Taming Traffic

STRATEGIES TO REDUCE DRIVING AND PRIORITIZE SUSTAINABLE TRANSPORTATION IN CITIES

ITDP

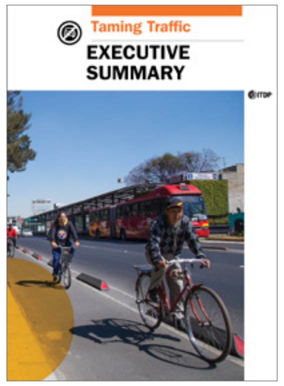
AUTHORS AND ACKNOWLEDGEMENTS

AUTHOR
Dana Yanocha

CONTRIBUTORS
Tara Eisenberg
Jacob Mason
Heather Thompson

Background information, data, and internal review was provided by ITDP regional office staff:
Etsa Amanda, ITDP Indonesia
Carolynn Johnson, ITDP US
Christopher Kost, ITDP Africa
Clarisse Linke, ITDP Brazil
Edgar Mejia, ITDP US
Alphonse Nkurunziza, ITDP Africa
Gonzalo Peon Carballo, ITDP Mexico
Vaishali Singh, ITDP India
Clara Vadillo, ITDP Mexico
Xianyuan Zhu, ITDP China

ITDP would also like to acknowledge the following experts who generously provided their time for informational interviews during the scoping phase and/or to review the draft report:
Daniel Firth, TransLink Vancouver
Kate Laing, C40
Shomik Mehndiratta, World Bank
Carlos Pardo, NUMO
Michael Replogle
Carolina Tohá
Rachel Weinberger, Weinberger & Associates
Lloyd Wright, Asian Development Bank



COVER PHOTO: Complete Street Eje 3 Oriente, Ing. Eduardo Molina, Ciudad de México
SOURCE: Héctor Ríos, ITDP México

CONTENTS

FOREWORD

Before the COVID-19 pandemic, congestion posed a major challenge to cities large and small, contributing to climate change, air and noise pollution as well as other negative outcomes. To combat rising congestion levels, cities have considered implementing aggressive traffic reduction measures such as priced parking, congestion charges, and low emission zones. While some of these efforts have lost momentum or face an uncertain path forward due to shifted priorities in response to the pandemic, poor air quality, congestion, and constrained municipal budgets now pose an even greater threat to quality of life in cities, giving even more reason to advance these measures.

As cities and countries moved to slow the spread of the virus, previously jammed streets saw some of the lowest traffic volumes in decades. Air pollution fell sharply. During this time, many cities paused collection of or reduced parking fees and suspended operation of low emission and congestion charging zones to ease burdens for those making essential trips. As cities lessened restrictions on nonessential travel, however, congestion on city streets returned—as expected. Travel surveys show that in Chinese cities, private vehicle owners are choosing to drive instead of returning to public transit for commuting and other trips. Similar trends have been observed in European cities—after initial pandemic restrictions were lifted, congestion levels have been higher than in previous years. These outcomes demonstrate that now more than ever, cities need to move forward with traffic reduction measures instead of allowing them to stall. Indeed, some cities are committing to more stringent actions to curb traffic: Notably, London's mayor announced plans to transition central London into a car-free zone, citing the need for physical distancing and the resiliency benefits of enabling more trips by walking and cycling.

Successful traffic reduction is about more than reducing congestion, though. It's about redistributing funding, priority, and space on the street to make cities more livable for people. By prioritizing low-cost, widely accessible modes like walking, cycling, and public transport and disincentivizing modes that lead to climate change and most harm society overall—and vulnerable people in particular—we can create more equitable transportation systems. A shift toward cycling is already happening in many places, facilitated by pop-up cycle lanes and slow and car-free streets implemented as a response to the COVID-19 pandemic. Cities can further curb the return to private vehicles

OPPOSITE PAGE:
SOURCE: ITDP Indonesia

by better integrating personal and shared micromobility modes, including bicycles and e-bikes, into the transport network.

And in some cases, traffic reduction strategies can create a reliable revenue stream that further supports improvements to walking, cycling, and public transport infrastructure. Low ridership and expanded space and cleaning requirements have caused us to rethink how public transport is funded. Revenue from traffic reduction strategies like congestion pricing could fill in gaps, redistributing subsidies for driving to support more equitable and efficient transport. For vulnerable communities pushed to urban fringes, it is especially critical that disincentives to driving be coupled with strong policies and investment in public transportation that serves longer-distance trips.

Now is the time for cities to be proactive. Well-designed traffic reduction strategies can be a winning solution to curb congestion, generate revenue, and make walking, cycling, and public transport the easiest, fastest, and cheapest options for getting around. In this report, we introduce and evaluate ways that cities can achieve these outcomes, such as pricing parking, pricing emissions, pricing congestion, and reallocating road space for people. While these strategies are sometimes considered separate from one another, this report underscores the benefits of implementing multiple strategies together to maximize impact and reduce potential challenges.

1 INTRODUCTION

Historically, underpricing road use has led to a disproportionate dependence on low-occupancy, private vehicle travel in cities around the globe. This has wrought congestion, pollution, and sprawl, resulting in serious negative consequences for accessibility, the environment, and quality of life. These harmful outcomes have disproportionately affected the most vulnerable populations, including the poor, older adults, children, and people with disabilities.

Vehicle ownership rates are increasing in cities in many low and lower middle income countries[1] (L/LMIC), though rates are still generally lower than in high income countries.[2] And though use of public transport, walking, and cycling tends to be higher in low income cities, infrastructure can be inefficient. Meanwhile, transport budgets often prioritize building and expanding roads as a solution to traffic congestion despite research and experience that show this only fuels demand for driving and leads to congestion. Unless governments step in, vehicle ownership, use, and traffic in cities—especially rapidly urbanizing cities—will continue to grow.

In places where rates of walking, cycling, and use of public transit are high, such as in L/LMIC cities, there is an opportunity to leapfrog[3] vehicle ownership and directly link traffic reduction strategies with improvements to public transit, pedestrian, and cycling infrastructure. This approach is a more equitable alternative to what has occurred in higher income countries, where income growth is connected to the ownership and use of private vehicles, bringing more congestion and, simultaneously, challenges to improving public transit, walking, and cycling.

In large, high income cities, decades-old constituencies of vehicle owners and users present strong political opposition to policies that eliminate subsidies or charge drivers for the negative outcomes they contribute to. However, cities currently experiencing vehicle ownership growth have a unique opportunity to adopt traffic reduction strategies *before* widespread vehicle dependency. Momentum is building globally, as seen in efforts like the C40 Green Healthy Streets initiative[4]—mayors from over 35 cities, including Quito, Santiago, Mexico City, Rio de Janeiro, and Jakarta, have committed to identifying a significant area of their city as "zero emission" and electrifying public bus fleets. However, capacity, resource, and technological constraints may prevent successful implementation of traffic reduction strategies, so they will need to be designed to account for these limitations. Any successful policy design for traffic reduction must ensure that the needs of lower income and marginalized groups are recognized and addressed, and that these groups do not bear a disproportionately higher cost than wealthier groups as a result of the policy.

1 For the purposes of this paper, country income classifications are determined according to the World Bank—a city in a High-Income Country is a High-Income City (HIC), etc.
2 Private Motorization in Worldwide Developing Countries' Metropolitan Areas: Patterns in the Early 21st Century.
3 "Leapfrog" as defined in Final Report High-Volume Traffic: Urban Transport Theme 2: "The phenomenon of disruptive technologies and innovations that provide latecomers opportunities to enter the market and to skip certain trial-and-error phases, thereby accelerating their success" (p.147).

Fortunately, cities have a number of options at their disposal to significantly reduce motor vehicle traffic and address multiple issues.

This can be done by prioritizing the safety and comfort of pedestrians, cyclists, and public transport users and ensuring that road users understand and pay for the true costs of driving and parking.

BOX 1 THE BIG PICTURE: TRAVEL DEMAND MANAGEMENT

Travel demand management (TDM) is a widely used catch-all term for strategies that seek to reduce traffic and private vehicle use by curbing demand for driving. In other words, TDM strategies seek to increase the efficiency of the transport system and achieve specific policy goals by changing how, when, and where trips happen.[5]

There is general agreement that TDM policies include deterrents or "push" measures that discourage the use of private vehicles, as well as incentives or "pull" measures that make alternatives to driving more attractive (see graphic below). However, implementing "push" measures without adequate options to supplement driving tend to be rejected by the public or, in some cases, lead to more travel, as was seen with some license plate schemes.[6] Similarly, "pull" incentives do not attract enough drivers to meet policy goals if walking, cycling, and public transit options do not satisfy travelers who can afford to continue to drive.

PUSH

PRICE DRIVING TO REFLECT ITS TRUE COST

- Congestion pricing
- Low emission zones
- On-and off-street parking pricing
- Parking maximums
- Fuel taxes
- Vehicle registration fees/quotas
- Toll roads

PUSH & PULL

- Reallocate road space for people
- Limited traffic zones
- Transit-oriented development
- Traffic bans (e.g.: odd/even license plate schemes)

PULL

IMPROVE SUSTAINABLE TRANSPORT, SERVICE AND AFFORDABILITY

- Improve public transit frequency, reliability
- Improve walking and cycling facilities
- Shared micromobility
- Carshare
- Multimodal integration
- Transit-only lanes
- Commuter benefits for transit, cycling & walking

OFF-PEAK TRIP PRIORITY/TRIP AVOIDANCE

- Flexible working hours
- Work from home
- Teleservices (grocery delivery, telemedicine)
- Off-peak transit fare discount

OPTIMIZE STREET NETWORKS OR VEHICLE OCCUPANCY

- High occupancy toll (HOT) lanes
- High occupancy vehicle (HOV) lanes
- Carpool/vanpool/employer shuttles
- Rideshare/shared taxi
- Intelligent transportation systems (ITS), rerouting tools

4 Our Commitment to Green and Healthy Streets.
5 Parking Management Best Practices; Practical Guidebook: Parking and Travel Demand Management Policies in Latin America; Transportation Demand Management: Training Document.
6 Practical Guidebook: Parking and Travel Demand Management Policies in Latin America.

What is often less clear is to what extent traffic reduction strategies link to broader outcomes that cities have committed to, such as improving air quality, mode shift away from single-occupancy vehicles, reducing vehicle kilometers traveled (VKT), or encouraging a cleaner vehicle fleet, and, more narrowly, their role in sustainable transportation networks. Furthermore, there is a conspicuous lack of understanding about the potential for many of these strategies to successfully reduce traffic and demand for driving in cities with few resources and limited capacity, such as small cities and those in low- and middle-income countries.

This paper helps decision makers understand five key strategies to reduce traffic and select the measures that align best with their goals and resources. We do this by evaluating traffic reduction strategies based on 1) their ability to reduce traffic and improve well-being, 2) their ability to advance sustainable transport goals, and 3) the level of capacity required to implement them. Based on this evaluation, we find that:

1 → **Implementing multiple traffic reduction strategies together** maximizes impact and reduces potential challenges related to political will and equity.

2 → **Reallocating road space for people over cars** should be considered as part of a comprehensive traffic reduction strategy, especially in limited capacity cities.

3 → **The presence of alternative transportation options is critical,** particularly when most or all private vehicles are restricted from a zone.

4 → **If capacity is limited, adoption of traffic reduction strategies could follow a progression,** starting with low-cost, low-technology options and working toward more robust, complex strategies.

These key takeaways are discussed in detail in section IV.

BACKGROUND

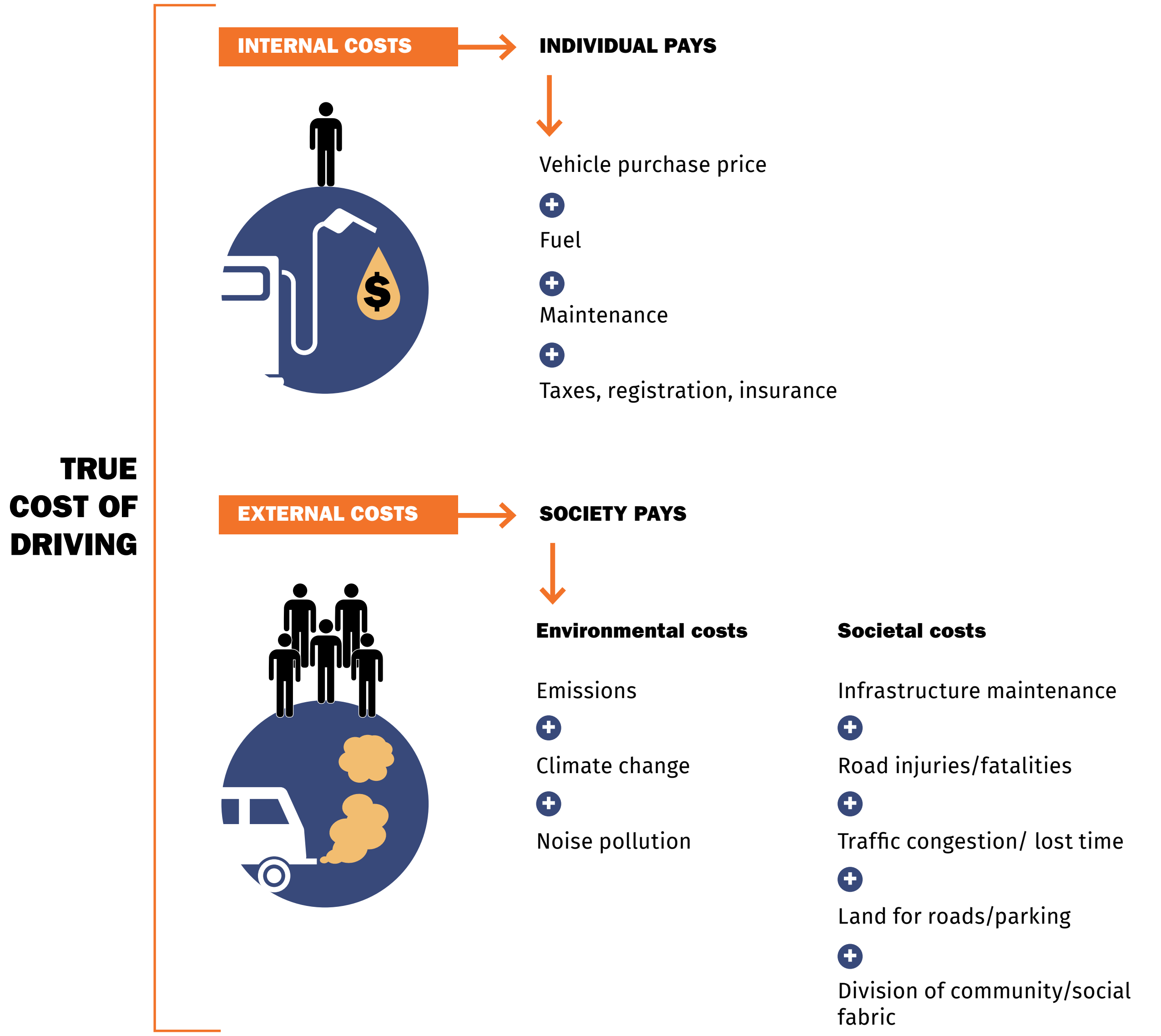
As part of the research for this paper, ITDP conducted an internal survey and follow-up discussions with our staff about opportunities and challenges related to traffic reduction in different regions. Interviews were also conducted with external experts who have specific knowledge and experience related to this topic.[7] Information gleaned from both the internal and external discussions contributed to the overall structure and approach of the paper and, in particular, informed the evaluation criteria used in section 3.3.

7 External interviews were conducted with Shomik Mehndiratta (World Bank); Kate Laing (C40); Lloyd Wright (Asian Development Bank); and Daniel Firth (Translink, Vancouver).

Traffic reduction has been a key issue for ITDP: We have conducted extensive work in the area of on- and off-street parking reform, compact transit-oriented development, and prioritizing space and resources for walking, cycling, and public transit over private vehicles. And we know that by encouraging a shift to these sustainable transportation modes, cities can reduce air pollution and emissions that contribute to climate change, improve road safety, and provide more livable urban environments.

TRAFFIC REDUCTION STRATEGY TYPES: FEE-BASED AND NON-FEE-BASED

Introducing a fee for use (also referred to as "pricing") is a demand management tool used in the context of transport to make some of the true cost—including social and environmental externalities—of unsustainable transport choices more transparent to users of those modes. **In short, transport pricing seeks to disincentivize use of private vehicles by imposing a fee on drivers that accounts for external costs.**



While **fee-based strategies** such as congestion charging or low emission zones tend to have high implementation and operating costs, their ability to raise revenue helps establish a dedicated funding source to offset upfront costs and support ongoing operation as well as to improve, maintain, or create alternative transportation options that can accommodate those who shift away from the priced mode.[8] There is consensus within the academic literature that transport pricing has a strong impact on behavior change.[9]

REVENUE GENERATION

Given further strains on municipal budgets as a result of the COVID-19 pandemic, revenue generation is top of mind for many cities.
We discuss the revenue generation potential of traffic reduction strategies in sections 3.1 and 3.2 of this report.

Non-fee-based traffic reduction strategies, such as road space reallocation, can also disincentivize the use of private vehicles by shifting space and prioritization on the street away from vehicles, making driving less convenient. The antithesis of induced demand (where widening and building new roads increases travel demand and VKT), road space reallocation strategies reduce space for vehicles, thereby reducing travel demand (a concept sometimes referred to as “reduced demand” or “traffic degeneration”).[10]

Typical highway traffic in Los Angeles. The city government is seeking to manage travel demand through a new zero emission area. **SOURCE:** Luke Jones (Flickr)

8 Policy design should recognize the potential incentive that tying funding for sustainable transport to unsustainable transport can create. In other words, if more revenue is generated by more people driving into a priced zone, there is an incentive to keep drivers entering that zone despite the intention of reducing traffic and vehicle trips.
9 Transitions Towards Sustainable Mobility: New Solutions and Approaches for Sustainable Transport Systems.
10 Induced Demand and Rebound Effects in Road Transport.

