The Opportunity of Low Emission Zones:

A Taming Traffic Deep Dive Report

ITDP

ACKNOWLEGEMENTS

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COVER PHOTO:
Low Emmision Zones can transform and open public spaces. Zapopan, Jalisco, Mexico.
SOURCE: Chris K.

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INTRODUCTION

Cities around the world are facing complex, multi-dimensional challenges: rising motorization and congestion, worsening air quality, and the devastating impacts of climate change. Mitigating these challenges requires bold, comprehensive solutions that reduce demand for driving (and the negative outcomes associated with vehicle use), as well as encourage a transition to electric vehicles and bolster investment in public transportation, cycling, and walking—both of which are critical to decarbonizing the transportation sector and avoiding the most catastrophic impacts of climate change.[1] Low emission zones (LEZs) are an important tool for cities to consider as they work to achieve this transformation. Though low emission zones have been primarily implemented as an air quality improvement strategy, they have the potential to catalyze a faster transition to electric vehicles and encourage more compact development that facilitates walking, cycling, and using public transportation.

Momentum around low emission zones is growing. As of 2022, Europe has over 320 low emission zones, a growth of 40% since 2019. There are also successful non-European examples of LEZs, such as in Haifa, Seoul, and several Chinese cities.[2] Many other cities, including Bogotá, Jakarta, Mexico City, and Cape Town, have committed to implementing low (and zero) emission zones as part of the C40 Green and Healthy Streets initiative.[3] As more and more cities consider designing and implementing low emission zones, it is important to understand what a low emission zone is (and is not), what impacts they can deliver, and how to ensure equity and success.

In Bogotá, where a low emission zone is planned, the city has already begun reallocating street space for people riding bicycles and public transport.
SOURCE: Carlos Felipe Pardo via Flickr

1 The Compact City Scenario–Electrified.
2 320 European cities now have active Low Emission Zones.
3 Green & Healthy Streets.


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DEFINING A LOW EMISSION ZONE

1

The first low emission zones originated in European cities to address dangerously poor air pollution and its health impacts, with the very first one adopted in Sweden in 1996.[4] LEZs aimed to improve air quality by limiting high-polluting, heavy-duty vehicles like commercial trucks from driving in city centers (or charging them to do so).[5] However, many LEZs now include light-duty vehicles like passenger cars, and restrictions or charges vary based on the emission level of the vehicle.[6] Cities justified expanding LEZs to more types of vehicles to more effectively combat worsening air quality and accelerate the uptake of cleaner vehicles.[7] In recent years, LEZs have expanded in size and scope. They are increasingly complemented by policy initiatives that help achieve goals beyond air quality improvement, such as reducing demand for driving, accelerating fleet turnover,[8] reducing noise, increasing safety for cyclists and pedestrians,[9] and incentivizing public and active transport use.[10]

DEFINITION

A LOW EMISSION ZONE RESTRICTS OR BANS POLLUTING VEHICLES FROM ENTERING A DESIGNATED AREA TO IMPROVE AIR QUALITY (IDEALLY ENCOURAGING SUSTAINABLE TRANSPORT AND PROMOTING IMPROVED LIVABILITY).

4 Review of European Low Emissions Zone Policy.
5 Impact of the implementation of Lisbon low emission zone on air quality.
6 Transport & Environment, 2018.
7 Browne et al., 2007.
8 Low emission zones: the likely effects on the freight transport sector.
9 Low- and Zero-Emissions Zones: Opportunities and Challenges in Designing Equitable Transportation Policies.
10 Global overview of zero-emission zones in cities and their development progress.

WHAT IS A LOW EMISSION ZONE?

A defined zone that restricts the use of polluting vehicles

Car-free zones are low emission zones

LOW EMISSION ZONES CAN APPLY TO

- **Passenger vehicles** (cars, taxis, motorcycles)
- **Public vehicles** (buses, municipal vehicles)
- **Vans and small trucks**
- **Heavy-duty freight vehicles**

A LOW EMISSION ZONE CAN BE

- **Priced** vehicles pay to enter, price varies based on emissions level
- **Not priced** vehicles below a minimum emission standard are banned, non-compliant vehicles that enter pay a fine

A LOW EMISSION ZONE IS NOT

A single corridor → **A street or area that does not explicitly restrict vehicles**

LOW EMISSION ZONES CAN CONTRIBUTE TO MORE LIVABLE CITIES

When implemented alongside policies that prioritize sustainable transportation and development, **low emission zones help cities achieve a broader set of goals** beyond air quality improvement, such as improving access, safety, and equity.

1 STREET REDESIGNS
- Car-free areas
- Complete streets
- Safe Routes to School programs

2 SERVICE IMPROVEMENTS
- Frequent rail/bus service (10-minute transit)
- Multimodal integration

3 INCENTIVES
- Low- and zero-emission vehicle purchase subsidies
- Public transportation discounts

4 LAND USE REFORM
- On-street parking pricing
- Transit-oriented development
- 15-minute neighborhoods

5 STRICTER SUB-ZONES
- Zero-emission area (ZEA)
- Congestion pricing zone

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Low emission zones can have different sizes, pricing structures, operating models, and restrictions. They can also have different names—the term "low emission zone" has been used interchangeably with "clean air zones" (United Kingdom[11]), "environmental zones" (Germany), and "limited traffic zones" (Italy and elsewhere).

But the central components are that they:

1. Restrict high-polluting vehicles
2. Exist as a contiguous zone

Notably, car-free areas larger than an individual corridor restrict vehicle use, exist as a zone, and therefore align with this definition of an LEZ. While car-free areas are not commonly thought of as LEZs, they can result in similar air quality outcomes, a shift to sustainable transport, and improved livability. Similar to LEZs, small car-free areas (relative to the size of the city) will be less impactful in reducing pollution or encouraging uptake of cleaner vehicles because they can be more easily circumvented.

Other areas in cities achieve similar goals as LEZs (air quality improvement, noise reduction, livability) but are not low emission zones. For example, while transit malls and limited through-access streets—where pedestrians, cyclists, and transit vehicles have priority access—limit emissions, they do not directly restrict the use of polluting vehicles. However, these interventions can complement an LEZ (see Section III).

1 Restricting High-Polluting Vehicles

Low emission zones can restrict light-duty (passenger) vehicles, freight vehicles, or both. Early LEZs in European cities started by restricting freight vehicles because they emitted the most pollution. Restrictions were then broadened to passenger vehicles over time. Other cities have simultaneously implemented restrictions on freight and passenger vehicles to achieve faster and more significant impacts.

Two mechanisms restrict high-polluting vehicles from entering a low emission zone: pricing and prohibiting access.

