

Planning and implementation of low- and zero-emission zones in cities

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Introduction

Zero-emission zones (ZEVs) are deployed by city governments to mitigate air pollution, congestion, and carbon emissions from road traffic.¹ They can also help deliver significant health and economic benefits to communities overburdened by pollution concentrated in areas adjacent to high-traffic activity.² Several cities are implementing or planning ZEVs to spur the transition from internal combustion engine vehicles (ICEVs) to vehicles that have zero emissions at the tailpipe, to reduce traffic overall, and to support modal shifts from driving to walking, cycling, and public transport.³ This paper offers insights into how European and North American cities are planning and implementing ZEVs and provides important lessons for other cities considering similar policies.

There are very few ZEVs in force today. Five cities—Brussels, Copenhagen, Amsterdam, Eindhoven, and Paris—have announced plans to implement a ZEV starting from 2023 to 2030.⁴ Two boroughs in London have implemented a pilot scheme that allows zero-emission and plug-in hybrid vehicles to enter the zone. Other schemes focus on regulating only certain classes of vehicles in the initial stages, such as the zero-emission

1 Beyond zero-emission and low-emission zones, cities also use other urban-access regulations, including clean air zones (CAZs), ultra-low-emission zones (ULEZs), zero-emission areas (ZEAs), congestion charging zones (CCZs), urban road tolls, limited traffic zones (LTZs), emergency air pollution schemes, pedestrian zones, or car-free zones. In some cases, these schemes can overlap or be used interchangeably.

2 Union of Concerned Scientists and The Greenlining Institute, *Low- and Zero-Emissions Zones: Opportunities and Challenges in Designing Equitable Transportation Policies* (July 2021), <https://www.ucsusa.org/sites/default/files/2021-07/low-and-zero-emissions-zones.pdf>.

3 In this paper, zero-emission vehicles refer to battery electric (BEVs) and fuel cell vehicles (FCEVs) with zero tailpipe emissions. As opposed to conventional cars with gasoline and diesel engines, ZEVs have an electric motor which eliminates exhaust emissions.

4 Sandra Wappelhorst and Hongyang Cui, *Update on Zero-Emission Zone Development Progress in Cities*, (Washington, DC: ICCT, 2022), <https://theicct.org/wp-content/uploads/2022/08/Global-ZEVs-update-FINAL.pdf>.

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freight zone in Rotterdam. The Dutch government envisions establishing zero-emission delivery zones in 30 to 40 cities by 2025.⁵

Many European cities already regulate urban access for polluting vehicles with low-emission zones (LEZs), where older and more polluting vehicles are not allowed to enter the zone or are charged a fee. While types of restricted vehicles and emission requirements may vary, these areas have effectively improved air quality in cities.⁶ After the adoption of the EU's Air Quality Directive in 2008 and the Dieselgate scandal in 2015, these zones have proliferated to address air pollution in cities. From 2019 to 2022, the number of LEZs implemented in Europe jumped from 228 to 320, registering a 40% increase.⁷ As discussed in this paper, some of these cities plan to introduce stricter restrictions and gradually evolve the LEZ into a ZEZ.

This paper aims to aid cities in planning and implementing LEZs and ZEZs by sharing lessons learned from other cities. Although cities can also use different urban-access regulations, this paper primarily focuses on LEZs and ZEZs, including a discussion of complementary measures that inform the design of these zones. The paper compares the zones planned or implemented in Europe and North America, featuring information from interviews with city officials. First, it investigates how these plans have evolved, including information on the underlying legal frameworks and enforcement mechanisms. Second, the paper reviews the financial and nonfinancial incentives implemented by cities to encourage the transition to zero-emission vehicles and a shift to other modes of mobility, such as public transport, cycling, and walking. Finally, it concludes with recommendations for cities to follow in planning LEZs and ZEZs, such as early stakeholder engagement, public communication, and ensuring equitable policy design.

Status of zero-emission zones

This paper defines ZEZs as regulated areas that allow access only to zero tailpipe-emission vehicles, such as battery electric and fuel cell electric vehicles, in addition to pedestrians and cyclists.⁸ These schemes must fulfill four criteria to be considered a ZEZ or one of its variants: a commitment published in an official document or formal announcement, an implementation date, information on the specific vehicle types affected, and binding requirements for access. When plug-in hybrid vehicles are allowed into the zone, we treat it as a near-ZEZ. We define the zone as ZEZ-F if it allows only zero-emission freight, or near-ZEZ-F when it also allows plug-in hybrid delivery vehicles. Table 1 summarizes our classification of emission zones and their benefits.

5 Government of the Netherlands, "Kabinet Komt Ondernemers Tegemoet Bij Overstap Op Schone Bestelbus of Vrachtwagen" [Cabinet Provides Support to Entrepreneurs When Switching to a Clean Van or Truck], October 5, 2020, <https://www.rijksoverheid.nl/actueel/nieuws/2020/10/05/kabinet-komt-ondernemers-tegemoet-bij-overstap-op-schone-bestelbus-of-vrachtwagen>.

6 Greater London Authority, "Expanded Ultra Low Emission Zone - 6 Month Report," July 2022, https://www.london.gov.uk/sites/default/files/expanded_ultra_low_emission_zone_six_month_report.pdf.

7 Zachary Azdad, Barbara Stoll, and Jens Muller, *Clean Cities: The Development Trends of Low- and Zero-Emission Zones in Europe*, (Clean Cities Campaign/Transport & Environment, 2022), <https://cleancitiescampaign.org/wp-content/uploads/2022/07/The-development-trends-of-low-emission-and-zero-emission-zones-in-Europe-1.pdf>.

8 Wappelhorst and Cui, *Update on Zero-Emission Zone Development Progress in Cities*.

Table 1. Summary of emission zones

Zone type	Vehicle restrictions	Benefits
Zero-emission zone	Only BEVs and FCEVs are allowed	Reduces air and noise pollution, and traffic congestion
Near-zero-emission zone	BEVs, FCEVs and PHEVs are allowed	
Zero-emission zone for freight	Only BEV and FCEV freight are allowed	Reduces greenhouse gas emissions Incentivizes adoption of ZEVs and charging infrastructure
Near-zero-emission zone for freight	BEV, FCEV and PHEV freight are allowed	
Low-emission zone	Certain vehicle types, such as diesel cars and vans, can be restricted	Reduces air and noise pollution, and traffic congestion
	Vehicles are subjected to certain emission standards to access the zone	Reduces greenhouse gas emissions Emission standards can be gradually tightened

Note: BEV = battery electric vehicle, FCEV = fuel cell electric vehicle, PHEV = plug-in hybrid vehicle

We interviewed officials from nine European and North American cities to understand the challenges and lessons learned during the planning process for low- or zero-emission zones. These cities provide important insights into effective policy measures that could accelerate zero-emission vehicle adoption. Seven of these cities are signatories of the C40 Green and Healthy Streets Accelerator, through which they have committed to procuring only zero-emission buses starting no later than 2025 and creating a major zero-emission area by 2030.⁹ For this study, we asked city officials about their legal frameworks and enforcement mechanisms, incentives offered to promote ZEVs, availability of public transport and active forms of mobility, stakeholder engagement, and communication activities (See Appendix).