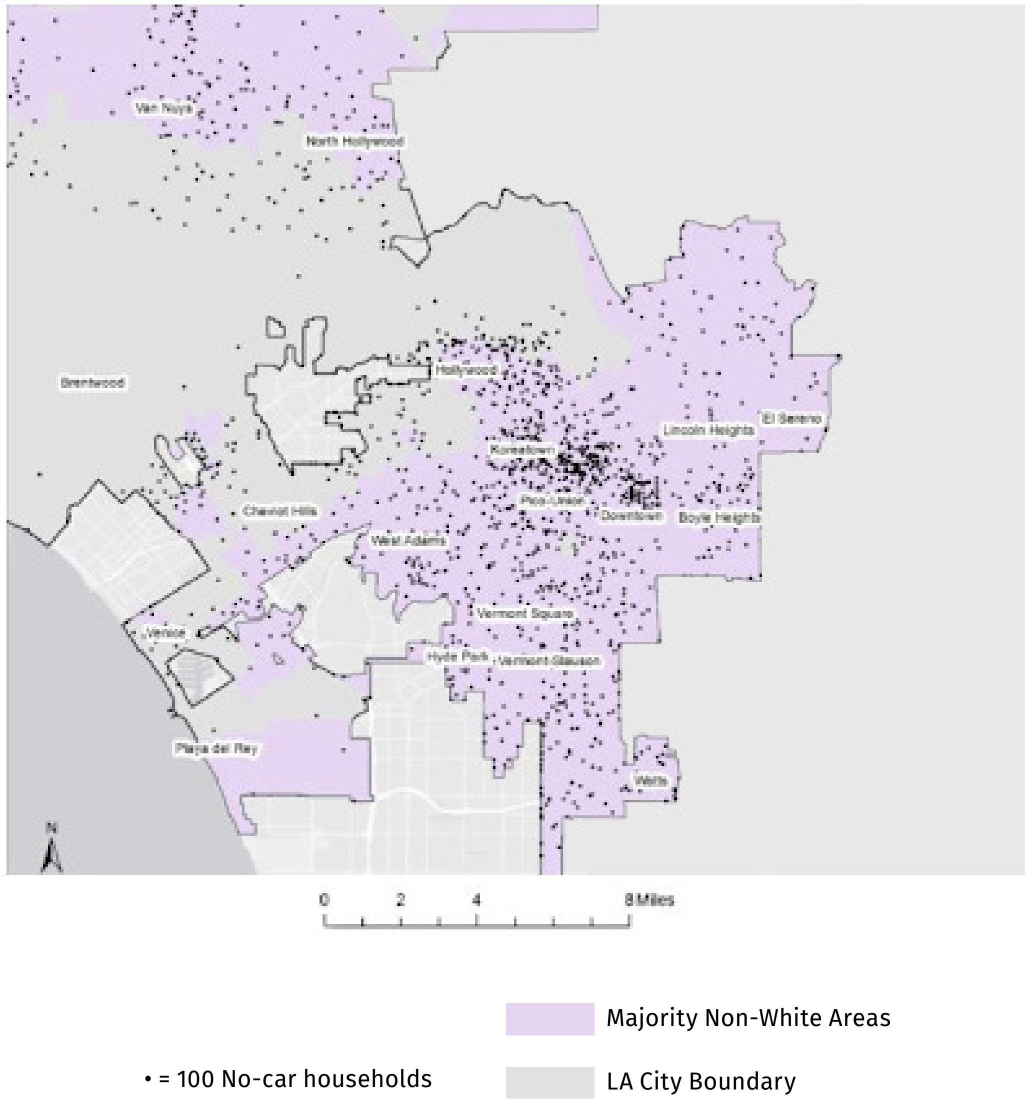
Strategies that do not charge users directly do not generate revenue and thus may present a net cost to the city to implement and maintain. However, these strategies can improve local economic vitality and present indirect cost-savings from fewer traffic crashes resulting in injury or death, and improved public health in the long-term. Non-fee-based strategies also typically carry lower operating costs as compared to fee-based strategies[11], and can be more politically palatable because they do not impose an explicit fee on drivers. Many people have a strong negative reaction to being charged for things they expect to be free.

	KEY OPPORTUNITIES	CHALLENGES
FEE-BASED	Revenue generation (offset cost to implement, maintain) Strong impact on behavior change	High capital and operating costs High potential for political challenges Potential equity concerns (monetary)
NON-FEE-BASED	Lower operating costs More politically palatable	No revenue generation (net cost to implement, maintain) Potential equity concerns (time)

Recognizing that there are opportunities and challenges with both types of strategies, a few cities are starting to take a comprehensive approach, implementing fee-based and non-fee-based strategies together to maximize impacts, often alongside additional “pull” measures (see Box 1). Over time, these strategies can work in tandem, creating space and opportunity for the other to succeed. In other words, the sum of multiple strategies working together is greater than what each strategy might accomplish alone, as each additional measure makes the other measures more effective. More coordination across strategies presents the potential for more impacts. In Mexico City, the government is evaluating how a low emission zone could operate with and enhance on-street parking reforms, a model currently operating successfully in Madrid. Brussels implemented

11 Metro Vancouver Mobility Pricing Could Cost Up to $8 per Day per Family: Report.

a citywide low emission zone and has focused heavily on provision of and communication around non-car options. Los Angeles is working to implement a zero emission area that could combine road space reallocation with congestion or parking pricing, keeping a strong focus on equity.



Traffic reduction strategies must not exacerbate existing inequities in the transportation system. In Los Angeles, households without access to a car are concentrated in majority non-white communities. **SOURCE:** ITDP

EQUITABLE TRAFFIC REDUCTION IS DESIGN DEPENDENT

It is exceedingly important that traffic reduction strategies—those that impose a fee and those that do not—are designed to ensure equitable outcomes across socioeconomic groups. Harmful health and environmental outcomes from vehicle emissions disproportionately impact low income and marginalized groups because pollution hotspots are often located near low income communities. No traffic or emissions reduction strategy is inherently equitable; instead, equity will be achieved (or not) through careful design decisions. For example, price instruments generate revenue that can reduce costs and improve the quality of public transportation, walking, and cycling if strictly allocated to that end. This is more equitable than the status quo of not being charged to drive. If improvements to public transport, cycling, and walking are not prioritized as part of the design, pricing travel in a designated area could push opportunities or destinations outside the priced zone and catalyze sprawl. Similarly, if these sustainable modes are unreliable, unsafe, or unfeasible, access to destinations within a priced zone could become inequitable for those who cannot afford to pay. In countries like Brazil, where metropolitan areas are already sprawling, with many low income residents living on the far outskirts of cities, walking or cycling is not practical for a 15km commute. In these cases, policy design may need to bolster multimodal integration efforts such as improving public transport feeder routes or launching an extended-rental bikeshare program, like Fortaleza's Bicicleta Integrada. This program enables users to keep a shared bicycle overnight in order to ride to and from bus terminals, and it integrates payment with the city's transit fare card. Alternatively, pricing structures could include discounts for lower income drivers.

Notably, equity outcomes may differ from city to city depending on the mode share of private vehicle trips—which groups own or rely on private vehicles and who will be directly affected by vehicle use restrictions versus other strategies like road space reallocation away from vehicles. For example, streetscape and placemaking improvements that make certain areas more desirable for pedestrians could drive up property values and housing costs along with them. At the same time, maintaining the status quo (e.g., taking no action) may be politically preferred but it likely still has equity implications due to historical and structural disadvantages for marginalized groups.

Fortaleza's Bicicleta Integrada, one of four public bikeshare systems in the city, is meant to bring commuters to and from outer public transit terminals by allowing users to keep bikeshare bicycles overnight. **SOURCE:** City of Fortaleza

2 MENU OF OPTIONS: TRAFFIC REDUCTION STRATEGIES

In this paper, we examine five broad options for reducing traffic. Each option includes one or more traffic reduction strategies, for which we provide several brief case studies. In cases where post-implementation impact evaluation data is available, key traffic reduction outcomes and related sustainability benefits are highlighted as part of the case studies. While this paper does not describe the nuances of how to implement each measure, design and implementation resources are included in Appendix A. This paper focuses narrowly on strategies that can be implemented by city governments and have documented success. It does not include all strategies under the "push" umbrella of TDM. Thus, we do not evaluate strategies such as:

Fuel taxes (including cap and trade schemes and taxes on fuel suppliers), **corridor tolling, and increasing the cost of purchasing a private vehicle** (e.g., vehicle registration fees): These strategies are not typically implemented by local or municipal governments and can, in some cases, be regressive.

Traffic bans such as those proposed on two-wheelers in Jakarta, Kuala Lumpur, and Hanoi: The link between bans and equitable, long-term traffic reduction is unclear.

Odd-even license plate schemes. The link to traffic reduction has been minimal, and in some cases schemes have led to increased traffic and emissions. [12 13]

Finally, it is worth noting that emissions-based charges are not typically included in conversations around TDM and traffic reduction. The focus of these types of strategies is often primarily on transitioning to a cleaner vehicle fleet to improve air quality. However, we include these approaches in this paper because there has been growing interest in policies such as low emission zones,[14] and LEZs have resulted in traffic reduction in the short-term as people shift modes or limit vehicle trips. Long-term traffic reduction will only occur if LEZs are designed to become more stringent over time. We see an opportunity for cities to galvanize the political will and public support that may be present for this type of strategy and to reimagine the goals of emissions-based pricing to include both cleaning up vehicles and trip and VKT reduction (see Box 2).

12 Practical Guidebook: Parking and Travel Demand Management Policies in Latin America.
13 Getting Around a License-Plate Ban: Behavioral Responses to Mexico City's Driving Restriction.
14 Spain to Introduce Low-Emission Zones Amid "Climate Emergency."

PRICE (AND REFORM) PARKING	
Reduce or eliminate subsidies for parking; disincentivize off-street parking to more accurately reflect the true cost of driving	• On-street demand-based pricing and off-street parking maximums • Commercial parking tax

PRICE EMISSIONS	
Charge a fee each time a vehicle enters a zone based on the vehicle's emissions level, making trips taken by the most polluting vehicles more expensive to reflect their external costs	• Low emission zones • Clean air zones

PRICE CONGESTION	
Require vehicles to pay a fee to enter or drive within an area, more accurately reflecting the true cost of driving	• Cordon pricing • Distance-based pricing

REALLOCATE ROAD SPACE FOR PEOPLE	
Redesign streets so that the majority of space is dedicated to pedestrians, cyclists, and public transportation, so that these modes become faster, safer, and more convenient than driving	• Pedestrianization • Transit malls • Complete streets

LIMIT TRAFFIC IN SPECIFIC ZONES	
Restrict most vehicles from a designated area and impose a high fine on unauthorized vehicles that enter. This includes strategies to ban vehicles based on emission level.	• Limited traffic zones • Zero emission areas

PARKING PRICING

1. ON-STREET DEMAND-BASED PRICING + OFF-STREET MAXIMUMS

Demand-based on-street pricing enables parking managers to charge a market-based price for parking to manage demand for vehicles and driving.[15] While on-street parking meters in many cities charge one price regardless of location or time of day, demand-based prices vary depending on the location, time of day, and other factors. Because parking is less expensive at certain times (i.e., off-peak hours in the afternoon), drivers are incentivized to make trips during those times. Demand-based pricing makes drivers consider the price of parking, just as they might consider the price of fuel or maintenance when deciding whether and when to drive.

Implementing off-street parking reforms alongside on-street parking pricing ensures that when the supply of off-street parking is reduced, demand is not simply transferred to on-street parking. Some cities, like Pune, India, require on- and off-street parking to be managed together at the district level by a single private operator.[16] Off-street parking reforms include several strategies for reducing the supply of long-term vehicle storage. One example is reducing or eliminating parking minimums, which require developers to build a designated amount of parking to serve residential and commercial uses. Parking minimums increase housing costs and unnecessarily incentivize the use of personal vehicles.[17] As a complementary policy, adopting off-street-parking maximums enables cities to set an upper limit for spaces provided by a particular building type. Parking maximums discourage car trips (and, potentially, car ownership) by decreasing parking supply and increasing prices. Some cities allow developers to build parking beyond the maximum (up to a strict ceiling) for an additional fee or tax, which can be allocated to public transport or active transportation improvements.

15 Getting the Prices Right: An Evaluation of Pricing Parking by Demand in San Francisco.
16 Smart Pune's Push Towards Sustainable Transportation.
17 How Much Does One Parking Spot Add to Rent?

MEXICO CITY, MEXICO

In 2012, Mexico City began piloting ecoParq, a paid on-street parking meter program in its Polanco neighborhood. ecoParq priced 6,000 curbside spaces where parking had previously been free. Revenue from parking fees was allocated to sidewalk and other pedestrian infrastructure improvements in Polanco. The pilot resulted in reduced traffic and improved streetscapes, and it generated demand for similar pilots in nearby neighborhoods.

The success of the ecoParq program for on-street parking catalyzed momentum to reform off-street parking, which surpassed market demand and accounted for 40% of floor area[18] in the city. In 2017, Mexico City passed legislation establishing off-street parking maximums (as opposed to minimums) and a fund to collect impact fees from developers who build parking beyond the maximum.

KEY OUTCOMES MEXICO CITY, MEXICO			
	Reduced VKT from parking search (an estimated 2 kilometers per trip) yielded an annual reduction of 18,000 tons of CO_2.	Increased parking space turnover from 3.5 to approximately 5 vehicles per day.	In its first year of operation, 30% of revenues from ecoParq were reinvested in sidewalk improvements and other public space renewal projects in Polanco.

LEFT: A street in Mexico City before (top) and after (bottom) the implementation of the ecoParq program. Space previously taken by cars for illegal parking has been reallocated to pedestrians. **SOURCE:** Google Maps/ Paul Buendia

RIGHT: Revenues from the ecoParq program support pedestrian infrastructure improvements in the neighborhood. **SOURCE:** Alejandro, Flickr

18 "Floor area" is defined as the total horizontal area of buildings and above-grade covered parking.

SAN FRANCISCO, USA

San Francisco's SFpark program, adopted in 2011, used sensors to monitor parking space availability on every block and parking meters that charge drivers based on the time of day. Prices are typically lower before noon (compared to before SFpark was implemented), increase between noon and 3 p.m., and fall somewhere in between after 3 p.m. The city also adjusts parking prices periodically in response to observed occupancy rates. The Municipal Transportation Agency (SFMTA) set a target occupancy rate of 60% to 80% per block: If average occupancy for a given block falls in this range, the price will not change following the periodic review. San Francisco has also been easing minimum off-street parking requirements along transit corridors and in certain neighborhoods for decades. In early 2019, San Francisco eliminated minimum off-street parking requirements citywide.

KEY OUTCOMES SAN FRANCISCO

Improved parking availability led to an 8% reduction in traffic.	Fewer instances of double parking led to a 2% increase in public transit speeds.	Greenhouse gas emissions fell by 30% in SFpark areas compared to a 6% decrease in control areas during the same period.	Increased net parking revenues by USD $1.9 million per year.

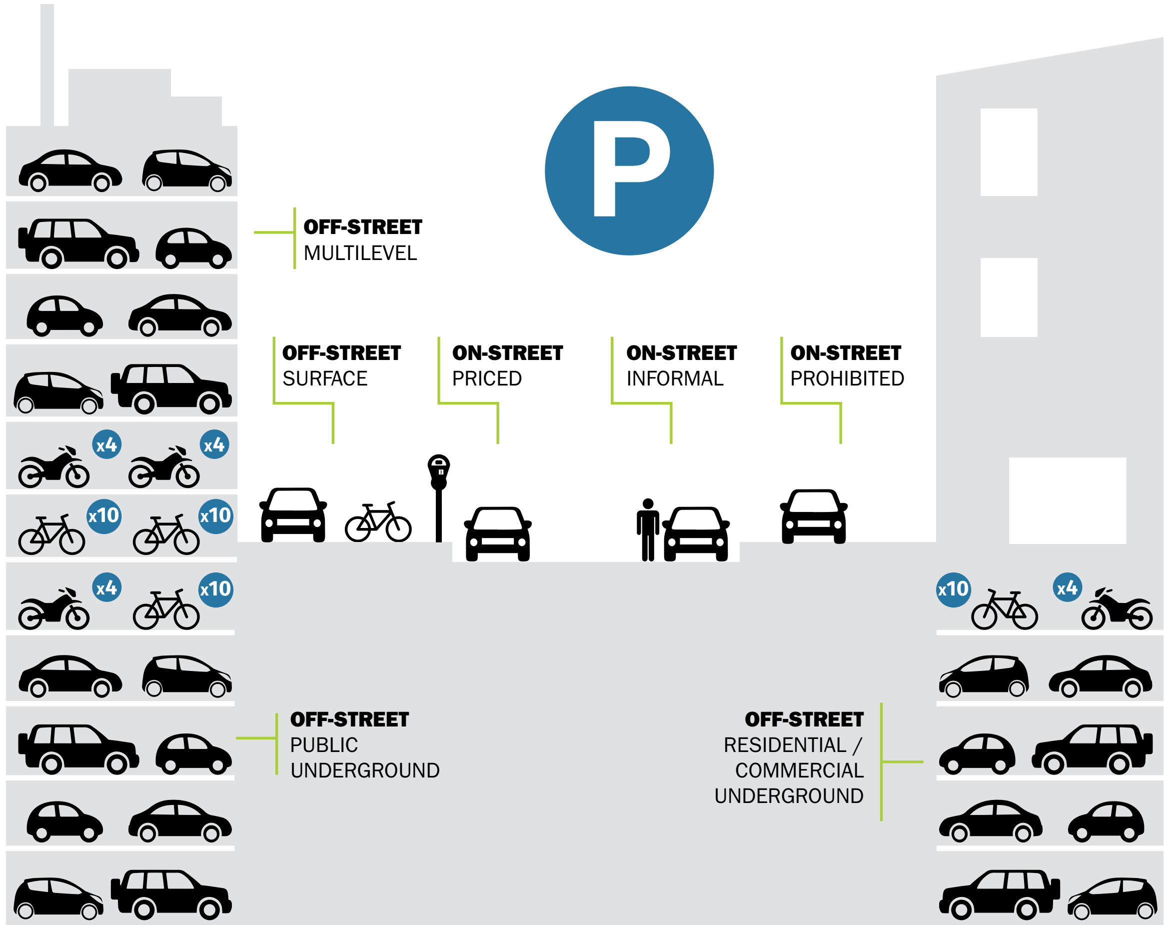
Meters for the SFpark program. **SOURCE:** Carlos Felipe Pardo

SÃO PAULO, BRAZIL

São Paulo reformed its on-street parking in 2016, replacing paper coupons with a digital system known as Zona Azul Digital. The automated system sought to improve parking compliance by reducing fraud and reselling, which was common with the paper coupon system. The Zona Azul Digital platform also provides São Paulo the opportunity to implement demand-based parking in the future.[19] In addition, São Paulo eliminated off-street parking minimums for all land uses and adopted parking maximums for residential and commercial buildings along transit corridors.

KEY OUTCOMES SÃO PAULO

In the years following adoption of parking maximums, developers reported being able to build public housing closer to the city center because they do not have to include parking in development costs.	On-street parking revenues increased by 60% after the first year of operation, largely due to more efficient agent inspections, enabled by digital parking space occupancy tracking.[20]



With goals to increase turnover and limit long-term parking in commercial areas, São Paulo analyzed and reformed both on- and off-street parking policies. **SOURCE:** ITDP Brazil

19 "São Paulo" in Parking: An International Perspective. Pp. 36–38.
20 "São Paulo" in Parking: An International Perspective. P. 56.