11 Clean Air Zone Framework.

London's ULEZ requires drivers of high-polluting vehicles (Euro 3 petrol, Euro 5 diesel, Euro 2 motorcycles or below) to pay a fee each time they enter the zone.
SOURCE: citytransportinfo via FLICKR

Priced LEZs, like in London and Antwerp, allow most vehicles to enter but charge an entry fee based on the vehicle's emission level each time it enters the designated zone. Introducing a price encourages more people to seek alternatives to driving a high-polluting vehicle. However, it can be politically challenging to implement and requires a high level of capacity. For example, vehicle emission standards must be established (if they do not already exist), and routine vehicle emissions testing should be conducted. Transparent, accurate payment options for fees and fines, and competent and equitable enforcement at every zone entrance point (either through the use of cameras or enforcement officers), are also critical for success.

Non-priced LEZs prohibit high-polluting vehicles from entering the zone entirely. This design is used in Seoul, Haifa, Brussels, and Lisbon, among other cities. In non-priced LEZs, drivers of vehicles that do not meet the emissions standards cannot enter the zone. Instead, they must shift to a cleaner vehicle, install a particulate filter, or use an alternative mode such as public transportation, cycling, or walking. Like priced LEZs, non-priced LEZs require establishing vehicle emission standards if they do

In the downtown Lisbon LEZ, vehicles below Euro 3 or manufactured before 2000 are prohibited.
SOURCE: grzegorzmielczarek via Flickr

not already exist, and equitable enforcement is critical. Non-priced LEZs typically pose higher fines for non-compliant vehicles entering the zone to deter this behavior. For example, the fine for entering the LEZ with a non-compliant vehicle in Lisbon is $120; in Seoul, it is $212; and in Brussels, it is $350. Still, non-priced LEZs can be more politically palatable than priced LEZs—especially if reliable, affordable alternatives to driving are in place—because non-priced LEZs do not charge per entrance into the zone.

2 Establishing a Zone

Low emission zones range in sizes from, for example, a modest 3.7 km^2 in Jinan, China, to the entire Brussels Capital Region at 161 km^2. To significantly improve air quality and other related goals, a low emission zone must not be an individual corridor. Individual corridors and small zones (easily avoided or bypassed by drivers) will not sufficiently encourage the uptake of cleaner vehicles or a modal shift away from driving. In addition, small zones may displace pollution to neighboring streets, doing little to improve air quality and leading to inequitable impacts. However, small zones may be effective if large ones surround them. In some cities, like Lisbon, a small low emission zone (0.6 km^2) with tighter restrictions located in the city center where traffic and emissions are very high is surrounded by a much larger zone (26 km^2) with slightly more lax restrictions. On the other hand, very large zones may also have drawbacks, requiring more enforcement (technological or human-powered) and coordination to operate successfully.

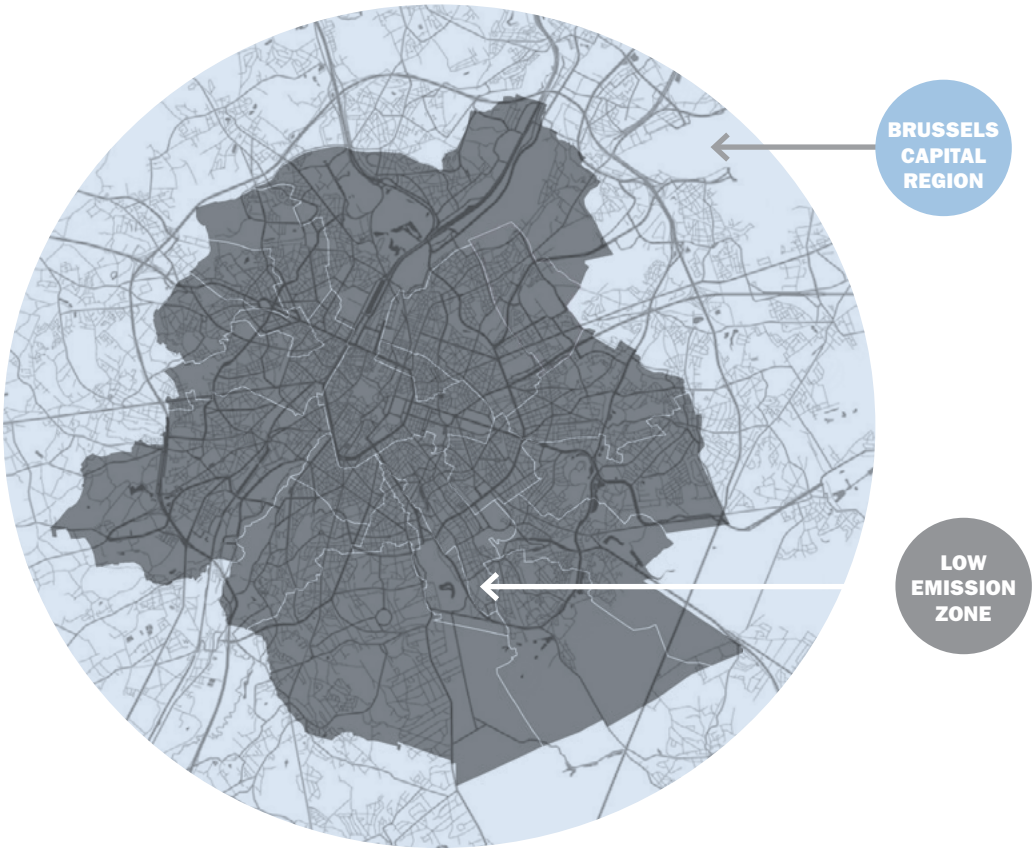
There is no consensus on minimum or appropriate sizing for low emission zones. A 2016 report on low emission zones in Mexico suggests that an LEZ should cover at least 30% of a city's population.[12] Other experts suggest that LEZs should (at the very least) cover "pollution centers" where arterials and other high-traffic, high-emission thoroughfares are located.

ITDP developed a methodology for selecting sites for zero-emission areas (ZEAs) in Los Angeles, which includes prioritizing:

1. communities with high concentrations of harmful pollutants like particulate matter and ozone, and

2. dense, walkable neighborhoods with significant potential for public transit, cycling, and walking.[13]

12 Low Emissions Zones (LEZ) in Mexico: Recommended Essentials for LEZ Schemes in the Mexican Megalopolis Region.
13 Achieving a Zero-Emission Area in Los Angeles: A Planning Guide.



Low emission zones vary widely in size. Brussel's LEZ covers the entire region, making it nearly impossible for drivers to avoid.

