The Electric Assist:

LEVERAGING E-BIKES AND E-SCOOTERS FOR MORE LIVABLE CITIES

ITDP

THE ELECTRIC ASSIST: LEVERAGING E-BIKES AND E-SCOOTERS FOR MORE LIVABLE CITIES

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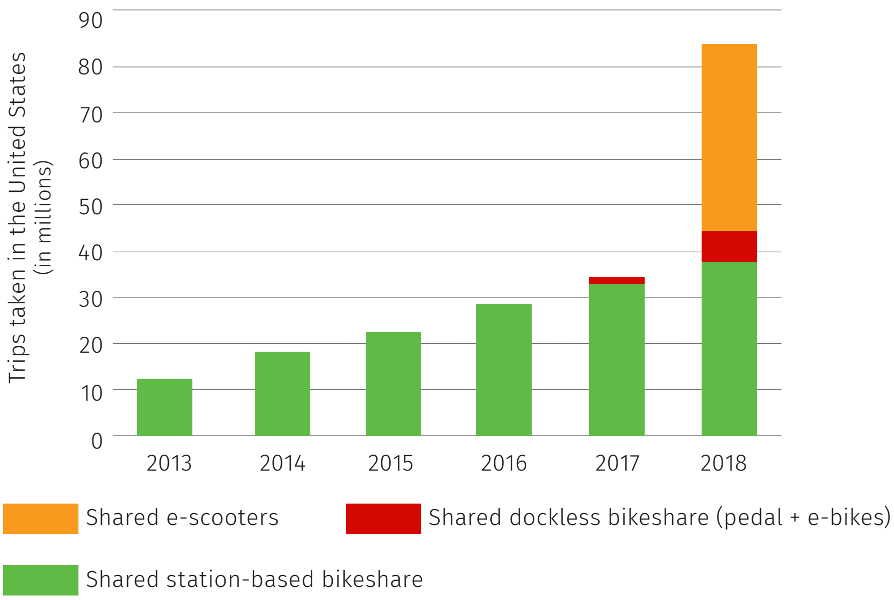
WHAT IS ELECTRIC MICROMOBILITY?

Micromobility, though not yet universally defined, has been used to refer to a number of different modes. In this report, we use the term "electric micromobility" to refer to electric-powered modes of transport that are low-speed (comparable to a bicycle), small, lightweight, and typically used for short distance trips. These include primarily electric bicycles and standing e-scooters, but also other small electric devices, and can be shared or personally owned.

Credit: BikePortland, Flickr CC

Why Does Electric Micromobility Matter?

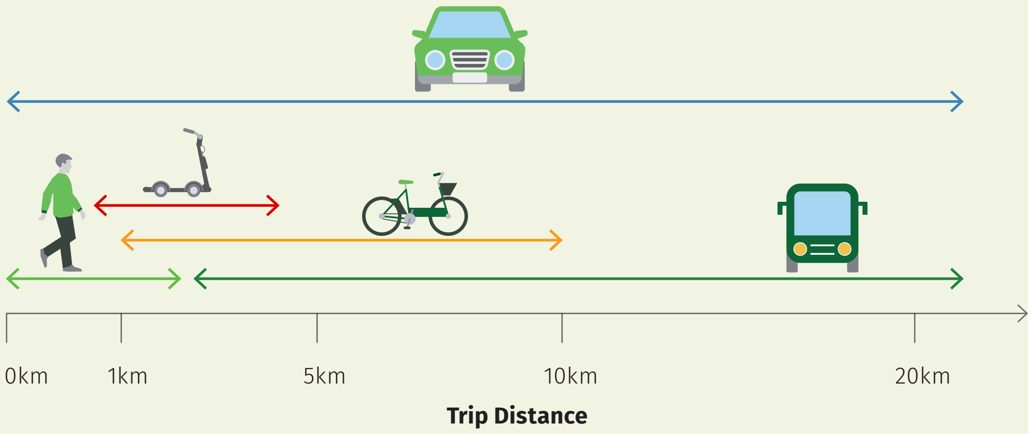
Electric micromobility has enormous potential to improve sustainable urban transportation systems. Recent technological advancements and the rapid growth and adoption of shared mobility services have enabled small electric modes to scale. As a result, e-bikes and e-scooters could serve as a point of entry to the broader sustainable transportation network, enabling more people to rely on walking, cycling, and public transit for more trips—and perhaps consider not owning a car at all.



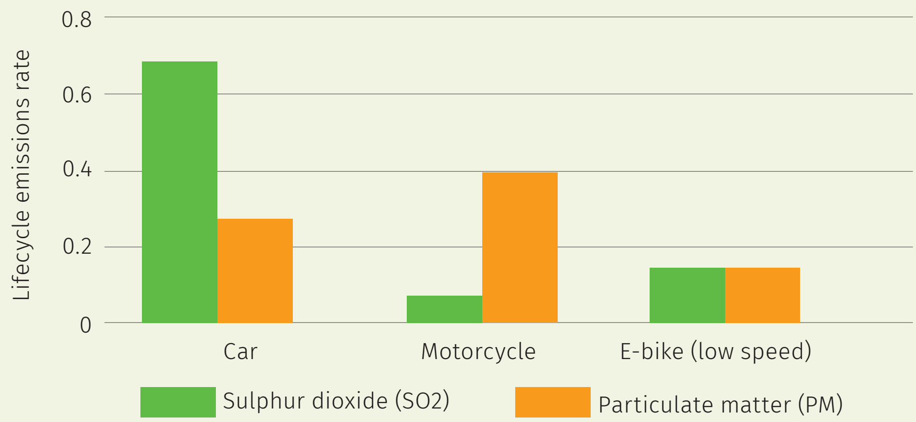
Source: Adapted from NACTO's "Shared Micromobility in the US: 2018" report

Most urban trips are less than ten kilometers, a distance easily traveled using electric micromobility. As the share of short and mid-distance trips completed using e-bikes and e-scooters instead of cars grows, we can expect to see:

MORE TRIPS MADE BY BICYCLE, WALKING, AND TRANSIT, and a combination of these with electric micromobility

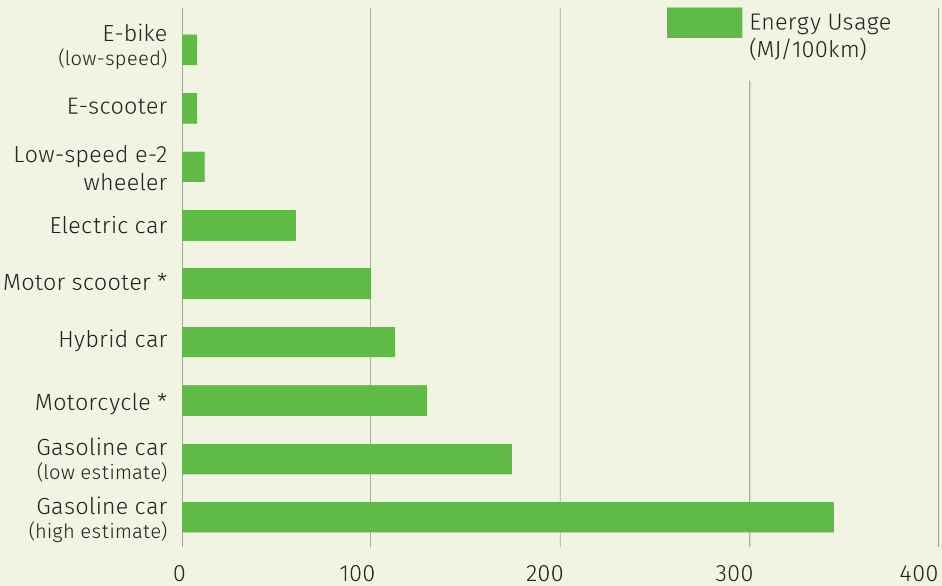


IMPROVED AIR QUALITY from a reduction in harmful pollutants



Source: Cherry et al., 2009

MORE EFFICIENT USE OF ENERGY



*Energy usage based on one model, recognized as an average.

Source: ITDP data

HOW CAN E-BIKES AND E-SCOOTERS LINK TO SUSTAINABLE TRANSPORT GOALS?

Successful urban transportation systems increase access to destinations, activities, goods, and services, and do so in a form that is safe and equitable (both to access and in terms of benefits distribution), minimizes environmental harm, uses resources efficiently, and mitigates negative health impacts. Using this framework, we can evaluate the role of e-bikes and e-scooters in moving cities toward more sustainable transportation networks and identify potential negative impacts that will need to be addressed.

Sustainable Transport Goal	Potential Positive Impacts +	Potential Negative Impacts -
Access	+ Offer travel times competitive with vehicles for short trips + Provide connections to transit and economic and social opportunities + Increase use by more types of users and for more kinds of trips than pedal bicycles	- Demand for public parking and charging infrastructure
Environment	+ Reduce single-occupancy vehicle trips + Improve air quality + Reduce harmful emissions from passenger and local freight transport	- Increase net emissions and materials use (shared devices with short life spans) - Displace transit, cycling, and walking trips
Equity + Affordability	+ Shared systems offer alternative to purchasing outright + Connect underserved areas to transit + Provide travel alternatives that enable car-free or car-light living	- Availability limited to higher-income neighborhoods (shared systems) - Present barriers to use by those without a smartphone and/or credit card - Too expensive for low-income groups, especially without fare integration with transit (shared systems)
Efficiency	+ Free up street space for more efficient uses + Increase energy efficiency in transport + Decrease need for public investment in road maintenance	- Oversupply and indiscriminately parked devices clutter sidewalks (shared dockless systems) - Increase energy use due to inefficient charging and redistribution of shared devices
Safety	+ Contribute to “safety in numbers” effect where the presence of pedestrians and cyclists leads to safer streets for all + Increase demand for safe cycling and pedestrian infrastructure	- Increase crashes and injuries - Prompt harassment or social stigmatization
Health	+ (E-bikes) Increase physical activity levels for those who would not consider pedal cycling + Reduce noise pollution when replacing car and motorcycle trips	- (E-scooters) Reduce physical activity levels if replacing walking or pedal cycling trips

WHAT SHOULD CITIES DO TO LEVERAGE THE BENEFITS OF E-BIKES AND E-SCOOTERS?

Only a handful of published studies look at the impact of electric micromobility on sustainability goals. Few best practices of outcome-oriented planning in regards to electric micromobility have emerged given how recently e-bikes and e-scooters have grown in popularity in many cities. Recognizing this knowledge gap, we reviewed existing policies on e-bikes and e-scooters and developed the following recommendations for cities to minimize potential harm and maximize benefits.

Policies	Goal(s)	Recommendation
Classification	N/A	• Classify e-bikes and scooters as non-motor vehicles • Clearly define maximum speeds for low- and moderate-speed devices
Infrastructure	Safety	• Define the infrastructure that electric modes are permitted to use • Design safe, inclusive on-street infrastructure • Enforce safe use of cycling infrastructure
Adoption and Use	Access Equity and affordability Efficiency	• Increase exposure and access to small electric modes • Encourage trip replacement by making car travel less convenient • Design and implement parking and charging spaces
Crash Reduction	Safety	• Design safe, inclusive on-street infrastructure • Offer public safe-riding courses
Strategic Planning	Environment Health	• Integrate small electric modes into citywide strategies and plans • Collect data for analysis and enforcement

ASSESSING CAPACITY NEEDS FOR SUCCESSFUL MANAGEMENT

Some cities are better equipped than others to implement supportive infrastructure, like cycle lanes and parking, and monitor the provision of shared e-bike and e-scooter services by the private sector. Cities that are less equipped should build capacity to better position themselves to manage e-bike and e-scooter use and to operate a sustainable transport network more broadly. Building capacity and partnerships between public and private stakeholders will be critical for these modes to achieve scale and related benefits, and to ensure they are well-integrated into urban transportation networks.

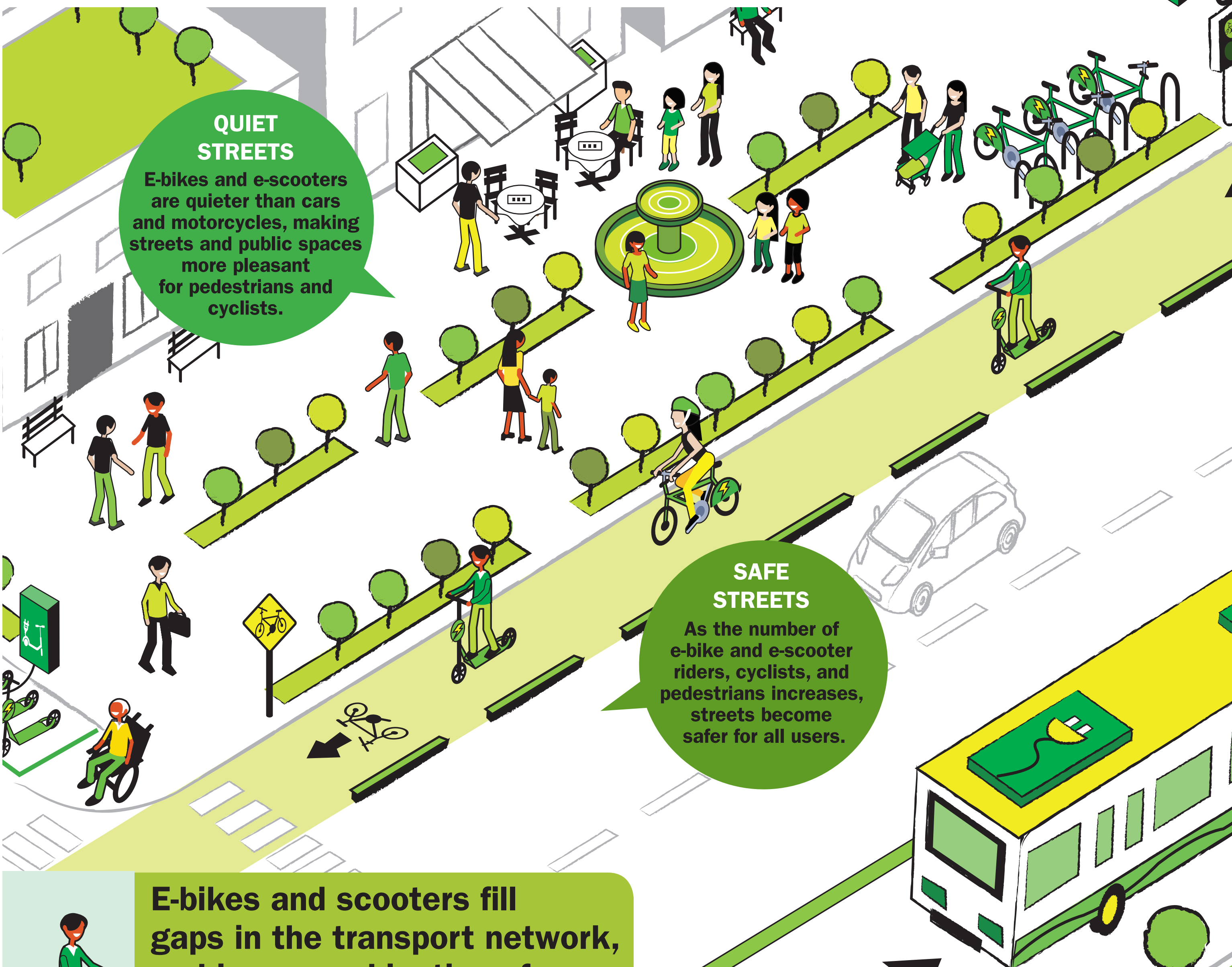
CONCLUSIONS

Additional research and analysis across the board—and especially in low-income contexts outside North America and Europe—is needed to better understand the right role for both personal and shared electric micromobility in urban transport. In the meantime, regardless of location, cities can take the following steps to expand access to and oversight of electric micromobility in the near term: **Legalize** use; **standardize** speed maximums for electric modes when using cycling infrastructure; **design** safe cycling infrastructure that accommodates both electric and non-electric devices; **manage** and regulate shared electric micromobility systems; and monitor use and ridership trends.

ELECTRIC MICROMOBILITY HAS THE POTENTIAL TO BECOME A CRITICAL COMPONENT IN THE SHIFT AWAY FROM PRIVATE VEHICLES AND TOWARD TRANSPORTATION SYSTEMS THAT PRIORITIZE PEOPLE. TO ACHIEVE THIS PIVOT, CITIES WILL NEED TO TAKE AN ACTIVE ROLE TO MAXIMIZE BENEFITS AND LIMIT NEGATIVE OUTCOMES.

E-BIKES AND E-SCOOTERS: DRIVERS OF CLIMATE ACTION

Electric bikes and scooters are more than a convenient first-last mile solution in cities. They also reduce emissions while catalyzing a broader shift toward sustainable transport.



E-bikes and scooters fill gaps in the transport network, making a combination of cycling, walking, and public transit the easy choice over cars for more trips:

In Portland, Oregon, **6% of e-scooter users reported getting rid of a car** due to the availability of micromobility options.

What cities can do:

LEGALIZE

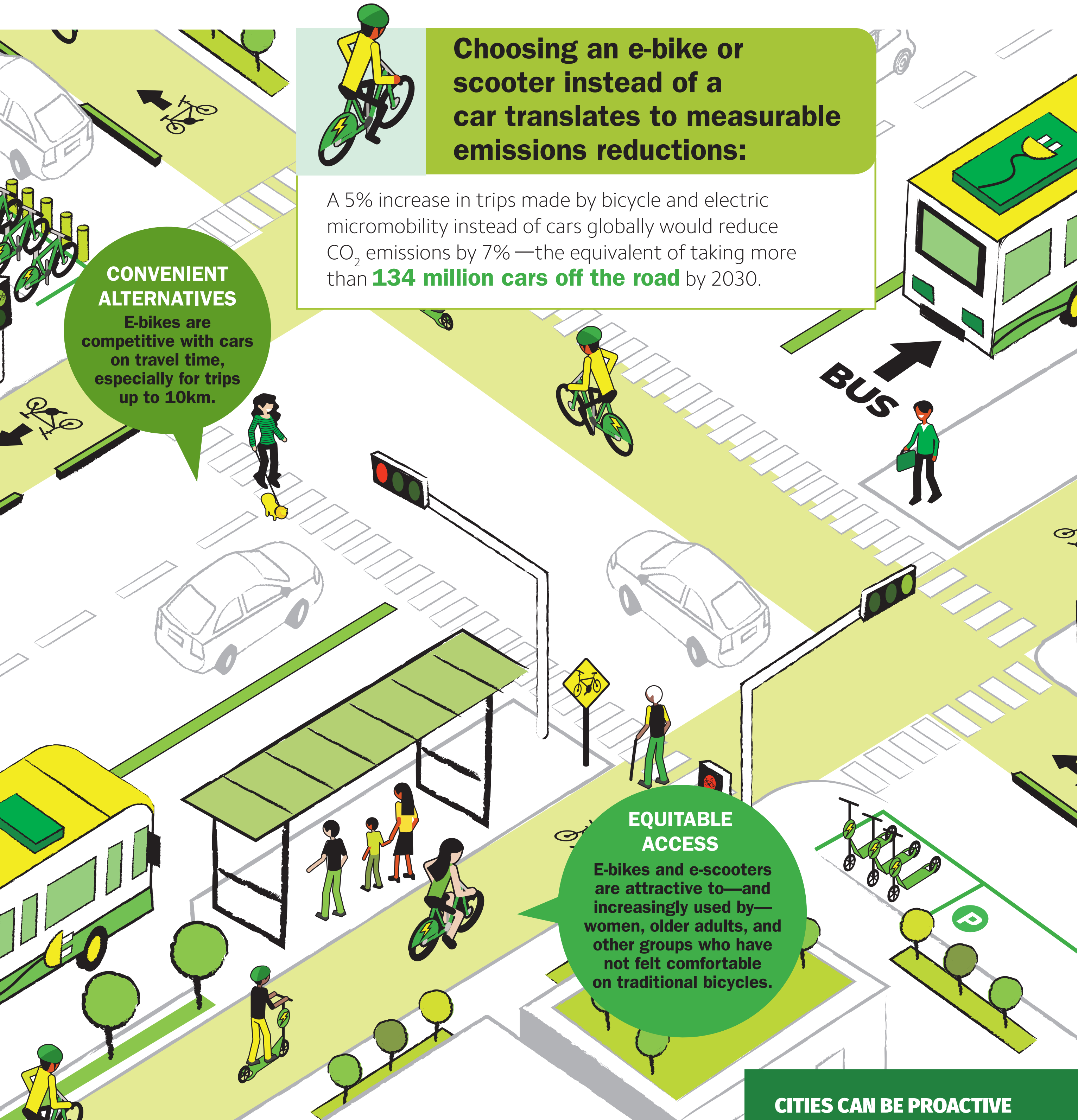
Make low-speed e-bikes and scooters legal in cities. Regulate them as bicycles, not motor vehicles, so license and insurance are not required to ride.