2. COMMERCIAL PARKING TAX/FEE

Commercial parking taxes are levied either on revenues generated by commercial parking operators or based on the number of spaces or parking surface area. Notably, this does not necessarily need to function as a "tax" in the legal sense, and could just as easily be referred to as a fee if that is more politically palatable. Commercial lots that offer free parking are required to pay the tax, which is typically remitted annually. While the commercial lot owner is responsible for collecting and remitting the tax to the city, the tax itself is added to parking rates and ultimately paid by drivers. While the theory behind commercial parking taxes is to increase the cost of parking and, thus, raise the cost of (and reduce demand for) private vehicle trips, few impact evaluations have been conducted to draw the connection between these policies and reductions in driving. The major success of commercial parking taxes in practice has been raising revenue, which is often reallocated to local transport-related projects, including public transit facilities.

SYDNEY, AUSTRALIA

The city imposes an annual Parking Space Levy (PSL) of AU $2,490 (USD $1,717) per commercial off-street parking space in the central business district (CBD) and North Sydney/Milsons Point district, and AU $880 per space in four other neighborhoods outside of the CBD.[21] Parking managers are required to maintain records that show how often each space is used, and facilities that are only used periodically (such as seasonal lots) pay a prorated amount. The tax raises approximately AU $100 million annually, and revenues are kept in a special fund for transportation-related projects. PSL revenues have been used to finance transit station upgrades, secure covered bicycle parking at transit stations, and build commuter park and ride lots.[22][23]

MELBOURNE, AUSTRALIA

Melbourne's Long Stay Car Park Levy (AU $800/USD $550) applies to long-stay and permanently leased parking spaces in off-street commercial car parks within the city's CBD. The levy was implemented to encourage parking managers to limit the number of long-term parking spaces, thereby enabling more turnover and efficient use of space through short-term parking. Revenues are allocated to public transport improvements within the CBD.[24]

In Melbourne, Australia, parking revenues are redirected to public transport, including the city's tram system--the largest in the world. **SOURCE:** Bernard Spragg

21 Parking Space Levy
22 Parking Taxes: Evaluating Options and Impacts.
23 Parking Space Levy.
24 Parking Price Policies: A Review of the Melbourne Congestion Levy.

NOTTINGHAM, ENGLAND

In 2012, Nottingham began the Workplace Parking Levy program, which charges business owners with 11 or more parking spaces £387 (USD $488) per space annually.[25] Employers with 10 or fewer spaces are exempt. With this program, Nottingham raises about £9 million annually, of which £500,000 is used to operate the program. In addition, the city pursues match funding, and for each £1 raised from the program it receives an additional £3 to £4.[26] The revenue is used for public transportation projects, such as the redevelopment of the Nottingham rail station and the local tram network.

Revenues from the workplace parking levy support upkeep and redevelopment of the Nottingham tram. **SOURCE:** Ed Webster / CC B

SEATTLE, USA

Since 2010, a commercial parking tax of 12.5% has been in place for all commercial surface parking lots in Seattle.[27] The tax is collected by commercial lot owners on top of the base price to park (free parking is also subject to the tax, assessed at 12.5% of the market value of an off-street parking space) and then paid to the government when filing taxes.[28] The tax yields upwards of $21 million annually, and funds are used to support transportation infrastructure and redevelopment, such as the Mercer Corridor project.[29] Despite attempts to raise the tax rate to generate more funding for metro service in 2014, the commercial parking tax amount has not changed for the past decade.[30]

BELOW: Seattle's commercial parking tax has funded infrastructure improvements, like protected cycle lanes and pedestrian space along Mercer Corridor. **SOURCE:** Seattle Department of Transportation

25 "1: Nottingham Workplace Parking Levy" in Funding and Financing Inclusive Growth in Cities.
26 A Winning Policy: Nottingham's Workplace Parking Levy.
27 The Case for a Tax on Parking Lots.
28 Commercial Parking Tax.
29 Mercer Corridor Project.
30 The Case for a Tax on Parking Lots.

EMISSIONS PRICING

Emissions pricing strategies charge high-polluting vehicles to enter a designated zone. The primary goal is to encourage a shift to cleaner vehicles in the short term; however, some cities, like Brussels, are starting to align emissions pricing with broader traffic reduction goals as a strategy to address climate change. Restrictions typically do not differentiate between fuel technologies (e.g., CNG) but instead focus on the performance of the vehicle. Low emission zones (LEZ), clean air zones (CAZ), and similar policies fall into this category.

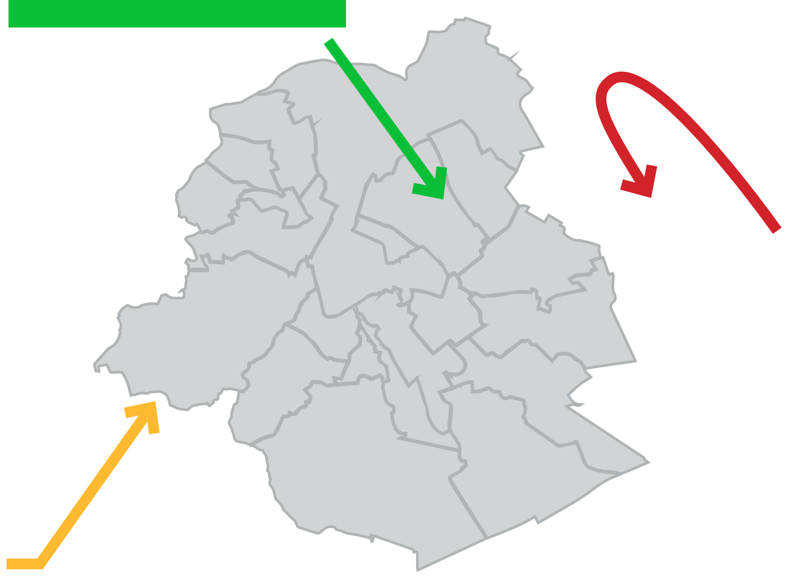
LOW EMISSION ZONES

A low emission zone (LEZ) or clean air zone (CAZ) requires vehicles to pay an entry fee based on the vehicle's emission rating. **An LEZ differs from congestion pricing because it sets a charge based on the emission level of the vehicle; a flat congestion charge applies to all vehicles entering the zone, regardless of their emission rate.**

Depending on the design, LEZs can limit the use of vehicles—particularly those with the highest emission levels—by making the external costs of those trips more apparent to drivers. High emitting vehicles may be charged more, or low emission vehicles may receive a discount. Zero emission vehicles (ZEVs) may be exempted from the charge altogether. At the time of writing, over 200 LEZs have been implemented throughout Europe.

Outcomes for stricter LEZ schemes that completely prohibit high-polluting vehicles (non-fee-based) can be quite different from those of fee-based LEZs, as shown in this graphic. The non-fee-based design is discussed in this paper under "limited traffic zones."

VEHICLES THAT MEET THE EMISSIONS STANDARD CAN ENTER THE ZONE.



NON FEE-BASED DESIGN

VEHICLES THAT DO NOT MEET THE EMISSIONS STANDARD ARE BANNED. VIOLATORS ARE FINED.

In Madrid, non-compliant vehicles cannot enter the zone. All violators are assessed a €90 fine

FEE-BASED DESIGN

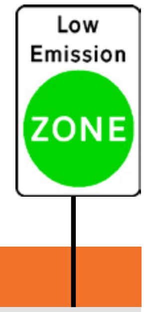
VEHICLES THAT DO NOT MEET THE EMISSIONS STANDARD CAN ENTER THE ZONE IF THEY PAY A FEE. VIOLATORS ARE FINED.

In London, drivers of non-compliant vehicles can purchase a day pass for about €14. Violators are assessed a €176 fine

In Brussels, drivers of non-compliant vehicles can purchase a day pass for €35 to enter the zone (max 8/year). Violators are assessed a €350 fine

LESS BURDENSOME
MORE VEHICLES ENTER THE ZONE

MORE BURDENSOME
FEWER VEHICLES ENTER THE ZONE



BOX 2 THE EVOLUTION OF LOW EMISSION ZONES

The earliest low emission zones emerged in Europe in the late 1990s and were focused primarily on reducing pollution from heavy-duty trucks—the highest emitters on the road—in high density urban areas. LEZ restrictions in Stockholm and other Swedish cities, London, Strasbourg, and Amsterdam only applied to heavy-duty vehicles such as trucks and buses for the first few years of LEZ operation.[31]

LOW EMISSION ZONE 1.0

• Performance-based emission standards on heavy-duty vehicles

To further reduce emissions, similar performance-based restrictions were extended to light-duty vehicles. However, this has raised new equity challenges that had not been a factor in the original LEZ model because fees or restrictions had been shouldered by private companies that own the heavy-duty trucks or buses, not by individual drivers. The efficacy of low emission zones that include light-duty vehicles is limited by the relative ease for middle- and high-income drivers to either pay the fee or purchase a more efficient vehicle to avoid fees or fines. It is often much more difficult for low-income drivers to afford to replace their vehicle, and paying a fee to enter the LEZ represents a larger share of their transportation budget compared to higher-income drivers.

LOW EMISSION ZONE 2.0

• Performance-based emission standards on heavy-duty vehicles

• Performance-based emission standards on light-duty vehicles

Recognizing the equity implications and the lack of consensus on the long-term impacts of LEZs on air quality, a few cities are transitioning into what we refer to as the "3.0" version of low emission zones. This approach builds on the performance-based aspect of a traditional low emission zone but uses complementary measures (e.g., parking reforms, street redesigns, bus electrification) to meet defined outcomes and address equity concerns.

LOW EMISSION ZONE 3.0

• Performance-based emission standards on heavy- and light-duty vehicles

• Complementary policies operating within LEZ support emissions and traffic reduction outcomes

• Focus on equity through redistributive pricing policies

31 Low Emission Zones in Europe: Requirements, Enforcement, and Air Quality.

MILAN, ITALY

A low emission zone known as Ecopass was first implemented in Milan in 2008. Located in the Cerchia dei Bastioni area of central Milan, the zone occupied 8.2 square kilometers. A tiered payment system was based on vehicle emissions, with fees of €10 for Euro 0 diesel cars; €5 for Euro 0 gasoline and Euro 1–4 diesel cars; and €2 for Euro 1 and 2 gasoline cars. Electric and hybrid-electric light-duty vehicles were not charged. There was a 50% discount for residents and a 40% discount for multiple-entry tickets.[32] Ecopass helped reduce traffic by 21% during its first year, as many people switched to transit to avoid paying the fee. However, over time people replaced their vehicles with cleaner ones to avoid the Ecopass charge, and the number of vehicles entering the area eventually increased.[33] By 2012, congestion had returned to pre-Ecopass levels. Around the same time, the city held a referendum on upgrading and expanding Ecopass, which passed with nearly 80% support. The city ultimately upgraded the Ecopass scheme to a congestion charge zone that uses increasingly strict standards to ban high emitting vehicles year over year. The transition was highly supported by the public.[34]

KEY OUTCOMES MILAN			
	Mode shift to public transport was only observed in the short term while residents purchased cleaner vehicles.	After 4 years, traffic returned to pre-Ecopass levels.	The Ecopass zone saw slightly fewer traffic crashes compared to outside of the zone.

Yellow and green signage and cameras alert drivers of the Area C congestion pricing zone in Milan, Italy.
SOURCE: wikicommons

32 An Economic, Environmental and Transport Evaluation of the Ecopass Scheme in Milan: Three Years Later. https://www.researchgate.net/publication/249322950_An_economic_environmental_and_transport_evaluation_of_the_Ecopass_scheme_in_Milan_three_years_later
33 Cede l'effetto-Diga, 7 Mila Auto in Più.
34 Milan: Area C: Fewer Cars, More Public Spaces, Better Life for All.

LONDON, ENGLAND

In 2019, central London implemented an Ultra Low Emission Zone (ULEZ) that requires private and commercial cars, motorcycles, and vans to pay a £12.50 (USD $15.88) fee to enter the zone if their vehicles do not meet the ULEZ emission standards (below Euro 4 gas engines and Euro 6 diesel engines). This fee is in addition to the daily congestion charge paid by nearly all vehicles entering Central London, but it replaces the city's Low Emission Zone and Toxicity (T) charge. Automatic number plate recognition (ANPR) cameras are used to enforce the boundaries of the ULEZ. Drivers must register their car and credit card online to pay the ULEZ charge if their vehicle does not meet the Euro 4/Euro 6 standards. Those who enter the ULEZ without preregistering their vehicle are assessed a £160 penalty. Residents who live within or adjacent to the ULEZ are exempt from the charge until late 2021, when the zone will be expanded.

KEY OUTCOMES LONDON ULEZ		
	13,500 fewer high-polluting vehicles entering the zone daily resulted in a 4% reduction in CO_2 emissions.	Nitrogen dioxide levels fell by one third, and particulate matter (PM) was reduced by 13% within the zone during the first six months.

London's ULEZ and congestion charge operate together on weekdays.
SOURCE: David Hawgood, CC BY-SA 2.0,

BRUSSELS, BELGIUM

The Brussels LEZ covers the entire Brussels-Capital region, which includes 19 municipalities, and was implemented in January 2019. As of January 2020, vehicles that do not meet the Euro 2 standard for gasoline or the Euro 4 standard for diesel are not permitted to enter the LEZ. Noncompliant vehicles can purchase a day pass for €35, but drivers are restricted to a maximum of eight passes per year. Noncompliant vehicles that enter the LEZ without a pass are assessed a €350 fine. **While the LEZ was implemented to combat harmful air pollution, reducing VKT and promoting mode shift away from vehicles are also stated goals of the scheme, which aligns with the Brussels-Capital regional mobility plan.**[35] To this end, the city has also implemented supportive "pull" policies to encourage and maintain a shift away from personal vehicle use and toward public transport, walking and cycling, and shared modes. Residents are given free access to public transit and carshare if they scrap an older vehicle that is not compliant with the city's LEZ standards. Brussels also provides free "mobility visits," which allow people to test out transport services like bikeshare as alternatives to driving.[36] Model estimates anticipate the LEZ will contribute to a two-thirds decline in NO_x emissions across the Brussels-Capital region by 2025.[37]

KEY OUTCOMES BRUSSELS

A 4.7% reduction in NO_x and a 6% reduction in PM were observed during the first six months of LEZ operation.

A 71% reduction of NO_x and a 67% reduction of PM emissions from Euro 0 and Euro 1 diesel vehicles were observed during the first six months.

In Brussels, efforts to encourage a shift to sustainable transport modes, not just a reduction in private car use, contribute to more vibrant, people-focused streets. **SOURCE:** Eo Naya, Shutterstock

35 Expected Effects From the Low Emissions Zone on Car Fleet and Air Quality in the Brussels Region.
36 "Primes" in Quelles Sont les Offres de Mobilité Alternatives Proposées par la Région Bruxelloise?
37 Expected Effects From the Low Emissions Zone on Car Fleet and Air Quality in the Brussels Region.

CONGESTION PRICING

A congestion charge is a fee levied on drivers to enter a designated area that is highly congested. A congestion charge aims to price the additional time each driver imposes on other drivers and to make drivers more aware of congestion and related negative outcomes when making decisions about travel (e.g., mode, trip time, route, or destination). Raising travel costs for private vehicles leads to lower traffic volumes and related co-benefits, such as improved air quality, reduced emissions, less noise, and faster travel times for public transit vehicles. Studies suggest that congestion charging is optimal in areas with limited road capacity, large shares of long-distance commute trips, and alternate travel modes already available.[38 39] Congestion pricing must be accompanied by improvements in public transport, walking, and cycling to support the shift away from private vehicle use.

1. CORDON PRICING

Cordon pricing is the primary congestion charging strategy currently used in cities: An area is cordoned and a fee is charged for vehicles to enter or travel within the cordon. The first city to implement cordon pricing was Singapore in 1998, and it has served as a model for other cities' program designs (see Singapore case study below). Cordon pricing has been primarily implemented as a flat fee to enter, regardless of congestion level. In other words, entering the zone during peak commuting hours is the same price as entering during the middle of the day. Cordon pricing can, however, more directly target peak-hour congestion by charging more during peak times. Cordon pricing requires nearly all vehicles to pay a fee to enter, so travelers must choose an alternative to driving to avoid paying the fee (or share a ride with others to reduce the cost). For this reason, cordon pricing schemes need to be accompanied by high-quality, affordable public transportation as well as safe and comfortable walking and cycling infrastructure.

A portion of revenues from congestion charging in London are funding the expansion of the city's cycling network and other sustainable transport modes. **SOURCE:** European Cyclists' Federation, Flickr

38 The Welfare Effects of Cordon Pricing and Area Pricing: Simulation with a Multi-Regional General Equilibrium Model.
39 "Appendix B19: Cordon Congestion Tolls" in Moving Los Angeles: Short-Term Policy Options for Improving Transportation.

LONDON, ENGLAND

In 2003, London implemented a congestion charge to reduce trip times within the CBD, improve bus service on-time rates, and encourage a shift to public transport. The charging zone covers 21 square kilometers of Central London, and drivers are required to pay a flat fee (£15 in 2020, up from £11.50 in 2019 and £5 when the scheme launched) to enter between 7 a.m. and 10 p.m. every day. Previously, the charge ended at 6 p.m. to lessen the burden on evening shift workers in the theater and restaurant sectors. People living within the charging zone were given a 90% discount, though the zone includes relatively few residential properties. People with disabilities, emergency vehicles, and motorcycles are exempt from the charge. "Ultra low emission" vehicles, which include electric vehicles and cars and vans that meet the Euro 5 standard, are exempt until 2021, when the exemption will be tightened to Euro 6.[40] Private hire vehicles, including ridehail, were initially exempt; however, the number of vehicles operated by companies like Uber has grown significantly in recent years—nearly 10% between 2015 and 2016.[41] Thus, citing air quality concerns, London removed the exemption for private hire vehicles in mid-2019.[42] Taxis, however, are still exempt from the charge.

From the start, the city was committed to providing high-quality transportation alternatives, and it added 300 buses and new routes to the network the day the congestion charge went into effect. Investments in cycling and walking infrastructure projects have also been prioritized to support modal shift. Transport for London capitalized on the lower traffic volumes that resulted from the charge, claiming space for new bus and cycle lanes. Revenues from the charge are legally allocated to public transit, cycling, and walking improvements—a critical move to secure public support and to maintain quality and reliability for driving alternatives.[43]

KEY OUTCOMES LONDON				
	After one year, 29,000 more bus passengers entered the zone during morning peak hours compared to the previous year, and peak-period bus delays dropped by 50%. There was a 15% reduction in VKT within the charging zone after one year of operation; an additional 11% VKT reduction was observed after the Western Extension zone was implemented.	After three years, congestion had been reduced by 30%, and by 2014, 39% fewer private vehicles were entering the congestion charge zone.	Revenues of at least £100 million (USD $129 million) have been generated annually since 2008; revenues surpassed £150 million (USD $194 million) each year between 2014 and 2018.	Despite mode share increases for cyclists and pedestrians, a 17% decrease in traffic crashes with cyclists and a 15% decrease in crashes with pedestrians during congestion charge hours were observed.

40 How Road Pricing Is Transforming London–and What Your City Can Learn.
41 London Congestion Charge Has Been a Huge Success. It's Time to Change It.
42 PHVs and the Congestion Charge.
43 How Road Pricing Is Transforming London—and What Your City Can Learn.