Table 2 summarizes these cities' plans for a zero-emission zone as of November 2022. Amsterdam, Brussels, London, and Paris have set a clear pathway toward establishing a zero-emission zone by 2035. We include pilot projects that do not meet all four criteria but include elements of a ZEZ, including a combination of urban-access regulations and public-private partnerships to promote ZEV adoption. Oxford's combined ZEZ and charging pilot program charges polluting vehicles to access the restricted area. Other voluntary efforts, such as those planned in California and Montreal, demonstrate public-private partnership programs that could serve as a model for other cities to follow in the early planning stages of ZEZ implementation.

⁹ C40 Cities, "Green & Healthy Streets Accelerator," accessed January 18, 2022, <https://www.c40.org/accelerators/green-healthy-streets/>.

Table 2. Selected cities with zero-emission zone plans and pilot projects

City	Status	Implementation date	Vehicles affected	Territories covered	Legal framework	Enforcement
Amsterdam, Netherlands	ZEZ, planned	2022–2030	Buses and coaches (2022), all (2030)	Inner city (2022); Citywide (2030)	The National Climate Agreement of 2019; Amsterdam Climate Neutral Roadmap 2050; Action Plan for Clean Air	Cameras, police enforcement, penalties
Brussels, Belgium	ZEZ, planned	2030–2035	LDVs (2030), minibuses and medium-duty trucks (2035)	Brussels-Capital Region	Low Emission Mobility Strategy 2022	Cameras, penalties
London, United Kingdom	Near-ZEZ, planned	2025–2050	Unspecified	City center (2025), inner city (2040) and citywide (2050)	Transport Act of 2020; London Transport Strategy	Cameras, daily charge, and penalties
Los Angeles, United States	ZEZ-F pilot, planned	Unspecified	Delivery vehicles	Five pilot areas, unspecified	Voluntary	Cameras, and penalties
Montreal, Canada	ZEZ, planned	2030	Unspecified	Inner city	Transportation Electrification Strategy 2021–2030	Cameras
Oslo, Norway	ZEZ pilot, planned	2022–2026	LDVs (2022), all (2023–2026)	City center (Ring 1 by 2023, Ring 2 by 2026)	Climate Plan for 2021–2030; Oslo Climate Budget 2021	Unspecified, feasibility study of police and cameras
Oxford, United Kingdom	ZEZ pilot, implemented	2022	LDVs	Nine streets in old city center	Transport Act of 2020; Oxford Transport Strategy	Cameras, daily charges, and penalties
Paris, France	ZEZ, planned	2030	All	Grand Paris metropolitan region	The Energy Transition for Green Growth Law; The Mobility Orientation Law	Police enforcement, penalties
Santa Monica, United States	ZEZ-F Pilot, implemented	2020–2023	Delivery vehicles	Downtown, Main Street	Voluntary	Parking space signage and cameras

Legal framework sources: Government of the Netherlands, “National Climate Agreement,” 2019, <https://www.klimaataakkoord.nl/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands>; City of Amsterdam, “New Amsterdam Climate – Climate Neutral Roadmap 2050,” February 2020, https://assets.amsterdam.nl/publish/pages/887330/roadmap_climate_neutral.pdf; City of Amsterdam, “The Clean Air Action Plan,” October 2019, <https://www.amsterdam.nl/en/policy/sustainability/clean-air/>; Environment Brussels, “Low Emission Mobility Brussels Roadmap,” June 2022, https://leefmilieu.brussels/sites/default/files/2022-09/BE_roadMap_NL_final_MD.pdf; UK Government, “Transport Act 2000,” 2000, <https://www.legislation.gov.uk/ukpga/2000/38/contents>; Mayor of London, “London Mayor’s Transport Strategy,” March 2018, <https://www.london.gov.uk/programmes-strategies/transport/our-vision-transport/mayors-transport-strategy-2018>; City of Montreal, “Transportation Electrification Strategy 2021–2023,” August 11, 2022, https://portail-m4s.s3.montreal.ca/pdf/strategie_electrification_des_transports_2021-2023_ang_finale.pdf; Norwegian Ministry of Climate and Environment, “Norway’s Climate Action Plan for 2021–2030,” January 2021, <https://www.regjeringen.no/contentassets/a78ecf5ad2344fa5ae4a394412ef8975/en-gb/pdfs/stm202020210013000engpdfs.pdf>; City of Oslo, “Climate Budget 2021,” February 2021, <https://www.klimaoslo.no/wp-content/uploads/sites/88/2021/02/Climate-Budget-2021-Oslo.pdf>; Oxfordshire County Council, “Oxford Transport Strategy,” 2015, <https://www.oxfordshire.gov.uk/sites/default/files/file/roads-and-transport-connecting-oxfordshire/ConnectingOxfordshireOxfordTransportStrategy.pdf>; Republic of France, “Law 2015-992 of August 17, 2015 on Energy Transition for Green Growth,” 2015, <https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000031044385/>; City of Paris, “The Low Emission Zone,” July 7, 2022, <https://www.paris.fr/pages/la-zone-a-faibles-emissions-zfe-pour-lutter-contre-la-pollution-de-l-air-16799>

Legal framework and enforcement

Some countries have national laws that allow cities to create low- and zero-emission zones. The United Kingdom’s Transport Act of 2000 established the legal basis for introducing charging schemes in restricted traffic zones, allowing the Oxford City Council to trial a combined ZEZ and emissions charging scheme that levies a fee on all vehicles that are not zero emission in order to access the city center.¹⁰ France’s Energy Transition Law for Green Growth empowered cities to impose access restrictions on highly polluting vehicles.¹¹ Initiated in 2015, Paris became the first city in France to introduce an LEZ, which will be progressively tightened to allow only zero-emission vehicles by 2030.¹² The National Climate Agreement of 2019 set out a requirement for the 30–40 largest Dutch cities to implement a zero-emission delivery zone by 2025.¹³

10 The UK Government, “Transport Act 2000,” 2000, <https://www.legislation.gov.uk/ukpga/2000/38/contents>.

11 Republic of France, “Law 2015-992 of August 17, 2015 on Energy Transition for Green Growth,” 2015, <https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000031044385/>.

12 City of Paris, “The Low Emission Zone,” July 7, 2022, <https://www.paris.fr/pages/la-zone-a-faibles-emissions-zfe-pour-lutter-contre-la-pollution-de-l-air-16799>.

13 Government of the Netherlands, “National Climate Agreement,” 2019, <https://www.klimaataakkoord.nl/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands>.

Enforcement mechanisms for ZEZs are required to ensure vehicles follow the rules. In the initial stages, cities may grant exemptions based on disability status, age, and income, and allow special access rules for residents and businesses living or operating in or near the zone. Police enforcement, automated cameras, or a combination could monitor compliance with the zone rules. However, policymakers need to ensure these methods are fair and do not hurt marginalized communities.¹⁴ Moreover, cities can use revenues from fines to meet the mobility needs of communities, such as subsidized public transit, bike path installations, and sidewalk repairs.¹⁵

This section explores three case studies in Europe: Amsterdam and Paris, which plan to allow only ZEVs to access the wider city or metropolitan area by 2030; and Oxford, which is piloting a combined ZEZ and emissions charging scheme for noncompliant vehicles. In North America, cities do not have the legal power to enforce ZEZ rules, which will be discussed later in the paper.

