essential to determine the support for the program. However, there has not been any public perception survey conducted to assess the general perception towards the ideal concept of LEZ. ITDP Indonesia (2023) conducted a study in the "Public Perception Towards the ERP in Metropolitan Jakarta" report, providing an overview of the current perception of air pollution and the intervention needed from the transportation sectors. Although this survey does not explicitly identify perception for LEZ intervention, it provides insightful information related to the public perception towards the issue of air pollution from transportation sectors and the limitation of private vehicle uses.

Based on the survey with 1,012 respondents, 511 (50.5%) respondents were private vehicle users and were asked about their perception of the relationship between motorised vehicle usage and the issue of air pollution. Figure 57 shows if motorised vehicles are the main contributor to air pollution and whether they harm the environment and public health.

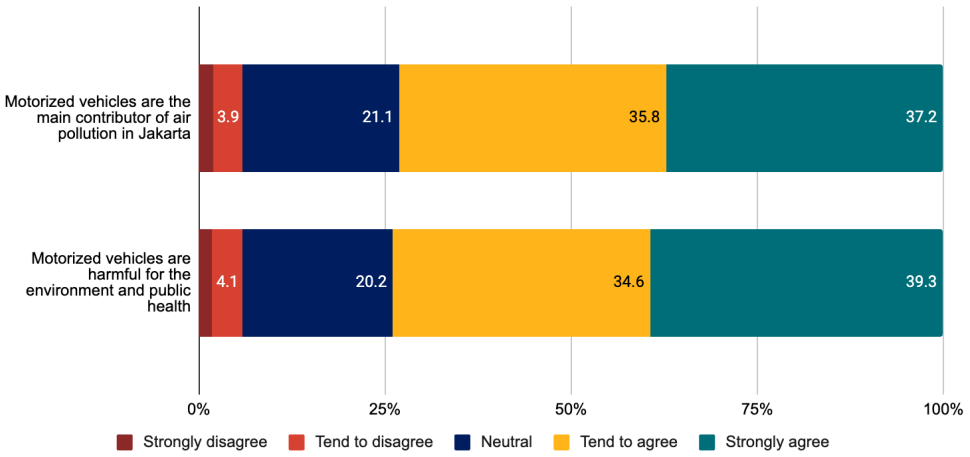


Figure 57. Perceptions of non-public transport user commuters on motorised vehicles as contributors to urban issues

More than 75% of private vehicle users in Jakarta agree that motorised vehicles are the main contributors that harm the environment and public health. Around 20% take a neutral stance, and only around 5% of respondents disagree with the notion. These results indicate that even the private vehicles users are already aware there is a need to limit the use of private vehicles, and LEZ objectives are already aligned with the public concern.

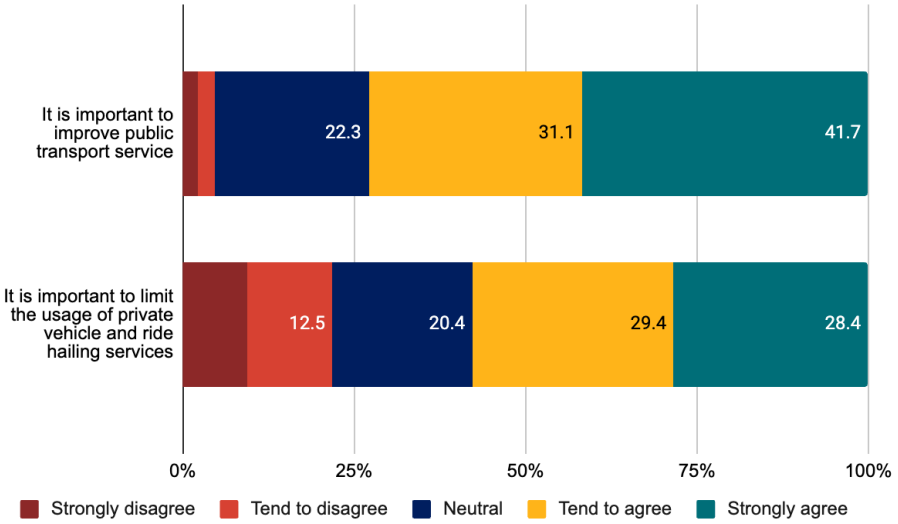


Figure 58. Perceptions of non-public transport user commuters the importance of public transport improvement and motorised vehicle usage limitation

Regarding the specific intervention to address the issue of air pollution from transportation sectors, respondents were asked about the pull policy with the improvement of public transportation and push policy with limiting the use of private vehicles and ride-hailing services, as

illustrated in Figure 58. It shows significant support for a shift toward more sustainable transportation with public transportation, which reached 72.8, with 22.3% taking a neutral stance and 4.8% disagreeing. Meanwhile, the direct limitation of private vehicles resulted in less support but was still a major proportion, with 57.6% agreeing with the notion, 20.4% being neutral, and 21.9% disagreeing.

This survey shows that air pollution is an urgent issue that needs intervention in the transportation sector. Improvement of public transportation services and limitation of private vehicles and ride-hailing services are required. The limitation of private vehicles already receives a majority of support which local governments can take advantage of to implement the LEZ policy.

However, special attention is needed for specific groups that might disagree with the policy and those whom the policy may negatively impact. These groups may include lower-income communities, people with disabilities or other mobility restrictions, taxi drivers, ride-hailing drivers, and private office workers.

People with Disabilities

People with Disabilities and mobility restrictions may be severely impacted by the implementation of the LEZ. This may include those with physical disabilities, visual disabilities, hearing disabilities, and those with mobility restrictions, such as older persons. These individuals may already have to rely heavily on personal vehicles for their mobility, as public transportation in Jakarta still poses many barriers for these individuals. Suppose the Jakarta public transportation system is accessible. In that case, these individuals may still have concerns regarding the need for a vehicle to access a public transportation system, which may require them to be driven by a caregiver or use a taxi/ride-hailing service. Some individuals with disabilities may use specialised vehicles or modifications to meet their unique mobility needs. The availability of low-emission options for such vehicles may be limited, which can cause difficulties in finding suitable alternatives. Several testimonies from ITDP's Kampung Kota Bersama Project (2019) showed the reliance on personal vehicles of People with Disabilities due to the lack of accessibility of public transport systems.

"The problem is that when we go to transit stations it is quite difficult because of the high steps at bus stops or train stations. For Transjakarta services, you should get free card facilities for passengers with a disability. Transjakarta Care also does not allow to take its passengers outside Jakarta, even if it is only slightly outside the boundaries of Jakarta. For KRL services, the gap between the train and the platform is very far and high. At the KRL station, officers were also not guided and fell into a gap in the platform" - Dedi, 31, Visual Disability

These barriers may cause the urgent need for these individuals to upgrade or change their vehicles to keep up with their current mobility needs, which may be difficult. This can also be seen as an extra burden as some of these individuals may already face financial challenges, and the cost of upgrading or replacing a vehicle can be a significant burden. In terms of older persons who also face mobility restrictions, these individuals possibly do not earn an income anymore, which may also be seen as a constraint. It must be noted that these individuals might also face barriers in obtaining information regarding the LEZ, the emission standards they must follow, the delineation area, and other LEZ-related information (which is also constantly changing). Thus, an inclusive communication strategy must be conducted to ensure they have access to the correct information.

Lower income group

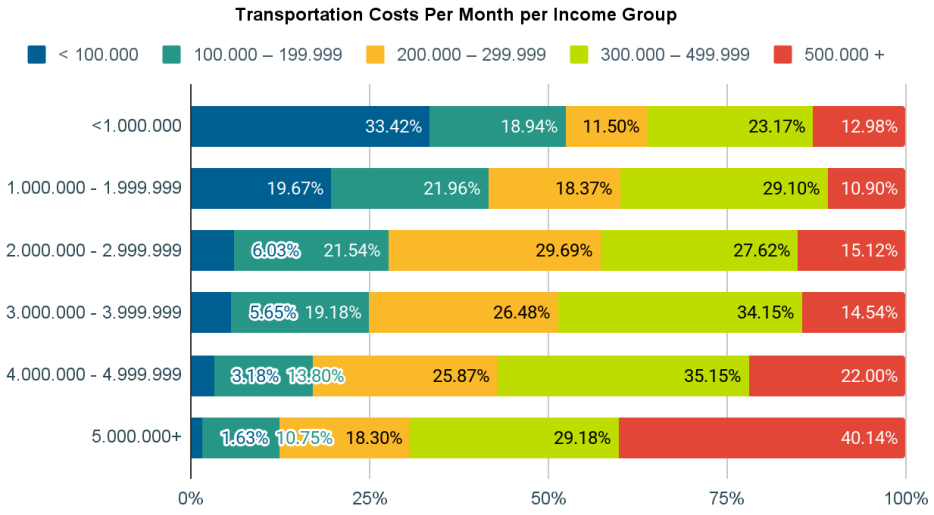


Figure 59. Transportation costs per month per income group

Lower-income communities will face similar challenges, as they will experience more burden in upgrading or changing their vehicles. Figur e 59 shows data from the Indonesian Central Bureau of Statistics (BPS, 2019), showing that those who earn less than IDR 1,000,000 spend around one-third of their expenses on transportation, which suggests that the implementation of LEZ may be a possible financial burden. Moreover, these individuals may be more likely to own older vehicles that do not meet the required emission standards, meaning that they may likely be one of the first few groups who must upgrade or change their vehicles to comply with the emission standards. It also must be noted that many of these individuals may work in informal sectors that may require personal vehicle usage, such as delivery services, street vendors or small-scale businesses, and restrictions on their mobility due to the implementation of LEZ may impact their livelihoods. In an extreme case, LEZ may cause displacement of these lower-income communities, which must be mitigated.

Ride-hailing drivers

For taxi drivers and ride-hailing drivers, both for motorcycles and cars, formal and informal, the LEZ policy would subject them to meet the emission standards to be still able to operate. These drivers also may be using older vehicles or vehicles that do not meet the emission standards; upgrading or replacing their vehicles may be burdensome for those who may already be facing financial hardship. Moreover, drivers may also be concerned about a potential decrease in ridership or demand for their services, as customers may be discouraged by possible higher fares due to the need to upgrade their vehicles or due to the lower supply of eligible vehicles. Similar concerns were raised for electronic road pricing, as drivers worried about the potential price increase (Septiani, 2023). These possible scenarios may have an overall impact on job security and the drivers' source of income, especially if they are unable to afford the necessary changes to their vehicles.

Private office workers

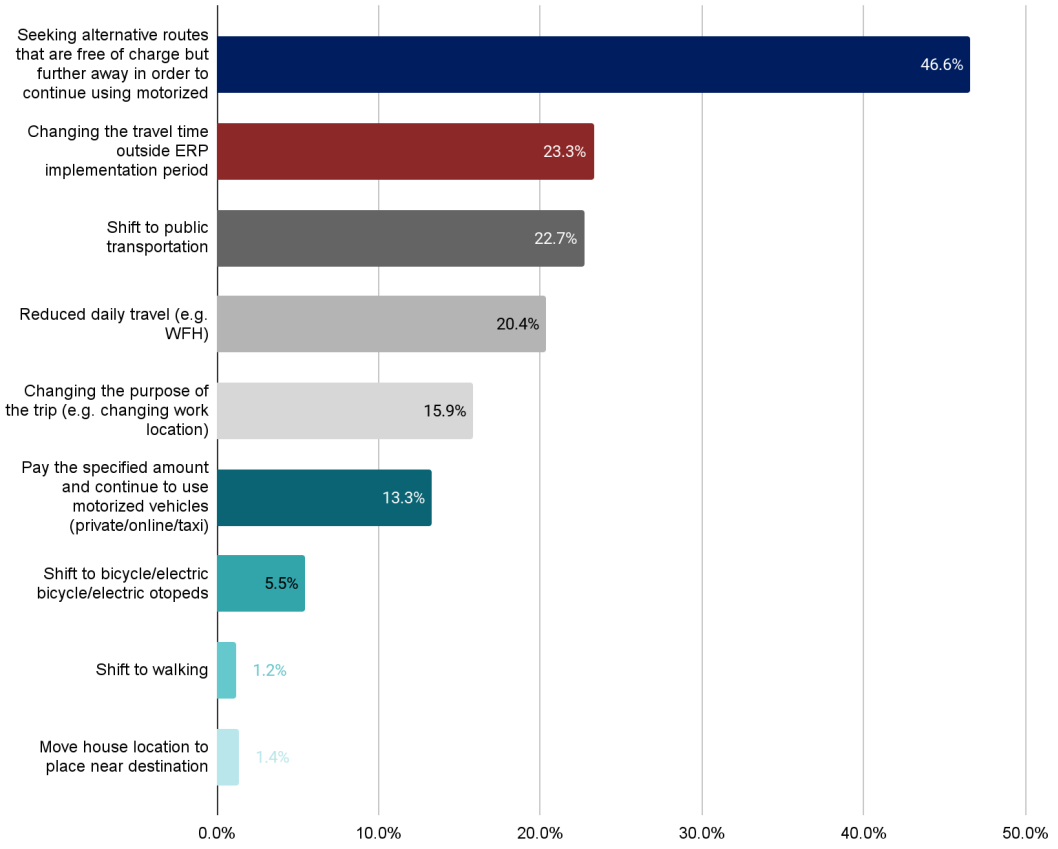


Figure 60. Willingness to pay for electronic road pricing

Private office workers may also be affected, although not as strongly as the previously mentioned groups. Private office workers might have more capital to afford or upgrade their vehicles to meet

the emission standards. However, as expected from the implementation of an LEZ, some may choose to shift to using public transport. It is important to increase the quality and capacity of the public transportation system and to increase integration between modes of transportation to accommodate these new users and other users. Failure to accommodate these users may cause a lack of comfort, an increase in travel time, poor user experience faced by users, or non-compliance with the LEZ. Supporting this, Figure 60 shows that 46.6% of respondents are willing to pay for ERP, so non-public transportation users prefer to reroute rather than pay the road charges (ITDP Indonesia, 2023). This may indicate the low willingness to change to public transport due to the current quality of public transportation. Moreover, although this group may not be as vulnerable or as negatively affected as others, it is important to ensure a smooth transition towards the LEZ and cater to as many people as possible to reduce the amount of resistance from the public.

5.2.5. Exemption policy of LEZ in Jakarta

As elaborated in previous sections, the old town in Jakarta, also known as Kota Tua, has been declared a low emission zone. No vehicles are allowed to enter several road segments to reduce pollution. However, the government has made some allowances for several groups, which include residents who live inside the area, business owners, and Transjakarta buses. Residents and business owners are given specific stickers to differentiate them from other vehicles. Unfortunately, the vehicle limitation in Old Town has not been continued. Hence, the exemption policy also stopped.

For the future implementation of LEZ in Jakarta, the provincial government should provide a more comprehensive exemption policy. Jakarta has provided several exemption policy measures for different transportation programs which might be relevant for LEZ implementation. This sub-chapter also provides recommendations for the exemption policy of LEZ in Jakarta.

A. Existing exemption policy in transportation

Jaklingko Priority Groups

Jak Lingko is a fare integration system for public transportation in Jakarta that encompasses Transjakarta (including mikrotrans), MRT Jakarta, and LRT Jakarta. With this fare integration system, instead of paying multiple times each time one uses multiple modes of transportation, payments of multimode trips are simplified to have a more seamless and efficient travel experience. Using the Jaklingko fare integration system will ensure multimode transportation in Jakarta has a maximum fee of IDR 10,000. The basic fare for Jaklingko users is IDR 2,500, with an additional charge of IDR 250 per kilometre, with a total fare that will not exceed IDR 10,000.

Referring to DKI Jakarta Governor Decree no 5 of 2014 and no 160 of 2016, The committee of Jakarta's People representative mandated to expand the reach of free public transportation to 15 citizen groups through the Jaklinko system. These groups include:

- Active DKI Jakarta Civil service staff and pensioners
- DKI Jakarta contracted workers
- Students with KJP A
- Some types of private employees
- Residents of simple flats
- Kepulauan Seribu Residents (shown through ID card)
- Jabodetabek Raskin Recipient
- National Police and Soldiers
- Veterans (shown through ID card)
- Disabled People (shown through ID card)
- Elderly
- Kindergarten teachers
- Mosquito larvae surveillant
- Family Welfare Movement (TP.PKK)
- Mosque manager

Odd-Even policy

The odd-even policy in Jakarta regulates the type of vehicle that can enter specific road segments in Jakarta during peak hours from Monday to Friday, excluding national holidays. These restrictions are applicable from 07:00 to 10:00 and 18:00 - 20:00. The rule is based on a vehicle's number plates, where on odd dates, only vehicles with odd number plates are allowed to operate on these road segments, while on even dates, only even-numbered plates are permitted.

Regarding the monitoring method, police and the transportation agency mostly monitor it manually. However, several cameras exist in certain road segments or electronic traffic law enforcement (ETLE). Violators of the odd-even policy will face sanctions up to a maximum fine of IDR 500,000. Certain vehicles are exempted from this policy, which include the following:

- vehicles of certain state institutions
    a. President and Vice President;
    b. Chairmen of the People's Consultative Assembly, Chairman of the Council;
    c. People's Representative's Council, or Regional Representative Councils
    d. Chief Justice, Chief Justice of the constitutional Court;
    e. Chief of the Judicial Commission; and
    f. Ministers and leaders of non-ministerial government institutions.
- Vehicles of foreign state leaders and officials as well as international institutions who are state guests;
- Official vehicles with red base colour and/or military/police official vehicle numbers;
- Firefighting vehicles;
- Ambulances;
- Public transport vehicles with yellow base colour;

- Battery-based electric vehicles;
- Specially marked vehicles carrying people with disabilities;
- Freight transport vehicles: fuel or gas, money transport, livestock, fertiliser, free round-trip motorcycles, and essential goods, including rice, corn, sugar, flour/wheat/tapioca, cooking oil and butter, vegetables and fruits, fish, meat, eggs, salt, soybeans, milk, poultry meat, chilli, and onions.

B. Recommendation for Exemption Policies in Jakarta

If Jakarta were to implement a city-wide Low Emission Zone (LEZ), exemptions should be considered for specific groups and vehicles to ensure a balanced and inclusive approach to environmental regulations. Drawing inspiration from exemption policies in other cities and Jakarta's existing mobility policies, several categories could be eligible for exemption from the LEZ restrictions. The exemption can be categorised into the following categories.

Vulnerability of movement

Imposing LEZ will oblige people to follow specific vehicle emission standards, which require capital if the existing vehicle does not meet the standard. People With Dissabilities (PWD) will be one of the group impacted most by LEZ policy. The transportation network in Jakarta still has not been able to ensure the accessibility of first- and last-mile connectivity. PWD faces difficulty in accessing the infrastructure since it does not include the different needs of the PWD group (ITDP, 2022). They are forced to use private vehicles to mobilise and are often accompanied by their caretaker. The LEZ policy should give a full or temporary exemption policy for PWD or caretaker vehicles to ensure their mobility is not limited.

Firstly, individuals with disabilities, as evidenced by a valid disability card or sticker, could be exempted from the LEZ regulations. Similar to the practices in Edinburgh and Brussels, where blue badge owners and drivers with disabilities are granted exemptions, Jakarta can prioritise the needs of those with mobility challenges. The provincial government could also give temporary exemptions as implemented in London. With this scheme, PWD will have a longer grace period to adapt to the LEZ standard (usually 2-3 years longer).

The current Jaklingko priority group must be addressed carefully since not all of the groups listed in the regulation should be included in the exemption for implementation of LEZ in Jakarta. To ensure the programme’s sustainability and to create an environment that answers the needs of different groups, a universal approach is recommended to provide accessible and affordable transportation for all. Determining the incentivised groups needs to be based on the vulnerability of that group, not their profession. Vulnerable groups experience poverty risk and social exclusivity compared to the general public, including minimum access to resources, which hinders them from enjoying various public facilities.

In many countries, the elderly group and PWD enjoy subsidies based on economic needs and the probability of requiring a guardian, which may cause trip costs to double. Similar approaches are also used for children and students up to high school. With this reasoning, applying the exemptions to citizens should also consider those most vulnerable and who are highly impacted by the LEZ, not just based on one's profession.

Vulnerability of socio-economic conditions

Another vulnerability perspective that must take into consideration is from the socio-economic conditions; they might be unable to purchase or upgrade to cleaner vehicles but have high mobility within the LEZ area. Impoverished households could be classified depending on kartu miskin recipients, including KJP, Raskin, simple flat residents (rusunawa) from impoverished backgrounds, or those living in slums. Figure 61 shows the distribution of slums in Jakarta against the suggested Intercity LEZ area, showing various slums that overlap with the plan of the LEZ area. This neighbourhood could be prioritised to receive the exemption policy of LEZ since they already live in the area and are impacted significantly by the policy.

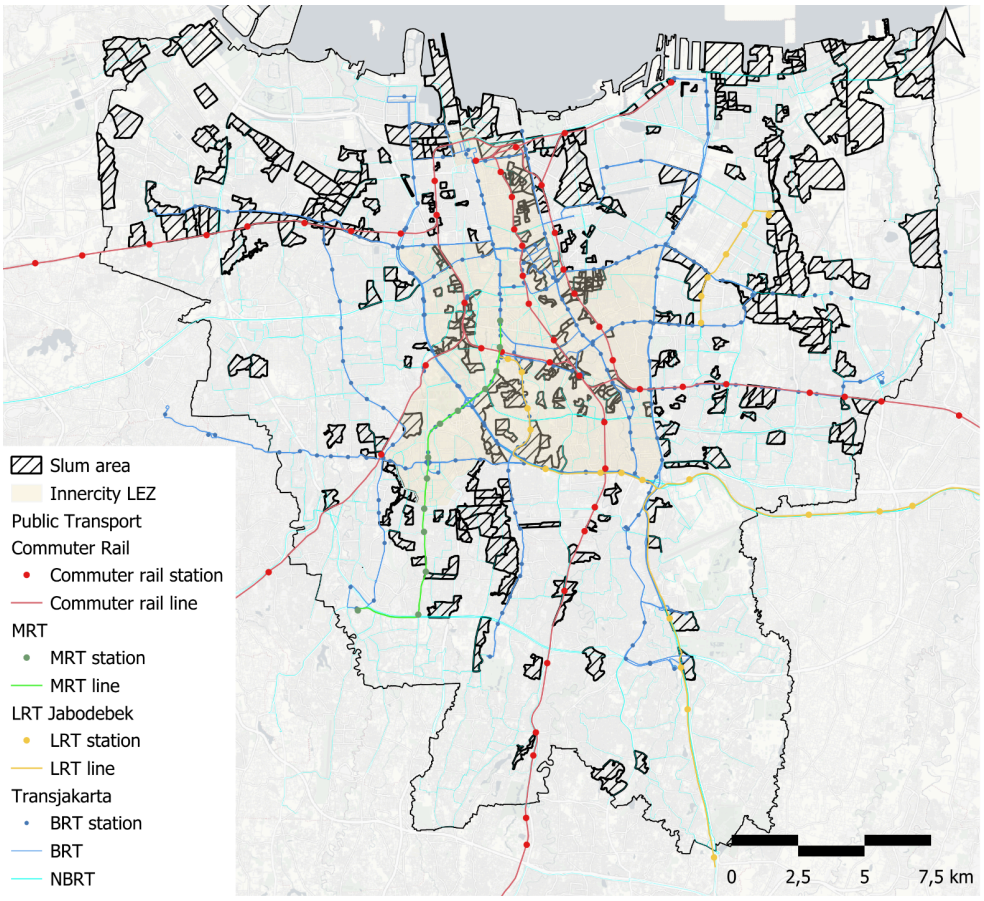


Figure 61. Spatial distribution of slums in Jakarta

It must be noted that as the LEZ is situated in the city centre, it should be assumed that it is located in areas with good public transport infrastructure and improvement. Therefore, although citizens of impoverished households may not be able to afford a cleaner vehicle, they still have the option to shift to public transport. With this reasoning, groups from low economic classes can be given an exemption policy, which should be temporary. They can be given extended grace periods to adapt while the provincial government provides incentive mechanisms for them. The incentive could be in the form of a subsidy to upgrade their vehicles or a public transportation fee subsidy.

Special Exemption
Lastly, exemptions could be extended to certain types of vehicles that serve essential functions. These types of vehicles include firefighters, ambulances, and police, where emergency conditions should be prioritised first. Exemption for construction vehicles can be applied, however it must be obtained with permit mechanism. This system is implemented in London where construction vehicle can apply for daily permits during the construction process.

5.2.6. Incentive mechanism

The provincial government could explore more incentives to increase the adoption of greener vehicle emission standards from other cities that have successfully implemented LEZ. Several policies have already been implemented and can be improved further in the future.

A. Existing incentive mechanism

Tariff integration
One of the policy recommendations that could improve the number of people using public transportation is introducing tariff integration. The 'Public Perception Towards ERP in Metropolitan Jakarta' from ITDP shows that the willingness to shift from private vehicles to public transport will increase by 25% if a tariff integration scheme is implemented. The provincial government is currently in the pilot phase of launching tariff integration for the public.

The tariff integration is the cost incurred when riding more than one public transportation in Jakarta, namely the Jakarta MRT, Jakarta LRT, and Transjakarta, with a maximum fare of IDR 10,000. The integration tariff will be calculated when passengers switch modes, with an initial fixed fee of IDR 2,500 and a per kilometre rate of IDR 250.

The public can also access the integration tariff through the JakLingko Application by purchasing a destination ticket using multimodal (more than one type of public transportation). The tariff automatically obtained is the Integration Tariff. Travel tickets booked through the JakLingko application will expire at 03.00 am. In addition, the integration tariff also applies to Electronic Money Cards issued by banks. Unlike the application on the Electronic Money Card, the Integration Tariff is valid for a period of 180 minutes.