Ensuring equity when designing LEZs

In priced LEZs, drivers of high-polluting vehicles, especially those who commute daily into the zone, will quickly accrue costs. This cost can be very burdensome to low-income drivers since it represents a larger portion of their transportation budget.[14] Low-income drivers are also less able to afford the higher cost of a newer, fuel-efficient vehicle that meets the LEZ standard for entry. In addition, drivers transitioning to other modes to avoid purchasing a compliant vehicle or being fined could face time costs, especially those who live in outer neighborhoods forcing them to travel longer trip distances.[15]

These burdens can be mitigated by reducing the cost of compliance with the LEZ through tax credits, subsidies, and discounts to help people afford cleaner vehicles, particulate filters, and to scrap older cars. Cities should also provide high-quality, affordable, reliable alternatives to driving. Some of the revenue generated from priced LEZs can be used for these purposes.[16] Revenues can also be invested to upgrade public transportation, cycling, and walking infrastructure outside the zone, to ensure access for vulnerable communities living in the city's periphery.[17]

» For more on equitable LEZ design, see Section III.

14 Taming Traffic: Strategies to Reduce Driving and Prioritize Sustainable Transportation in Cities.
15 Low- and Zero-Emissions Zones: Opportunities and Challenges in Designing Equitable Transportation Policies.
16 Taming Traffic: Strategies to Reduce Driving and Prioritize Sustainable Transportation in Cities.
17 Low- and Zero-Emissions Zones: Opportunities and Challenges in Designing Equitable Transportation Policies & Taming Traffic: Strategies to Reduce Driving and Prioritize Sustainable Transportation in Cities.

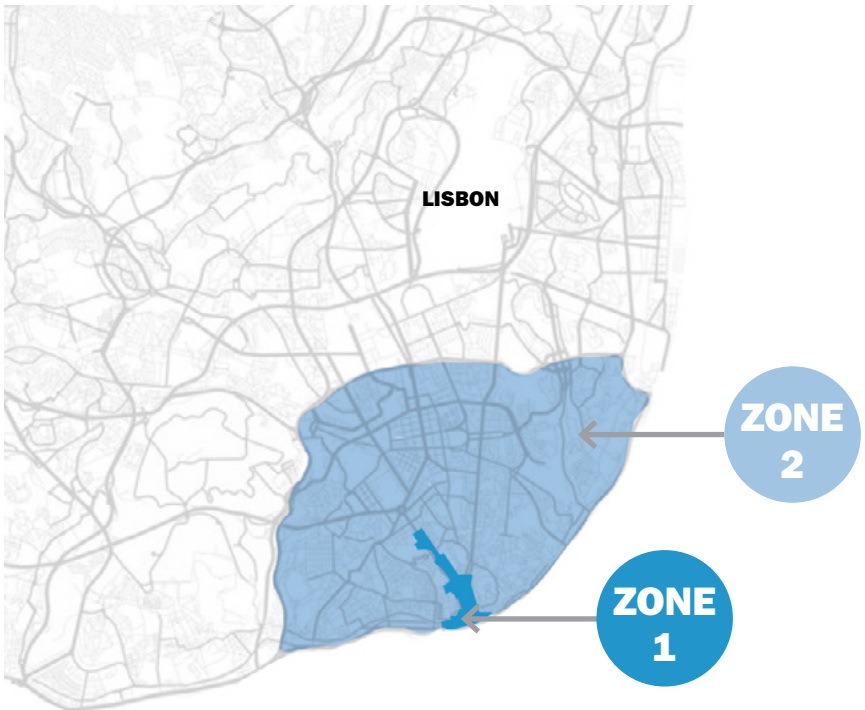
WHAT WE KNOW ABOUT LOW EMISSION ZONE OUTCOMES

2

Air Quality

Low emission zones have primarily been adopted to reduce air pollutants and vehicle emissions that harm human health. The most dangerous pollutants for humans are fine particulate matter (PM), which includes PM2.5 (and black carbon) and PM10, and nitrogen oxides (NOx), which include NO and NO_2. Exposure to these pollutants can lead to respiratory diseases, reduced lung function, asthma, cardiovascular disease, and premature death.

Large LEZs —those that cover most or all of a city— with tight emission restrictions can significantly improve air quality and respiratory health.[18] However, the design, and the presence of strategic components (see Section III), will impact the effectiveness of an LEZ. The extent to which LEZs affect air pollutants (notably PM and NOx) has varied widely by city and scheme design (see Appendix for a detailed review of existing LEZ schemes). It is also worth noting that studies have shown that LEZs in many European cities did not, on their own, reduce air pollution enough to meet EU-recommended PM and NOx levels.[19]



Lisbon has two overlapping LEZs; Zone 1 covers downtown with strict entry standards, while Zone 2 is much larger with a lower minimum standard for entry.

18 Impact of London's low emission zone on air quality and children's respiratory health: a sequential annual cross-sectional study.
19 Review of European Low Emissions Zone Policy & Impact of London's low emission zone on air quality and children's respiratory health: a sequential annual cross-sectional study & Health effects of Low Emission Zones: Evidence from German hospitals.

A Note on Low Emission Zone Impact Studies

There are few studies of observed impacts once LEZs are operating (expost studies as opposed to ex ante, which project outcomes based on modeling expected scenarios). This makes it difficult to evaluate and compare outcomes both over time in one city and across cities. Studies that have been conducted focus almost exclusively on air quality outcomes, and rarely evaluate other potential LEZ impacts such as on traffic volumes, vehicle crash incidence, greenhouse gas emissions, or modal shift. Therefore, this section focuses on the observed impacts of LEZs on air quality. One can infer a correlation between observed air quality changes and greenhouse gas emissions.

It is unclear if the size of LEZs is directly linked to the impact on pollutant reduction. The Brussels LEZ, which covers approximately 161 km^2, reduced PM2.5 concentrations by 38% and NOx by 9% in its first year of operation. Seoul's "Green Transport Zone" LEZ saw a 16% drop in PM2.5 concentrations in its first year, despite being about one-tenth of the size of the Brussels LEZ. Haifa, Israel's LEZ is a little more than one-quarter of the size of the Brussels LEZ, at about 45 km^2, and has achieved a 19% reduction in NOx––10 percentage points greater than in Brussels.[20]

Other factors like location, operating times, and enforcement also play important roles. In particular, stringency and the presence of non-car alternatives appear to be critical for an LEZ to improve air quality. In Berlin and Munich, Germany, the largest PM10 reductions resulted from the most stringent restrictions placed on vehicles in stage three of those cities' LEZs, compared to stages one and two, which had more lax emissions standards.[21] Berlin also complemented its LEZ with improvements to public transportation and efforts to encourage multimodal, cycling, and walking trips.[22] Similarly, Lisbon's Zone 1 LEZ (see image left) generated higher PM10 reductions but lower NO_2 reductions compared to Zone 2, which covers a much larger area but with more lax restrictions (Euro 3 is the minimum standard for Zone 1 versus a Euro 2 minimum for Zone 2).[23] Lisbon's air quality action plan also identifies promoting public transportation and lowering speed limits as actions to complement the city's LEZ.[24]

