

WSP



Leading the Charge

on Canadian **E-bike** Integration

A Discussion on the Emerging and
Uncharted Role of Micromobility



Table of Contents

Why is micromobility rapidly increasing as a travel mode choice?	2	5. How do practitioners perceive micromobility?	31
What can the emergence of micromobility mean?	3	5.1 Results	
1. What are e-bikes and how do we define them?	5	5.2 Discussion	
2. What is the existing role of e-bikes and how could this change?	9	6. How can micromobility address the missing middle of transportation?	39
2.1 A snapshot of the existing role of e-bikes		6.1 Micromobility and destination-bound trips	
2.2 Cost and availability of e-bikes		6.2 Intersecting micromobility and shared mobility	
2.3 The users and uses of e-bikes		6.3 Multimodal integration	
2.4 Facilitators and barriers to e-bike ridership		6.4 Social equity	
2.5 Looking at the future role of e-bikes		7. What are the best tools for integrating micromobility and e-bikes in the canadian context?	45
3. How does legislation impact e-bike integration? Exploring the legislative landscape of e-bikes	15	7.1 Legislation	
3.1 Canadian e-bike legislation		7.2 Planning documents	
3.2 Reviewing examples of international e-bike legislation		7.3 Bikeshare	
4. What lessons can be learned from current e-bike regulation?	23	7.4 Cycling infrastructure	
4.1 How fast should an e-bike go?		7.5 Incentives and pilots	
4.2 Which e-bikes should be defined as bicycles?		7.6 Education	
4.3 What features can be used to regulate e-bikes?		8. Conclusions and next steps	53
4.4 How should the regulations be communicated?		Contributors	55
4.5 The impact of unanswered questions on public perception of e-bikes in Canada		References	56

Why is *Micromobility* Rapidly Increasing as a *Travel Mode Choice*?

Mobility is fundamental to the health of our communities. It is the means to connect people to their homes, their activities, and to each other. As recent societal trends impact where we live, where we go and how we connect, the ways in which we can, and want to, travel are also changing. Both the reality and attitude towards mobility are influencing a paradigm shift in more sustainable, inclusive and healthy transportation patterns. This results in more active modes of transport on our roads, with some being previously unseen. Micromobility, small human and electric-powered transportation solutions¹, is just one of the many mobility shifts we are experiencing to support the larger societal trends. As a mode of micromobility, e-bikes are bicycles with an electric motor that assist the user in propelling the bicycle, and e-scooters are kick-scooters fitted with an electric motor that increases

the rider's speed with minimal physical exertion. Current adoption trends for e-scooters are bordering on rampant; their presence is consistently growing along with municipalities' challenges to regulate them. This paper aims to better explain how we can be future-ready, to maximize the potential of e-bikes and other forms of micromobility in supporting sustainable, inclusive and healthy travel.

The term “micromobility” is inclusive of e-bikes, e-scooters, mopeds & more¹.

Social, Economic and Environmental trends affecting mobility



Social and Health

We live in a technologically connected, yet physically fragmented society, and social isolation is becoming more prevalent across many communities². The effects of social isolation are greater for vulnerable

populations, including the growing demographic of older adults³. In 2016, the population of Canadian older adults (55+) exceeded the youth population for the first time⁴. Furthermore, research is exploring the public health impacts of long auto commutes - finding links to obesity, decreased cardiorespiratory fitness, higher blood pressure, diabetes, fatigue, anxiety and depression, and chronic stress⁵.



Economic

The shared-mobility sector is shifting how we access transportation options. By 2025, it is expected that the shared-mobility sector will be an 827-billion-dollar global market⁶. The on-demand nature of shared mobility makes it a mobility-complement to the gig economy, where the labour market is characterized by on-demand work as opposed to permanent jobs.



Environmental

In the Canadian-specific context, emissions from the transportation sector have increased by 34% since the 1990s⁷. Increased use of micromobility can reduce emissions.

What can the Emergence of Micromobility mean?

Depending on perspective, micromobility is both one of the solutions and one of the problems in transportation. For some, the uncertainty surrounding micromobility makes it a nuisance, which should have careful regulations. For others, the increased active-travel shed (the distance one can travel using active transportation), comparable low cost, and increased sustainability offer an unprecedented level of freedom and flexibility. Even with diverging opinions, many regions have seen a rapid uptake

of micromobility options, most notably e-bikes and e-scooters, as new alternatives to addressing shifting transportation needs.

Micromobility appears to seamlessly address some, if not all, of our shifting mobility-needs and close the evident gaps in transportation, which limit the inclusivity and sustainability of travel. For this paper, we frame these shifting transportation needs as **the missing middle of transportation**.

THE MISSING MIDDLE



WALKING



AUTO DEPENDENCE

What is the missing middle?

The missing middle can refer to trip types, technology options, network connections and demographics that are currently left out of how we plan for, and implement, transportation. Planning for transportation options that can fill the missing middle would allow for a wider demographic to access their communities and essential amenities, offer sustainable alternatives to the automobile, and provide new industries within the transportation field. A notable element of the missing middle is the first and last mile trips – the distances between transit stops and the beginning and end of a trip.

Despite the evident potential of micromobility to address crucial gaps in transportation, it remains an emerging transportation field that is expanding rapidly with minimal guidance. Safety, implementation, regulation and accessibility are growing concerns as the market continues to gain popularity. These concerns give rise to several important questions, including: How can micromobility fit into the existing transportation network? Are micromobility options a complement or disturbance to the existing framework? How do we ensure micromobility maximizes its potential to fill crucial mobility gaps?

In the current transportation landscape, realizing the full potential of emerging technologies is paramount, and micromobility could have the potential to address social, economic and environmental issues within transportation. However, it is equally important to contemplate the appropriate introduction of these new modes, so that they are integrated and operated in a way that supports and enhances a sustainable and resilient transportation network. We frame seven key questions that will guide the discussion of this paper:

1 ***What are e-bikes & how do we define them?***

2 ***What is the existing role of e-bikes and how could this change?***

3 ***How does legislation impact e-bike integration?***

4 ***What lessons can be learned from current e-bike regulation?***

5 ***How do practitioners perceive micromobility?***

6 ***How can micromobility address the missing middle of transportation?***

7 ***What are the best tools for integrating micromobility and e-bikes in the Canadian Context?***

What are
E-Bikes
& How do we
define them?



Electric bicycles (also referred to as e-bikes, electric-cycles, e-cycles) are one of the leading and rapidly emerging modes of micromobility. E-bikes build upon the capability of traditional bicycles by reducing the physical stress of cycling with electric-power assistance to the pedals, permitting the rider to travel longer and farther than a traditional bicycle⁸. The speed, weight and functionality of the motor are dependent on the type of e-bike, as well as the specific area where the e-bike is operated. At present, there are regions across North America that have not established whether, or where, e-bikes should fit into their transportation networks. Currently, the term e-bike encompasses any two or three-wheeled electrically motorized bicycle/sit-down scooter with pedals. However, as shown in the graphics, the different types of e-bikes are not only visually contrasting as shown in **Figure 1** but also differ in capabilities (**Table 1**).

The Typologies

To assist in clarifying the differences between the models, we will adopt a definition previously used in e-bike literature: Bicycle-Style E-Bikes (BSEB) and Scooter-Style E-Bikes (SSEB). Despite the segregation in definition, in Canada and some countries around the world, there is no legal difference between the models.

Bicycle-Style E-Bikes (BSEB)

BSEB models have a similar physical appearance to non-motorized or conventional bicycles. In Canada, they are capped at 500 watts of power and a speed of 32km/h⁹. They are known across the globe as pedal-assist bicycles (PABs), pedelecs, and low-speed electric bicycles⁹.

There are two key typologies within the BSEB category: pedal-assist and throttle-assist. With pedal-assist models, the motor only runs when the

Figure 1 : Visually contrasting e-bikes

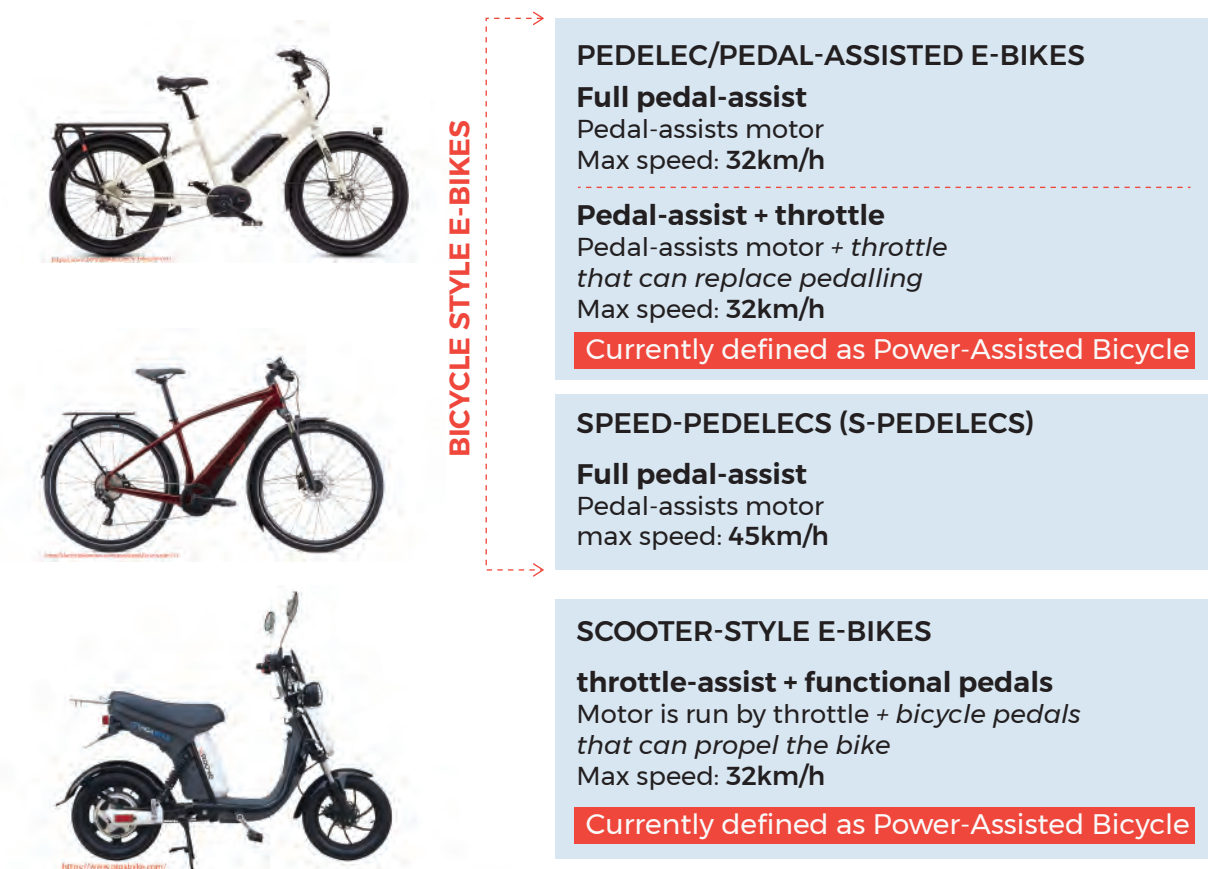


image sources in the reference page

rider is pedalling, relieving excess physical strain and expanding the bicycling range. They are most commonly known as pedelecs and PABs⁹. The term pedelec is predominantly European, whereas PAB is more common in North America. More powerful speed pedelecs are known as s-pedelecs, and operate at a higher maximum speed of 45km/h. Some pedelecs/PAB models offer a start-up aid, which allows the motor to run briefly (at a maximum speed of 6km/h) to help

the rider start after a stop. A start-up aid is not the same functionality as a throttle. Models with start-up aids are still considered pedal-assisted. In contrast, throttle-assist models still operate the motor as the rider pedals, but can also run the motor independently from pedalling through a throttle – normally located on the handlebars. These models are known as throttle-assisted PABs.

Table 1 : BSEB and SSEB typologies

	BICYCLE-STYLE E-BIKE	SCOOTER-STYLE E-BIKE
<p>POWER MODE To legally comply with the definition of an e-bike, each model must have pedals that could be operated by human power. However, the exact capabilities of the pedals differ between BSEB and SSEB. This section focuses on primary power mode.</p>	Motor assists pedalling (with the optional throttle)	Motor runs independently from pedalling (with optional pedalling)
<p>BATTERY RANGE An important facilitator of public uptake is the battery life of the e-bike. For both models, this parameter is commonly influenced by the quality of the manufacturer and the frequency of use. A typical range is provided for both models.</p>	30-70 km on average	~100 km on average
<p>WEIGHT As e-bikes have more built-in technology, they can often weigh more than a regular bicycle. The weight is once again dependent on the specific manufacturer. Generally, BSEB models are lighter than SSEB models.</p>	Approximately 22-30 kg	Approximately 75-100 kg
<p>MOTOR LOCATION The location of the motor affects other key metrics such as weight and maneuverability. Depending on the model and location, the location of the motor can vary.</p>	Front-wheel, rear-wheel or hub options	Front-wheel, rear-wheel or hub options
<p>LEGAL CLASSIFICATION As e-bikes are an emerging technology, they have different legal classifications depending on the region. For Canada, see the paragraph below.</p>	Legally classified as a bicycle	Legally classified as a bicycle

Scooter-Style E-bikes (SSEB)

SSEB models resemble mopeds in their frame and operate the motor independently from pedalling, via a throttle. However, to comply with the legal definition of an e-bike, SSEB models mandate pedals that could be operated by human-power. As such, SSEB models straddle the definition of electric bicycles¹⁰ ; although their pedals are mandated, they are rarely functional. In Canada, they are capped at 500 watts of power and a speed of 32km/h⁹. They are known as e-bikes, electric scooters and electric mopeds.

It is important to note that these terminologies are not universal on a global scale. In the following chapters, we will distinguish how the term e-bike is used internationally, and the effects of terminology on public perception and ridership trends. Currently, both BSEBs and SSEBs are gaining popularity in Canada. Specifically, the potential of BSEBs have increased significantly in the past year¹¹. For the remainder of this paper, “e-bike” refers to a bicycle-style pedelec type e-bike, unless BSEB or SSEB is used to delineate one from the other.



What is the
existing role of
E-Bikes
& How could this
change?