Electric Vehicles Exempt from Odd-Even Rule

The provincial government implemented an incentive mechanism for electric vehicles during the odd-even policy. Based on the Governor Regulation 88 of 2019 about the Traffic Management by Odd-Even Policy, electric vehicles are exempted from the limitation. This type of incentive could persuade private vehicle users who still use high-emitting vehicles to adopt more environmentally friendly vehicles.

Electric Vehicles Purchase

The national government imposes incentives on companies that import electric vehicles as a complete package by reducing import duty. This incentive is regulated by Presidential Decree 79 of 2023 about the Acceleration of Battery Electric Vehicle for Road Transportation. In addition, the government also provides incentives to companies that will build battery-based electric vehicle manufacturing facilities in the country, that have invested in domestic battery-based electric vehicle manufacturing facilities in the context of introducing new products, and/or that will increase production capacity for battery-based electric vehicles in the context of introducing new products.

B. Incentive mechanism for LEZ in Jakarta

Scrappage scheme

Currently, there is no scrappage scheme implemented in Indonesia because incentives are still focused on electrification. If the government want to provide a scrappage scheme, it should focus on the vulnerable group mentioned in the exemption policy. Logistic vehicles could also receive incentives for cleaner vehicles since it will significantly reduce pollution.

Exemptions and discounts

The recommended exemption policy in Jakarta can follow the explanation in the previous section, which prioritises the group with vulnerability in movement and socio-economic status. Discounts can be given to public transportation services in the LEZ area. Users will get cheaper rates if they stop at stations inside LEZ.

5.2.7. Engagement strategy

The implementation of LEZ as a push policy will require a careful communication strategy to ensure well-received responses from the public. Local government can increase the likelihood of successful LEZ implementation by ensuring a well-planned communication strategy. It must be noted that public acceptance is not the prerequisite of LEZ; rather, it is the expected outcome. The main objective is to maximise the awareness of the program, which will lead to a high level of compliance. This communication strategy will use the study from Pickford et al. (2017) based on the study of consultation strategies of ERP and LEZ in 12 cities across the world. Two things need to

be ensured in the communication strategy for LEZ can be concluded into the aspect of message and engagement strategy.

The content of the message

- Objectives of LEZ

  Clearly state the objectives and expected outcomes of the consultation process, ensuring alignment with pollution reduction, health goals, and economic productivity. The provincial government introduced the ERP program in 2023 with huge resistance from ride-hailing services since it will impact their fee to the customers. Government should differentiate the LEZ implementation from the ERP from its objective that LEZ tried to solve the issue of air pollution with the existing regulation and not to impose another access fees for people.

- Outcomes of LEZ

  Government should emphasise the benefit of LEZ implementation for the general public in terms of health and economic perspectives. Reducing polluting vehicles that are harmful to human health can reduce respiratory and cardiovascular diseases, benefiting public health. This will especially benefit children, pregnant women, older persons, or other individuals with pre-existing conditions who are more susceptible to the health effects of poor air quality. LEZ measures can therefore contribute to creating a healthier environment for these groups. It must be noted that a decrease in cardiovascular disease may also lead to a healthcare reduction in costs for both individuals and the government (in terms of public healthcare services).

  Syuhada et al. (2023) identify the impact of air pollution on health and the cost of illness in Jakarta. The PM 2.5 concentration in Jakarta is three times the national standard, which creates long and short-term health impacts. Annual exposure to PM 2.5 causes 6,100 cases of stunting, 330 infant deaths, 700 infants with adverse birth outcomes, and 9,700 premature mortality. Meanwhile, daily exposure to PM 2.5 was associated with over 3,500 hospitalisations in a year.

  On top of increased public health, the LEZ may also have secondary benefits. As more people shift towards public transportation for their day-to-day mobility, this may affect the reduction of private motorised vehicles on the road. This effect may improve the safety and comfort of pedestrians and cyclists. Reducing vehicular emissions can lead to safer and more comfortable environments for pedestrians and cyclists and may encourage people to adopt active transportation options. Furthermore, pedestrians and cyclists, along with those who live near high-traffic areas (may include low-income households and slums), will also experience noise reduction as more people shift towards public transportation. In

addition, as more people adopt electric vehicles and buses become electrified, this benefit will become even more significant.

- Tone of the message:

  Based on the lesson learned by Transport from London (TfL) when implementing the congestion charging, they chose a rational and comprehensive perspective when promoting the policy. An over-optimistic and persuasive tone should be avoided to minimise opposition from groups that disagree with the policy (e.g. vehicle drivers). LEZ should not be communicated as a stand-alone policy but as a part of a larger policy package for sustainable mobility to reduce rejection from the public. Government should present as the enforcer of the policy and the provider with different incentive mechanisms they provide.

- Vulnerability perspectives

  Adding to the health benefit of the LEZ program, a focus on vulnerable groups that benefited from this policy is important to persuade the public. The listed group includes children, elderly, expecting mothers, and the working productive age group.

- Nominate an Expert Roundtable

  Form diverse expert groups to manage the consultation and policy design process, including representation from internal stakeholders and international experts for comprehensive insights.

- Message phasing over time:

  Disseminating information about LEZ will require phasing to ensure a well-received perception in the public. Figure 63 explains the general phasing for the type of message to the public.

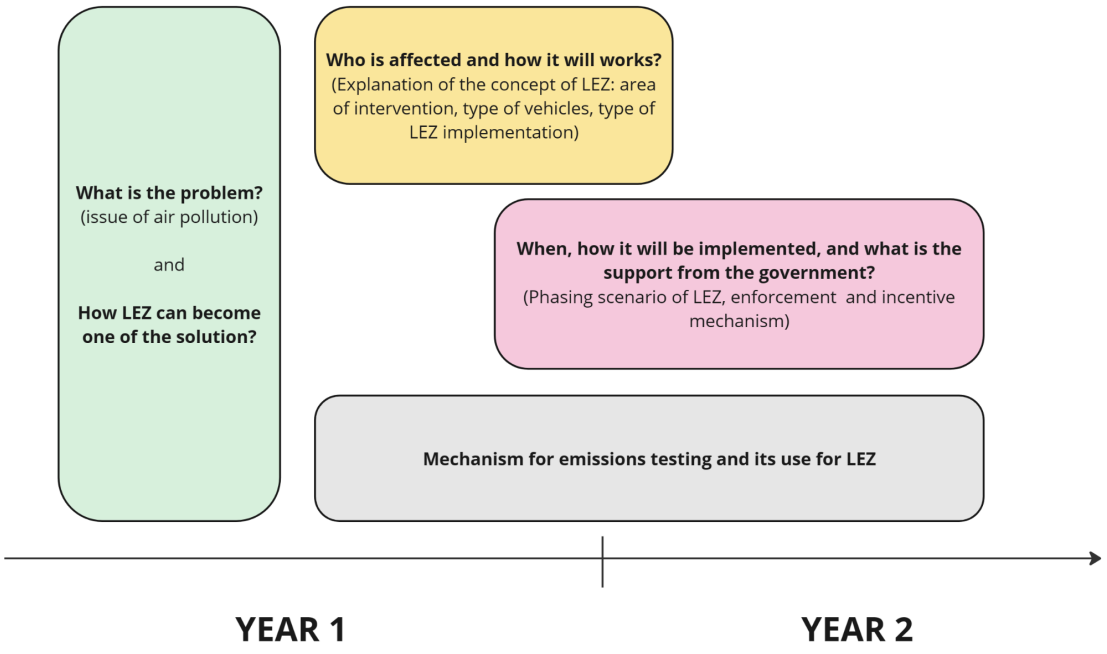


Figure 62. Phasing of messaging content for LEZ

The initial message for LEZ should focus on introducing the issue of air pollution to increase the urgency to solve the issue and the cost of inaction if this condition continues. LEZ comes as one of the potential solutions to solve the issue of air pollution from the transportation sector. The next step will introduce in more detail the concept of LEZ related to the potential area of implementation, the type of vehicles LEZ will impose, and the positive impact it might bring to persuade the public.

The detailed implementation technicality about the time period, type of enforcement and incentive mechanism for specialised groups can be disseminated near the end of the 1st year. Messages related to the detail of the emission testing mechanism and its relation with the LEZ policy can be disseminated together during the explanation of the LEZ concept.

Engagement strategy

1. Identify Stakeholders and Interaction Methods: identify stakeholder groups and develop targeted measures to engage difficult-to-reach stakeholders. Low-income groups that predominantly use old vehicles will be the main group that is difficult to persuade. As explained in the previous section, online motorcycle taxis and motorcycle groups in general will require more in-depth consultation.
2. Ensure Legitimacy through Consultation Procedures: design transparent consultation procedures involving stakeholders from various sectors affected by the LEZ. Consultation

should not be limited only to experts but also to the general public. A concerned citizen should be able to express their concern and receive a response from the officials. The provincial government of Jakarta can utilise the current mechanism to express opinions at the city level. Officials from district (Kecamatan) and subdistrict (Kelurahan) should receive an information package related to LEZ to gather information and answer questions from the public.

3. Utilise Various Forms of Interaction: employ diverse interaction methods (leaflets, workshops, online resources, etc.). Physical information with a banner or leaflet can be focused on every road around the LEZ delineation.
4. Routine consultation check: during the consultation process, conducts regular public surveys to assess the current state of understanding of the LEZ program. If the survey shows people were confused about the scheme, a targeted message to fill the gap is needed and revised strategies can be implemented.
5. Establish a quick response mechanism: LEZ, as a push policy, will often result in misleading information. Local government or respected agencies should ensure the constant validation of the information that is spread to the public. The government could also give specific inquiries to the media and provide concrete information to earn positive exposure.

6. Impact of LEZ implementation

The emission reduction calculation from LEZ is calculated by multiplying the Emission Factors by the annual activity for each type of vehicle types. This chapter explains the overview of the LEZ impacts on the Vehicle Kilometre Travelled (VKT). It continues with the methodology and assumption used to calculate the EF by different vehicle types. This EF is used to calculate air pollution reduction under different scenarios.

This chapter consists of the air pollution reduction model under the ES approach and MY approach, a comparison between the model, and a key summary of the modelling results.

Vehicle Kilometre Travelled (VKT) of each type of vehicles

The evaluation of emission benefits from adopting a LEZ in Jakarta starts with the identification of the contribution of each of the vehicle activities and their emission within the intervention areas. At the same time, the implementation should aim to reduce the impact on a broad range of drivers and minimise public resistance to this type of program.

Figure 63 provides an overview of vehicle activity by vehicle type in Jakarta. The data was obtained from traffic modelling work by the Japan International Cooperation Agency (JICA) from the study of Jabodetabek Urban Transportation Policy Integration (JUTPI) Phase 2 in 2019. Motorcycle travel contributes by far the largest share of vehicle activity in the city, with close to 14 billion km travelled per year in 2024. Cars are second, at 2.5 billion kilometres. Large and medium trucks contribute the smallest amount of travel, with 18 and 16 million kilometres travelled per year. MCs travel about 767 times more than large trucks and 843 times more than medium trucks at the city-wide level.

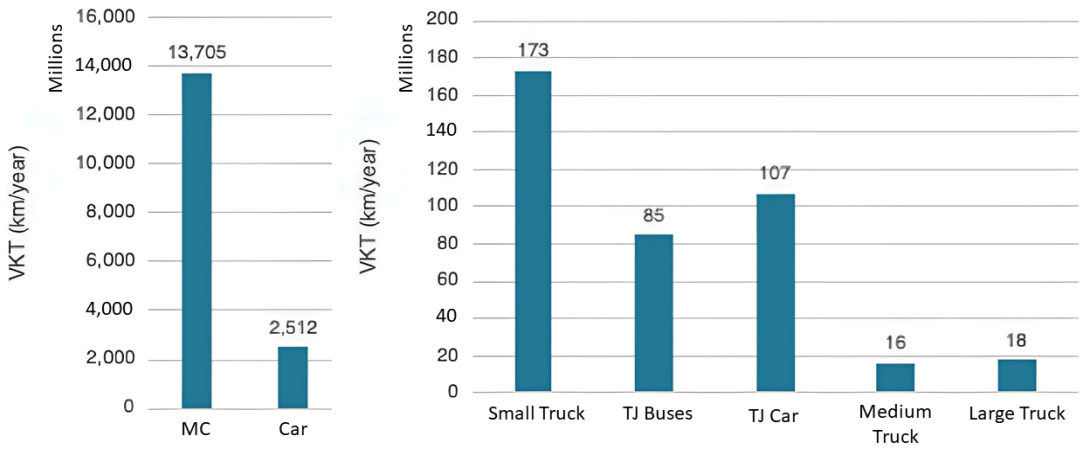


Figure 63. Vehicle kilometres travelled (VKT) by vehicle type in Jakarta. Source: ITDP analysis based from JICA 2019

Table 25 explains the proportion of vehicle activity covered in the LEZ area compared to the total city-wide activity. The pilot LEZ will only cover a small amount of vehicle activity as the intervention area only covers 2.9% of the area of Jakarta. It will only cover the activity of 5.3% of motorcycles, 6.2% of cars, and 8.3% of LCVs. The proportion of HDVs in this area is small because vehicle access is already limited in the inner city of Jakarta. As the area of intervention is larger in phase 2 of Innercity LEZ, more vehicle activity is covered by the program. In the Innercity LEZ, it will impact nearly a quarter of vehicle activity for passenger vehicles. As for Transjakarta fleets, it will affect 50% of the total vehicle activity. At the same time, the Outer LEZ, which covers all of Jakarta, will impact all vehicle activity for MDV and HDV.

Table 25. Vehicle kilometres travelled (VKT) by vehicle type in Jakarta. Source: own work

Vehicle	Pilot LEZ (18 km2, 2.9%)	Innercity LEZ (87 km2, 13%)	Outer LEZ (100%)
MC	5.30%	23.00%	-
Car	6.20%	25.90%	-
LCV	8.30%	29.60%	-
MDV	6.30%	28.00%	100.00%
HDV	1.80%	16.30%	100.00%
TJ Car	1.90%	12.50%	-
TJ Bus	16.40%	50.30%	-

Estimating Emission Factors (EF) of each vehicle types

Estimating emission factors from all vehicle types required two inputs: pollutant emission factors for each vehicle model year and fuel type and the age distribution of vehicles operating in Jakarta by fuel type and emission standard.

Distance specific NOx and PM emission factors by fuel type for each vehicle type were obtained from two sources. The main source of EFs comes from a database of more than 100 thousand remote sensing (RS) emission measurements that ICCT collected in the greater Jakarta area in 2021 (Mahalana et al., 2022). Remote sensing data recently sourced from Jakarta under local environmental and road conditions provide an accurate representation of real-world vehicle emissions. The RS campaign in Jakarta covered PCs, MDVs, HDVs and buses. However, motorcycle emissions data were not included due to the limitations of the RS technology in capturing tailpipe plumes from such small vehicles. For those vehicle types and fuels not covered by the Jakarta EF dataset, the ICCT Roadmap emission database and the European Environment Agency were adopted (EEA, 2023). Detailed emission factor values for each vehicle type and Euro standard are available in Annex 2.

The vehicle age distribution also comes from the 100 thousand data points from the remote sensing measurements. Age distribution is needed to derive the average emission factors for

vehicles within and outside the LEZ areas of intervention. Figure 64 provides the age distribution for the Jakarta vehicle fleet. The average motorcycle in Jakarta is 11 years old, while the average car is only 8 years old, according to the RS database. Commercial vehicles present average age of 9 years for small trucks (i.e., light commercial vehicles) and 11 years for Medium and Large trucks - older trucks are present at higher rates than other vehicles, with 16% of trucks being older than 20 years. An older fleet of motorcycles explains the strong contribution of these vehicles to the NOx and PM emissions inventories.

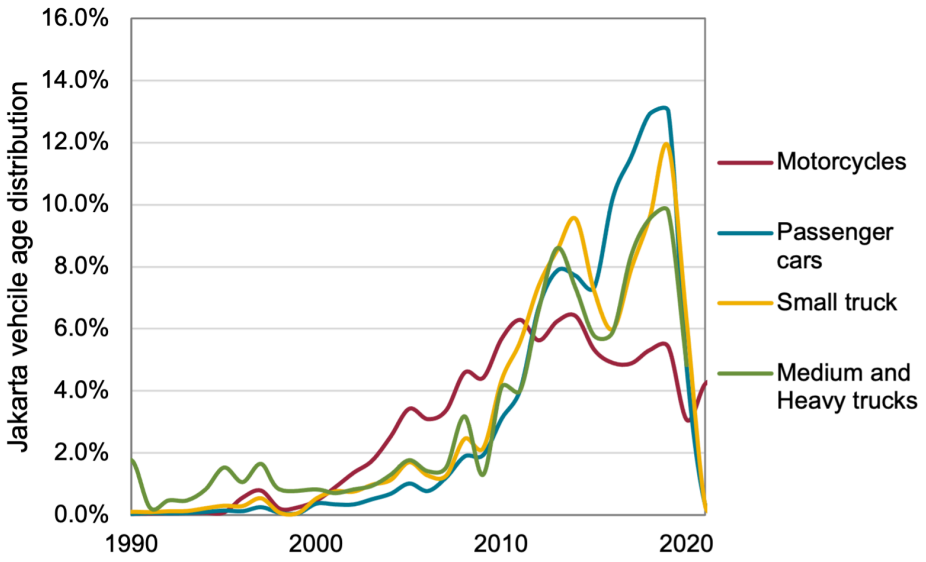


Figure 64. Age distribution of vehicles in Jakarta

The evaluation of emission contributions into the future requires an understanding of the projected vehicle activity (i.e., VKT) until 2030. For future estimations, the model uses a natural turnover scheme based on yearly retirement ages and sales. Retirement probabilities were estimated using Indonesia-wide data from the ICCT Roadmap model, adjusting for Jakarta's specific age distribution. The retirement rate is modelled with a Weibull distribution.[4] Assuming yearly relative fleet and activity growth equal the average yearly fleet growth of vehicles in Indonesia from 2016 to 2021[5]. The yearly sales are then calibrated to meet the assumed activity growth.

Figure 65 provides an overview of the forecasted change in VKT by vehicle type. The expected VKT increase is between 37.6% and 44.0% between 2023 and 2030. Transjakarta buses are excluded here because their fleet renewal and growth plans define their growth (ITDP, 2023). TJ bus activity is expected to grow by 2.5 times by 2030, while TJ Car (Microbuses) activity is expected to grow by 3 times for the same period.

[4] The Weibull distribution is a continuous probability distribution used to model the nature of time-to-failure. In transport this refers to time to vehicle failure.

[5] Badan Pusat Statistik (BPS) Indonesia yearly vehicle stock data. Source: https://www.bps.go.id/en

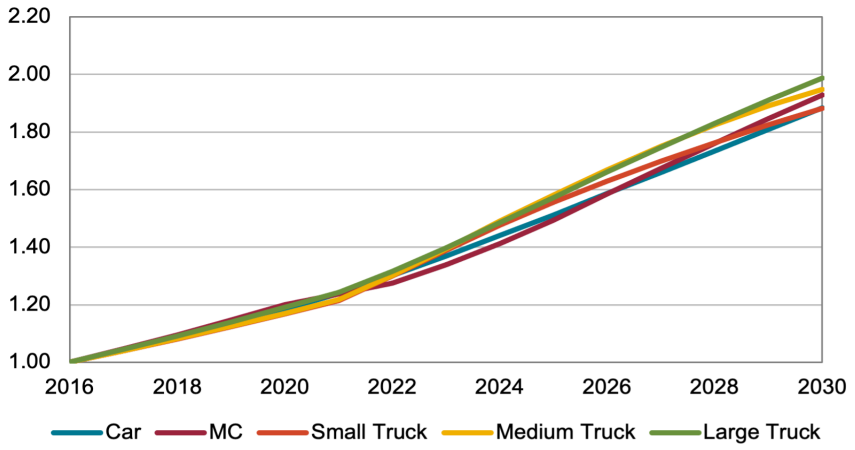


Figure 65. Estimated VKT growth for private and commercial vehicles in Jakarta

Four different scenarios of air pollution reduction

The impact on average vehicle emission factors was calculated under four response scenarios with different assumptions depending on how the vehicle owners will respond to the LEZ implementation: one baseline scenario, two options for conventional vehicle responses, and one assuming electric vehicle responses. The scenarios considered are:

- No LEZ or natural: this baseline assumes that no LEZ expansion is adopted.
- Buy worst: assumes that the response from the vehicle owners is to replace the non-compliant vehicle with a vehicle that just meets the LEZ criteria, i.e., a 10-year-old conventional model of the same type.
- Buy best: assumes that vehicle owners would respond by replacing the non-compliance model with the newest internal combustion engine model available, meeting the latest emission standards.
- Buy EV: assumes that vehicle owners replace non-compliant vehicles with battery electric vehicles.

The results presented here provide an indication of the potential responses to the LEZ adoption, focusing on emissions reductions. This evaluation does not attempt to estimate the share of drivers that would respond to the LEZ by doing nothing, adopting the bare minimum compliant vehicle, adopting the best compliant internal combustion engine vehicle, or adopting an EV. It must be noted again that the EF scenario also left out the assumption of shifting from private vehicles to sustainable transportation and vehicle route shifting because of LEZ limitations. Hence, this modelling result presents a more conservative effect on emission reduction.

A literature review on the effects of LEZ adoption shows that most studies on ex-post evaluation provide evidence of positive air quality outcomes. Unfortunately, the topic of fleet renewal or modal shifts is less documented (ITDP, 2023). An evaluation from London's Major Office about the

benefits of London's LEZ after 6 months of its implementation shows a 38% reduction in the number of non-compliant vehicles.[6] London's LEZ also resulted in a 3-9% reduction in traffic flows, suggesting a shift towards active or public transport. The ex-post impact evaluation found a 29% reduction in NO2 emissions thanks to the LEZ program. A recent study published in February 2023 shows that the LEZ has had significant impacts on fleet composition, especially diesel use reduction and EV acceleration.[7] The report documents diesel car kilometres reduced by 25-32% within the zone; at the same time, the LEZ has pushed for higher EV kilometres use, from 4% to 8% depending on the zone, and including electric vans. In the past four years, the constant reevaluation of the LEZ design has reduced cumulatively NOx by 26% and PM by 10% for the overall fleet within the zone.

6.1. LEZ design based on Emission Standard Assumption

The first approach of LEZ is the implementation based on the limitation of vehicles on their emissions standard. Table 26 shows the minimum emission standard emission standards levels for private, commercial and public transit vehicles in the city. In this case, the LEZ would apply to all non-Euro II-compliant vehicles in 2024. In 2026 motorcycles would need to meet at least Euro III standards to meet the LEZ criteria; cars would be required to meet Euro IV emission standards. For diesel vehicles, the LEZ scheme shown here would restrict diesel vehicle operation for the vast majority of vehicles currently in operation in Jakarta in 2023. This is because the sale of 50 ppm maximum sulphur diesel started in June of 2022, according to media reports.[8] Based on the age distribution, we estimate that Euro IV diesel commercial vehicles may represent 10-11 % of the diesel fleet by the time the LEZ restrictions apply. Thus, this LEZ case is a conceptual design that would require significant support from national authorities to make the right diesel fuel available and price competitive and to commit vehicle manufacturers and importers to offer those Euro IV-compliant vehicles in the immediate future.

Table 26. LEZ design phase-in based on vehicle emission standards

Type of Vehicle	Fuel	Fuel share	LEZ Scenario Phasing						
			2024	2025	2026	2027	2028	2029	2030
AREA OF INTERVENTION			LEZ Phase 1 (Pilot)				LEZ Phase 2 (Innercity)		
Motorcycles	Petrol	100%	Euro II		Euro III		Euro III		
Passenger cars	Petrol	88%	Euro II		Euro IV		Euro IV		

[6] Mayor of London (Oct. 2019). Central London Ultra Low Emission Zone – Six Months Report. Retrieved from: www.london.gov.uk/sites/default/files/ulez_six_month_evaluation_report_final_oct.pdf
[7] Mayor of London (Feb. 2023). Inner London Ultra Low Emission Zone - One Year Report. Retrieved from: https://www.london.gov.uk/sites/default/files/2023-02/Inner%20London%20ULEZ%20One%20Year%20Report%20-%20final.pdf
[8] Pertamina announces the sale of Solar 51, a 50 ppm maximum sulphur diesel compliant with Euro IV standards. Retrieved from: https://money.kompas.com/read/2022/04/02/065632326/mengenal-bbm-jenis-baru-pertamina-bernama-solar-51?page=all

Type of Vehicle	Fuel	Fuel share	LEZ Scenario Phasing						
			2024	2025	2026	2027	2028	2029	2030
	Diesel	12%	Euro II		Euro IV		Euro IV		
LCV	Petrol	45%	Euro II		Euro IV		Euro IV		
	Diesel	55%	Euro II		Euro IV		Euro IV		
TJ Car	Petrol	100%	Euro II			BEB only	BEB + Euro IV		
TJ Bus	Diesel	100%	Euro II			BEB only	BEB + Euro IV		
MDV + HDV			Euro II - MT + LT (access restriction based on time for HDV)		Euro IV MT+LT (access restriction for HDV based on time		Euro IV MT (total access of restriction for HDV)		
							Citywide LEZ		
	Diesel	100%					Euro IV MDV + HDV		

6.1.1. Emission Factor Calculation

In this study, all of the driver response scenarios provide a reduction of emission factors both for PM and NOx as cleaner vehicles are expected to enter the LEZ area. Figure 66 presents the EF changes for NOx and PM for all vehicle types. **Note that the EFs change due to vehicle renewal processes and the expansion of the LEZ area**. Under the emission standards-based design, the EFs change more markedly, as almost the entire diesel fleet, which is non-Euro IV, is removed from the pool of LEZ compliance vehicles from 2026 - this is evident in all the truck segments, which are diesel. PM reductions are quite significant for these segments, even under the ICE response options. For cars with the same Euro IV requirements, mainly gasoline-powered, the Euro IV requirement provides a halving reduction in NOx and PM.