STANDARDIZE

Clearly define and enforce speed maximums for e-bikes and e-scooters to distinguish where they can safely share cycle lanes with pedal bicycles.

Choosing an e-bike or scooter instead of a car translates to measurable emissions reductions:

A 5% increase in trips made by bicycle and electric micromobility instead of cars globally would reduce CO_2 emissions by 7% —the equivalent of taking more than **134 million cars off the road** by 2030.



CONVENIENT ALTERNATIVES

E-bikes are competitive with cars on travel time, especially for trips up to 10km.

EQUITABLE ACCESS

E-bikes and e-scooters are attractive to—and increasingly used by—women, older adults, and other groups who have not felt comfortable on traditional bicycles.

DESIGN

Ensure cycle lanes are protected and form a complete network, safely accommodating low-speed e-bike and e-scooter riders in addition to pedal cyclists.

MANAGE

Enforce rules for bikeshare and scootershare operators to ensure that sidewalks are clear, and shared bicycles and scooters are well-maintained.

MONITOR

Collect and analyze data on trip length, frequency of use, and destinations to better quantify personal e-mobility use, and scale and improve shared systems.

CITIES CAN BE PROACTIVE IN MAXIMIZING THE BENEFITS OF ELECTRIC MICROMOBILITY BY ENACTING MEASURES TO LEGALIZE, STANDARDIZE, DESIGN FOR, MANAGE, AND MONITOR THESE MODES. DOING SO CAN HELP ENSURE THAT E-BIKES AND E-SCOOTERS PUSH FORWARD GOALS LIKE THOSE RELATED TO CLIMATE.

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1 INTRODUCTION

Electric bicycles and scooters, referred to collectively as electric micromobility[1] or small electric modes, have enormous potential to improve sustainable urban transportation systems. In particular, small electric modes present a competitive alternative to private vehicles in terms of travel time, and they could play a key role in reducing single-occupancy vehicle trips. The rapid growth and adoption of shared mobility services have exposed more people to e-bikes and e-scooters, with fewer barriers to entry. As they continue to scale, shared e-bikes and e-scooters can serve as a point of entry to the broader sustainable transportation network, enabling more people to rely on walking, cycling, and public transit for more trips—and perhaps even consider not owning a car at all.

Electric micromobility is growing in popularity and scale in many locations thanks to a number of recent developments, including:

- expanded distance ranges as battery technology improves
- falling purchase costs as the industry achieves economies of scale
- investments in supportive infrastructure such as cycle lane networks.[2]

And, e-bikes and e-scooters can fill a critical role in the sustainable transport system by:

- fostering modal shift away from private vehicles, thereby locally reducing harmful emissions and improving air quality
- expanding access to public transport and other key destinations, especially with physical and fare integration between modes
- promoting more efficient use of energy and public space (in terms of streets and parking)
- improving health outcomes for a larger and more diverse population than pedal bicycles.[3]

Potential negative impacts from electric micromobility must be addressed too, including safety, displacement of bicycle and walking trips, inequitable access, and environmental concerns related to manufacturing, materials sourcing, and disposal. The severity of these impacts could grow as electric micromobility achieves scale. Other considerations that may act as barriers to adoption include affordability, ease of use, and social stigma.[4] Many of these barriers are common to traditional cycling as well, and addressing them will help to grow both electric and non-electric mode shares.

About this report

Electric bicycles, electric kick scooters, and other small personally-operated devices account for a limited percentage of trips in most cities. A robust body of academic and industry literature exists on the design, sale, performance, and, to a lesser extent, uptake of small electric modes; however, we found very few published studies that consider if or how electric micromobility might contribute more broadly to accessible, affordable, sustainable transportation systems. These studies, listed in Appendix A, tend to address the impact of a specific mode on one or two sustainable transport goals (e.g., the impact of e-bikes on greenhouse gas emissions). Our research produced few replicable best practice policies that expand e-bike and e-scooter use as a direct action to achieve emissions reductions, mode shift, or other targets (see Appendix A). This may be because electric bicycles, scooters, and other electric micromobility modes are just beginning to emerge in many countries.

Based on a review of existing academic and industry literature and interviews with ITDP field office staff and external experts, this report aims to:

1. Catalog the current use of small electric modes and their impact on sustainable transportation more broadly.
2. Provide an overview of existing policies governing small electric modes across different regions and recommend actions to strengthen and improve policies for more widespread access to and use of e-bikes and e-scooters.
3. Consider capacity requirements for governments to successfully position electric micromobility to meaningfully contribute to their sustainable transport goals.

1 Micromobility does not yet have a consensus definition and has been used to refer to a number of different modes. In this report, we use the term “electric micromobility” to refer to electric-powered modes of transport that are low-speed (comparable to a bicycle), small, lightweight, and typically used for short distance trips. These include primarily electric bicycles and standing e-scooters, but also other small electric devices, and can be shared or personally owned.

2 Weiss et al., 2015. On the Electrification of Road Transportation: A Review of the Environmental, Economic, and Social Performance of Electric Two-Wheelers.

3 Castro et al., 2019. Physical Activity of Electric Bicycle Users Compared to Conventional Bicycle Users and Non-Cyclists.

4 Identified through an internal survey of ITDP’s field office staff in Mexico, Brazil, Kenya, India, Indonesia, and China (referenced hereafter as ITDP Internal Survey, 2019).

Given that speed, weight, and/or motor wattage are often used to differentiate between types of e-bikes and e-scooters, this report focuses on what we have categorized as low- and moderate-speed electric devices. **Table 1** identifies the devices that we focus our analysis on and provides additional details for specific types of devices that fall within these broader definitions.

Low- and moderate-speed electric bicycles (e-bikes)
For the purposes of this report, we define an electric bicycle as a two and three-wheeled device equipped with pedals and a battery-powered motor that provides an assist to the rider. These are referred to as pedal-assist bicycles or pedelecs. The electric assist on **low-speed e-bikes** will cut out once the rider reaches a speed not compatible with pedal bicycles. We define **moderate-speed e-bikes**, which include speed pedelecs (rider must pedal to activate assist) and throttle e-bikes (rider can pedal or engage throttle to activate assist), as similar in size, weight, and operation to low-speed e-bikes. However, these can reach higher speeds before the assist cuts out.[5]

Electric scooters (e-scooters)
Electric scooters are defined in this report as two-wheeled standing kick scooters with a battery-powered motor that propels the scooter when the rider engages the throttle with their thumb. We define e-scooters as vehicles that operate at speeds comparable to those achieved by pedal bicycles.

Table 1. Defining small electric mobility modes

MODE	SPEED	TYPE
Low-speed e-devices	Comparable with pedal bicycles, typically up to 25 kph	Electric bicycle (also referred to as pedal assist, pedelec, or electric assist)
		Electric scooter (also referred to as battery-electric scooter, motorized kick scooter)
		E-rickshaw
Moderate-speed e-devices	Comparable with vehicles on city streets, typically up to 45 mph, but can quickly self-limit speed to be comparable with pedal bicycles when necessary	Throttle electric bicycle
		Speed pedal-assist bicycle (also referred to as speed pedelec and some moped style moderate-speed seated scooters)
High-speed e-devices	Comparable with vehicles on highways, typically up to 100 kph	Electric seated scooter (also referred to as Vespa-style scooter or moped)
		Electric motorcycle (also referred to as electric two-wheeler [E2W])

Gray = not included in the scope of this paper

In addition to the more common modes of micromobility described above, a proliferation of electric skateboards, unicycles, and similar products are hitting the market every day that qualify as low-speed electric devices and operate similarly to e-scooters. However, due to their relative nascency and the lack of centralized data on trips completed, this paper focuses primarily on pedal-assist electric bicycles and battery-electric scooters when referring to low-speed electric devices. E-rickshaws, which have been growing in popularity as a replacement for auto and pulled rickshaws in several Asian countries, can also be categorized as low-speed electric devices. While these are not specifically called out in this report, recommendations made could be contextualized to apply to e-rickshaws.

5 Fishman and Cherry, 2015. E-bikes in the Mainstream: Reviewing a Decade of Research.

Electric seated scooters and motorcycles (electric two-wheelers or E2Ws) are also not included in this paper. It is important to note that electric two-wheelers tend to be overlooked in the context of sustainable transportation research. E2Ws have enormous potential to address some of the challenges two-wheelers present, namely noise and air pollution. However, since they operate at significantly higher speeds, E2Ws present vastly different challenges compared to e-bikes and e-scooters in terms of safety; infrastructure needs and use of street space; and policy approaches. We also decided to exclude E2Ws from this analysis because they function differently from e-bikes and e-scooters in their ability to contribute to the sustainable transport goals defined in Section III.

Over the past few years, low-speed electric bicycles have been integrated into city bikeshare systems like Mexico City's Ecobici. Credit: Enrique Abe, Mexico City's Ministry of Environment, Department of Cycling, Culture, and Infrastructure

CONTEXT

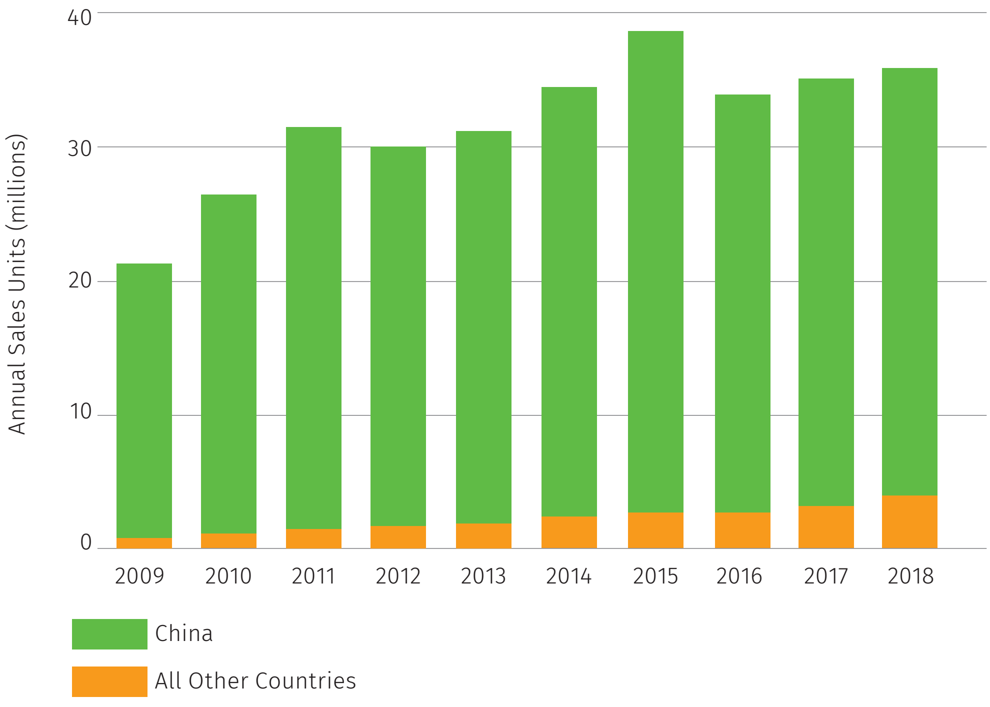
2

E-BIKES

Research on electric mobility varies widely in scope. A review of academic literature on e-bikes published in 2018 found that the engineering field carries out the majority of e-bike research, covering topics related to transportation, product development, materials manufacturing, and battery technology. More limited research exists around e-bike design as it relates to energy distribution and charging, and around analyses of safety and crash prevention.[6] Fishman and Cherry find in their comprehensive literature review that research produced in China and other Asian countries tends to focus on operations, safety, and market growth due to the high number of e-bikes operating in those locations. Western studies, coming mostly from North America and Europe, focus primarily on health, behavior, and the emerging market for e-bikes.[7]

Sales data on e-bikes is notably limited and ambiguous: It does not account for all e-bikes in use, since kits are available to convert pedal cycles into e-bikes. Still, sales data indicates growing demand for e-bikes, and that could lead to a growth in supply as manufacturers scale up production. Over the past two decades, e-bike sales have grown exponentially across many countries, even outselling traditional bikes in the Netherlands in 2018. Outside of eastern Asia, e-bike sales have seen enormous increases in recent years. The United States, on the other hand, has seen a somewhat inconsistent rate of growth in e-bike sales, an irregularity among available data. Figure 1(a) shows annual e-bike sales for select regions, clearly dominated by China, while Figure 1(b) shows annual sales excluding China.

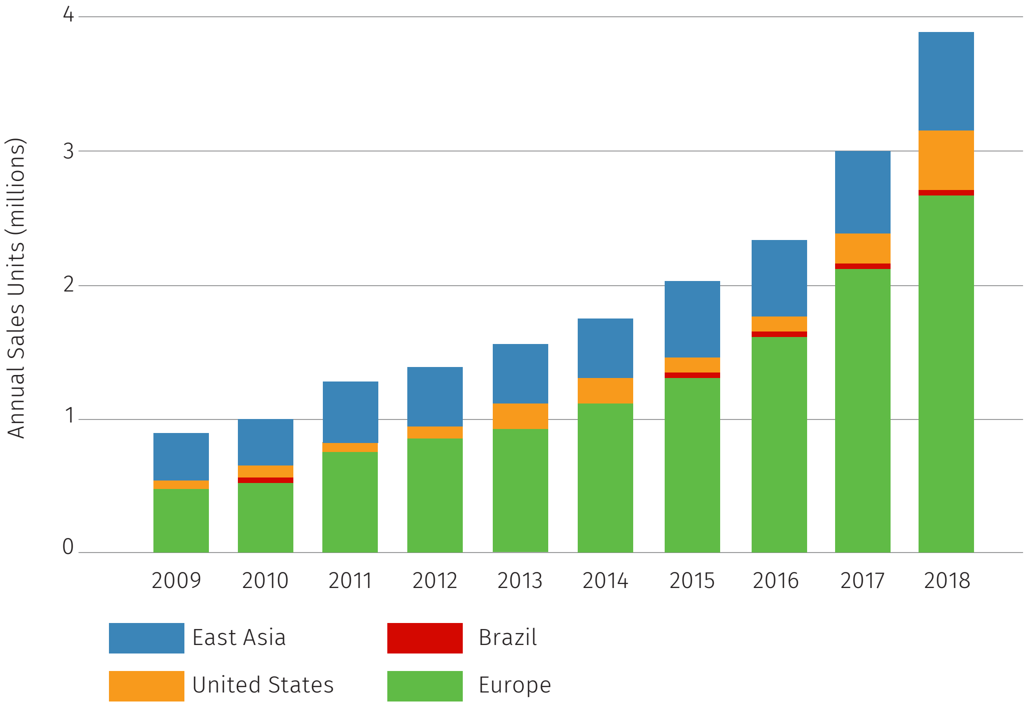
Figure 1a. Global Annual E-Bike Sales



6 Salmeron-Manzano and Manzano-Agugliaro, 2018. The Electric Bicycle: Worldwide Research Trends.

7 Fishman and Cherry, 2015.E-bikes in the Mainstream: Reviewing a Decade of Research.

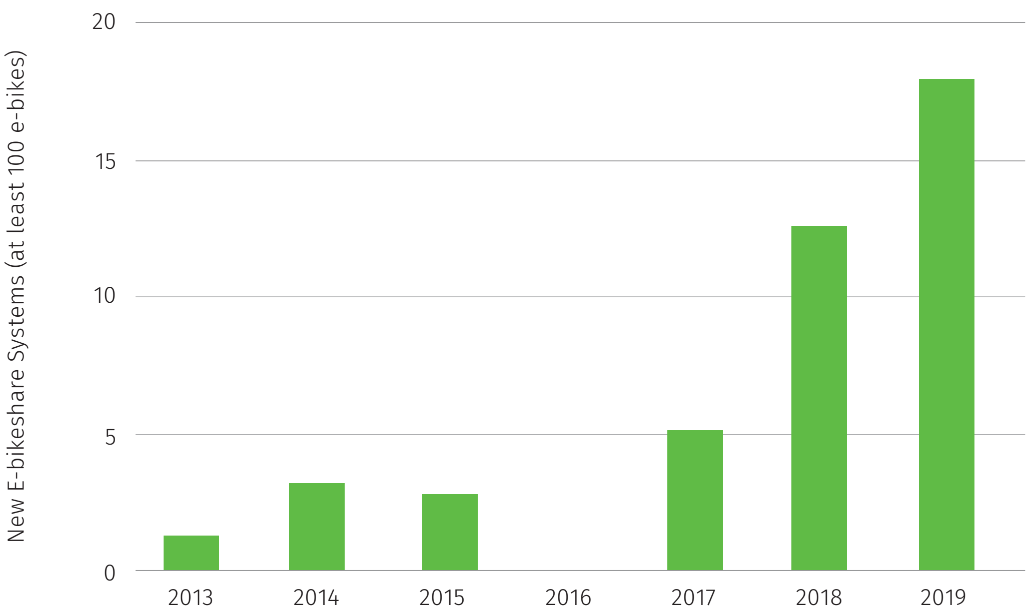
Figure 1b. Global E-Bike Sales (Excluding China)