Amsterdam plans to create a ZEZ for taxis, delivery and goods vehicles, mopeds, municipal ferries, and buses in the city center by 2025, with the intention of extending the zone to the entire city for all vehicles by 2030. The Clean Air Action of 2019 outlined Amsterdam's ZEZ strategy to improve air quality and reduce CO₂ emissions from mobility.¹⁶ Air pollution in Amsterdam due to traffic is particularly acute in the city center, around Schiphol airport, and in the harbor area. Businesses generate about a third of city traffic.¹⁷ The city is required to follow national traffic rules; these allow the city to impose restrictions on business vehicles initially, followed by private vehicles. Amsterdam plans to regulate diesel vehicles which do not meet certain emission standards (e.g., Euro 4 or better for cars and vans, Euro 6 or better for heavy-duty vehicles) by limiting their entry to the city center.¹⁸ Restrictions will apply 24 hours a day, seven days a week, with diesel buses and coaches certified to Euro 6 standards or higher allowed in the wider ring road. By 2025, all vehicles except for passenger cars need to be zero-emission to circulate in the ZEZ, and all transport modes need to be zero-emission to access the city-wide ZEZ by 2030.¹⁹

The city plans to use police enforcement and automatic number plate recognition (ANPR) cameras to monitor the LEZ and ZEZ compliance. Penalties for noncompliant vehicles range from €110 for passenger cars, taxis, light-duty commercial vehicles, buses, and coaches, to €280 for trucks.²⁰ Van, truck, and coach operators can apply for up to 12 vehicle exemptions each year, paying a levy of €53.40 per vehicle per day if the vehicles comply with the Euro standard that is immediately below the minimum standard in the LEZ rules (e.g., a coach complying with Euro 5 rather than Euro 6 could receive an exemption).²¹

Oxford is the first city to implement a combined ZEZ and emissions charging scheme pilot in the UK, originally aiming to establish a ZEZ in the city center in 2020 and to gradually expand the zone citywide by 2035.²² The city and county council jointly commissioned a feasibility study and held stakeholder engagement workshops, which

14 Union of Concerned Scientists and The Greenlining Institute, *Low- and Zero-Emissions Zones*.

15 Union of Concerned Scientists and The Greenlining Institute, *Low- and Zero-Emissions Zones*.

16 City of Amsterdam, "The Clean Air Action Plan," October 2019, <https://www.amsterdam.nl/en/policy/sustainability/clean-air/>.

17 Michiel Vlam with Zero-Emission Mobility, city of Amsterdam, interview with author, November 23, 2022.

18 City of Amsterdam, "Low Emission Zone for Diesel Vehicles," accessed November 1, 2022, <https://www.amsterdam.nl/en/traffic-transport/low-emission-zone/>.

19 Vlam with Zero-Emission Mobility, Amsterdam, interview with author.

20 City of Amsterdam, "Low Emission Zone for Diesel Vehicles."

21 City of Amsterdam, "Information per Vehicle," accessed November 1, 2022, <https://www.amsterdam.nl/en/traffic-transport/low-emission-zone/information-per-vehicle/#hd04fbf66-df18-4dd8-840d-52a070e936c6>.

22 Oxfordshire County Council, "Oxford Transport Strategy," (2015), <https://www.oxfordshire.gov.uk/sites/default/files/file/roads-and-transport-connecting-oxfordshire/ConnectingOxfordshireOxfordTransportStrategy.pdf>.

led to delays in the project's timeline.²³ A small-scale ZEZ pilot was launched on February 28, 2022.²⁴

Oxford's pilot zone aims to address concerns raised by local businesses in the old city center by offering a flexible charging scheme with operating hours from 7 a.m. to 7 p.m.²⁵ The daily charge ranges from £2 to £10, based on vehicles' CO₂ emission levels.²⁶ From August 2025, the daily charge will increase to a range of £4–£20. Businesses within the pilot area are eligible for a 90% discount for up to 10 vehicles, while full exemption is granted to Oxford-licensed taxis, emergency vehicles, and registered local buses.²⁷ The city plans to expand the zone to a wider area in the second stage, which will include almost all shopping and commercial activity in the city.

The city enforces the rules using five ANPR cameras. Drivers can pay the daily charge in advance or by midnight on the day of travel. Nonpayment incurs a £60 penalty charge to be paid within 28 days.²⁸ This payment scheme operates similarly to other cities' nationally mandated clean air zones (CAZs), but Oxford's pilot project established a ZEZ at its conception.

Paris has implemented an LEZ to address air quality issues from polluting vehicles. It was first established in 2015 as a restricted traffic zone in the city center and was expanded to 70 municipalities in the Greater Paris area in 2021.²⁹ The Mobility Orientation Law of 2019 requires all cities with more than 100,000 inhabitants to establish low-emission zones.³⁰ The Climate and Resilience Law of 2021 transferred regulation of the LEZ to the Greater Paris Metropolis.³¹

Paris plans to introduce stringent vehicle access rules for all vehicle segments by 2030. Diesel vehicles will no longer be able to access the LEZ by 2024, and only ZEVs will be allowed by 2030. Under the existing LEZ, buses, coaches, and trucks are subject to restrictions between 8 a.m. to 8 p.m., seven days a week, and noncompliant private vehicles and motorbikes cannot access the zone from 8 a.m. to 8 p.m. during weekdays, except for public holidays.³² Full exemptions are granted to some vehicles, such as vehicles used by people with disabilities, public transport, refrigerated trucks, and emergency vehicles. These are temporary exemptions and will be reconsidered in 2023.

Police enforce LEZ rules through visual inspection, and drivers are required to display a Crit'Air air quality rating sticker on their windshield.³³ Fines for noncompliance range

23 Bryan Evans and Duncan Enright with Oxfordshire County Council, interview with author, November 22, 2022; Guy Hitchcock, David Birchby, Celine Bouvet and Dan Clarke, *Oxford Zero Emission Zone Feasibility and Implementation Study*, (Ricardo Energy & Environment for Oxford City Council, July 31, 2017), https://www.oxford.gov.uk/download/downloads/id/4019/zero_emission_zone_feasibility_study_october_2017.pdf.

24 Government Business, "GB Q&A: Less Cars and Zero Carbon in Oxford," accessed November 1, 2022, <https://governmentbusiness.co.uk/features/gb-qa-less-cars-and-zero-carbon-oxford>.

25 Oxfordshire County Council, "View A Map of the Zero Emission Zone," accessed November 1, 2022,

<https://www.oxfordshire.gov.uk/residents/roads-and-transport/oxford-zero-emission-zone-zez/view-map-zez>.

26 Oxfordshire County Council, "Charges for Oxford's Zero Emission Zone," accessed November 1, 2022, <https://www.oxfordshire.gov.uk/residents/roads-and-transport/oxford-zero-emission-zone-zez/charges-oxfords-zez#:~:text=Charges%20apply%20from%207%20am,zone%20and%20do%20not%20move>.

27 Oxfordshire County Council, "Discounts and Exemptions From The ZEZ Charge," accessed November 1, 2022, <https://www.oxfordshire.gov.uk/residents/roads-and-transport/oxford-zero-emission-zone-zez/discounts-and-exemptions>.

28 Oxfordshire County Council, "Fines for Non-Payment of Zero Emission Zone (ZEZ) Charges," accessed November 1, 2022, <https://www.oxfordshire.gov.uk/residents/roads-and-transport/oxford-zero-emission-zone-zez/fines>.