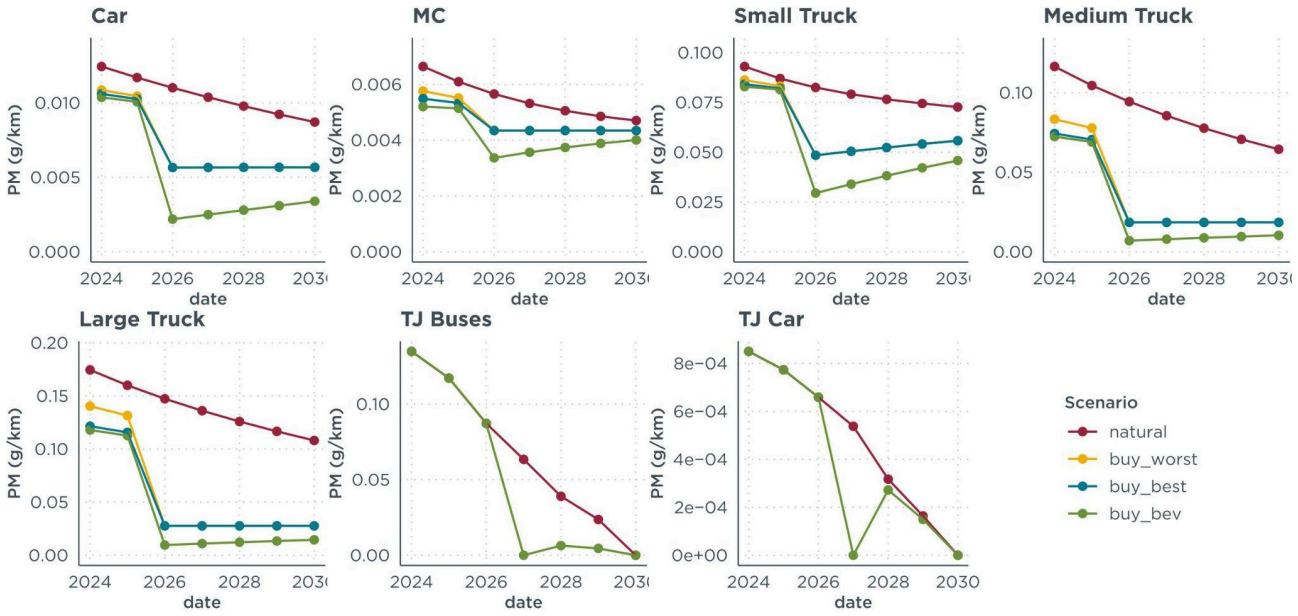


Figure 66. NOx and PM yearly vehicle emission factor for LEZ design based on vehicle emission standard. The EF values cover only the vehicles that are affected by the LEZ adoption phases - not the overall fleet

The natural scenario with the red line represents air pollution reduction, assuming natural vehicle retirement and vehicle sales. Emission reductions for the natural scenario are expected because as the older vehicles are removed, newer vehicles enter with lower emissions, even though there is a growth in vehicle activity. The buy worst and the best ICE scenario under the emission standard design shows the same value since the standard emission available is capped at Euro IV, meaning the minimum and cleanest vehicle options are the same.

A significant reduction in the average emission factor is seen in the Transjakarta fleet because all of the fleet will be fully electrified by 2030. There is an increase in 2028 since the LEZ entered phase 2 (Innercity LEZ), where a larger LEZ area will include additional diesel vehicles. A significant average EF reduction also happens with four-wheeled vehicles as newer vehicles with the assumption greener vehicles enter the LEZ. This is caused by the newer Euro IV vehicle emission standard for four-wheelers in 2018 for gasoline and 2022 for diesel.

6.1.2. Total Emission Reduction Benefit

A. Emission reduction inside the LEZ area

Emission reduction from LEZ Phase 1 Pilot

Emission benefits within the LEZ Phase 1 area were estimated between 2024 and 2027. Figure 67 presents the emission under LEZ response scenarios considered. Implementation of LEZ will reduce NOx in 2024 compared to baseline values ranging from 3% to 10% and 10% to 16% for PM concentration.

In 2027, the buy minimum requirement scenario and buy cleanest ICE will reduce the level of NOx by 29% and PM by 44% if compared to the BAU scenario. Similar to the previous explanation of EF value from the ES approach, the emission reduction between the buy worst and buy best scenarios shows the same results. The buy EV response scenario has a higher reduction impact in 2027 of 44% for NOx and 55% for PM.

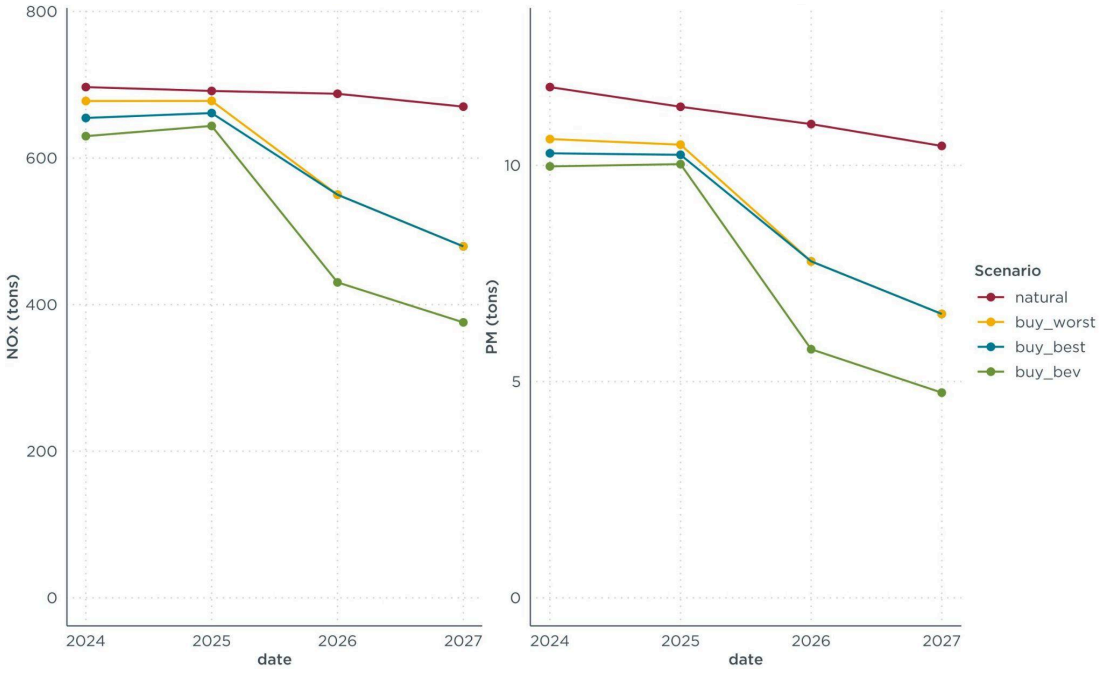


Figure 67. Phase 1 pilot emission reduction for all response scenarios and vehicle types (ES approach)

At the end of phase 1 in 2027, the Buy minimum and cleanest ICE scenario will have the same reduction of 190.7 tons NOx and 3.9 tons PM. Higher reduction is expected under the buy EV scenario with a reduction of NOX and PM reaching 294.3 tons and 5.7 tons. A high portion of the reduction comes from motorcycles, passenger cars, and TJ buses because of its massive share of activity in the middle area of the city.

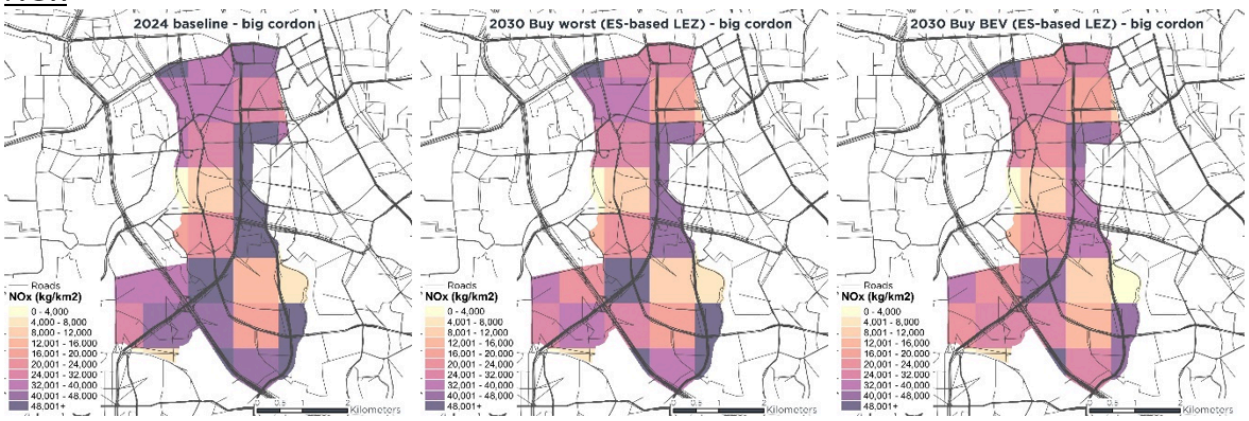
Table 27. NOx and PM phase 1 pilot emission reduction in Jakarta with different scenarios from 2024 - 2027 (ES approach)

NOx	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2024	696.8	677.8	654.7	629.9	-2.7%	-6.0%	-9.6%
2025	691.6	678.0	661.4	643.8	-2.0%	-4.4%	-6.9%
2026	687.7	550.0	550.0	430.4	-20.0%	-20.0%	-37.4%

2027	670.1	479.5	479.5	375.8	-28.5%	-28.5%	-43.9%
PM	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2024	11.8	10.6	10.3	10.0	-10.2%	-13.0%	-15.5%
2025	11.4	10.5	10.2	10.0	-7.7%	-9.8%	-11.7%
2026	11.0	7.8	7.8	5.7	-29.0%	-29.0%	-47.5%
2027	10.4	6.6	6.6	4.7	-37.2%	-37.2%	-54.6%

The projected emission reduction from LEZ implementation in terms of emissions concentration (kg/km2) is shown in Figure 68. Similar to the results of the model year-based LEZ design, the regions along the eastern edge and southern edge of the pilot area show the largest reductions in NOx and PM in 2030 from the Buy EV response compared to the 2024 baseline. Again, more modest but noticeable reductions are observed in the map showing the Buy worst response in 2030.

NOx



PM

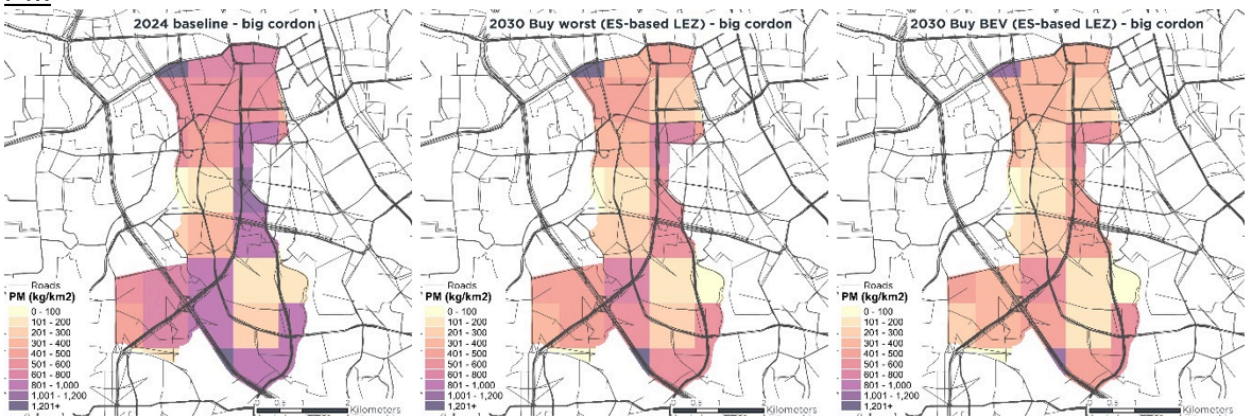


Figure 68. LEZ Phase 1 Pilot NOx and PM spatial distribution in 2024 (left figures) and the two LEZ responses in 2030 (centre and right figures) using LEZ restrictions based on ES approach

Emission Reductions Phase 2: Inner LEZ

Emission benefits increase over the second phase of LEZ implementation from 2028 to 2030. Figure 69 shows the NOx and PM emissions from the range of LEZ responses considered. Emissions under the LEZ responses assuming a transition to cleaner ICEs show a 21% to 35% emission reduction in the first year of the Inner City adoption. Emissions increase over time as the only available technology in the new vehicle market is Euro IV. The electrification scenario response generates emissions benefits above 33% and 48% for NOx and PM, respectively.

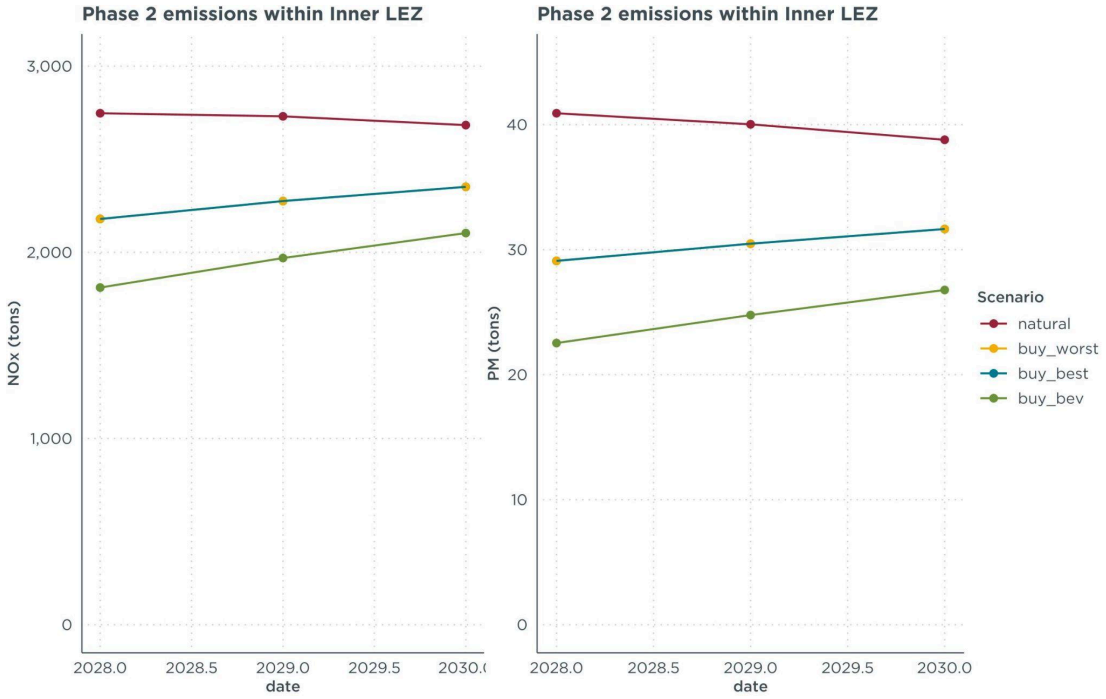


Figure 69. Phase 2 inner LEZ emission reduction for all LEZ response scenarios (ES approach)

Table 28 provides the details of emission reduction for each scenario in Phase 2 implementation. A reduction of 331.6 tons NOx and 7.1 tons PM is expected from the buy minimum and cleanest ICE scenario in 2030. Higher reduction is identified in buy EV scenarios, 580.0 ton NOx and 12.0 ton PM.

Table 28. NOx and PM phase 2 pilot emission reduction in Jakarta with different scenarios from 2028 - 2030 (ES approach)

NOx	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2028	2747.2	2179.3	2179.3	1810.8	-20.7%	-20.7%	-34.1%

2029	2730.6	2275.5	2275.5	1969.4	-16.7%	-16.7%	-27.9%
2030	2683.5	2351.8	2351.8	2103.4	-12.4%	-12.4%	-21.6%
PM	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2028	40.9	29.1	29.1	22.5	-28.9%	-28.9%	-44.9%
2029	40.0	30.5	30.5	24.8	-23.9%	-23.9%	-38.1%
2030	38.8	31.7	31.7	26.8	-18.4%	-18.4%	-31.0%

The LEZ Phase 2 projected emission reduction in terms of emissions concentration (kg/km2) is shown in Figure 70. NOx reductions can be observed across the LEZ area for the Buy BEV response in 2030 compared with the 2024 baseline. More modest NOx reductions are observed for the Buy Worst response in 2030 compared with the 2024 baseline. For PM emissions, the most heavily polluted area along the southern edge of the LEZ area shows lower emissions for both the Buy worst and Buy BEV responses in 2030 compared with the 2024 baseline.

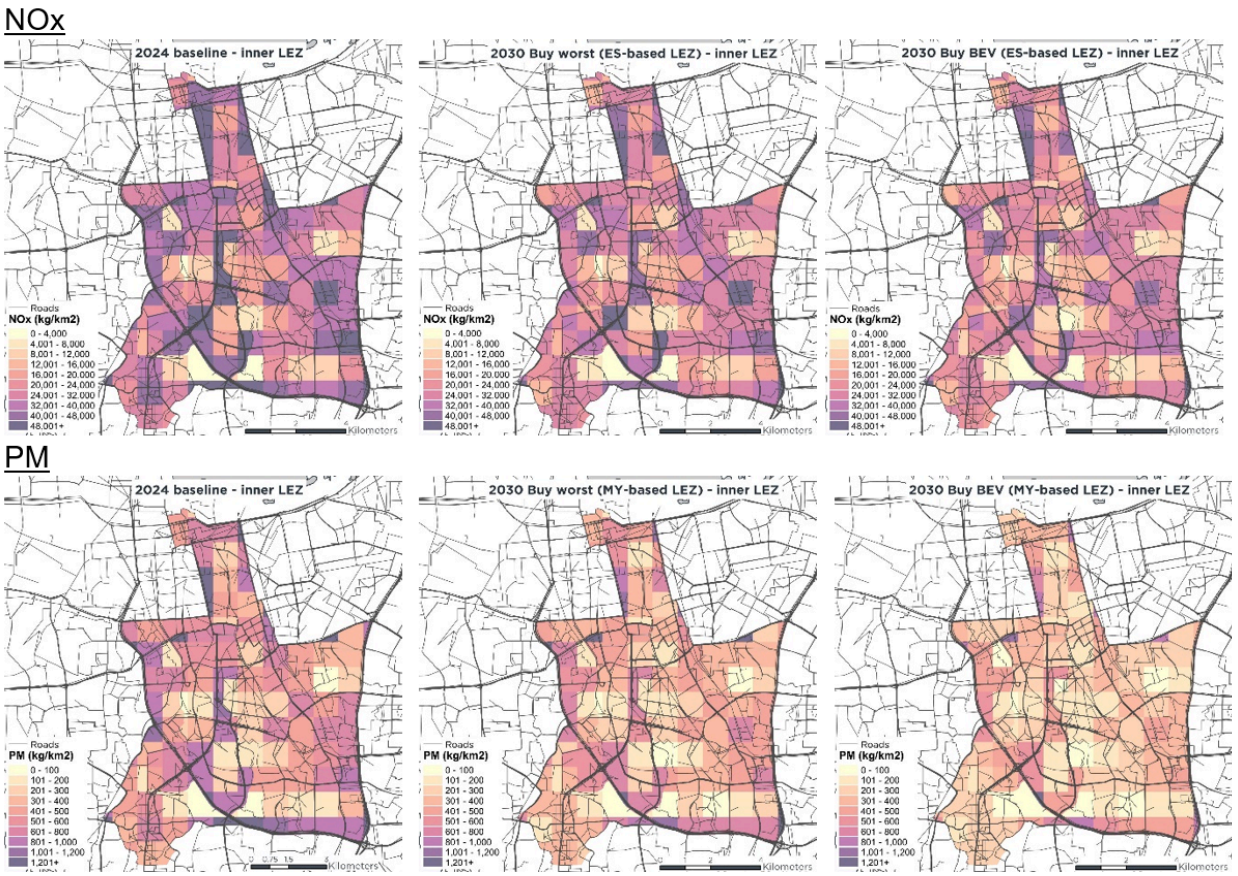


Figure 70. LEZ Phase 2 Pilot NOx and PM spatial distribution in 2024 (left figures) and the two LEZ responses in 2030 (centre and right figures) using emission standard assumption

B. Total Emission Reduction Results in The Provincial Scale of Jakarta

The emission benefits at the citywide level are presented here. City-level NOx and PM benefits are estimated at 2.9% to 5.1% and 4.8% to 7.8%, respectively, by 2030. This type of LEZ scheme would generate higher emission benefits than the model year restrictions assumption but would have a significant impact on diesel vehicle use. The lack of cleaner new ICE options limits the environmental benefits offered by conventional vehicles. A response from the public that centres on the ICE route tend to provide minimum improvement concerning BAU benefits.

Table 29. NOx and PM total emission reduction in Jakarta with different scenarios from 2024 - 2027 (Emission Standard Assumption)

NOx	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2024	11322.9	11303.9	11280.8	11256.0	-0.2%	-0.4%	-0.6%
2025	11334.6	11321.0	11304.4	11286.9	-0.1%	-0.3%	-0.4%
2026	11399.4	11261.7	11261.7	11142.0	-1.2%	-1.2%	-2.3%
2027	11392.0	11201.3	11201.3	11097.7	-1.7%	-1.7%	-2.6%
2028	11385.9	10818.0	10818.0	10449.5	-5.0%	-5.0%	-8.2%
2029	11440.6	10985.5	10985.5	10679.4	-4.0%	-4.0%	-6.7%
2030	11440.5	11108.8	11108.8	10860.4	-2.9%	-2.9%	-5.1%
PM	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2024	179.7	178.5	178.2	177.9	-0.7%	-0.9%	-1.0%
2025	174.3	173.5	173.2	173.0	-0.5%	-0.6%	-0.8%
2026	170.3	167.2	167.2	165.1	-1.9%	-1.9%	-3.1%
2027	166.4	162.5	162.5	160.7	-2.3%	-2.3%	-3.4%
2028	163.0	151.2	151.2	144.6	-7.2%	-7.2%	-11.3%

2029	161.2	151.7	151.7	146.0	-5.9%	-5.9%	-9.5%
2030	159.0	151.9	151.9	147.0	-4.5%	-4.5%	-7.6%

The visualisation of city-wide emission reduction for NOx and PM is presented in Figure 71. The NOx reductions associated with the two responses in 2030 compared to the baseline in 2024 are most significant in the centre of the city, where the Inner LEZ area is located. The emissions reductions are most prominent for the Buy BEV response, though small reductions can also be observed for the Buy worst response.

For PM emissions, the Buy BEV response map shows that within the Inner LEZ area, PM decreases substantially to be in line with the surrounding, less polluted areas of the city. The Buy worst response is also associated with sizable PM reductions compared with the 2024 baseline. This analysis only accounts for the vehicle traffic impacted inside the LEZ area of intervention. Although the same vehicle might be travelling outside the LEZ area, it is not considered in the modelling and the visualisation. Hence, this visualisation provides a more conservative illustration.

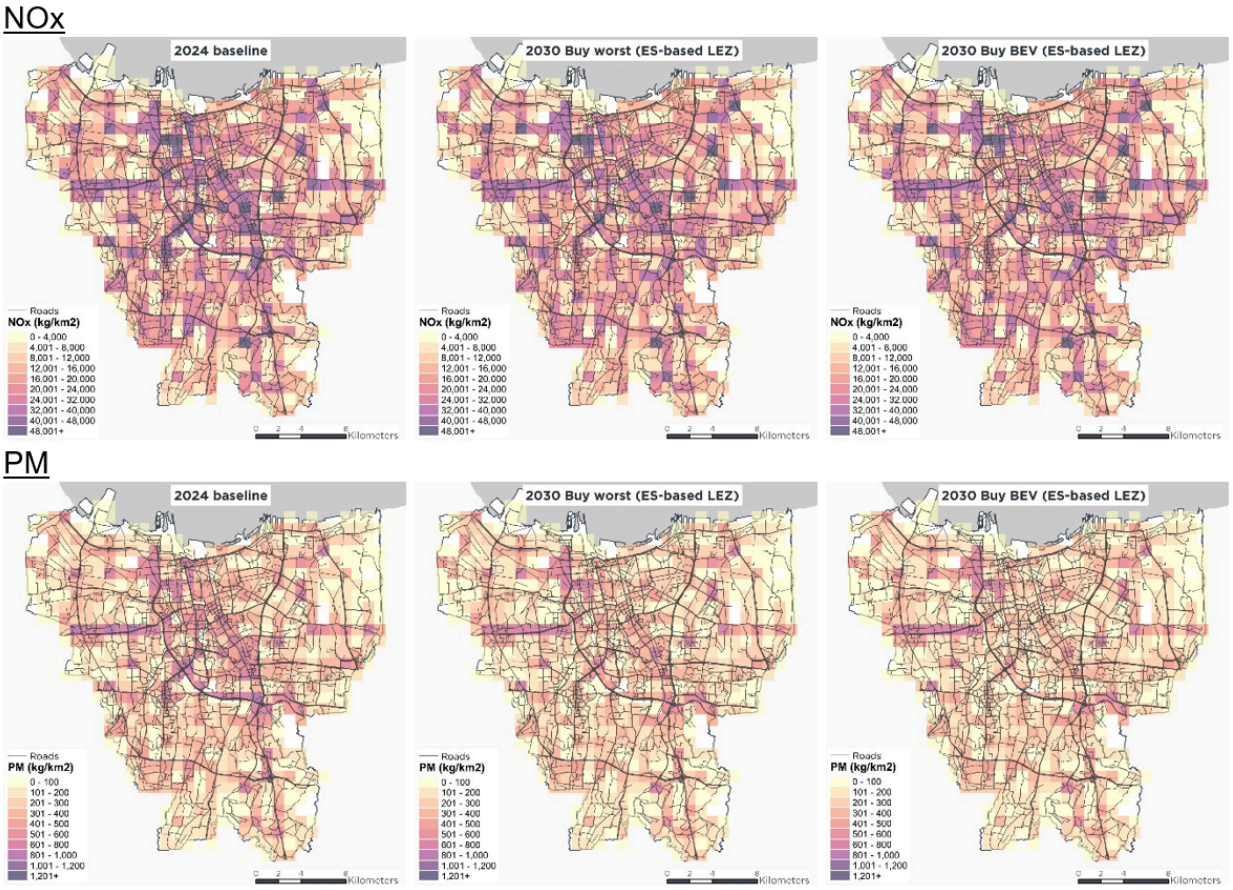


Figure 71. NOx and PM emission distribution between 2024 and 2030 for different scenarios (ES approach)

6.2. LEZ design based on Model Year Assumption

6.2.1. Emission Factor Calculation

Similarly to the emission standard-based LEZ design, EFs for the average vehicle in the intervention area would change according to LEZ restrictions. Figure 72 presents the change in NOx and PM emission factors (EF) for the average vehicle covered by the LEZ under scenarios considered by vehicle type. The EF values cover only the vehicles that are affected by the LEZ adoption phases - not the overall fleet.