Note: Data gathered by ITDP. Some numbers are estimated

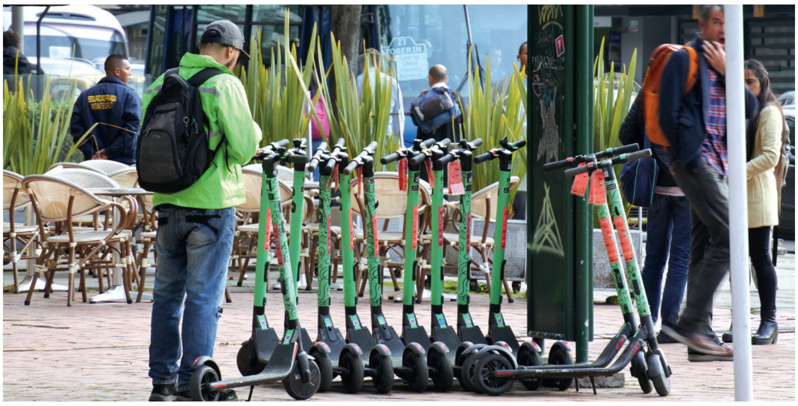
In addition to the increase in e-bike ownership, e-bikeshare has also grown in popularity over the past decade. Though slowly, more e-bikeshare systems are emerging globally year by year (see Figure 2). Still, fewer than 60 of more than 1,600 publicly financed bikeshare schemes worldwide offer at least 100 e-bikes, and less than half of those are full e-bike systems (see Appendix B). Private companies have also introduced e-bikeshare systems separate from existing government-financed systems.[8]

Figure 2. New Publicly Financed E-bikeshare System Openings (100+ e-bikes) by Year



Source: ITDP data

8 ITDP Internal Survey, 2019.



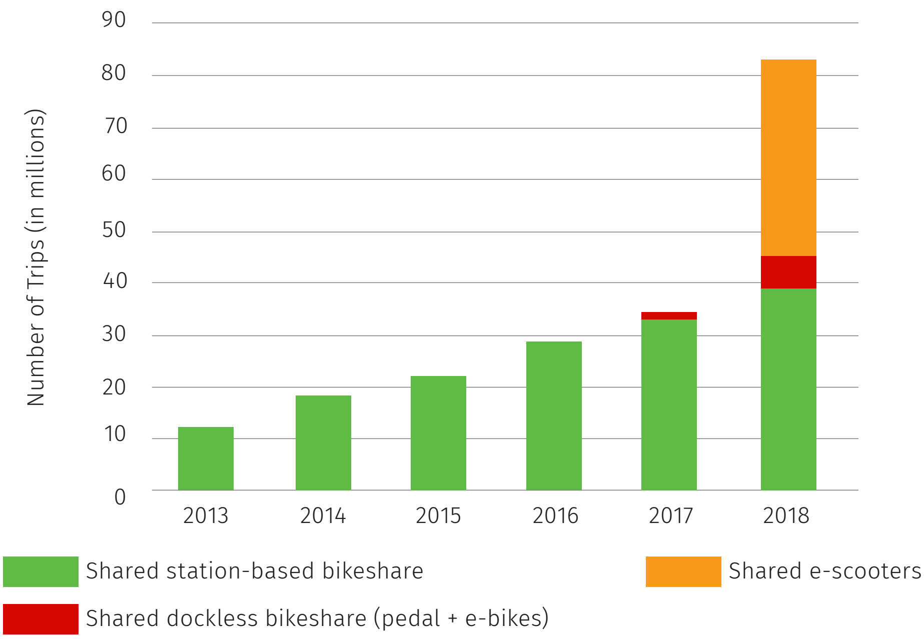
Mexico City-based operator, Grin, launched e-scooters in Bogota in 2018.
Credit: Carlos Felipe Pardo

E-SCOOTERS

While personal e-scooters have been on the market for decades, the more recent emergence of shared e-scooter systems in cities has significantly elevated this mode in terms of public awareness and number of trips. Major US cities were among the first to see shared e-scooters on streets in late 2017, with companies expanding into major European markets like Paris in 2018 and Latin American cities like Bogotá and Mexico City the same year. Still, research is relatively limited. Academic literature has been largely unable to keep pace with the rapid rate of change in the shared e-scooter industry. However, there are a number of non–peer reviewed analyses of shared micromobility more broadly, which tend to encompass electric and traditional bikeshare as well as e-scootershare systems.[9] Industry and NGO reports—such as those produced by Remix, the National Association of City Transportation Officials (NACTO), Transportation for America, and the National League of Cities—evaluate e-scooter ridership trends; environmental, equity, and safety impacts; and other intersections between e-scooters and urban transport (see Appendix A). All of these publications focus geographically on e-scooter ridership and trends in the United States.

To put e-scooter ridership in context for the United States: There has been steady growth in bikeshare trips taken in recent years, followed by an explosion of trips—84 million—taken with bikeshare and scootershare in 2018 (see Figure 3). Nearly 46% of those trips were taken on shared e-scooters, and 8% were taken on shared e-bikes. That's compared to 35 million total trips in 2017, 1.4 million (4%) of which were taken on dockless bicycles, and no trips were taken on shared e-scooters.[10]

Figure 3. Trips Taken Using Shared Micromobility in the United States



Note: Adapted from NACTO's "Shared Micromobility in the US: 2018" report

9 Shaheen and Cohen, 2019. Shared Micromobility Policy Toolkit.
10 NACTO, 2019. Shared Micromobility in the US: 2018.

ROLE OF ELECTRIC MICROMOBILITY IN SUSTAINABLE TRANSPORTATION NETWORKS

3

Interest in cultivating more livable cities around the world has led to a focus on the critical role of public transit, walking, and cycling in successful urban transportation networks. Indeed, the primary goal of urban transportation is to increase access to destinations, activities, goods, and services. ITDP believes a successful, sustainable transportation system:

- Provides widespread **access**
- Minimizes harm to the **environment**
- Promotes **equity and affordability**
- Maximizes resource **efficiency**
- Maintains **safety** for all users and
- Promotes **health and quality of life**.[11]

In this section, we use these measures as a framework for evaluating the role of small electric modes within the broader transportation network.

ACCESS

The prioritization of personal cars as the dominant means of transport has led to deep divides between those who have widespread access to destinations and opportunities and those who do not. Demands are changing, however, with calls for affordable, reliable transportation options that compete with the convenience of car travel. In many cities, electric bicycles and e-scooters provide a new transportation option, expanding access to public transit, jobs, and other key destinations. Shared e-bike and e-scooter riders have also reported that the availability of shared options enabled them to make trips they otherwise would not or could not have made, indicating that these modes are meeting unmet demand for travel.

Because of their competitiveness on travel times with cars and the potential for connection to transit, e-bikes can provide accessible alternatives to owning a car. E-bike trips have been shown to have similar—sometimes shorter—travel times to cars during peak congestion hours for distances up to 10 km, especially on routes where high-quality cycling infrastructure is available.[12 13] In some cities, one third of shared e-bike and e-scooter users report replacing car trips with a small electric mode (see Environment section for more on mode shift potential).[14 15] Infrastructure that considers e-bike use could improve the competitiveness of e-bike travel times versus cars, as the inability to pass conventional bicycle users can inhibit use of the electric-assist and therefore slow travel times.[16] Adding passing lanes could help non-electric bicycle riders feel more comfortable maintaining slower speeds in the presence of e-bike riders.

Like public transit, cycling, and traditional bikeshare, electric micromobility provides another non-car transportation option.
Credit: MV Jantzen, Flickr CC

11 Sustainable Mobility for All, n.d. Our Ambition.
12 European Cyclists' Federation, 2016. Electromobility for All: Financial Incentives for E-cycling.
13 Allan, 2016. EBike Performance in Urban Commuting. How Does it Compare to Motorized Modes?
14 Hollingsworth et al., 2019. Are E-Scooters Polluters? The Environmental Impacts of Shared Dockless Electric Scooters.
15 PBOT, 2018. 2018 E-Scooter Pilot User Survey Results.
16 Allan, 2016. EBike Performance in Urban Commuting. How Does it Compare to Motorized Modes?

E-bikes and e-scooters expand the area most people are willing to travel using a pedal cycle or on foot.
Credit: Sonia Medina, ITDP

Furthermore, efforts to encourage connections between e-bikes and e-scooters and transit, such as secure parking at transit stations or fare integration between shared e-bike and e-scooter systems and transit, can expand access to public transit. In lower-density cities, such as those in Australia or the United States, where conventional cycling is not seen as a viable option by most commuters because destinations are spread out, electric modes can provide an attractive non-car alternative. However, use of e-bikes should not substitute for building more density to ultimately reduce trip lengths.

Electric modes can also replace commuting or other utilitarian trips that people might otherwise default to a vehicle for. E-bikes—particularly e-cargo bikes—enable users to transport goods or even additional riders (i.e., children) without a car. Similarly, e-scooters are popular among commuters who cite the need to change clothes or shower as a barrier to choosing a pedal bicycle to travel to work. E-bikes and e-scooters also reduce the physical effort needed to travel uphill, enabling more comfortable, widespread access to hilly areas without needing to rely on a vehicle.

Job Accessibility

Accessibility studies conducted by ITDP show that protected cycle lanes—and, by extension, having the option to safely and comfortably use a non-car mode to connect to transit—can increase the percentage of jobs accessible by rapid transit by up to 10%.[17] Research shows that high-quality cycling and walking routes that connect to transit also support Transit Oriented Development (TOD). A study in Nashville found that e-scooters (on their own or combined with transit) doubled the citywide average number of jobs accessible in 45 minutes.[18] Accessibility gains were accentuated for workers with the lowest current access to transit, with a 10-fold average increase in accessible jobs (from 1,500 to 20,000).

These findings indicate that electric micromobility may present important benefits for those who have historically been disconnected from jobs and other destinations. It is worth noting, however, that these analyses do not disaggregate data by gender, race, or other criteria that may impact use and accessibility. Still, the ability to travel farther distances with a similar level of effort on an e-bike (compared to a pedal cycle) could connect people who are underserved by public transit and cannot afford to live close to amenities and employment centers to these areas. (Note that affordability of electric micromobility is explored in the Equity section).

17 ITDP, 2019. Minneapolis (ITDP Indicators for Sustainable Mobility).

18 The Micromobility Coalition, 2019. Micromobility and Job Access in Nashville.

Increasing Access for Different Types of Users

E-bikes and e-scooters are attractive to a wide range of user groups, appealing to a more diverse population than traditional cycling in most cities.[19] [20] Expanding beyond the traditional demographics of cycling will be critical to achieving more widespread use of low-cost, efficient modes and the benefits they offer. As e-bikes and e-scooters gain popularity, the pool of interested users is expanding to include those who would not otherwise consider cycling for commuting or personal trips.[21] Such groups include older adults, women, those who may not consider themselves physically able to ride a bicycle. Many people in these groups have typically had less power and their mobility can be more constrained, either physically or by the types of trips they need to make. Thus, e-bikes and e-scooters may provide more accessible transport solutions for these previously underserved groups. For example, the increased speed of an e-bike enables less confident or able riders to keep pace with family and friends.[22] Many e-bike riders have noted that the electric assist makes cycling more enjoyable, either to keep pace with other cyclists or to cycle a wider range of terrain more easily.[23] Surveys of e-bike users have also shown that both longtime cyclists and novice riders find e-bikes a fun way to travel.[24]

Charging and Parking Concerns: Barriers to Use

While e-bikes and e-scooters add to the menu of transportation options available to people in cities, several factors—like the ability to charge, park, and maneuver an e-bike or e-scooter—present physical barriers to use. For potential personal e-bike users, "range anxiety," or the fear of being unable to reach a destination (or return home), with sufficient battery charge is a concern.[25] Seasonal fluctuations in battery life, including lower charge in winter months, can exacerbate these concerns.[26] The ability to take an e-bike or e-scooter on public transit decreases range anxiety; however, storage on public transit, such as front bus racks, cannot always accommodate the larger size of e-bikes and can be difficult to use given an e-bike's weight. Riders of e-scooters may be less affected by range anxiety because those have a lighter, more maneuverable design, making it easier to carry an e-scooter onto public transit, where permitted, or into a taxi or other vehicle if the battery dies. Secure public e-bike parking and charging infrastructure would help address access barriers related to charging, but these amenities are limited (or nonexistent) in most cities.[27] [28] A lack of secure public storage is especially problematic for users who live in high-rise housing, as many e-bikes are too heavy to routinely carry up stairs.

E-bikes enable lots of different types of trips, including those that require transporting additional passengers.
Credit: BeyondDC, Flickr CC

19 Rose, 2011. E-bikes and Urban Transportation: Emerging Issues and Unresolved Questions.
20 Fyhri and Fearnley, 2015. Effects of E-bikes on Bicycle Use and Mode Share.
21 Jones et al., 2016. Motives, Perceptions, and Experiences of Electric Bicycle Owners and Implications for Health, Well-Being, and Mobility.
22 Johnson and Rose, 2015. Extending Life on the Bike: Electric Bike Use by Older Australians.
23 Dill and Rose, 2012. E-bikes and Transportation Policy: Insights From Early Adopters.
24 Fishman and Cherry, 2015. E-bikes in the Mainstream: Reviewing a Decade of Research.
25 Dill and Rose, 2012. E-bikes and Transportation Policy: Insights from Early Adopters.
26 Jones et al., 2016. Motives, Perceptions and Experiences of Electric Bicycle Owners and Implications for Health, Well-Being, and Mobility.
27 Astegiano et al., 2015. A Preliminary Analysis Over the Factors Related With the Possession of an Electric Bike.
28 Dill and Rose, 2012. E-bikes and Transportation Policy: Insights From Early Adopters.

ENVIRONMENT

Mode Shift and Emissions Reduction Potential

Cities pursuing reduction strategies for greenhouse gas and other emissions are starting to consider the potential for e-bikes and e-scooters to help travelers shift away from high-polluting vehicles. When they are exposed to more transport options, people are more likely to consider alternatives to driving alone or, better yet, to decide not to own or replace a vehicle.[29]

Electric bicycles and scooters offer a timely opportunity to political leaders under pressure to improve air quality and reduce pollution like sulphur dioxide (SO_2) and particulate matter (PM) (see Figure 4). Exposure to these emissions is dangerous for human health and results in respiratory and cardiovascular complications that have been linked to premature death. These pollutants also present harmful environmental impacts, including reduced visibility, acidification of bodies of water, increased rates of acid rain, and soil nutrient depletion, among others.[30]

E-bikes and e-scooters can help to improve local air quality and reduce negative environmental outcomes by replacing high-emitting modes like fuel-engine cars and motorcycles. Even when electricity for charging is considered, e-bikes emit one third the amount of PM per passenger km as motorcycles and half the amount of cars. Because of the (typically non-renewable) energy required to charge them, e-bikes do emit slightly higher levels of SO_2 compared to motorcycles, but these emissions will fall as energy portfolios transition away from dirty sources.

Figure 4. Pollutants Emitted by Mode

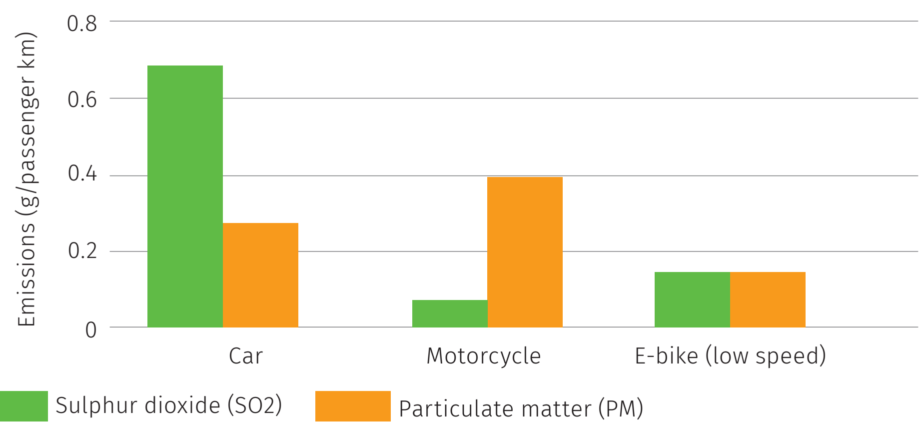


Chart created with data from Cherry et al., 2009.

Even without implementing policies that heavily discourage car use—such as congestion pricing—models show that higher e-bike mode shares in European cities resulted in fewer trips made by cars (and public transit) and more trips made using active modes.[31] We did not find data on the potential for e-bikes and e-scooters to replace motorcycle (two-wheeler) trips. However, displacing motorcycling trips could be beneficial in terms of not only emissions reductions and air quality improvement but also noise pollution reduction and improved safety for pedestrians. ITDP's 2015 High Shift Cycling study forecasted that pedal cycling and e-bikes together could make up 18% of urban trips by 2030 and 22% of urban trips by 2050 worldwide.[32] The study additionally found that if a combined e-bike and pedal bicycle mode share of 14% can be achieved, transportation emissions overall could be reduced 11% by 2050.[33] This is supported by recent work, which found that a 15% increase in e-bike mode share in Portland, OR, would result in an 11% reduction in CO_2 emissions (even holding for the "dirtiest" electricity generation in the United States).[34]

29 Moss, 2015. End of the Car Age: How Cities Are Outgrowing the Automobile.

30 World Health Organization, 2013. Health Effects of Particulate Matter.

31 Astegiano et al., 2019. Investigating the Impact of E-bikes on Modal Share and Greenhouse Emissions: A System Dynamic Approach.

32 Mason et al., 2015. A Global High Shift Cycling Scenario: The Potential for Dramatically Increasing Bicycle and E-bike Use in Cities Around the World, With Estimated Energy, CO_2, and Cost Impacts.

33 Ibid.

34 McQueen et al., 2019. The E-Bike Potential: Estimating Person Miles Travelled and Greenhouse Gas Emissions.

A La Poste worker in France delivers mail using an e-bike
Credit: BeyondDC, Flickr CC

There is promise for such a shift from private vehicles to e-bikes and e-scooters and related emissions reductions. Since the early 2000s, e-bike sales have grown dramatically and present a larger and faster uptake than alternative-fuel vehicles.[35] In the United States, adoption of e-scooters in major cities in the first year they were available is estimated at 3.6%—a relatively high rate compared to carsharing and bikesharing.[36] In Europe, willingness to commute using an e-bike ranges from around 20% in Germany and Denmark to 47% in the Netherlands.[37] People who commute are of particular note for mode shift, as those willing to purchase an e-bike tend to cycle less at present but are also interested in driving less.[38] Potential for car trip displacement is significant: in Kunming, China, 25% of e-bike riders reported substituting their car trips for e-bike trips.[39] Comparatively, 34% of e-scooter trips in Raleigh, North Carolina, and Portland, Oregon, replaced personal or shared (e.g., Uber) vehicle trips.[40 41] In Brighton, UK, participants in a study who were given an e-bike to use for several weeks reduced their vehicle kilometers traveled (VKT) by 20%.[42] Data on mode shift and impacts on VKT are largely unavailable for cities outside Western Europe, North America, and China.

SINCE THE EARLY 2000S, E-BIKE SALES HAVE GROWN DRAMATICALLY AND PRESENT A LARGER AND FASTER UPTAKE THAN ALTERNATIVE-FUEL VEHICLES.