29 City of Paris, "The Low Emission Zone," July 7, 2022, <https://www.paris.fr/pages/la-zone-a-faibles-emissions-zfe-pour-lutter-contre-la-pollution-de-l-air-16799>.

30 Government of France, "The Mobility Orientation Law," Official Journal of France no. 0299 (2019), <https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000039666574>.

31 Government of France, "The Climate and Resilience Law," Official Journal of France, no. 0196 (2022), <https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000043956924>.

32 City of Paris, "The Low Emission Zone."

33 Government of France, "Low Emission Zones: To Breathe Easier in the City," March 14, 2022, <https://www.gouvernement.fr/les-actions-du-gouvernement/transition-ecologique/zones-a-faibles-emissions-pour-mieux-respirer-en>.

from €68 for private cars and motorbikes to €135 for buses, coaches, and trucks. Paris lacks legal authority to implement ANPR cameras, but the Mobility Guidance Law allows for the automated recording of noncompliant vehicles.³⁴ As of April 2023, Paris does not have automated enforcement, but the city may adopt it in the future.

Key takeaways

European cities are implementing LEZs and ZEZs to improve air quality and address traffic congestion. These zones may require a national legal framework to regulate vehicle access and enforce compliance. However, cities can still proceed with planning an LEZ or ZEZ in the absence of a national legal framework. Paris initially implemented a restricted traffic zone, which was later voluntarily adopted by all municipalities in the metropolitan area. Municipalities can also rely on local and regional laws, in addition to providing economic benefits to incentivize businesses and private individuals to follow the zone rules.

Zone restrictions often target specific vehicle types, such as taxis, buses, and delivery vans, based on pollution criteria. Amsterdam and Oxford initially prioritized commercial vehicles circulating in the city center and plan to broaden the zone rules to all vehicle types by 2030–2035. The planning stage included extensive stakeholder engagement to better understand their specific needs without creating unnecessary burdens on residents.

Policies for accelerating ZEV uptake

Many European cities have seen a rapid uptake in electric vehicles and charging infrastructure since 2020.³⁵ In Oslo, the share of battery electric vehicles in new passenger car sales reached 71% in 2021, up from 60% in 2020. As of the end of 2022, 34% of all public chargers in the United Kingdom were located in London. Amsterdam had 25% of all public chargers installed in the Netherlands and Paris had 22% of all public chargers in France.³⁶

Local policies play an important role in accelerating these cities' electric vehicle and charging infrastructure growth. These measures include offering vehicle incentives, promoting zero-emission last-mile deliveries, and charging infrastructure policies to support their ZEV planning.

Incentives for vehicle replacement

Several cities provide purchase incentives to consumers to replace an older polluting vehicle with an electric vehicle, in addition to national subsidies.³⁷ These subsidies could target the most polluting vehicles and can be used to ensure equitable outcomes in restricted zero-emission areas.

London provides an example of incentives to support the electrification of taxis and vehicles for disabled travelers in preparation for a citywide near-ZEV. London has established an ultra-low-emission zone (ULEZ), where only light-duty vehicles meeting Euro 4 (petrol) or Euro 6 (diesel) emission standards can enter without charge.³⁸ From August 2023, the ULEZ will expand from inner London to all boroughs, covering over

34 Caroline Daud and Cecile Honore of the Mobility Agency, city of Paris, interview with author, November 17, 2022.

35 Irem Kok and Dale Hall, *Battery Electric and Plug-In Hybrid Vehicle Uptake In European Cities*, (Washington, DC: ICCT 2023), <https://theicct.org/publication/bev-phev-european-cities-mar23/>.

36 Data from Eco-movement, <https://www.eco-movement.com/>.

37 Sandra Wappelhorst, "Economic Recovery Packages In Response To COVID-19: Another Push For Electric Vehicles In Europe?," *ICCT staff blog*, August 3, 2020, <https://theicct.org/economic-recovery-packages-in-response-to-covid-19-another-push-for-electric-vehicles-in-europe/>.

38 Transport for London, "ULEZ Standards," December 8, 2022, <https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/ways-to-meet-the-standard>.

5 million people.³⁹ London-licensed taxis are exempt from paying a daily charge of £12.50, as they play a key role for disabled travelers.⁴⁰ Instead, the city provided other incentives for taxis, such as access to rapid charge points and priority for taxi queues.⁴¹ In 2017, the mayor introduced a £42 million taxi delicensing scheme to scrap older diesel taxis for those of the highest diesel standard and promote zero-emission capable vehicles.⁴² The delicensing scheme removed more than 4,000 older taxis in London, and provided up to £10,000 for taxi drivers to trade in their older diesel vehicles early.⁴³ Starting in January 2018, newly registered taxis could only obtain a license if they are zero-emission capable with no more than 50 g/km of CO₂ emissions. Older, more polluting taxis can stay in circulation for no more than 12 years.⁴⁴

With the planned expansion of the ULEZ, the city introduced a new £110 million vehicle-scrappage scheme to prepare low-income groups, disabled people, small businesses, and charities for the transition.⁴⁵ This builds on previous scrappage schemes which removed or retrofitted 15,200 older taxis.⁴⁶ Eligible vehicle owners can receive £2,000 for scrapping a car that does not meet ULEZ emission standards, £5,000 to scrap a wheelchair-accessible vehicle, and up to £9,500 for businesses employing 10 or fewer people, sole traders (self-employed individuals), and charities.⁴⁷ Registered disabled vehicle-owners are exempt from paying the ULEZ charges until October 24, 2027.⁴⁸

Electric car-sharing programs

The high upfront cost of EVs can be a barrier to switching to a cleaner alternative for low-income groups, even with purchase incentives. Car sharing can be an affordable option for disadvantaged communities.

Los Angeles has launched electric car sharing pilot programs to improve air quality and provide affordable mobility options among Black and Latino communities. First initiated in 2015, the BlueLA program aims to deploy 100 electric cars and 200 charge points in “low-income” neighborhoods.⁴⁹ The California Air Resources Board granted a total of \$4.6 million to the Los Angeles Department of Transportation for the project, including financing for an additional 200 electric vehicles, 600 e-bikes, and 300 charge points. The city is currently working on making membership in the BlueLA program more seamless to remove barriers and enable higher usage of other forms of transit for impacted communities.⁵⁰

The Los Angeles Cleantech Incubator (LACI), through its Zero Emissions Mobility and Community Pilot Project Fund, supports emissions-free mobility projects in four low-

39 Transport for London, “ULEZ Expansion in 2023,” December 8, 2022, <https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/ulez-expansion-2023>.

40 Inga Mills and Taryn Ferguson of Greater London Authority, interview with author, December 6, 2022; Transport for London, “ULEZ: Discounts and Exemptions,” accessed November 2, 2022, <https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/discounts-and-exemptions>.

41 Greater London Authority, “Sadiq Khan Heralds New Era for London’s Taxi and Private Hire Trades,” September 13, 2016, <https://www.london.gov.uk/press-releases/mayoral/new-era-for-londons-taxi-and-private-hire-trades>.

42 Transport for London, “Taxi Delicensing,” accessed November 2, 2022, <https://tfl.gov.uk/info-for/taxis-and-private-hire/taxi-delicensing-scheme>.