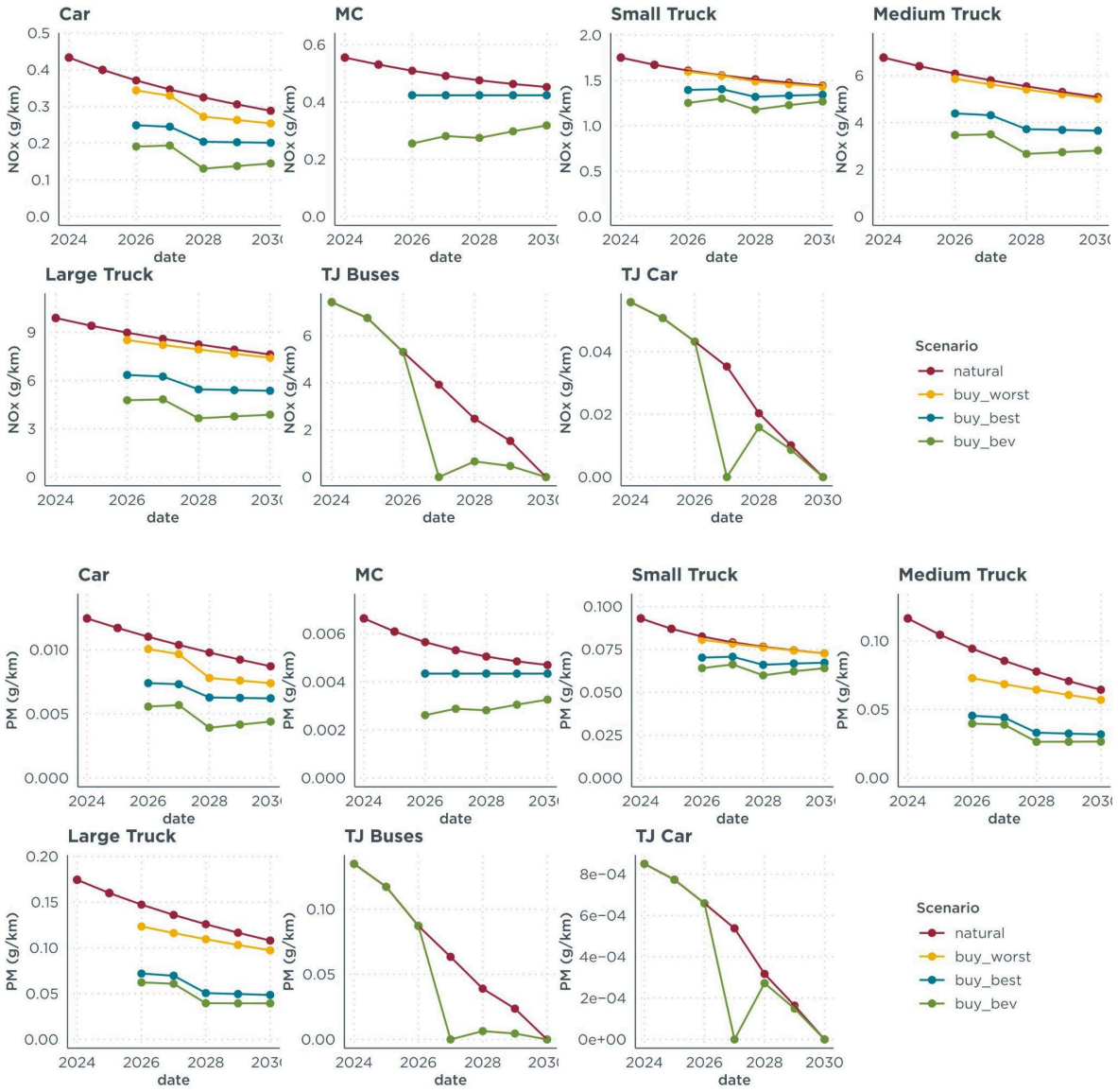


Figure 72. NOx and PM yearly average vehicle emission factor for LEZ design based on vehicle model year. The EF values cover only the vehicles that are affected by the LEZ adoption phases - not the overall fleet

Under the MY approach, the Buy Worst and Buy Best ICE scenarios may result in similar values if the vehicle emission standards distribution is such that the new best vehicles are the same as the 10-year-old minimum requirements.

The impact of the LEZ phase in motorcycles shows a 50%-54% reduction in NOx and PM emission factors in 2026 under the Buy EV scenario- which assumes that affected owners would replace them with e-motorcycles. As time passes, the older non-compliant MCs will be replaced with zero emission ones. However, the newer models are Euro III, which is not different from the allowed fleet - thus, the reduction achieved by the older MC replacements is not enough to overcome the emissions from new Euro III models. There is no EF difference between natural and buy, which is the best scenario for motorcycles as the newer vehicles share that same emission standard level with the allowed pool. It must be noted that the responses of these ban scenarios only replace the LEZ banned vehicle and not the replacement of retired vehicles.

6.2.2. Total Emission Reduction Benefits

A. Emission reduction inside the LEZ area

Emission reductions from LEZ Phase 1 Pilot

The first phase of LEZ adoption, which covers 2024 to 2027, provides large emission savings with respect to the baseline scenario. As can be seen in Figure 73, Phase 1 Pilot LEZ implementation will significantly improve transport emissions inside the intervention zone. During LEZ implementation, a grace period between 2024-2025 will be introduced. By the end of Phase 1, in 2027, the buy minimum requirement scenario is expected to reduce the level of NOx by 21.2% and PM by 22.1%, compared to the BAU scenario. More significant emission reduction impacts are seen in the other two scenarios, and the cleanest ICE scenario reduces NOx by 24.7% and PM by 29.1%. Meanwhile, the buy EV scenario reduces NOx by 47.7% and PM by 47.1% compared to the BAU scenario.

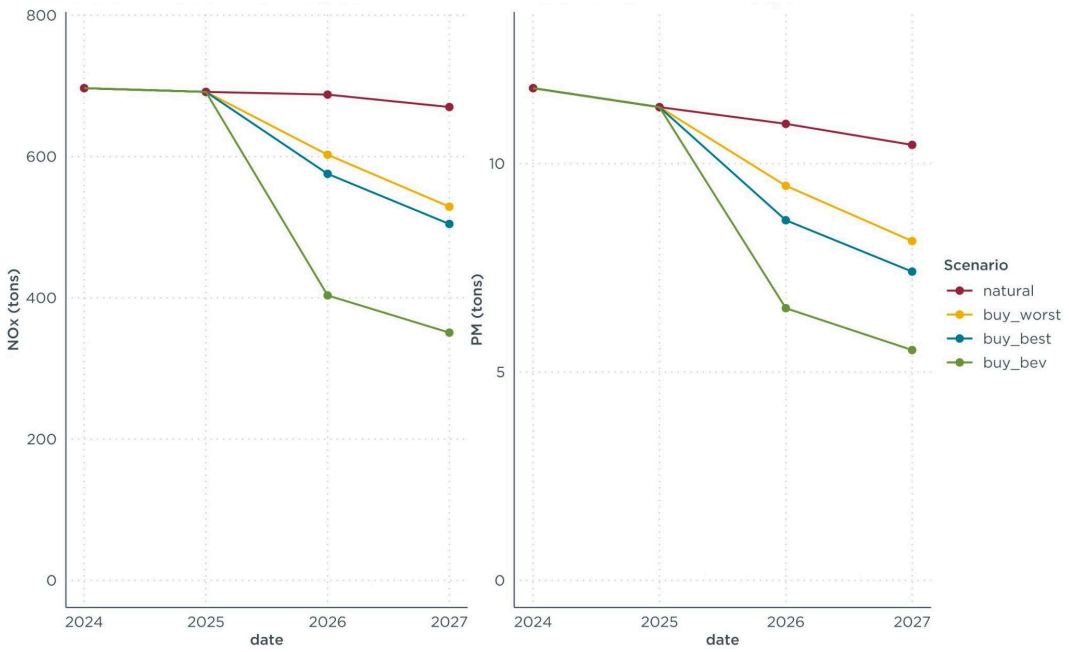


Figure 73. Phase 1 pilot emission reduction for all response scenarios and vehicle types (MY approach)

Under a Buy cleanest ICE scenario, a reduction of 165.6 tons of NOx and 3.0 tons of PM is predicted in 2027, or 21.1% and 22.1%, respectively. Further reductions are anticipated under the electrification scenario, with the reduction of NOx and PM reaching 319.4 tons and 4.9 tons, or 47.7% and 47.1%, respectively. Most of the benefits are generated by passenger cars and motorcycles, the largest sources of these pollutants, and TJ buses, which have a large share of activity in this area of the city.

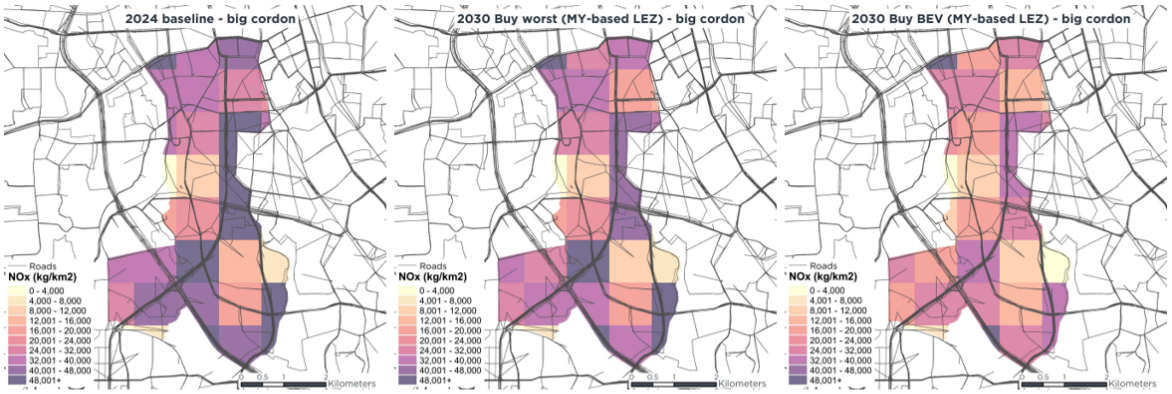
Table 30. NOx and PM phase 1 pilot emission reduction in Jakarta with different scenario from 2024 - 2027

NOx	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2024	696.8	696.8	696.8	696.8	0.0%	0.0%	0.0%
2025	691.6	691.6	691.6	691.6	0.0%	0.0%	0.0%
2026	687.7	602.6	575.5	403.4	-12.4%	-16.3%	-41.3%
2027	670.1	529.0	504.6	350.7	-21.1%	-24.7%	-47.7%
PM	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV

2024	11.8	11.8	11.8	11.8	0.0%	0.0%	0.0%
2025	11.4	11.4	11.4	11.4	0.0%	0.0%	0.0%
2026	11.0	9.5	8.6	6.5	-13.6%	-21.1%	-40.4%
2027	10.4	8.1	7.4	5.5	-22.1%	-29.1%	-47.1%

Figure 74 provides a description of spatial emissions distributions (kg/km2) for the Phase 1 LEZ Pilot area for 2024. The improvements over time due to the LEZ adoption are also presented for the Buy worst response and the best-performing Buy EV response in 2030. The regions along the eastern and southern edges of the pilot area show some of the highest levels of NOx and PM emissions in 2024, and sizable reductions are observed in the map showing the Buy EV response in 2030. More modest but still noticeable reductions are observed in the map showing the Buy worst response in 2030.

NOx



PM

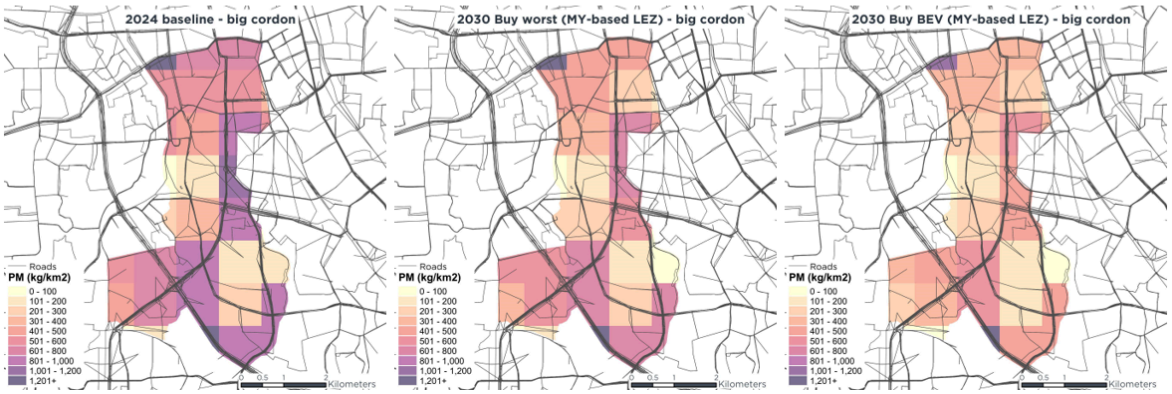


Figure 74. LEZ Phase 1 Pilot NOx and PM spatial distribution in 2024 (left figures) and the two LEZ responses in 2030 (centre and right figures) using an LEZ design under model year restrictions

Emission Reductions Phase 2: Inner LEZ

The Phase 2 LEZ Innercity area expands the Phase 1 LEZ from 18.8 km2 to 87.8 km2 and covers roughly one-quarter of the overall vehicle activity of the citywide Jakarta area. As a result, the LEZ adoption results in larger amounts of PM and NOx emission reductions.

Figure 75 illustrates the change in emissions between 2028 and 2030 for all vehicles. Total emissions under the natural vehicle-renewal scenario show a reduction due to large numbers of cleaner vehicles entering the market. The emission tonnage changes from Phase 1 in 2027 at 670.1 tons of NOx and 10.4 tons of PM to 2747.2 and 40.9 tons in 2028, respectively, as the intervention area in Phase 2 grew by a factor of 4.7. The adoption of the LEZ would bring important reductions starting in 2028: between 15.6% and 18.9% NOx reductions and 18.6-24.6% PM reductions for the ICE-based cases; the EV scenario increases those benefits to 46.1% and 47.9%, respectively.

Although initially, in 2028, there is a significant reduction in both NOx and PM emissions, the emissions will increase again from 2029 and 2030 compared to previous years. This is happening because the newer population of ICE vehicles with no upgraded emission standard (Euro IV for 4-wheelers and Euro III for motorcycles) are entering the zone, increasing emissions inside the zone. This can only be reversed by adopting more stringent emission standards for all vehicle types - which requires national-level action on fuel quality and vehicle emission standard upgrades.

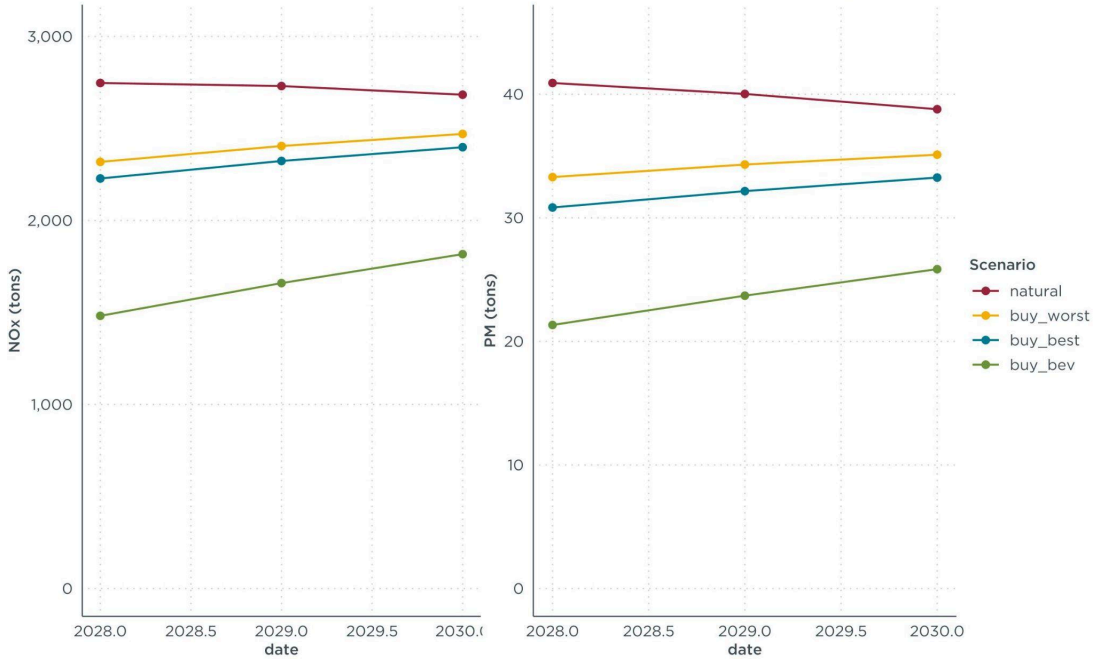


Figure 75. Phase 2 inner LEZ emission reduction for all LEZ response scenarios (MY approach)

Details for all subsequent years are presented in Table 31, with a reduction of 285.4 tons of NOx and 5.5 tons of PM expected by the year 2030 if it follows the cleanest ICE scenario. A significant

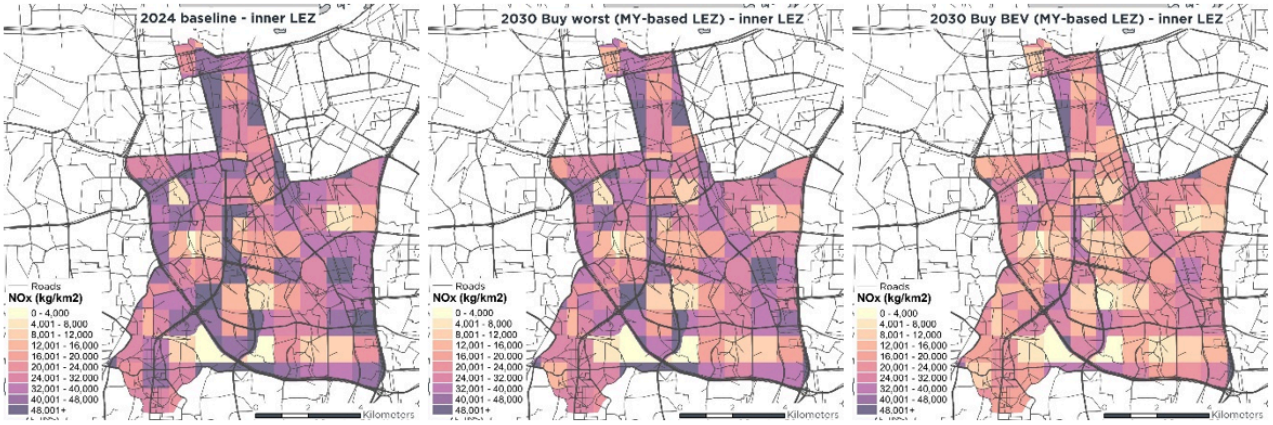
reduction can happen if the electrification scenario is implemented. It will further reduce NOx to 866.5 tons and PM to 12.9 tons.

Table 31. NOx and PM phase 2 inner LEZ emission reduction in Jakarta, all response scenarios, 2028 - 2030

NOx	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2028	2747.2	2318.4	2228.3	1481.9	-15.6%	-18.9%	-46.1%
2029	2730.6	2404.7	2323.4	1659.7	-11.9%	-14.9%	-39.2%
2030	2683.5	2470.3	2398.1	1817.0	-7.9%	-10.6%	-32.3%
PM	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2028	40.9	33.3	30.8	21.3	-18.6%	-24.6%	-47.9%
2029	40.0	34.3	32.2	23.7	-14.3%	-19.7%	-40.8%
2030	38.8	35.1	33.3	25.8	-9.5%	-14.3%	-33.4%

Figure 76 presents the spatial emissions distributions (kg/km2) for the Phase 2 Innercity LEZ area for 2024. The improvements over time due to the LEZ adoption are also presented for the Buy Worst response and the best performing Buy EV response in 2030. The map displaying the NOx emissions associated with the Buy BEV response in 2030 shows significant reductions across the entire area compared to the baseline 2024 NOx emissions. The Buy Worst response in 2030 shows more modest reductions in NOx emissions. For PM emissions, the region along the area's southern edge will be most polluted in 2024 and will see noticeable decreases with both the Buy Worst and Buy BEV responses in 2030. The Buy BEV response in 2030 also shows quite significant reductions in PM across the entire LEZ area compared to the 2024 baseline.

NOx



PM

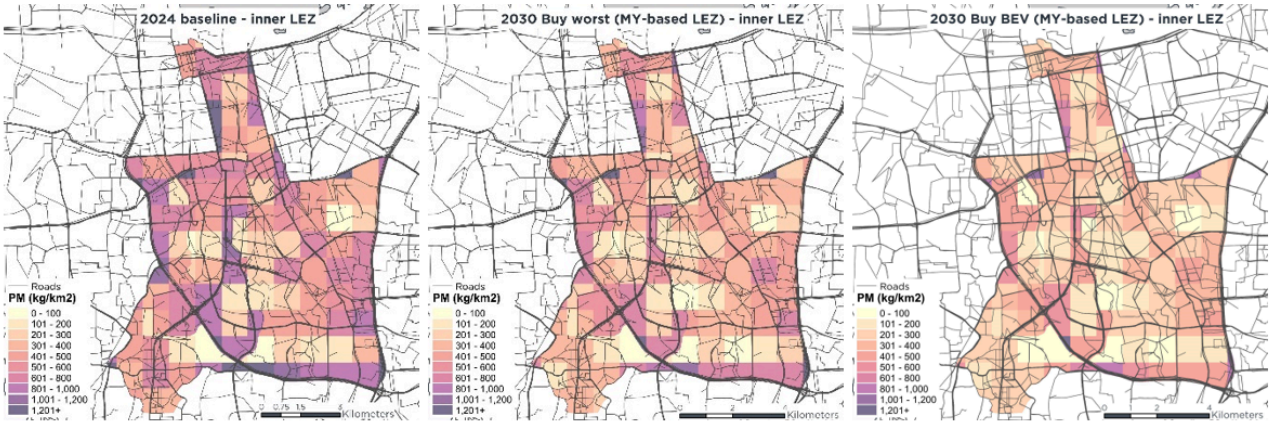


Figure 76. LEZ Phase 2 Innercity NOx and PM spatial distribution in 2024 (left figures) and the two LEZ responses in 2030 (centre and right figures) using an LEZ design under model year restrictions

B. Total Emission Reduction Results in The Province Scale of Jakarta

The emission reduction contribution from each vehicle type (in tons) for NOx and PM is visualised in Figure 77. A sharp decline will happen in 2028 as the LEZ enters Phase 2. The biggest emission reduction is observed with the Transjakarta fleets as they will follow their services electrification program. A meaningful reduction also happens to logistic vehicles, especially medium and large trucks. A significant decline is expected in 2028 as limitations for large trucks are imposed in the Innercity area and massive restrictions on a Citywide scale.

Most private cars and some small trucks are powered by gasoline engines, which are relatively clean Euro IV and have been replacing older vehicles since 2018. These cleaner Euro IV cars provide a city-wide benefit even under the natural renewal scenario. The adoption of the LEZ pilot phase shows emission reductions in the scenario with the best emission standard requirement, especially if cars are electrified.

Meanwhile, LEZ implementation on motorcycles at the citywide level has a very small positive impact on this fleet. Most of the gains are obtained in the electrification scenario. The main issue is that the newer models are sold as Euro III, which has been the same standard for the past 10 years. PM has a 7.6% reduction potential with a transition to e-motorcycles. If the motorcycle fleet transitions to electric options, NOx emissions will also improve by 9.3% at the citywide level.