Emissions Reduction Potential From E-bikes as Delivery Vehicles

E-bikes are emerging as a viable option for delivery of local goods, replacing heavier, higher-polluting trucks and vans for freight and food delivery.[43] There is enormous potential for mode shift to e-bikes in the urban delivery sector, and these replacements could significantly reduce transport sector emissions. Up to 85% of all car trips by courier services in Berlin could be replaced with e-cargo bicycles,[44] and 25% of all goods (and 50% of light goods) could be delivered with bicycles in Europe.[45] Pilots implemented to shift from motor vehicles to e-cargo cycles consistently show increased environmental and health benefits, including reduced greenhouse emissions, energy use, and noise pollution, as well as improved safety and walkability.[46 47] Cities like Seattle and Austin are working with delivery companies like UPS to replace some local delivery vans with e-cargo bicycles to reduce emissions and traffic congestion.[48] Many postal services in Europe have already integrated e-bikes into their fleets, including La Poste in France with 30,000 and DHL's Express delivery in nine European countries, which features 9,000 e-bikes.[49] In the central core of New York City, logistics companies envision replacing 40% of truck trips with e-cargo bicycles. This could reduce double-parking and congestion, in turn boosting the speed of buses and other traffic from very low levels and cutting pollution.[50]

35 Fishman and Cherry, 2015. E-bikes in the Mainstream: Reviewing a Decade of Research
36 Populus, 2018.. The Micromobility Revolution: The Introduction and Adoption of Electric Scooters in the United States.
37 Bike Europe, 2019. Study Reveals: Widespread E-bike Adoption Coming.
38 Fyhri et al., 2017. A Push to Cycling—Exploring the E-bike's Role in Overcoming Barriers to Bicycle Use With a Survey and an Invention Study.
39 Fishman and Cherry, 2015. E-bikes in the Mainstream: Reviewing a Decade of Research.
40 Hollingsworth et al., 2019. Are E-Scooters Polluters? The Environmental Impacts of Shared Dockless Electric Scooters.
41 PBOT, 2018. 2018 E-Scooter Pilot User Survey Results.
42 Guidon et al., 2018. Electric Bicycle-Sharing: A New Competitor in the Urban Transportation Market?
43 Conway et al., 2014. Freight Tricycle Operations in New York City.
44 De Decker, 2012. Cargo Cyclists Replace Truck Drivers on European City Streets.
45 Choubassi et al., 2016. Economic Analysis of Cargo Cycles for Urban Mail Delivery.
46 Ibid.
47 Nocerino et al., 2016. E-Bikes and E-Scooters for Smart Logistics: Environmental and Economic Sustainability in Pro-E-Bike Italian Pilots.
48 Ronan, 2018. UPS, Seattle to Launch eBike Downtown Delivery Program.
49 Fistrek and Rzewnicki, 2016. A New Move For Business: Electric Cycle Logistics in European Cities
50 Personal communication with Michael Replogle, Deputy Commissioner for Policy, New York City Department of Transportation, 2019.

While multiple pilots have been conducted in North America and Europe, there has not yet been a large commercial conversion to e-cargo bicycles for delivery outside Europe. Most cities are experiencing low but growing use of e-bikes for low-volume delivery, while a few cities in Brazil and China are seeing higher levels of use.[51] In many Global South cities, freight is moved by non-motorized transport (e.g., headloading, handcarts, pedal bicycles) and there may be opportunities to improve efficiency, boost productivity, and leapfrog past truck delivery. There appears to be immediate interest, especially in the private sector, in using e-bikes for mobile app-based small goods deliveries. This type of utilization is slightly different than companies like UPS and DHL replacing existing vehicles with e-cargo bicycles, but it still has implications for both VKT and emissions reductions. Food delivery services, such as Doordash in the United States, Glovo and Rappi in Argentina, and Zomato in India, allow drivers to make deliveries using e-bikes instead of vehicles.[52 53 54] In this early-adoption phase, companies are experimenting with different structures and partnerships, like rental programs and partnering with study pilots, businesses, or governments to receive subsidies for e-bike and e-trike purchases.[55] Rappi in Argentina and Deliveroo in the UK have begun dockless rental programs in which employees may rent e-bikes, e-scooters, or e-mopeds by the hour.[56 57]

Lifecycle Emissions and Maintenance

Not all e-bikes and e-scooters are manufactured and maintained to the same standards, which results in varied life cycle emissions from materials sourcing, assembly, maintenance, and disposal. Shared e-scooters have a relatively short life span, sometimes averaging only a few weeks or months.[58 59] Tough use, as well as theft and vandalism of shared e-bikes and e-scooters, have contributed to their limited life span. Many operators report increased retention rates (defined as the percentage of operable devices) as they improve the design and durability of their vehicles as well as the sophistication of their operations over time. Given the relatively recent availability of shared e-scooters, peer-reviewed research on their life cycle emissions is only just beginning and may indicate that a new approach to life cycle emissions accounting is needed. One of the few studies available, Hollingsworth et al., found the most significant factors contributing to e-scooter life cycle emissions to be the resources used to produce the scooters as well as the emissions from their decentralized collection and redistribution by independent contractors, not manufacturer-to-city delivery or the charging or actual use of the e-scooter.[60] Lowering life cycle emissions to a desirable level will require e-scooters to remain in circulation for much longer—at least two years, by some estimates.[61]

A food delivery driver using an e-trike in Melbourne, Australia.
Credit: Marcus Wong, Flickr CC

51 ITDP Internal Survey, 2019.

52 Cheema, 2017. Making Dashing Faster, Easier, and Greener With Electric Bikes.

53 Silvestrini, 2019. Alto Tránsito, Imposible Estacionar: Más Personas usan Una Movilidad en Auge, Ahorran Nafta y Estacionamiento.

54 Khatri, 2019. Zomato Rolls Out Delivery on Bicycles In 12 Cities.

55 Fistrek and Rzewnicki, 2016. A New Move For Business: Electric Cycle Logistics in European Cities.

56 Silvestrini, 2019. Alto Tránsito, Imposible Estacionar: Más Personas usan Una Movilidad en Auge, Ahorran Nafta y Estacionamiento.

57 Toll, 2019. Deliveroo Is Now Renting Electric Mopeds to Delivery Riders by the Hour.

58 Wilson, 2018. This Is the Worst Design of 2018.

59 Griswold, 2019. Shared Scooters Don't Last Long.

60 Hollingsworth et al., 2019. Are E-Scooters Polluters? The Environmental Impacts of Shared Dockless Electric Scooters.

61 Ibid.

New technology, such as swappable batteries, may help to optimize the logistics of collecting e-scooters for charging and reduce emissions in the process.[62] Private e-scooter companies are working to produce larger, sturdier scooters with longer life spans to reduce life cycle emissions and increase safety. In addition to new models, companies have also begun purchasing renewable energy credits for electricity use and carbon offsets for emissions generated from in-house and independently contracted charging.[63]

Displacing Transit, Bicycle, and Walking Trips
Notably there is also potential for e-bikes and e-scooters to displace public transit trips given the overlap in trip lengths for these modes.[64] Few studies have assessed the incidence of replacing transit trips with electric micromobility or the impact such replacement would have on emissions overall. In some cases, displacing transit trips could help address overcrowding, especially during peak hours and for short distance trips, where it may make sense to use an alternate mode. Data from a user survey conducted in Portland, OR, shows that 10% of shared e-scooter riders would otherwise have taken transit for their most recent trip.[65] The rate was lower in Santa Monica, CA, where 4% of e-scooter riders would have otherwise taken transit.[66] Over time, though, displacing transit trips could also result in unwanted outcomes, such as reduced funding and prioritization due to falling ridership. In Bangalore, e-bikes and e-scooters present significant time and cost savings compared to the city's public bus system. Similarly, a broader analysis of the impacts of shared mobility on transit use in large US cities found that bus ridership is particularly vulnerable to displacement by shared services, falling almost 2% following the introduction of bikeshare. Declining bus ridership is often symptomatic of low system reliability, which can be exacerbated by increased congestion, service cuts, and poor network design. In cities with robust bikeshare (and other shared services, by proxy) systems, these modes could be perceived as more reliable than buses. However, bikeshare was shown to increase subway ridership by almost 7% and light rail ridership by 4%.[67]

E-bikes and e-scooters may also displace pedal bicycle and walking trips. The Portland, OR, user survey found that 37% of e-scooter users would have walked if an e-scooter had not been available for their most recent trip. Nearly 45% of trips would have been made by bicycle or walking if an e-scooter had not been available in Santa Monica, CA.[68] And while e-bike and scooter trips are *low*-carbon, walking and cycling are *no*-carbon. There is little to no data available about the displacement of bicycle and walking trips by electric micromobility modes in other regions. However, in cities where walking is the dominant travel mode (due to affordability constraints presented by other modes), some shift to other modes may be less detrimental, as long as those modes are low- or no-carbon.

EQUITY AND AFFORDABILITY

Equitable transportation systems address the needs of previously underserved populations, enabling these groups to conveniently and affordably access destinations and opportunities. Equitable transportation also means that system benefits (and externalities) are distributed equitably.

Affordability is cited as one of the most significant barriers to e-bike and e-scooter use in Latin American, African, Indian, and Indonesian cities.[69] The upfront cost to purchase an e-bike or e-scooter and recurring costs such as battery replacement can be unaffordable for potential users.[70] Similarly, lower household incomes have been associated with lower likelihoods of e-bike adoption.[71] Introducing e-bikes and e-scooters via sharing programs allows people to try these modes before committing to the high upfront costs of personal ownership. These programs can also provide occasional alternatives to private vehicles for casual users. However, these systems still pose cost barriers, particularly for multimodal trips without fare integration. Most shared e-bike and e-scooter systems are smartphone-based, meaning users must download a mobile application to access the system map, find the closest vehicle, and unlock that vehicle. A credit card is also typically required to create an account. These requirements—a smartphone and credit card—present equity concerns.

62 Marshall, 2018. 2018 Was the Year of the Scooter. What Happens Now?

63 Peters, 2019. How Bird Is Working to Make Its Scooters a Truly Sustainable Transportation Option.

64 Guidon et al., 2018. Electric Bicycle-Sharing: A New Competitor in the Urban Transportation Market?

65 PBOT, 2018. 2018 E-Scooter Pilot User Survey Results.

66 City of Santa Monica, 2019. Shared Mobility Device Pilot Program User Survey Results.

67 Graehler et al., 2019. Understanding the Recent Transit Ridership Decline in Major U.S. Cities: Service Cuts or Emerging Modes?

68 City of Santa Monica, 2019. Shared Mobility Device Pilot Program User Survey Results.

69 ITDP Internal Survey, 2019.

70 Dill and Rose, 2012. E-bikes and Transportation Policy: Insights From Early Adopters.

71 Arsenio et al., 2017. Assessing the Market Potential of Electric Bicycles and ICT for Low-Carbon School Travel: A Case Study in the Smart City of Águeda.

Recognizing this, many cities are working with e-bike and e-scooter providers to offer alternative and affordable ways to use these systems. For example, Seattle's dockless bikeshare permit rules require operators to provide at least one "low-barrier rental" option for riders without a smartphone, bank account, or credit card.[72] Chicago's e-scooter pilot program requires operators to describe how they plan to offer a cash payment option and the capability to unlock scooters without a smartphone as part of their initial permit application.[73] Portland and Detroit require operators to offer discounts to qualifying low-income users, with most operators complying by providing free or reduced unlocking fees and a lower rate per minute.[74][75]

E-bike and e-scooter affordability is often assessed by comparing it to that of a traditional bicycle, assuming that an e-bike or e-scooter will primarily displace bicycle trips. However, these modes can serve as competitive replacements for taxis and rideshare as well as private cars and motorcycles, given good conditions and high-quality infrastructure.[76] Thus, purchase price comparisons should also include motor vehicles. Purchase prices of motor vehicles, e-bikes, and e-scooters in Brazil and Mexico (pre-emerging markets), the US (emerging market for e-bikes), China (long-term developed market), and the Netherlands (short-term developed market) are included in Appendix C. In the US, China, and the Netherlands, purchasing an e-bike accounts for less than 6% of annual income, while purchasing a vehicle accounts for half to almost four times the annual household income. In Brazil, a less developed market for electric micromobility, purchasing an e-bike accounts for nearly 17% of annual income. Purchasing a vehicle in Brazil is still much more expensive, comparatively, at 167% of annual income. The relatively low purchase price of e-bikes as a percentage of income may indicate that they can provide mobility in the near term, since most people will need to save for multiple years to be able to afford to purchase a car.

Given the very early stages of electric micromobility adoption, purchase price data to conduct a similar comparison for most Latin American, African, Indian, and Indonesian markets is not yet available. It is reasonable to assume that the proportional cost (e-bike purchase price to annual household income) would be greater than the examples above, similar to the disparity between proportional cost for Brazil and the more developed markets.

Equitable Distribution of Shared Services

Shared e-bike and e-scooter systems have the potential to provide reliable transportation at a low cost per trip and with minimal public investment compared to the infrastructure required to support other modes (BRT, subway, commuter rail, etc.). Because many shared e-bike and e-scooter systems are dockless, the distribution of vehicles throughout the city can be much more flexible than it would with a station-based system. Early analysis of Chicago's shared e-scooter pilot indicates that scooters are more widely dispersed in areas of high economic hardship compared to the city's station-based bikeshare system.[77] This, in theory, can result in a more equitable distribution of shared e-bikes and e-scooters. However, in practice, dockless programs in some cities like Seattle have found differing use patterns of dockless bicycles by socioeconomic group due to inequitable spatial access.[78] Thus, many cities are—rightfully—not leaving equitable distribution to chance and instead are requiring shared e-bike and e-scooter providers to deploy and maintain a certain percentage of their e-bikes and e-scooters in designated underserved areas.[79]

Many cities require shared e-bike and e-scooter providers like Lime to deploy and maintain a certain percentage of their fleet in designated underserved areas. Credit: Elvert Barnes, Flickr CC

72 Seattle Department of Transportation, 2018. Free-Floating Bike Share Program Permit Requirements.

73 City of Chicago, 2019. Requirements for Scooter Sharing Emerging Business Permit Pilot Program.

74 PBOT, 2019. Low-Income Pricing Plans.

75 City of Detroit, 2019. Scooters.

76 Guidon et al., 2018. Electric Bicycle-Sharing: A New Competitor in the Urban Transportation Market?

77 Smith and Schwieterman, 2019. A Day in the Life of Chicago's E-Scooter Pilot Program.

78 Hirsch et al., 2019. Residents in Seattle, WA, Report Differential Use of Free-Floating Bikeshare by Age, Gender, Race, and Location.

79 National League of Cities, 2019. Mobility in Cities: A History and Policy Overview.

EQUITY IMPACTS OF BANS

E-bikes in particular have extended economic opportunities to delivery workers in many cities, many of whom are immigrants or otherwise economically vulnerable. Delivery workers have been repeatedly ignored in conversations around e-bike classification, safety, and use. Bans on e-bikes, such as in the case of New York City, and generally unclear e-bike regulations directly affect—and even target—delivery workers, placing them in the crossfire between urban legislation, enforcement, and the companies they work for.[80 81] This often results in inequitable working conditions. A 2018 study found that Latino and Chinese delivery workers in New York City are more likely to receive frequent and higher fines for e-bike use than other delivery workers.[82] While the New York City Department of Transportation clarified the legality of low-speed pedal-assist e-bikes in 2018, an estimated 40,000 moderate-speed e-bikes with throttles as well as thousands of e-scooters in the city remain illegal. Legislation that would legalize moderate-speed e-bikes, throttled pedal-assist e-bikes, and e-scooters passed the New York State Legislature in May 2019 but has been stalled waiting to be signed by the governor.

Even partial bans, such as the one implemented in Atlanta preventing shared e-bikes and e-scooters from operating after dark, can raise equity concerns because they limit access for late-night workers to a flexible, affordable transportation option when other transit services are likely closed or running limited service.

EFFICIENCY

E-bikes and e-scooters can contribute to more productive transportation systems by using finite resources like street space, energy, and public funding efficiently.

Street Space

E-bikes and e-scooters are efficient compared to cars in terms of travel space and parking requirements. Most trips taken in dense cities are under ten kilometers, with the majority of car trips having just one occupant—the driver. While e-bikes and e-scooters may not be the optimal choice for transporting a passenger or loads of groceries or other goods, they can serve many short, single-occupancy vehicle trips using much less space. Additionally, the space needed to park an e-bike or e-scooter when not in use is vastly smaller than the space needed to park a car, with approximately 10 e-bikes able to occupy the space needed for a single parked car. This could mean freeing up vehicle parking space for more productive uses like cycle lanes, dedicated transit lanes, pedestrian bulb-outs, parklets, etc. Over time, mode shift from private vehicles to electric micromobility could lead to greater social and political empowerment for a growing number of users, garnering the attention necessary to demand implementation of protected infrastructure and other changes needed to encourage street safety. This, in turn, could yield a prioritization of street space not only for small electric modes but for complementary modes like cycling and walking.

Cities will need to designate space for and manage orderly and secure parking of electric micromobility modes as these modes continue to scale. Flexible parking that allows for storage of both private and shared devices, as well as pedal bicycles, will help to ensure widespread use. Adding charging capabilities to these parking areas—similar to public electric vehicle charging available in some cities—could also be considered.

80 Aratani, 2019. 'It's Persecution': New York City Delivery Workers Fight Electric Bike Ban.

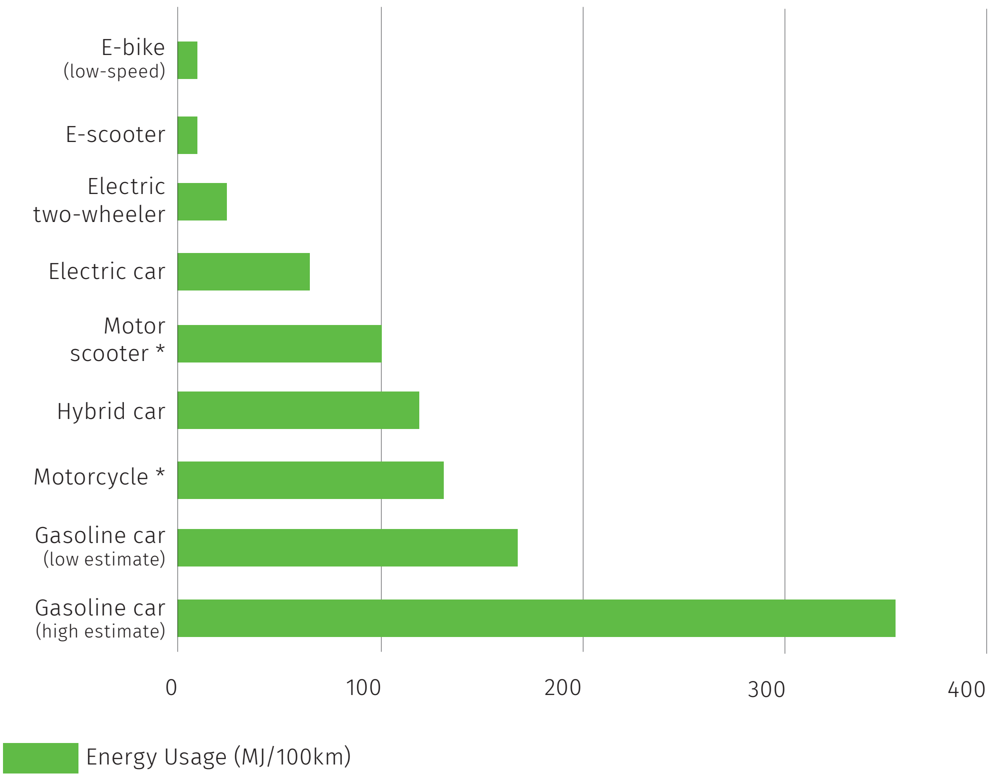
81 Conner, 2019. Op-Ed: Stop Targeting Food-Delivery Workers. Legalize Throttle Bikes.