2.1 A snapshot of the existing role of e-bikes

The largest e-bike market is in China, where high gas prices, government incentives, and supportive e-bike policies sparked uptake in the late 1990s¹². When first introduced, e-bikes were part of a government initiative for energy efficiency which coincided with rising fuel prices in the early 2000s that made car and gasoline-scooter ownership less affordable¹². The legislation combined BSEB and SSEB models under an umbrella definition, which allowed SSEBs to operate as bicycles, with fewer restrictions than the popular gas-scooter alternative¹². This combination promoted widespread e-bike adoption, particularly for SSEB models that did not require gasoline, but mimicked the feel and capabilities of the popular gasoline-scooters. It should be noted that since gasoline-scooters were a major element of the previous modal-split, SSEB models account for 70% of e-bike use in China¹².

This uptake was mirrored in parts of Western Europe – more notably with BSEB models, where the e-bike market continues to grow in popularity among commuters, travellers, and leisure cyclists. In Western Europe, e-bike uptake is supported by a European-Union legislative framework, which delineates between the multiple types of e-bikes, giving pedelec models similar freedoms as bicycles (see **Chapter 3.2** for more details).

When considering the global context, e-bikes have a smaller presence in North America, which is commonly attributed to climate, car-culture and lack of bicycling-supportive infrastructure. In the last few years, e-bikes have been more noticeable on the roads of major urban cores – both BSEB and SSEB models¹¹. Particularly with bicycling food-delivery drivers for companies such as uber eats, foodora, skip the dishes, etc¹³.

2.2 Cost and availability of e-bikes

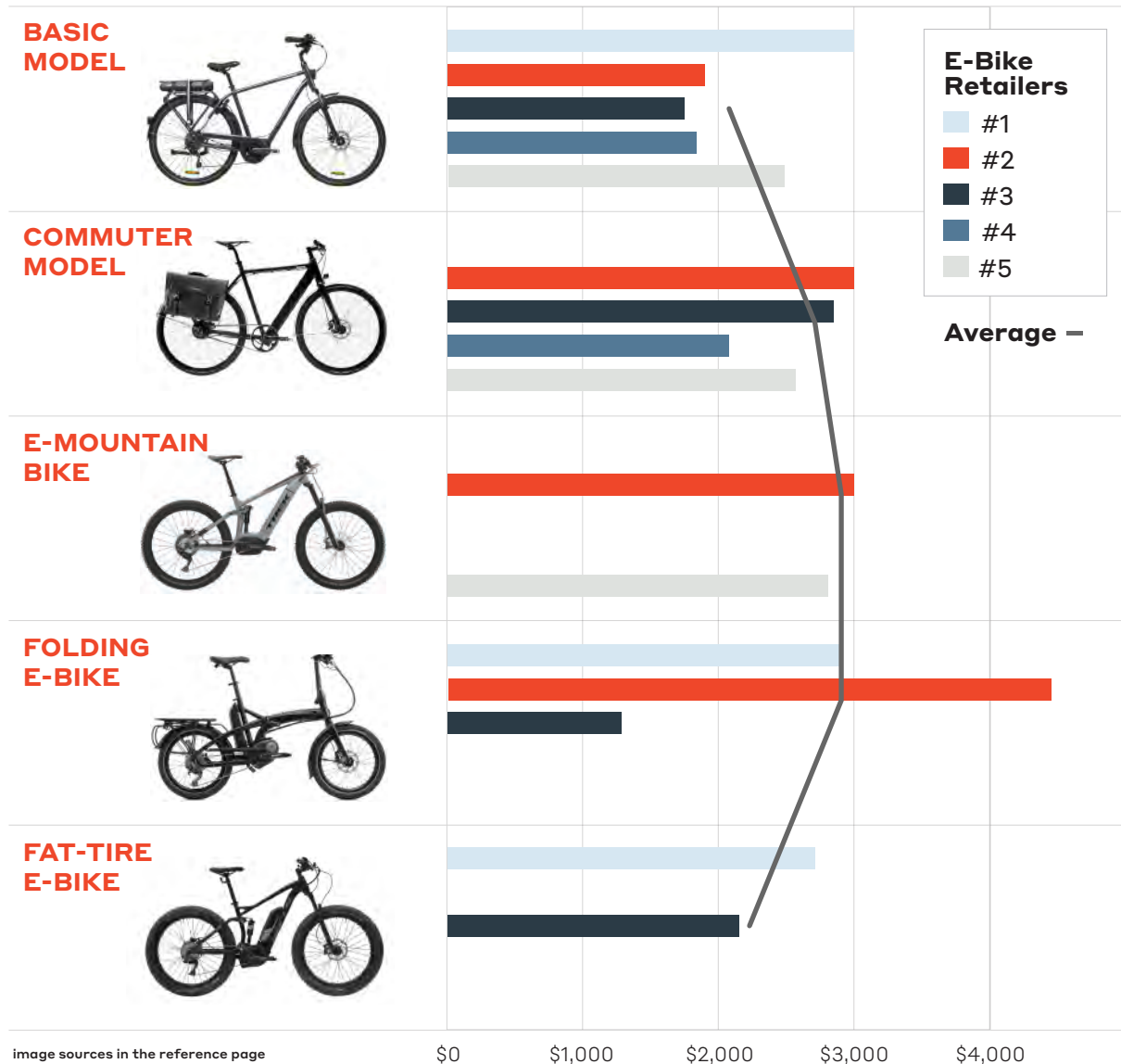
E-bike prices are reducing as they become more popular for mainstream retail¹⁴. E-bikes are still more costly than conventional bicycles; however, they have some of the highest economic advantages when comparing their cost per kilometre travelled to other modes of travel. Per kilometre travelled, e-bikes are estimated to cost less than 0.7 cents (including purchase and maintenance), compared to 3.1 cents/km for a gasoline-scooter, or 6.2 cents/km travelled by car¹⁵.

Within Canada, BSEBs are typically sold at speciality retailers or from manufacturer-direct, with many bicycle retailers introducing BSEBs to their in-store stock. Pricing depends heavily on the brand, battery quality, motor location, and supplementary features – lightweight design, foldable frame, step-through model, etc. Generally, all e-bike retailers provide at least 3-5 different levels, ranging from beginner/basic models to higher-level models that can withstand longer commutes or more difficult terrains¹⁶. Certain features are more desirable for different demographics. For example, urban commuters may prefer folding e-bikes or commuter-style e-bikes, whereas older adults may prefer step through or lightweight models. The “fat-tire” e-bikes are a rapidly growing market for those who complete longer trips or for off-road recreational use. To simplify the comparison of the many different e-bike models, we chose five general typologies of BSEBs and compared them nationally across multiple Canadian suppliers and manufacturers.

\$ 2,574

Figure 2 : Price comparison of BSEBs

Average BSEB price in Canada



SSEB models serve a different market than the BSEB models. Typically, SSEB models are only available in speciality stores or online. Despite having fewer models, SSEBs still vary widely in their capabilities. Common SSEB prices are around \$1,800-\$2,000, for a basic model. Higher-end models can reach up to \$3,000 in price¹⁷.

Compared to traditional bicycles, both BSEBs and SSEBs are significantly more expensive and less readily available. By comparison, the average cost of a conventional bicycle in Canada ranges between \$300-\$1500.

2.3 The users and uses of e-bikes

Multiple studies across Europe and North America have found that e-bikes can promote bicycling to a wider demographic when compared to conventional cycling. Specifically, research suggests e-bikes are favourable among populations who feel insecure cycling, such as some women and older adults. According to the 2014 Census Canada report, women cycled 12% less than men, and only 27% of the older adult population commonly cycled – clearly reflecting a generational and gender gap in cycling in Canada²⁰.

Moreover, current research shows that despite the e-bikes' reputation to increase the accessibility of cycling, most e-bike riders already have some history of cycling before adopting electric bicycling¹⁸. The new technology, heightened speed and additional controls can be daunting for non-cyclists or those already reluctant to cycle.

In addition to a diverse user-profile, the uses of e-bikes are equally broad. Recent research suggests that a wide range of infrastructure typologies currently support e-bikes. In North American cities that have autocentric built-form and transportation infrastructure, the faster pace and reduced physical stress of e-bikes position them as a reasonable replacement to motor vehicles. Additionally, there is increased rider comfort on routes with minimal cycling infrastructure^{14,21}. This is found in the European contexts as well, where utilizing e-bikes, rather than cars, is prevalent in the U.K and Netherlands²². When interviewing e-bike riders in Sacramento, California, some users were found to have fully adopted their e-bikes instead of their cars²¹. In contrast, Chinese e-bike use was found to have replaced public transit¹².

For leisure trips, research suggests that e-bikes are popular for joyrides with friends, e-mountain biking and longer regional trail trips^{18,21,22,23}. It has also been noted that leisure trips via e-bikes are more common for novice or beginner cyclists. While avid cyclists favour e-bikes when there is limited cycling infrastructure, timid or first-time cyclists prefer to ride their e-bikes where existing cycling infrastructure is in place to support their trip. In multiple studies, research found that complete cycling networks are a key facilitator for increasing adoption of e-bikes^{14,24}.

E-Mountain Biking

A subset of the e-biking community is the e-mountain biking community. As e-bikes are faster and allow for longer trips, more mountain bikers have been adopting the technology to complete advanced routes. However, e-mountain bikers face a unique backlash – not only are they accused of “cheating” or “laziness”, but advocacy groups also claim that they cause trail degradation due to their motorized power.



This is a long-disputed claim in the community, with some reports claiming e-mountain bikes cause no more significant harm to trails than traditional bicycles²⁵. However, other associations claim e-bikes cause significant damage that results in high maintenance costs, which translates into higher fees for trail users²⁶. Furthermore, some mountain bikers, and governments, fear the safety

issues caused by e-mountain bikers for other trail users, such as mountain equestrian riders, and traditional mountain bikers.

Case Study: US Forestry Services e-mountain bike lawsuit

The controversy surrounding e-mountain biking received a spotlight in 2016 when a Seattle woman with a physical disability filed a lawsuit against US Forestry Services claiming that prohibiting e-bikes on mountain bike trails was against Americans with Disabilities Act (ADA) standards. To date, any class of e-bike is considered motorized by the Forestry Services and is not allowed on any trail system. The US Forestry Services upheld this decision in a claim that e-bikes are not designed for disabled or less-able riders and, therefore, cannot be claimed as an accessibility device²⁷.

2.4 Facilitators and barriers to e-bike ridership

Many facilitators and barriers are affecting the global market for e-bikes. Notably, through this review, many e-bike riders refer to convenience as a major advantage to e-bikes^{13,18, 20, 24}. As previously mentioned, the cost per kilometre travelled for e-bikes is cheaper than a car¹⁵, and the capabilities of e-bikes makes them a more comfortable active travel alternative for autocentric conditions^{21,22}. Personal enjoyment is another promoter; some riders found e-bikes make them more confident as cyclists, or they associate e-bikes with more freedom as they can cycle longer with less physical exertion¹⁹.

For those who have limited independence in mobility, the increased quality of life experienced from restored independent mobility is crucially beneficial^{18,28}. Even for able-bodied riders, the ability to cycle rather than drive is occasionally named as a facilitator, as it increases the perceived quality of life¹⁹. Cycling has been long-proven to have positive mental health effects, as opposed to driving which has been associated with negative mental-health effects²⁹.

Similar to the facilitators of e-bikes, there are societal and individual barriers to e-bike adoption. At the societal level, widespread stigma and lack of e-bike education have contributed to public confusion. Moreover, a lack of supportive cycling infrastructure can deter novice e-bikers. Individual barriers can also impact e-bike ridership; e-bikes require a battery and motor, and are commonly heavier than conventional bicycles, which can be inconvenient for riders who may need to lift their bike during travel.

E-bikes also remain significantly more expensive than entry-level conventional bicycles in most markets, and the upfront cost can discourage potential purchasers. The high cost also intensifies the fear of theft. Studies that interviewed e-bike riders found that they would not take their e-bike to a destination unless they were certain they could securely lock the bike upon arrival²⁴.

Finally, as e-bikes operate at a higher speed than traditional bicycles, a common barrier is fear of injury – especially in circumstances where the existing cycling infrastructure does not protect the cyclist from interactions with motor vehicles. The experience and macho view of some people who considered themselves ‘hard core cyclists’ can also be a barrier to e-bike adoption. As discussed, some avid cyclists believe that e-bikes appeal to

less confident or weaker cyclists. As such, for some avid cyclists, e-bikes are commonly associated with “cheating”, as the motor assists in pedalling and reduces the amount of physical exertion required. The belief that e-bikes are not providing any physical activity is a common misconception. A study released in November 2018 confirmed that while e-bikes require less exertion than traditional cycling, they still offer more physical activity than walking, and can result in health benefits³⁰.

Table 2 summarizes key facilitators and barriers to e-bikes.

Table 2 : Facilitators and Barriers

FACILITATORS	BARRIERS
 Replacing cars (utilitarian trips)	 Weight
 Sustainable alternative travel mode	 Cost
 Support lifelong cycling	 Range-Anxiety
 Last-mile travel	 Stigmatization
	 Confusion
	 Lack of exercise

2.5 Looking at the future role of e-bike

The growth of the e-bike market in the past year suggests possible future adoption trends for the coming years. Despite barriers to widespread adoption, in Canada there was record growth of e-bike sales in 2018, with more local bicycle stores stocking e-bikes³¹. In the Netherlands, viewed by many as one of the most advanced bicycle-friendly countries in the world, e-bike sales exceeded conventional bike sales for the first time in 2018 – excluding racing and children’s bikes³². Automotive companies are also leaping at the opportunity to capitalize on this growth. In November 2018, General Motors (GM) released its first BSEB e-bike model³³, ARiV. Electric-bikeshare is also growing in popularity in North America, increasing the public’s awareness of the functionality of e-bikes. In 2018, Lime (the micromobility sharing company, formally known as Lime Bike) began their first e-bikeshare pilot in Calgary, where they reported that over 2,000 residents trialed their e-bikes in the first week³⁴. As more e-bikes join the transportation network, we need to ask how updated legislation, policy and regulations can impact their uptake and usage patterns.

How does
legislation impact

E-Bike

integration?