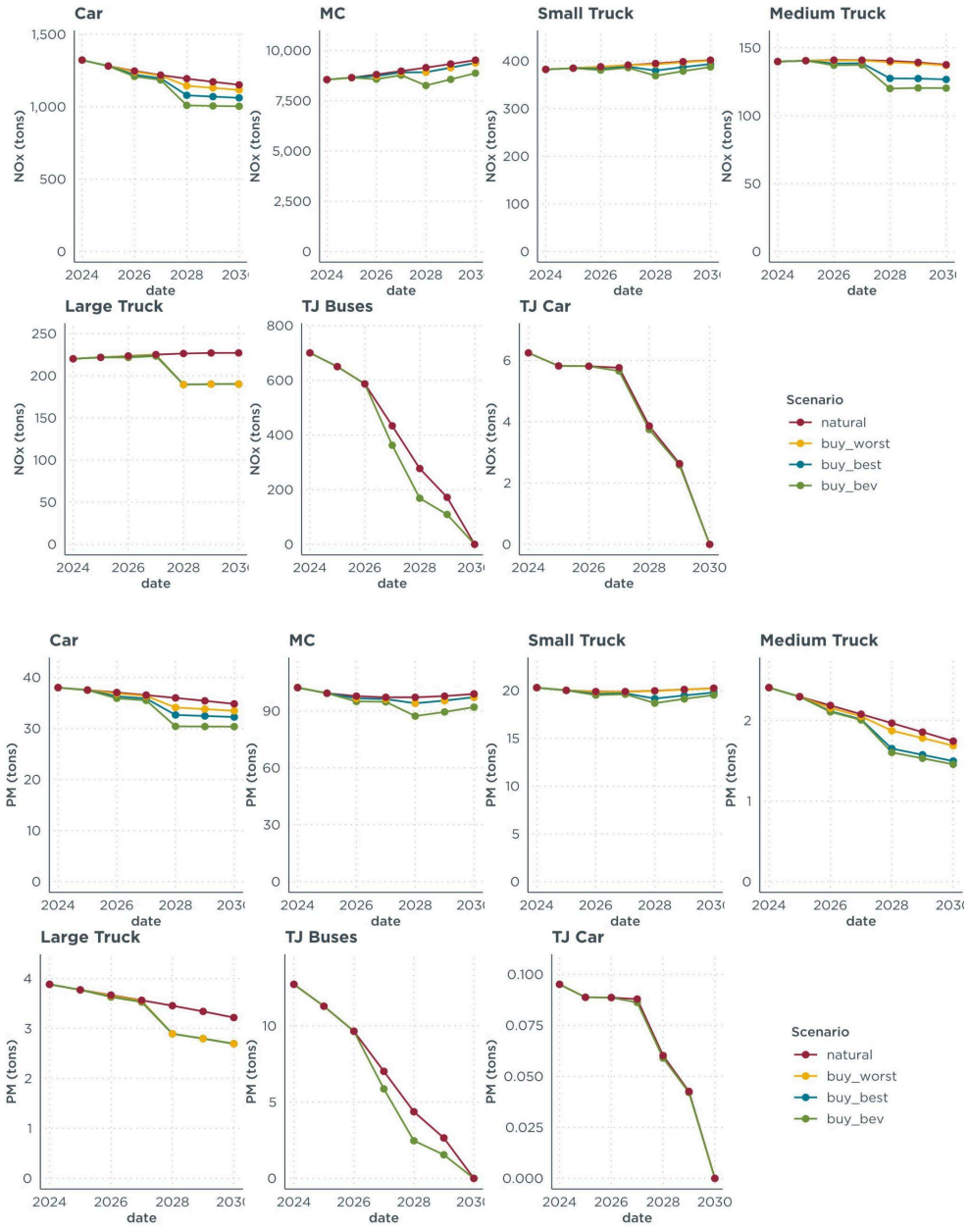


Figure 77. Citywide NOx and PM annual total emission in tons by vehicle type and LEZ response scenario

The overall impact of LEZ implementation on all vehicle types and measured at the city scale is much more modest, given that the LEZ is focused on critical pollution areas. At the citywide level, the relative benefits are much smaller than the local benefits, as the broader area is not impacted by the LEZ, as explained in the vehicle activity shared by vehicle type for each of the LEZ phases.

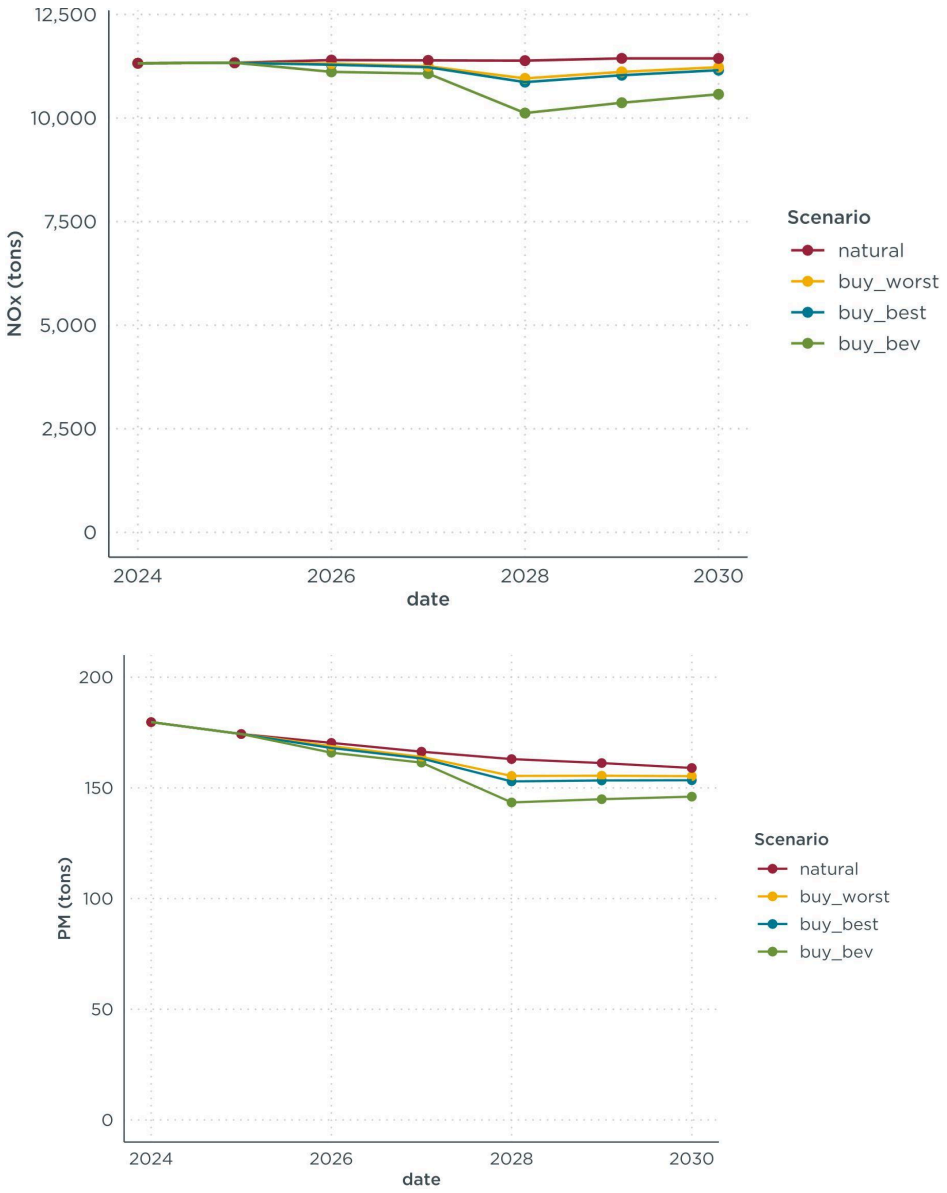


Figure 78. Citywide NOx and PM emission totals by LEZ response scenario

In 2027, at a citywide level, the NOx emission reduction achieved for the minimum requirement scenario will yield a 1.2% reduction compared to the BAU scenario. As for the cleanest ICE scenario, it will achieve 1.5% and increase if it follows the electrification scenario with a reduction of up to 2.8%. During the transition period of LEZ between 2027 and 2028, there will be an

increase in emission benefits since the area of LEZ implementation is expanded from Pilot to Innercity LEZ and limitation of logistic vehicles on a Citywide scale.

Table 32. NOx total emission reduction in Jakarta with different scenarios from 2023 - 2030

NOx	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2024	11322.9	11322.9	11322.9	11322.9	0.0%	0.0%	0.0%
2025	11334.6	11334.6	11334.6	11334.6	0.0%	0.0%	0.0%
2026	11399.4	11314.2	11287.2	11115.1	-0.7%	-1.0%	-2.5%
2027	11392.0	11250.9	11226.4	11072.6	-1.2%	-1.5%	-2.8%
2028	11385.9	10957.1	10867.0	10120.5	-3.8%	-4.6%	-11.1%
2029	11440.6	11114.7	11033.4	10369.7	-2.8%	-3.6%	-9.4%
2030	11440.5	11227.3	11155.1	10574.0	-1.9%	-2.5%	-7.6%

The PM reduction at the citywide level in 2027 shows that the minimum requirement scenario will achieve 1.4%, 1.8% for the cleanest ICE scenario, and 3.0% for the electrification scenario. Similar to the NOx results, the transition phase of LEZ between 2027 and 2028 will improve the PM emission reduction. However, the benefit of NOx and PM reduction will decrease in 2030 as the number of vehicles keeps increasing. This condition is also caused by the limited option of a cleaner emission standard for the new vehicles entering the fleet.

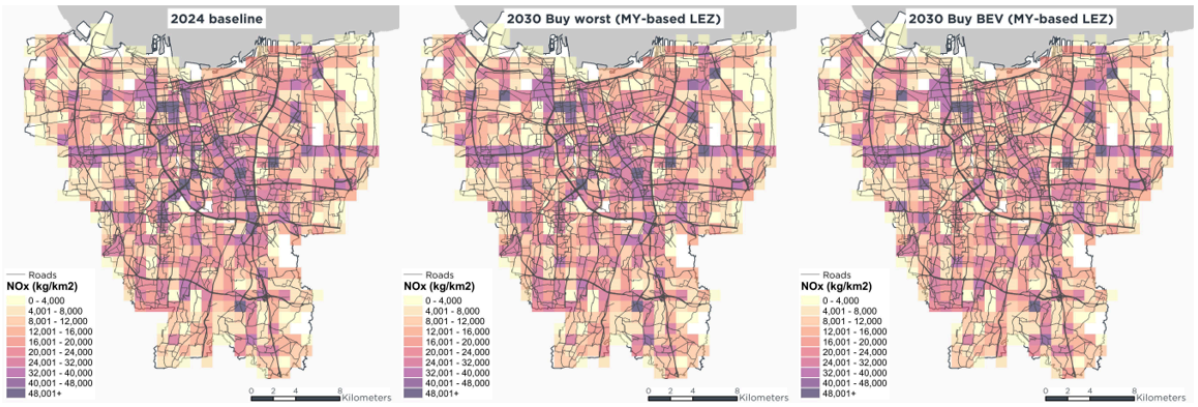
Table 33. PM total emission reduction in Jakarta with different scenario from 2023 - 2030

PM	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2024	179.7	179.7	179.7	179.7	0.0%	0.0%	0.0%
2025	174.3	174.3	174.3	174.3	0.0%	0.0%	0.0%
2026	170.3	168.9	168.0	165.9	-0.9%	-1.4%	-2.6%

PM	Total emissions (tons)				%Reductions		
Year	BAU	Buy minimum requirement	Buy cleanest ICE	Buy EV	Buy minimum requirement	Buy cleanest ICE	Buy EV
2027	166.4	164.1	163.3	161.4	-1.4%	-1.8%	-3.0%
2028	163.0	155.4	152.9	143.4	-4.7%	-6.2%	-12.0%
2029	161.2	155.5	153.4	144.9	-3.5%	-4.9%	-10.1%
2030	159.0	155.3	153.5	146.1	-2.3%	-3.5%	-8.1%

Achieving the level of benefits observed within the LEZ areas at the province scale of Jakarta would require extending LEZ requirements to most drivers and vehicle types. The amount of emission reduction will become a consideration to strengthen the standard or extend the implementation area in the future. The visualisation of city-wide emission reduction for NOx and PM is presented in Figure 79.

NOx



PM

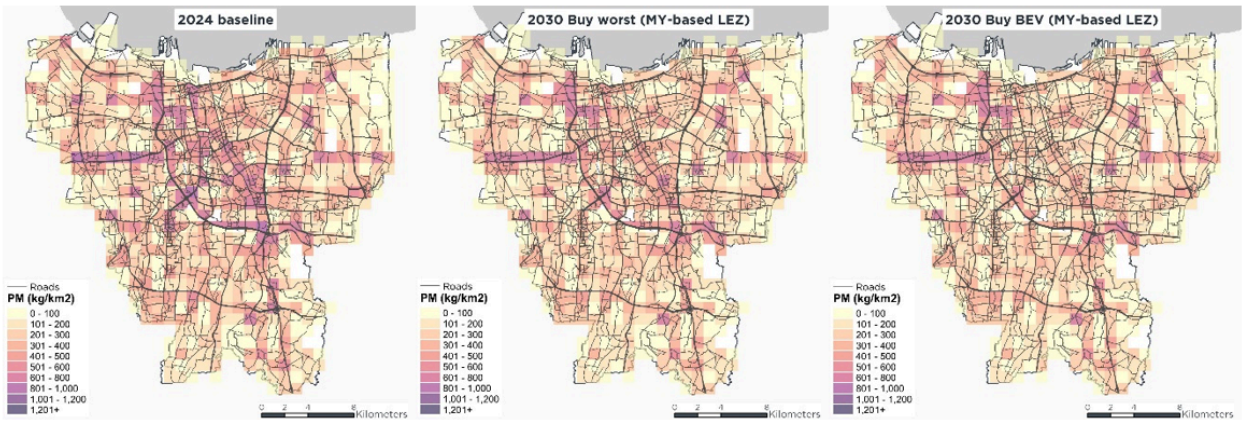


Figure 79. NOx and PM emission distribution between 2024 and 2030 for different scenario (model year assumption)

The NOx reductions associated with the two responses in 2030 compared to the baseline in 2024 are most significant in the centre of the city, where the Inner LEZ area is located. The emissions reductions are most prominent for the Buy BEV response, though small reductions can also be observed for the Buy worst response.

Similarly, the reductions in PM associated with the two responses in 2030 compared to the baseline in 2024 can mainly be observed in the city's centre. While the emissions around the Gatot Puri Kencana-Kedoya Raya-Arjuna Utara street, which is along the southern edge of the Inner LEZ area, decrease substantially from 2024 to 2030 under both responses, the emissions along Gatot Subroto street, just outside and to the west of the LEZ area sees only small decreases due to natural fleet turnover. This demonstrates the impact of the LEZ restrictions in reducing PM emissions in highly trafficked areas within the LEZ.

6.3. City Scale comparison of benefits for LEZ program designs: emission standard based and model year based

Table 34 presents the city-wide NOx and PM emission reduction comparison between the two LEZ adoption designs evaluated in this project: emission standard and model year. Both programs present similar emission reduction trends, with slightly larger benefits for PM emissions. Higher PM benefits could be achieved in the future once a transition to Euro VI is available in Indonesia - as this is the only standard that requires diesel particulate filters for PM control.

At the City Scale for the ICE response scenarios, at the end of phase 2 in 2030, the reduction of NOx under the model year and emission standard assumption is estimated to be 1.9-2.5% and 2.9%, respectively, if compared to the BAU scenario. In 2030, the reduction of PM will be 2.3-2.5% and 4.5% under the model year and emission standard LEZ designs calculation, respectively. The EV response scenarios generate the largest benefits at the city-wide level. EVs can achieve between 7.6% and 5.1% NOx reductions under the model year and emission standard LEZ designs, respectively; PM emissions can be higher, at 8.1% and 7.6% for the evaluated LEZ designs.

Table 34. LEZ Emission Benefits Comparison Between Model Year and Emission Standard Assumption

NOx	LEZ emission benefits - Model Year assumption			LEZ emission benefits - Emission Standard assumption		
Year	Buy minimum requirement (MY)	Buy cleanest ICE (MY)	Buy EV (MY)	Buy minimum requirement (ES)	Buy cleanest ICE (ES)	Buy EV (ES)
2024	0.0%	0.0%	0.0%	-0.2%	-0.4%	-0.6%
2025	0.0%	0.0%	0.0%	-0.1%	-0.3%	-0.4%

2026	-0.7%	-1.0%	-2.5%	-1.2%	-1.2%	-2.3%
2027	-1.2%	-1.5%	-2.8%	-1.7%	-1.7%	-2.6%
2028	-3.8%	-4.6%	-11.1%	-5.0%	-5.0%	-8.2%
2029	-2.8%	-3.6%	-9.4%	-4.0%	-4.0%	-6.7%
2030	-1.9%	-2.5%	-7.6%	-2.9%	-2.9%	-5.1%
PM	LEZ emission benefits - Model Year assumption			LEZ emission benefits - Emission Standard assumption		
2024	0.0%	0.0%	0.0%	-0.7%	-0.9%	-1.0%
2025	0.0%	0.0%	0.0%	-0.5%	-0.6%	-0.8%
2026	-0.9%	-1.4%	-2.6%	-1.9%	-1.9%	-3.1%
2027	-1.4%	-1.8%	-3.0%	-2.3%	-2.3%	-3.4%
2028	-4.7%	-6.2%	-12.0%	-7.2%	-7.2%	-11.3%
2029	-3.5%	-4.9%	-10.1%	-5.9%	-5.9%	-9.5%
2030	-2.3%	-3.5%	-8.1%	-4.5%	-4.5%	-7.6%

As can be seen in Figure 80, NOx emission reduction may vary depending on the scenarios. Under the emission standard calculation, buy cleanest ICE and buy minimum requirement NOx tends to have the same reduction percentage as Euro IV is both the lowest requirement to enter the LEZ and the highest emission standard available in Indonesia. Meanwhile, the buy EV scenario shows higher emission reduction for model year calculation.

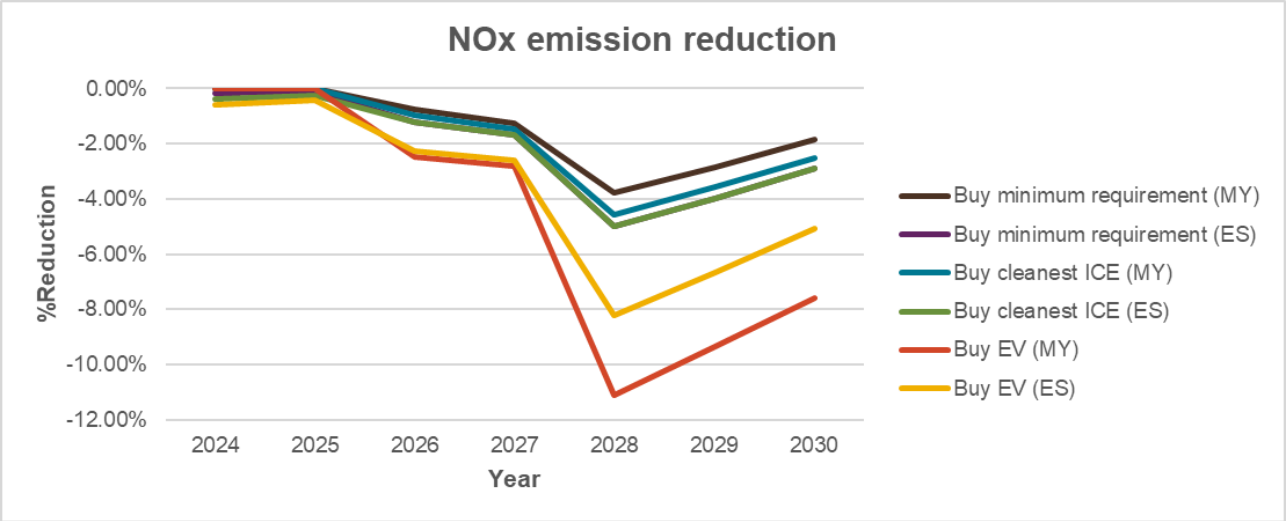


Figure 80. NOx Emission Reduction Emission Standard (ES) and Model Year (MY) Restriction Based Comparison

The same pattern can be seen in Figure 81 for the reduction of PM emissions. However, there is a slight difference where the buy EV scenario under the emission standard calculation overtook model year calculation in 2026 and 2027. Emission reduction using different assumptions (model year vs emission standard) does not differ much as it still uses the same emission standard vehicle implementation year based on Indonesia regulation.

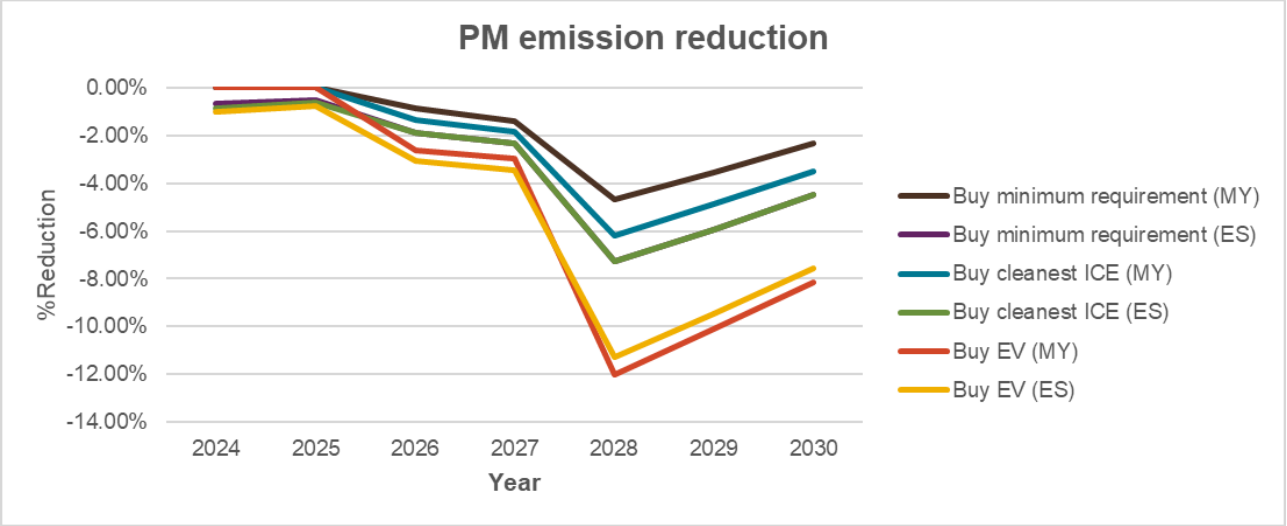


Figure 81. PM Emission Reduction Emission Standard (ES) and Model Year (MY) Restriction Based Comparison

Both approaches of MY and ES show a decreasing trend of emission reduction after the second year of Phase 2 (2029-2030) for different scenarios. This trend is caused by the increasing compliance rate of vehicles meeting the restriction requirement, which increases the traffic volume and reduces the impact of emission reduction. This trend could be countered with other push and policy measures to decrease the use of private vehicles.

6.4. Key Summary from the modelling

- The implementation of expanding the current LEZ program from Kota Tua to areas in the city with high population density and high traffic numbers (VKT) will have large emission reduction benefits in 2030 within the targeted zones.
- The Phase 1 area would experience a NOx and PM emission reduction benefit between 21% and 47% under a LEZ design based on model-year restrictions. The emissions benefits in this Phase 1 area are expected to range from 28-44% for NOx and 37%-54% for PM under a broader emission standards LEZ restriction.
- The Phase 2 area would achieve larger total emission reductions as the vehicle travel impact increases by a factor of 5 for most vehicle types. In the Phase 2 Inner city area, the emissions benefit range from 8-32% for NOx and 9-33% for PM emissions under the

model year LEZ restriction; the emission standard restriction generates slightly higher benefits, ranging from 12%-32% for NOx and 18-33% for PM reductions.

- LEZ implementation using Model Year considerations will be very effective and provide significant benefits within the implementation areas. However, the vehicle emission standard based LEZ scheme will target more vehicles and result in higher emission reduction but at the cost of higher driver and VKT impact. The vast majority of diesel vehicles, mainly commercial ones and some private diesel vehicles would be most affected by either restriction.
- The results show that investment in the electrification of vehicles will significantly contribute to the effort to reduce the emissions in the city. The transition to EV would effectively halve the emission contribution from transport within the LEZ Phase 1 intervention areas and would achieve more than 30% reduction in the wider LEZ Phase 2 area. These benefits would improve the health of all residents and commuters in the short term. Promoting zero emission vehicle uptake in the city would extend those benefits to wider areas in the city.
- Higher Vehicle Emission Standard is needed to ensure more significant results of emission reduction. The current standard for motorcycles is Euro III and the standard for four-wheeled vehicles is Euro IV. More than 80% of the global vehicle market, including China and India, have already implemented higher standards up to Euro VI; Euro VII standards are currently being developed in Europe.
- The area intervention of LEZ already covers a highly dense area, but it is not significant at the provincial level since the Innercity LEZ only covers 13% of the total area. Extending the current Innercity LEZ in phase 2 is crucial to improve the impact of emission reduction in the city.
- The results of the current model do not include the consideration of shifting to public transportation. To substantially reduce air pollution, it is imperative to concentrate on enhancing both the standards for new vehicle emissions and implementing policies and programs to promote the utilisation of public and non-motorized modes of transportation. The implementation of LEZ must be supported with other push-and-pull policies to shift the use of private vehicles to cleaner transportation.

7. Supporting Measures

LEZ is not a stand-alone policy and requires additional measures to ensure the impact of reducing air pollution in the city is significant. This chapter provides three categories of supporting measures for LEZ: enabling policy, policy to anticipate LEZ negative impact and other additional measures.

7.1. Enabling policy of LEZ

The LEZ policy focuses on pushing people to use more sustainable modes of transportation, where LEZ aims to improve the emission standards of vehicles. Enabling policy is define as a set of policy to ensure the impact of LEZ can be maximised. In the future, the LEZ implementation will need a higher vehicle emission standard to increase its impact. This improvement needs to be supported with adequate fuel technology since the conditions in Indonesia still have not supported it. This section also highlights the importance of electrification, which can increase the impact LEZ policy significantly. Another important policy to ensure the success of LEZ implementation is the emission testing activity. This activity has been formally regulated and implemented in Jakarta. However, the implementation is still not matched with the requirements from LEZ standards.