STOCKHOLM, SWEDEN

Stockholm was one of the first cities to implement a low emission zone (LEZ) to reduce pollution from heavy-duty vehicles. However, in 2007, after a decade in operation, congestion was still increasing and ran the risk of negating other positive benefits of the LEZ, like pollution reduction. At that time the idea of implementing a congestion charge was politically contested, with only 36% of the public supporting the idea.[44] As a result, the city's coalition government introduced a six-month pilot that would be followed by a referendum. During the pilot period, congestion fell by over 20% and many commuters shifted to public transit. Many drivers liked that their trip times were more reliable and that revenues helped support not just public transport but also some road improvements. After the pilot period ended, public approval for congestion pricing increased to over 50%, and a permanent plan was implemented.[45] Over time, public support has grown even further. The Stockholm program also adopted a fiscal incentive to ease public resistance: Congestion charge fees paid for commuting can be deducted from income taxes.[46] The congestion charge zone covers a smaller area than the LEZ (30 km^2) and applies to all vehicles except buses and foreign-registered cars. Monitoring of the congestion zone perimeter is done via automatic license plate recognition. Drivers are charged each time they pass the entrance cordon, but this is capped daily for each individual vehicle. Fees vary throughout the day, and failure to pay the fee triggers a penalty of SEK 500 (€48). A congestion charge fee increase was implemented in 2016, raising the peak price by 75% from €2 to €3.5 and the off-peak price from €1 to €1.1. Traffic volumes fell by 5% following the price increase compared to the previous year, and the program generated €140 million in revenue.[47]

KEY OUTCOMES STOCKHOLM			
	Trip times in central Stockholm declined; queuing times were reduced by about 33% during morning peak hours and by 50% during evening peak times.	Compared to 2005 traffic levels, traffic reductions between 18% and 22% were observed annually between 2006 and 2013.	Generates approximately USD $155 million in annual revenue, which supports public transport and road improvements.

Revenues from congestion pricing in Stockholm, Sweden support public transportation improvements. **SOURCE:** Iulianna Est, Shutterstock

44 Toward Car-Free Cities: Stockholm Shows the Sometimes-Bumpy Road to Congestion Charges.
45 Study on International Practices for Low-Emissions Zone and Congestion Charging.
46 The Potential of Road-Pricing Schemes to Reduce Carbon Emissions.
47 Long-Term Effects of the Swedish Congestion Charges: Discussion Paper.

MILAN, ITALY (AREA C)

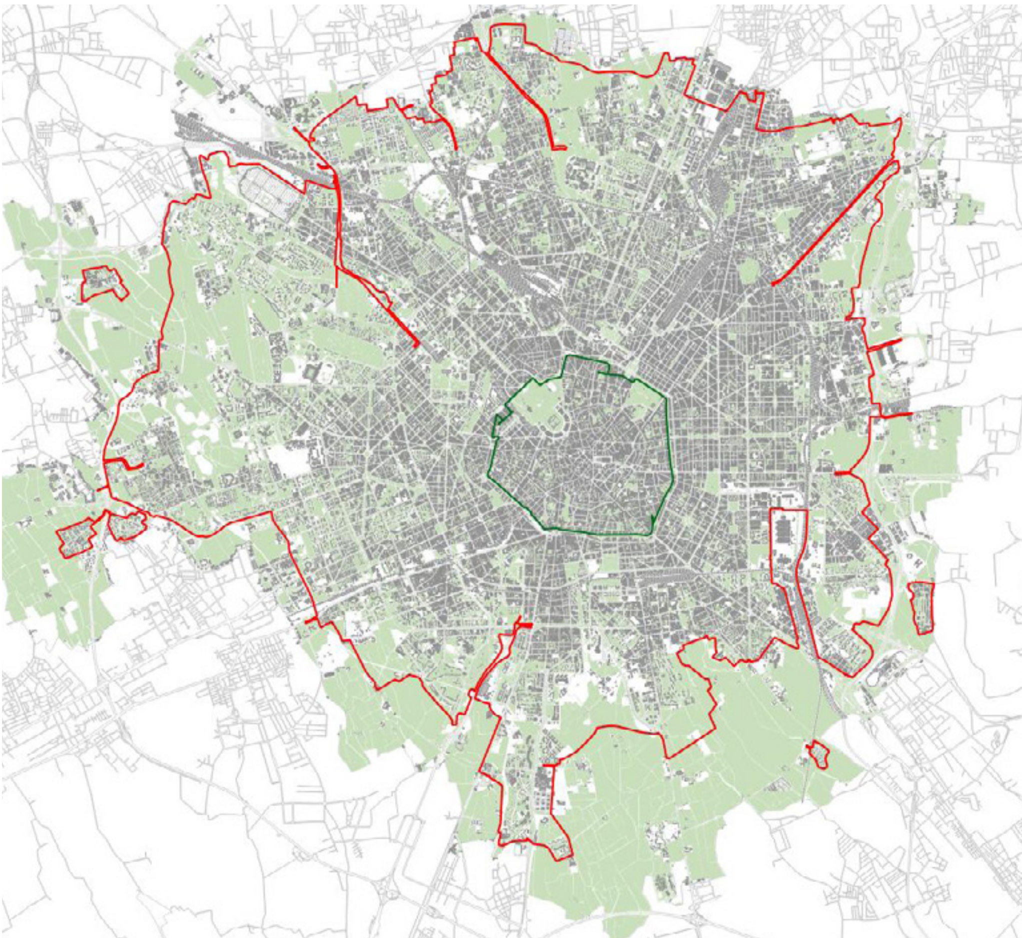
Replacing Milan's Ecopass emissions pricing program in 2012, the Area C program established a €5 congestion charge for most vehicles entering the previously established Ecopass area on weekdays from 7:30 a.m. to 7:30 p.m. Electric vehicles, motorcycles, taxis, and public transit vehicles are exempt from the charge. Highly polluting diesel (below Euro 4 engines) and gasoline cars (below Euro 0 engines) are not permitted to enter the zone at all. Violators are assessed a €87 fine. In 2019, Milan implemented Area B, a limited traffic zone that surrounds Area C and covers most of the city. Area B carries additional emissions-based vehicle restrictions.

KEY OUTCOMES **MILAN AREA C CONGESTION CHARGE**			
	After three years, CO_2 levels within the zone had decreased 33% compared to 2010 levels.[48]	The program generated €30 million in revenues in 2017, with about €4 million covering program operating costs and the rest funding public transit frequency improvements and other sustainable transport projects.[49]	Having fewer cars in the city center enabled Milan to repurpose 15,000m2 along the front of the Castello Sforzesco into a pedestrian area and to replace on-street parking spaces with bikeshare and carshare stations throughout the city.[50]

Area B

Milan city boundary

Area C



Milan's Area B, a limited traffic zone that covers almost the entire city, requires vehicles to meet emissions-based criteria to enter. Area C, the congestion charge zone that covers the city center, requires vehicles to pay to enter. **SOURCE:** wikicommons

48 The Potential of Road Pricing Schemes to Reduce Carbon Emissions.
49 https://www.transport.govt.nz/assets/Uploads/Report/DArtagnan-appendices-to-be-released.pdf
50 Charging Scheme in City Center (Area C) and Other Strategies in Milan.

2. DISTANCE-BASED PRICING

Unlike cordon pricing, which charges drivers a flat fee to enter a zone, distance-based pricing charges a variable fee based on time spent and/or distance traveled within a zone. The dynamic fee can increase during peak congestion periods, which aligns more closely to the economic principle underlying congestion pricing than does a one-time flat fee.[51] Thus, unlike a flat fee charged through cordon pricing, distance-based pricing links the amount of driving an individual does (and, relatedly, the amount of congestion, air pollution, and other negative externalities they are responsible for) to the amount they pay. Academic models show that distance-based congestion pricing and cordon pricing both reduce congestion; however, distance-based pricing more effectively reduces delays and can do so with lower fees.[52] Though Singapore announced plans to implement a "next generation" distance-based congestion charge sometime in 2020, there are no examples of distance-based central area congestion pricing schemes in current operation.[53]

Vehicle miles traveled (VMT) fee pilots in Oregon and California in the United States are a type of distance-based pricing as they charge drivers based on the distance they travel, though these are not congestion-based. High-occupancy toll lanes or dynamically priced express lanes in San Diego, Orange and Riverside Counties in California, Houston, Denver, Maryland, northern Virginia, and a few other regions in the United States charge time-of-day and distance-based tolls using special express lanes, with fees adjusted to keep traffic flowing. Some of these facilities are free or discounted for high-occupancy vehicles, and some dedicate a portion of toll revenue to support bus service or to allow free or discounted passage for buses. These are not located in central urban areas, however, and primarily serve to distribute traffic among parallel uncharged routes.

In Singapore, the congestion charge zone is delineated by overhead gantries which show the current price to enter the zone. **SOURCE:** Tim Adams (Flickr)

SINGAPORE

In 1998, Singapore became the first city in the world to use electronic road pricing (ERP)—namely, gantries and in-vehicle readers—to operate a congestion charging zone, replacing the area licensing program that had been operating since 1976. Singapore's ERP is the most sophisticated road-user charging scheme globally, with prices adjusted as frequently as every few minutes at more than 75 charging points across the network. Prices are set with a goal of keeping the roads free-flowing at least 85% of the time. Citing increases in operating and maintenance costs of its now decades-old ERP system, Singapore's Ministry of Transport announced in 2014 that it would begin to transition to a distance-based ERP in 2020. Vehicles will be tracked using GPS and charged based on distance traveled. The new system will replace existing in-vehicle ERP readers with on-board units (OBUs) that provide real-time information about road prices, traffic, and on-street parking availability. Existing ERP gantries will also be phased out. Heavy road users such as taxis and other private-hire vehicles expect high charges, which could be passed to consumers.[54] Additional concerns have been raised about privacy and unlawful surveillance generated from the presence of GPS-enabled OBUs in every vehicle.[55]

51 Congestion is understood as a "commons" problem in that a good that is held in common will be overused—no single entity is incentivized or authorized to protect it, so it is overused to the detriment of all. Congestion pricing, a Pigouvian tax, is meant to internalize to the user the externality of economic harm caused by the use of the common, thus ensuring appropriate use.
52 Distance-Dependent Congestion Pricing for Downtown Zones.
53 Ministry of Transport: ERP.
54 Shift to New ERP System Starts Next Year with Free in-Vehicle Unit Swap.
55 Singapore Losing Sight of Privacy in Next-Gen Tech Ambitions.

REALLOCATING ROAD SPACE FOR PEOPLE

Reallocating road space and priority away from private vehicles improves safety and comfort for pedestrians, cyclists, and public transit users. Road space reallocation strategies can range from pedestrian-priority streets, where all vehicle traffic is banned, to complete streets, where vehicles are permitted but space is clearly prioritized for people and public transit. Limiting vehicle access through street design incentivizes drivers to seek alternative routes and encourages people to shift away from driving as walking, cycling, and public transit become the fastest, safest options. This allows for some traffic diversion to higher capacity streets without the need to establish or enforce a designated zone.

It is worth noting that these strategies, perhaps more so than the others evaluated in this paper, can pose significant challenges to urban freight logistics. Streets with cycle lanes and high pedestrian volumes can create new curbside access challenges for commercial vehicles, which can in turn lead to commercial vehicles blocking cyclist or pedestrian infrastructure and creating unsafe conditions for these groups. Strong curb management (see Parking Pricing, above) and freight movement strategies are needed to reduce these interactions.

1. PEDESTRIAN-PRIORITY STREETS

Pedestrian-priority streets ban or heavily restrict vehicle access (e.g., off-peak delivery or emergency vehicles only) and prioritize space and safety for pedestrians and cyclists. Access and travel within pedestrian-priority streets is easiest for pedestrians and cyclists, which can help encourage a shift away from driving and toward these modes. This design treatment is typically implemented on streets with lots of commercial activity that generates demand for many types of uses, such as shopping, dining, gathering, and vending. Integrating placemaking elements, seating, and programming throughout can elevate a pedestrian-priority street to a destination in and of itself in addition to its ability to provide a comfortable connection to other places.

Renderings of the anticipated Imbuga City Walk car-free corridor in Kigali, Rwanda. **SOURCE:** Kigali Master Plan 2050

KIGALI, RWANDA (KN 4 AVENUE/IMBUGA CITY WALK)

Kigali began prioritizing pedestrianization of streets in its 2013 Master Plan, highlighting the need to provide green, livable spaces that facilitate economic vitality and social equity. In August 2015, the city introduced a plan to pedestrianize KN 4 Avenue located in Kigali's central business district. A master plan to improve pedestrian conditions along the car-free corridor, branded the Imbuga City Walk, was developed in 2017 and is awaiting implementation.[57] In the meantime, the corridor is used for bi-monthly car-free days in Kigali and serves as the gathering and starting point for walking and cycling. This has led to use of the corridor for other types of gatherings where vehicles are restricted—it's a downtown open market for local producers and a preferred place for events such as art exhibitions, concerts, and fitness clinics.

Streets in the Liuyun Xiaoqu neighborhood in Guangzhou are designed for people instead of cars. **SOURCE:** ITDP

GUANGZHOU, CHINA (LIUYUN XIAOQU)

Just a short walk from BRT and metro transit stations, Liuyun Xiaoqu is an accessible commercial area and center for public life in Guangzhou. The neighborhood was designed in the 1980s and prioritizes pedestrians by creating a continuous walking network made up of 125 safe, accessible walkways and streets shared with bicycles. In contrast to similar neighborhoods in China that are gated, Liuyun Xiaoqu's paths are accessible throughout the day, encouraging diverse users and walkway connectivity throughout the area. By removing parking and making alleys public, this development has become a center for commerce, recreation, and enjoyment. However, property values within Liuyun Xiaoqu have increased at a faster rate compared to the surrounding Tianhe District, which, on the one hand, demonstrates the social value of and demand for this type of design, but has also resulted in reduced affordability.[58]

Rua XV de Novembro in Curitiba, Brazil has become a social gathering place since it closed to cars in 1972. **SOURCE:** Shutterstock

CURITIBA, BRAZIL (RUA XV DE NOVEMBRO)

Originally known as Rua das Flores, Rua XV de Novembro was the first major pedestrian street in Brazil and started restricting access to vehicles in 1972. The pedestrianization effort was unpopular at first, as the transformation had not been previously announced. Planners realized that they had not garnered sufficient input from local stakeholders. Eventually they designed alternate traffic patterns that reduced the need to drive on Rua XV de Novembro, and they consulted shop owners along the street about their preferences in regards to streetscape redevelopment. Having no loud or dangerous vehicle traffic has led to tangible livability improvements—Rua XV de Novembro is now a gathering place and commercial destination for both tourists and residents.[59] Cultural and social events are common throughout the space, set against a backdrop of traditional architecture, flower boxes, and street furniture.

56 Freight in a Bicycle-Friendly City: Exploratory Analysis with New York City Open Data.

57 Car-free Zone Redevelopment to Commence Early Next Year.
58 TOD Best Practical Case: A Mixed-Mode Open Court.
59 Jaime Lerner on Making Curitiba's First Pedestrian Street.

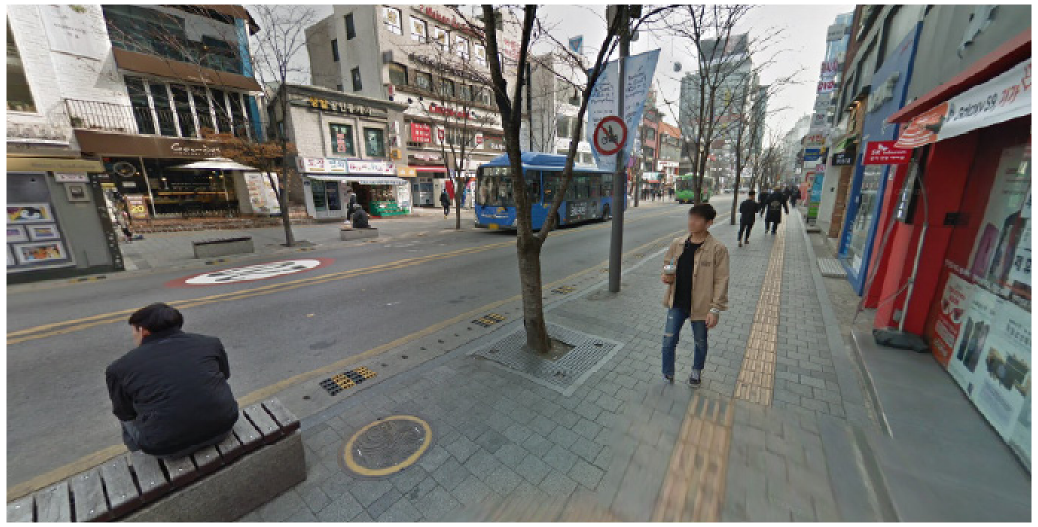
2. TRANSIT MALLS

Transit malls are typically made up of a corridor or multiple streets where vehicle traffic is banned or heavily restricted and public transit vehicles, cyclists, and pedestrians are prioritized. Transit malls reduce traffic by restricting access to most vehicles during the day, creating a safer, quieter, less polluted environment for people walking, cycling, and visiting public spaces. Transit malls may be located at "transport hubs" where multiple public transit systems come together, facilitating easier transfers between systems and modes.

SEOUL, SOUTH KOREA (YONSEI-RO)

Seoul's first transit mall opened in 2014 along Yonsei-ro in the Sinchon neighborhood, which also includes Yonsei University. Once a heavily congested four-lane road, Yonsei-ro is now car-free from the University to the Sinchon metro station. Buses (and taxis from midnight to 4 a.m. when public transit is not operating) are the only vehicles permitted in the corridor.[60] Intersection improvements and detour routes were implemented on surrounding roads to support traffic diversion off Yonsei-ro and mitigate spillover congestion. On Yonsei-ro, one traffic lane in each direction was removed and the sidewalks on both sides of the street were widened significantly. Permanent vending stalls were installed to limit vendors' use of carts, which previously had blocked the pedestrian right-of-way on sidewalks.[61]

KEY OUTCOMES YONSEI-RO TRANSIT MALL			
	Surveys showed an 11% increase in bus commuters along the corridor following implementation.	Commercial businesses along the corridor saw an 11% increase in revenue-generating transactions and a 4% increase in total revenues.	Traffic crashes were reduced by 34% compared to before the project was implemented, and pedestrians reported feeling safer walking through the corridor.



Once crammed with traffic, Yonsei-ro has been converted into a bus-only transit mall where pedestrians enjoy wide sidewalks, seating, and a low-stress walking environment. **SOURCE:** Google Maps

60 [Road Diet for a More Active Street.]
61 [Yonsei-ro, Seoul's First Transit Mall.]