43 Transport for London, “Taxi Delicensing.”

44 Transport for London, “ULEZ: Discounts and Exemptions.”

45 Greater London Authority, “Ultra Low Emission Zone Will Be Expanded London-Wide,” November 25, 2022, <https://www.london.gov.uk/ultra-low-emission-zone-will-be-expanded-london-wide>.

46 Office of the Mayor of London, email message to author, March 30, 2023.

47 Transport for London, “Scrappage Schemes,” December 8, 2022, <https://tfl.gov.uk/modes/driving/scrappage-schemes>.

48 Transport for London, “ULEZ: Discounts and Exemptions.”

49 California Air Resources Board, “EV Carsharing Pilot Program (BlueLA Carsharing) Project,” accessed December 8, 2022, <https://ww2.arb.ca.gov/sites/default/files/movingca/pdfs/bluela.pdf>.

50 Michael Samulon with Sustainability Office, City of Los Angeles, interview with author, December 1, 2022.

income communities.⁵¹ In 2020, the car-sharing platform Envoy (one of LACI's portfolio companies) and the Housing Authority of the City of Los Angeles initiated an electric car sharing pilot program in Rancho San Pedro. The program offered affordable membership rates and alternative payment options for people without bank accounts.⁵²

Zero-emission delivery benefits

Transitioning to zero-emission delivery fleets is an important component of ZEZ planning. In Europe, last-mile delivery trucks constituted 11% of the vehicle stock in 2020, representing a key segment to decarbonize.⁵³ Several cities have prioritized accelerating fleet electrification by imposing emission charges, providing parking and urban logistics spaces, and offering economic benefits to local businesses and delivery companies. In the absence of a national legal framework, cities still have considerable authority over regulating vehicle traffic and parking spaces in their jurisdictions.⁵⁴ Two innovative pilot schemes in North America are Santa Monica's zero-emission delivery zone and Montreal's Colibri urban cycle logistic hub.

Montreal's Climate Plan for 2020–2030 aims to establish a nonbinding zero-emission zone in the downtown area by 2030, with a plan to electrify a quarter of urban deliveries annually by 2023. The Transportation Electrification Strategy for 2021–2023 targets a half-million parcel deliveries per year to be electric by 2023.⁵⁵

Montreal supported e-cargo bike courier and delivery companies by providing city-owned land for an urban logistics hub, Colibri, in 2019.⁵⁶ The pilot project reduces heavy-duty trucks on city roads and delivers up to 5,000 packages weekly to the downtown area with e-cargo bikes.⁵⁷ The city plans to establish more urban logistics hubs in other neighborhoods close to the planned ZEZ.⁵⁸

Santa Monica has launched a pilot zero-emission delivery zone in partnership with the Los Angeles Cleantech Incubator through the Transportation Electrification Partnership.⁵⁹ The pilot project aims to reduce emissions from light- and medium-duty deliveries in downtown Santa Monica and Ocean Park. The city incentivizes participating companies by providing loading curb areas and parking spaces, with curbside cameras monitoring the use of the 11 loading spaces.⁶⁰ The zone covers a one-square-mile area with the highest density of businesses and traffic activity. At most, one parking spot is dedicated on each block.

51 Los Angeles Cleantech Incubator, "Zero Emissions Mobility and Community Pilot Project Fund," accessed December 8, 2022, <https://lincubator.org/mobility-pilots/>.

52 Los Angeles Cleantech Incubator, "LACI Launches Second Community EV Car-Share Program in San Pedro," September 25, 2020, <https://lincubator.org/laci-san-pedro-pilot/>.

53 Hussein Basma, Felipe Rodriguez, Julia Hildermeier, and Andreas Jahn, *Electrifying Last-Mile Delivery: A Total Cost of Ownership Comparison of Battery-Electric and Diesel Trucks in Europe* (Washington, DC: ICCT, 2022). <https://theicct.org/publication/tco-battery-diesel-delivery-trucks-jun2022/>

54 Amy E. Turner, "Legal Tools for Achieving Low Traffic Zones (LTZs): LEZ, ULEZ & Congestion Pricing in the U.S. Law Context," *Environmental Law Reporter* 50, no. 10329 (2020), https://scholarship.law.columbia.edu/cgi/viewcontent.cgi?article=1056&context=sabin_climate_change.

55 City of Montreal, "Transportation Electrification Strategy 2021-2023," August 11, 2022, https://portail-m4s.s3.montreal.ca/pdf/strategie_electrification_des_transports_2021-2023_ang_finale.pdf.

56 City of Montreal, "Colibri: Mini-Hubs to Decarbonize Parcel Delivery," November 7, 2022, <https://montreal.ca/en/articles/colibri-mini-hubs-to-decarbonize-parcel-delivery-16318>.

57 C2 Montreal, "Sustainable Mobility: How Montreal Is Leading the Charge," accessed December 9, 2022, <https://www.c2montreal.com/post/sustainable-mobility-how-montreal-is-leading-the-charge/>.

58 Jessie Pelchat and Melina Planchenault with the Office of Ecological Transition and Resilience, City of Montreal, interview with author, November 1, 2022.

59 City of Santa Monica, "Zero Emission Delivery Zone," accessed November 1, 2022, <https://www.santamonica.gov/zero-emission-delivery-zone>.

60 Ariana Vito with the Office of Sustainability and the Environment, City of Santa Monica, interview with author, November 23, 2022; City of Santa Monica, "Zero Emission Delivery Zone Pilot Program Lessons Learned," November 15, 2022, https://santamonica.cityca.igm2.com/Citizens/Detail_LegiFile.aspx?Frame=&MeetingID=1365&MediaPosition=&ID=5299&CssClass=

The pilot project aims to demonstrate the scalability of new delivery technologies and convince businesses and delivery companies to adopt zero-emission alternatives.⁶¹ The project tested electric cargo vans and shuttles, e-scooters and cargo bikes, along with remote-controlled robots, and allowed free parking in the vicinity of the zone. Contactless deliveries by autonomous robots with cheaper fees appealed to small restaurants and businesses operating on a thin profit margin during the pandemic.

Charging infrastructure roll-out

City governments can streamline planning and implementation for faster and more efficient charging infrastructure installation.⁶² Amsterdam leads in EV charging, with 6,600 public chargers per million population in 2021, providing valuable insights for other cities to implement charging strategies. Amsterdam has a comprehensive charging infrastructure strategy, with a Strategic Plan for Charging Infrastructure 2020–2030 that aims for 82,000 chargers by 2030.⁶³ The plan focuses on the right-to-charge to ensure access to reliable, accessible, and affordable chargers.⁶⁴ It has three components: demand-driven public charging, fast-charging through concessions, and a focus on taxis.⁶⁵

Amsterdam adopted a demand-driven approach to siting charging, allowing electric vehicle users to request an on-street public charger be installed close to home. Under Amsterdam’s charging strategy, the city provides financial support for the installation and operation of city-owned chargers by a private company. In 2016, the city awarded energy provider Nuon and construction firm Heijmans a seven-year contract to expand public charging infrastructure in partnership with EVBox.⁶⁶ The support will be gradually phased out as the market reaches maturity.