7.1.1. Improve Vehicle Emission Standard

The modelling results of LEZ from the previous chapter have shown the importance of increasing the current emission standard since if there is no improvement, the increasing number of vehicles will overcome the current emission standard requirements. The Ministry of Environment and Forestry regulation is still limited to Euro III for motorcycles and Euro IV for four-wheeled vehicles. Compared with other Asian countries, Indonesia's minimum vehicle emission standard is still low and was implemented late. Table 35 compares the minimum emission standard for petrol cars and light trucks.

Table 35. Minimum emission standard of petrol cars in Asian countries (Krisna, 2020)

Country	2000	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Indonesia				**Euro 2**															**Euro 4**		
Malaysia	Euro 2															Euro 4					
Singapore		Euro 2													Euro 4			Euro 6			
Thailand	Euro 2							Euro 3					Euro 4								
Philippines				Euro 1					Euro 2								Euro 4				
China	Euro 1			Euro 2				Euro 3				Euro 4					Euro 5				
Vietnam	Euro 1							Euro 2									Euro 4				

Implementation of LEZ needs the improvement of vehicle emission standards to achieve a significant air pollution reduction. Paris is one of the cities that implement higher emission standards progressively in the LEZ area. The city is moving further by planning to allow only zero-emission vehicles in the City of Paris by 2030.

7.1.2. Improve Fuel Technology

The improved vehicle emission standard must be supported by suitable fuel technology according to the specifications. The current fuel type in Indonesia is still dominated by sulphur levels that only comply with the Euro II specification. For petrol vehicles, the dominant used type of vehicle is the Petrol 90 (Pertalite) and Petrol 92 (Pertamax) with price per litre Rp 10.000 and Rp 12.950, respectively (in the Province of Jakarta, 1st December 2023). As for Petrol 98 (Pertamax Turbo), the price per litre is Rp 14.400. The use of higher quality petrol for Euro IV specification is still low because the economic capacity for people's purchasing power in Indonesia is still low (Purwanto, 2021). As for the diesel vehicle, the dominant fuel type is still Diesel 48 (Dexlite) with a sulphur level of 1200 ppm, while Diesel 50 (Pertamina Dex), which complies with Euro IV standards, has just recently been introduced. However, the availability of Diesel 50 is still limited and is not generally used by the public.

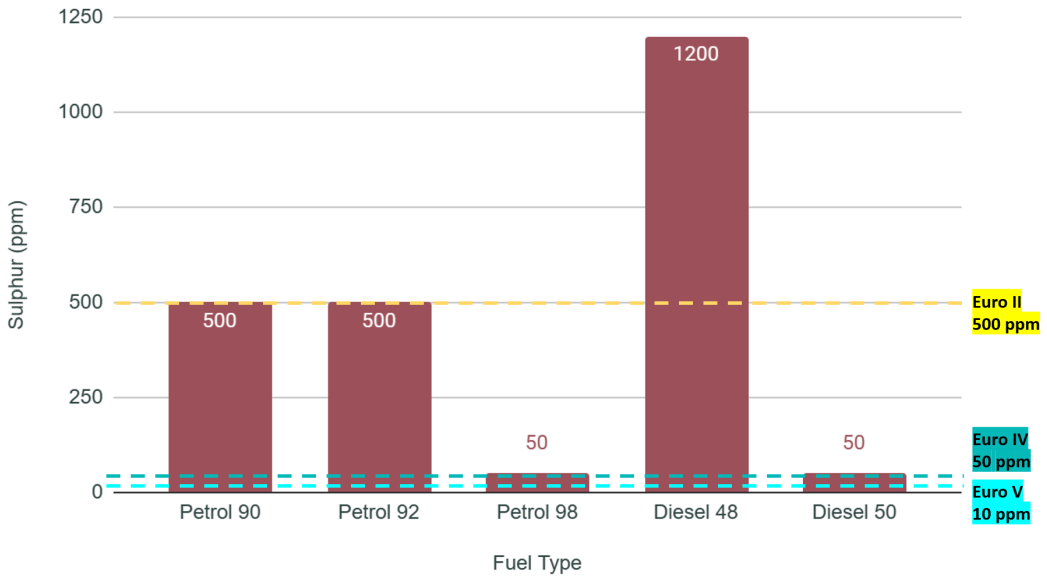


Figure 82. Current fuel technology compared to the vehicle emission requirement

The national government needs to introduce higher quality petrol and diesel for vehicles in Indonesia with the concern of people purchasing power. The national government has just introduced Petrol 95 (Pertamax Green), combining bioethanol technology to achieve more

environmentally friendly fuels. The price per litre of Petrol 95 is Rp 13.900, which is cheaper than Pertamax.

7.1.3. Electrification

The previous chapter explains the potential of electrification, which can improve air pollution reduction in the future. Improvement of vehicle emission standards in the latest technology (Euro VI) should be sufficient to reduce emissions. However, it can be significantly improved with electrification, where electrification should seen as an improvement strategy with a long-term realisation target (as planned in Paris, Amsterdam, or Stockholm).

Electrification should prioritise public transportation, followed by ride-hailing services and private vehicles. The electrification of public transportation guarantees the infrastructure will be used since the government backs it up for public use. The grid infrastructure for public transport will become the basis for future electrification of other vehicles. Ride-hailing services could follow electrification since they travel longer distances compared to ordinary passenger vehicles.

Electrification of Public Transportation

In 2023, ITDP Indonesia assisted the provincial government of Jakarta in the roadmap of the Transjakarta bus electrification program with the report "Business Case of Transjakarta's First Phase E-Bus Development". By 2030, all of Transjakarta armada, which amounts to 10.047, will be fully electrified. The electrification will include articulated buses, low-entry buses, single buses (high deck), medium buses and microbuses, of which the number of electrified armadas per year is explained in Table 36.

Table 36. Transjakarta electrification plan until 2030

Type of Bus	Number of deployed e-bus per year (unit)								
	2022	2023	2024	2025	2026	2027	2028	2029	2030
Articulated bus	0	0	0	111	165	19	22	23	24
Low Entry bus	74	26	0	0	0	0	190	98	21
Single bus (high deck)	0	100	150	31	224	264	113	110	375
Medium bus	0	100	0	50	204	250	253	260	401
Microbus	0	0	100	200	400	600	1129	1800	2160
Annual e-bus deployment	74	226	250	392	993	1133	1707	2291	2981
Cumulative number of e-buses	74	300	550	942	1935	3068	4775	7066	10047
Percentage of e-buses in Transjakarta fleet	2%	7%	14%	24%	38%	51%	69%	85%	100%

As explained in the previous chapter of the Innercity LEZ concept, it is expected that all 51% of the electrified armada in 2027 will serve the LEZ delineation. The electrification of the Transjakarta fleet alone will result in 45% tailpipe PM 2.5, 47% tailpipe NOx, and 47% tailpipe SOx reduction compared to Business as Usual (BAU) when using ICE or CNG fleets.

Electrification of Ride-Hailing Fleet

Jakarta has its own unique characteristic mode of transportation; the inability of public transportation services to provide seamless mobility prompts commuters to use ride-hailing services. In 2019, the proportion of people using ride-hailing services in Jakarta reached 11.25%, higher than the mode share of public transportation, reaching 9.86%. ITDP produced “Road Map and Timetable of Two-Wheeler Electrification in Greater Jakarta” (2022) to assess the impact of all 900.000 fleets of two-wheeler ride-hailing services if electrified. The electrification of ride-hailing services will significantly reduce air pollution from CO, NOx, PM 10 and SO2.

7.1.4. Improve Emission Testing Activity and Standard

Regulation for emission testing in Jakarta has been regulated with the Governor Regulation 66 of 2020 about Emission Testing for Motorised Vehicles. This regulation targets all two-wheelers and passenger vehicles with a minimum operation time of three years. All private vehicle owners must check and pass their vehicles' emissions once a year. At the same time, the local government could enforce the emission testing activity every six months or according to the needs.

The current state of vehicle emission testing in Jakarta shows only a small percentage of vehicles already following the emission testing activity. Figure 83 shows the rate of 30.8% for passenger cars and only 0.64% for motorcycles. The online dashboard provided by the Environment Agency of Jakarta from *ujiemisi.jakarta.go.id/dashboard* shows that passenger cars that passed the emission test reached 99.8% and 98.1% for motorcycles.

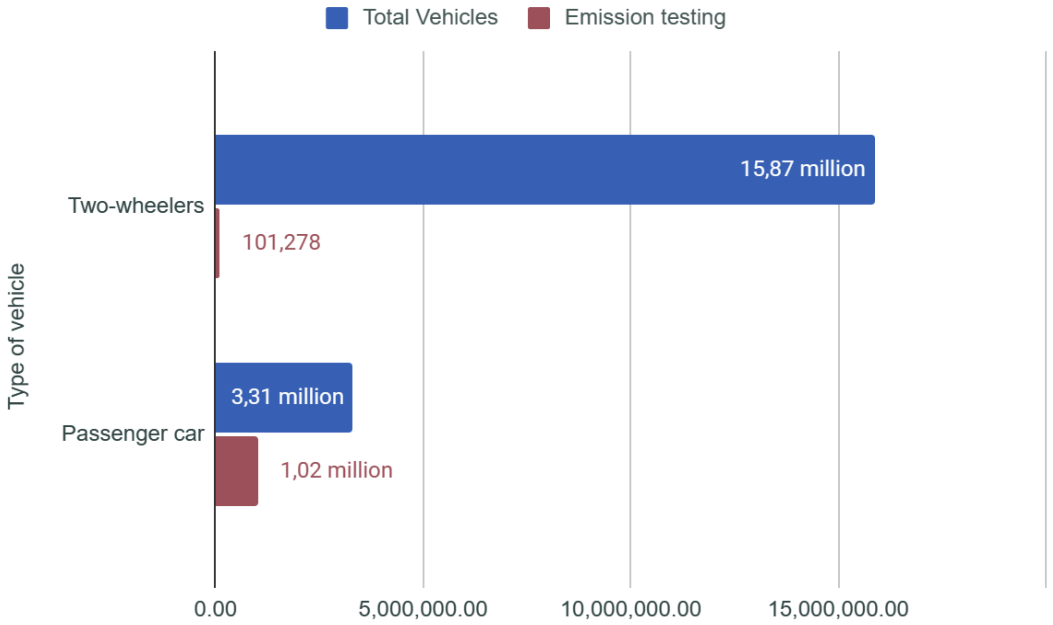


Figure 83. Emission testing rate in Jakarta

However, the emission testing activity conducted by the provincial government only assesses the Carbon Monoxide (CO) and Hydrocarbon (HC) as regulated in the MoEF 8 of 2023. Whilst the implementation of LEZ requires a stringent standard that also involves NOx and PM. The baseline data to determine the Vehicle Emission Standards should follow the Euro model of vehicle manufacturing standards set by the MoEF 20 of 2017 for motorcycles and MoEF 23 of 2012 for four-wheelers. New vehicles can be automatically registered, while vehicles older than three years must participate in emission testing using NOx and PM indicators.

7.2. Anticipation of LEZ negative impact

7.2.1. Congestion charging

As explained previously, the implementation of LEZ aims to reduce the number of vehicles entering an area by limiting highly polluting vehicles, while congestion charging aims to reduce congestion issues by imposing a charge for all of the vehicles entering a location or corridor. From the example of several cities, the implementation of LEZ is successful in reducing the pollution emitted from vehicles. However, as the number of vehicles passing the standard increases, the vehicle volume also increases, creating a congestion problem. Milan and London are examples of cities that implement supporting measures of congestion charging together with the LEZ to address the issue.

Milan has been implementing the LEZ since 2008 under the program named Ecopas. The LEZ intended to reduce the number of highly polluting vehicles by implementing a charging scenario that ranges from 2-10 Euro for highly emitting vehicles according to the severity of emission. In 2012, the local government changed the scheme with congestion charging since the number of

vehicles accessing the area diminished the Ecopass policy's initial objective. The criteria now are not limited to limiting vehicles based on the emission standard but for all vehicles with a flat fare of 5 Euro with an exemption of electric and hybrid vehicles.

The other cases of congestion charging implementation come from London, England, where it was implemented together with LEZ policy. The first limitation of passenger vehicles based on emission standards started in 2019 under the Ultra Low Emission Zone (ULEZ) name. The limitation targeted diesel vehicles under Euro IV and petrol under Euro VI standards. It initially covered only the Central Zone of London with an area coverage of 21 km2; it expanded 18 times in 2021 and reached the whole Greater London area in 2023. At the same time, the City of London also implemented a congestion charge zone in the Central Zone of London to solve the traffic congestion issue in the inner city. Unlike the ULEZ, which limits specific vehicles based on its emission standard, where unstandardised vehicles must pay GBP 12.5, with a congestion charge, every vehicle that enters the area must pay GBP 15.

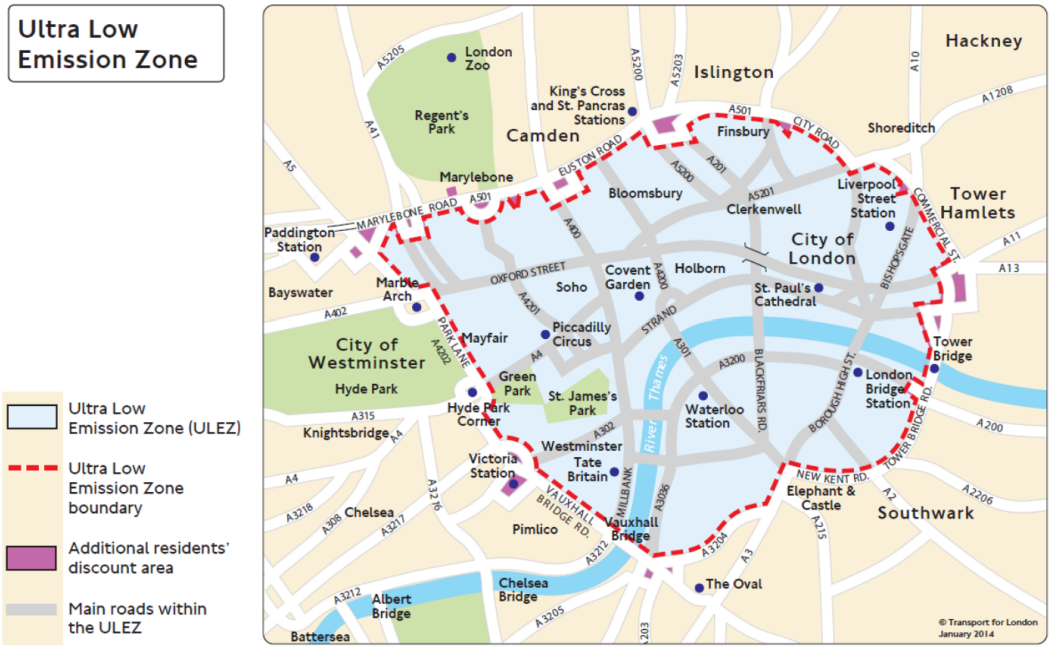


Figure 84. ULEZ and Congestion Charging Area in London (source: london.gov.uk)

ITDP (2022) has planned the implementation area/corridor for ERP in Jakarta with four scenarios that are categorised into cordon (area) and corridor based as visualised in Figure 85.

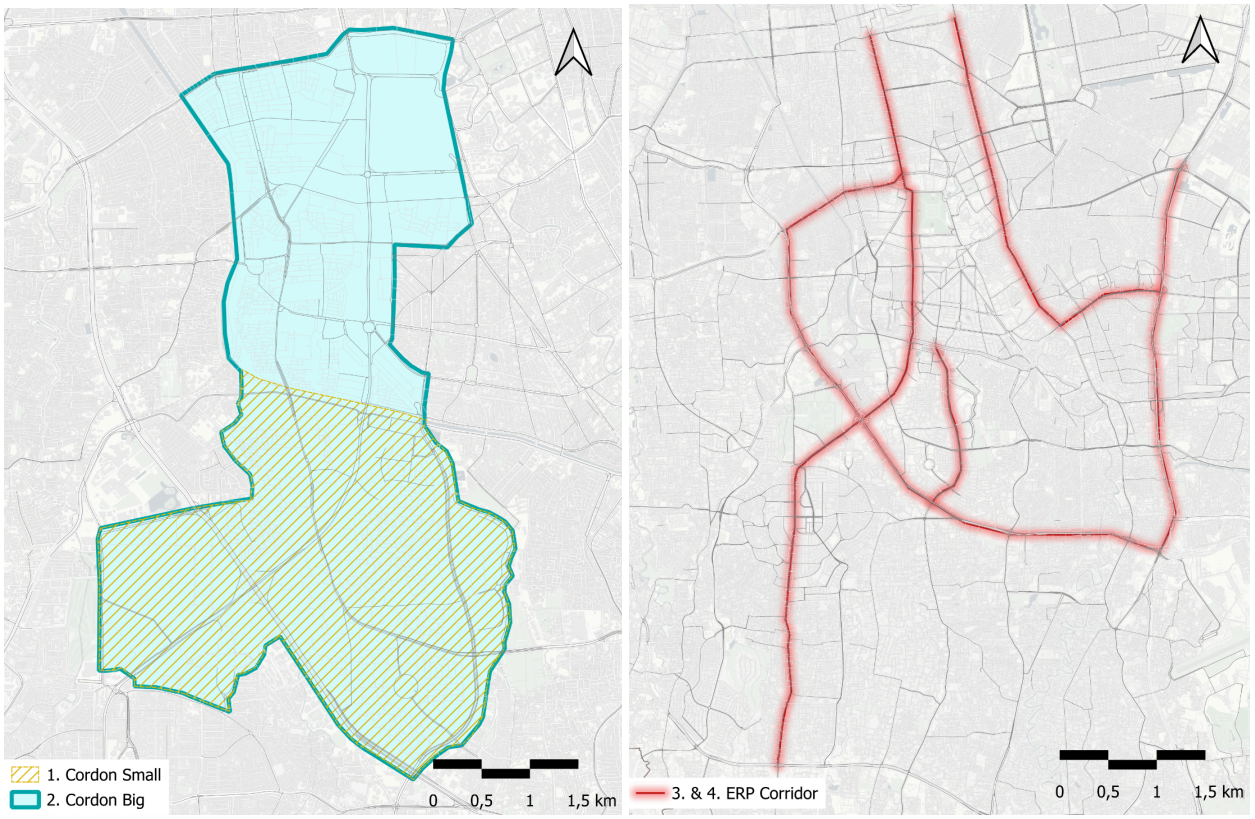


Figure 85. Congestion pricing scenario in Jakarta (source: ITDP, 2022)

The first ERP scenario is an area/cordon-based scenario located in the Central Business District of Jakarta. This scenario encompasses the Gelora Bung Karno Stadion area, Selong, Karet Tengsin, Karet Semanggi, Kuningan Timur, Karet Kuningan, Karet, Setiabudi, Karet Tengsin, and the southern part of Bendungan Hilir. The borders of the zones are placed in a way that minimises the number of entry and exit points. This zone covers an area of 10.77 km^2. Through traffic on the toll roads, which do not have an origin or destination within the cordon, are not subject to charges. Scenario 2 features a larger cordon, encompassing a more significant number of destinations in the city core. The main objective of this scenario is to mitigate the negative effects on travel time caused by rerouting. This scenario encompasses the same areas as Scenario 1 plus Kebon Melati, Kebon Kacang, Kampung Bali, Petojo Selatan, Gambir, and Kebon Sirih. This cordon covers an area of 18.7 km^2, 1.7 times larger than the small cordon scenario.

The corridor scenario is based on the default scenario developed by the Transport Agency, which covers 25 roads totalling 58 kilometres. The third scenario will charge a fixed amount to the

vehicles passing through the road, while the fourth scenario will use a distance-based charging mechanism. The implementation of LEZ could consider the ERP scenario to mitigate the unintended consequences of LEZ, which can solve the traffic congestion issues. The proposed Pilot LEZ location mentioned in the previous section tried to accommodate this plan if it is implemented together with a congestion charging policy.

7.2.2. Parking Management

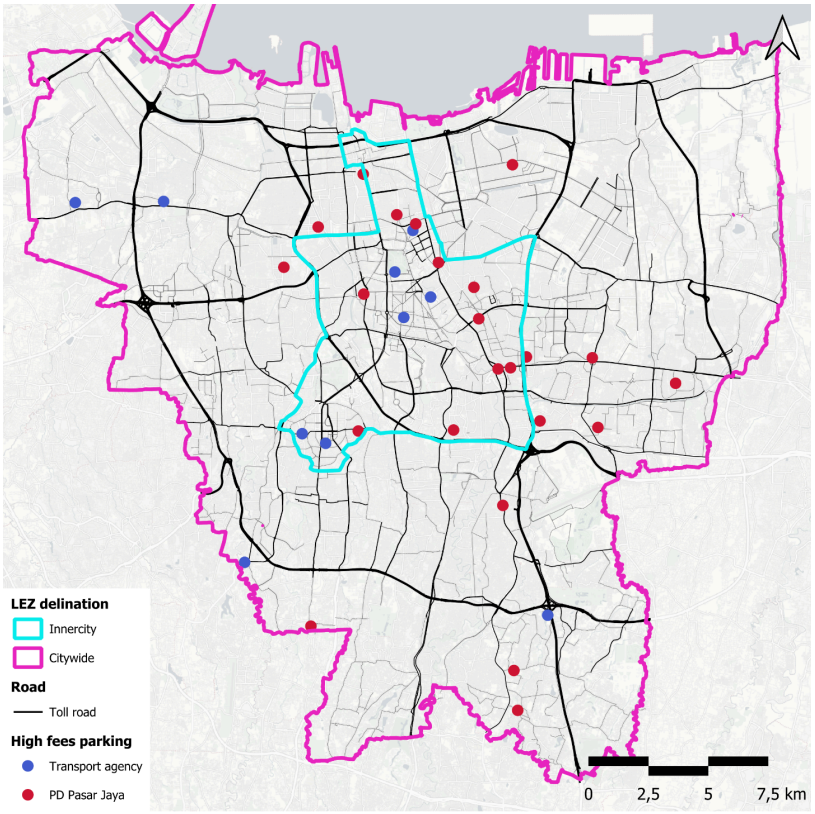


Figure 86. High parking fee locations in Jakarta

Another policy to reduce the number of vehicles entering the LEZ is by implementing parking management inside the LEZ area. The provincial government has just implemented a high parking fees policy for vehicles that do not check or comply with the emission standard. The disincentive mechanism is regulated by Governor Regulation 66 of 2020 about the Emission Testing of Motorized Vehicle. Vehicles will be subject to a minimum parking fee of IDR 7,500 IDR per hour, and it can increase progressively except in the park-and-ride facility. The policy is implemented in 33 locations, where 10 locations are under the management of the Transport Agency, and 23 locations are under PD Pasar Jaya, as illustrated in Figure 86. The disincentive mechanism should be implemented more widely by incorporating other public and private parking facilities.

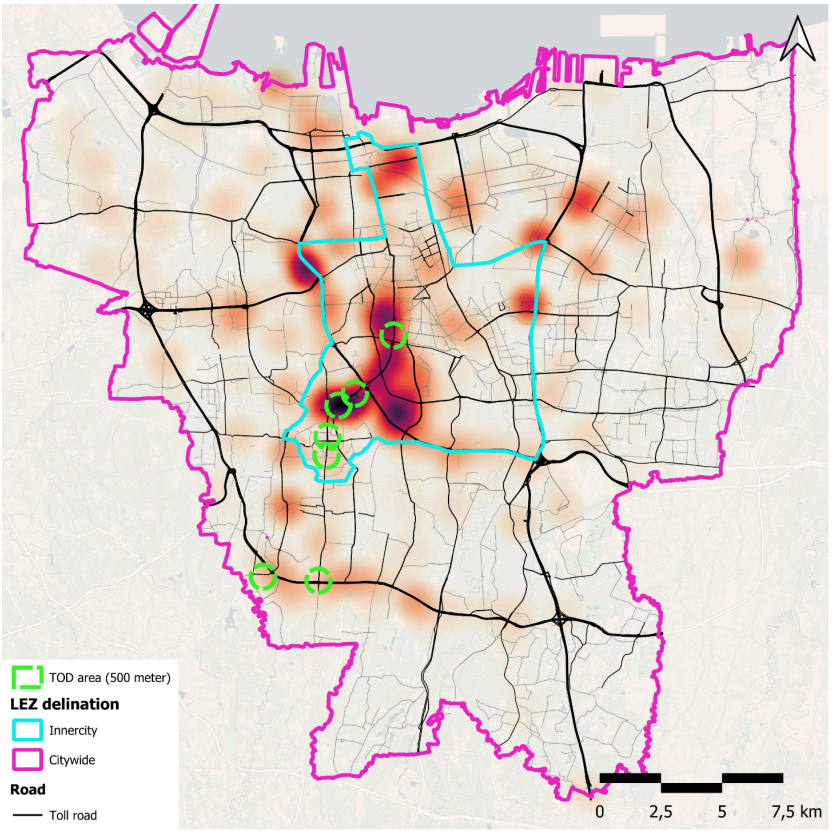


Figure 87. Off-street parking heat map and parking management area in Jakarta

Another disincentive mechanism to discourage the use of private vehicles is imposing a maximum parking capacity in certain areas. The Governor Decree 31 of 2022 about the Spatial Planning and Zoning Ordinance set the Transit Oriented Development (TOD) area as an area with maximum parking capacity. Land use with economic services will have a maximum capacity of 50% of the existing capacity and further limitations for residential land uses. However, there should be an additional parking space limitation precisely for the LEZ area since the concentration of high parking capacity is still located outside the TOD zone. Figure 87 illustrates the distribution of 660 parking locations with the parking capacity in Jakarta (Parking Management Unit of Jakarta Transport Agency, 2022).