In some cities, LEZs have had uneven impacts on different pollutants. For example, NO_2 concentrations fell in London after LEZ implementation (and fewer children were living in locations that exceeded the EU limit of NO_2 compared to pre-LEZ implementation), but there were no significant changes in PM2.5.[25] Lisbon observed similar results: PM10 and NO_2 concentrations were significantly reduced, but NOx and PM2.5 had insignificant reductions.[26] Berlin and Munich's LEZs reduced PM10 concentrations but did not affect NO_2.[27]

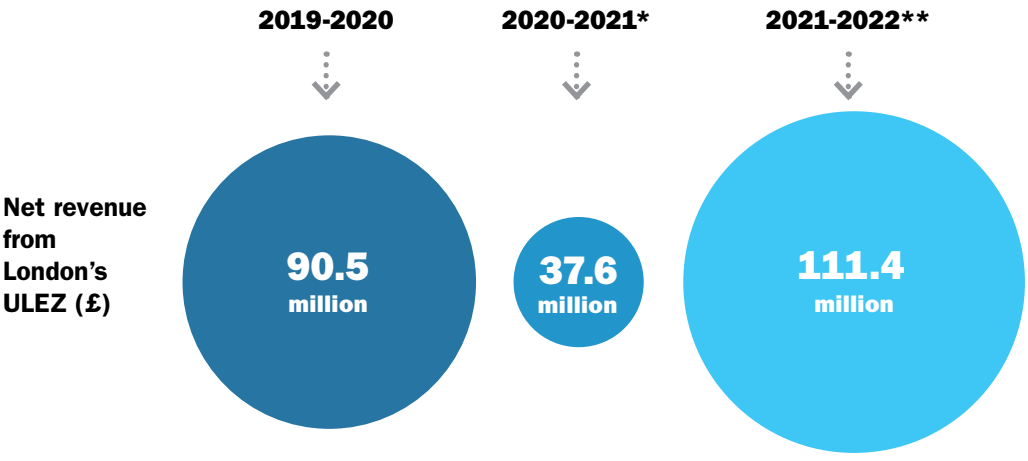
20 Air Quality Impacts of Low Emission Zones in Haifa & Ministry Measures, Including Creation of Low Emission Zone, Result in Decrease in Black Carbon in Haifa.
21 Low emission zones reduced PM10 but not NO2 concentrations in Berlin and Munich, Germany.
22 The Low Emission Zone in Europe: Access restriction criteria, vehicle identification essentials for implementation.
23 Impact of the implementation of Lisbon low emission zone on air quality.
24 Impact of the implementation of Lisbon low emission zone on air quality.
25 Impact of London's low emission zone on air quality and children's respiratory health: a sequential annual cross-sectional study.
26 Impact of the implementation of Lisbon low emission zone on air quality.
27 Low emission zones reduced PM10 but not NO2 concentrations in Berlin and Munich, Germany.

Revenue Generation

Though revenue generation should not be the primary goal, low emission zones —particularly priced LEZs— have the potential to generate revenue for a city. Publicly available data on revenues from LEZs is limited. However, data from London's Ultra Low Emission Zone (ULEZ) shows that revenue generation can be significant. The ULEZ was Transport for London's fourth largest revenue stream in 2021 and accounts for between 3-5% of total revenues, depending on the year.[28]

London's ULEZ is a priced system where most vehicles must pay to enter. Non-priced LEZs will likely not generate as much revenue because revenue only comes from fines for non-compliant vehicles entering the zone. Furthermore, compliance should increase over time, meaning revenue from fines should decrease.

In London, the ULEZ generates around 5% of Transport for London's total revenue, with funds supporting improvements to public transportation, cycling, and walking infrastructure.
SOURCE:
Julian Walker via Flickr



*Operation of the ULEZ was suspended from March to May 2020 due to the COVID-19 pandemic.
**The ULEZ was expanded from 21 km² to 380 km² in October 2021.

28 Annual Report—Transport for London.

Fleet Turnover

If low emission zones are large enough (i.e., drivers cannot simply take a different route to avoid entering the zone), they can encourage the uptake of low- and zero-emission vehicles. While providing many high-quality alternatives to driving when implementing an LEZ is important, some trips will still need to be made with vehicles, and those vehicles should be as low-emitting as possible. Data on fleet turnover due to LEZs is limited. However, there is some evidence that low (and zero) emission zones have helped to accelerate the transition to electric vehicles. In Shenzhen, China, zero-emission freight zones implemented around the city in 2018 led to the adoption of over 70,000 battery-electric freight vehicles after just one year. The zones have also led to installing over 20,000 freight vehicle charging stations, further encouraging electric freight vehicle uptake.[29]

In Shenzhen, China, electric vehicle charging stations are being installed to support uptake of electric freight and passenger vehicles.
SOURCE: MeinaLiao via Shutterstock

29 Lessons from Shenzhen's Green Logistic Zones: Fast-Tracking Zero-Emissions Freight.

WHAT CAN MAKE A LOW EMISSION ZONE MORE SUCCESSFUL?

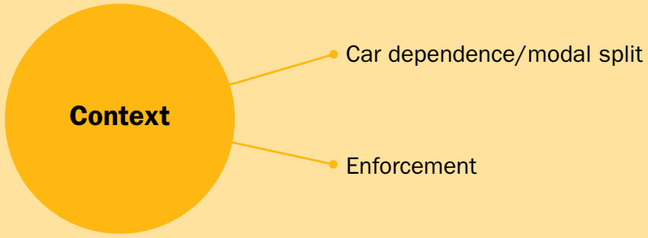
3

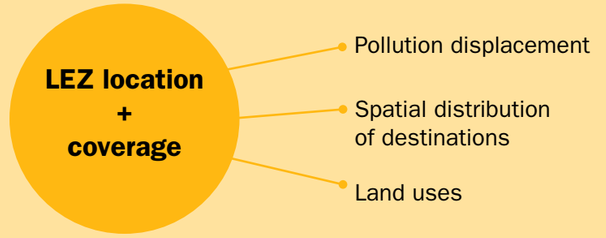
A low emission zone designed to be equitable and link to other strategic components is critical to reducing air pollution and achieving related goals.