82 Lee, 2018. Delivering Justice: Food Delivery Cyclists in New York City.

Up to ten bicycles or e-bikes - and even more e-scooters - occupy the same space as a single parked car.
Credit: Glen Buhlmann

Energy
Transportation sector-wide energy efficiency gains are possible from replacing highly inefficient fuel-powered vehicle trips with e-bikes or e-scooter trips. Single-occupancy vehicle trips are extremely inefficient because of the significant amount of energy needed to move the weight of the vehicle itself (in addition to the person inside). It takes much less energy to move an e-bike or e-scooter transporting a single passenger (see Figure 5).[83]

Figure 5. Energy Usage by Vehicle Type



* Energy usage based on one model, recognized as an average.

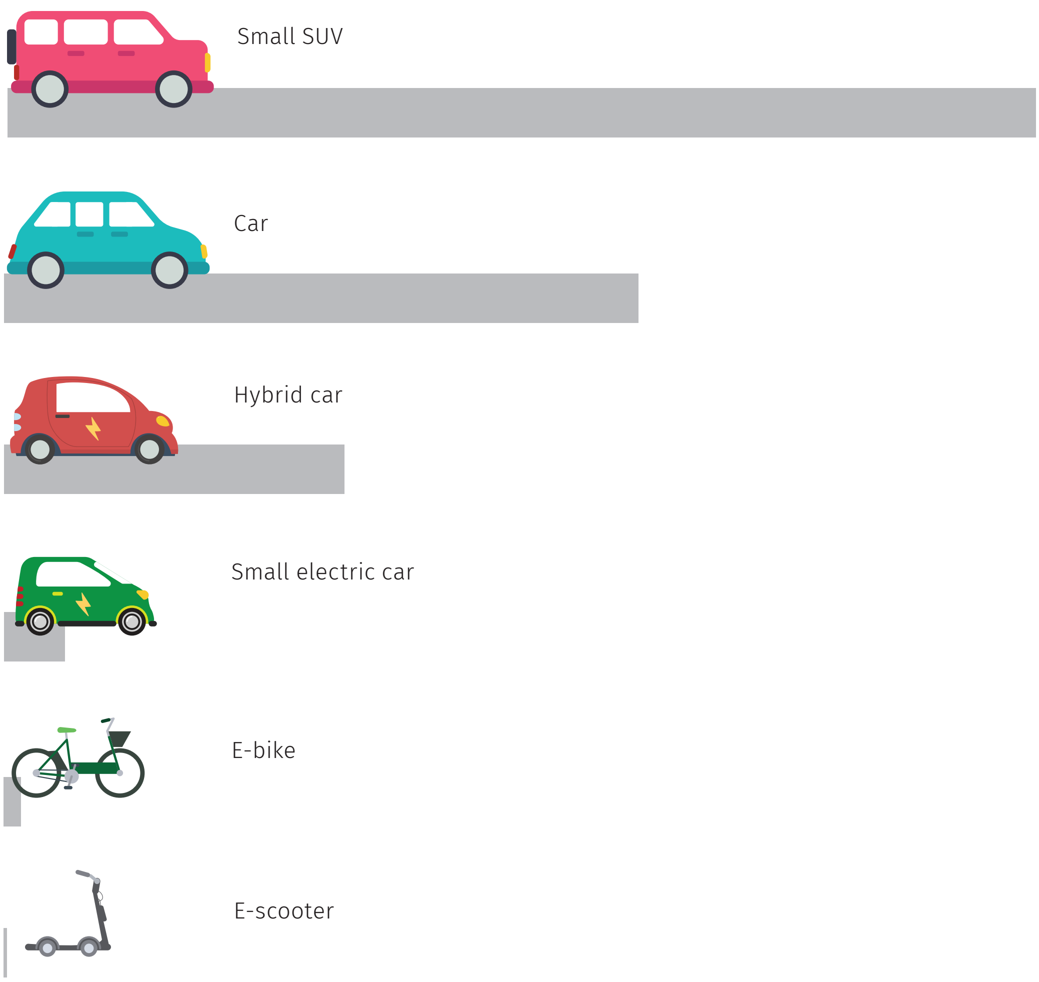
83 Tilleman, 2019. E-scooters Are Better for Cities Than Cars

However, the collection of shared e-bikes and particularly e-scooters for charging and redistribution is not energy efficient when done with fuel-inefficient vehicles and without centralized management. While public and private shared e-bike operators oversee charging and rebalancing as part of their operations portfolio, many e-scooter companies outsource charging to individuals, who are compensated by the company to pick up scooters with depleted batteries, charge them overnight, and return them to the street in the early morning. Because the logistics of finding and transporting low-battery e-scooters are left up to each individual charger, the process can be very inefficient. While research in this area is nascent, a 2019 study suggests that greater efficiency, namely limiting the average driving distance per scooter and using only fuel-efficient vehicles for collection, would yield significant life cycle emissions reductions.[84]

Public Funding

Compared to cars and other passenger vehicles, e-bikes and e-scooters have much lower weights, producing less wear on streets. Figure 6 shows the amount of road damage generated by each mode relative to the road damage of an average car trip, calculated using a formula from Cohen and Roth.[85] It would take more than 16,000 e-bike trips and 25,000 e-scooter trips to equal the road damage caused by an average car trip per kilometer of road. Thus, a large-scale shift toward small electric modes over time could result in fewer public resources needed to fund street maintenance stemming from weight damage, like repaving and filling potholes.

Figure 6. Road Damage Relative to an Average Car

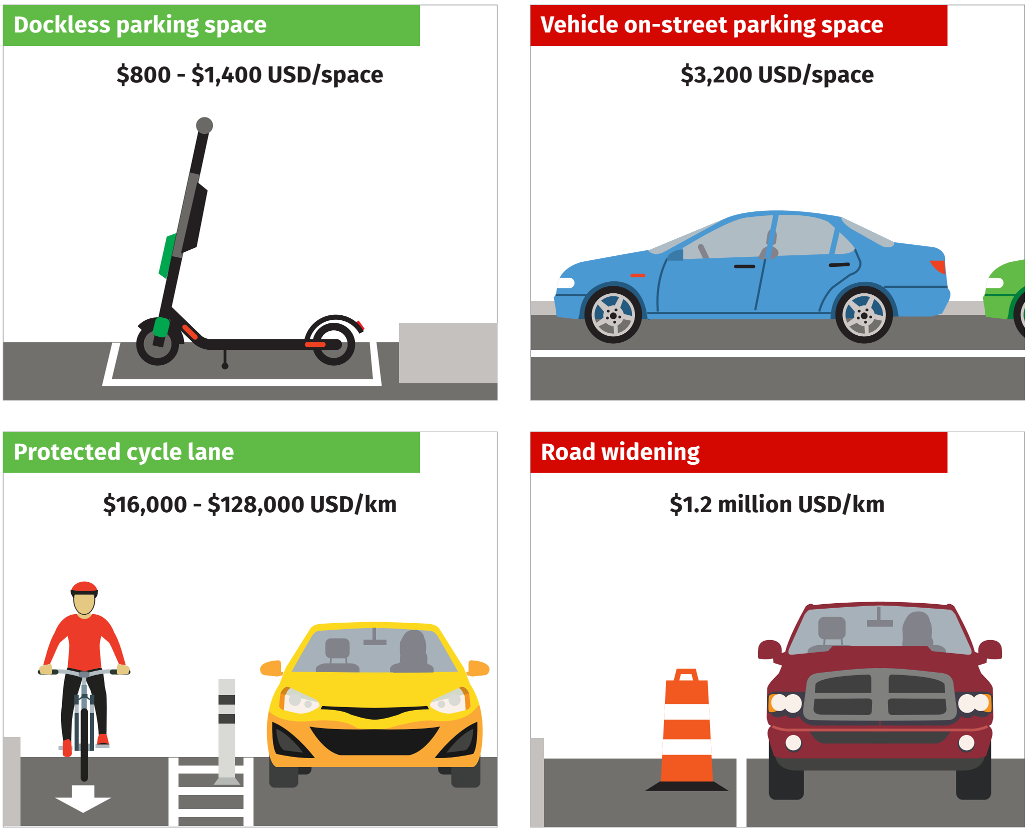


Similarly, the investment and upkeep in infrastructure needed to support both personal and shared e-bikes and e-scooters, such as bicycle lanes, parking areas, and even electrified stations for charging shared vehicles, costs significantly less than surface street lanes, parking garages, and other car-supportive infrastructure.

84 Hollingsworth et al., 2019. Are E-Scooters Polluters? The Environmental Impacts of Shared Dockless Electric Scooters.

85 Cohen and Roth, 2017. Fuel Cost and Road Damage: Evidence From Weigh-in-Motion Data [Presented at the UCCS Forum, Sacramento, CA].

CITIES WILL NEED TO DESIGNATE SPACE FOR AND MANAGE ORDERLY AND SECURE PARKING OF ELECTRIC MICROMOBILITY MODES AS THESE MODES CONTINUE TO SCALE. FLEXIBLE PARKING THAT ALLOWS FOR STORAGE OF BOTH PRIVATE AND SHARED DEVICES, AS WELL AS PEDAL BICYCLES, WILL HELP TO ENSURE WIDESPREAD USE.



Sources (clockwise from top left): Email communication with Joel Miller, Bikeshare Program Manager, Seattle DOT, 2019; Victoria Transport Policy Institute, n.d. Transportation Cost and Benefit Analysis II – Parking Costs; Andersen, M, 2017. No, Protected Bike Lanes Do Not Need to Cost $1 Million per Mile; Texas A&M Transportation Institute, n.d. Adding New Lanes or Roads.

SAFETY

More people riding low-speed modes like e-bikes and e-scooters on streets can help to improve road safety over time. In short, there is “safety in numbers.”[86] Cities with large shares of cyclists and pedestrians tend to see lower rates of cyclist and pedestrian road fatalities. That is likely due to some combination of the presence of protective infrastructure (cycle lanes, crosswalks, protected intersections) and heightened attention and learned behavior by drivers expecting cyclists and pedestrians on the road.[87] Riders of bicycles with electric assist have also reported improved feelings of safety stemming from being able to react more quickly in traffic and a greater likelihood of full-stopping (because the motorized assist makes starting from standing easier).[88] As more people shift out of cars and onto e-bikes and e-scooters—in addition to pedal bicycles and walking—public calls for investment in more and better infrastructure to protect non-car users may contribute to improved safety conditions.

At present, however, there are a number of safety concerns with small electric modes as they continue to grow in popularity. Differences in speed between moderate-speed e-bikes, low-speed e-devices, conventional bicycles, and motor vehicles have led to a lack of consensus about where e-bike and e-scooter riders “belong.” In most cities, a lack of high-quality, well-connected infrastructure that separates e-bike and e-scooter riders from both vehicles and pedestrians results in e-bike and e-scooter riders traveling with high-speed traffic or on the sidewalk or pedestrian realm. This uncertainty can lead to conflicts with drivers, law enforcement, pedestrians, and other cyclists. For less experienced bicycle riders or users with additional safety considerations such as parents with children or elderly riders, the prospect of riding in mixed traffic may prevent use of e-bikes or e-scooters altogether.

Recent findings from an e-scooter safety study indicate that as adoption increases there may be an important learning curve for users about how to operate e-scooters and for the public about expectations of use on streets. One third of all e-scooter crashes in Austin, Texas, occurred during the rider’s first trip, and two-thirds of crashes involved users who had ridden

86 Jacobsen, 2003, Safety in Numbers: More Walkers and Bicyclists, Safer Walking and Bicycling.

87 Badger, 2014. Actually, Cyclists Make City Streets Safer.

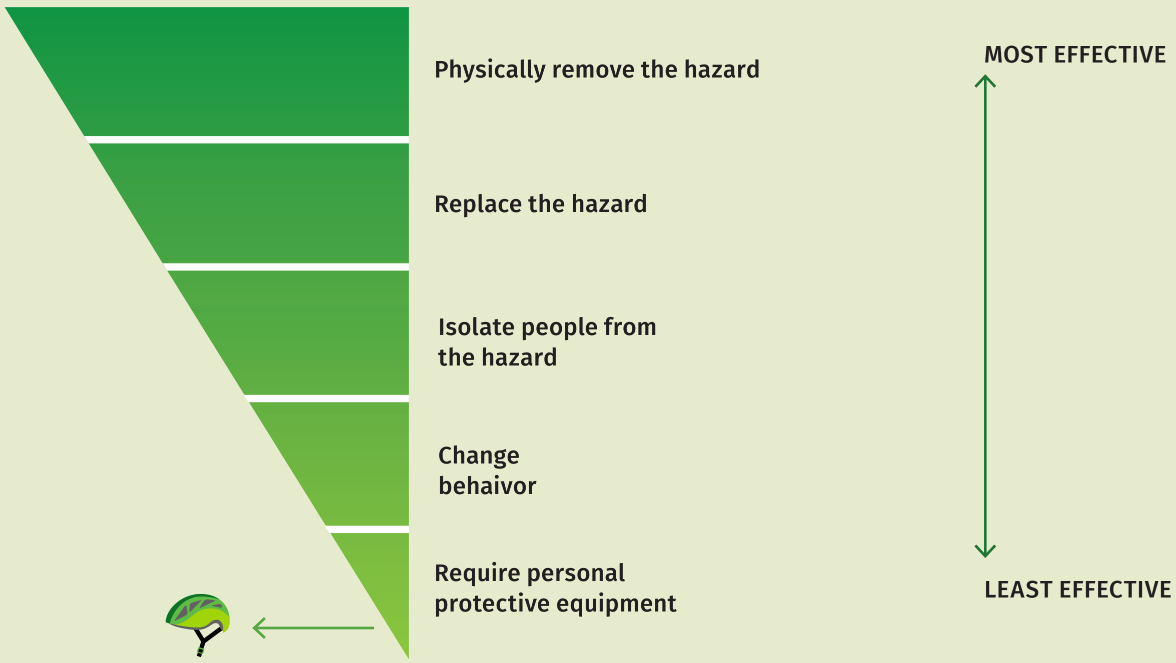
88 Rose, 2011. E-bikes and Urban Transportation: Emerging Issues and Unresolved Questions.

nine or fewer times.[89] Further, the vast majority of crashes are designated as "single vehicle," in which the user falls or otherwise mis-operates the e-scooter, resulting in the user's injury. Only 10% of crashes involved a motor vehicle. In response to the clear need for improving user knowledge and experience, e-scooter operators are beginning to offer free training courses to help decrease first-use injury and single-vehicle crashes.[90] Other cities, like Washington, DC, have considered banning the use of electric micromobility modes overnight to cut down on instances of reduced visibility and intoxicated riding.[91] This, however, raises important equity implications—it removes a transportation option for shift workers and other late-night travelers when transit services are closed or running limited service.

HELMETS

Helmet use among riders of electric micromobility should be encouraged. However, mandatory helmet laws present barriers to use, particularly for shared systems, and there is little evidence that these mandates actually reduce injury rates. Cycling advocacy groups typically oppose mandatory helmet laws because the negative consequence of limiting access outweighs the benefits. Instead, helmet use should be encouraged through education campaigns, free giveaways, etc.

A helpful framework for thinking about improving road safety for all users comes from a standard approach to workplace safety, where attention and investment in interventions is prioritized by their effectiveness in minimizing risk (see below). Within this framework, requiring helmet use falls in the lowest impact intervention category and should be undertaken after more effective efforts have been made (limiting vehicle speeds and volume, encouraging mode shift away from vehicles, and building protected infrastructure).



Adapted from the National Institute for Occupational Safety and Health's Hierarchy of Controls.

Harassment/Social Stigma
Intimidation from drivers and harassment from pedestrians and other cyclists can deter people from considering an e-bike or e-scooter for regular use. Harassment and social stigmatization about owning an e-bike, in particular, has been noted in multiple studies. In a Portland, Oregon, case study, multiple participants reported being told that they were getting old or felt that they were "cheating" by riding an e-bike, leading many to feel apologetic or self-conscious while on the road.[92] Another study noted similar findings in the UK and the

89 Austin Public Health, 2019. Dockless Electric Scooter-Related Injuries Study.
90 Smith, 2019. First-time Scooter Users Creating Headaches in Chicago and Other Pilot Cities.
91 Braverman, 2019. Atlanta Mayor Imposes Nighttime E-scooter and E-bike Ban, Effective Friday.

Netherlands, with many participants slowing down to avoid conflict with conventional bicycle users and, in some cases, disguising the electric-assist of their e-bike.[93]

As with pedal bicycles, gender, racial, and socio-economic gaps in use have been noted between e-bike riders and non-riders. While studies have found greater proportional use of e-bikes by women (underrepresented in traditional cycling) and greater age diversity (particularly for older individuals), the threat of violence or unwanted attention will likely deter marginalized populations from considering walking, cycling, or electric micromobility even if safe infrastructure is available. Lack of ability to purchase or own these modes or learn to ride them—particularly for women—can often contribute to low rates of cycling (and use of electric micromobility by proxy).

As use and awareness of electric micromobility grows, unsafe riding behavior (whether accidental or intentional) by some early adopters may result in harassment of the broader population of electric micromobility users. Early e-bike use in New York City serves as an example. There, immigrant delivery workers who use e-bikes have faced significant backlash, both from the public and the police, due to some e-bike users violating traffic laws and threatening pedestrian safety. In these cases, immigrant delivery workers were targeted because of their lower power status, and these uneven power dynamics exacerbate their vulnerability. This kind of few-spoiling-for-the-many dynamic—and the resulting stigma—can be curbed over time through enforcement of clear traffic rules (see Infrastructure Recommendations).

HEALTH AND QUALITY OF LIFE

Expanding active transportation, which includes cycling and walking, has been identified by many cities as a means of achieving positive health outcomes. Net health benefits from active transportation have been supported in a number of different regions.[94] E-bikes, in particular, can contribute to healthier lifestyles, even though the electric-assist reduces some physical activity. Studies show that e-bikes can provide moderate-intensity physical activity, which falls somewhere between pedal cycling and walking. E-cycling can also improve fitness levels for those who otherwise experience low physical activity.[95] In other words, for those who would not consider pedal cycling, e-bikes provide a transport option that is more active than walking or driving a personal vehicle. E-bikes may also present a more attractive (yet still active) alternative to pedal cycling in terms of travel time and convenience.[96]

Higher mode shares of walking, cycling, and small electric modes also result in quieter, more comfortable public spaces for people. Noise pollution, which can be high in cities with high car and two-wheeler use, is a health concern, leading over time to stress, hearing loss, sleep disturbance, and learning problems in children.[97] Displacing noisy fuel-engine vehicle trips with electric modes (particularly at lower speeds) can help to reduce noise pollution and improve livability.