7.3. Additional measures

7.3.1. Public transportation

The public transportation system in Jakarta will continuously improve its catchment area, with an added route for both road and rail-based transportation. Table 37 provides information on the future routes of MRT, LRT Jakarta and BRT Transjakarta. MRT will extend its phase 2A from Bundaran, HI, to Kota and is expected to be fully operational in 2027. Phase 3 and 2B are expected to be fully operational by 2029 and 2030, respectively. This planned route will increase the

connectivity of central Jakarta, which is also assigned as LEZ area to the east-west and northern parts of Jakarta.

LRT Jakarta will have an extension of the Velodrome to Manggarai route that connects east Jakarta to the centre, with an expected operation in 2025. The next phase will be the 2C (Velodrome - Klender), which will improve the connectivity in the East Jakarta area and the 3A (JIS - Rajawali) for improved connectivity in the northern part of Jakarta. As for the planned BRT corridors, there will be six additional corridors.

Table 37. Public transportation plan in Jakarta

Mode of Transportation	Public transportation route plan
MRT	Phase 2A: Bundaran HI - Kota Phase 2B: Kota - Ancol Barat Phase 3: Kembangan - Ujung Menteng via Grogol Phase 4: Fatmawati - Kampung Rambutan
LRT Jakarta	Phase 2A: Velodrome - Manggarai Phase 2B: Kelapa Gading - JIS Phase 2C: Velodrome - Klender Phase 3A: JIS - Rajawali Phase 3B: Klender - Halim Phase 4: Pulogebang - Joglo
BRT	Corridor 14: Senen - JIS Corridor 15: JIS - Pulogebang Corridor 16: Kampung Melayu - Tanah Abang Corridor 17: Ancol - Tanjung Priok Corridor 18: Puri Kembangan - Pluit Corridor 19: Manggarai - Universitas Indonesia

In the future, after 2030, the delineation of the Innercity LEZ should be adapted to the future public transportation network in Jakarta. With more public transportation routes implemented, there is a possibility of increasing the scope of LEZ delineation. Figure 88 visualises the future mass public transportation network in Jakarta. It shows an increasing connectivity inside the Innercity LEZ area and to the east-west, as well as to the north-south part of Jakarta.

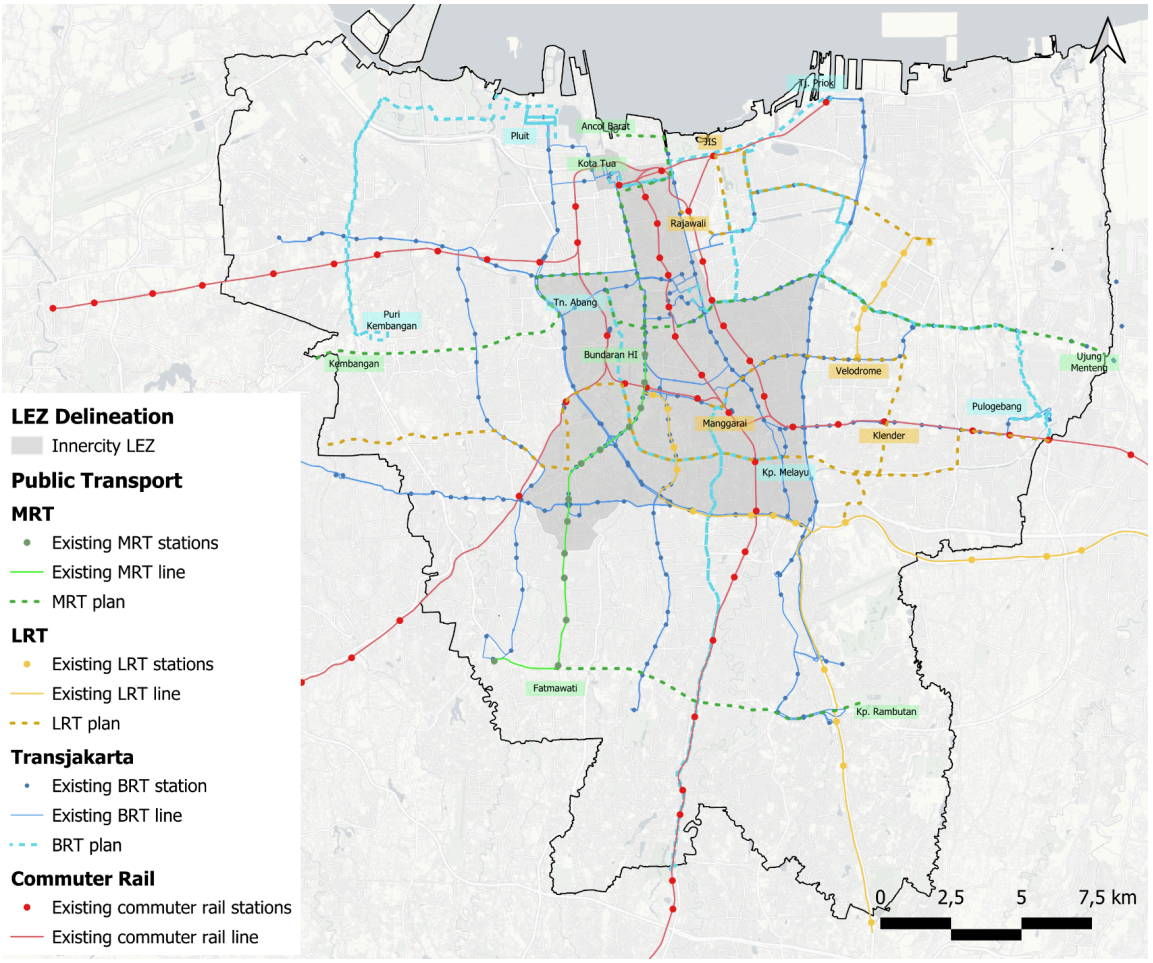


Figure 88. Future of mass public transportation network in Jakarta

7.3.2. Walking and Cycling

A network of sidewalks and cycling infrastructure supports the accessibility to a more sustainable mode of transportation. The existing sidewalk infrastructure is mainly located in central Jakarta and the centre-south economic corridor. ITDP and the Public Works Agency (Dinas Bina Marga) of Jakarta have planned the sidewalk infrastructure masterplan until 2030. Figure 89 visualises the sidewalk and bicycle path plan in Jakarta. The sidewalk development will be adjacent to the existing and future plans for mass public transportation routes. It also shows the delineation of the Innercity LEZ already covers a future extension plan of the sidewalk, and there is a possibility to extend the delineation accordingly.

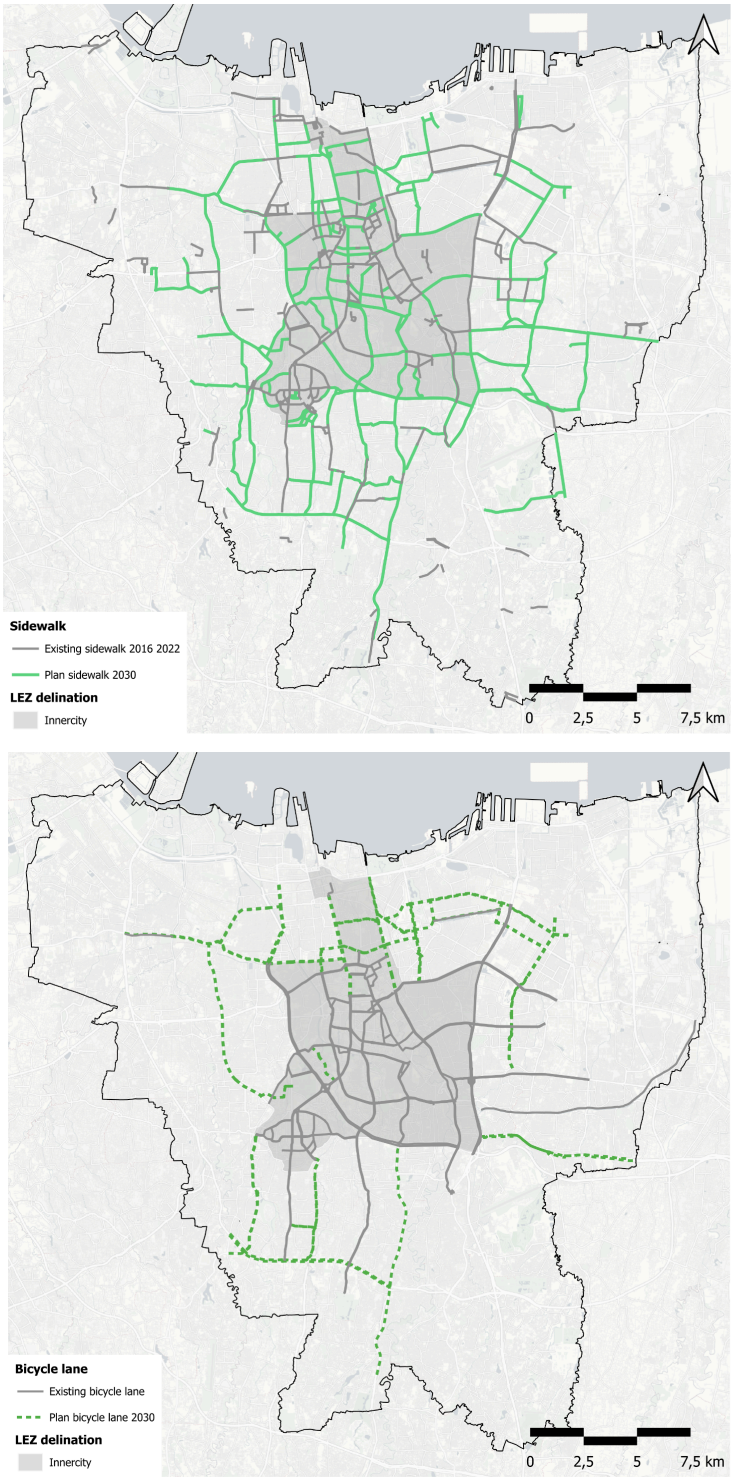


Figure 89. Walking and cycling infrastructure plan until 2030 in Jakarta

As for the bicycle lane network in Jakarta, the existing lane already covers most of the Innercity LEZ area. ITDP and the transport agency have planned the master plan of the cycling network in Jakarta, which has been integrated with the Spatial Planning Document of Jakarta. The future

cycling network will be expanded to 500 kilometres by 2030, with the existing cycling lane already reaching 196.5 kilometres. The future network will expand to the north-south and east-west corridor. This condition shows the possibility of extending the LEZ delineation to the area with an available and suitable cycling network.

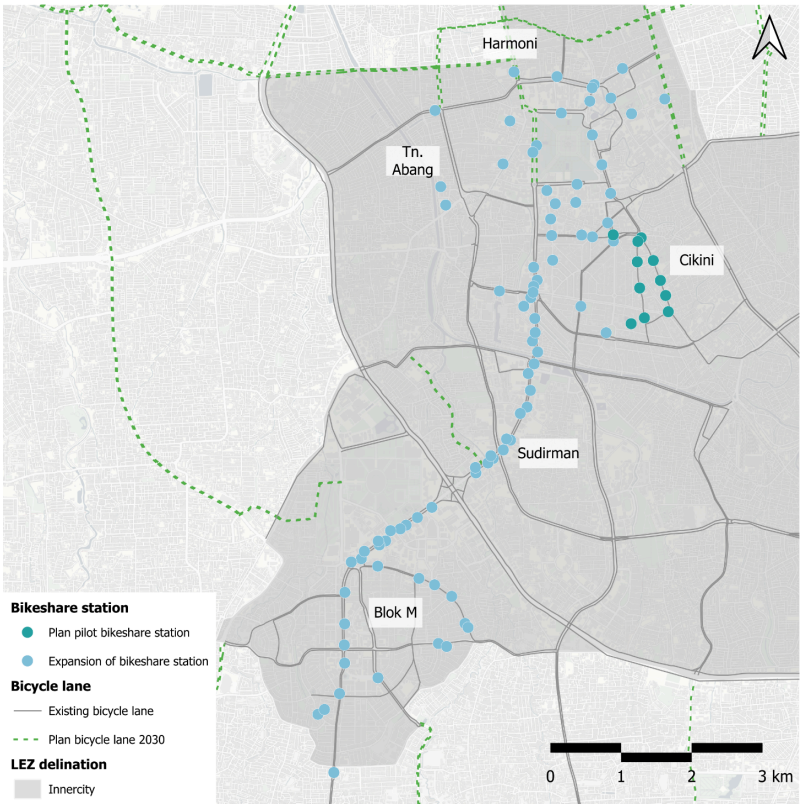


Figure 90. Bikeshare station infrastructure plan in Jakarta

The bicycle infrastructure can be further supported by the operation of a bike-sharing system. With bike sharing, commuters can use the bike rental for a period of time to meet the first and last-mile connectivity. Bike sharing will be a suitable mode of transportation to serve the LEZ area since it is a zero-emission vehicle. The bike share operation has been operating since 2019, but unfortunately, it stopped in 2021 due to the inability of local operators to deliver good services. ITDP and the Transport Agency plan to revive the bike-sharing operation in early 2024 with multiple operators in a small-scale area of Cikini, as illustrated in Figure 90. The bike-share station locations will be expanded to the northern services area in Harmoni and the south of Jakarta to Blok M, which is covered in the Innercity LEZ area.

7.3.3. Improvement of logistic system

Following the recommendation of limiting the access of Heavy Duty Vehicles (HDV) inside the Innercity LEZ area, the future logistical system in Jakarta must be developed with a more

sustainable approach. The existing logistic system still relies on diesel HDVs to send goods to the city's inner area. Although there is already a time limitation by only allowing them access during the night, it still produces a significant proportion of emissions in Kota Tua Jakarta (Yulinawati, 2022). Improving the emission standard of HDV might not be enough to reduce emissions, and electrifying HDV is still a scarce technology that can be implemented.

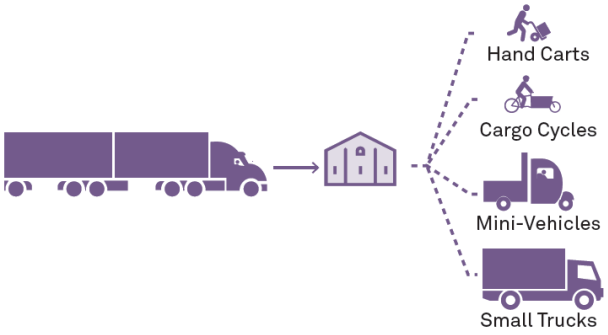


Figure 91. Micro consolidation logistic scheme (Source: NACTO, 2016)

The future of the logistic system could be improved following the micro-consolidation or distribution centres. A warehouse facility can consolidate all logistics around the perimeter of urban or designated areas before delivering on smaller vehicles. The type of last-mile vehicles, including small trucks, mini vehicles, and cargo vehicles, will be more likely to have zero emissions with electrification. This system will not only alleviate air pollution emitted from HDV but also improve the efficiency of road space. Figure 91 illustrates the micro-consolidation logistical scheme.

Figure 92. Zero emission logistic vehicle in London (Source: DPD UK, 2023)

One of the best examples of integrating the LEZ and management of logistics is happening in London. The City of London (2020) produces a Delivery and Servicing Plan (DSP) with three main objectives:

- Reduce: decrease the number of deliveries by implementing more efficient servicing trips through consolidation centre
- Re-mode: phasing out the petrol or diesel vehicles for deliveries with low to zero emissions vehicles
- Re-time: ensuring deliveries outside peak hours

This plan is aligned with the urgency of LEZ, which prioritises an emission reduction from freight as it is responsible for 33% of NOx despite comprising only 17% of the total VKT. The existing LEZ policy in London is already imposing a minimum Euro VI standard for HDV above 3.5 tonnes. However, further action is needed since the target of annual PM 2.5 must be under 10 uq/m3 by 2030.

One of the key concepts to ensure a better logistical system is planning consolidation location. Consolidating freight could improve load utilisation and reduce delivery vehicle kilometres. London intends to create micro-consolidation locations in the commercial area that are being served by zero-emission deliveries. One of the UK's express delivery companies, DPD, opened an entirely zero emission system where incoming parcels are served by electric lorries, while a fleet of electric vans and micro-vehicles serves the last mile deliveries.

7.3.4. Land Use Management with TOD

The effort to reduce emissions from the transportation sector will not be sufficient if it only depends on increasing the emission standard or electrifying the vehicle. ITDP (2021), in "The Compact City Scenario - Electrified", analyses the goal of limiting global warming to less than 2C, which can only be achieved if the electrification of vehicles is combined with the compact city scenario. The concept of a compact city in Indonesia is integrated under the term Transit Oriented Development (TOD). It has been regulated at the national level with the Ministry of Spatial and Agrarian Affairs 16 of 2017, and a more detailed explanation at the provincial level with the Governor Regulation 31 of 2022. The provincial regulation has set six areas to become TOD as follows:

- Lebak Bulus
- Fatmawati
- Blok M
- Sisingamangaraja
- Istora - Senayan

- Dukuh Atas - Bundaran HI

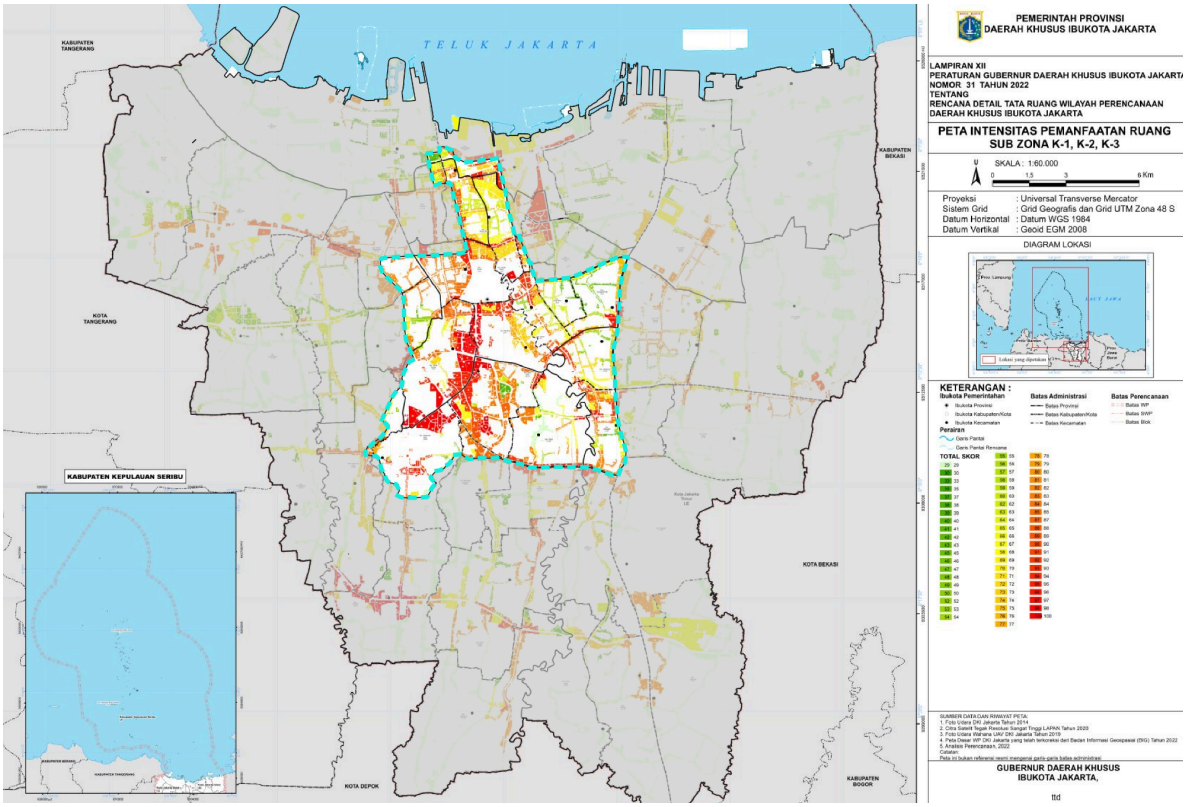


Figure 93. High density land use in the Innercity LEZ

Areas assigned as TOD will be developed with a compact, dense, mixed-use, and priority for sustainable transportation. They are also set to have a higher allowance for the Floor Area Ratio (FAR) and an opportunity for a density bonus to build more dense development in the area. Figure 85 visualises the area set to have a higher allowance for FAR that is not limited to the TOD area but for all roads adjacent to public transit corridors. The delineation of the Innercity LEZ has already been situated with the requirement of a higher FAR allowance. With more dense development oriented with public transportation, the LEZ will be impacted with lesser VKT from private vehicles, which in the end will reduce the air pollution from the transportation sector.

8. Summary

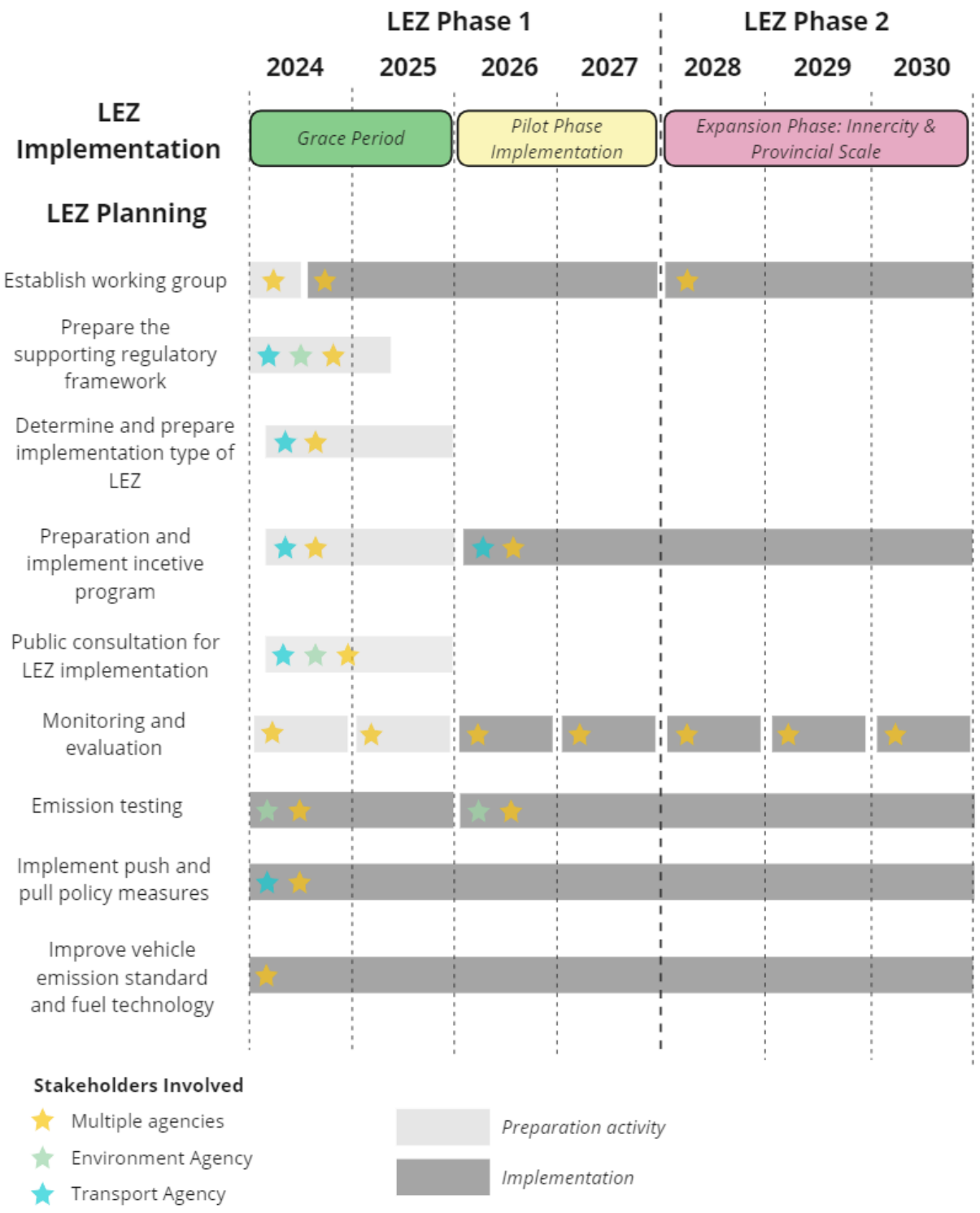


Figure 94. Implementation recommendation of LEZ roadmap in Jakarta

The implementation of LEZ can be implemented in two main phases, with phase 1 as the pilot phase and phase 2 as the expansion phase. Phase 1 will range from 2024 to 2027, where the first two years will be allocated as the grace period year where socialisation and all of the processes to prepare LEZ. Phase 2 will expand the pilot phase with a larger intervention area and more types of vehicles included in the limitation. The LEZ roadmap must be supported with a series of planning activities. Figure 87 visualised some of the highlights of the planning activities, which are indicated by the time period of implementation and the responsible stakeholders.

This report highlights several important elements of LEZ planning and implementation. The summary and recommendations of this report are compiled into several main points:

- Establish a working group: the first initiative to plan LEZ is to create a working group led by the Environment Agency, where Transportation Agency leads the technical aspects for the implementation. Organisations outside the government body, such as NGOs, researchers, universities, associations, and other relevant civil society organisations, must be incorporated. This type of involvement will create a collaborative planning process with a higher impact on the public. The working group will work together until the target of 2030 is reached, with a comprehensive evaluation nearing the 2nd phase of LEZ.
- Determine the potential area for LEZ: the scope of area for LEZ implementation in Jakarta should be focused on areas with a high concentration of air pollution from motorised vehicles, high coverage of public transportation, availability of Non Motorised Transportation infrastructure (walking and cycling), existing push policy, coverage of active land use, and low residential density. This study provides a potential LEZ area with 87.8 km2 or 13% of the total land area of Jakarta. The area covers the north, south, and southeast main economic corridors of Jakarta.
- Develop a roadmap of LEZ implementation: LEZ requires phasing of implementation from the development of LEZ area and improvement of vehicle emission standards. This study targeted a roadmap of implementation until 2030, where there will be two phases of implementation. The first phase from 2024 to 2027 will be the pilot phase, where the first two years become the grace period, and the last two years are the implementation phase according to the minimum Euro standard in the pilot area. The second phase starts from 2028 - 2030 with two types of implementation in the Innercity for stringent standards and Outer LEZ for logistics.
- Model the impact of LEZ roadmap of implementation: the roadmap of LEZ implementation potentially resulted in a significant reduction of air pollution in the LEZ area of intervention. The Emission Standard (ES) design and Model Year (MY) design will significantly decrease air pollution concentration, especially the ES design. In the Provincial scale of Jakarta, the reduction will be more modest since the area of intervention for LEZ Innercity needs to be larger and higher vehicle emission standards.