Jaffa Road in Jerusalem features a wide, safe pedestrian footpath **SOURCE:** commons.wikimedia.org

JERUSALEM, ISRAEL (JAFFA ROAD)

Jaffa Road is one of the oldest streets in Jerusalem and connects the city's east and west sides. Once a major artery for vehicles, Jaffa Road was redeveloped decades ago to only allow public buses and taxis as part of a broader effort to revitalize downtown Jerusalem and attract businesses and residents back to the city center. However, due to the high number of old diesel buses traveling through the corridor, travel speeds were relatively low and noise and air pollution were major concerns.[62] Since 2011, the Jerusalem Light Rail's red line has replaced the chaotic and congested network of buses as the sole public transit offering along the Jaffa Road corridor. The street now supports dense numbers of pedestrians and cyclists, commercial activity, and gathering spaces.

NEW YORK CITY, USA (14TH STREET BUSWAY)

In October 2019, 14th Street between 3rd and 9th Avenues in Manhattan was closed to through traffic as part of a pilot, creating an exclusive thoroughfare for public buses and commercial and emergency vehicles. Cars are able to enter the corridor to pick up or drop off, but signage directs them to turn off 14th Street at each intersection. Drivers who stay on the corridor for longer are subject to a fine of USD $50; a graduated fine structure for subsequent violations is meant to encourage compliance. Enforcement is facilitated by cameras mounted to buses.[63] Some area residents were strongly opposed to the 14th Street Busway plan, mounting legal challenges to the project that cited concerns about spillover traffic onto side streets surrounding the corridor. The busway was made permanent in June 2020, with plans to expand it further east.

KEY OUTCOMES NEW YORK CITY 14TH STREET BUSWAY			
	Bus trip speeds increased by up to 47%, and ridership on certain bus routes along the corridor increased an average of 24% during morning peak hours.	Trip times using side streets increased slightly, between 0 and 3 minutes; vehicle volume on parallel streets saw little change (12th Street) or decreased (13th Street).	A 17% increase in Citi Bike ridership on 14th Street and nearby streets, compared to the previous year, was observed, which outpaced bikeshare-usage growth in the rest of the city.[64]

The 14th Street Busway in New York City prioritizes buses and commercial vehicles along a six-block corridor, and resulted in increased bus speeds and ridership. **SOURCE:** Metropolitan Transportation Authority (Flickr)

62 [From Mule Tracks to Light-Rail Transit Tracks: Integrating Modern Infrastructure into an Ancient City—Jerusalem, Israel.]
63 [14th Street Select Bus Service with Transit & Truck Priority Pilot Project.]
64 [14th Street Transit + Truck Priority Pilot Project Quarterly Report, Winter 2020.]

3. COMPLETE STREETS AND OTHER PEOPLE-FIRST STREET DESIGNS

Complete streets are designed to meet the needs of all road users, which means all ages and abilities of pedestrians, cyclists, public transit riders, and drivers. Instead of prioritizing vehicle speeds, complete streets incorporate elements that make travel by non-car modes easier, safer, and more comfortable. These elements can include bicycle lanes, transit-only lanes, wider sidewalks, raised crosswalks, median islands, accessible transit stops, seating, and shade. Complete streets also provide continuous facilities for walking, cycling, and public transport. Vehicles are not banned from complete streets; instead, some of the space dedicated to cars is reallocated to sustainable transport modes and improved public spaces.

BELOW: Pedestrians enjoy vibrant areas meant for social interactions along the renovated JM road in Pune. **SOURCE:** ITDP India

ABOVE: Av. Central, Cidade 2000. Fortaleza, Brazil **SOURCE:** City of Fortaleza

PUNE, INDIA (JANGALI MAHARAJ OR "JM" ROAD)

Since 2009, Pune has been improving its network of sidewalks and cycle tracks to support safe, convenient walking and cycling. The success of early projects encouraged city officials to develop the Pune Streets Program, a plan to build out 100 kilometers of Complete Streets.[65] The first phase began in 2018 with a commercial section of Jangali Maharaj or "JM" Road. Regulating what was once haphazard vehicle parking freed up space to add a cycle track and widen sidewalks, as well as green spaces acting as buffers between pedestrians and cyclists. Seating, play spaces for children, and improved lighting and signage further activate the street.[66]

FORTALEZA, BRAZIL (AV. CENTRAL, CIDADE 2000)

Avenida Central is a 100-meter street that runs through the center of the Cidade 2000 neighborhood of Fortaleza, Brazil. Previously a space almost exclusively for vehicle travel, the street was redeveloped in 2017 under Fortaleza's City for People project, which aims to improve safety and enhance public spaces for people. A low-speed zone—the first phase of the project—was implemented in just two days using flexible, inexpensive materials like paint, planters, and movable furniture. One lane for vehicle traffic was preserved, but the majority of the street space was reclaimed for pedestrians. Following the intervention, survey respondents reported feeling much safer walking on the street than they had previously, and pedestrian volumes increased by 350%. Vehicle counts conducted in the neighborhood showed no change in throughput as a result of the changes.[67]

NEXT PAGE: Lavalle street in Microcentro, Buenos Aires is fully pedestrianized, with a wide footpath that facilitates a lively pedestrian zone. **SOURCE:** ITDP

BUENOS AIRES, ARGENTINA (ÁREA MICROCENTRO)

With the implementation of its Sustainable Mobility plan in 2009, Buenos Aires has sought to use pedestrian and cyclist prioritization as a way to "democratize the street," allocating space away from vehicles that only

account for 10% of downtown trips.[68] Nearly two out of every three households in Buenos Aires and its surrounding areas do not own a car. In the past decade, the city has installed over 100 blocks of pedestrian streets downtown—some are completely car-free, others include widened protected spaces for pedestrians and cyclists, with one lane for vehicles restricted to a maximum of 10km/h.[69] Improved lighting, trees and planters, and new cycle lanes further increased comfort and safety along these streets.

BARCELONA, SPAIN (SUPERBLOCKS)

Perhaps one of the most recognized examples of the complete streets approach is Barcelona's Superblocks. The city has been committed to pedestrianization since the 1980s, starting with pedestrianizing the old quarter and other plazas throughout the city. Barcelona's Urban Mobility Plan for 2013–2018 introduced the Superblock model, an approximately 400-by-400-meter area made up of 150-by-150-meter blocks.[70] On streets within the Superblock, vehicles are restricted to 20km/h and through-access is limited by right-turn-only streets. Parking and intersection space is reclaimed for walking and cycling facilities and public gathering areas. Alongside the implementation of Superblocks, Barcelona has also committed to building out its network of cycling infrastructure and introducing a new orthogonal bus network designed to increase access and reliability.[71] Three Superblocks have been implemented and six more are in progress. These have been found to generate positive health outcomes, including reducing air and noise pollution and improving activity levels and access to green space.[72]

KEY OUTCOMES BARCELONA SUPER-BLOCKS		
	Traffic volumes on internal streets within the Gràcia Superblock have been reduced by 40%, and volumes are 26% lower across the superblock.[73]	The Sant Antoni Superblock has reclaimed more than 25,000 square meters of public space from vehicles.[74]

Before and after the superblock implementation at Carrer de Sancho de Ávila in Barcelona. Trees, benches, and a play area for children replaced car parking and wide traffic lanes. **SOURCE:** Google Maps

65 Complete Streets Best Practices | Complete Streets Toolkit: Volume VII.
66 In India, the City of Pune Is Making Space for Transit and People.
67 Reshape Streets, Reconnect Communities: Reclaiming Streets in Fortaleza, Brazil.
68 El Plan de Movilidad Sustentable para la Ciudad de Buenos Aires.

69 Walk This Way: In Buenos Aires Pedestrian Streets Are the Way of the Future.
70 Mobility and Transport: Urban Mobility Plan. https://www.barcelona.cat/mobilitat/en/about-us/urban-mobility-plan
71 Barcelona's New Bus Network. https://bcnroc.ajuntament.barcelona.cat/jspui/bitstream/11703/115929/5/NovaXarxaBus_20-09-2019_eng.pdf
72 Changing the Urban Design of Cities for Health: The Superblock Model.
73 Spain's Plan to Create Car-Free "Superblocks" Is Facing Protests.
74 The new Sant Antoni superblock regains 5,000 square meters for use by local residents.

LIMITED TRAFFIC ZONES & ZEAS

Limited traffic zones (LTZs) restrict access into the zone for most vehicles and charge a high penalty to unauthorized vehicles that enter the zone. Residents, public transit, emergency vehicles, and often taxis are typically exempt and able to enter the zone without restriction. Delivery vehicles are typically restricted to enter the zone only during overnight or off-peak hours. Permitted vehicles are given a sticker or decal or are able to lower bollards installed around the perimeter of the zone to enter. No other vehicles are permitted. Limited traffic zones have been particularly popular in cities with historic centers, such as Rome and Tehran, which were not built to handle heavy vehicle congestion. Limited traffic zones can quickly reduce vehicle volume, freeing up space for streetscape redesigns that prioritize walking and cycling.

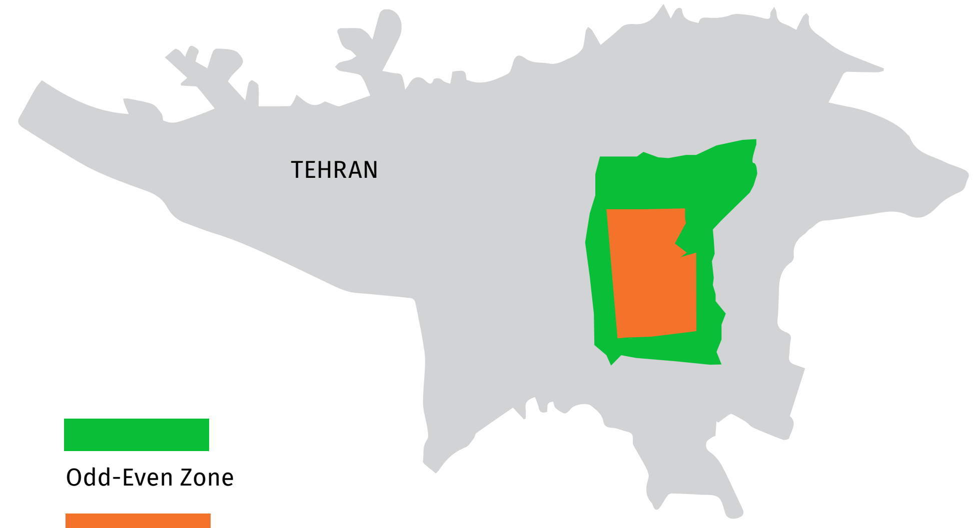
Although none are yet in operation, proposed zero emission areas (ZEAs) would function in a similar way to limited traffic zones, at least in the short term, until enough people shift to electric cars to cause traffic to rebound. A ZEA is designed to be more stringent compared to a low emission zone, allowing only zero emission vehicles and other authorized vehicles to enter. While this stringent design may result in less driving (i.e., fewer trips and VKT) than a traditional fee-based low emission zone that allows noncompliant drivers to pay to enter the zone, equity concerns may still arise and will need to be addressed by the design. For example, low income groups are most likely to own older, less fuel-efficient vehicles, which would prevent them from driving into the zone. Therefore, as in the case of limited traffic zones, ZEAs must prioritize alternatives to driving such as public transport, walking, and cycling.

TEHRAN, IRAN

Tehran's Restricted Traffic Zone (RTZ) has been operating in some form since 1979. In its current form, the RTZ restricts car access within a 32km² zone in downtown Tehran on weekdays. Drivers may enter this zone only if they have a daily, weekly, or annual pass, and only certain types of drivers, including government and medical staff and people with disabilities, qualify for passes. Unauthorized vehicles that enter the zone are assessed a penalty of up to USD $230. Unlike most other limited traffic zones, authorized vehicles are still required to pay a fee, similar to cordon pricing, to enter the zone. The RTZ perimeter is monitored electronically with cameras. Tehran's RTZ is surrounded by a larger Odd-Even Zone (OEZ), which only allows access to drivers with license plates ending in an odd number on odd days of the week and an even number on even days of the week.

KEY OUTCOMES TEHRAN RESTRICTED TRAFFIC ZONE			
	Car use has decreased in both restricted zones, compared to the rest of the city where no restrictions are in place.	Car use in the RTZ is much lower than use of public transit and walking compared to in the OEZ.[75]	Travel times in the RTZ and OEZ have increased, possibly due to limited and low-quality infrastructure for non-car modes.

Tehran has two simultaneous traffic reduction strategies: an odd-even zone which restricts which days certain vehicles can drive, and a restricted traffic zone which, on top of the odd-even license plate restrictions, only allows permitted vehicles to drive into downtown on weekdays.
SOURCE: Adapted from Salarvandian et al., 2017. https://doi.org/10.5198/jtlu.2017.1087



ROME, ITALY

In Italy, restricted traffic zones are known as "zonas a traffico limitato" (ZTLs). In many Italian cities, like Rome, these zones encircle historic centers that predate vehicle traffic. Thus, street capacity cannot support typical traffic volumes. Furthermore, in Rome in particular, city officials were concerned about the impact of vehicle emissions on ancient landmarks like the Coliseum. The city's first ZTL perimeter, established in 1989, was marked with signs, which proved difficult to enforce. Signs were replaced in 1994 with gates staffed by police officers tasked with fining violating vehicles. Starting in 1999, the city installed an Automatic number plate recognition (ANPR) system to monitor zone entrances. As of 2015, Rome has seven ZTLs, each with slightly different restrictions and operating hours. Exemptions to Rome's ZTLs are made for residents, taxis, buses, and emergency vehicles, as well as motorcycles and vehicles transporting people with disabilities.[76]

KEY OUTCOMES ROME ZTL			
	A 13% reduction in traffic (2004 evaluation) was observed compared to before ANPR cameras were installed, and an additional 5% reduction in car trips was reported as part of a 2014 evaluation.	Public transport trips increased by nearly 4% and pedestrian/cycling trips increased by 1.5%.	Ownership rates of motorcycles and motor scooters, which are exempt from the ZTL restriction, increased by 50%.

75 Impact of Traffic Zones on Mobility Behavior in Tehran, Iran.

76 The Most Widespread Traffic Control Strategy You've Never Heard of: Traffic Restricted Zones in Italy.

In Madrid, road markings alert drivers to streets that are part of Madrid Central, the city's limited traffic zone. **SOURCE:** Thomas Holbach, wikicommons

MADRID, SPAIN

Known as Madrid Central, the city's limited traffic zone covers nearly five square kilometers of the city center and integrates parking with emissions-based restrictions. Residents, people with disabilities, and zero-emission, emergency, and public transit vehicles are permitted to enter the zone without restriction. All other vehicles are subject to entering and parking restrictions within the zone depending on their emissions level, and they are assessed a €90 fine for violating these rules. Vehicles with an ECO sticker (hybrid vehicles) can enter and park within the zone up to a maximum of two hours. Vehicles with a C or B sticker (petrol cars and light-duty vans manufactured after 2000, and diesel cars and light-duty vans manufactured after 2014) are permitted to park in a public lot or garage but cannot park on the street.[77] Older vehicles may not enter the zone. Initially launched in November 2018, these restrictions are set to tighten over time, and by 2025, non-stickered vehicles will not be permitted to enter Madrid Central at all.

KEY OUTCOMES MADRID CENTRAL

Early evidence showed traffic volumes fell between 5% and 32%, depending on the corridor.[78]

Public bus speeds increased by 14%.

Reductions in through traffic and the number of high-polluting vehicles driving into the zone resulted in reduced nitrogen dioxide levels at nearly all monitoring stations throughout the entire city and a 20% reduction within Madrid Central one year after implementation.[79]

77 Madrid Central. Información General.
78 El Centro de Gestión de la Movilidad de Madrid: "Parece que los Coches han Desaparecido."
79 Madrid Central Reduces Pollution by 20% in Its First Year.

3 STRATEGY EVALUATION

In this section we introduce three criteria for evaluating the strategies outlined in Section II.

3.1 Ability to reduce traffic and improve well-being
City elected officials often tout the link between traffic reduction and improved livability. We evaluate how each strategy contributes to targets that many cities have identified as resulting in a more livable urban environment, such as reducing vehicle access to certain areas, reducing vehicle kilometers traveled, and raising revenue for street improvements that benefit all users.

3.2 Ability to further sustainable transport goals
We explore how well traffic reduction strategies meet the sustainable transport goals of a) improving access, b) reducing harm to the environment and human health, c) improving safety, and d) using resources efficiently. These may be more theoretical and complicated to measure (given confounding factors) compared to the traffic reduction outcomes described in 3.1.

3.3 Capacity required for effective implementation
The capacity required to implement traffic reduction policies may have a significant impact on the decision to adopt certain policies over others. For example, the large majority of fee-based traffic reduction policies have been implemented in large cities in high income countries. Road space reallocations and other non-fee-based strategies have been successfully implemented in large, medium, and small cities of all income levels. By assessing the capacity needed to implement a policy, governments can more effectively select policies suited to their situations.

The evaluations in 3.1 and 3.2 combine to produce an overall link (low, medium, or high) to traffic reduction for each strategy, whereas 3.3 evaluates the capacity required to implement each strategy. The impacts of traffic reduction strategies can be complicated to measure, which makes it difficult to evaluate their success. It can be particularly challenging to identify the extent to which confounding factors, such as weather patterns (in the case of emissions) or complementary policies, contribute to observed impacts.[80] While the evaluations in this section do not involve sophisticated quantitative modeling techniques, they follow findings from literature related to these topics and ITDP's field experiences to provide a framework for comparison and outcome-oriented decision making (see Our Approach).