E-bikes can contribute to healthier lifestyles, improving fitness levels for those who would not consider pedal cycling as an alternative to driving.
Credit: Enrique Abe, Mexico City's Ministry of Environment, Department of Cycling, Culture, and Infrastructure

92 Dill and Rose, 2012. E-bikes and Transportation Policy: Insights From Early Adopters.

93 Jones et al., 2016. Motives, Perceptions, and Experiences of Electric Bicycle Owners and Implications for Health, Well-Being, and Mobility.

94 Mueller et al., 2015. Health Impact Assessment of Active Transportation: A Systematic Review.

95 Bourne et al., 2018. Health Benefits of Electrically Assisted Cycling: A Systematic Review.

96 West et al., 2018. Increasing Active Transportation Through E-Bike Use: Pilot Study Comparing the Health Benefits, Attitudes, and Beliefs Surrounding E-bikes and Conventional Bikes.

97 Transport & Environment, n.d. Vehicle Noise.

POLICY ANALYSIS AND RECOMMENDATIONS

4

Informed by the research and interviews we conducted during the development of this report, this section catalogs existing policy areas governing the use of small electric modes. We follow up each existing policy analysis with recommendations intended to maximize the benefits of e-bikes and e-scooters to sustainable transportation networks and minimize negative outcomes.

	DESCRIPTION
1 Classification	Policies that define bicycles, small electric modes, and motorized vehicles
2 Infrastructure	Policies that a) govern the use of cycle lanes by small electric modes or b) enable shared micromobility systems to operate **GOALS ADDRESSED:** Safety
3 Adoption and use	Policies that facilitate the purchase and habitual, convenient use of small electric modes **GOALS ADDRESSED:** Access, Equity and affordability, Efficiency
4 Crash reduction	Policies intended to reduce injuries sustained by electric micromobility riders, pedestrians, and other cyclists **GOALS ADDRESSED:** Safety
5 Strategic planning	Policies that identify electric micromobility as a strategy to achieve broader citywide goals **GOALS ADDRESSED:** Environment, Health

RECOMMENDATION

- **Classify e-bikes and e-scooters as non-motor vehicles**
- **Clearly define and enforce maximum speeds for low- and moderate-speed devices**
  - Low-speed e-devices should have a maximum speed of 25 km per hour
  - Moderate-speed e-devices should have a maximum speed of 45 km per hour.

- **Define the infrastructure electric modes are permitted to use**
  - Low-speed modes should be permitted in all cycle infrastructure
  - Moderate-speed modes should be permitted in cycle infrastructure, context-permitting:
    - Lower-density areas with low cycling volumes could permit moderate-speed modes
    - Higher-density areas with high cycling volumes and slower mixed-traffic speeds should not allow moderate-speed modes
  - High-speed e-devices (over 45 km per hour) should not be permitted to use cycling infrastructure

- **Design safe, inclusive on-street infrastructure**
  - Shared systems should accommodate different user and trip types
  - Cycle lanes should be designed as a complete and connected network for use by all potential users
  - Some cycle lanes should facilitate longer-distance trips by e-bike

- **Enforce safe use of cycling infrastructure**
  - Train enforcement officers to cite violators in cycling infrastructure (high-speed modes)
  - Use events and campaigns to develop norms for safe infrastructure use

- **Increase exposure and access to small electric modes**
  - Incorporate e-devices into existing shared systems using incentives and pilots
  - Require shared electric micromobility systems to offer discounts and payment and smartphone alternatives for universal access
  - Pilot programs like e-bike-for-car swaps, cycle-to-work, and long-term rental

- **Design and implement parking and charging spaces**
  - Designate space for parking that considers volume and demand
  - Consider public charging options (perhaps in partnership with the private sector)
  - Develop a universal standard for charging to expand utility of public charging spaces

- **Encourage trip replacement by making car travel less convenient**
  - Limit access to certain zones for polluting vehicles
  - Charge a fee for single-occupancy vehicle trips
  - Review parking minimums and on-street parking costs

- **Design safe, inclusive on-street infrastructure**
  - Shared systems should accommodate different user and trip types
  - Cycle lanes should be designed as a complete and connected network for use by all potential users
  - Some cycle lanes should facilitate longer-distance trips by e-bike

- **Offer public safe riding courses**
  - Partner with civic groups, schools, operators, etc. to provide safe riding courses

- **Integrate small electric modes into citywide strategies and plans**
  - Determine how e-bikes and e-scooters can contribute to existing city-wide goals, and what gaps they can fill in the transportation system
  - Set targets for use linked to city-wide goals, including equity and inclusion targets
  - Include electric micromobility in electrification strategies, climate plans, etc.
  - Strengthen city staff capacity to plan for, support, monitor, and enforce the use of personal and shared electric modes

- **Collect data for analysis and enforcement**
  - Amend travel surveys to collect data on electric micromobility use that is disaggregated from traditional cycling
  - Require aggregated ridership data from private shared service operators

1. CLASSIFICATION POLICIES

A number of countries classify e-bikes according to weight, speed, and power, allowing or disallowing their use on bicycle infrastructure and requiring licensure, registration, and insurance based on those classifications. The way that cities classify small electric modes within regulatory frameworks directly determines how safe, accessible, equitable, and environmentally-friendly (or not) these modes will be. In addition, cities' goals, such as promoting health or maintaining safety, may determine the kind of vehicle functionality (pedal vs. non-pedal assist) or vehicle weight their classification system prioritizes.

Recently, countries that had initially classified all electric bicycles as mopeds or motorized vehicles have reevaluated those policies in favor of fewer restrictions on pedal-assist e-bikes under 25 km per hour. This was the case in Brazil, where federal legislation passed in 2009 classified all electric bicycles as mopeds, which have a maximum speed of 50 km per hour. E-bike riders were required to be at least 18 years old and carry a driver's license for mopeds, which limited e-bike sales and use. Mopeds (including e-bikes) were restricted from using cycle lanes or paths. A new resolution passed in 2013, however, separated e-bikes from mopeds and eliminated the age restriction and license requirement for e-bike riders. Under this new classification, e-bikes are limited to a maximum speed of 25 km per hour and cannot include an accelerator (throttle), only a battery-powered pedal assist. The updated resolution permits (and encourages) e-bikes to be ridden in cycle lanes and paths. At the municipal level, São Paulo, Fortaleza, and Rio de Janeiro have specific legislation regarding e-bikes that directs use and provision of shared services in those cities.

IN ENGLAND, SCOTLAND, AND WALES, ELECTRICALLY ASSISTED PEDAL CYCLES (EAPCS) DO NOT REQUIRE A LICENSE, REGISTRATION, OR INSURANCE. EAPCS MUST HAVE PEDALS AND SPEED LIMITERS THAT RESTRICT THEIR MAXIMUM SPEED TO 25 KM PER HOUR. SINCE EAPCS ARE CLASSED AS CONVENTIONAL BICYCLES, THEY CAN BE USED IN CYCLE LANES AND PATHS.

Similarly, China released national *E-bike Standards* in 1999, which classified e-bikes by speed, weight, and power. The specification stated that any electric bicycle with functional pedals could be classified as an e-bike, which meant that scooter-style electric bicycles fell under the same rules as pedal-assist electric bicycles. Many manufacturers took advantage of this loophole by installing pedals and speed limiters—required by law for licensure—that could be easily removed after purchase. In 2004, the N*ational Road Transportation Safety Law* specified e-bikes as non-motorized vehicles akin to pedal bicycles. This enabled e-bike riders to legally use bicycle infrastructure and defend e-bike use in the context of bans on motorized two-wheelers.[98]

However, the *Electric Bicycle Safety Technical Specifications* released in 2019 provide a new definition for e-bikes in China. This legislation lowers the weight and maximum speed that differentiate e-bikes from mopeds and motorbikes and allows for the use of cycle lanes. To qualify as an e-bike, the vehicle must weigh less than 55 kg, have a maximum speed of 25 km per hour, and have pedals. Vehicles above this weight and speed can no longer use cycle lanes, and riders must carry a license. Since the new legislation took effect, enforcement of moderate-speed e-bikes using cycle lanes or not carrying the proper license has been high, with riders being fined for violations.

In England, Scotland, and Wales, electrically assisted pedal cycles (EAPCs) are classified separately from mopeds and motorbikes and do not require a license, registration, or insurance. EAPCs must have pedals and speed limiters that restrict their maximum speed to 25 km per hour. Since EAPCs are classed as conventional pedal bikes, they can be used in cycle lanes and paths. On the other hand, countries that do not distinguish between pedal-assist e-bikes and motorbikes can severely restrict use. For example, in Northern Ireland, all electric bicycles are considered motorbikes and require a license, registration, and insurance and are subject to taxes. All e-bikes are restricted from using cycle lanes or paths, regardless of speed.[99]

The United States is an interesting case, as a three-tier classification system based on speed and motor assist has become popular for many states. Class I and II e-bikes cannot exceed 32 km per hour, while class III e-bikes may reach up to 45 km per hour. This system is viewed favorably by many non-governmental organizations, state governments, and community organizations alike. Despite adoption of the three-tier classification in 22 states, approximately 11 states still do not specifically classify e-bikes as bicycles. This results in the regulation of e-bikes as mopeds or scooters, in some cases, or a complete lack of clarity around regulation in others. The latter scenario often stems from a strict legal definition of bicycles, which specifies operation solely by human power.[100] Many existing laws that classify e-bikes and e-scooters as motor vehicles have simply not been reviewed and updated in light of recent technological developments and are, thus, not motivated by safety or other legitimate concerns.[101] Classifying e-bikes and e-scooters as motor vehicles creates confusion for consumers, retailers, and manufacturers, and it can discourage consumers from understanding or realizing the benefits of these small electric modes. Doing so likely also imposes unnecessary and cumbersome administrative requirements, such as licensing, registration, or insurance, which are not required for riders of pedal bicycles.

98 Weinert et al., 2007. The Transition to Electric Bikes in China: History and Key Reason for Rapid Growth.

99 GOV.UK, n.d. Electric Bikes: Licensing, Tax and Insurance.

100 People for Bikes, 2018. Electric Bicycle Law Basics.

101 Personal interview with Morgan Lommele, Director of State and Local Policy, People for Bikes, 2019.

Classification Recommendations

- **Classify e-bikes and e-scooters as non-motor vehicles**
  Both low- and moderate-speed e-bikes and e-scooters (up to 45 kph) should be classified in legislative and regulatory codes as non-motor vehicles. Doing so will reduce administrative barriers such as licensing, registration, and additional taxes that are typically required for motor vehicles.

- **Clearly define and enforce maximum speeds for low- and moderate-speed devices:**
  - Low-speed e-devices should have a maximum speed of 25 km per hour
  - Moderate speed e-devices should have a maximum speed of 45 km per hour.

  Further classification to differentiate e-devices with different motor capacities and maximum speeds, as well as which types of e-devices are permitted to use cycling infrastructure, should also occur (see Infrastructure Recommendations). Generally, the electric assist for low-speed devices should be restricted to 25 kph, and moderate-speed devices should be restricted to 45 kph.[102 103]

  Enforcement will be a challenge in terms of what type of e-device is allowed where and at what speeds. It is important to establish clear, visual distinctions between low- and moderate-speed devices to facilitate easier recognition of violations. In other words, moderate-speed devices should look out of place in low-speed infrastructure. Strict penalties should be set and enforced for modifying low- and moderate-speed devices to travel at higher speeds, as well as for counterfeiting manufacturer labels that differentiate between devices.

Low-speed e-bikes and e-scooters should be permitted to use cycling infrastructure.
Credit: MV Jantzen, Flickr CC

2. INFRASTRUCTURE POLICIES

2.1 Cycle lanes

Due to differences in speed, power, and perceptions about safety, confusion has emerged about where e-bikes and e-scooters “belong” on the road. Clear policies that permit use of low-speed (and, in some cases, moderate-speed) modes in bicycle infrastructure help to reduce confusion. Of course, protected infrastructure—as part of a network of connected bicycle lanes and low-speed, low-volume streets—is critical to encouraging cycling and use of electric micromobility for more trips.

In most cities, low-speed electric devices (up to 25 kph) are permitted to use bicycle infrastructure like lanes and off-street paths. Since low-speed electric bicycles and scooters travel at similar speeds to a fit pedal cyclist, safety concerns around these modes sharing space with bicycles are relatively low. In the United States, most states allow Class I and II e-bikes (up to 32 kph) to ride everywhere that traditional bicycles are permitted, including bicycle lanes, whereas additional restrictions exist for Class III e-bikes (up to 45 kph).

There is less of a consensus about whether moderate-speed e-bikes (up to 45 kph) should be permitted to use cycle lanes and paths given their higher speed, weight, and risk of damage in a crash. In 2018 the Danish Road Safety Agency launched a pilot program allowing moderate-speed e-bikes to use cycle lanes. Now, a year later, the agency is reviewing crash data, user counts, and other metrics to better understand the impacts of moderate-speed e-bikes on safety in cycle lanes.[104] However, in the Netherlands, moderate-speed e-bikes are required to use mixed-traffic lanes (not cycle lanes) in urban centers.[105] The European Cyclists’ Federation recommends that in urban areas, moderate-speed e-bikes utilize the road instead of bicycle or pedestrian infrastructure, and in non-urban areas only use bicycle infrastructure that’s

102 People for Bikes, 2018. Electric Bicycle Law Basics.
103 ECF, n.d. Electric Bicycle (Pedelec) Regulation.
104 Danish Road Safety Agency, 2018. Ny forsøgsordning for Speed Pedelecs.
105 Bakker, 2018. Electric Two-Wheelers, Sustainable Mobility and the City.

designed for vehicles that exceed 25 kph. It is worth noting that cities with high cycling densities, such as in the Netherlands and elsewhere in Europe, adopt policies that account for high use of cycle lanes and thus may not be relevant for lower-volume cycling contexts. Further analysis of safety implications is needed for permitting e-bike and e-scooter use in contexts such as crowded pedestrian areas or on inconsistent grades (e.g., bridges).

In Europe, cities are adopting infrastructure policies to encourage longer-distance commuting via e-bike. Copenhagen and its neighboring municipalities are implementing a network of bicycle superhighways intended to provide direct, safe routes for bicycle trips of more than five kilometers throughout the region.[106] With passing lanes, intersection signals timed for cycling (known as “green waves”), and fewer stops, these superhighways, which are typically at grade and along the street network, are particularly ideal for e-bike commuting. A similar strategy is being undertaken in London. The city’s *Cycling Action Plan*, part of the Mayor’s Transport Strategy, aims to connect London with its outer suburbs using high-quality cycle superhighways.[107] However, implementation of that infrastructure has been fraught with delays and limited prioritization of funding.[108]

CYCLE HIGHWAYS: WHAT ARE THEY AND HOW CAN THEY ENABLE LONGER-DISTANCE TRAVEL BY E-BIKE?

Designed for ease and directness, cycle highways (also known as bicycle freeways or superhighways) are a type of cycling infrastructure intended for inter- and intra-city commuting. Essentially a nonstop protected bicycle lane, cycle highways are often at least 10 kilometers (ranging to upwards of 100 km) and designed to facilitate longer-distance travel.[109] Their development has coincided with the growing adoption of e-bikes in multiple countries, which has expanded interest and physical access to these cycleways. Cycle highways can help e-bike riders compete with car trips on time because they have limited intersections or instances where riders need to decrease their speed. Thus, cycle highways allow for practical, safe commuting by bicycle, especially for workers traveling from outer suburbs to city centers.

Interest and implementation of cycle highways has occurred mostly in Europe, with major projects in London, the Ruhr region in Germany, and the Arnhem-Nijmegen region in the Netherlands.[110] Outside of these regions, where cycling has enjoyed political support, the cost of construction and lack of political will present barriers to implementing cycle highways. While the cost per kilometer is comparable to road widening, political will to designate funding and space for cyclists tends to be much lower than it is for vehicle infrastructure projects.[111] While a cost-benefit study in Belgium identified major public health savings over time from cycle highways, the initial capital cost coupled with low political will could present challenges to implementing cycle highways in some cities.[112]

106 Super Cykelstier, n.d. Cycle Superhighways.
107 Transport for London, 2018. Cycling Action Plan: Making London the World’s Best Big City for Cycling..
108 Gilligan, 2019. London’s Cycle Network Overhaul Has Come to a Standstill.
109 Bliss, L., 2017. Cruising a Superhighway Built for Bikes.
110 Ferro, S., 2014. A Brief History of Bike Superhighways.
111 van der Zee, R., 2016. Could Intercity Cycle Highways Revolutionize the Daily Commute?
112 Buekers, J., 2015. Health Impact Model for Modal Shift From Car Use to Cycling or Walking in Flanders: Application to Two Bicycle Highways.

2.2 Shared Electric Micromobility Systems

Shared electric micromobility systems are increasingly provided or managed by cities as a way to achieve broad transportation goals, such as mode shift and reducing VKT. Barcelona is an example of this kind of goal-oriented integration. The city added e-bikes into its public bikeshare system in 2018 as part of a goal to increase bicycle trips by 10% over 10 years.[113] Similarly, Lisbon launched its public bikeshare system, Gira, with pedal and e-bikes to make cycling easier in the notoriously hilly city center. The city also found that the electric-assist bicycles, coupled with a commitment to building safe bicycle infrastructure, helped to expand use beyond recreational trips during the summer months, toward its overall goal of congestion reduction.[114] Other cities have made commitments to add e-bikes to their existing bikeshare systems, like London, through its *Cycling Action Plan*.

Privately operated and financed shared e-bike and e-scooter systems are also growing in popularity. While these systems are not operated using public funding, they do use public assets—streets and sidewalks. Cities have recognized the need to manage private operators to maximize system-wide benefits and minimize negative outcomes. Understanding the potential access, equity, and environmental gains presented by e-bikes and e-scooters, many cities have enacted policies that regulate private shared systems toward these goals.

Parking and public space management have required careful consideration on the part of cities, particularly with dockless shared e-bikes and scooters. Disorderly parking is a common complaint, and it can limit the mobility of people already experiencing limited mobility (such as people in wheelchairs). In some cases, cities have designated public space on sidewalks and streets to park shared e-bikes and e-scooters. In Sacramento, California, the Regional Transit District and a private operator, JUMP, partnered to install physical charging stations (similar to traditional bikeshare stations) for JUMP's shared e-bikes. Decisions to designate space for electric micromobility parking can be politically challenging, as space may need to be converted from car parking.