Exploring the legislative
landscape of e-bikes



3

*The introductory chapters have shown that e-bikes provide a unique and sustainable mobility option to the transportation network. By offering this mobility, e-bikes can be considered a practical and affordable solution to the transportation missing middle – sustainable travel that supports active transportation while remaining accessible to a wider or less mobile population (see more in **Chapter 6**).*

Moving forward, there are multiple opportunities for e-bikes to maximize their potential. The first step, however, will be to establish a supportive governance structure that will set e-bikes up for success.

Although research has painted a generally supportive perspective on e-bikes, the reality of integrating e-bikes is much more complex, and speaks to the larger practicality question surrounding all micromobility. Clear and informed legislation is a key facilitator to leverage e-bikes within a transportation network and promote adoption. However, defining clear and informed legislation for e-bikes and micromobility is difficult, as they are still emerging technologies with differing functionalities and prominence. This chapter reviews the existing legislative frameworks in Canada, the United States, and the European Union to determine how legislation has impacted integration, thus far, and where lessons can be learned to regulate e-bikes and micromobility moving forward, proactively.

3.1 Canadian e-bike Legislation

In Canada, both BSEB and SSEB are defined nationally by Transport Canada, in the Motor Vehicle Safety Regulations³⁵ of the Motor Vehicle

Safety Act, as power-assisted bicycles. Transport Canada enacted the Motor Vehicle Safety Act in 1971, which subsequently lead to the development of the Motor Vehicle Safety Regulations (MVSR)⁹. Power-assisted bicycles have been defined since 2000. Under these regulations, provinces are still responsible for licensing, infrastructure planning and maintenance, and vehicle regulations.

POWER-ASSISTED BICYCLE MEANS A VEHICLE THAT⁴⁵:

- (a) has steering handlebars and is equipped with pedals,
- (b) is designed to travel on not more than three wheels in contact with the ground,
- (c) is capable of being propelled by muscular power,
- (d) has one or more electric motors that have, singly or in combination, the following characteristics:
 - (i) it has a total continuous power output rating, measured at the shaft of each motor, of 500 W or less,
 - (ii) if it is engaged by the use of muscular power, power assistance immediately ceases when the muscular power ceases,
 - (iii) if it is engaged by the use of an accelerator controller, power assistance immediately ceases when the brakes are applied, and
 - (iv) it is incapable of providing further assistance when the bicycle attains a speed of 32 km/h on level ground,
- (e) bears a label that is permanently affixed by the manufacturer and appears in a conspicuous location stating, in both official languages, that the vehicle is a power-assisted bicycle as defined in this subsection, and
- (f) has one of the following safety features,
 - (i) an enabling mechanism to turn the electric motor on and off that is separate from the accelerator controller and fitted in such a manner that it is operable by the driver, or
 - (ii) a mechanism that prevents the motor from being engaged before the bicycle attains a speed of 3 km/h.

All subsequent provincial regulation must adhere to the specifications of this definition. Therefore, in Canada, all e-bike typologies (bicycle-style and scooter style) are legally classified as a bicycle, and all types of e-bikes are interchangeable as the definition regulates both pedal-assist and throttle-assist e-bikes.

Although this legislation is federal, provinces still have the autonomy to require licensing, define the vehicle, and request additional requirements such as helmets or age-restrictions. In a few provinces, additional regulations distinguish helmet types, licence and registration requirements, weight, etc. **Table 3** shows a comparison of different provincial e-bike regulation frameworks.

It is important to note that at the time of publishing, the Canadian government is proposing to deregulate power-assisted bicycles so that federal legislation will no longer regulate

e-bikes, thereby excluding them from any prescribed class. If this amendment were to be adopted, the MVSR would no longer define Power Assisted Bicycles. The objective of this amendment is to harmonize Canadian e-bike vehicle regulations to the United States and reduce trade barriers. With this change, many types of “micromobility”, including e-bikes, e-scooters and low-speed vehicles, would not be subject to federal regulation, and instead would be subject to the provincial or territorial jurisdictions. As such, provinces and territories would have the freedom to decide whether or not to permit the use of these vehicles in their jurisdictions. This change was proposed in May 2018³⁶.

A quick note on e-scooters :

Currently, e-scooters are illegal on public roads in Canada. However, in some cities pilots are underway to explore their potential in the transportation network.



Table 3 : Provincial Review of e-bike regulations

Province	Defined Terminology	Differentiates between pedelecs and scooter-style e-bikes	Age	Maximum Speed	Maximum Power	Licensing	Additional Requirements
British Columbia	Electric Motor Assisted Cycle (MAC)	No	16+	32 km/h	500 watts	No Licensing or Registration	Helmet required
Alberta	Power bicycles	No	12+	32 km/h	500 watts	No Licensing or Registration	Motorcycle Helmet, headlamp, tail lamp, brake lamp, reflectors, brakes, a horn & mirror
Saskatchewan	Power assisted bicycle Can also be classified as a moped or mobility scooter based on its speed	Yes: Electric assist bicycles are two or three wheeled bicycles that uses pedal and motor at the same time Power cycle: uses either pedals and motor or motor only	16+ for power cycles No requirement for electric assist	32 km/h	500 watts	Learner's drivers license required for power cycles	Helmets required for both types
Manitoba		No	14+	32 km/h	500 watts	No Licensing or Registration	
Ontario	Power assisted bicycle	No	16+	32 km/h	500 watts	No Licensing or Registration	Headlight required Maximum weight 120Kg
Quebec	Power assisted bicycle	No	14+	32 km/h	500 watts	From Age 14-17: Class 6D Moped or Scooter License required From 18+: No License required No Registration required	
New Brunswick	Power assisted bicycle	No	n/a	32 km/h	500 watts	No Licensing or Registration	Headlight required at night Required rims larger than 22cm & a seat at least 68cm off the ground
Nova Scotia	Power assisted bicycle	No	n/a	32 km/h	500 watts	No Licensing or Registration	Helmet required with chinstrap engaged
Prince Edward Island	Motor Assisted Pedal Bicycles	Classifies all e-bikes as mopeds	16+	32 km/h	500 watts	Licensing & Registration required	
Newfoundland and Labrador	No Provincial Legislation. Follows Federal Definition Per Transport Canada definition						
Territories	No Provincial Legislation. Follows Federal Definition Per Transport Canada definition						

Information from Table 3 was retrieved from: Pedego Bikes. (2019). Are Electric-Bicycles Illegal in Canada? <https://pedegoelectricbikes.ca/are-electric-bikes-legal-in-canada/>

3.2 Reviewing examples of international e-bike legislation

Internationally, the existing landscape of e-bike legislative frameworks has permitted a myriad of different rules, policies, regulations, and definitions that

dictate the operation of e-bikes around the world. What is considered an e-bike in Europe is not the same in Canada, which is not the same e-bike in the United States. This results in difficulty defining e-bikes consistently, with varying bicycle vs. motorcycle/moped classifications, maximum speed regulations, and permitted vs.

prohibited trails and cycling infrastructure. Essentially, each region's e-bike framework is unique to the location. Below, we have introduced a review of these nuances to form a global look at e-bike integration. However, policies and regulations for the micromobility sector are rapidly evolving and adapting to a changing transportation landscape. The findings of this review are subject to change as new legislation and regulation develop.

3.2.1 The European Union e-bike legislation

In Europe, the European Union directive 168/2013 provides an overarching definition of e-bikes³⁷. The current legislation (enacted in 2017) is an updated replacement of the original, which was enacted in 2002. The legislation is known as "Type-Approval" and provides both manufacturing and operational regulatory requirements. Many of these regulations align with the United Nations Economic Commission for Europe regulations to promote global cohesion. E-bikes are defined under the L1e vehicle category, fitting into the two subcategories of "powered cycles" and "mopeds". Other forms of micromobility are also categorized through Type-Approval and are included for the context of this review.

Once again, it is important to define the semantics surrounding e-bikes. Unlike in North America, where e-bike refers to pedal-assist, throttle assist, BSEB and SSEB types, in the EU pedelec is used to define pedal-assist electric bicycles, and e-bike refers to throttle-assist electric bicycles³⁷. Pedelecs, being any pedal-assist e-bike that has a maximum power of 250 watts and a maximum speed of 25km/h, are an exception Type-Approval and are legally classified and regulated as bicycles. In contrast, e-bikes are subject to Type-Approval. To

give a brief overview of the relationship of the different Type-Approval categories, we compare e-bikes and other micromobility modes in **Table 4**. One of the notable changes of the new legislation was the addition of the powered cycle category for e-bikes with a speed limit of 25 km/h, but with higher power.

A quick note on e-scooters :

E-scooters are not explicitly placed in one of the Type- approval categories. Instead, they are regulated as Personal Light Weight Electric Vehicles (PLEV). However, not all countries adopt PLEV regulation and as such, e-scooters are permitted in some EU countries and banned in others.



Table 4 : Micromobility Type-Approval






TYPE	REGULATIONS	TYPICAL APPEARANCE
<p>Pedelecs – not subject To type-approval</p>	<p>Max. Power : <250W Max. Speed : 25 Km/h Pedal assistance only</p>	
<p>Powered Cycles – L1e-A</p>	<p>Max. Power : >250W - <1 kW Max. Speed : 25 Km/h Pedal assistance+Motor only</p>	
<p>Mopeds – L1e-B</p>	<p>Max. Power : <4kW Max. Speed : 45 Km/h Pedal assistance+Motor only</p> <p>Note: an s-pedelec is defined under this Type-Approval Category</p>	
<p>Three-wheeled mopeds – L2e</p>	<p>Max. Power : <4kW Max. Speed : 45 Km/h Pedal assistance+Motor only Max. Mass : <270 Kg Max. 2 persons</p>	
<p>Light Quadricycles – L6e</p>	<p>Max. Speed : 45 Km/h Pedal assistance+Motor only Max. Mass : <450 Kg Max. 2 persons</p>	

image sources in the reference page

3.2.2 American e-bike legislation

In the United States, e-bikes are known by federal regulation as Low-Speed Electric Bicycles⁹. They are defined as:

A two- or three-wheeled vehicle with fully operable pedals and an electric motor of fewer than 750 watts (1 h.p.), whose maximum speed on a paved level surface, when powered solely by such a motor while ridden by an operator who weighs 170 pounds, is less than 20 mph.

This definition is provided by the Consumer Product Safety Act (CPSA) legislation for the manufacturing and first sale of consumer products. This definition does not affect licensing and use of consumer products – in this case, e-bikes¹⁸.

Like Canada, the American CPSA federal regulation also distinguishes low-speed electric bicycles from motor vehicles.

“For the purposes of motor vehicle safety standards [...], a low-speed electric bicycle [as defined above] shall not be considered a motor vehicle [per 49 U.S.C. § 30102(a)(6)].”

The National Highway Transportation Safety Administration also aligns with the CPSA definition, and does not

consider e-bikes (Low-Speed Electric Bicycles) motor vehicles. This defers the authority of regulation from the National Highway Transportation Safety Administration (NHTS) back to the CPSA. All other legislative powers surrounding the operation and use of e-bikes are left to state and local municipality jurisdiction.

A quick note on e-scooters:

Just as e-bike laws vary from state to state, the same is true for e-scooters. However, unlike Canada, there are many e-bikesharing systems in a multitude of American cities³⁸.

3.2.3 Bicycle product suppliers association three-tier e-bike classification model for the united states

An important difference to note between American and Canadian e-bike legislation is the applicability of the federal legislation to the state/provincial-level regulation. In Canada, the federal legislation is mandated through the Motor Vehicle Safety Regulations and acts as the overarching definition to which the provincial definitions must comply. While provinces can further legislate, their

Figure 3 : E-scooter share programs in the U.S.

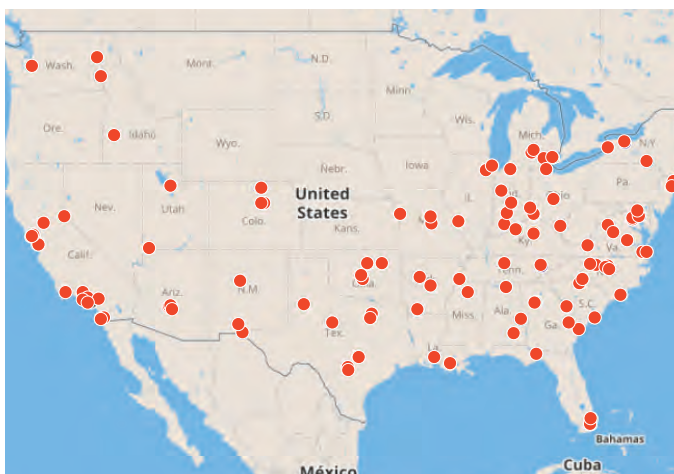
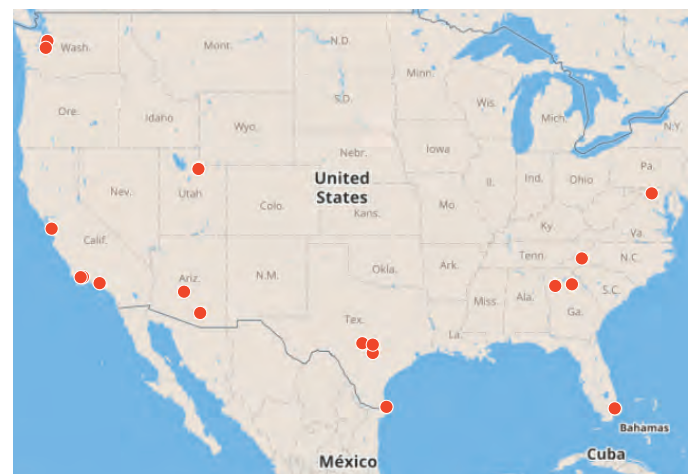


Figure 4 : U.S. cities where e-scooters are banned



regulations must still comply with the standards of the power-assisted bicycle. In the U.S., the federal legislation only regulates the manufacturing and first sale of e-bikes, not their use or operation in any of the states. As a result, many states have different regulations and considerations of e-bikes. Consequently, the culture surrounding e-bikes in America also varies from state to state.

As e-bikes gain popularity in the emerging market, some states are moving towards more progressive e-bike legislation, which delineates between the different types of e-bikes available, developed at the state-level by the Bicycle Products Suppliers Association, with support from the People for Bikes Coalition³⁹. California was the first state to adopt this model, with several other states following this precedent. Today, 13 states operate with this three-tier model⁴⁴. This model mirrors the delineation in the European model, although all e-bikes regulated, including s-pedelecs and scooter-style e-bikes, are still considered bicycles.