3.1 ABILITY TO REDUCE TRAFFIC AND IMPROVE WELL-BEING

First, we evaluate whether and how the policies introduced in Section II achieve livability and well-being goals, which may already be identified by cities. For example, if a city is trying to reduce overall vehicle kilometers

80 Review of the Efficacy of Low Emission Zones to Improve Urban Air Quality in European Cities.

traveled (VKT), implementing a commercial parking tax or low emission zone alone will not yield that outcome long-term. Or, an emissions pricing scheme that requires high-emitting vehicles to pay a fee might successfully satisfy a pollution reduction goal, but it may not reduce the number of vehicles on the road. Certain strategies, such as parking reform, can help achieve multiple outcomes. Of course, the specific policy design will significantly impact the extent to which these outcomes are achieved (or not). **In addition, it is important not to let a specific "solution" or technology define the problem or outcomes.**

	Revenue generation ↑	Fewer cars in specified areas ↓	Cleaner cars ↑	Fewer VKT ↓	More trips by sustainable transport ↑
DEMAND-BASED PARKING	●	●	X	●	**design dependent**
OFF-STREET PARKING REFORMS	X	●	X	●	X
COMMERCIAL PARKING TAX	●●	X	X	X	X
EMISSIONS-BASED PRICING (LEZ/CAZ)	X	X	●●	**design dependent**	X
CONGESTION PRICING	●●	●●	X	●	●
REALLOCATING ROAD SPACE FOR PEOPLE	N/A	●	X	●	●●
LIMITED TRAFFIC ZONES (ZEA)	N/A	●	X	X	X

X No evidence found ● Link supported by evidence ●● Link strongly supported by evidence

REVENUE GENERATION

While all fee-based strategies inherently generate revenue, revenues are, in many cases, largely used to operate and maintain the system itself. However, some strategies generate significant revenue beyond what is needed to manage the program. Congestion charging schemes produce substantial revenues over a relatively short time. London's congestion charge has consistently generated over £100 million (USD $129 million) annually since 2008, surpassing £150 million (USD $194 million) each year between 2014 and 2018.[81] Stockholm's congestion charge, in operation since 2007, costs nearly USD $12 million per year to operate, but it generates an annual revenue of approximately USD $155 million.[82] Revenues are often used to support public transport, cycling, or pedestrian infrastructure improvements. These investments strengthen the scheme, providing safe, affordable, reliable alternatives to driving. In some cases, a portion of revenue is used to help people transition to a more sustainable mode (such as free or reduced public transport fares).[83]

Pricing on-street parking also generates revenue. In its first year of operation, ecoParq in the Polanco neighborhood of Mexico City generated 57.7 million pesos (USD $4.49 million) in revenue. Much of that was used to cover program expenses, but 17.3 million (USD $1.35 million) went towards public space renewal projects, like sidewalk improvements in Polanco where ecoParq first operated.[84] San Francisco's demand-based parking program, SFpark, increased net parking revenues by USD $1.9 million per year.[85] Commercial parking taxes have also proved successful in raising significant revenues. Sydney's commercial parking tax generates approximately AU $100 million (USD $65.5 million) annually, and Seattle's brought in approximately USD $21 million in 2010, which is on par with municipal parking meter revenues of $28.6 million the same year.[86]

FEWER CARS IN SPECIFIED AREAS

Cities can restrict vehicle access to certain areas (like central business districts) using fee-based and non-fee-based strategies. Both cordon (in practice) and distance-based (in theory) congestion charges require drivers to shoulder more of the social and environmental costs of driving, and therefore fewer cars will enter the charge zone as people shift to cheaper alternatives. Indeed, bus ridership and use of bicycles increased during morning peak commute hours following the introduction of Central London's congestion charge.[87] Fewer cars entering downtown may not, however, result in reduced congestion if space previously used by cars (e.g., parking, travel lanes) is repurposed for other modes, as was done in Milan and London. Thus, congestion reduction may not be a sufficient proxy for reducing car use. Parking reforms, particularly introducing off-street parking maximums, can also result in fewer cars by restricting the space available for longer-term vehicle storage. Off-street parking restrictions may also discourage people from owning more than one vehicle.[88]

81 London Congestion Charge: What Worked, What Didn't, What Next.
82 Why It's Time for Congestion Pricing in New York City.
83 Primes" in Quelles Sont les Offres de Mobilité Alternatives Proposées par la Région Bruxelloise?
84 Impacts of the EcoParq Program on Polanco.
85 SFpark Pilot Project Evaluation Summary.
86 Evaluating Seattle Parking Tax Options.
87 London Congestion Charge: What Worked, What Didn't, What Next.
88 Residential Off-Street Parking Impacts on Car Ownership, Vehicle Miles Traveled, and Related Carbon Emissions: New York City Case Study.

Pedestrians and cyclists enjoy streets closed to vehicles during Ciclovía in Bogotá, Colombia. **SOURCE:** Saul Ortega (Flickr)

Cities can also achieve the goal of fewer cars through pedestrianization, prioritizing street space for public transit, or limited traffic zones. Tehran's restricted traffic zone (RTZ) sees lower car usage than its surrounding odd-even zone (OEZ) and significantly lower car usage than the rest of the city, which has no car restrictions.[89] Similarly, Rome's Zone a Traffico Limitato (ZTL) successfully reduced the number of cars entering the zone daily.[90]

CLEANER CARS

Emissions-based pricing has been shown to incentivize the purchase of cleaner vehicles because drivers of high-polluting vehicles must pay a fee to drive within the zone (or, in a non-fee-based scheme, are barred from accessing the zone altogether), while cleaner vehicles have unrestricted access. For example, in London, nearly two out of every five drivers of vehicles that did not conform with the city's original low emission zone purchased a new vehicle to meet the updated ULEZ standard and avoid paying the charge.[91] Indeed, over time, the retail market for higher-polluting vehicles in cities with emissions-based pricing is reduced, an important market signal for auto manufacturers.[92] In some cases, these vehicles may be exported to locations without emissions-based vehicle restrictions, as has been observed in cities with proposed diesel bans.[93] The benefits from a cleaner vehicle fleet in one city may be offset if high-polluting vehicles are simply being displaced to other locations. This is particularly concerning if dirty vehicles are being relocated and sold in cities in low and lower middle income countries—another rationale for L/LMIC cities to adopt emissions-based restrictions. Government-sponsored vehicle buy-back programs could help to limit this, however.

89 Impact of Traffic Zones on Mobility Behavior in Tehran, Iran.
90 ITE Journal 2016-2017: Looking Back and Moving Forward.
91 Central London Ultra Low Emission Zone: Six-Month Report.
92 Reality Check: What Should Owners of Old Diesels Do?
93 How to Get Rid of Dirty Diesels on City Roads.

FEWER VEHICLE KILOMETERS TRAVELED (VKT)

Shorter (and fewer) car trips reduce overall vehicle kilometers traveled (VKT), which is linked to harmful emissions that degrade air quality, water sources, and wildlife habitats, contribute to climate change, and threaten human health. Declining VKT is also linked to improved road safety and related economic and social cost savings.[94] Cordon-based congestion pricing in Central London yielded a 15% reduction in VKT within the charging zone after one year of operation; an additional 11% VKT reduction was observed after the Western Extension zone was implemented.[95] Distance-based congestion pricing could result in more significant VKT reduction because drivers would be charged based on the distance of their trip (longer trips are more expensive). However, there are no distance-based congestion pricing schemes in place, so their VKT impacts are speculative.

Demand-based parking programs have been adopted in a number of cities in recent years, but few studies evaluate their impact on VKT. An evaluation of San Francisco's SFpark pilot showed the program had decreased daily VKT by 30% within SFpark areas from 2011 to 2013 compared to a 6% VKT decrease outside of SFpark areas.[96] For other cities, assumptions about VKT outcomes can be made based on available data. For example, in Washington, DC, officials found that the city's demand-based parking pilot reduced parking search times by seven minutes.[97] Assuming a 12km/h "cruising speed," this time savings equates to approximately 1.4 fewer kilometers driven per trip.[98] After demand-based parking was implemented in the Polanco neighborhood of Mexico City, parking search times dropped by over 10 minutes, reducing VKT by an estimated two kilometers per trip. Evidence shows that the availability of off-street parking is linked to increased likelihood of using a vehicle for commute and noncommute trips, even when trips are well-served by transit. Therefore, reducing off-street parking availability (by instituting parking maximums, for instance) can reduce the propensity to drive.[99] Notably, increasing the cost of off-street parking through a commercial parking tax can make non-commercial parking subsidies (such as from employers or bundled into housing costs) more valuable to drivers, because commercial lots become less affordable which can lead to increased vehicle travel.[100]

Shorter, less convenient trips for vehicles can also be achieved by street design improvements aimed at restricting vehicle through-access. Prioritizing street space for pedestrians, cyclists, and transit vehicles, with personal vehicles at the bottom of the hierarchy, makes driving for short trips less convenient and direct. Barcelona's Superblock plan, which restricts interior neighborhood streets to one-way and right-turn-only for vehicles and limits vehicle speeds, makes driving less convenient. Traffic levels on some internal Superblock streets have fallen by 40%.[101]

94 Cutting Greenhouse Gas Emissions Is Only the Beginning: A Literature Review of the Co-Benefits of Reducing Vehicle Miles Traveled.
95 Synthesis of Congestion-Pricing-Related Environmental Impact Analyse: Final Report.
96 SFpark Pilot Project Evaluation Summary.
97 parkDC: Penn Quarter/ Chinatown Parking Pricing Pilot.
98 Impacts of the ecoParq Program on Polanco: Preliminary Overview of the Parking Meter System After One Year Running.
99 Death by a Thousand Curb Cuts: Evidence on the Effect of Minimum Parking Requirements on the Choice to Drive.
100 Evaluating Seattle Parking Tax Options.
101 Changing the Urban Design of Cities for Health: The Superblock Model.

MORE TRIPS BY SUSTAINABLE TRANSPORT

Road space reallocation, which repurposes street space as high-quality walking, cycling, and public transit facilities, yields more safe spaces for people. This makes sustainable transport a more attractive option than it may have been previously. Indeed, road space reallocation has been shown to shift travelers away from private vehicles and to sustainable modes more than any other traffic reduction strategy.[102] For example, extensive efforts in Bogotá to establish car-free public spaces—particularly the city's commitment to Ciclovia, which closes over 100 kilometers of streets to vehicles every Sunday—yielded an increase in cycling mode share from 0.8% in 1995 to 3.2% in 2003. Since then, the city has implemented 540 kilometers of bicycle lanes, and cycling mode share has increased to 9%. A similar effect occurred in Seville, Spain, where 80 kilometers of protected bicycle lanes were implemented in 2008, increasing cycling mode share from 0.5% to 9% of all trips by 2014.[103] In some cases, on-street parking spaces were converted into bicycle lanes. By managing demand for parking, demand-based on-street pricing can enable the replacement of parking spaces with higher-value uses like cycle lanes or bikeshare stations. Complete street designs within Barcelona's Superblocks have yielded a 10% increase in walking trips and 30% increase in cycling trips surrounding the interventions. Similarly, after Yonsei-ro in Seoul was converted to a transit mall with improved pedestrian spaces, the area saw an 11% increase in bus commuters.[104]

Additionally, congestion pricing has been shown to shift travelers away from driving and toward public transit, cycling, and walking, especially when cities commit to improving the quality of those modes. London, which heavily invested in transit as an alternative to driving, saw 37% more bus commuters after the first year of its congestion charge compared to the previous year, and bus service reliability improved as excess wait times due to traffic congestion fell.[105]

3.2 ABILITY TO FURTHER SUSTAINABLE TRANSPORT GOALS

Successful traffic reduction strategies reduce demand for driving—particularly of single-occupancy, high-polluting vehicles during peak times—and generate a shift toward sustainable, equitable transportation modes. In this section we map the strategies introduced above against the sustainable transport goals (see summary table on next page). It is important to note the presence of confounding factors in many cases, which can make it difficult to attribute outcomes such as emissions reductions or vehicle-related crash reductions directly to the implementation of a traffic reduction strategy.[106] Where possible, comparisons to control areas are noted.

	Improves access ↑	Maintains safety ↑	Protects environment + health ↑	Efficient use of revenue + space ↑
DEMAND-BASED PARKING	●	●	●	●
OFF-STREET PARKING REFORMS	●	X	X	●
COMMERCIAL PARKING TAX	X	X	X	●●
EMISSIONS-BASED PRICING (LEZ/CAZ)	X	●	●	●
CONGESTION PRICING	●	●	●●	●●
REALLOCATING ROAD SPACE FOR PEOPLE	●●	●●	●●	●
LIMITED TRAFFIC ZONES (ZEA)	●	X	●	X

X No evidence found ● Link supported by evidence ●● Link strongly supported by evidence

102 Benefits of Pedestrianization and Warrants to Pedestrianize an Area.
103 How Seville Transformed Itself into the Cycling Capital of Southern Europe.
104 Road Diet for a More Active Street.
105 Synthesis of Congestion Pricing–Related Environmental Impact Analyses—Project Summaries.
106 Review of the Efficacy of Low Emission Zones to Improve Urban Air Quality in European Cities.

IMPROVES ACCESS

Access to jobs and economic development

While traffic reduction strategies can make driving more expensive and less convenient, many have been shown to ultimately improve access to jobs and other services by improving the reliability of public transit and the comfort of walking and cycling. For example, parking reforms like Mexico City's ecoParq demand-based parking program increase vehicle turnover in on-street spaces.[107] This helps ensure that more people can access and patronize commercial areas. Demand-based parking programs have also helped to improve speeds and reduce excess wait times for public transit vehicles along corridors where double parking had caused unpredictable delays.[108] Congestion pricing and limited traffic zones have shown similar effects. Congestion pricing reduced trip times across modes in Stockholm, and it reduced peak-period bus delays by 50% in London.[109] Rome's limited traffic zone resulted in a 5% increase in travel speeds for public buses.[110]

It is widely held that wider sidewalks, bicycle lanes, and designated transit lanes increase street capacity, thereby increasing access by reducing trip times and lowering stress for users of these spaces.[111] Increased comfort and accessibility for pedestrians and cyclists in particular has been linked to economic benefits, including higher local business activity and property values.[112] In fact, commercial businesses located along Seoul's Yonsei-ro saw an 11% increase in revenue-generating transactions and a 4% increase in total revenues after the street was converted to a transit mall.[113]

Impact on transportation and housing costs

Both fee-based and non-fee-based traffic reduction strategies can impact the cost of transportation and, relatedly, housing for certain groups. Strategy design can often anticipate and minimize negative cost burdens, particularly for lower income people and other more vulnerable people. In São Paulo, off-street parking maximums have enabled developers to build public housing closer to the city center by removing expensive parking requirements.[114] Similarly, commercial parking taxes make low-value land uses (like parking lots) more expensive to maintain, which could encourage owners to convert that land to higher-value uses like housing, thereby increasing housing supply and lowering costs.

Certain traffic reduction strategies may increase housing costs, although it can be difficult to separate the impact of a traffic reduction policy from other economic factors, such as interest rates. In Guangzhou, property values in the heavily pedestrianized Liuyun Xiaoqu neighborhood have increased at a faster rate than in surrounding districts, resulting in reduced affordability.[115] Measures such as rent control or stabilization, housing subsidies, social housing, etc., should be considered as a means of reducing the impact of pedestrianization projects on housing costs.

107 Impacts of the ecoParq Program on Polanco: Preliminary Overview of the Parking Meter System After One Year Running.
108 SFpark: Pilot Project Evaluation.
109 Impact of Traffic Zones on Mobility Behavior in Tehran, Iran.
110 Road User Charging.
111 Smart Congestion Relief: Comprehensive Analysis of Traffic Congestion Costs and Congestion Reduction Strategies.
112 Pedestrian-Only Streets.
113 Road Diet for a More Active Street.
114 Learning from Parking Reforms in Other Cities.
115 TOD Best Practical Case: A Mixed-Mode Open Court.

By design, congestion pricing makes driving into the CBD more expensive, particularly for those who cannot realistically shift to a different mode or travel outside the charge hours. Aside from increasing per-trip costs for drivers of nonconforming vehicles, emission-based pricing incentivizes purchasing a new vehicle that meets the emissions standard. Scrappage schemes, like the one available to commercial van owners to upgrade to a cleaner vehicle in London, can help offset this burden.[116]

Protected cycle lanes in Seville, Spain increase street capacity and access for more people who do not have access to a vehicle. **SOURCE:** adrimcm (Flickr)

IMPROVES SAFETY

Well-designed traffic reduction strategies can improve safety by reducing the frequency and severity of traffic crashes and improving the comfort and perceptions of safety for vulnerable road users like pedestrians and cyclists. In San Francisco and Washington, DC, on-street demand-based parking programs resulted in reduced incidents of double parking and unsafe commercial loading, improving safety for both drivers and nondrivers.[117] Similarly, reduced VKT from searching for parking has been linked to fewer crashes caused by distracted driving.[118]

Zone-based traffic reduction strategies, like LEZs and congestion pricing, have shown lower rates of crashes inside those zones compared to outside. Milan's LEZ and London's congestion charge zone saw fewer crashes between vehicles and pedestrians and cyclists despite mode share increases for both walking and cycling.[119] [120] We were not able to find evidence of a link between limited traffic zones and vehicle crashes; however, we expect to see similar results given similar restrictions on vehicles entering the zone.

116 Mayor Accelerates Bold Action to Remove Dirty Vehicles from London.
117 parkDC: Penn Quarter/Chinatown Parking Pricing Pilot.
118 SFpark: Pilot Project Evaluation.
119 Urban Road Pricing: A Comparative Study on the Experiences of London, Stockholm and Milan.
120 Appendix B19: Cordon Congestion Tolls in Moving Los Angeles: Short-Term Policy Options for Improving Transportation.

Reallocating road space for people is strongly linked to reduced crash rates, severity, and injury risk for pedestrians and cyclists.[121] The likelihood that a pedestrian or cyclist will be involved in a vehicle crash decreases as the number of pedestrians and cyclists on the street increases, a phenomenon often referred to as “safety in numbers.”[122] With vehicle speed reductions resulting from vehicle lane narrowing or removal, for every five km/h speed decline, crash frequencies decrease by 15%.[123] In Seoul, the Yonsei-ro transit mall saw a 34% decrease in traffic crashes compared to before the project was implemented, and survey respondents reported feeling safer walking through the corridor.[124]

PROTECTS HEALTH AND ENVIRONMENT

Impact on mode shift from single-occupancy vehicles
The ability for traffic reduction strategies to effectively “push” people to public transit, cycling, and walking for most trips is a critical criteria for long-term success. This shift yields co-benefits such as the reallocation of space for vehicle travel and storage to more productive uses. It can be challenging to link reduced vehicle volumes to congestion charging, limited traffic zones, or even reallocating road space to mode shift, as some of those trips could still be taken by a vehicle outside of charged hours (in the case of congestion pricing) or along an alternative route (in the case of limited traffic zones and road space reallocation). Still, fewer vehicle trips and increased walking, cycling, and public transit use have been reported after these three strategies were implemented. Public bus commutes increased by 37% after London’s congestion charge was implemented, and bus commutes increased by 11% after Yonsei-ro in Seoul was converted from a four-lane street to a transit mall.[125] Similarly, Rome saw a nearly 4% increase in public transit and a 1.5% increase in cycling and walking trips in its limited traffic zone after implementation.[126]

Emissions-based pricing schemes have also generated mode shifts away from vehicles; however, these shifts are temporary, as those with nonconforming vehicles eventually purchase cleaner ones that meet the emissions standard and continue to drive. This was the case in Milan, where a more stringent congestion charge eventually replaced the city’s LEZ, in part to facilitate a more sustained mode shift.[127]

Studies show that compact neighborhoods generate fewer vehicle trips (“trip degeneration”) and see lower vehicle ownership and parking demand compared to more sprawling areas with ample space for vehicle storage.[128] This indicates that limited off-street parking availability and priced on-street parking, common characteristics of compact development, can result in modal shift away from vehicles, and lower rates of vehicle ownership may extend this trend in the long-term.

122 Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling.
123 Effects of Different Urban Traffic Mitigation Actions on Cities’ Noise Levels.
124 Road Diet for a More Active Street.
125 Road Diet for a More Active Street.
126 Piano Generale del Traffico Urbano di Roma Capitale.
127 Milan: Area C: Fewer Cars, More Public Spaces, Better Life for All
128 Trip and Parking Generation Rates for Different Housing Types: Effects of Compact Development.