- Prepare the supporting regulatory framework: the current regulations have still not been able to incorporate the need to limit vehicle access based on the emission standards. However, there are already regulations that mention the need to prioritise green mobility and planning to create areas for air quality management on a national scale. These existing regulations act as a basis for consideration for more operationalised LEZ regulation in the province of Jakarta. Transport and environmental agencies will play a crucial role in the regulation, where the former will consider traffic management, and the latter will provide the target to achieve emission reduction, and the criteria of vehicle needs to be limited.
- Determine and prepare the implementation type of LEZ: the transport agency will determine the kind of limitation and the technicality according to the existing resources. Other agencies should give their recommendation regarding the type of LEZ implementation since it will impact the social-economic conditions of people and the readiness of the provincial government of Jakarta to implement it.
- Conduct public consultation: engagement with the public must be started after the creation of the working group to gather input related to all of the rules of LEZ. The transport agency and environment agency will be responsible for leading the consultation activity. The transport agency will act as the enforcer, while the environment agency will provide technical assistance related to the vehicle emission standard requirement.
- Monitor and evaluate LEZ implementation: the monitoring and evaluation of LEZ should assess the condition of air quality monitoring results, proportion of vehicle type, traffic, and compliance rate. This information must be gathered before the implementation of LEZ as the base data to be compared later as the measure to evaluate the success of LEZ implementation. Every year or month, agencies should provide public information related to the evaluation of LEZ as a strategy to improve transparency and communicate the policy. Agencies should also open a communication channel where the public can provide feedback with various forms of communication to ensure its inclusivity.
- Prepare and implement supporting measures for LEZ: the benefit of LEZ can be improved with the implementation of supporting policies related to the enabling policy, policy to anticipate the negative impact and additional measures. Various provincial government agencies will be highly responsible for delivering the policy. The national government's involvement will also be crucial to improving vehicle emission standards and the fuel technology.
- Further study is required: LEZ implementation requires a more comprehensive study related to the Cost Benefit Analysis (CBA) and technical analysis for the type of LEZ scheme (between automatic/manual and fee/non-fee based scheme).

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Annex 1. Explanation of Relevant Regulation with LEZ

No	Regulation	Relevance to LEZ	Potential Impact
1	Law 32 No. 32 of 2009 on Protection and management of environment	Air pollution is included as an indicator to measure environmental quality. Every individual who violates the environmental quality will become a legal subject and receive a fine.	Beneficial Impact: In the context of air quality, individuals who damage the environment can be fined. LEZ is an intervention that penalises drivers that still drive high-polluting vehicles, and fines or fees can be applicable to them.
2	Ministry of Environments Regulations No. 20 of 2017 on Exhaust emission quality standards for vehicle category M, N, O	Establishes national emission standards for four-wheeled vehicles to Euro IV, potentially forming the basis for LEZ criteria. The goal of the regulation is to reduce pollution at a national scale, but it could also contribute to local air quality. Euro IV standard for petrol has been implemented since 2018, while diesel vehicles just recently implemented in 2022	Beneficial Impact: promotes cleaner technology adoption aligning with LEZ
3	Ministry of Environments Regulations No. 23 of 2012 on Exhaust emission quality standards for vehicle category L3	Sets out emission standards for motorcycles which may contribute to air quality improvement with Euro III standard	Beneficial Impact: limits environmental impact from motorcycles which aligns with LEZ goals
4	Ministry of Environments Regulations No. 8 of 2023 on Implementation of exhaust emission quality standards for vehicle category M, N, O, L3	Emission testing is used as the basis for vehicle tax collection. The emission testing data can be used by the provincial government for inventive or disincentive mechanisms	Beneficial Impact: LEZ depends on the result of emission testing of the vehicle, this regulation also provides an opportunity for provincial government to use LEZ as one of the incentive and disincentive mechanism

No	Regulation	Relevance to LEZ	Potential Impact
5	Governor Regulation No. 66 of 2020 on emissions tests	Obligates vehicle owners to undergo emission testing, which is a crucial aspects for enforcing LEZ standards. This regulation also introduces disincentive mechanism with a high parking fee for vehicles that do not meet the emission standard.	Beneficial Impact: Ensures vehicles meet emission standards, which will provide accurate data for LEZ implementation, enforcement, baseline analysis, and for the staging of restrictions. Unfavourable Effect: Currently, enforcement for emission testing is still low, and the high parking fee location is still limited.
6	DKI Jakarta Regional Regulation Number 2 of 2005 concerning Air Pollution Control	Obliges air pollution inventory based on ambient air quality and potential pollution sources (including transportation). Mentions car-free days for strategies to reduce pollution, which may serve as a catalyst for more policies such as LEZ	Beneficial Impact: supports air quality restoration measures and contributes to the decrease of LEZ Unfavourable Effect: Car free days in Jakarta are only on the main corridor, whereas LEZ should be implemented city-wide. Although car free days can be used to increase understanding of LEZ
7	Government Regulation Number 32 of 2011 concerning Traffic Impact Management and Engineering	Traffic management of different types of vehicles on the road (personal vehicle, freight, and public transportation). Traffic management with a levy mechanism is also possible to implement	Beneficial Impact: The traffic management objective for environmental reasons is aligned with the LEZ. Unfavourable Effect: There is still no clear explanation for limiting vehicle access based on the emission standard

No	Regulation	Relevance to LEZ	Potential Impact
8	Minister of Transportation Regulation 82 of 2021 concerning Regulation of Individual Motorized Vehicle Traffic on Roads in Certain Areas	Promotes cleaner transportation modes with policies to reduce air pollution such as odd-even policies, with exemptions on electric vehicles.	Beneficial Impact: Possibility for local government to implement their own traffic management mechanism, in which LEZ could play an important role. Unfavourable Effect: There is still no clear explanation for limiting vehicle access based on the emission standard
9	DKI Jakarta Regional Regulation Number 5 of 2014 concerning Transportation	Ensures more environmentally friendly transportation is adopted, and the limitation of vehicles in certain areas/time is also mentioned which is in line with LEZ objectives, although it's not mentioned explicitly. Also include the implementation of vehicle taxes and stickers for vehicles that comply/do not comply with emission standards.	Beneficial Impact: Shares common objectives with LEZ, including vehicle taxes, limitations with stickers, limitations of old vehicles, and traffic management with charging. Unfavourable Effect: LEZ is still not explicitly mentioned
10	National Government Regulation Number 22 of 2021 concerning Implementation of Environmental Protection and Management	Requires the establishment of air quality protection and management areas which could be in line with the scope of LEZ. Emphasises the need to control air pollution sources such as vehicles.	Beneficial Impact: LEZ can act as a tool to control air pollution from vehicle sources, and this regulation can be a basis for justification for LEZ. Unfavourable Effect: Detailed explanation of the type of program/action included in the RPPMU is not regulated. However, the lack of clarity could provide a more flexible program for the provincial government to formulate their own RPPMU

No	Regulation	Relevance to LEZ	Potential Impact
11	Governor Regulation No. 90/2021 about Local Low Carbon Development Plan	Explicitly mentions LEZ as a strategy to reduce GHG emissions. Mention of supporting policies such as the improvement of Euro IV standard for industrial fleet, promotion of public transportation, TOD, NMT, ERP, and parking fee	Beneficial Impact: Provides a comprehensive plan, including the transportation sector and LEZ implementation. Directly binding to stakeholders involved. Unfavourable Effect: LEZ is still seen as a pedestrianisation project. This mindset could hinder the ideal intervention of LEZ, which should strive for larger-scale projects with the foundation of limiting access for highly emitting vehicles.
12	Governor Instruction No 66 of 2019 on Air Quality Control	Tighter emission testing for all vehicles that ensures no vehicles are above 10 years by 2025 will support the phasing out of high-polluting vehicles. Mention of supporting policies such as odd even policies, increases in parking tariffs, congestion pricing	Beneficial Impact: Extensive vehicle testing could provide benefits for the LEZ intervention. Supporting policies to limit the use of private vehicles and encourage the use of public transportation is aligned with the LEZ objective. Unfavourable Effect: The regulation does not explicitly mention LEZ
13	Governor Decree No. 576 of 2023 on Strategy of Air Quality Control	Sets strategies for air quality control with transportation as one of the main focus. The document directly mentions LEZ as a strategy, as well as the need to create a study regarding LEZ, the need to make specific regulations for LEZ and the establishment of a permanent LEZ. The document also mentions the need for emission inventory, increase in air quality monitoring systems, and other related supporting policies.	Beneficial Impact: Sets out an action plan and timeline for the implementation and staging for LEZ. Unfavourable Effect: The regulation only set a target for the formulation of the regulation itself but it still haven't set a target for the implementation of the LEZ program

Annex 2. Emission Factor of Vehicle

Vehicle type	Emission standard	Fuel type (G/D/NG)	PM (g/km)	CO (g/km)	HC (g/km)	NOx (g/km)
Car	Euro 6	Gasoline	0.002	1.418	0.367	0.053
Car	Euro 5	Gasoline	0.002	1.422	0.355	0.050
Car	Euro 4	Gasoline	0.002	1.362	0.496	0.117
Car	Euro 3	Gasoline	0.002	2.002	0.538	0.190
Car	Euro 2	Gasoline	0.007	2.642	0.580	0.262
Car	Euro 1	Gasoline	0.008	7.070	1.308	2.310
Car	Euro 0	Gasoline	0.023	11.498	2.036	4.358
Motorcycle	Euro 6	Gasoline	0.005	4.915	0.787	0.329
Motorcycle	Euro 5	Gasoline	0.005	4.915	0.787	0.329
Motorcycle	Euro 4	Gasoline	0.005	5.189	0.787	0.422
Motorcycle	Euro 3	Gasoline	0.004	6.309	0.670	0.424
Motorcycle	Euro 2	Gasoline	0.009	11.756	1.210	0.789
Motorcycle	Euro 1	Gasoline	0.022	31.365	2.517	0.903
Motorcycle	Euro 0	Gasoline	0.075	56.040	4.561	1.530
Pickup	Euro 6	Gasoline	0.001	1.015	0.075	0.050

Pickup	Euro 5	Gasoline	0.001	1.015	0.075	0.050
Pickup	Euro 4	Gasoline	0.001	1.721	0.741	0.201
Pickup	Euro 3	Gasoline	0.001	2.922	0.905	0.360
Pickup	Euro 2	Gasoline	0.002	4.123	1.069	0.519
Pickup	Euro 1	Gasoline	0.002	15.078	2.239	3.450
Pickup	Euro 0	Gasoline	0.002	26.032	3.409	6.382
Microbus	Euro 6	Gasoline	0.001	0.756	0.056	0.037
Microbus	Euro 5	Gasoline	0.001	0.756	0.056	0.037
Microbus	Euro 4	Gasoline	0.001	1.471	0.094	0.047
Microbus	Euro 3	Gasoline	0.001	3.749	0.140	0.096
Microbus	Euro 2	Gasoline	0.002	4.419	0.228	0.173
Microbus	Euro 1	Gasoline	0.002	6.748	0.470	0.431
Microbus	Euro 0	Gasoline	0.001	14.621	1.972	1.772
Car	Euro 6	Diesel	0.002	0.051	0.009	0.475
Car	Euro 5	Diesel	0.002	0.043	0.009	0.581
Car	Euro 4	Diesel	0.033	0.097	0.015	0.612
Car	Euro 3	Diesel	0.045	0.102	0.027	0.883

Car	Euro 2	Diesel	0.064	0.874	0.343	1.977
Car	Euro 1	Diesel	0.174	1.024	0.385	2.789
Car	Euro 0	Diesel	0.285	1.175	0.427	3.601
Large Truck	Euro 6	Diesel	0.001	0.119	0.011	0.481
Large Truck	Euro 5	Diesel	0.027	0.120	0.012	4.416
Large Truck	Euro 4	Diesel	0.028	0.122	0.012	4.484
Large Truck	Euro 3	Diesel	0.147	1.696	0.312	7.120
Large Truck	Euro 2	Diesel	0.175	8.998	1.879	10.669
Large Truck	Euro 1	Diesel	0.334	10.920	2.310	13.229
Large Truck	Euro 0	Diesel	0.439	12.841	2.741	15.788
Medium Truck	Euro 6	Diesel	0.001	0.081	0.009	0.322
Medium Truck	Euro 5	Diesel	0.018	0.082	0.009	2.936
Medium Truck	Euro 4	Diesel	0.019	0.082	0.009	2.938
Medium Truck	Euro 3	Diesel	0.097	1.030	0.202	4.606
Medium Truck	Euro 2	Diesel	0.106	6.449	1.347	7.647
Medium Truck	Euro 1	Diesel	0.217	7.695	1.628	9.320
Medium Truck	Euro 0	Diesel	0.428	8.941	1.909	10.993

Small Truck	Euro 6	Diesel	0.001	0.111	0.052	1.423
Small Truck	Euro 5	Diesel	0.001	0.112	0.052	1.722
Small Truck	Euro 4	Diesel	0.062	0.568	0.053	1.258
Small Truck	Euro 3	Diesel	0.114	0.692	0.137	1.506
Small Truck	Euro 2	Diesel	0.167	1.639	0.524	3.006
Small Truck	Euro 1	Diesel	0.168	2.365	0.770	4.227
Small Truck	Euro 0	Diesel	0.521	3.090	1.016	5.449
Bus Medium	Euro 6	Diesel	0.006	0.139	0.013	0.575
Bus Medium	Euro 5	Diesel	0.034	1.521	0.015	3.476
Bus Medium	Euro 4	Diesel	0.034	1.610	0.014	3.483
Bus Medium	Euro 3	Diesel	0.124	1.520	0.213	5.306
Bus Medium	Euro 2	Diesel	0.154	2.878	0.503	8.563
Bus Medium	Euro 1	Diesel	0.286	4.482	0.902	11.063
Bus Medium	Euro 0	Diesel	0.674	6.085	1.302	13.563
Bus Single	Euro 6	Diesel	0.008	0.187	0.018	0.773
Bus Single	Euro 5	Diesel	0.046	2.044	0.020	4.672
Bus Single	Euro 4	Diesel	0.045	2.144	0.019	4.638

Bus Single	Euro 3	Diesel	0.166	2.025	0.284	7.070
Bus Single	Euro 2	Diesel	0.205	3.837	0.670	11.414
Bus Single	Euro 1	Diesel	0.376	5.672	1.138	14.074
Bus Single	Euro 0	Diesel	0.832	7.507	1.606	16.733
Bus Articulated	Euro 6	CNG	0.018	2.802	0.011	1.104
Bus Articulated	Euro 5	CNG	0.055	2.802	0.027	4.800
Bus Articulated	Euro 4	CNG	0.055	2.802	0.027	8.400
Bus Articulated	Euro 3	CNG	0.294	3.817	0.039	11.999
Bus Articulated	Euro 2	CNG	0.466	4.183	0.052	16.128
Bus Articulated	Euro 1	CNG	0.861	4.445	0.086	16.622
Bus Articulated	Euro 0	CNG	0.861	4.445	0.086	16.622

Annex 3. Emission Factor Modeling Result

Emission Standard (ES) Based Restriction

Vehicle type: Car	Natural (No LEZ)		LEZ active	Buy worst scenario		Buy best scenario		Buy BEV scenario	
	NOx	PM	Threshold ES	NOx	PM	NOx	PM	NOx	PM
2024	0.433	0.012	2	0.3737	0.0109	0.3633	0.0106	0.3580	0.0104
2025	0.400	0.012	2	0.3586	0.0105	0.3506	0.0103	0.3465	0.0101
2026	0.371	0.011	4	0.1766	0.0057	0.1766	0.0057	0.0826	0.0022
2027	0.346	0.010	4	0.1767	0.0057	0.1767	0.0057	0.0913	0.0025
2028	0.325	0.010	4	0.1768	0.0057	0.1768	0.0057	0.1000	0.0028
2029	0.306	0.009	4	0.1768	0.0057	0.1768	0.0057	0.1086	0.0031
2030	0.288	0.009	4	0.1769	0.0057	0.1769	0.0057	0.1172	0.0034
Large Truck									
2024	9.890	0.174	2	9.2309	0.1404	8.4348	0.1215	7.8577	0.1179
2025	9.407	0.160	2	8.8560	0.1315	8.1901	0.1157	7.7073	0.1127
2026	8.980	0.147	4	4.4839	0.0277	4.4839	0.0277	1.5584	0.0096
2027	8.597	0.136	4	4.4839	0.0277	4.4839	0.0277	1.7802	0.0110
2028	8.248	0.126	4	4.4839	0.0277	4.4839	0.0277	1.9846	0.0122
2029	7.926	0.117	4	4.4839	0.0277	4.4839	0.0277	2.1756	0.0134
2030	7.626	0.108	4	4.4839	0.0277	4.4839	0.0277	2.3564	0.0145
MC									
2024	0.555	0.007	2	0.5474	0.0058	0.5235	0.0055	0.4958	0.0052
2025	0.531	0.006	2	0.5256	0.0055	0.5097	0.0053	0.4913	0.0051
2026	0.509	0.006	3	0.4236	0.0043	0.4236	0.0043	0.3282	0.0034
2027	0.491	0.005	3	0.4236	0.0043	0.4236	0.0043	0.3477	0.0036
2028	0.476	0.005	3	0.4236	0.0043	0.4236	0.0043	0.3645	0.0037

2029	0.463	0.005	3	0.4236	0.0043	0.4236	0.0043	0.3788	0.0039
2030	0.452	0.005	3	0.4236	0.0043	0.4236	0.0043	0.3906	0.0040
Medium Truck									
2024	6.763	0.116	2	6.4194	0.0834	5.9355	0.0743	5.6337	0.0724
2025	6.399	0.105	2	6.1217	0.0778	5.7310	0.0705	5.4873	0.0690
2026	6.082	0.094	4	2.9379	0.0185	2.9379	0.0185	1.1154	0.0070
2027	5.799	0.086	4	2.9379	0.0185	2.9379	0.0185	1.2630	0.0080
2028	5.542	0.078	4	2.9379	0.0185	2.9379	0.0185	1.3987	0.0088
2029	5.306	0.071	4	2.9379	0.0185	2.9379	0.0185	1.5258	0.0096
2030	5.084	0.064	4	2.9379	0.0185	2.9379	0.0185	1.6468	0.0104
Small Truck									
2024	1.473	0.077	2	1.7034	0.0862	1.6696	0.0842	1.6452	0.0830
2025	1.361	0.069	2	1.6466	0.0832	1.6280	0.0821	1.6145	0.0814
2026	1.267	0.063	4	1.0257	0.0485	1.0257	0.0485	0.6180	0.0295
2027	1.186	0.058	4	1.0599	0.0505	1.0599	0.0505	0.7082	0.0340
2028	1.116	0.053	4	1.0926	0.0524	1.0926	0.0524	0.7926	0.0382
2029	1.054	0.050	4	1.1236	0.0541	1.1236	0.0541	0.8711	0.0422
2030	1.001	0.047	4	1.1522	0.0558	1.1522	0.0558	0.9435	0.0458
TJ Car									
2024	0.056	0.001	2					0.0558	0.0009
2025	0.051	0.001	2					0.0507	0.0008
2026	0.043	0.001	2					0.0432	0.0007
2027	0.035	0.001	bev					0.0000	0.0000
2028	0.020	0.000	4					0.0158	0.0003
2029	0.010	0.000	4					0.0087	0.0001

2030	0.000	0.000	4					0.0000	0.0000
TJ Buses									
2024	7.423	0.135	2					7.4230	0.1349
2025	6.750	0.117	2					6.7496	0.1172
2026	5.306	0.087	2					5.3057	0.0872
2027	3.920	0.063	bev					0.0000	0.0000
2028	2.475	0.039	4					0.6630	0.0064
2029	1.533	0.024	4					0.4708	0.0045
2030	0.000	0.000	4					0.0000	0.0000

Model Year (MY) Based Restriction

Vehicle type: Car	Natural (No LEZ)		LEZ active	Buy worst scenario		Buy best scenario		Buy BEV scenario	
	NOx	PM	Threshold MY	NOx	PM	NOx	PM	NOx	PM
2024	0.4331	0.0124	2015	0.4331	0.0124	0.4331	0.0124	0.4331	0.0124
2025	0.3996	0.0117	2015	0.3996	0.0117	0.3996	0.0117	0.3996	0.0117
2026	0.3710	0.0110	2017	0.3438	0.0101	0.2488	0.0074	0.1910	0.0056
2027	0.3463	0.0104	2017	0.3291	0.0097	0.2449	0.0073	0.1937	0.0057
2028	0.3248	0.0098	2019	0.2723	0.0078	0.2040	0.0063	0.1307	0.0039
2029	0.3057	0.0092	2019	0.2631	0.0076	0.2026	0.0062	0.1378	0.0042
2030	0.2883	0.0087	2019	0.2539	0.0074	0.2011	0.0062	0.1448	0.0044
Large Truck									
2024	9.8897	0.1745	2015	9.8897	0.1745	9.8897	0.1745	9.8897	0.1745
2025	9.4072	0.1600	2015	9.4072	0.1600	9.4072	0.1600	9.4072	0.1600
2026	8.9804	0.1474	2017	8.5195	0.1235	6.3500	0.0720	4.7772	0.0623
2027	8.5973	0.1361	2017	8.2136	0.1162	6.2523	0.0697	4.8305	0.0609
2028	8.2483	0.1259	2019	7.9316	0.1096	5.4527	0.0507	3.6558	0.0396

2029	7.9263	0.1166	2019	7.6682	0.1033	5.4080	0.0496	3.7696	0.0395
2030	7.6257	0.1081	2019	7.4188	0.0974	5.3668	0.0486	3.8793	0.0395
MC									
2024	0.5549	0.0066	2015	0.5549	0.0066	0.5549	0.0066	0.5549	0.0066
2025	0.5306	0.0061	2015	0.5306	0.0061	0.5306	0.0061	0.5306	0.0061
2026	0.5091	0.0057	2017	0.4236	0.0043	0.4236	0.0043	0.2551	0.0026
2027	0.4910	0.0053	2017	0.4236	0.0043	0.4236	0.0043	0.2812	0.0029
2028	0.4756	0.0051	2019	0.4236	0.0043	0.4236	0.0043	0.2748	0.0028
2029	0.4628	0.0049	2019	0.4236	0.0043	0.4236	0.0043	0.2977	0.0031
2030	0.4523	0.0047	2019	0.4236	0.0043	0.4236	0.0043	0.3182	0.0033
Medium Truck									
2024	6.7632	0.1165	2015	6.7632	0.1165	6.7632	0.1165	6.7632	0.1165
2025	6.3992	0.1045	2015	6.3992	0.1045	6.3992	0.1045	6.3992	0.1045
2026	6.0819	0.0944	2017	5.8590	0.0729	4.3875	0.0455	3.4694	0.0397
2027	5.7992	0.0855	2017	5.6225	0.0685	4.3130	0.0441	3.4961	0.0390
2028	5.5425	0.0777	2019	5.4050	0.0645	3.7205	0.0331	2.6695	0.0265
2029	5.3056	0.0707	2019	5.2013	0.0607	3.6875	0.0325	2.7431	0.0265
2030	5.0841	0.0645	2019	5.0072	0.0571	3.6570	0.0319	2.8147	0.0266
Small Truck									
2024	1.4734	0.0767	2015	1.4734	0.0767	1.4734	0.0767	1.4734	0.0767
2025	1.3611	0.0688	2015	1.3611	0.0688	1.3611	0.0688	1.3611	0.0688
2026	1.2667	0.0625	2017	1.2536	0.0606	1.0528	0.0503	0.9108	0.0441
2027	1.1858	0.0575	2017	1.1800	0.0567	1.0329	0.0491	0.9289	0.0446
2028	1.1156	0.0534	2019	1.0916	0.0530	0.9215	0.0428	0.7801	0.0367
2029	1.0543	0.0500	2019	1.0381	0.0498	0.9117	0.0422	0.8066	0.0377

2030	1.0005	0.0470	2019	0.9900	0.0469	0.9002	0.0415	0.8255	0.0383
TJ Car									
2024	0.0558	0.0009	2018					0.0558	0.0009
2025	0.0507	0.0008	2018					0.0507	0.0008
2026	0.0432	0.0007	2018					0.0432	0.0007
2027	0.0353	0.0005	bev					0.0000	0.0000
2028	0.0204	0.0003	2022					0.0158	0.0003
2029	0.0101	0.0002	2022					0.0087	0.0001
2030	0.0000	0.0000	2022					0.0000	0.0000
TJ Buses									
2024	7.4230	0.1349	2018					7.4230	0.1349
2025	6.7496	0.1172	2018					6.7496	0.1172
2026	5.3057	0.0872	2018					5.3057	0.0872
2027	3.9200	0.0635	bev					0.0000	0.0000
2028	2.4751	0.0390	2022					0.6630	0.0064
2029	1.5332	0.0237	2022					0.4708	0.0045
2030	0.0000	0.0000	2022					0.0000	0.0000

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