The new legislation identifies specifications for “Class 1”, “Class 2” and “Class 3” e-bikes, shown below

A “class 1 electric bicycle” is a bicycle equipped with a motor that provides assistance only when the rider is pedalling, and that ceases to provide assistance when the bicycle reaches the speed of 20 miles (32 km) per hour.

A “class 2 electric bicycle” is a bicycle equipped with a motor that may be used exclusively to propel the bicycle, and that is not capable of providing assistance when the bicycle reaches the speed of 20 miles (32 km) per hour.

A “class 3 electric bicycle” is a bicycle equipped with a motor that provides assistance only when the rider is pedalling, and that ceases to provide assistance when the bicycle reaches the speed of 28 miles (45 km) per hour and is equipped with a speedometer.



What lessons can
be learned from current
E-Bike
regulation?



Upon completing the legislative review, it is evident there are key questions surrounding e-bike legislation and operations. The discussions surrounding these questions could inform how legislation is developed, and the success in regulating e-bikes. We identified the following questions as the most important to informing the direction of future legislation in Canada.

How fast should an e-bike go?

Why it is important? : speed is a key indicator of safety, and can help to manage the types of mode-interactions and conflicts we experience in on-road and off-road cycling infrastructure.

Which e-bikes should be defined as bicycles?

Why it is important? : when e-bikes are defined as bicycles, they do not require licensing or registration, and have the same infrastructure permissions as bicycles. Depending on their functionality, which varies across the different typologies, this can cause potential safety and usage concerns.

What vehicle features can be used to regulate e-bikes?

Why it is important? : beyond speed, there are many different vehicle characteristics and uses that can affect how an e-bike operates. It is important to understand how these different features impact the operation of e-bikes.

How should the regulations be communicated?

Why it is important? : communicating the regulations is paramount to ensuring riders comply with the rules of the road when interacting with the transportation network and other transportation modes — clear and easily understandable educational materials are most effective in completing this.

We discuss each of these questions below. Our commentary is not meant to provide definitive answers. Instead, it is

intended to help inform the ongoing conversation surrounding each of these questions in Canada.

4.1 How fast should an e-bike go?

One of the biggest differences noted in the legislation review is the speed restriction placed on European operated e-bikes. Through the EU legislation, pedelec e-bikes (e-bikes with motors that cannot operate without pedal-assistance) cannot exceed 25 km/h. This is similar in China and Australia^{12,40}. In North America, e-bikes have a maximum speed limit of 32 km/h for all pedelecs and throttle-assisted e-bikes. Normally, even BSEB models will still have a throttle-assist feature, which permits the rider to accelerate even when not pedalling. In the EU and Australia, these types of e-bikes are regulated differently and are normally not considered bicycles.

Beyond speed, the power capabilities of e-bikes in different regions are also very location-specific. In the EU, pedelecs have a maximum power output of 250 watts. Comparatively, in Canada the maximum power output is 500 watts, and in the U.S. 750 watts. When comparing watts to mechanical horsepower, EU pedelec e-bikes operate at a level of 0.3 hp, Canadian e-bikes operate at 0.7 hp, and American e-bikes operate at 1 hp. Moreover, the American standard of 750 watts and 32 km/h is not universal throughout all states. The federal definition is not entirely prescriptive, and allows for some differences in definitions regarding both speed and power.

From a regulatory standpoint, the lower power output and 25 km/h speed limit are more comparable to the average speed of a cyclist. However, there has been pushback from the e-biking

community. In the EU and Australia, some riders are lobbying for an increase in maximum speed, as some cyclists can surpass 25 km/h without pedal-assistance, causing maximum pedelecs to be less appealing than a conventional bicycle⁴¹.

In the U.S., the University of Tennessee completed a study on perceived and achieved speeds of e-bikes. Although the speed limit is higher in North America, it is interesting to note that, when only using pedal-assist, riders were observed to operate their e-bikes at a comparable speed to conventional cyclists – even with a 32 km/h maximum speed. The average speed of an e-bike rider is 13.3 km/h, and a cyclist is 10.7 km/h⁴². For e-bikes that use the throttle or operate the motor independently from pedalling, the average speed would likely be higher.

4.2 Which e-bikes should be defined as bicycles?

The comparison of e-bikes to bicycles raises an important question of when e-bikes should be considered bicycles. As simple as the question may seem, the answer is not straightforward. Due to the many differences in governance between jurisdictions, e-bikes of all types straddle the line between motor vehicle, motorcycle and bicycle. In North America, we tend to be either permissive or prohibitive, in that many (if not all) types of e-bikes are bicycles or are classified as motor vehicles without a licensing system, and are banned entirely⁴³. Furthermore, the indicators that are used to determine whether or not to classify e-bikes as bicycles are also inconsistent. Some jurisdictions opt for speed, whereas others include power, weight, wheel-diameter, pedal style, etc.

Table 5 : Defining when e-bikes are bicycles

Is this a bicycle in...	European Union	Canada	U.S. (Bicycle Product Suppliers Association definitions)
Pedelec (25 km/h or 32 km/h)	Yes	Yes	Yes
Throttle-assisted pedal-assist bicycle	No	Yes	Yes
S-Pedelec (45 km/h)	No	No (not considered a power-assisted bicycle if operating over 32 km/hr)	Yes (with regulations)
Scooter-style e-bike	No	Yes	Yes

Case Study: German Approach to Defining E-bikes as Bicycle

Germany regulates its e-bike framework through these three categories: pedelec, s-pedelec and e-bike. Each type has specific regulations that determine their licensing and permissions^{44,45}. See **Table 6** below:

Table 6 : Germany e-bike regulations

	Pedelec	S-Pedelec	E-Bike
How the motor runs	Supportive to the driver's pedalling, up to 25 km/hr. Some models are permitted a maximum of 6 km/hr motor power without pedalling.	Supportive to the driver's pedalling up to 45 km/hr.	Independent from pedalling, up to 25 km/hr.
Legal Classification	Bicycle	Motorcycle	Motorcycle
Other Regulations	None Required	Klasse AM: Bicycles & four-wheeled lightweight vehicles with a design-orientated maximum speed of not more than 45 km/hr & a nominal continuous output of up to 4 kW electric motors.	Certificate test for motorbikes
Where it can be driven	Anywhere standard bicycles are allowed	Must be driven on the road	Must always stay in the drive lane. They can drive in bike trails if signage permits

A key takeaway from this table is the legal classification row. Unlike in North America, Germany does not classify higher-power e-bikes as bicycles. This separation allows for incentives and direction for pedelecs that would otherwise be unclear. In the U.S., some states have adopted a tiered system; however, in these systems the base speed is still 32 km/h, as opposed to the 25 km/h in Germany. Moreover, all tiers are still considered bicycles in the U.S.

Even the throttle feature can determine if an e-bike should be considered a bicycle. In Germany, any bike that has a throttle, which would permit the rider to accelerate without pedalling, is not a bicycle. Only pedelecs, where the motor cannot run without pedal-assistance, are considered bicycles. In some cases, pedelecs are permitted to have a

start-up aid, which allows the rider to accelerate the motor up to 6 km/h without pedalling. This feature helps e-bike riders start from a stopped position, given that e-bikes are often heavier than traditional bicycles and starting without any motor assistance can be challenging.

The safety concerns of the throttle are notable in comparison to pedal-assist models, given the increased speed capabilities. In North America, most BSEB models sold include the throttle feature, which throughout many EU countries would render them motorcycles. Given that throttles make pedelecs legally motorcycles in Germany, pedelecs are much more popular than the s-pedelec or e-bike categories. In Germany, one in every thirty cyclists rides a pedelec⁴⁴.

Scooter-Style E-bikes as Bicycles

In the United States, a survey completed in 2014 by the League of American Cyclists asked 246 participants to define which e-bike type they considered a bicycle⁴⁶. The responses showed that of the eight e-bike types that were surveyed, only four were considered a bicycle by the majority: the pedelec BSEB, throttle-assist BSEB, s-pedelec, and throttle-assist folding BSEB. These findings speak to the important role appearance plays in public perception. The scooter-style e-bikes had the same specifications as the throttle-assist BSEB (aside from weight), however, 72% of participants were certain that an SSEB should not be considered a bicycle⁴⁶.

In Canada and the United States, our definitions regulate the SSEB as a bicycle, and the ambiguity of SSEB models on the existing transportation infrastructure is one of the conflicts observed with e-bikes – both in research and in practice. When referring to the three-tiered approach, SSEBs have the same operating functionality as Class 2 (throttle-assist) e-bikes, and can be legally ridden in bike lanes without requiring any additional licensing or registration for operation. However, SSEBs are wider, heavier and more obtrusive than bicycles/BSEBs on the existing bike lanes, and have contributed to animosity in conversations about e-bikes and their emerging role.

The difficulty of regulating SSEBs is that since they technically operate within the specifications of the power-assisted bicycle in Canada, the definition that permits throttle-assisted BSEBs also permits SSEBs due to their manufactured, albeit rarely-used, bicycle pedals.

4.3 What features can be used to regulate e-bikes?

Up to this point in e-bike regulation, speed has been the most useful regulatory tool. However, the confusion surrounding e-bike regulation suggests that although it is the most commonly used regulator of e-bikes, speed is still relative to the user and is not exclusively reliable to regulate the functionality of e-bikes. Throughout the different jurisdictions previously explored – Canada, U.S., and EU – additional regulations are used to further define the functionality and operational requirements of e-bikes.

AGE

As shown in the provincial review, many Canadian provinces are utilizing age restrictions to regulate e-bikes. Similarly, the Bicycle Product Suppliers Association classification model places an age restriction on 45 km/h e-bikes. Normally, the minimum age for an e-bike rider is 16, although there is some variation depending on the jurisdiction.

Why consider age?

Requiring a minimum age can help increase the safety of riders by restricting use by children. However, it can also limit the usage potential and inclusivity of micromobility, depending on the expected ridership of the jurisdiction. The applicability of age requirements should be explored contextually.

HELMET REQUIREMENT

Depending on jurisdiction, a helmet requirement is optional. Some municipalities/regions require bicycle helmets, while others require motorcycle helmets for faster e-bike models. The province of Ontario requires e-bike riders to wear helmets.

Why consider helmet requirement?

Helmets are a proven safety feature that can reduce the severity of injury during a collision, according to the medical field. Support for a helmet requirement can be cross-compared to other considerations of e-bike riders – including speed, age, and presence of a throttle-assist.

MOTOR CESSATION

The EU, Canada and the United States currently use the requirement for the motor to cease operating once the user stops pedalling or the brakes are applied.

Bicycle Product Suppliers Association model legislation section on motor cessation: Section 206 – motor disengagement: An electric bicycle shall operate in a manner so that the electric motor is disengaged or ceases to function when the rider stops pedalling or when the brakes are applied³².

Why consider motor cessation?

The pedal-assist motor cessation requirement creates a clear difference between its capabilities and the throttle-assist capabilities. For the pedal-assist models, the motor will cease when pedalling ceases. However, for those that operate with the throttle-assist feature, the motor will only cease when the brakes are applied. The difference in motor capability creates a wide range of speed capacity between pedal-assist and throttle-assist.

THROTTLE-ASSIST

In North America, many throttle-assist e-bikes, being any e-bike model outfitted with a throttle that allows the rider to propel the bike solely using motor power and without any pedal assistance, are still regulated as bicycles. In Europe, very few e-bike models that have the throttle functionality are considered bicycles. Once the bike can propel itself without human power, it becomes

subject to further licensing and operational requirements.

Why consider the throttle-assist?

The regulation stance toward e-bike throttles is one of the biggest differences between North American and European approaches. In Europe, throttles create a separate category of regulation; in North America, we consider throttle-style e-bikes as bicycles, even when placed in a tiered system. The throttle can be associated with the difference in achieved-speed between the different e-bike typologies.

WEIGHT

Weight is a key indicator in the transportation sector. For e-bikes, weight can distinguish between BSEB and SSEB typologies.

Why consider weight?

In addition to the throttle, weight can distinguish between the SSEB models, which are generally heavier, and the BSEBs. When including weight as an identifying characteristic, certain heavier e-bike models can be restricted from certain infrastructure types. However, including a weight restriction can also impede e-bike cargo trips.

SPEEDOMETER REQUIREMENT

Many jurisdictions require that any legal e-bike is outfitted with a speedometer to ensure the rider is aware of their speed³².

Why consider the speedometer?

The speedometer increases accountability and transparency for e-bike riders. When a speedometer is required, jurisdictions can also implement posted-speed requirements other than the manufacturer's maximum speed.

LICENCE AND REGISTRATION

As discussed in previous sections, both provinces and states in North America can request licensing of e-bikes.

Currently, very few states and provinces have introduced legislation mandating the licensing or registration of e-bikes. In some of the European legislative frameworks, licensing is required for “motorcycle” defined e-bikes – this includes both s-pedelects and throttle-assisted e-bikes.