Impact on air quality and health
Traffic reduction strategies are often pursued as a way to improve urban air quality and related health outcomes. Tailpipe emissions, including particulate matter (PM) and nitrogen oxides (NOx) are dangerous to human health and can lead to a number of respiratory complications. In fact, annually more deaths around the world are linked to air pollution than to traffic crashes.[129] Noise pollution, which has been linked to sleep disturbance and stress in the short term and learning and productivity challenges, hearing loss, and heart disease in the long term, is also cited as a negative health outcome of high traffic volumes.[130]

Fewer kilometers driven searching for parking as a result of demand-based parking programs may reduce tailpipe emissions, but the link between these programs and overall air quality has not been evaluated extensively. As mentioned previously, confounding factors, such as weather, can make it difficult to establish a direct link between an intervention like demand-based parking and changes in air quality. Low emission zones have had varied impacts on air quality based on their stringency: For example, London’s original LEZ had no significant impact on PM or NO_x, but the stricter ultra low emission zone (ULEZ) has reduced PM by 13% and NO_x by 31%. Madrid’s LEZ yielded a 38% reduction in NO_x and a 32% reduction in NO_2 compared to 2018, the lowest levels the city has seen since 2012.[131] LEZs in Berlin and other German cities, some of which only apply to heavy-duty vehicles, have had more modest effects on nitrogen oxide levels (12% reduction in Berlin and 4% at most across 17 German cities.)[132][133] Congestion pricing has shown similar air quality impacts: London’s congestion charge has generated an 18% reduction in NO_x and a 22% reduction in PM. Few air quality assessments have been conducted before and after road space reallocation projects, though reduced tailpipe emissions can be inferred from reductions in the volume of vehicles. For example, interior streets within the Gracia Superblock in Barcelona have seen a 40% reduction in traffic volumes compared to a 26% reduction observed in the surrounding area.[134] Furthermore, a recent study found that if the entire Superblock plan is implemented, 700 premature deaths from air and noise pollution could be avoided each year.[135]

Emissions-based pricing and congestion pricing schemes have not been found to reduce noise pollution—Stockholm and London’s programs have had no observable traffic noise reductions. Some evidence suggests that limited traffic zones may reduce noise pollution if they restrict freight and other heavy-duty vehicles. In Naples, surveys and interviews showed residents noticed reduced noise levels following the city’s limited traffic zone implementation, but noise returned to pre-implementation levels after the city permitted freight vehicles to enter the zone.[136]

Impact on climate change
Traffic-reduction strategies may also help to lessen the impacts of climate change if they reduce greenhouse gas (GHG) emissions, namely carbon

129 A Beginner's Guide to NO_x, NO, and NO_2 as Air Pollutants.
130 Environmental Noise Pollution in the United States: Developing an Effective Public Health Response.
131 Madrid Could Become First European City to Scrap Low-Emissions Zone.
132 People Power and Courts Fight First-Ever Attempt to Scrap Low-Emissions Zone.
133 Effectiveness of Low Emission Zones: Large-Scale Analysis of Changes in Environmental NO_2, NO, and NO_x Concentrations in 17 German Cities.
134 Spain’s Plan to Create Car-Free “Superblocks” Is Facing Protests.
135 Changing the Urban Design of Cities for Health: The Superblock Model.
136 Effects of Different Urban Traffic Mitigation Actions on Cities’ Noise Levels.

dioxide (CO_2), nitric oxide (NO), and methane. On-street parking reforms in San Francisco and Mexico City have yielded significant decreases in GHGs within demand-based parking zones compared to other parts of the city. San Francisco's SFpark program yielded a 30% decrease in GHG emissions from traffic compared to a 6% decrease in control areas, and in Mexico City reduced VKT from avoided searching for parking was calculated to yield a reduction of 18,000 tons of CO_2 annually, or the equivalent of taking more than 3,500 passenger vehicles off the road.

Similar to air quality, the design of an emissions-based or congestion pricing system will heavily impact its ability to reduce GHG emissions. Again, London's LEZ had no impact on GHG emissions, though the stricter ULEZ showed a 4% reduction in CO_2 in the first six months. **Indeed, while local CO_2 emissions reductions may be observed, lifetime CO_2 could increase if people replace their vehicles before the optimal replacement frequency (estimated at 19 years) to avoid a LEZ charge or if high-polluting vehicles are sold secondhand in locations that do not impose emissions-based restrictions.**[137] More widespread emissions-based restrictions in L/LMIC cities can, however, counteract the latter.

Few studies evaluate the link between reallocating road space for people and GHG emissions reductions. However, walking and cycling are particularly attractive substitutes for short vehicle trips. Vehicle use for short trips is particularly fuel inefficient due to cold engines and congestion, so making walking and cycling safer and more comfortable through street designs that prioritize those modes would likely yield emissions reductions.[138]

Mexico City's ecoparq program reduced CO_2 emisisons equivalent to taking more than 3,500 passenger vehicles off the road
SOURCE: Héctor Ríos, ITDP México

137 CO_2 Emissions from Cars: The Facts.
138 Reducing Carbon Emissions Through Transport Demand Management Strategies: A Review of International Examples.

EFFICIENT USE OF REVENUE AND SPACE

Efficient use of revenues

In the context of traffic reduction strategy design, using revenues efficiently largely refers to the potential to rebalance implicit subsidies for driving by applying revenues to improve public transit, cycling, and walking facilities. Demand-based on-street parking pricing has been shown to generate significant revenues (see above, Ability to Achieve Traffic Reduction Outcomes: Revenue Generation) beyond what is needed for program operation. In several cases, a portion of these revenues has been dedicated to hyper-local public space improvements. For example, in 2012, Mexico City's ecoParq program generated nearly 58 million pesos in revenue, 17.3 million of which was reinvested into public space and sidewalk improvements in the Polanco neighborhood where the parking program was located.[139] Off-street parking reforms have also integrated revenue reallocation: In Mexico City, revenues from fees charged to developers who want to build parking beyond the city's off-street maximum (up to ceiling) are allocated to public transit and social housing improvements. Substantial revenues have also been generated from commercial parking taxes, and these are often allocated to public transit improvements.[140] However, increasing commercial parking tax rates to support public transit has been unsuccessful in some cases, such as in Seattle, where a 2014 proposal to raise the city's commercial parking tax, which would help prevent cuts to Metro service, failed.[141]

Revenues generated from direct charges to drivers, such as through emissions-based pricing or congestion pricing, are often allocated to public transit, cycling, and walking improvements as a way to generate public support and to provide high-quality alternatives to driving. Indeed, revenues from emissions-based pricing schemes are likely to shrink over time with the uptake of cleaner vehicles (and, therefore, fewer drivers needing to pay the fee), but revenues from congestion pricing schemes have been shown to increase over time, particularly if more stringent requirements are phased into the design.[142] London has used a portion of its congestion pricing revenues to improve public bus service, enhancing a mode already heavily used by many low income travelers.[143] Efficient use of resources is not inherent to a strategy but will ultimately come from strategy design and the prioritization of directing revenues toward equitable sustainable transport improvements.

The potential to generate revenue can enable cities to secure revenue bonds used to finance infrastructure or related implementation costs. Revenue generated from the program is then used to pay interest and/or principal to the bond holders. This approach has been used to finance passenger rail and toll road projects.

Efficient use of space

Space in cities is finite, and streets are often overlooked as a city's most valuable open space asset. For example, compared to a general purpose traffic lane, a bus rapid transit (BRT) or bus-only lane is a more efficient use of the resource because it can serve more people with

139 Impacts of the ecoParq Program on Polanco: Preliminary Overview of the Parking Meter System After One Year Running.
140 Mexico City Got Rid of a Ridiculous Subsidy for Drivers, and Other Cities Should Too.
141 The Case for a Tax on Parking Lots.
142 London Congestion Charge: What Worked, What Didn't, What Next.
143 Income-Based Equity Impacts of Congestion Pricing—A Primer.

fewer negative externalities. Similarly, on a busy urban street, a loading zone is a more efficient use of space compared to free parking. Demand-based on-street parking is more efficient compared to static or free on-street parking because it incentivizes turnover and reduces driving in circles looking for open spaces. Reallocating road space away from inefficient single-occupancy vehicles and toward high-volume modes like public transportation and space-efficient modes like cycling and walking maximizes the performance of limited street space and is more equitable.[144]

3.3 CAPACITY NEEDED FOR EFFECTIVE IMPLEMENTATION

Local governments require effective management and problem-solving capabilities to implement effective programs.[145] Such capabilities include:

- Awareness and buy-in from decision-makers ("having a vision");
- Technical ability of city staff (or ability to hire consultants) to facilitate policy adoption and implementation, write contracts, and conduct related program planning, design, and implementation;
- Strong institutions and the ability to create structures, when appropriate, to coordinate and plan actions;
- Funding for project implementation, operations, and maintenance.

To effectively implement policies, cities must understand the political, technical, and funding requirements of different traffic reduction policies as well as their government's own capacity constraints. Based on available literature and information gleaned from internal and external expert interviews, we consider the following concepts in the context of capacity requirements for effective traffic reduction policy implementation: data privacy and surveillance concerns, technology needs, political complexity, and upfront government investment needed (for further explanation of these concepts, see Appendix B).

Pune has reallocated public space for pedestrians and cyclists along many major roads, including DP road, shown here.
SOURCE: ITDP India

POLITICAL WILL

Political will is needed to advance any traffic reduction strategy. It is critical to identify political champions and understand the degree of political or bureaucratic complexity (e.g., is the scope of the problem multi-jurisdictional and/or regional? Which lobby groups might resist or support the idea of making the cost of driving more explicit?) when trying to advance traffic reduction policies.

Cultivating political will often requires:

1

IDENTIFYING POLITICAL CHAMPIONS AND EDUCATING KEY TECHNOCRATS

Champions can help introduce and move a traffic reduction strategy forward, fostering credibility in the eyes of allies and calming naysayers. At the same time, it is beneficial to develop the knowledge base of ministry technocrats who can directly influence internal understanding and messaging. Their interest and curiosity about the underlying issues can be a hook for engagement and eventual alliance.

2

CONTEXTUALIZING STRATEGY NARRATIVES WITHIN LOCAL POLITICAL CLIMATE

Understanding the current political and cultural climate is important in selecting the most promising policy option(s) as well as when promoting adoption of policy reforms. Contexts—including political, logistical, demographic, economic, and cultural factors—differ from city to city.[146] Thus, "lessons learned" from one context cannot necessarily be mapped onto another. With this in mind, messaging around the traffic reduction strategy should be crafted to reflect the particular city's context and climate. Whenever possible, objectives should align with other current policy priorities. Similarly, narratives could be developed around traffic reduction as a solution to challenges political leaders are trying to address or one that advances their stated policy goals. For example, if an elected official cares less about environmental issues and more about the local economy, the strategy narrative should underscore potential economic gains from congestion reduction. Regardless, narratives should be simple, feasible, and sellable. They should not offer arguments that are overly complex or moralistic.

144 Transit Street Design Guide: Designing to Move People.
145 Institutional Capacity-Building in Urban Planning and Policy-Making for Sustainable Development: Success or Failure?
146 Urban Transport Pricing.

	Privacy concerns	Technology needs	Political complexity	Upfront govt investment	**Capacity required for effective implementation**
PARKING REFORM (ON- AND OFF-STREET)	NONE	●●	●●	●●	MED
COMMERCIAL PARKING TAX	NONE	NONE	●●	●	LOW
EMISSIONS-BASED PRICING AND CONGESTION CHARGING	●●	●●	●●●	●●●	HIGH
REALLOCATING ROAD SPACE FOR PEOPLE	NONE	●	●●	●	LOW
LIMITED TRAFFIC ZONE	●●	●●	●●●	●●●	MED

● Low ●● Medium ●●● High

REALLOCATING ROAD SPACE FOR PEOPLE

CAPACITY REQUIRED FOR EFFECTIVE IMPLEMENTATION:

LOW

Pedestrianization, transit malls, and complete streets have been successfully implemented in a wide variety of cities, including in L/LMICs. These strategies require minimal technology to operate (transit malls and pedestrianized streets may feature bollards or access gates that can be lowered by emergency vehicles, for example) and can even be implemented without any technology at all by using cones, paint, and street furniture. These approaches present no privacy concerns and do not charge a fee for access, and they may yield less public pushback than some other traffic reduction strategies that may be seen as punitive. In cities where walking already accounts for a substantial share of trips and safety for pedestrians and cyclists is underprioritzed, there may be stronger support for this type of policy. Well-documented case studies of road space reallocation for people in LIC/MIC cities—such as Buenos Aires and Pune—and in-depth guides such as ITDP India's Complete Streets Framework toolkit and ITDP Africa's Non-Motorized Transport toolkit provide reference points for implementing similar designs in other locations. Thus, the capacity required for effective implementation is low.

Capacity will be needed to develop plans to guide the implementation of road space reallocation, which typically includes tasks such as goal setting, stakeholder engagement, drafting, and adopting policies.[147] It is recommended that local governments coordinate with key stakeholders from agencies, utilities, and other related fields to contribute their expertise to policies or designs. Developing a master plan for people-first streets will help to ensure projects connect to form a network, establish minimum standards and design guidelines, and commit long-term funding for implementation and maintenance.

Governments will also need to effectively communicate the benefits of road space reallocation to businesses and the public. In some cases, temporary interventions that use flexible, low-cost materials can be implemented, reducing upfront costs and enabling people to observe and physically interact with a vehicle-restricted environment. These interventions can be made permanent more easily after people have had the opportunity to experience the design and provide feedback on what works and what could be improved. A phased implementation approach (e.g., block by block or neighborhood by neighborhood) can also help manage costs, and setting baselines and collecting data during these temporary interventions helps to underscore their benefits.

147 Complete Streets: Policy Workbook.

PARKING REFORMS

CAPACITY REQUIRED FOR EFFECTIVE IMPLEMENTATION:

MEDIUM

On- and off-street parking reforms require moderate capacity for successful implementation. Demand-based pricing in particular requires lower levels of capacity because the technology needed is accessible and affordable, and it presents virtually no privacy concerns. While the concept of demand-based pricing may be new to some drivers, many people who live in cities are already familiar with the idea of paying to park near high-density destinations. Well-documented case studies of established demand-based parking programs and complementary parking reforms can provide useful guidance for designing and evaluating similar programs in other locations. There is some consensus that parking reform acts as a kind of “gateway” policy: It is easier to implement than more complex policies such as congestion pricing, and once implemented, it can provide an opening to considering more complex reforms.

Demand-based parking does require some upfront investment in new technology, typically smart parking meters and sensors. However, this equipment is relatively inexpensive and tends to be publicly accepted because people are generally familiar with how parking meters operate. Smart sensors used to implement demand-based parking can also make enforcement of unpaid or expired meters more efficient. Using a mobile application, parking control officers can automatically view the location of unpaid or expired meters where a vehicle is also parked, as opposed to circling blocks to issue citations to violators.[148] This more efficient enforcement could enable cities to reduce the number of parking control officers needed.

Political complexity to implement demand-based parking is moderate. Parking supply does not need to change (at least in the short term), and those who have the flexibility to do so can avoid the highest parking fees if they shift their trips to non-peak times and/or non-prime parking locations. However, political pressure in cities like Bogotá has prevented parking prices from being raised at all. Some public pushback has been documented where it’s believed that city governments are implementing demand-based parking programs and increasing parking prices to boost municipal revenues. This critique can be countered if governments are transparent about the share of revenues needed to operate the system and dedicate surplus revenues to specific programs. For example, Mexico City’s ecoParq program allocated surplus revenue from parking fees to be used for sidewalk and other pedestrian infrastructure improvements in the Polanco neighborhood where the parking program was operating. This type of local reinvestment of revenues can help to build public acceptance and political will.[149]

148 SFpark Pilot Project Evaluation.
149 Parking Reform Has Big Implications for Sustainable Transit—and for Ride-Hailing, too.

COMMERCIAL PARKING TAX

CAPACITY REQUIRED FOR EFFECTIVE IMPLEMENTATION:

LOW

Commercial parking taxes are a straightforward approach to limiting parking supply and generating revenue. They are relatively inexpensive and simple to implement, and they require no additional technology and present no privacy concerns. And, while a commercial parking tax is typically passed on to consumers, it is bundled into parking fees the driver is already paying, making it less visible. Commercial parking taxes reduce excess parking supply and un- or underutilized surface lots, which can help build density and potential for walkability.

However, commercial parking taxes have not been strongly linked to changes in driver behavior (e.g., mode shift away from vehicles). In fact, in places where parking subsidies (such as from employers or bundled into housing costs) are common, increasing the cost of parking through a commercial tax can make these subsidies more valuable to drivers and can actually increase vehicle travel.[150] Cities should be aware of this potential outcome and consider a commercial parking tax as a complementary policy (to, say, emissions-based or congestion pricing) and not a stand-alone solution.

Political complexity may arise around ensuring that parking managers report revenues accurately. Political challenges may also stem from the ability to generate significant revenues from commercial parking taxes, so it is important for cities—particularly those that struggle with corruption—to be transparent about what these revenues will be allocated toward and to set up a specific fund to house these revenues. In many cases, revenues from commercial parking taxes are used to improve public transit facilities. The revenue-generation potential of commercial parking taxes could also be a reliable way to support other traffic reduction strategies, like road space reallocation.

150 Evaluating Seattle Parking Tax Options.

LIMITED TRAFFIC ZONES + ZEAS

CAPACITY REQUIRED FOR EFFECTIVE IMPLEMENTATION:

MEDIUM

Limited traffic zones require a high degree of capacity to implement effectively due to moderate privacy concerns and technological needs as well as the high political complexity and upfront government investment required. In terms of technological needs, limited traffic zone entrance points can be monitored manually by traffic officers. Tehran's Restricted Traffic Zone (RTZ) operated without automatic entrance monitoring until 2015, when the city installed ANPR cameras.[151] While stationing police officers at zone entrances instead of investing in automated technology is an option, cameras have a distinct efficiency advantage over manual monitoring because they can identify multiple noncompliant vehicles at a time and automatically assess fines. Comparatively, when officers in Tehran cited violators, many drivers engaged in "fine bargaining," which led to traffic holdups, not to mention corruption. Cameras resulted in a nearly threefold increase in identified violations; however, some drivers have taken to covering their license plates and engaging in other behaviors, such as vandalism of camera equipment, to evade fines.[152]

The process of identifying, processing, and sending fines to violators can involve multiple government agencies or private contractors. In Tehran, this process includes three government sectors and two contractors, and it has led to fines not being issued consistently. In cities where coordination between the public and private sector is not transparent or where corruption is widespread, this process could present challenges.