SUCCESSFUL LEZ

1

Equitable design





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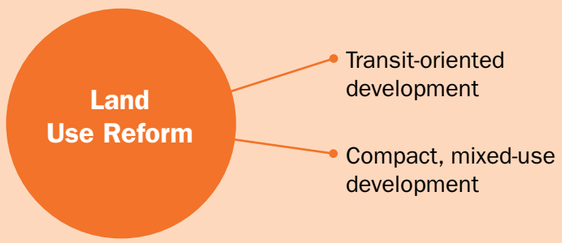
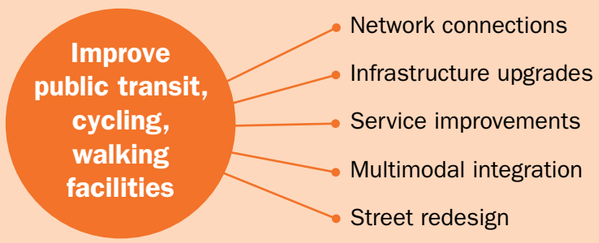
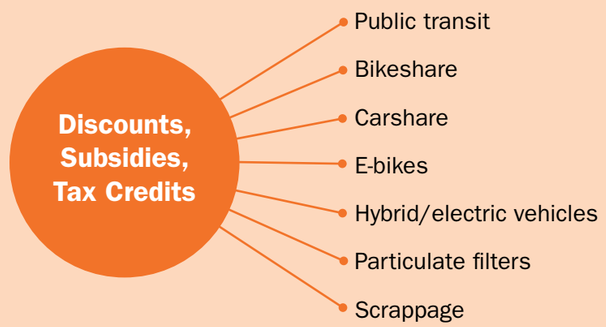
2

Strategic components

*Can be financed with revenue from LEZ







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Expanded access

EQUITABLE DESIGN

Communities with the highest pollution exposure and those disproportionately impacted by air pollution are often home to low-income people and minority groups.[30] This higher exposure makes these populations more susceptible to harmful health and environmental effects.[31] LEZs may address these inequities by limiting pollution from the transport sector; however, the design and availability of alternative modes (or lack thereof) could pose other equity concerns related to affordability and access.[32]

The context, coverage, and access to alternative modes and less-polluting vehicles must be considered when designing an LEZ. Understanding the LEZ's impact on people will lead to a more equitable design that maximizes benefits. An LEZ designed to make it easy for people to comply (meaning they have viable alternatives to driving, or can afford and access compliant, low- or zero-emission vehicles) will result in fewer high-polluting vehicles and, thus, reductions in harmful air pollutants. Ultimately, the goal of a low emission zone is to reduce emissions, not to maximize revenue; compliance (and low occurrences of violations and fines) is key.

IMAGE: Brussels LEZ map

In car-dependent cities like Vancouver, a larger proportion of drivers are likely to be people with low incomes driving older, higher-polluting vehicles. A low emission zone needs to be paired with viable alternatives to driving to be equitable.
SOURCE: StoneMonkeyswk via Shutterstock.

Designing an equitable LEZ requires cities to understand how and where people travel and consider how the program design––namely, introducing pricing or banning high-polluting vehicles from the zone––will impact people across socio-demographic groups. It is important to understand the existing modal split and who has access to (or is dependent on) a private vehicle. For example, in Buenos Aires, Argentina, and Mumbai, India, where 82% and 73% of people walk, cycle, or take public transportation, most people who can afford a car and drive regularly have higher incomes. Therefore, an LEZ entrance fee burdens people who can afford to pay if they want to continue driving. In car-dependent cities like Vancouver, Canada,

30 Low- and Zero-Emissions Zones: Opportunities and Challenges in Designing Equitable Transportation Policies.
31 Car restriction policies for better urban health: a low emission zone in Madrid, Spain.
32 Low- and Zero-Emissions Zones: Opportunities and Challenges in Designing Equitable Transportation Policies

ANPR cameras at LEZ entrance points can help avoid biases held by police. **SOURCE:** : Alena Veasey via Shutterstock.

and Melbourne, Australia, where, in both cities, 72% of people drive to work, and public transportation is limited, a larger share of drivers are likely to be low-income, drive older, higher-polluting vehicles, and have no viable alternative to driving.[33]

Other elements of LEZ program design, particularly enforcement, should also be considered with an equity lens. For example, using automatic number plate reader (ANPR) cameras instead of manual inspections by police officers can improve enforcement equity because cameras remove any explicit or implicit biases (race, gender, income, class, etc.) police officers may hold. However, ANPR cameras have limitations as they can inaccurately read smaller number plates, such as those used on motorcycles. Using cameras to monitor zone entrance points could also contribute to concerns around hyper-surveillance, which tends to be directed at and impacts minority groups more frequently.[34]

In Buenos Aires, where 82% of people walk, cycle, or take public transportation, a LEZ would impact a small share of the population who can afford to drive regularly. **SOURCE:** Ciclovías en Avenidas. Señalética Contramano

When considering the location and size of the LEZ, it is important to evaluate how the spatial distribution of activities and destinations and existing land uses influence how and where people travel. Understanding where clusters of people with different socioeconomic backgrounds live, work, and gather can help determine the location and coverage of an LEZ.[35] It is also necessary to determine how pollution and high-polluting vehicles might be displaced outside the zone.[36] Sizing the LEZ to the entire city could help to reduce this pollution spillover. However, as discussed in Section I, it is important to maintain strict emission standards for large zones since pollutant reductions can diminish with very large, less strict zones.

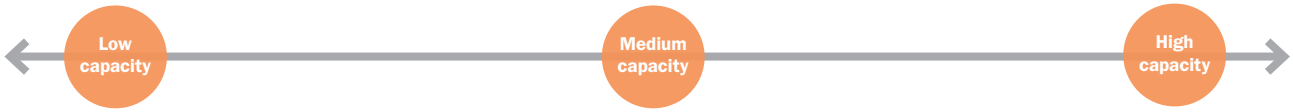
33 Modal split of passenger transport in selected cities worldwide as of 2017, by city and transport mode
34 Low- and Zero-Emissions Zones: Opportunities and Challenges in Designing Equitable Transportation Policies
35 Traffic Congestion Pricing: Methodologies and Equity Implications
36 Low- and Zero-Emissions Zones: Opportunities and Challenges in Designing Equitable Transportation Policies.

STRATEGIC COMPONENTS OF LEZs

Policies that complement LEZs include street redesigns, public transportation service improvements, financial incentives, parking and land use reform, and sub-zones with stricter requirements for entry. Cities with some of these policies or initiatives already in place will have a better foundation for implementing a low emission zone[37] —particularly if revenue is generated (i.e., from a priced parking program) to support LEZ operation. Implementing an LEZ without these strategic components is possible, but it will be much less impactful on its own.

Strategic Components of LEZs & Capacity Required for Effective Implementation

Street Redesigns	Service Improvements	Incentives	Land Use Reform	Stricter Sub-Zones
LEVEL Neighborhood	LEVEL City-wide	LEVEL City-wide	LEVEL Neighborhood and city-wide	LEVEL Neighborhood
• Car-free areas • Complete streets • Transit-priority streets • Cycle lanes and sidewalks • Safe Routes to School programs	• Bus network redesigns • Frequent rail/ bus service (10-minute transit) • Multimodal integration	• Low- and zero-emission vehicle purchase subsidies • Tax credits • Public transportation discounts • Mobility packages	• On-street parking pricing • Off-street parking reform (remove parking minimums, adopt maximums) • Transit-oriented development • 15-minute neighborhoods	• Zero-emission area (ZEA) • Congestion pricing zone



37 Low Emissions Zone in Mexico & Ecozonas.

Street Redesigns, Service Improvements, and Financial Incentives

Street redesigns, public transportation service improvements, and financial incentives or discounts for public transportation and low- and zero-emission mobility support LEZ outcomes by giving people access to more alternative modes that are competitive with driving. It is important to provide as many low- to zero-emission transport options as possible, especially for people who own vehicles that do not comply with LEZ minimum standards.