The city supported fast-charging solutions for taxis, which are considered a critical target group due to covering many kilometers in the city and during airport transfers.⁶⁷ In 2016, the sector agreed to adopt emission-free taxi transportation under the Clean Taxis for Amsterdam Covenant.⁶⁸ The city also committed to expanding publicly available fast-charging stations for taxis at strategic locations. Clean taxis have priority access to the Central Station taxi rank and fast chargers installed at the station and other locations in the city.⁶⁹ The Royal Schiphol Group is among the signatories, and currently has 400 chargers installed at Schiphol airport with plans to add 10,000 new stations by 2030.⁷⁰

Key takeaways

Cities have implemented financial and nonfiscal incentives to accelerate ZEV uptake and charging infrastructure deployment in low- and zero-emission zones. London

61 City of Santa Monica. “Zero Emission Delivery Zone Pilot Program Lessons Learned.”

62 Marie Rajon Bernard and Dale Hall, “Efficient Planning and Implementation of Public Chargers: Lessons Learned from European Cities” (Washington, DC: ICCT, 2021), <https://theicct.org/wp-content/uploads/2021/06/European-cities-charging-infra-feb2021.pdf>.

63 City of Amsterdam, “Laad Me: Strategisch Plan Laadinfrastructuur 2020-2030” [Charge Me: Charging Infrastructure Strategic Plan 2020-2030], November 2020, <https://www.amsterdam.nl/wonen-leefomgeving/duurzaam-amsterdam/publicaties-duurzaam-groen/laad-strategisch-plan-laadinfrastructuur/>.

64 Vlam with Zero-Emission Mobility, Amsterdam, interview with author.

65 Michiel Vlam, “The Amsterdam Approach to Building A (Fast) Charging Network,” City of Amsterdam, accessed November 23, 2022.

66 Hugo Pereira, “Power to Amsterdam: An EV Role Model City,” January 12, 2016, <https://blog.evbox.com/powering-amsterdam-ev-role-model-city>.

67 Vlam, “The Amsterdam Approach.”

68 City of Amsterdam, “Covenant Schone Taxis Amsterdam,” February 2016, <https://www.amsterdam.nl/en/policy/policy-traffic/policy-taxis/>.

69 City of Amsterdam, “Plan Amsterdam: The Electric City,” April 2018, https://issuu.com/gemeenteamsterdam/docs/plan_amsterdam_4-2018_the_electric_.

70 Schiphol Airport, “Royal Schiphol Group to Significantly Expand Number of Electric Charging Points in Coming Years,” November 9, 2022, <https://news.schiphol.com/royal-schiphol-group-to-significantly-expand-number-of-electric-charging-points-in-coming-years/>.

has rolled out scrappage schemes for older taxis and disabled vehicles, while Los Angeles has supported electric car-sharing programs for marginalized communities. Montreal and Santa Monica focused on decarbonizing urban deliveries, and Amsterdam prioritized fast-charging options for taxis, which cover many miles between the city and the airport.

Promoting public transport, walking, and cycling

Zero-emission zones can encourage cities to adopt alternative forms of transportation beyond zero-emission variants of cars, vans, and trucks, such as public transit, walking, and cycling. These zero-emission modes of transportation improve air quality, reduce greenhouse gas emissions, create reliable and accessible transport to enable residents to move around cities at lower cost, and create car-free spaces, enhancing the infrastructure for walking and cycling.

Amsterdam plans to remove over 10,000 parking spaces for cars by 2025 to create more space for cyclists, pedestrians, and public transport.⁷¹ The Bicycle Plan (2017–2022) allocated €54 million for smooth cycling routes, accessible bike parking spots close to destinations, and improved cycling practices.⁷² As a part of the plan, the city aims to expand the car-free Green Network, which will connect cycling routes into an extensive network.

Brussels plans to tighten access rules for GHG-emitting motorcycles, passenger cars, vans, and minibuses in the Brussels-Capital region between 2030 and 2035.⁷³ The city's urban mobility plan, Good Move (2020–2030), aims to reduce private car use by 24%, improve public transport efficiency, and promote cycling and walking.⁷⁴ The Bruxell'Air scheme offers a bonus for scrapping a car in exchange for using public transport, walking, cycling and car sharing.⁷⁵ Low-income and disabled individuals receive a higher mobility bonus. Brussels Environment offers the public access to a "mobility coach" to provide information on alternative modes of transportation for those interested in the Bruxell'Air bonus.⁷⁶

Oslo's Car Free Livability Program aims to improve the quality of life by reducing private car traffic.⁷⁷ The city government removed 760 municipal parking spaces to create green spaces, free seating, cultural activities, better roads for cyclists and public transport. Some of these reclaimed parking spaces are reserved for delivery vehicles and vehicles for those with physical disabilities to improve accessibility. Oslo is planning to establish a ZEZ in the city center area, overlapping with the car-free zone, and to expand the zone to the broader city area.⁷⁸

Oxford is currently consulting on a new Central Oxfordshire Travel Plan, which proposes to reduce car trips by a quarter by 2030 and achieve net-zero transport

71 City of Amsterdam, "Implementation Plan: Pleasant Neighbourhoods, Liveable City," accessed November 1, 2022, <https://www.amsterdam.nl/en/policy/ambitions/pleasant/>.

72 City of Amsterdam, "Long-Term Bicycle Plan 2017-2020: For Cyclists and A Health and Accessible City," n.d., https://assets.amsterdam.nl/publish/pages/867885/long-term_bicycle_plan_2017-2022.pdf.

73 Brussels Environment, "Calendrier Lez Pour La Periode 2025–2035" [Calendar for the Period 2025–2035], October 6, 2022, https://environnement.brussels/sites/default/files/user_files/calendrier_de_sortie_du_thermique_2025-2035_1_0.pdf.

74 Brussels Mobility, "Summary of the Good Move: Regional Mobility Plan 2020-2030 of the Brussels-Capital Region," March 2021, https://mobilite-mobiliteit.brussels/sites/default/files/2021-03/GOODMOVE_summary.pdf.

75 Brussels Environment, "Prime Bruxell'Air," May 23, 2022, <https://environnement.brussels/citoyen/services-et-demands/prime-et-aides-financieres/prime-bruxellair>.

76 Brussels Mobility, "What Are the Alternative Mobility Offers Offered by the Brussels Region?," accessed January 3, 2022, <https://lez.brussels/mytax/alternatives?tab=MobilityCoach>.

77 Oslo Kommune, "The Car-Free Livability Programme 2019," accessed January 5, 2023, <https://daf9627eib4jq.cloudfront.net/app/uploads/2020/01/The-Car-free-Livability-Programme-2019.pdf>.