Infrastructure Recommendations:

Define the infrastructure electric modes are permitted to use:

- Low-speed modes should be permitted in all cycle infrastructure
- Moderate-speed modes should be permitted in cycle infrastructure, context-permitting:
  - Lower-density areas with low cycling volumes could permit moderate-speed modes
  - Higher-density areas with high cycling volumes and slower mixed-traffic speeds should not allow moderate-speed modes
- High speed e-devices (over 45 km per hour) should not be permitted to use cycling infrastructure.

Defining which types of devices can safely use cycling infrastructure—and communicating that distinction clearly—is important to limit confusion for electric micromobility users, cyclists, pedestrians, and drivers and to improve safety. With speeds comparable to those of a pedal cyclist, low-speed electric devices should be authorized to ride in cycle lanes and other bicycle infrastructure city-wide. Clear rules for when and where it is appropriate to use low-speed e-bikes and e-scooters on sidewalks should also be considered. Geo-fencing to limit speeds or disable riding altogether on sidewalks in areas with high foot traffic, as is used in Baltimore's Inner Harbor and around the city's stadium complex, can help reduce conflicts between electric micromobility riders and pedestrians.[115]

For moderate-speed devices, we recommend differentiating between the ability to use bicycle infrastructure in high- and low-density urban areas. The European Cyclist Federation (ECF) recommends that in high-density urban areas where vehicle speeds tend to be low (comparable to moderate-speed e-devices) and cycling and walking are prolific, moderate-speed electric devices should not be permitted to use cycling or pedestrian infrastructure unless that infrastructure has been designed to accommodate moderate-speed devices without compromising the safety of cyclists or pedestrians.[116] This could include passing lanes, for example. Additionally, non-shared streets in dense urban areas should be designed to limit vehicle speeds to those appropriate for travel by moderate speed e-devices (under 40 kph). However, in lower-density areas farther from the city center, where vehicle speeds may be higher and cycling infrastructure is likely to be less crowded, moderate-speed e-devices should be permitted to use cycling infrastructure where available. High-speed e-devices, including electric motorcycles and seated scooters, should never be permitted to use cycling infrastructure.

113 Ajuntament de Barcelona, 2018. New Bicing System: 24-hour Service, More Geographical Cover, and a New Design.
114 Laker, L., 2017. Hilly Lisbon Launches Electric Bike Share System in Bid to Solve Congestion.
115 Personal communication with Meg Young, Shared Mobility Coordinator, City of Baltimore, 2019.
116 ECF, 2017. An ECF position on the market introduction of L category power-assisted cycles.

Design safe, inclusive on-street infrastructure:
Also listed as a Crash Reduction Recommendation

- Shared systems should accommodate different user and trip types
- Cycle lanes should be designed as a complete and connected network for use by all potential users
- Some cycle lanes should facilitate longer-distance trips by e-bike.

E-bikes and e-scooters are attractive to a variety of user groups, including women, older adults, and parents of young children, many of whom have been underrepresented in traditional cycling. Shared e-bike and e-scooter programs and infrastructure should be designed and implemented with these groups in mind. Shared e-bike systems could include a variety of bicycle types, such as e-cargo bikes or bicycles with baskets or child seats, to accomodate trips in which riders are carrying goods or transporting small children.

Infrastructure—namely, a complete network of cycle lanes—should function for all potential pedal and electric bicycle and scooter riders. Bicycle lane design should consider wider lanes to accommodate higher volumes and wider devices (such as e-cargo bicycles), and it should integrate passing lanes where appropriate. Slow-speed shared streets with traffic-calming measures can supplement designated cycleways. Studies have shown that women rely more than men on protected cycling infrastructure to feel comfortable riding on the street and that clear signage designating and connecting cycling routes is also critical. Bike boxes and other visual cues that remind drivers to expect cyclists and riders of other small mobility modes help to improve safety at intersections, where cyclists often feel most vulnerable. Lighting should also be considered when designing and installing infrastructure that supports cycling, e-bike, and e-scooter use. Inclusive infrastructure improves safety for all potential users and can also help encourage people to try cycling, e-bikes, and e-scooters if they observe people similar to them riding comfortably.

Infrastructure should also be designed to safely facilitate longer journeys by non-car modes. Bicycle highways offer a direct route with few intersection stops (thanks to signal coordination from green waves), enabling fast, convenient commute trips by bicycle, often across municipal borders. Bicycle highways are particularly useful to e-bike riders who live far outside urban centers. Having a direct route to and from downtown makes commuting by e-bike—especially for trips up to 10 km—competitive with driving in terms of trip time. Thus, these routes should be planned in tandem with intra-city cycle lanes.

Protected lanes, like this one in Washington, DC, make e-bikes and e-scooters a viable commute option for more types of people.
Credit: BeyondDC, Flickr CC

Enforce safe use of cycling infrastructure

- Train enforcement officers to cite violators in cycling infrastructure (high-speed modes)
- Use events and campaigns to develop norms for safe infrastructure use.

A strategy to enforce correct use of cycling infrastructure—and violations of traffic laws while riding in the street—by riders of electric modes should also be developed. This will be critical for maintaining safety for all users, especially as usage of electric micromobility continues to grow in many locations. In many Chinese cities where moderate-speed e-bike use is high and has not been banned[117], e-bike riders often disregard traffic laws, overrun cycle lanes and sidewalks, and ignore stop signs and signals because enforcement is low. Enforcement has proved to be challenging for police because the population of e-bike riders is so substantial

117 In the early 2000s, major cities in China, including Beijing, Guangzhou, and Fuzhou, banned two-wheelers in response to rider fatalities and related safety concerns stemming from a rapid rise in use (Cherry and Cervero, 2007).

and violations occur frequently.[118] Similarly, Yogyakarta, Indonesia, saw poor enforcement when gasoline-powered scooter riders violated rules preventing them from using cycle lanes in the early 2000s. This led to unsafe, uncomfortable conditions for pedal cycling, which declined rapidly as a result.[119]

Norms for safe use of cycling infrastructure may also be developed over time through education and awareness campaigns. Learn-to-ride classes, community rides, and car-free-day events can provide opportunities to communicate safety rules for infrastructure use to riders.

3. ADOPTION AND USE POLICIES

3.1 Expanding Shared and Personal Use

To support the growth of electric micromobility as an alternative to car travel, cities and countries are working to incentivize the use of electric micromobility by expanding access to shared systems and reducing upfront purchase costs for personal use.

Lowering Barriers to Shared Micromobility Systems
Well-designed shared micromobility systems can increase access to non-car alternatives for populations who cannot afford to purchase an e-bike or e-scooter outright. Shared systems can also address other potential access barriers to small electric modes, such as maintenance costs and need for storage. However, in many locations outside the US and Europe, shared e-bikes and e-scooters are expensive on a per-trip basis for the user compared to public transit or walking and are seen as a mode that caters to those with higher incomes. Because of high trip costs, shared electric micromobility may not be feasible for people traveling from extreme peripheries of large cities like Rio de Janeiro or Mexico City into downtown, even as a connection to transit.[120]

To expand access and affordability, many cities require bikeshare and scootershare operators to offer reduced fares for low-income residents and alternatives to using credit cards or smartphones.
Credit: Sonia Medina, ITDP

A number of cities with publicly owned bikeshare systems have integrated e-bikes as a way to expand access to more types of users (see Appendix B). However, e-bikeshare remains a relatively small percentage of all publicly owned bikeshare systems. This may stem from the logistical challenges presented by the need to electrify stations for charging or by higher costs for purchase and maintenance of electric bicycles. Cities could also be restricted by an existing contract with their bikeshare operator, which may not offer e-bikes.

In addition to providing e-bikeshare, cities have started to identify alternative methods for accessing shared mobility systems (both publicly and privately financed) that require bank accounts and smartphones. These two requirements can restrict access for low-income, unbanked users and in places with unreliable internet access. Many cities have created (or require private operators to provide) discounts for low-income users and have enabled users to pay for trips with cash. Finally, marketing of e-bikeshare and e-scootershare programs and direct engagement with previously underrepresented groups may help to communicate the availability of discounted and alternative access programs, expanding ridership.

Financial Incentives for Purchase and Use
While relatively limited outside Europe, some countries and cities offer financial incentives to encourage the purchase and use of e-bikes as an alternative to private-vehicle travel. Both Austria and Spain have national incentive programs to subsidize personal e-bike purchases.

118 Shepard, W., 2016. Why Chinese Cities Are Banning the Biggest Adoption of Green Transportation in History.

119 Personal interview with Michael Replogle, Deputy Commissioner for Policy, New York City Department of Transportation, 2019.

120 ITDP Internal Survey, 2019.

In Austria, a subsidy of €400 is available to people who purchase an electric cargo bike. Home charging stations and cables also qualify for a €200 subsidy. In Spain, a €200 subsidy can be applied to personal e-bike purchases. In countries where national-level subsidies do not exist, regional and local programs can incentivize e-bike use through subsidies and/or trade-in programs.[121] A subsidy program recently adopted by the municipality of Angers, France, enables residents who have purchased an e-bike or e-cargobike to receive 25% of the purchase price (including value-added taxes [VAT]) back.[122]

In 2015 Switzerland piloted a campaign to lend participants a free e-bike to use for two weeks in exchange for their car keys. More than 1,800 people participated, and surveys showed that 15% of participants purchased an e-bike after the program, and many indicated they intended to drive less in the future.[123] More permanent trade-in programs, through which car owners trade in their older, high-polluting vehicle to receive a purchase incentive for a less-polluting option, are also being considered. The California State Senate recently passed a bill that will give car owners trading in an older vehicle the option to receive a purchase incentive that can be applied not only to a cleaner vehicle but to transit costs, a carshare or bikeshare membership, or an electric bicycle.[124]

Financial incentives have also been established to habitualize e-bike use. Mileage reimbursement programs in the Netherlands (North Brabant province) and Italy (Bari) compensate riders based on distance traveled on their e-bikes. In the case of North Brabant, the program was successful in attracting new riders to use e-bikes for utilitarian trips; however, it was unclear whether riders continued using e-bikes at the same levels after the compensation program ended.[125] Bari recently implemented a program to reimburse cyclists per kilometer ridden to and from work, and for non-work trips at a lower rate per kilometer (up to €25 per month). A subsidy of up to €150 for purchasing a pedal bicycle and €250 for an e-bike is also available.[126]

3.2 Lowering or Removing Import Tariffs

Import tariffs or value-added taxes on bicycles, including e-bikes, make these modes less affordable to purchase. Many countries (representing the majority of world trade) have attempted to lower these tariffs through international bodies such as the World Trade Organization (WTO) without success. There has been movement in some countries to reduce VAT on e-bikes and other sustainable mobility modes, including pedal bicycles, to encourage their use. The United Nations Environment Program (UNEP) is working to reduce import tariffs on e-bikes and electric two-wheelers in African countries to expand affordability. The Belgian parliament has called for a VAT reduction on e-bikes from 21% to 6%, which will only become effective if the European Union changes existing legislation.[127]

There are two common barriers to lowering import tariffs or VAT. First is the designation of electric bicycles as luxury goods. A number of African countries, including Kenya, maintain import tariffs on bicycles, classified as “luxury items” despite their impact on affordability and uptake of sustainable transport modes. Similarly, Brazil maintains a 35% IPI (a federal tax on industrial products) on e-bikes, compared to 10% on conventional bicycles.[128]

Second, tariffs have been maintained to ease concerns over low-quality imported models oversaturating the market or undercutting locally produced models. There have been ongoing international attempts to eliminate tariffs on bicycles to expand their affordability. Notably, the negotiations for the WTO’s Environmental Goods Agreement (EGA), aimed at eliminating trade barriers to environmental solutions, began in 2014 but never concluded. Among the most significant disagreements for the list of tariff-free goods were bicycles (both traditional and electric).[129] Negotiations stalled over concerns from EU members over China’s bicycle production capacity flooding European markets.[130] In future negotiations, e-bikes and other small electric modes stand to face similar pushback, given the global domination of e-bike production and consumption by China.[131 132]

121 Randall, 2019. Austria Presents New EV Subsidy Packet.
122 Themayor.EU, 2019. Buy an E-bike, Get 25 Percent Back.
123 McQueen and Cherry, 2019. How E-bike Incentive Programs Are Used to Expand the Market.
124 C.A. State Senate. SB-400. Reg Sess. 2019-2020 (2019).
125 McQueen and Cherry, 2019. How E-bike Incentive Programs Are Used to Expand the Market.
126 Forrest, A., 2019. The Netherlands Pays People to Bike to Work.
127 Haubold, 2019. Belgian Government Calls for Reduced VAT on Bike and E-bike Sales.
128 Mendonça de Vargas Pinto, 2019. A Lei e as Bicicletas Elétricas.
129 CONEBI, 2016. No Deal on Environmental Goods.

Adoption and Use Recommendations:

Increase exposure and access to small electric modes:

- Incorporate e-devices into existing shared systems using incentives and pilots
- Require shared electric micromobility systems to offer discounts and payment and smartphone alternatives for universal access
- Pilot programs like e-bike-for-car swaps, cycle-to-work, and long-term rental.

Exposure to and the ability to easily try an e-bike can expand people's level of comfort with leaving their car at home and using other modes for commuting or other utilitarian trips. Decreases in VKT observed as a result of studies in which e-bikes were provided to users indicate that shared e-bike (and e-scooter) systems could have an even more significant impact on vehicle use than traditional bikesharing.[133] Thus, cities should work to increase exposure to e-bikes and e-scooters through shared programs. These programs should be distributed equitably across the city, offer discounts for low-income residents, and provide access alternatives for people without smartphones or credit cards.

Other opportunities for people to try small electric modes should also be explored. Short- and long-term bicycle swaps have been shown to shift perceptions and behavior in terms of substituting certain car trips with an e-bike. Employer-supported cycle-to-work programs and financial reimbursements could also increase exposure to e-bikes and e-scooters. Albeit relatively nascent, monthly subscription services that provide an e-bike to a user (similar to leasing a vehicle)—as well as maintenance and replacement bicycles when needed—can help to reduce concerns about owning and maintaining a personal e-bike.[134] Similar incentive programs have not yet arisen for e-scooters, though shared scooter operator Bird piloted a monthly rental option in San Francisco and Barcelona that included access to a personal e-scooter and unlimited trips.[135] While perhaps not achieving utilization numbers comparable to those of short-term shared systems, these types of programs may offer greater reliability—a common shortcoming for shared systems—or cater to users outside the service areas of shared systems. Thus, short- and long-term shared options should be considered to increase exposure among a wider base of potential users.

Designs for e-scooter parking and charging were built in on-street car parking spaces for Parking Day in Denver, CO.
Credit: WalkDenver

Design and implement parking and charging spaces:

- Designate space for parking that considers volume and demand
- Consider public charging options (perhaps in partnership with the private sector)
- Develop a universal standard for charging to expand utility of public charging spaces.

130 Miles, 2016. Chinese Bikes Just One Obstacle for WTO Environmental Trade Talks .

131 WTO, n.d. Environmental Goods Agreement (EGA).

132 Office of the U.S. Trade Representative, n.d. Environmental Goods Agreement.

133 Guidon et al., 2018. Electric Bicycle-Sharing: A New Competitor in the Urban Transportation Market?

134 Swapfiets, n.d.

135 Bird, 2019. Bird Introduces Monthly Personal Rentals.

Cities should consider siting and funding the installation of secure parking and public charging locations to address adoption barriers like range anxiety and concerns of theft. This type of infrastructure could also serve as an opportunity for placemaking or activation of public spaces, as was done in Denver through a parking and charging design competition initiated by e-scooter operator Spin.[136] Convenient, reliable parking and charging infrastructure can help expand access to and use of electric micromobility modes. Universal charging capabilities across shared and personal electric devices would be needed for maximum usability. Public private partnerships (PPPs) could be effective in sharing costs for charging and parking infrastructure, similar to PPPs developed to facilitate public electric vehicle charging. Private companies in China and Mexico are already providing charging infrastructure for e-bikes.[137]

Encourage trip replacement by making car travel less convenient:
- Limit access to certain zones for polluting vehicles
- Charge a fee for single-occupancy-vehicle trips
- Review parking minimums and on-street parking costs.

Improving affordability of purchasing an e-bike or e-scooter through financial incentives or reducing import tariffs could result in higher ridership and reduced VKT. Coupled with these, implementing pricing or other related policies that make vehicle travel less convenient or attractive can encourage people to consider alternatives to driving like public transportation, cycling, or walking. However, the potential for e-bikes and e-scooters to contribute to emission reductions and other benefits rests largely on their replacement of car trips. Thus, implementing policies that directly encourage replacing car trips with small electric modes should be explored.

REDUCING OR ELIMINATING OFF-STREET PARKING MINIMUMS, ADOPTING PARKING MAXIMUMS, AND INCREASING THE PRICE OF ON-STREET PARKING COULD ENCOURAGE MODE SHIFT TO NON-CAR ALTERNATIVES LIKE E-BIKES AND E-SCOOTERS.

For example, low-emission zones—typically implemented as an air-quality improvement measure—restrict through-street access for certain types of polluting vehicles or require polluting vehicles to pay a fee to drive within a certain area. Because low-emission zones can lengthen car trip times or make them more expensive in places where internal combustion engine (ICE) vehicles are still widely used, these zones make small electric modes—and cycling and walking—more competitive with driving in terms of speed, comfort, and cost. This effect diminishes as ICE vehicles are phased out and replaced with electric vehicles. Some cities, however, are limited in their authority to create low-emission zones that operate like those in European and Asian cities. In these cases, cities may be able to regulate curbside loading and unloading—zero-emission loading zones—limiting delivery space to electric trucks or smaller zero-emission modes like e-cargobikes. Low-emission loading zones may be a good way to encourage a transition from heavy-duty delivery vehicles to e-cargo devices in crowded downtowns. New York City is exploring such approaches.[138]

Congestion pricing can also encourage mode shift away from private vehicles by making drivers immediately aware of the true costs of driving. Congestion pricing heavily disincentivizes single-occupancy-vehicle trips, shifting travelers to non-car modes not subject to the charge, like cycling, walking, and public transit. Thus, congestion pricing requires strong and competitive alternatives to driving—namely, frequent transit and safe, comfortable cycling and walking routes—that can adequately support those who choose not to or cannot afford to pay the congestion charge. Well-designed shared e-bike and e-scooter schemes and other efforts to lower barriers to access to e-bikes and e-scooters could serve as such alternatives.

Reducing or eliminating off-street parking minimums, adopting parking maximums (as was done in Mexico City in 2017), and increasing the price of on-street parking to reflect the true cost of that space could also be used to encourage mode shift to non-car alternatives like e-bikes and e-scooters.

4. CRASH REDUCTION POLICIES

The relatively limited research on e-bike and e-scooter safety, coupled with strong media and public attention to crashes and risk (particularly for e-scooters), has resulted in uncertainty about the right approach for many cities. The first interventions for reducing crashes and their severity are protected cycle lanes and lower vehicle speeds. Streets, for the most part, are still designed with vehicles as the primary and dominant mode. That design hierarchy needs to be inverted and updated with clear rules that designate where on the street electric micromobility users are permitted to ride, and safe cycle lanes that separate users from higher-speed modes are critical (see Infrastructure Recommendations).