In downtown Rio de Janeiro, new cycle lanes can support people shifting away from high emission modes of transport.
SOURCE: ITDP

Street Redesigns

Redesigning streets to prioritize efficient, low- to zero-emission mobility like public transport, walking, and cycling helps these modes compete with driving. This re-prioritization supports behavioral changes and makes people feel safer and more comfortable choosing a mode other than driving. For example, alongside its LEZ, Berlin promoted cycling and walking by implementing a network of cycle lanes and redesigning sidewalks and intersections to give space and priority to people.[38] By 2008, six years after the LEZ was implemented, walking and cycling mode shares increased by three percentage points each.[39] Cycling mode share increased another two percentage points by 2017, while driving mode share held steady.[40]

Alongside a LEZ, pedestrian-priority streets, like Meir Street in Antwerp, make walking and cycling more comfortable and attractive alternatives to driving.
SOURCE: Albert Pego via Shutterstock.

38 The Low Emission Zone in Berlin: Rationale, Impact, and Framework Conditions.
39 The Low Emission Zone in Berlin: Rationale, Impact, and Framework Conditions.
40 Mobility in Germany: Short report.

Service Improvements

Investing in a public transportation system that is competitive with private vehicles provides a reliable, long-term alternative to driving. Frequent and rapid public transport must be available not only within but extend outside of the low emission zone so that those who live on the city's periphery are not penalized because they cannot afford to live close to downtown. Lisbon implemented its Zone 1 LEZ in the Baixa (downtown). While over 80% of the population can reach the Baixa by bus or metro, the city added electric buses, extended tram lines, and expanded night bus service (used heavily by the service industry and other shift workers) to ensure strong alternatives to driving.[41]

Lisbon added electric buses within the Zone 1 LEZ as an alternative to driving. **SOURCE:** Mounir Taha via Shutterstock.

41 Zona de Emissões Reduzidas Avenida Baixa Chiado

Incentives

Purchase subsidies and tax credits for low-emission vehicles like bicycles, e-bikes, and cargo bikes, especially for people with limited incomes, can help ensure equitable LEZ compliance in the near-term. Similarly, public transport discounts, including reduced fares for bikeshare, provide additional options for people as alternatives to driving. In Brussels, an LEZ was implemented to combat harmful air pollution, however, reducing vehicle kilometers traveled and promoting mode shift away from vehicles are also stated goals of the scheme. To this end, the city implemented multiple incentive policies to encourage a shift toward public transport, walking and cycling, and shared modes. For example, residents who scrap an older vehicle that is not compliant with the city's LEZ standards have access to "mobility packages," which provide free public transit and carshare programs for one year. Brussels also provides free "mobility visits," which allow people to test out and become more familiar with transport services like bikeshare as alternatives to driving.

Incentives that offset the cost of purchasing an electric bicycle, especially for people with limited incomes, contribute to a more equitably-designed LEZ. Brussels, Belgium. **SOURCE:** Mounir Taha via Shutterstock.

Parking and Land Use Reform

Policies encouraging compact development, like transit-oriented development and on- and off-street parking management, help minimize the need to drive. These policies reduce trip lengths and enable vibrant, mixed-use neighborhoods where walking, cycling, and public transit are the most convenient modes. In some cases, LEZs integrate vehicle parking restrictions as another mechanism to reduce the number of high-polluting vehicles driving into the zone.

Madrid Central, the city's downtown LEZ, integrates parking restrictions to limit vehicle circulation. Neighborhoods like Las Letras see fewer cars and utilize street space for outdoor dining.
SOURCE: Page Light Studios via Shutterstock.

This is the case in Madrid, where residents, drivers with disabilities, and zero-emission, emergency, and public transit vehicles can enter the low emission zone without restriction. All other vehicles are subject to entering and parking restrictions depending on their emissions level: Hybrid vehicles can enter the zone and park on the street for up to two hours; petrol cars and light-duty vans manufactured after 2000; diesel cars and light-duty vans manufactured after 2014 can enter the zone but can only park in a public lot or garage; and older vehicles may not enter the zone at all. Another example is Jinan, China, where a pilot low emission zone aims to achieve emission reductions through effective parking management and improvements to public transportation. Jinan's LEZ will integrate multiple parking management strategies: In 2022, Jinan started charging for on-street parking within the zone to better manage demand for driving and parking. The city is also considering adding off-street parking maximums to help limit parking supply, implementing time limits for on-street parking, and limiting parking construction near public transport stations.[42]

42 ITDP China. (2022). Research on Approaches and Policies for Transportation Demand Management in the Low Emission Zone. Unpublished internal project report.

Stricter Sub-zones or Future Phases

Recently, LEZs have become a means of transitioning to stricter policies that limit polluting vehicles.[43] London, Amsterdam, Paris, and Milan have plans to transition all or parts of their LEZs to Zero Emission Areas (ZEAs)—where only zero-emission forms of mobility, including electric passenger, freight, and transit vehicles, bicycles, and pedestrians have access—by 2030.[44] In March 2020, London piloted a near-ZEA corridor on a street within the ULEZ, restricting vehicles below the Euro 5 standard.[45] While the pilot covered only a small area within the LEZ, the city aims to implement a ZEA in Central London (City of London district, most of Westminster borough, and part of Camden) by 2025, expanding this to Inner London and, ultimately, the whole city by 2050.[46] Amsterdam has plans to implement a ZEA using a similar phased method, starting with the city center (6.5 km^2) only for buses and coaches in 2022; then expanding to the A10 ring road (70 km^2) except for passenger cars by 2025, and the entire LEZ area for all vehicle types by 2030.[47] Paris plans to take a slightly different approach, progressively tightening its LEZ restrictions across the entire zone to become a ZEA by 2030.[48]

In Paris, on-street electric vehicle charging supports a long-term plan to transition the current LEZ to a zero emission area by 2030. **SOURCE:** Aimur Kytt via Shutterstock

43 Transport & Environment, 2018.
44 Green & Healthy Cities: How C40 Cities Are Implementing Zero Emissions Area.
45 A global overview of zero-emission zones in cities and their development progress.
46 Zero Emission Zones: Taking forward the Mayor's Transport Strategy proposal for Zero Emission Zones.
47 A global overview of zero-emission zones in cities and their development progress.
48 A global overview of zero-emission zones in cities and their development progress.