78 City of Oslo, "Nullutslippssone" [Zero Emission Zone], accessed January 5, 2023, <https://www.oslo.kommune.no/slik-bygger-vi-oslo/nullutslippssone/#toc-1>.

by 2040.⁷⁹ In 2021, Oxford committed to becoming a zero-carbon city by 2040 and decreasing road travel by 30% by 2040 through cycling, walking, car-sharing, and remote work.⁸⁰ The city plans to install more ZEZ enforcement cameras around the periphery of the center, provide day passes, and impose a workplace parking levy for employers with at least 10 employees.⁸¹ In March 2022, the county council received £32.8 million from the Zero Emission Bus Regional Areas scheme, in addition to £43.7 million committed by Oxford bus companies, to introduce 159 electric buses by 2024.⁸²

Paris is planning to create a Limited Traffic Zone by 2024 to reduce traffic and make more room for pedestrians, cyclists, and public transport in the city center and select areas north of Boulevard St German.⁸³ The city allocated €250 million for 180 km of new cycling roads and over 130,000 new bicycle parking spaces. The French government offers up to €4,000 to low-income households in the LEZ for swapping their old polluting cars for electric bikes.⁸⁴

Key takeaways

Promoting active transport, such as walking and cycling, along with affordable public transport options, is central to reducing air pollution and greenhouse gas emissions in cities. Low-emission zones in Oxford and Brussels encourage a mode shift from car travel to active transport, while other European cities prioritized car-free areas and bike lanes. Paris plans to create a calm zone with less traffic and to expand bike lanes by the mid-2020s, while Amsterdam and Oslo have implemented car-free areas. Public consultation on how these spaces will be used and reinvestment of emission zone funds into alternative transport systems are essential for equitable outcomes.

Communicating the benefits of zero-emission zones

Zero-emission zones have the potential to benefit quality of life, air quality, equity, and the climate, but their successful implementation requires support from many stakeholders. Cities have worked with local communities, businesses, and scientists to develop support for measures that limit air pollution and protect health. Measuring tailpipe pollution from vehicles could offer insights into the air quality crisis and inform awareness campaigns.

London's ULEZ communication strategy focused on air pollution and health, using data on pollution from vehicles to garner public support.⁸⁵ The mayor's office collaborated with community stakeholders, health workers, parents, campaigners, and experts to push for a clean air agenda. The city published air quality data to make a case for the expansion of the ULEZ and improve public understanding of its health benefits. Since the ULEZ came into force in April 2019 and expanded in October 2021, nitrogen dioxide (NO₂) levels declined 20% in inner London and 44% in Central London.⁸⁶

79 Oxfordshire County Council, "Consultation Report: Central Oxfordshire Travel Plan," accessed November 1, 2022, https://mycouncil.oxfordshire.gov.uk/documents/s63547/CA_NOV2922R05%20Annex%202%20-%20Consultation%20Analysis%20Report.pdf.

80 Carbon Trust, "Zero Carbon Oxford Partnership: 2040 Net-Zero Action Plan," July 2021, <https://zerocarbonoxford.com/roadmap/>.

81 Evans and Enright with Oxfordshire County Council, interview with author; Oxfordshire County Council, "Workplace Parking Levy," accessed January 3, 2023, <https://www.oxfordshire.gov.uk/residents/roads-and-transport/workplace-parking-levy>.

82 Oxfordshire County Council, "Successful Funding Bid Set to Bring 159 Electric Buses to Oxfordshire," March 29, 2022, <https://news.oxfordshire.gov.uk/successful-funding-bid-set-to-bring-159-electric-buses-to-oxfordshire/>.

83 City of Paris, "Paris Creates a Peaceful Zone in the Center of the Capital," April 15, 2022, <https://www.paris.fr/pages/paris-cree-une-zone-apaisee-dans-le-centre-de-la-capitale-20426>.

84 Charles Bremner, "On your ebike, and here's €4,000 for it, says Macron," *The Times*, August 17, 2022, <https://www.thetimes.co.uk/article/on-your-ebike-and-heres-4-000-for-it-says-macron-z8sb80629>.

85 Mills and Ferguson, Greater London Authority, interview with author.

86 Mayor of London, "Expanded Ultra Low Emission Zone - Six Month Report," July 2022, https://www.london.gov.uk/sites/default/files/expanded_ultra_low_emission_zone_six_month_report.pdf.

Breathe London, hyperlocal air quality monitoring project launched in 2019, aimed to empower local communities to monitor air pollution, raise public awareness, and generate cleaner air solutions.⁸⁷ The pilot phase involved collaboration with the Environmental Defense Fund, the Mayor of London, Kings College London, Google Earth Outreach, local community groups, doctors, and schools.⁸⁸ The monitoring was done by air quality sensors installed on lamp posts and buildings, mobile sensors equipped on two Google Street View cars, and by schoolchildren using backpacks with sensors to measure the air quality around primary schools located in the most polluted areas of London.⁸⁹ Low-cost air quality sensors were found to be effective in monitoring the local impacts. The data published by the mayor's office showed that 40% of the Breathe London sensors detected air pollution above legal limits, including in neighborhoods in outer boroughs where such levels of air pollution were not anticipated.⁹⁰

The Mayor of London committed to extending community-led air quality monitoring at sites like schools and hospitals under the Breathe London Community Programme.⁹¹ As of December 2022, the initiative had granted 40 free sensors to 40 low-income and ethnic minority communities in London, enabling them to track local air pollution in real time.⁹²

Brussels emphasized the air quality, health, and climate benefits of the city's LEZ to raise public awareness. The city commissioned a series of environmental and health-impact studies that measured air pollutant and greenhouse gas emissions from vehicles in the Brussels-Capital Region.⁹³ In partnership with Brussels Environment, The International Council on Clean Transportation measured real-world tailpipe air pollution from 130,588 vehicles using remote sensing technology.⁹⁴ The results of the study supported the city's decision to restrict diesel vehicles from driving in the LEZ. The measurements showed Euro 4 diesel cars were responsible for almost half of the particulate matter emissions from all passenger cars in 2020 despite accounting for just 12% of vehicles. The city used this data linking air pollution and diesel vehicles to promote the air quality benefits of the LEZ to the public.

In 2021, the city launched CurieuzenAir, a project measuring NO₂ exposure in the Brussels-Capital Region in partnership with the University of Antwerp, Citizens Action Brussels (BRAL), Université libre de Bruxelles, and Bloomberg Philanthropies.⁹⁵ The campaign, involving 3,000 participants from lower income communities, highlighted areas with higher pollution levels due to heavy road traffic. BRAL—partnering with local organizations that work on health and poverty issues to identify the most vulnerable

87 Environmental Defense Fund, "The Breathe London Blueprint: How Cities Can Use Hyperlocal Air Polluting Monitoring to Support Their Clean Air Goals," February 2021, https://globalcleanair.org/files/2021/02/EDF-Europe-BreatheLondon_Blueprint-guide.pdf.

88 C40, "The Breathe London Blueprint: Supporting Cities' Air Polluting Monitoring Goals," February 2021, https://www.c40knowledgehub.org/s/article/The-Breathe-London-Blueprint-Supporting-cities-air-pollution-monitoring-goals?language=en_US.

89 Breathe London, "Wearables Study: Engaging Primary School Children to Monitor Air Pollution in School," accessed January 5, 2023, <https://breathelondon.edf.org/wearables.html>.

90 Mayor of London, "Mayor Publishes First Data from Breathe London Network," July 24, 2019, <https://www.london.gov.uk/press-releases/mayoral/first-breathe-london-data-published>.

91 Breathe London, "About The Breathe London Network," accessed January 5, 2022, <https://www.breathelondon.org/about>.

92 Bloomberg Philanthropies, "Mayor of London and Bloomberg Philanthropies Announce Second Round of London Community Groups to Receive Free Sensors to Monitor and Tackle Local Air Pollution," December 9, 2022, <https://www.bloomberg.org/press/mayor-of-london-and-bloomberg-philanthropies-announce-second-round-of-london-community-groups-to-receive-free-sensors-to-monitor-and-tackle-local-air-pollution/>.