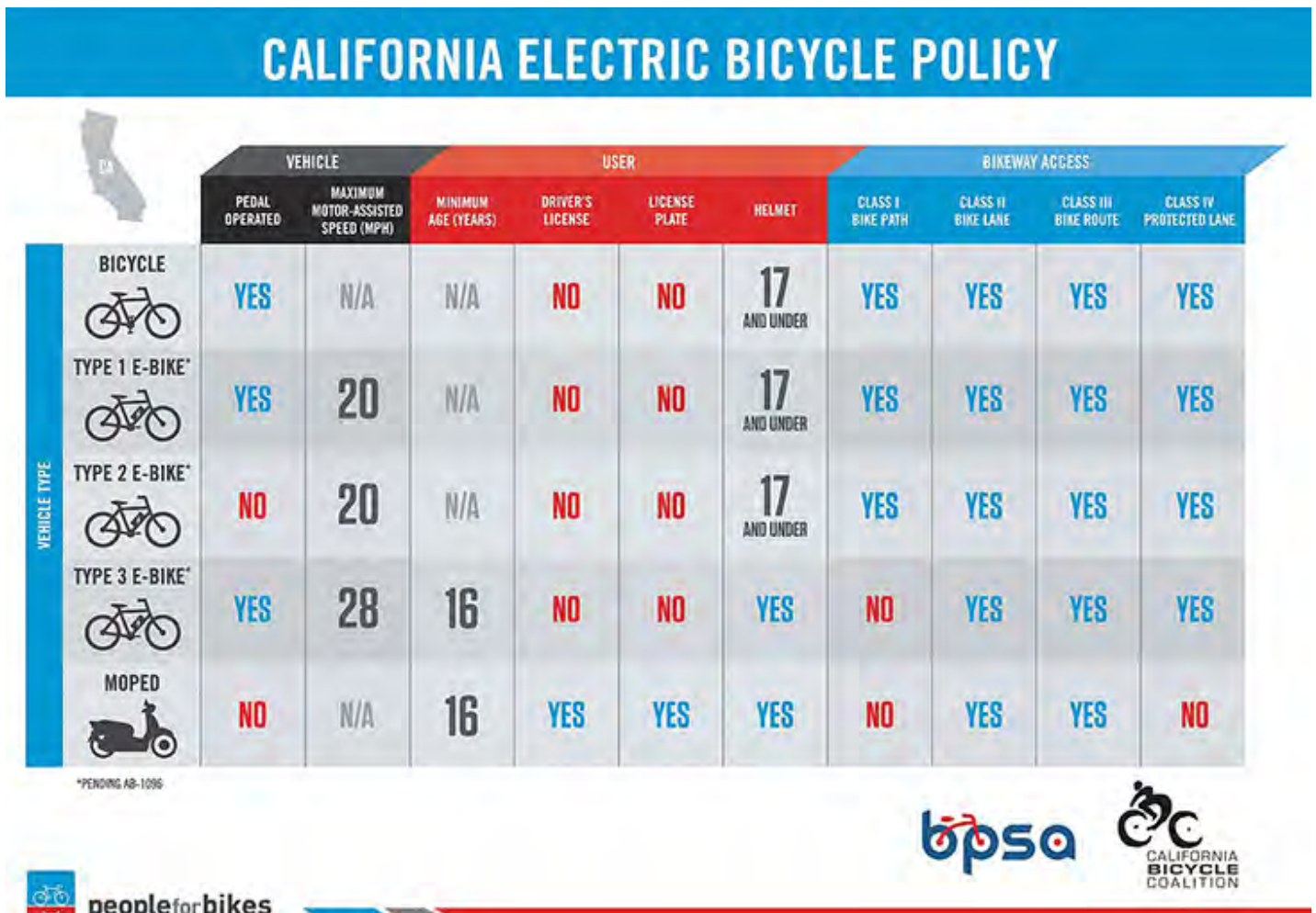
Why consider licensing and registration?

When delineating between multiple micromobility types, licensing and registration are a helpful tool to inform a gradient of operation. If a model requires a license and registration, they can be more strenuously regulated and monitored. Moreover, the licensing process inherently teaches and tests riders on the proper rules of the road.

4.4 How should the regulations be communicated?

Widespread education about e-bike functionality is another key lesson from the EU. In Germany, pamphlets are available that describe the different typologies of e-bikes, and each e-bike is easily identifiable and communicated as one of the types. As a by-product of this education, any e-bike purchaser is confident of the permissions and prohibitions of their e-bike model. The Bicycle Product Suppliers Association definition also looks to create this same inherent public knowledge. (Figure 5)

Figure 5 : Sample e-bike educational pamphlet from California



The image shows a sample e-bike educational pamphlet from California. It features a title 'CALIFORNIA ELECTRIC BICYCLE POLICY' and a table detailing regulations for different vehicle types. The table is organized into three main sections: VEHICLE, USER, and BIKEWAY ACCESS. The VEHICLE section includes Pedal Operated, Maximum Motor-Assisted Speed (MPH), and Minimum Age (Years). The USER section includes Driver's License, License Plate, and Helmet. The BIKEWAY ACCESS section includes Class I Bike Path, Class II Bike Lane, Class III Bike Route, and Class IV Protected Lane. The table lists regulations for Bicycle, Type 1 E-Bike, Type 2 E-Bike, Type 3 E-Bike, and Moped. A small map of California is in the top left corner. Logos for bpsa and California Bicycle Coalition are in the bottom right. The peopleforbikes logo is in the bottom left.

VEHICLE TYPE	VEHICLE		USER				BIKEWAY ACCESS			
	PEDAL OPERATED	MAXIMUM MOTOR-ASSISTED SPEED (MPH)	MINIMUM AGE (YEARS)	DRIVER'S LICENSE	LICENSE PLATE	HELMET	CLASS I BIKE PATH	CLASS II BIKE LANE	CLASS III BIKE ROUTE	CLASS IV PROTECTED LANE
BICYCLE	YES	N/A	N/A	NO	NO	17 AND UNDER	YES	YES	YES	YES
TYPE 1 E-BIKE*	YES	20	N/A	NO	NO	17 AND UNDER	YES	YES	YES	YES
TYPE 2 E-BIKE*	NO	20	N/A	NO	NO	17 AND UNDER	YES	YES	YES	YES
TYPE 3 E-BIKE*	YES	28	16	NO	NO	YES	NO	YES	YES	YES
MOPED	NO	N/A	16	YES	YES	YES	NO	YES	YES	NO

*PENDING AB-1096

4.5 The impact of unanswered questions on public perception of e-bikes in Canada

Although Canada has an existing definition for e-bikes, there remains ambiguity. Many of the above questions remain unanswered, and the lack of clarity surrounding Canadian e-bike legislation that filters from the federal to municipal regulation is impactful on the public perception of e-bikes. There is strong evidence to suggest that confusion regarding where e-bikes are allowed is widespread, and is directly impacting trends in adoption and usage. Inconsistencies in existing legislation may be contributing to the confusion. In addition to this, existing legislation may not fully capture and respond to safety concerns associated with e-bike users and other transportation network users. Safety concerns manifest into hostility surrounding shared infrastructure, shared trails and illegal driving behaviour. There is significant scope to address these issues through legislative reform in Canada.



How do
Practitioners perceive
Micromobility?



Given the current landscape of legislation and perceptions surrounding micromobility in Canada, we engaged with stakeholders and municipal representatives as part of this research to understand how this landscape is impacting key regulators and advocates in Ontario. The comprehensive survey contained over 50 questions regarding sustainable mobility, new mobility, e-bikes, e-scooters and existing e-bike and e-scooter legislation. The survey was primarily distributed via Share the Road Cycling Coalition to the Association of Municipal Administrators from February 21st, 2019 to March 18th, 2019. We also shared the survey via WSP Canada's LinkedIn profile and on Twitter by WSP employees.

5.1 Results

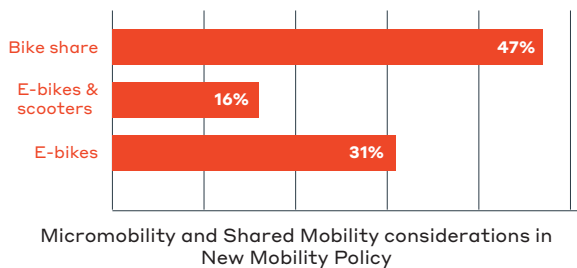
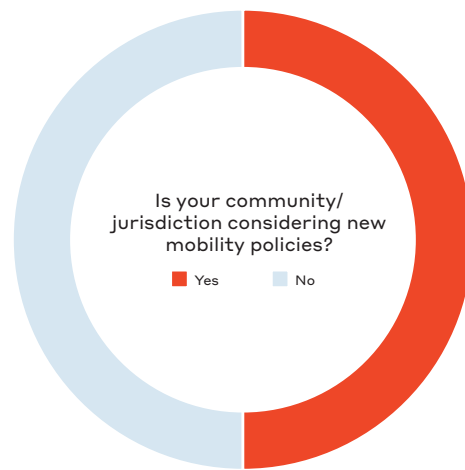
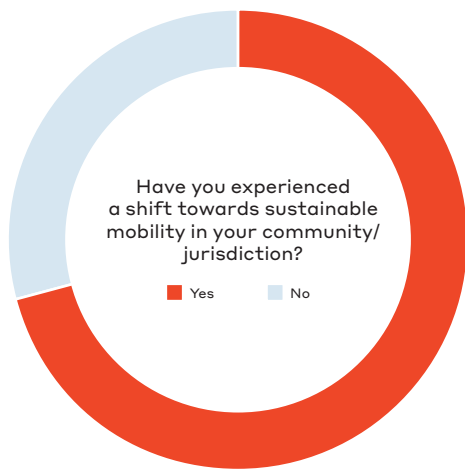
In total, approximately 40 participants completed the survey; 58% identified as a municipal representative and 42% identified as a stakeholder – including business analysts, advocates, student researchers and citizens. Participants were from municipalities across Canada. Primarily, respondents were from jurisdictions within the Greater Golden Horseshoe (GGH).

The purpose of this survey was to engage with practitioners about how micromobility is changing in their communities, focusing on sustainable and new mobility perspectives. Approximately 71% of respondents indicated that they had observed a shift towards sustainable mobility in their community. However, we received a range of justifications as to why this shift is occurring.

Environmental awareness and different mobility options were the most common rationale, while others felt that the cost of car ownership, the preferences of the younger generation, traffic, better cycling infrastructure, and resident demand for sustainability were also key factors in affecting a larger shift to sustainable mobility. When discussing new mobility, we asked our participants if they were aware of any new mobility considerations in their transportation planning documents. Of the 77% that were aware of their current transportation policy, 50% had some form new mobility policy, and 50% did not. Moreover, only 31% of the policies considered e-bikes, and another 16% considered both e-bikes and e-scooters. In comparison, 47% considered bikeshare.

Figure 6 : Map of practitioners surveyed





5.1.1 Comparing micromobility modes

To better understand the perception of different types of micromobility by policy makers and key stakeholders, we showed our participants three modes of micromobility and asked them if they perceived each mode as sustainable transportation or active travel, and the types of transportation infrastructure where they should be permitted. A bicycle-style e-bike, scooter-style e-bike, and e-scooter were compared. Photos of each type were shown to ensure clarity between the types. Questions that referred to the

scooter-style e-bike used “moped-style e-bike” to reduce potential mix-up with the e-scooters (*Table 7*).

Sustainable Mobility: 96% of respondents felt that a bicycle-style e-bike is a form of sustainable mobility. In comparison, 86% felt that a scooter-style e-bike is a form of sustainable mobility. As for e-scooters, 75% felt they represent sustainable mobility.

Active Travel: 92% of respondents indicated that a bicycle-style e-bike is a form of active travel. The scooter-style e-bike and e-scooter had mixed reactions when asked if they could be considered active modes of transportation, unlike sustainable mobility, where each mode was more likely to be perceived as sustainable than not. For the scooter-style e-bike, over 78% of participants felt it was not a form of active travel. As for the e-scooter, reactions were split: 54% felt that an e-scooter is an active form of travel, whereas 46% did not.

Figure 7

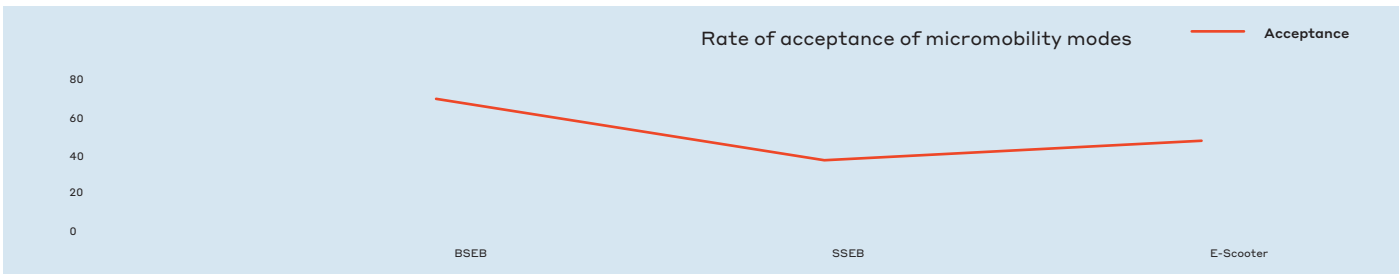


Table 7: Comparing micromobility modes

■ AGREE
■ SOMEWHAT AGREE
■ DISAGREE



SUSTAINABLE?	96%	86%	75%
ACTIVE?	92%	22%	54%
SIDEWALKS?	11%	0%	19%
BIKE LANES?	96%	66%	57%
MULTI-USE PATHS?	82%	15%	81%
OFF-ROAD TRAILS?	68%	15%	62%
ON-ROAD?	75%	93%	12%
SPEED CONCERNS?	14%	60%	14%



The next part of the questionnaire asked participants to rank the types of infrastructure where they felt e-bikes and e-scooters should be permitted. For each mode, participants could choose any of the following infrastructure types: multi-use paths on the boulevard of a roadway, sidewalks, bicycle lanes, the road in mixed traffic, and off-road trails in parks and green spaces. Just as each type had a mixed reaction to their sustainability and activity, each micromobility type also had a unique array of responses regarding where they should be permitted.

Overall, most of the participants supported permitting bicycle-style e-bikes on bicycle lanes (96%), multi-use paths on the boulevard of a roadway (82%), the road in mixed traffic (75%), and on off-road trails in parks and green spaces (68%). The only non-preferred infrastructure type was sidewalk (11%).

For scooter-style e-bikes, most participants felt they were best suited on the road in mixed traffic (93%) or in

bicycle lanes (66%). Fewer participants supported scooter-style e-bikes for multi-use paths on the boulevard of a roadway or on off-road trails in parks or green spaces (both at 15%). Interestingly, 0% of the participants felt they should be allowed on sidewalks.

E-scooters were more likely to be preferred on off-road infrastructure or on-road bike lanes rather than in mixed traffic, with 81% of respondents seeing them as suitable for multi-use paths on the boulevard of a roadway, and 62% perceiving them as suitable for off-road trails in parks or green spaces. Also, 57% were in favour of bicycle lanes. Of all the types, e-scooters received the highest approval to be on the sidewalk, with 19% of respondents seeing them as suitable. Only 12% felt they should be allowed on the road in mixed traffic.

We also asked participants if they had ever received speed-related complaints - a common concern with micromobility - for any of the types above. We found that although some participants

received complaints regarding bicycle-style e-bikes and e-scooters (both 14%), most respondents experienced complaints regarding scooter-style e-bikes (60%).