Finally, governments will need to provide high-quality, reliable, affordable alternatives to driving that are available when the zone goes into effect. If people can no longer drive into the zone to access their jobs, schools, or other destinations, there needs to be a viable alternative that does not pose significant time, cost, or security losses. This stems from a commonly held tenet of transportation planning: Everyone has a right to equitable transportation services.[153] Governments that do not have the capacity—whether its financial resources, technical expertise, or both—to provide viable alternatives to driving may not be successful implementing an LTZ or other vehicle access restrictions. For example, commuters in Manila reported preferring to alter their schedule (going to work early and arriving home late) to avoid license plate–based vehicle restrictions over using public transport because of poor service.[154] Governments also need to carefully consider—and be transparent about their decision—which drivers will be permitted to access the zone. In most Italian limited traffic zones, residents, people with disabilities, and public service vehicles like transit, taxis, and emergency vehicles can enter. Motorcycles are also permitted. Tehran's limited traffic zone also allows government officials to purchase permits to enter. In fact, 40% of vehicles entering the limited traffic zone in Tehran are government-owned.[155]

151 Impact of Traffic Zones on Mobility Behavior in Tehran, Iran.
152 Challenges of Implementation of Intelligent Transportation Systems in Developing Countries.
153 Traffic Congestion Pricing: Methodologies and Equity Implications.
154 How Travel Pattern Changes After Number Coding Scheme as a Travel Demand Management Measure Was Implemented.
155 Impact of Traffic Zones on Mobility Behavior in Tehran, Iran.

EMISSIONS-BASED PRICING (LEZ) AND CONGESTION CHARGING

CAPACITY REQUIRED FOR EFFECTIVE IMPLEMENTATION:

HIGH

Emissions-based pricing and congestion charging schemes require a high level of capacity for effective implementation, as they involve moderate to high privacy concerns and also high political complexity and upfront government investment. At the time of writing, we found only examples of emissions pricing programs and congestion charging schemes operating in HICs. However, Mexico City and Rio de Janeiro are evaluating how best to implement low emission zones, and Jakarta and Mumbai are considering congestion pricing approaches.

Many emissions-based pricing and congestion charging schemes use ANPR cameras (also known as "smart cameras") to enforce the boundaries of the priced zone. These cameras must be positioned at every entrance to the zone to scan the license plates of all entering vehicles, checking each against a database of conforming (in the case of a LEZ) or pass-holding (in the case of a congestion charge) vehicles.[156] This allows the system to quickly assess whether a vehicle meets the terms of the zone, is exempt, or has already paid the entrance fee. This database may be populated with information from an existing driver's license database, vehicle standards agencies, make and model data, and information from those who have purchased daily or annual passes to enter the zone. For an LEZ, residents and people who drive into the zone regularly are usually required to register their vehicle even if it complies with the emissions standard. Maintaining this database requires the government to process and house large amounts of personal data.

In cities or countries where personal data is not expressly protected through legislation or regulations do not limit the nonconsented use of personal data or the maximum period of retention, privacy concerns brought about by ANPR cameras could be high. Concerns may be highest among the most vulnerable populations, such as immigrants, who would be disproportionately impacted if personal data, say from a driver's license database, were to be used for ends other than zone enforcement. Similar concerns related to equitable enforcement and social justice can arise, however, if the zone is manually enforced by police.

Alternatives to ANPR cameras for automatic vehicle identification may be preferable for cities that are apprehensive about their ability to protect personal data. Radio Frequency Identification Device (RFID) tags attached to vehicles and read by a roadside unit when the vehicle drives past it function in a similar way to an ANPR system. While RFID tags pose lower privacy and data-handling concerns, they are also less effective than ANPR cameras because vehicles without an RFID tag cannot be identified, creating a challenge for enforcement.[157] This has been observed in South Africa, where surveys showed that 60% of drivers do not pay RFID-based electronic tolls.[158] Manual vehicle identification by traffic officers is another alternative, though issues of bribery and long traffic queues at entrance points could emerge (see Limited Traffic Zones above). LEZs and congestion charging zones tend to be larger in area than limited traffic

156 Privacy Statement.
157 Including Congestion Effects in Urban Road Traffic CO2 Emissions Modelling: Do Local Government Authorities Have the Right Options?
158 Why People Still Refuse to Pay E-Tolls—No Matter What Government Says.

zones, and so these effects may be even more pronounced. Further, manual enforcement may increase costs compared to implementing an automated solution in two ways. First, the ongoing labor costs incurred may be higher than the cost of purchasing and operating automated cameras. Officers need to be stationed at every entrance to the zone when the charging zone is operating. Second, manual enforcement has been shown to miss violating vehicles at a higher rate than an automated system, resulting in lower revenues from unassessed fines.[159] Therefore, emissions-based and congestion pricing may not operate optimally in cities where enforcement technology is not available or feasible.

Compared to parking pricing, emissions-based pricing and congestion pricing can be more challenging to "sell" to politicians and technocrats who may not be familiar with the necessary design elements or operational aspects. Interest groups that benefit from driving, such as taxi operators and delivery-based businesses, could present strong opposition, particularly in places where advocacy and support for sustainable transportation is limited. Notably, the freight industry strongly supported London's congestion charging proposal, as reduced congestion makes delivery trip times more reliable and costs are eventually passed on to customers.[160] Ridehail companies like Uber and Lyft have also voiced support for congestion pricing as a way to reduce transport emissions.[161] Successful schemes, defined in terms of their ability to reduce harmful air pollution, have proved difficult for political leaders to eliminate. For example, in 2019, Madrid's then newly elected mayor faced widespread public resistance and legal pushback when attempting to dissolve Madrid Central, given that the policy had reduced nitrogen oxide (NO_x) levels by 38% and NO2 by 32% compared to 2018, the city's lowest NO2 levels since 2012.[162]

Transparency around the use of revenues is also critical. As described in the previous subsection, congestion pricing can generate significant revenues. Cities need to be clear about how revenues will be used beyond covering operating expenses. For example, Transport for London publishes annual reports to bring transparency to the process. It is recommended that cities designate specific uses for these revenues—such as improving public transit and cycling and walking facilities, or offsetting costs for groups for whom the scheme presents a disproportionately high burden—as opposed to directing all revenues into a general operating fund. It is also good practice to establish a separate fund to house revenues, which can only be accessed if a project meets certain agreed-upon terms. This has been done in Mexico City, not for congestion pricing, but for other transport programs: The city set up a "taxi, mobility, and pedestrian fund" to house per-trip fees paid to the city by transportation network companies like Uber and Cabify, and started another fund for pedestrian and cycling improvements that houses revenue from bids from private dockless mobility companies to operate in the city.[163]

159 Challenges of Implementation of Intelligent Transportation Systems in Developing Countries.
160 Sustainable Freight: Impacts of the London Congestion Charge and Low Emissions Zones.
161 Your Taxi or Uber Ride in Manhattan Will Soon Cost More.
162 People Power and Courts Fight First-Ever Attempt to Scrap Low-Emissions Zone.
163 Presentation by María Fernanda Rivera Flores, general director of Road Safety and Sustainable Urban Mobility Systems, SEMOVI, January 14, 2020.

Finally, governments will need to identify groups that may be disproportionately affected by a vehicle restriction policy—namely, those who cannot afford to purchase a cleaner vehicle or for whom public transit, cycling, or walking is not a viable alternative (e.g., certain shift workers, people with disabilities). It is good practice to support these groups so that they can eventually comply with the emissions standard or congestion charge. Cities like London and Paris offer subsidies to small businesses and nonprofit organizations that use vehicles to help offset the cost of upgrading them to electric.[164] However, incentives for individuals can be more complicated and must be carefully designed to avoid the widespread use of public funds to purchase new vehicles. If subsidies are being considered for individuals, they should be limited to low income residents and time-bound, kick-starting the shift to clean vehicle adoption but not substituting for the automobile industry's manufacturing cleaner vehicles over time. Similarly, giving more time to residents who live within the priced zone to purchase a compliant vehicle or to find a viable alternate mode (in the case of a LEZ) or providing them with a time-bound exemption (in the case of a congestion charge) could ease the transition.

Demonstrators gathered in 2019 to defend Madrid Central, the limited traffic zone in the city center, against the newly-elected government's intent to remove the zone without an alternative plan to reduce air pollution. **SOURCE:** Thomas Holbach, wikicommons

164 Low-Emission Zones Are a Success—But They Must Now Move to Zero-Emission Mobility.

KEY TAKEAWAYS

4

In this paper, we selected several "push" TDM strategies, which we refer to as traffic reduction strategies, in the areas of parking pricing, emissions pricing, congestion pricing, limited traffic zones, and reallocation of road space for people. We evaluated these strategies, using the following criteria, to help city officials make more informed decisions that account for their needs and available capacity.

1) How the strategy contributes to individual traffic reduction targets that improve well-being (e.g., mode shift away from single-occupancy vehicles, fewer kilometers driven, or encouraging a cleaner vehicle fleet). Because cities have different priorities for which of these outcomes they intend to pursue, we do not provide a summary rating for this criteria.

2) How the strategy contributes to sustainable transportation goals of improving access, maintaining safety, protecting the environment and human health, and using resources efficiently, and

3) The level of capacity required for effective implementation.

		Link to livability and sustainability* (see 3.1 and 3.2)	**Capacity required for effective implementation** (see 3.3)
PARKING REFORMS	DEMAND-BASED PRICING	MED	MED
	OFF-STREET PARKING REFORMS	LOW	
COMMERCIAL PARKING TAX		LOW	LOW
EMISSIONS-BASED PRICING AND CONGESTION CHARGING	LOW EMISSION ZONE	LOW	HIGH
	CONGESTION PRICING	HIGH	
REALLOCATING ROAD SPACE FOR PEOPLE		HIGH	LOW
LIMITED TRAFFIC ZONE		MED	MED

*Evaluation considers the extent to which each strategy contributes to the livability targets identified in 3.1 and the sustainable transport goals in 3.2.

Together, these evaluations yielded the following key takeaways:

Key Takeaway 1

Implementing multiple traffic reduction strategies together maximizes impact and reduces potential challenges related to political will and equity.

There are only a few examples of cities that have implemented multiple strategies together, though this approach is gaining momentum. Notably, C40's Green and Healthy Streets initiative acknowledges the role of increased walking, cycling, and public transport in reducing the use of polluting private vehicles and encourages city mayors to pursue public bus and other fleet electrification and complementary strategies to reduce emissions and VKT.[165]

Fee-based strategies have the advantage of generating considerable revenue, depending on the design, which has been shown to successfully cover operational costs as well as fund improvements to walking, cycling, and public transit facilities—projects that may not otherwise have received funding. Revenue generation can be an attractive feature for cities with limited budgets. However, in addition to operations, revenue generated from fee-based strategies should be used to address equity concerns, offsetting burdens for low income people and other groups who may be disproportionately affected by the pricing policy. This can help to address concerns about regressivity that often arise in response to fee-based strategies.

Non-fee-based strategies, while not able to generate revenue directly, have been shown to stimulate economic activity and reduce societal costs from road injuries and fatalities. These can also be attractive to risk-averse cities that may not be willing to commit to a large-scale congestion pricing scheme, for example. Because these strategies do not impose fees on drivers, they can be less challenging to implement, politically, compared to fee-based strategies, especially in cities with high mode shares of pedestrians. However, behavior change may not be observed as quickly or at as large a scale compared to fee-based strategies, given that drivers can continue to drive, albeit less conveniently.

Implementing fee-based and non-fee-based strategies as part of a comprehensive traffic reduction policy could help to maximize the benefits of both while reducing political or public pushback. Designing a comprehensive traffic reduction policy may also allow for more transparency around the use of revenues from fee-based policies to support other interventions, like road space reallocation, which not only restricts drivers but improves conditions for non–vehicle users.

165 Amsterdam, Austin, Berlin, Jakarta and Liverpool Commit to Rid Fossil Fuels from City Streets by 2030.

Key Takeaway 2

Reallocating road space for people should be considered part of a comprehensive traffic reduction strategy, especially where capacity is limited.

Road space reallocation is not always a top-of-mind strategy for traffic reduction; however, it has been shown to generate mode shift toward sustainable modes. Physically reducing space for vehicles on the street makes driving less convenient and walking, cycling, and public transit faster, safer, and more enjoyable options. Street redesigns that de-prioritize vehicles without banning them outright or charging drivers can help with public acceptance. Phasing—starting with targeted corridor or intersection redesigns and replicating and expanding them over time—can ensure the development of a network of pedestrian, cyclist, and transit-priority streets, enhancing their impact and ability to provide a viable alternative to private vehicle use. Similarly, road space reallocations can be implemented gradually, whereas a low emission zone or congestion pricing zone needs to be a significant size to be effective. Furthermore, road space reallocation does not present the transparency concerns or technology requirements raised by other traffic reduction strategies. Additionally, in places where mode share of private vehicles is low, as is often the case in many L/LMIC cities, reallocating road space for people restricts private vehicle use *while* improving safety and comfort for the majority of people who already travel by foot, bicycle, or public transport.

Key Takeaway 3

The presence of alternative transportation options is critical, particularly when most or all private vehicles are restricted from a zone.

Impacts from any traffic reduction strategy will be bolstered by improvements to cycling, walking, and public transit facilities. Without such alternatives, those who can continue to afford (financially or with time) to drive will do so, and those who cannot will see their ability to access destinations disproportionately limited. Providing affordable, reliable alternatives to driving is consistently cited as a requirement for maintaining equity when implementing a traffic reduction strategy.[166] Furthermore, using revenues generated from fee-based strategies, like a congestion charge or demand-based on-street parking, to directly fund local improvements to cycling, walking, and transit helps make these strategies, which could be viewed as regressive, more progressive.[167]

166 Low-Emission Zones Are a Success—But They Must Now Move to Zero-Emission Mobility.
167 Traffic Congestion Pricing: Methodologies and Equity Implications.

Key Takeaway 4

If capacity is limited, adoption of traffic reduction strategies could follow a progression.

Cities with capacity limitations should consider alternatives to high-cost, high-technology traffic reduction strategies, at least to start, as lower-cost, low-technology strategies have documented success in reducing demand for driving. Indeed, road space reallocation projects, which do not require a lot of capacity to implement, can be a first step in catalyzing a shift to sustainable transport modes by establishing a network of high-quality walking, cycling, and public transport options and de-prioritizing vehicle use. Then, moderate-cost, moderate-capacity strategies like parking reform and limited traffic zones can be undertaken, continuing the momentum toward driving less and beginning to generate revenue to expand and improve sustainable transport options. Both road space reallocation and on-street parking pricing can be implemented incrementally, as needed, which may help with political palatability and public acceptance. Eventually, once the network is large enough and capacity is robust, high-cost, high-technology strategies like emissions-based and congestion pricing zones can be more seriously pursued, supported by a strong network of sustainable transport alternatives to driving.

APPENDIX A: DESIGN AND IMPLEMENTATION RESOURCES

PARKING

- Asian Development Bank. (2011). Parking Policy in Asian Cities.
- Inter-American Development Bank. (2013). Practical Guidebook: Parking and Travel Demand Management Policies in Latin America.
- ITDP. (2014). Shared Parking.
- ITDP. (2015). Parking Basics.
- ITDP China. (2015). Parking Guidebook for Beijing.
- ITDP India. (2014). Park It Right! How Smart Management Can Help Us Solve Our Parking Woes.
- ITDP Mexico. (2014). Less Parking, More City: A Case Study in Mexico City.
- ITDP Mexico. (2015). Menos Cajones Más Ciudad [Video].
- Victoria Transport Policy Institute. (2018). Parking Management: Strategies for More Efficient Use of Parking Resources.

LOW EMISSION ZONES AND EMISSIONS-BASED PRICING

- C40 Cities. (2019). How to Design and Implement a Clean Air or Low Emission Zone.
- WRI. (2017). Study on International Practices for Low Emission Zone and Congestion Charging.

CONGESTION PRICING

- Asian Development Bank and GIZ. (2015). Introduction to Congestion Charging: A Guide for Practitioners in Developing Cities.

REALLOCATING ROAD SPACE FOR PEOPLE

- ITDP. (2017). TOD Standard.
- ITDP. (2018). Pedestrians First: Tools for a Walkable City.
- ITDP Africa. (n.d.). How to Develop Non-motorised Transport Strategy or Policy.
- ITDP Africa. (2018). https://africa.itdp.org/publication/africa-streets-walking-cycling/
- ITDP India. (2019). Complete Streets Framework.
- NACTO/GDCI. (2016). Global Street Design Guide.
- Streetmix. (n.d.). Streetscape Design Tool.

APPENDIX B: DEFINITIONS OF 3.3 EVALUATION CRITERIA

Data privacy and surveillance concerns

The design of some traffic reduction strategies may raise concerns about governments' abilities to protect personal privacy, maintain data integrity, or prevent improper data sharing. For example, existing congestion pricing schemes in Stockholm, Singapore, Milan, and elsewhere use automatic number/license plate recognition (ANPR/ALPR) cameras or similar technology to identify vehicles without an on-board unit (OBU) that enter the congestion charge zone. Privacy concerns related to the ability to reidentify individuals based on their vehicle's travel patterns or the use of license plate records to track marginalized groups like immigrants could lead to pushback against this traffic reduction strategy design.[168]

Technology needs

Some traffic reduction strategies require technology to operate successfully. For example, cordon and distance-based pricing could require an OBU inside each vehicle to accurately charge local vehicles or might use ANPR cameras to charge vehicles without an OBU. Other technologies, like smart meters and sensors, are used to operate demand-based parking. Lack of access to these and other costly technologies, such as intelligent transportation systems (ITS), may prevent the successful implementation of certain traffic reduction strategies. However, while these technologies can help to automate operational aspects of traffic reduction strategies, they present monetary costs and can generate privacy concerns that threaten public acceptance.

Political complexity

Political complexity refers to the feasibility of designing and implementing a traffic reduction strategy given current and historical political willingness to do so. For example, even though fee-based strategies may be attractive from an economic standpoint, they have been difficult to pass politically because individuals and groups have pushed back against being charged for what had previously been free. Non-fee-based strategies also present political complexities, as demonstrated by legal challenges from drivers in Paris in response to the mayor's closing of streets along the Seine to vehicles.[169]

Upfront government investment

Some traffic reduction strategies are more costly to implement and maintain than others, especially if new technologies or systems are being pursued. London's congestion pricing scheme required $214 million in upfront investment, but it generated nearly $4 billion in revenue in its first 10 years of operation.[170] The need for significant initial investments from the government could lead to public backlash, especially if drivers are also being charged. Therefore, it is important to communicate clearly how the traffic reduction strategy will improve people's daily lives. Transparency around the use of revenues can also help to foster social acceptance. Funding for concrete benefits that can be observed locally in the short term should be prioritized, though some revenues should be set aside for longer-term system-level projects.[171]

168 Congestion Pricing Should Use Apps, Not Cameras.
169 Paris Car Ban: Court Upholds Mayor Anne Hidalgo's Plan.
170 https://www.nlc.org/resource/making-space-congestion-pricing-in-cities/
171 The Potential of Road Pricing Schemes to Reduce Carbon Emissions.

CONTACT

INSTITUTE FOR
TRANSPORTATION &
DEVELOPMENT POLICY

9 East 19th Street, 7th Floor
New York, NY 10003

T: + 1-212-629-8001

E: mobility@itdp.org

W: www.itdp.org