136 Spin, 2019. A Design Competition That's Putting a New Spin on Parking.
137 ITDP Internal Survey, 2019.
138 Personal communication with Michael Replogle, Deputy Commissioner for Policy, New York City Department of Transportation, 2019.

Moreover, the actual experience of riding these modes—particularly e-scooters—is unfamiliar to many users, which has, in some cases, resulted in injury. Recognizing this, some cities are considering additional crash reduction measures, although these are just emerging and have not yet presented opportunities for analysis. For example, Atlanta requires that shared e-bike and e-scooter operators disable devices overnight to reduce instances of intoxicated riding (an Austin Public Health study found that in 29% of e-scooter crashes, the rider had consumed alcohol within the previous 12 hours) and limited visibility.[139] However, these nighttime bans do not extend to personal e-bike or e-scooter riders. Another example is Austin, which passed an ordinance that authorizes police to cite and fine shared micromobility users who violate safety rules.[140] Still other cities have begun to work with shared operators to offer training classes for potential e-bike and e-scooter riders. Ultimately, safety policies should protect users of electric micromobility, pedestrians, and other cyclists, and align with existing efforts to improve safety for non-car users.

Crash Reduction Recommendations:

Design safe, inclusive on-street infrastructure

Also listed as an Infrastructure Recommendation

- Cycle lanes should be designed as a complete and connected network for use by all potential users.

Protected cycling infrastructure, as part of a complete and connected network, is critical for the safety of all road users. Slow speed, shared streets, traffic-calming measures, and clear signage designating and connecting cycling routes can also help improve safety for non-car users. Bike boxes and other visual cues that remind drivers to expect cyclists and riders of other small mobility modes make intersections, where cyclists often feel most vulnerable, safer. See Infrastructure Recommendations for additional information.

Offer public safe riding courses

- Partner with civic groups, schools, operators, etc. to provide safe riding courses.

The limited research available on e-bike and e-scooter crashes indicates that 33% of injuries occur on the first ride and that the majority of crashes involve only the user.[141] While most shared system operators provide information on how to use their devices in their mobile apps, safe riding courses will likely have a more profound impact on safe use. These courses can be particularly useful for getting more comfortable riding e-scooters, which feel fundamentally different to balance and operate than a bicycle. Cities with existing community-led safe riding

The City of Portland's Bureau of Transportation (PBOT) hosted an e-scooter safety event where e-scooter operators gave away free helmets and led rider trainings.
Credit: Sarah Petersen for PBOT, Flickr CC

139 Austin Public Health, 2019. Dockless Electric Scooter-Related Injuries Study.
140 Kamath, T., 2019. New Scooter Rules in Effect in Austin Starting Monday Target Misbehaving Riders.
141 Austin Public Health, 2019. Dockless Electric Scooter-Related Injuries Study.

or learn-to-ride classes could integrate shared e-bikes and e-scooters into those offerings. Or, cities can work with shared system operators to host and promote training courses. Learn-to-ride courses also provide an opportunity to share details of local traffic laws—like where and when sidewalk riding is permitted—with riders and distribute helmets. Increasing rider confidence could also help to reduce instances of problematic sidewalk riding, reducing potential incidents between electric micromobility users and pedestrians.

5. STRATEGIC PLANNING POLICIES

While cycling has, generally, been integrated into city-level planning over the past few decades in the form of bicycle master plans or active transportation strategies, e-bikes (and e-scooters, albeit though these have come on the scene much more recently) are rarely mentioned specifically as interventions to pursue or as tools for achieving goals such as congestion and emissions reductions, fewer single-occupancy vehicle trips, or reduced VKT. Specific targets or metrics for electric micromobility are also rare. We identified only a few examples (limited to English language sources). A notable example comes from the UK Department of Transport, which, in 2015, integrated e-bikes into its strategy for sustainable transportation, launching a pilot program to distribute £700,000 to bikeshare programs around the country to fund the addition of e-bikes into their fleets.[142]

Cities have, however, begun to specify electric micromobility as part of electrification strategies. While not as common as bicycle master plans and similar strategies have become over the years, electrification strategies seek to identify and anticipate opportunities to electrify the transport sector to meet emissions reduction and related climate goals. Cities including Portland, San Francisco, and Mexico City have electrification strategies in place, and others, like New York City, are considering them. In a few cases, like Seattle, electric utilities have spearheaded the development of electrification strategies to ensure that their business models align with coming transport electrification needs.[143] While these strategies are largely focused on electrification of private vehicles and public buses, targets for implementing parking and charging infrastructure for electric micromobility and scaling up shared programs are also included.[144][145][146] For example, Mexico City's electrification strategy establishes a goal of 30% of bicycles in shared bicycle systems (public and private) being electric by 2030. The strategy includes a baseline percentage of bicycles that are currently electric and commits to calculating this indicator annually using data from Ecobici to evaluate progress.

Unless e-bikes and e-scooters are integrated into comprehensive strategies or plans, including setting targets, cities are unlikely to prioritize or fund these types of projects and infrastructure. Further, development of incentives for use or access and collecting data on ridership and modal shift to e-bikes and scooters over time is also not likely. This lack of funding and awareness of e-bikes and e-scooters as a tool to encourage a shift away from personal vehicle use and toward more multimodal trips combining walking, cycling, small electric modes, and public transit will seriously limit the scalability of these modes and the related benefits that come from expanded use.

Strategic Planning Recommendations:

Integrate small electric modes into citywide strategies and plans

- Determine how e-bikes and e-scooters can contribute to existing city-wide goals and what gaps they can fill in the transportation system
- Set targets for use linked to city-wide goals, including equity and inclusion targets
- Include electric micromobility in electrification strategies, climate plans, etc.
- Strengthen city staff capacity to plan for, support, monitor, and enforce the use of personal and shared electric modes.

Cities should work to integrate e-bikes and e-scooters into active transportation or cycling plans, electrification strategies, or sustainability plans, setting specific goals for use and growth. There should be a clear link between electric micromobilty as an intervention and achieving goals like VKT reduction, mode shift away from private cars, increasing access for all, or improving the reach of transit networks. Without this link, e-bikes and e-scooters—and the infrastructure required to support their safe use—will remain disconnected from the broader transportation network and underfunded. Targets and indicators will help to measure progress over time and define success.

142 Jones et al., 2016. Motives, Perceptions, and Experiences of Electric Bicycle Owners and Implications for Health, Well-being, and Mobility

143 Daniels, L. & O'Donnel, B., 2019. Seattle City Light: Transportation Electrification Strategy Report.

144 City of Portland, 2016. 2017 City of Portland Electric Vehicle Strategy.

145 San Francisco Electric Vehicle Working Group, 2019. Proposed Electric Vehicle Roadmap for San Francisco.

146 C40 CFF & Carbon Trust Mexico, 2018. Estrategia de electromovilidad de la Ciudad de Mexico 2018–2030.

At present, for some cities, creating an electrification strategy allows for an acknowledgment of the growing importance of e-bikes and e-scooters and the desire to more intentionally incorporate electric micromobility into larger citywide goals without needing to update existing transportation plans. For example, Portland's *Electric Vehicle Strategy* establishes a link to the city's *Climate Action Plan*, which commits the city to reducing carbon emissions by 80% by 2050. Whether in separate plans or combined, there should be an emphasis on the intersectionality of electrification, sustainability, equity, and transportation strategies and an effort to align goals across these areas. Additionally, clear roles for different agencies (e.g., departments of transportation, transit agencies, departments of energy, etc.) should be identified and funding should be budgeted for implementation and maintenance of projects.

Cities should also consider strengthening staff capacity to plan, support, monitor, and enforce the use of electric micromobility. Designating clear roles and responsibilities for implementation, maintenance, and evaluation of projects will help to reduce inefficiency or duplication of efforts. This will also be important for managing public private partnerships (PPPs) and working with other stakeholders toward achieving stated goals.

Collect data for analysis and enforcement

- Amend travel surveys to collect data on electric micromobility use that is disaggregated from traditional cycling
- Require aggregated ridership data from private shared service operators.

Cities and national governments should work to collect data on e-bike and e-scooter use, disaggregating e-bikes from pedal bikes in order to better understand and evaluate travel patterns for both modes. Evaluating trip types and use cases other than commute trips as well as disaggregating usage data by gender, age, and socioeconomic status would provide a more accurate picture of use. Understanding who is using these modes and how is important to ensure that transportation interventions are meeting multiple goals—from safety to environment to equity.

Current data on e-bike use varies widely by location. The Dutch National Travel Survey separates e-bike and traditional cycling trips, but most countries do not collect this level of detail. This makes understanding usage trends, growth over time, and potential difficult. Most of the available data on e-bike use and perceptions comes from academic research trials using GPS or surveys to analyze study participants' travel habits. Most of these trials are limited in scope and time, and results can be difficult to generalize to other cities or user groups.

Furthermore, cities should require ridership data from private e-bikeshare and e-scootershare providers to evaluate use on a more regular basis than larger travel surveys allow. In spite of the recent emergence of shared e-scooter services, publicly available, comprehensive data on e-scooter ridership, mode shift, and trip replacement is minimal. This data does not exist for many Global South cities, which makes analyzing the impacts of these modes extremely difficult. Most of the data that is available has been gathered by city transit agencies or third-party groups (and private operators, in some cases) conducting intercept surveys with users either in person or via their app. These surveys are time-consuming and expensive, and results can be difficult to generalize to other cities. However, these surveys are important for understanding how electric micromobility modes are meeting the needs of a particular city. Ridership and mode shift data will be important evidence underscoring cities' decisions to link e-bikes and e-scooters to broader sustainable transport goals and to give priority and funding to projects that maximize the benefits of electric micromobility modes for all users. On the other hand, this data will also be critical for enforcement of rules managing shared e-bike and e-scooter programs. A clear strategy for enforcement, informed by the broad transport goals of access, safety, environment, and equity, should be developed and shared with operators prior to service provision.

CAPACITY BUILDING AND NEXT STEPS

5

Based on our research, electric micromobility modes like e-bikes and e-scooters could play an important role in sustainable transport networks. These modes have been shown to advance urban transport goals including access, equity, environment, efficiency, and safety, but can also present barriers to these goals if planning and oversight by city officials is insufficient or lacking.

Capacity to implement supportive infrastructure and monitor the provision of shared e-bike and e-scooter services by the private sector will vary from city to city. Capacity building may need to be undertaken prior to implementing policies or other efforts to manage e-bike and e-scooter use or to operate a sustainable transport network more broadly. Informed by ITDP's work assessing capacity limitations in South Asia and sub-Saharan Africa (publication forthcoming), the following actions may help to build capacity for cities to more effectively maximize the sustainable transport benefits described in Section III and to minimize the potential negative impacts of more widespread adoption of e-bikes and e-scooters.

- **Develop a vision** for the role of small electric modes in achieving broader transport goals
- **Strengthen city staff capacity** to plan for, support, monitor, and enforce the use of personal and shared electric modes
- **Build technical awareness** and understanding of replicable best practices
- **Review and update** outdated operating and planning standards
- **Cultivate interagency communication** to coordinate planning, design, implementation, and budgeting for projects that impact small electric modes
- **Expand and reform funding sources** for supportive infrastructure.

Building capacity and partnerships between public and private stakeholders to integrate electric micromobility into urban transportation networks will be necessary for these modes to achieve scale and related benefits. Such coordination will also be critical for managing negative outcomes, which could be exacerbated as more trips are taken on electric micromobility modes.

Still, there is a lot we do not know. Research conducted for this report has identified a number of gaps in knowledge, particularly in terms of the feasibility and potential for e-bikes, e-scooters, and other electric micromobility in Global South cities. The following are concepts we would like to explore in future work:

- Potential and implications for electric micromobility to displace two-wheeler trips in cities with high two-wheeler use
- Potential, especially for e-scooters, in low-income countries in the Global South given poor road conditions and street networks
- Usage rates of electric micromobility disaggregated by gender, race, and socioeconomic status, considering trip type and mode shift
- Mechanisms to integrate shared electric micromobility with transit (common fare payment, reduced fare transfers, parking at stations)
- Viability of different approaches to or designs for street space allocation that consider small electric modes (i.e., passing lanes, wider lanes, etc.)
- The impact of crash reduction measures (nighttime bans, public trainings, etc.) on injury rates
- The extent to which cities are identifying and positioning electric micromobility as a strategy to achieve broader sustainable transport goals.

Electric micromobility has the potential to become a critical piece of the shift away from private vehicles and toward transportation systems that prioritize people. Recognizing this, cities should work to reenvision their streets to support not only electric micromobility but all forms of sustainable transportation.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APPENDIX A:
PUBLISHED STUDIES LINKING SMALL ELECTRIC MODES TO SUSTAINABLE TRANSPORT GOALS

Environment:

Astegiano et al., 2019. Investigating the Impact of E-bikes on Modal Share and Greenhouse Emissions: A System Dynamic Approach.

Bucher et al., 2019. Energy and Greenhouse Gas Emissions Reduction Potentials Resulting From Different Commuter Electric Bicycle Adoption Scenarios in Switzerland.

McQueen et al., 2019. The E-Bike Potential: Estimating Person Miles Travelled and Greenhouse Gas Emissions.

Access/Equity:

European Cyclists Federation, 2016. Electromobility for All: Financial Incentives for E-Cycling.

Fistrek and Rzewnicki, 2016. A New Move for Business: Electric Cycle Logistics in European Cities.

German Environment Agency & ECF, 2018. Framing the Third Cycling Century.

Broad Strategies & Plans:

Smith, C. S. and Schwieterman, J. E-Scooter Scenarios: Evaluating the Potential Benefits of Shared Dockless Scooters in Chicago.

Jones et al., 2016. Motives, Perceptions, and Experiences of Electric Bicycle Owners and Implications for Health, Well-being, and Mobility.

McKenzie, G., 2019. Spatiotemporal Comparative Analysis of Scooter-Share and Bike-Share Patterns in Washington, DC.

C40 CFF & Carbon Trust Mexico, 2018. Estrategia de electromovilidad de la Ciudad de Mexico 2018–2030.

Daniels, L. & O'Donnel, B., 2019. Seattle City Light: Transportation Electrification Strategy Report.

San Francisco Electric Vehicle Working Group, 2019. Proposed Electric Vehicle Roadmap for San Francisco.

City of Portland, 2016. 2017 City of Portland Electric Vehicle Strategy.

APPENDIX B: PUBLICLY FUNDED BIKESHARE SYSTEMS WITH 100+ E-BIKES

E-BIKE LAUNCH YEAR	CITY	COUNTRY	SYSTEM	TOTAL E-BIKES	TOTAL BIKES	STATIONS
2013	Copenhagen	Denmark	Bycyklen	1860	1860	100
2014	Moscow	Russia	Smoove	260	4400	500
2014	Madrid	Spain	BiciMAD	2028	2028	165
2014	Barcelona	Spain	Bicing	1000	7000	519
2015	Quito	Ecuador	BiciQuito	300	658	25
2015	Milan	Italy	BikeMi	1000	4600	280
2015	Birmingham, AL	USA	Zyp	100	400	37
2017	Newscastle	Australia	BYKKO	100	100	19
2017	Hangzhou	China	Hangzhou Public Bicycle	5000	60,600	2,416
2017	Stuttgart	Germany	RegioRadStuttgart	270	970	100
2017	Park City, UT	USA	Summit Bikeshare	132	132	9
2017	New Orleans	USA	Blue Bikes Nola	700	700	68
2017	Lisbon	Portugal	GIRA	940	1410	Future: 350
2018	Lyon	France	Velo'v (Long term rental)	100	4000	348
2018	Paris	France	Velib	6,000	20,000	1800
2018	Mexico City	Mexico	Ecobici	340	6800	480
2018	Gdansk	Poland	Mevo	4080	4080	660
2018	Bilbao	Spain	Bilbaobizi	450	450	40
2018	Bern	Switzerland	Publibike	2400	2400	200
2018	Fayetteville, AR	USA	VeoRide (Partnered with city)	200	490	N/A (18 hb)
2018	Pioneer Valley, MA	USA	ValleyBike	500	500	51
2018	Eugene, OR	USA	PeaceHealth Rides	300	300	36

E-BIKE LAUNCH YEAR	CITY	COUNTRY	SYSTEM	TOTAL E-BIKES	TOTAL BIKES	STATIONS
2019	Montreal	Canada	BIXI	120	7250	600
2019	Tartu	Estonia	Tartu Rattaringlus	510	750	60
2019	Monaco	N/A	Monabike	300	300	35
2019	San Sebastian	Spain	dBizi	250	250	16
2019	Brussels	Belgium	Villo!	1800	5000	360
2019	Bordeaux	France	V3	1000	2000	164
2019	Paris	France	Veligo (Long term rental)	10,000	10,000	N/A
2019	Kigali	Rwanda	N/A	3000	5500	N/A
2019	Austin, TX	USA	Austin B/Cycle, Domain Bcycle	100	510	76
2019	Baton Rouge, LA	USA	Gotcha	500	500	50
2019	Cincinnati, OH	USA	Red Bike	102	541	57
2019	Syracuse, NY	USA	Gotcha Sync	200	200	35
2019	Madison, WI	USA	Madison B-Cycle	300	300	44
2019	Philadelphia, PA	USA	Indego	410	1600	136
2019	Colorado Springs, CO	USA	PikeRide	208	208	28
2019	Los Angeles, CA	USA	Metro Bike Share	300	>1300	>100
2019	Cedar Rapids, IA	USA	Cedar Rapids Bike Share	150	170	90
2019	Raleigh, NC	USA	Citrix Cycle	200	300	30
2019	St. Augustine, FL	USA	Gotcha (Partnered with city)	100	100	13

APPENDIX C: PURCHASE PRICE COMPARISON FOR ELECTRIC AND MOTORIZED PERSONAL TRANSPORT

COUNTRY	TYPE	COST*	YEAR	ANNUAL INCOME	YEAR	COST AS % OF ANNUAL INCOME
United States	Motor vehicle (ICE)	$36,115	2018	$61,372	2017	59%
	Motor vehicle (electric)	$49,408	2018			81%
	Motorcycle (gas)	$12,479	2018			20%
	E-bike (low-and moderate-speed)	$2,000 - 2,600	2018			4%
	E-scooter	$270 - $630	2019			0.75%
China	Motor vehicle	$20,700	2018	$5,300	2017	391%
	E-bike (moderate-speed)	$291	2018			5%
Brazil	Motor vehicle (ICE)	$10,675	2018	$6,379	2019	167%
	Motor vehicle (electric)	$54,761	2019			858%
	E-bike (low-and moderate-speed)	$1,080	2019			17%
	E-scooter	$720	2019			11%
Mexico	Motor vehicle (ICE), high estimate	$43,490	2019	$3,240	2018	1342%
	Motor vehicle (ICE), low estimate	$9,250	2019			285%
	E-bike	$1,450	2019			45%
Netherlands	Motor vehicle	$32,150	2016	$35,029	2017	92%
	E-bike (low speed)	$1,367	2018			4%

*Cost estimated using common models if data unavailable.

ITDP

PUBLICATIONS
2019