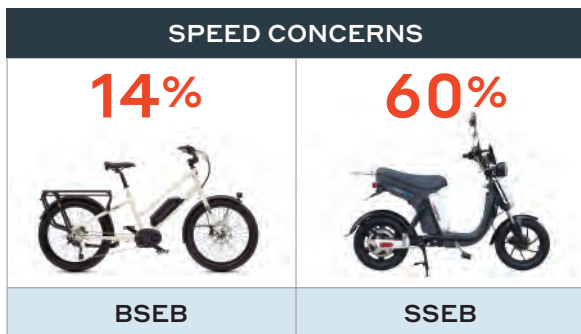


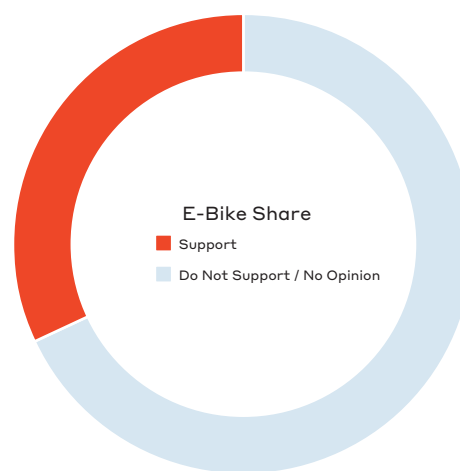
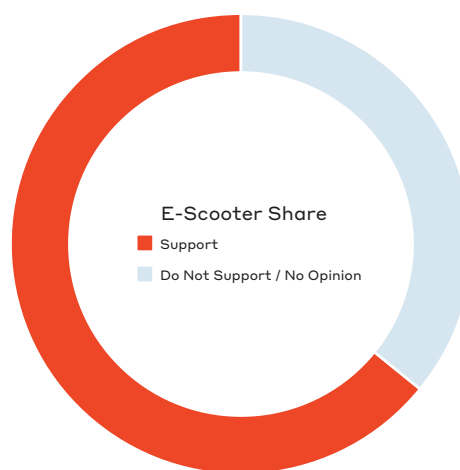
Table 7 graphically displays the responses on a coloured scale⁴⁷ to show the relationship of the responses to each mode – with red being disagree and green being agree.

5.1.2 Micromobility and shared mobility

Understanding how micromobility interacts and overlaps with shared mobility was another objective of the survey. We found that 48% of the jurisdictions surveyed have either implemented or are planning to implement a bikeshare program. For the most part, the increased cycling culture was the greatest benefit. Also, both first-last mile travel and transit integration were nearly equally as important, along with tourism promotion, reduced car dependency, and affordability. In terms of challenges, the most commonly observed barrier was the lack of cycling culture or low demand for bikeshare. Other participants also indicated the implementation and maintenance costs as the other most common barriers.

Bikeshare is implementable as either docked, dockless or hybrid. Docked bikeshare utilizes permanent stations, whereas dockless bikeshare accesses

the bikes via a mobile GPS, and hybrid systems are accessed via a mobile GPS but are picked up and returned to designated areas. According to our findings, docked are still the most common bikeshare model (24%), but dockless and hybrid are quickly becoming more common (both 16%). For e-bikeshare, participants noted external concerns that are not associated with traditional bikeshare. Since riders can travel further on e-bikes than traditional bicycles, many participants responded to the increased



liability issues that could arise. Others commented on the public opposition to e-bikes. The most common barrier, however, was the additional cost and maintenance associated with charging the battery.

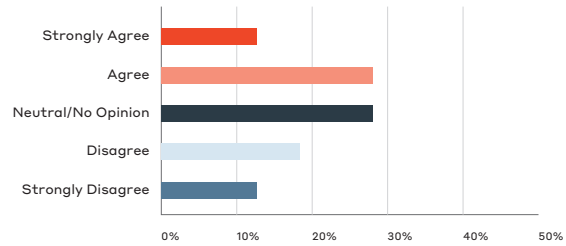
Despite these additional challenges, no participant directly opposed e-bikeshare in their community. Specifically, 40% of participants somewhat supported e-bikeshare in their community, while another 28% strongly supported. The remaining 32% had no opinion.

In comparison to e-bikeshare, e-scooter share had a predominantly neutral or negative reaction. Only 32% somewhat supported, 32% had no opinion and 24% did not support. Also, the participants noted that there were multiple unique challenges and opportunities associated with implementing an e-scooter share system. Firstly, practitioners perceived e-scooter share as more recreational than utilitarian, which reduces its effectiveness as a transportation mode. Others cited public opposition as a challenge, as well as “scooter-littering” – when scooters are discarded along the sidewalks and in the public realm. However, the largest barrier was the general lack of knowledge on how to regulate the new technology; many felt there wasn’t enough supportive infrastructure, while others felt that there was little regulation for e-scooter companies that operate the programs and the users.

5.1.3 Opinions on existing legislation

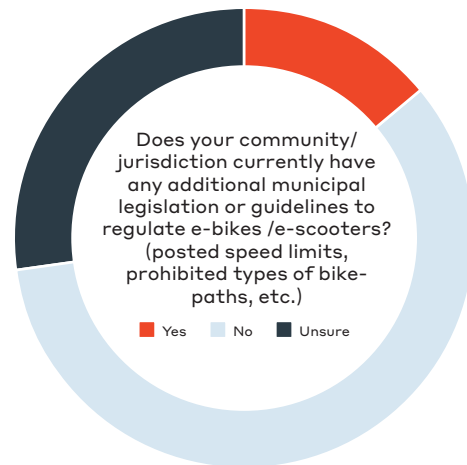
The next portion of the survey asked participants to review select excerpts from the Ontario e-bike regulation and provide commentary. Opinions on the adequacy of existing regulation were difficult to identify, the slight majority either agreed or had no opinion (54%), while 18% disagreed, 14% strongly disagreed, and 14% strongly agreed. Of those who disagreed, some felt the speed limit was too high or that the regulation should distinguish between e-bike types. For those who agreed, they generally felt that this regulation was a

Do you agree with how e-bikes are currently regulated with the existing provincial legislation for power-assisted bicycles?



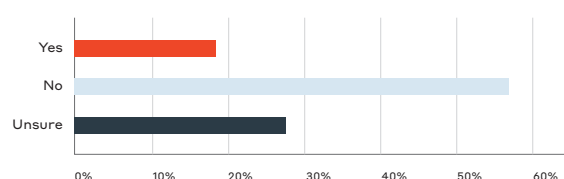
good start and allowed municipal governments to clarify definitions further.

However, only 14% of participants indicated that their jurisdiction had



adopted a municipal regulation that further regulates e-bike operations. The clear majority, 86%, either did not have additional regulation or were unsure. Many jurisdictions also did not further clarify any operational differences between the scooter-style e-bike and bicycle-style e-bikes. Of the 73% of participants that were aware of their e-bike regulation, 55% did not believe that their existing regulations clarified

Does any of the existing or planned municipal legislation or guidelines further clarify operational or usage differences between bicycle-style and moped-style e-bikes?



the differences between BSEB and SSEB models.

For those who did have some municipal by-laws for BSEB or SSEB models, the majority indicated that SSEB models were prohibited from multi-use trails, whereas BSEB models were permitted.

5.1.4 Users and uses of e-bikes

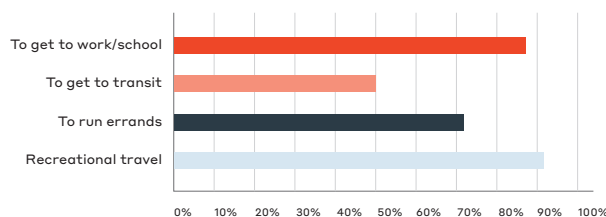
The final section of the survey asked participants their opinions on the use and users of both e-bikes and e-scooters. We classified the potential users to be Children (<16), Students (16-22), Adults (23-54), and Older Adults (>55). For e-bikes, most participants felt they would be utilized by almost all of the demographics (older adults, adults and students), with a high focus on adults (90%) and students (90%). For e-scooters, fewer participants felt they would be suitable for older adults (18%), and the majority once again saw the most potential for adults and students. An interesting shift occurred when we

DEMOGRAPHIC	E-BIKES	E-SCOOTERS
Children (<16)	n/a - Minimum age 16	45%
Students (16-22)	90%	87%
Adults (23-54)	90%	87%
Older Adults (>55)	68%	18%

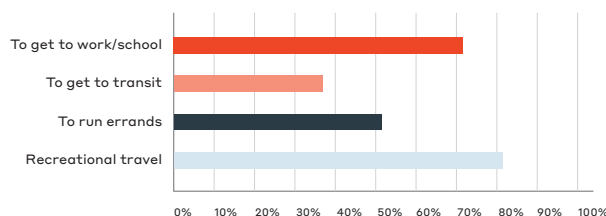
■ AGREE
 ■ SOMEWHAT AGREE
 ■ DISAGREE

asked participants to comment on the types of trips they foresaw e-bike riders taking. Although there had previously been a divide between the perception of e-bikes and e-scooters, generally both modes were perceived as suitable for all types of trips – including getting to work/school, getting to transit stations, running errands, and recreational travel. A small deviation was that for e-scooters, fewer participants felt they were suitable for getting to transit stations or running errands.

How do you foresee people using e-bikes?



How do you foresee people using e-scooters?



5.2 Discussion

The results of this survey speak to many of the previously mentioned trends regarding micromobility and e-bikes. Given the mixed reactions to the multiple micromobility modes, it is evident that the existing perceptions of bicycle-style e-bikes, scooter-style e-bikes and e-scooters vary greatly. Particularly, the difference in perception between SSEB and BSEB highlights their varied functionality and mirrors the results of previous studies^{10,46} where participants perceived BSEB as a separate mode than SSEB. Despite this, very few municipalities captured within this survey have opted to introduce further regulations on speed or permissions between BSEBs and SSEBs. This means that despite their polarizing perceptions, they are still regulated interchangeably in many Ontario jurisdictions, relying on existing federal and provincial laws without additional clarity at the local level.

Another key finding from this survey was the difference in support between e-bikes and e-scooters. Although e-bikes did not receive unanimous support, they were generally more supported than e-scooters, and were perceived to have less unique challenges to adoption – both individually and through shared mobility.

Overall, the view of e-bikes and micromobility by those who responded to the survey was positive, but more guidance is needed to ensure their implementation is thoughtful and functional. Many of the participants noted that the lack of understanding and knowledge regarding micromobility has led to difficulty in both regulation and operation. One of our survey questions asked participants to choose which barriers were preventing e-bike uptake. The barriers cited included lack of supporting infrastructure, lack of knowledge and lack of policy/legislation. This speaks to the complicated landscape of e-bikes and micromobility. Just as the background review and legislative landscape show, there is not one solution to integrating e-bikes and micromobility into our transportation networks because there is not one issue at play. When moving forward in the approach towards micromobility, we will need to identify and respond to each of the challenges and opportunities holistically.



How can

Micromobility

address the missing middle
of transportation?



The findings of our engagement show that despite the current legislative landscape, the opportunity for unlocking the true potential of micromobility in our transportation network is evident. Over 76% of participants felt that e-bikes will have a critical role in the future transportation network. However, the question remains: how can we foster the integration in an informed and responsible manner?

We introduced the concept of the missing middle in the introductory chapter. As mentioned, the missing middle refers to underrepresented transportation needs and options within our existing transportation network. When we introduce micromobility under the lens of the missing middle, we can see the potential in addressing these gaps and contributing to a sustainable and inclusive transportation future. The following chapter outlines key perspectives for integrating micromobility to close the missing middle.

6.1 Micromobility and destination-bound trips

In Canada, the average commute time for work journeys was 26.2 minutes by car, in 2016⁴⁸. This has been rising since the previous census in 2011. In Toronto, the average commute is 34 minutes. As such, auto-dependent commute patterns have become an expected reality. For many people, their errands, work, friends and community are outside of a walkable or bikeable distance. Even for those who do live within bikeable distance, barriers such as sweatiness, changing clothes, and difficulty carrying bags/cargo make biking for destination-bound trips seem infeasible¹⁴. One of the key findings of the background review was how e-bikes could mitigate some of these challenges.

In a study from Waterloo, ON, it was found that e-biking can help introduce sustainable destination-bound travel to populations who would have otherwise not considered their commute to be bikeable¹⁴. However, to generate more utilitarian travel trends, there will need to be a behavioural shift in the current use-patterns of e-bikes. A survey completed in 2018 by the National Institute for Transportation and Communities asked American e-bike riders to explain how they utilize their e-bikes. Although the majority of avid or experienced cyclists utilized their e-bikes for destination-bound trips, timid/less-experienced cyclists tended to use them for leisure/recreation. The difference between avid and novice cyclists is an evident gap in the utilization of micromobility and e-bikes.

Moving forward, there is an opportunity to leverage the potential of micromobility integration under a lens that supports its utilitarian travel potential. Although leisure and recreational trip-types are a subset of trip-type for e-bikes, we believe the larger opportunity for micromobility is within destination-bound trips to support a sustainable transportation future.

6.2 Intersecting micromobility and shared mobility

The opportunity to intersect micromobility and shared mobility is already being realized globally. According to a Navigant Research Study, the global e-bikeshare market is estimated to be worth \$24.4 billion by 2025⁵⁰. These programs are contributing to a market of micromobility that is more readily accessible. In the U.K., an e-bikeshare program with only 50 pilot e-bikes was ridden over 7,000 km in the

first few months⁵¹. In 2018, Paris expanded a pilot of their e-bikeshare program to become the largest e-bikeshare fleet in Europe, with 20,000 e-bikes⁵². North America introduced its first e-bikeshare in 2012⁵³, and as of now multiple cities across Canada and the United States have implemented an e-bike sharing system. At the time of publication, Calgary is believed to be the only Canadian city that has a full-time e-bikesharing system.