In a few cases, cities without an LEZ already in place have gone straight to implementing a ZEA, often experimenting first with a pilot. These, however, have been very small, targeted interventions.[49] For example, in February 2022, Oxford, United Kingdom, piloted a priced ZEA on eight streets. After assessing the scheme, the city plans to expand the size of the ZEA as part of a second phase.[50] Other cities have targeted ZEAs specifically to freight vehicles due to their disproportionate contribution to air pollution and, in many cases, their routes through disadvantaged communities.[51] For example, Shenzhen, China, piloted a freight-only ZEA made up of ten smaller zones ranging from 0.4 to 5.4 km^2 implemented around the city, which has helped to accelerate the adoption of battery-electric freight vehicles.[52] Santa Monica, California, piloted a 2.5 km^2 voluntary Zero-Emission Delivery Zone (ZEDZ) in the city's commercial core. The ZEDZ aims to reduce air pollution and congestion from medium-duty commercial trucks by encouraging the use of electric vehicles for most deliveries with curb priority for zero-emission vehicles, and supplementing with electric micromobility for last-mile, food, and parcel delivery.[53] Although the zone is not compulsory, incentives like subsidies and curb priority are available to companies that use zero-emission delivery vehicles.[54]

Oxford, UK is one of only a few cities to pilot a priced zero emission zone. The city plans to expand the ZEA after evaluating the pilot phase.
SOURCE: Alena Veasey via Shutterstock.

49 Low- and Zero-Emissions Zones: Opportunities and Challenges in Designing Equitable Transportation Policies & A global overview of zero-emission zones in cities and their development progress.
50 About Oxford's Zero Emission Zone (ZEZ).
51 How to Guide: Zero-Emission Zones.
52 How to Guide: Zero-Emission Zones & Lessons from Shenzhen's Green Logistic Zones: Fast-Tracking Zero-Emissions Freight & A global overview of zero-emission zones in cities and their development progress.
53 Santa Monica Zero Emission Delivery Zone Pilot & How-to Guide: Zero-Emission Zones.
54 Low- and Zero-Emissions Zones: Opportunities and Challenges in Designing Equitable Transportation Policies.

LEZs have also been complemented by or eventually transitioned into congestion pricing zones meant to decrease demand for driving and incentivize a shift to walking, cycling, and public transport.[55] For example, Milan transitioned its "Ecopass" low emission zone to a congestion pricing zone in 2012: the new "Area C" program established a €5 congestion charge for most vehicles entering what was previously the Ecopass zone. The new zone carried more strict emissions standards in addition to the charge, with high-polluting diesel (below Euro 4 engines) and gasoline cars (below Euro 0 engines) no longer permitted to enter the zone. Central London's congestion charge, implemented in 2003, was set up as a sub-zone within the city's larger LEZ. In 2019, a ULEZ was implemented in Central London alongside the congestion pricing zone that requires private and commercial cars, motorcycles, and vans that do not meet the ULEZ emission standard (below Euro 4 gas engines and Euro 6 diesel engines) to pay an additional fee to enter the zone.

55 Review of European Low-Emission Zone Policy.

APPENDIX

LOW EMISSION ZONE EXAMPLES

This table is not exhaustive and is meant to provide examples of low emission zones with different types (freight-only versus private vehicles), pricing approaches, sizes, designs, and outcomes for comparison. There are very few LEZs (that meet ITDP's definition) in operation outside of Europe, though several are in the planning stages.

	VEHICLE TYPE	PRICING	ZONE SIZE (% of city area)	DESIGN	STRATEGIC COMPONENTS	OUTCOMES
London, England Ultra Low Emission Zone (ULEZ) » 2019	Light duty	Priced £12.50/entry	**381 km²** 100% (Inner London)	**Vehicles required to pay to enter:** • Petrol vehicles Euro 3 or below • Diesel vehicles Euro 5 or below • Motorcycles Euro 2 or below[56] **Operation:** 24/7 **Enforcement:** ANPR cameras	£15 Congestion charge (Central London) London-wide LEZ (1,580 km²) covering high-polluting medium and heavy-duty vehicles Integrated metro and bus network Improved public transit, cycling, and walking infrastructure 8,500 park-and-ride spaces[57]	**First 10 months (Central London):** 44% NO2 reduction 27% PM2.5 reduction 13,500 fewer high-polluting vehicles entering the zone daily 4% reduction in CO2 emissions **First month of expansion in 2021:** 92% compliance rate[58]
Antwerp, Belgium Low emission zone » 2017	Light duty	Priced €30/week €50/month	**25 km²** 12%	**Vehicles required to pay to enter:** • Diesel Euro 4 vehicles pay per entry **Vehicles that can enter up to 8 times/year with day pass:** • Petrol vehicles Euro 1 or below • Diesel Euro 3 vehicles or below **Operation:** 24/7 **Enforcement:** ANPR cameras **Fines:** €150 - first violation €250 - second violation €350 - additional violations within 12 months	Scrappage incentives Promotion of public transit, cycling, and walking Park-and-rides implemented outside the LEZ	**Evaluation of pollutant concentrations 2005-2019** (before and after LEZ implementation): • PM10 and PM2.5 emissions decreased by 34%, and 40%, respectively in connection with an uptake of low-emitting vehicles • Localized black carbon concentrations also fell • Tighter restrictions through 2025 aim to target NO2 concentrations[59]

56 Transport for London: ULEZ Standards.
57 How Road Pricing Is Transforming London.
58 How Road Pricing Is Transforming London.
59 Luchtkwaliteit in de Antwerpse agglomeratie.

	VEHICLE TYPE	PRICING	ZONE SIZE (% of city area)	DESIGN	STRATEGIC COMPONENTS	OUTCOMES
Seoul, South Korea Green Transport Zone » Dec. 2019	Light duty	Non-priced	**16.7 km²** 3% (Central Seoul Historic Center)	**Vehicles impacted:** • Grade 5 vehicles (diesel vehicles before 2002 or 2005 depending on the size) • Petrol cars before 1987 **Operation:** 6 am – 9 pm every day **Enforcement:** 45 gateways with cameras **Fines:** 250,000 Won (US $212) for entering the zone with a non-compliant vehicle	All within the zone: Increased public bikeshare services Increased car rental services Four new public bus routes - 50% cheaper than regular public bus 90% subsidy to attach particulate exhaust filter[60] Restructuring of roads and streets for more walking space and less traffic[61]	**2019-2020 Preliminary Analysis:** 23-46% reduction in Grade 5 vehicles[62 63] 16.7% reduction in PM10 16% reduction in PM2.5[64] ~13% reduction in traffic flows
Lisbon, Portugal ZER Lisboa » July 2011	Light duty Heavy-duty trucks (freight)	Non-priced	**26 km²** 26% (0.6 km² - Zone 1)	**Vehicles prohibited from entering:** • Zone 1: Diesel and petrol vehicles Euro 2 and below or manufactured before 2000 • Zone 2: Diesel and petrol vehicles Euro 1 or below or manufactured before 1996 • Vehicles over 7.5 tons **Operation:** Every day 7 am – 9 pm except Sundays **Enforcement:** Manual inspection of the car by police authorities **Fine:** €120[65]	Resident exclusive parking Improvements in cycle infrastructure Converting some spaces to fully pedestrian square Pedestrian pavement widening Public transportation priority routes Extended tram route Speed limit reduced to 30 kph[66]	**Evaluation of pollutant concentrations 2009-2016** (before and after LEZ implementation): • **Zone 1:** 29% PM10 reduced 12% NO2 reduced • **Zone 2:** 23% PM10 reduced 22% NO2 reduced[67]