93 Brussels Environment, "'Low Emission Mobility' (LEZ) Strategy," 2021, <https://environnement.brussels/citoyen/nos-actions/projets-et-resultats/strategie-low-emission-mobility-lez>.

94 Yoann Bernard, Tim Dallmann, Kaylin Lee, Isabel Rintanen, and Uwe Tietge, *Evaluation of Real-World Vehicle Emissions in Brussels* (TRUE Initiative, 2021), <https://theicct.org/publication/evaluation-of-real-world-vehicle-emissions-in-brussels/>.

95 Fran Lauriks, Dirk Jakobs, and Filip Meysman, *CurieuzenAir: Data Collection, Data Analysis and Results* (University of Antwerp, March 18, 2022), https://curieuzenair.brussels/wp-content/uploads/2022/03/CurieuzenAir_AirQualityInBrussels-Report-Final-Version.pdf.

groups—held 11 workshops in low- and moderate-income neighborhoods, and organized walking tours to raise awareness about air pollution and health problems.⁹⁶ By focusing on public health, the city sought to emphasize quality of life and fewer hospital admissions.

Summary of city strategies and recommendations for planning a zero-emission zone

Although zero- and low-emission zones are in the early stages of implementation, they offer important insights into cities' motivations and planning processes. The majority of ZEZs are concentrated in Europe, while voluntary schemes are being trialed in North America. Through our research and interviews with city officials, we identified five strategies that cities have considered when planning and implementing zero-emission zones, which are shown in Table 3. Other cities may consider following similar approaches when designing their own zero-emission zones.

Table 3. Strategies employed in planning early zero-emission zones

Set clear targets and enforceable zone rules	<ul style="list-style-type: none"> • Set a timeline and implementation strategy for the types of vehicles and areas covered. • Develop enforcement mechanisms and make that information accessible; post visible signage to ensure compliance. • Grant exemptions to affected groups for a limited duration.
Gather data	<ul style="list-style-type: none"> • Measure air pollution and public health impacts from road traffic.
Support ZEV adoption and charging infrastructure	<ul style="list-style-type: none"> • Provide vehicle-replacement incentives to affected businesses, low-income groups, and disabled groups. • Dedicate curbside parking spaces and logistics hubs for zero-emission deliveries. • Dedicate priority access to parking and to fast charging for high-mileage commercial vehicles, such as taxis.
Support public transport and active forms of mobility	<ul style="list-style-type: none"> • Provide financial incentives, such as vehicle-scrappage and bike-purchase grants, to encourage the use of public transport and cycling. • Designate areas where traffic is limited and eliminate car parking spaces to create more room for walking and cycling. • Plan for future cycling infrastructure with sufficient bike parking spots and connected cycling routes.
Engage the public and other stakeholders	<ul style="list-style-type: none"> • Communicate motivation and vision ahead of ZEZ implementation. • Hold consultations with affected freight operators, local businesses, grassroots organizations, and residents to understand concerns and communicate the motivation for ZEZs. • In public communications around ZEZs, emphasize improved public health and quality of life.

Based on our interviews and review of LEZs and ZEZs in leading European and North American cities, this paper provides the following recommendations for cities looking to implement a ZEZ:

Legal frameworks at the national and local level can allow cities to establish enforceable low- and zero-emission zones. In Europe, some cities have a legal basis to restrict access to polluting vehicles. Enforcement mechanisms, such as police inspections, cameras, and penalties, often accompany these zones, along with accessible information about the timing of the restrictions and the vehicles affected. Even without a national framework, cities can establish an LEZ or ZEZ by using local and regional laws and voluntary pilot projects. Some cities have started designing

⁹⁶ BRAL, "Popular Neighborhoods Curious about Air Quality," August 25, 2021. <https://bral.brussels/nl/artikel/volksbuurten-curieus-over-luchtkwaliteit>.

these zones to protect public health, reduce greenhouse gas emissions, and offer economic benefits to affected businesses and residents.

Careful design and implementation of these zones can improve equity. Exemptions and financial incentives targeting impacted communities and small businesses could enable an equitable transition. These must be balanced against loopholes allowing access to the most polluting vehicles and the excessive use of public money to fund vehicle replacements for an extended time. Pilot projects with an equity focus can raise public awareness and support before fully implementing an LEZ or ZEZ.

Walking, cycling, and public transport can offer cleaner alternatives to private car travel. Several European cities aim to remove polluting vehicles from the city centers and promote safe movement via active and public transport. Cities can offer free public transport or bike purchase grants in exchange for scrapping a polluting car. A holistic approach to cycling infrastructure includes connected bike paths and bicycle parking spaces.

Public communication and consultation are critical in every stage of ZEZ schemes. In the initial stages, these zones could be challenging to communicate to the public and affected stakeholders. To ensure public support and address concerns, cities can work with experts, local organizations, and businesses to raise awareness about their benefits. Measuring and publishing data on pollution from internal combustion engine vehicles is one strategy to illustrate the potential health benefits of ZEZs.

Appendix: Interviews

Much of the Information presented in this paper is based on interviews with city officials in Europe and North America. A list of interviewees and sample questions are provided below.

Interviewed officials:

Jessie Pelchat and Melina Planchenault, Office of Ecological Transition and Resilience, city of Montreal, November 1, 2022.

Caroline Daude and Cecile Honore, Mobility Agency, city of Paris, November 17, 2022.

Louise Duprez, Brussels Environment, November 21, 2022.

Bryan Evans and Duncan Enright, Oxfordshire County Council, November 22, 2022.

Ariana Vito, Office of Sustainability and the Environment, city of Santa Monica, November 23, 2022.

Michiel Vlam, Zero-Emission Mobility, city of Amsterdam, November 23, 2022.

Michael Samulon, Sustainability Office, city of Los Angeles, December 1, 2022.

Inga Mills and Taryn Ferguson, Air Quality, Greater London Authority, December 6, 2022.

Ragnhild Arhus, Mobility Division, city of Oslo, December 20, 2022.

Interview questions:

Part 1: Legal framework and political acceptance

1. Could you start by explaining the process behind establishing ZEA in your city?
2. Are there any legal challenges in the city government's ability to regulate polluting vehicles?
3. What type of enforcement mechanisms are put in place? Are there any concerns, such as privacy issues, associated with sensors and cameras?
4. What type of exemptions and special rules are introduced for local businesses and residents within the ZEA? How have you encountered backlash, if any, against ZEA?

Part 2: Promoting ZEV transition, public transport, and other forms of mobility

1. What types of incentives are introduced for accelerating ZEV transition? Do you offer any incentives for vehicle replacement for taxis and urban vehicles?
2. Do you have any programs, such as car sharing, to make EVs accessible to disadvantaged users?
3. How do you plan charging infrastructure rollout for these vehicles?
4. Have you introduced new programs for zero-emission bus fleets? If so, what type of financial incentives are envisioned to support public transport in ZEA?
5. Does your ZEA planning incentivize other forms of mobility such as cycling or walking?

Part 3: Communication and public engagement

1. Have you introduced special policy measures to promote equity of access for residents and nonresidents?
2. Does your ZEA planning involve stakeholder engagement? If so, could you explain in what ways stakeholder engagement has influenced the public support for ZEAs?
3. How do you communicate the benefits of ZEAs to the public?