Madrid Case Study:

Madrid, Spain implemented their first e-bikeshare pilot in 2014, and in 2017 announced an expansion that would allow for 42 new stations and 486 new e-bikes⁵⁴. The program was a success, with a user-base that grew from 1,000 to 50,000⁵⁵. It is now one of the most popular e-bikeshare programs in Europe. In 2017, a paper that reviewed the survey distributed to Madrid residents about the pilot found that supportive infrastructure is not only the largest facilitator to e-bikeshare, but that cycling infrastructure also supports use by all demographics – including older adults, women, young adults and beginner cyclists⁵⁶. This pilot also pre-emptively illustrated some of the main benefits of combining e-bikes with bikeshare. In Madrid, many residents were already willing to cycle, however, the hilly landscape was a key barrier. Furthermore, although almost 90% of residents had heard of an e-bike, only 1% owned or had tried an e-bike. By combining the two emerging technologies, e-bikes could become more accessible to the public, and bikeshare could become more feasible to a larger demographic.

E-bikeshare is not the only quickly popularizing micromobility sharing

system. Possibly more well known is the e-scooter share phenomenon, with shared electrified kick scooter systems popping up across the globe. As previously noted, there are unique opportunities and challenges associated with integrating micromobility shared mobility as opposed to traditional bikeshare. More so, when comparing e-bikeshare and e-scooter share, e-scooter share faces a set of unique challenges. The popularity of e-scooters came in a rapid influx compared to e-bikes. Another key difference is safety. Where e-bikes are generally similar to bikes in terms of collision-rates, e-scooter riders have been observed to have higher rates of collision resulting in injury⁷³. Moreover, “littering”, where scooters/bikes are left on the side of roads and sidewalks, is more common with e-scooters as they operate utilizing a dockless model.

A key discussion for e-shared mobility is the need for and type of docking system and its corresponding opportunities and challenges. Docked bikeshares offer a structured approach to introducing e-bikeshare, but also come with an upfront investment cost for the municipality and offer less travel freedom for users. Dockless and Hybrid models offer more travel freedom, but have higher operational costs, as e-bike batteries need to be charged and are not returned to docks to charge. Also, there is an increased risk of bike loss or damage to dockless or hybrid models. As shown with our engagement, some of the biggest challenges with e-bikeshare implementation are cost and battery charging. In addition, some findings from our survey suggested that municipalities do not have ample regulatory tools to moderate privately operated bikeshare systems.

Just as the markets of bikeshare, e-bikes and, e-scooters expand, so do the companies offering e-bike/e-scooter

share. Some are pre-existing bikeshare companies that have expanded into the e-bikeshare, others have emerged specifically for the e-bikeshare/scooter share. While there are many e-bikeshare companies globally, the following section focuses on profiling e-bikeshare companies that target the North American market.

Jump

Jump is a recent American start-up that operates e-bikeshare and traditional bikeshare, called SoBi. In Canada, SoBi operates in Hamilton and Ottawa, ON⁵⁸. Notably, the company was sold to Uber in April 2018, for approximately \$200 million⁵⁹. The purchase by Uber is one of the first steps in the popular rideshare service entering new modal markets. In June 2018, Uber launched its first e-bikeshare program in Germany.

Lime

Lime Bike (now known as Lime) is an American e-bikeshare company that operates a dockless bike sharing system for e-bikes and e-scooters⁶⁰. Currently, Lime operates the e-scooter share pilot in Waterloo, ON and the e-bikeshare pilot in Calgary, AB.

Motivate

Motivate is an American bikeshare company that launched an e-bike pilot in San Francisco in April 2018⁶¹. In December 2018, it was purchased by the rideshare company Lyft⁶².

6.3 Multimodal integration

With the on-going objective for sustainable mobility, we commonly discuss transit as an attainable alternative that can discourage car travel. However, transit is a service of

communal convenience, meaning that it generally serves most, yet rarely perfectly serves any. The distance between a traveller's origin or destination point and the transit station is known as the first and last mile, and can greatly impact travel choice. When we plan for micromobility in our future transportation networks, a key focus should be on how the different modes interact to increase their service potential.



6.4 Social equity

The importance of inclusivity in transportation cannot be overstated. Mobility is a key indicator of health, and when transportation evolves inequitably, the consequences are unequally distributed throughout the population. When we look to close the missing middle, it is vitally important to consider how the gaps affect our most vulnerable populations, and how our policy and program responses will address their needs. There are opportunities for micromobility to help make mobility equitable. With our current use patterns of e-bikes in Canada, e-bikes are filling a key mobility gap for those multiple vulnerable populations^{14,24,63}. Moving forward with e-bike integration in Canada, it will be important to consider how the new policies, programs and laws will impact the livelihoods of those who have been relying on this mobility option, and further support equitable opportunity for adoption.

Key vulnerable populations can include, but are not limited to:



Recent Immigrants



Low-income residents



Physically disadvantaged populations



What are the best
tools for integrating

Micromobility & E-Bikes

in the Canadian Context?



In the previous chapters, we established the existing context of e-bike integration, the current legislative landscape, and opinions of key micromobility stakeholders. Through the findings of each of these reviews, we have compiled a toolbox of six e-bike integration methods that could support accessible, inclusive and sustainable e-bike adoption in communities across Canada.

7.1 Legislation

The ambiguity of e-bikes and, more largely, all micromobility modes in our transportation network is a key barrier to integration. As highlighted in our legislative review, there is no common delineation between the multiple types of e-bikes and how they should be regulated, or where they should be permitted.

In Canada, further evaluation should be conducted to determine whether a tiered approach to e-bike regulation (as shown in Europe and the United States through the Bicycle Product Suppliers Association definition) could assist in clarifying the role of e-bikes in our existing and future transportation network. Careful evaluation of the relationship between the throttle-assisted and pedelecs models, as well as the BSEB and SSEB models, should occur. As mentioned throughout this paper, there are operational differences between these models that affect how they interact with our infrastructure and other road-users. When planning for new regulation, we should give considerable attention to the legal classification of e-bikes as bicycles and to the regulators – speed, weight, throttle-power, wheel diameter, etc. – that are used to dictate the operational capacities of e-bikes.

Suggested Actions

Based on the findings of this paper, we suggest the following legislative changes be explored at the provincial level to address some of the current barriers to e-bike adoption. Graphically shown in **Figure 8**. The implementation of these changes should be subject to stakeholder engagement to further analyze the implications and effects on the e-bike sector.

Furthermore, depending on the outcome of the federal deregulation, these changes may be independent legislation for e-bikes or could act as further classification for power-assisted bicycles.

1. Regulate pedal-assisted e-bikes as bicycles in a two-tier model

Pedelecs and throttle-assisted pedal-assist bicycles are already regulated as bicycles, but are grouped together with Scooter Style E-Bikes (SSEBs). To maximize the potential of pedelecs/PABs as an integrated mobility option, they should be categorized separately from other e-bike models, and from each other. It is recommended that two tiers of pedal-assisted bicycles be classified, in that both pedelecs and throttle-assisted pedal-assist bicycles are categorized – as done with the American Bicycle Suppliers Product Association classification. By doing so, the slight capability differences between pedelecs and throttle-assisted bicycle style e-bikes are recognized without removing their permissions as bicycles.

This would lead to a better understanding of pedelecs and PABs by the public, so that more riders could make educated choices about their preferred e-bike typology. We propose these e-bikes be classified as Type A, with full-pedal assist bicycles being Type A-1 and throttle-assisted pedal-assist bicycles being Type A-2.

- Permit pedelecs and Permit Type A e-bikes similar to conventional bicycles
- Maintain the maximum speed of 32km/h
- Maintain all other existing requirements of power-assisted bicycles
- Require a speedometer on Type A e-bikes
- Require that the motor cease when human propulsion ceases for pedelecs, and that the motor ceases when brakes are applied for Type A-2
- Require a manufacturers label that distinguish between Type A-1 and Type A-2
- Monitor and evaluate e-bike usage to understand how pedelecs and PABs are being utilized
- Require helmets for Type A e-bikes
- Regulate that no person under the age of sixteen shall operate a Type A e-bike

2. Recognize s-pedelecs in the transportation network

Currently, s-pedelecs are not permitted within the power-assisted bicycle definition as they exceed the maximum 32 km/h speed. The Bicycle Product Suppliers Association permits s-pedelecs as bicycles in their classification model given that the U.S. does not explicitly prohibit e-bikes that can travel at a speed higher than 32 km/h. Currently, Canada does not have a definition for s-pedelecs. Based on the lessons learned from the EU, it is recommended that s-pedelecs be clearly defined in provincial legislation as a type of moped with required licensing that would recognize their pedal-assist nature, but also recognize their increased speed to reduce potential injuries and mode conflicts. We propose these s-pedelecs be classified as Type B e-bikes

- Define Type B e-bikes as mopeds
- Indicate a unique definition for Type B e-bikes within the existing moped definition

- Distinguish between Type B e-bikes and other less-active mopeds through language about human-propulsion
- Require a mandatory helmet for Type-B use
- Require a speedometer on Type B e-bikes
- Regulate that no person under the age of sixteen shall operate a Type B e-bike

3. Finding a place for SSEBs

With the above recommendations, SSEBs would still exist within the e-bike classification, as they functionally match the legal description of power-assisted bicycles. However, provinces can look to regulate SSEB via weight or wheel diameter requirements. In the city of Toronto, SSEBs are distinguished as e-scooters and are not permitted on multi-use trails. Toronto distinguishes between pedal-assisted e-bikes and SSEBs by mandating that e-bikes have a maximum weight of 40 kg and that the e-bike rider “pedals for propulsion” – building upon the “functional pedals” requirement within the power-assisted bicycle definition. Creating a functional classification, however, only begins to unravel the future role of SSEBs on the transportation network. There is minimal regulatory precedent for defining SSEB and as such, determining where, or if, SSEBs fit into our existing active transportation infrastructure requires a strong regulatory focus, especially when considering the conversations on safety and equity. It is recommended that stakeholder engagement be further conducted to determine the appropriate operating environment for SSEBs. We propose that scooter-style e-bikes be classified as Type C.

- Define a functional difference between Type A-2 and Type C through regulation requiring human-propulsion and maximum weight

- Require a speedometer on Type C e-bikes
- Prohibit Type C on multi-use trails and other off-road facilities
- Require Type C E-bikes to operate in motor vehicle travel lanes, similar to mopeds

4. Legalize e-scooters

Different modes of micromobility fill different transportation gaps. E-scooters can work with e-bikes to increase the efficiency and sustainability of our transportation network. However, specific attention should be given to how they are introduced. We propose the following considerations to e-scooter regulation⁶⁴:

- Introduce the legalization of e-scooters through a pilot program
- Limit the speed of e-scooters to 24 km/h, and consider requiring an emergency power shut off switch
- Use in dedicated cycling infrastructure e.g. bike lanes and multi-use paths but not on sidewalks or in motor vehicle travel lanes with posted speed limits greater than 40 km/h

- When part of an e-scooter share, specifically prohibit the e-scooter operator and riders from leaving e-scooters lying around on sidewalks in a way that impedes pedestrian traffic.

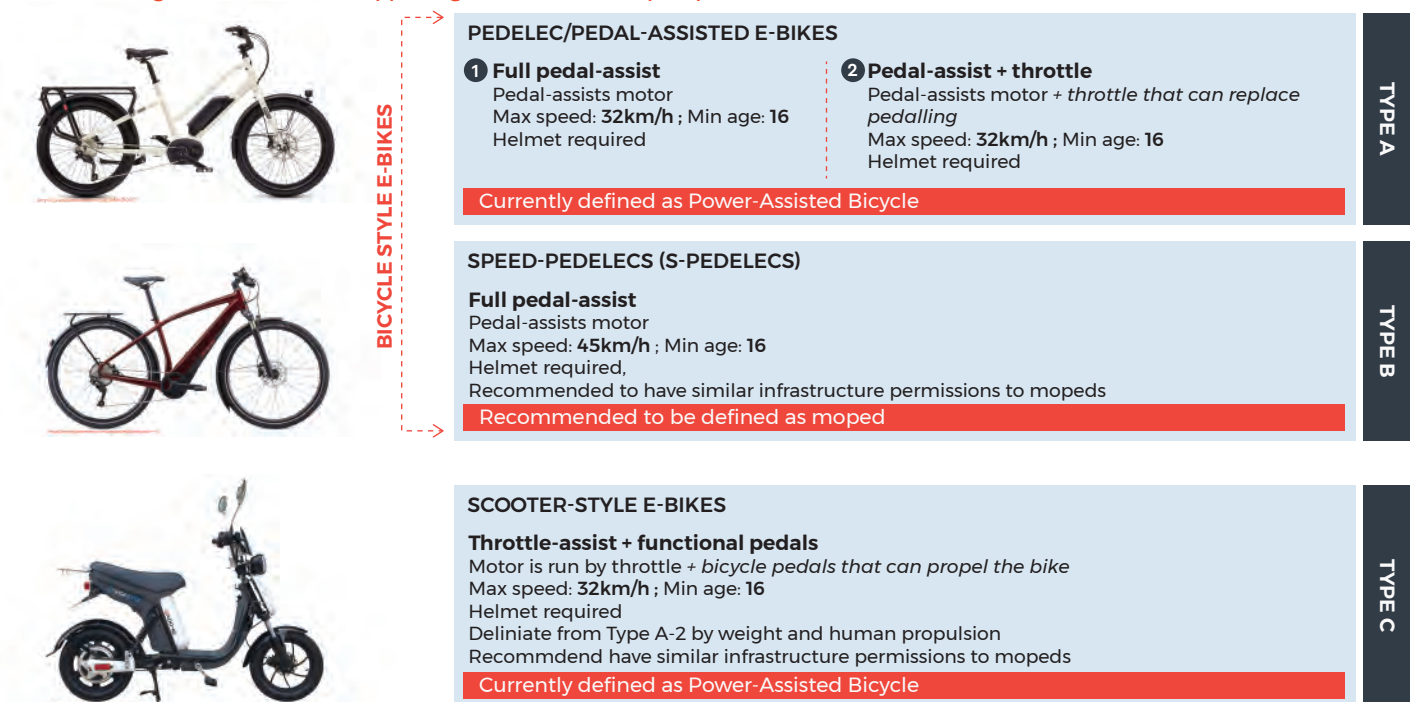
7.2 Planning documents

Our survey found that only 31% of respondents are currently planning for micromobility as part of their future transportation planning process. Plans that can incorporate micromobility include, but are not limited to:

- Official Plans
- Secondary Plans
- Transportation Master Plans
- Active Transportation Master Plans
- Road Safety/Vision Zero Action Plans
- Transportation Demand Management Plans

The new policy directives of these sections should consider the multiple modes of micromobility and their unique mobility capabilities. This paper started

Figure 8 : E-bike typologies and their proposed classifications



to identify the differences between micromobility modes. However, further analysis should be done to understand the interactions of these modes. Furthermore, much of transportation planning is reliant on modelling. When looking towards a micromobility-supportive transportation network, data, software and processes will need to be updated to reflect how e-bikes and e-scooters travel through the network.