60 What to know about new emission rules in Seoul.
61 Seoul to additionally designate Green Transport Zones in Gangman and Yeouido.
62 How C40 Cities are implementing zero emission areas.
63 Seoul to additionally designate Green Transport Zones in Gangman and Yeouido.
64 How can Low Emission Zones Drive a Just Transition to Sustainable Mobility.
65 Low emission zone Lisbon.
66 ZER ABC Lisboa Programme Brief.
67 Impact of the implementation of Lisbon low emission zone on air quality.

	VEHICLE TYPE	PRICING	ZONE SIZE (% of city area)	DESIGN	STRATEGIC COMPONENTS	OUTCOMES
Rome, Italy Zona Traffico Limitato » Jan. 2002	Light duty	Non-priced	**39 km²** 3% (Anello Ferroviario) (4.2 km² - Centro Storico) (Larger zone - Fascia Verde)[68]	**Vehicles prohibited from entering:** • Passenger and commercial vehicles: petrol Euro 2 and below; diesel Euro 3 and below • Mopeds and motorcycles diesel Euro 1 and below **Operation:** 24/7 for commercial vehicles, weekdays for passenger vehicles **Enforcement:** ANPR cameras **Fine:** €70[69]	Park-and-ride lots Improved public transit system	**2001-2005** In the intervention area: 33% reduction in PM10 58% reduction in NO2 15 days of life expectancy gained per person living within the LEZ[70] **2014** Centro Storico zone with tightest restrictions: 5% reduction of car trips 3.6% increase in public transit trips 1.5% increase of pedestrian and cycle trips[71] ~12% reduction in PM10 ~22% reduction in CO_2[72]
Haifa, Israel LEZ » 2018	Light duty Heavy-duty trucks (freight)	Non-priced	**45 km²** 70%	**Vehicles prohibited from entering:** • Heavy-duty trucks (3.5 tons or more) diesel Euro 3 or below and older than 2005 with no particle filter • Light-duty vehicles (less than 3.5 tons) Euro 3 or below and manufactured before 2006 (taxis manufactured before 2009) with no particle filter[73] **Operation:** 24/7 **Enforcement:** ANPR Cameras **Fine:** Yes, but not specified[74]	Subsidies for particulate filter installation in diesel vehicles[75] Subsidies for hybrid taxis Purchase incentives for electric buses Electric car share programs[76]	**Feb 2018-Feb 2020:** 34% reduction in black carbon 19% reduction in NOx[77]

68 All Information about the Rome's Limited Traffic Zone (LTZ).

69 Urban Access Regulation in Europe: Rome.
70 Health Benefits of Traffic Related Air Pollution Reduction in Different Socioeconomic Groups: The Effect of Low-Emission Zoning in Rome.
71 The Most Widespread Traffic Control Strategy You've Never Heard Of: Traffic-Restricted Zones in Italy.
72 Review of European Low Emissions Zone Policy.
73 Air Quality Impacts of Low Emission Zones in Haifa.
74 Low Emission Zone now operational in downtown Haifa; Israel's first; initially targeting heavy diesels.
75 Haifa's Low-Emission Zone.
76 Low-Emission Zone now operational in downtown Haifa; Israel's first; initially targeting heavy diesels.
77 Air Quality Impacts of Low Emission Zones in Haifa & Ministry Measures, Including Creation of Low Emission Zone, Result in Decrease in Black Carbon in Haifa.

	VEHICLE TYPE	PRICING	ZONE SIZE (% of city area)	DESIGN	STRATEGIC COMPONENTS	OUTCOMES
Brussels, Belgium[78] LEZ » 2018	Light duty	Non-priced	**161 km²** 100%	**Vehicles prohibited from entering:** • Diesel passenger cars, light commercial vehicles, and vans Euro 4 or below or petrol vehicles Euro 1 or below weighing 3.5 tons or less • Buses **Operation:** 24/7 **Enforcement:** ANPR cameras **Fine:** €350 Can purchase €35 day pass to enter with non-compliant vehicle (Max 24 per year/ vehicle)	Mobility package in exchange for deregistering a vehicle Subsidies Encourage alternate mobility[79]: - Public transport - Bicycles - Car sharing - Park and ride - Taxis Mobility coaches	**2018-2020:** 38% reduction in PM2.5 9% reduction in NOx 62% of diesel vehicles in 2018, and 50% of diesel vehicles in 2020 replaced with hybrid vehicles[80]
Shenzhen, China Green Logistics Zones » 2018	Light-duty trucks (freight)	Non-priced	**22 km²** total 1% (10 zones ranging from 0.4 to 5.4 km²)	**Vehicles prohibited from entering:** Light-duty fossil fuel trucks weighing less than 4.5 tons (buses, cleaning and waste collection vehicles exempt) **Operation:** 24/7 **Enforcement:** Manual police enforcement (hard to enforce due to drivers circumventing regulations) **Fines:** CNY 300 (US $45) 3 points per penalty, license suspended at 12 points[81]	Charging utility rate discounts Subsidies to install charging infrastructure Scrappage subsidies[82] Operational subsidies for electric freight vehicles Electric freight vehicle purchase subsidies 1 hour free parking for electric freight vehicles[83]	**By the end of 2019:** Accelerated the adoption of more than 70,000 battery-electric freight vehicles[84] **By the end of 2021:** 21,000 special charging stations installed for freight vehicles

78 Expected Effects from the Low Emissions Zone on Car Fleet and Air Quality in the Brussels Region.

79 What are the alternative mobility offers offered by the Brussels region?
80 Its Low Emission Zone has made Brussels a healthier city.
81 A global overview of zero-emission zones in cities and their development progress.
82 How to Guide: Zero-Emission Zones.
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84 Lessons from Shenzhen's Green Logistic Zones: Fast-Tracking Zero-Emissions Freight & How to Guide: Zero-Emission Zones.

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