When planning inclusively for new mobility trends, it is important to understand the inherent social and health impacts that could arise from a shift in the transportation status quo. The background review section and engagement showed that the demographics that could benefit from micromobility are broad, and ensuring that each demographic benefit equitably from the introduction of micromobility is essential to its overall success. As they become more normalized, a shift has occurred wherein e-bikes are now being adopted by those who may not have the same economic or social opportunities⁶³. When we think about micromobility from a population and demographic perspective, it is important to incorporate e-bikes, e-scooters and other forms of micromobility into our social/health planning to guide equitable adoption. We can achieve this by integrating micromobility into different policy documents such as age-friendly community planning, social equity planning, Vision Zero, and more.

Suggested Actions

- Define micromobility and the different micromobility modes within Official Plans and appropriate functional master plans
- Integrate micromobility into “future mobility” sections of Transportation Master Plans

- Update modelling processes to reflect the operational capabilities of micromobility
- Consider micromobility through an equity lens and, whenever feasible, adapt supportive micromobility policies for all applicable planning documents
- Acknowledge the unique benefit of micromobility to increase mobility for our ageing population, and appropriately plan for supportive micromobility policies within age friendly plans, transportation master plans, and other relevant planning policies.

7.3 Bikeshare

In the bikeshare sector, which is approximated to be in place in over 800 municipalities across 56 countries⁶⁵, e-bikeshare is still a comparably small subset. However, the opportunity is apparent; e-bikeshare could help make bikeshare a more viable alternative for “missing middle” trips in both urban and suburban landscapes. In addition to increasing exposure of e-bikes, e-bikeshare also allows the municipality to control the types of e-bikes in their transportation network. For example, in New York City, throttle-assisted e-bikes remain illegal, but a legal pedelec e-bikeshare was introduced⁶⁶.

Nevertheless, many e-bikeshare implementation questions still need answers. The most notable for Canada is the climate. Is it feasible to operate e-bikeshare in the winter months? When e-bikes are stored outside do their batteries continue to operate in sub-zero temperatures? Are there technological solutions to cold climate challenges, such as having powered charging docks that keep the battery at a minimum optimum temperature when not being used? We will need to address

these practical questions (highlighted through the engagement) as we introduce more e-bikeshares in Canada.

There is also an internal micromobility competition occurring between e-scooter share services and e-bikeshare services that can cause implementation challenges. In some cases, e-bikeshares are being discontinued in lieu of e-scooter shares, which are cheaper to operate⁶⁷. In some areas, these two services are being implemented interchangeably despite offering differing functionalities. Moreover, the New York City precedent raises an important challenge in e-bikeshare. As e-bikeshare promotes e-bike use, a major challenge is balancing the increase in uptake in jurisdictions that do not intrinsically support e-bikes with their legislation. When implementing e-shared mobility, we should think not only of the system itself but also the interaction of the program with legislation and other modes.

Suggested Actions

- Support e-bikeshare in relevant planning documents
- Pilot e-bikeshares, and monitor and evaluate their impact year-round to better inform future program rollouts
- Specifically prohibit e-bikeshare riders from parking e-bikes in areas where pedestrian traffic is impacted
- Engage with emerging academic research on the benefits and outcomes of e-bikeshares in comparable municipalities

7.4 Cycling infrastructure

In addition, the network of cycling infrastructure is a key motivator for e-bike adoption. Although some cyclists found that e-bikes allowed them to feel more confident in mixed-traffic conditions, having separated and comfortable cycling lanes encourages a broader range of cyclists and e-bike riders. When considering our ageing society, providing the technology solves only half the battle for inclusive cycling trips; the infrastructure must also be supportive of broad demographics. Also, route planning will influence the choice of trip type, between recreational and utilitarian.

Maintenance also affects e-bike adoption, mirroring a key barrier to cycling adoption. The cycling network should have its condition maintained to a suitable degree, especially when considering Canadian seasonality. Bike lanes that are poorly maintained discourage both cyclists and e-bike riders from utilizing the provided routes. For some contexts, thinking about supportive cycling infrastructure may need to be creative to sufficiently accommodate e-bikes and other emerging micromobility options. Innovative pavement material and markings, route planning and specific permissions may be required to support diversified cycling capabilities on the transportation network. Comprehensive and denser cycling networks that allow for choice of alternative travel modes are always preferred, as they permit users to choose the route that most appropriately matches their level of comfort.

Suggested Actions

- Plan for and maintain a complete and connected cycling network
- Consider micromobility in the planning of future cycling routes
- Consider micromobility in the functional design of future cycling routes

7.5 Incentives and pilots

As can be seen, e-bikeshare pilots are another option to introduce the technology on a trial basis. Several e-bikeshare pilots currently exist across the United States, and could be explored further in Canada to show the potential of e-bikes in addressing transportation gaps. To increase e-bike appeal and ownership, monetary incentives can also be used to make them more affordable to potential users. France is currently promoting pedelecs to the public through a \$300 purchase rebate⁶⁸. A similar program is also available in Norway, where residents are offered \$1,200 in Oslo to buy an e-cargo bike⁶⁹.

Utilizing financial incentives to increase uptake is not unique to e-bike technology and has been considered within Canada with other emerging technologies. In Ontario, the Electric Vehicle and Hydrogen Vehicle Incentive Program (EHVIP) provided financial rebates (\$14,000) and High Occupancy Vehicle lane privileges to electric vehicle purchasers. During the program, sales increased by 120%. This EHVIP program is no longer offered in Ontario by the provincial government; however, as of May 2019, the Canadian government announced a rebate of \$5,000 off electric vehicles that cost less than \$45,000⁷⁰. When promoting micromobility, incentives would be an worthwhile option that should be explored further within Canada.

Piloting e-bikes as a solution to urban goods movement

E-bikes are not only an option for personal trips, they also offer new mobility options for cargo deliveries. In our current retail economy, how we order and receive goods is changing, and

the sustainability of goods movement is an increasing environmental concern. Between 2005 and 2015, the number of parcels delivered globally grew by 128%⁷¹. Some companies are already integrating micromobility into their business plans – UPS introduced the service in late 2018⁷². A Seattle pilot introduces a specifically designed cargo e-bike to complete local delivery trips within the city, reducing the traffic congestion caused by delivery trucks and vehicles.

Suggested Actions

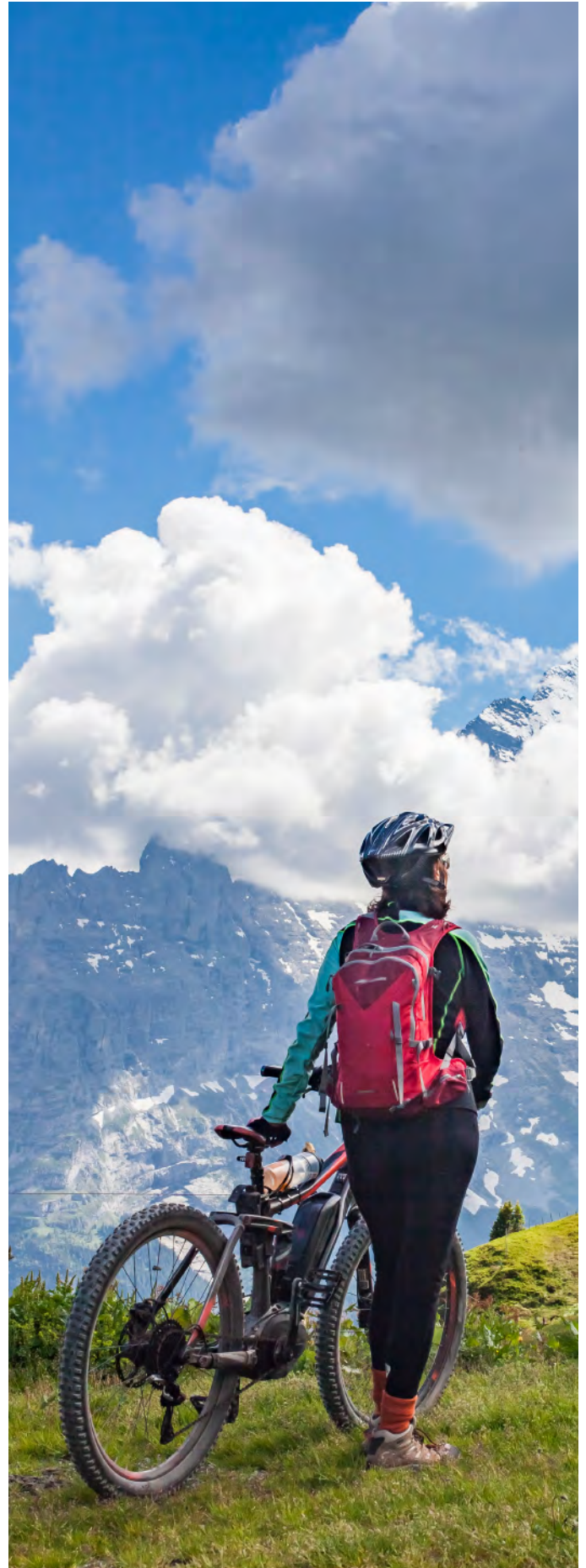
- Explore the opportunity for rebate programs for e-bikes and other provincial and/or federal micromobility modes
- Whenever feasible, introduce e-bike pilot programs that can explore potential new markets for e-bikes (such as urban goods movement)
- Approach the Canadian Government to expand their current electric vehicle incentive program to include a similar rebate for e-bikes. e.g. \$275 off a \$250-500 e-bike.

7.6 Education

The discussion surrounding micromobility is on going, and subject to change as new trends emerge. As such, practitioner and public education are vital to e-bike integration. We need to facilitate an open conversation around micromobility that supports knowledge-sharing across jurisdictions. Moreover, this knowledge should be communicated clearly and plainly to the public to encourage their support and opinions on micromobility.

Suggested Actions

- Clearly communicate the functionality of e-bikes in online and in-print educational materials
- Mandate that e-bikeshare operators provide educational videos for new-riders
- Update the Driver Training Manual to include information on e-bikes and e-scooters



Conclusions

and Next Steps

In a rapidly evolving society, we should be rethinking how travel patterns can adapt to our societal trends. The purpose of this paper was to raise key questions and initiate a discussion regarding how e-bikes, and subsequently all micromobility, can fit into the existing North American transportation network. We framed this discussion under seven key questions:

- 1** *What are e-bikes & how do we define them?*
- 2** *What is the existing role of e-bikes and how could this change?*
- 3** *How does legislation impact e-bike integration?*
- 4** *What lessons can be learned from current e-bike regulation?*
- 5** *How do practitioners perceive micromobility?*
- 6** *How can micromobility address the missing middle of transportation?*
- 7** *What are the best tools for integrating micromobility and e-bikes in the Canadian Context?*

Each of these questions informed the discussion. Based on the existing role of e-bikes, we cross-compared our future-ready trends to explore how e-bike trends could change. We then

looked to the legislation and practitioners to understand how we are currently permitting or prohibiting e-bikes on our transportation network. Based on these reviews, we identified opportunities in the Canadian e-bike context to better integrate e-bikes and e-scooters. The legislation, practitioners, existing and future trends, public perception, and available infrastructure are all elements that are impacting the growth of the micromobility market. The modes are being adopted by a diverse user-base to fill a missing middle in transportation.

We see the opportunity for e-bikes and kick-style e-scooters to promote sustainable commuting, further shared mobility, support multi-modal integration, and improve equity of transportation. However, this cannot be done without a few crucial changes to how micromobility is currently being introduced. There is ample scope within the Canadian transportation context to support redefining e-bikes and e-scooters to better inform their role in our transportation network. Most notably, the apparent operational differences between BSEB and SSEB should be reflected in regulation. The legislation is vital to how the public perceives e-bikes and e-scooters, and currently, the lack of definition between SSEB, BSEB, pedal-assist and throttle-assist models is contributing to perceived ambiguity surrounding e-bikes. Refined legislation could better inform new mobility planning,

e-bikeshare programs, infrastructure permissions, and future incentives and pilots. We provide preliminary legislation recommendations as part of this paper; however, the redefinition of e-bikes should be carefully considered and phased with stakeholder engagement to better understand the opportunities and associated challenges.

The onset of e-bikes and micromobility is already occurring and the response to this transportation change should be swift to best guide their future role within the transportation network. We have the opportunity now to redefine micromobility in Canada. Leveraging the potential of e-bikes and e-scooters

should be paramount, as their unique capability to address the missing middle of our transportation network is opportune, and could fundamentally shift how we perceive mobility in our communities.

Through further exploration of the above recommendations, alongside continued research and engagement, we could introduce micromobility as a practical travel mode choice for many that, along with public transit, can allow us to reduce greenhouse gas emissions while improving our quality of life.



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Additional Credits

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FIGURE 5:
California e-bike law: peopleforbikes.org
SURVEY IMAGES:
Bicycle Style E-Bike: Benno Boost E: <https://www.benno-bikes.com/e-bikes/>
Scooter Style E-Bike: GigaByke Groove- 750W Electric Motorized Bike: <https://www.giga-byke.com/groove-750w-electric-motorized-bike-black.html>
E-Scooter: CityBug 2: <https://www.citybug.com/>

FIGURE 7 & TABLE 7
Bicycle Style E-Bike: Benno Boost E: <https://www.benno-bikes.com/e-bikes/>
Motorized Bike: <https://www.giga-byke.com/groove-750w-electric-motorized-bike-black.html>
E Scooter: <https://www.skates.co.uk/city-bug-2-electric-scooter-white.html>

Images

FIGURE 1 & 8:
Bicycle Style E-Bike: Benno Boost E: <https://www.benno-bikes.com/e-bikes/>
S-pedelec: Specialized Turbo Vado 4.0 <https://electricbikereview.com/specialized/turbo-vado-4-0/>
Scooter Style E-Bike: GigaByke Groove- 750W Electric Motorized Bike: <https://www.giga-byke.com/groove-750w-electric-motorized-bike-black.html>

FIGURE 2:
Basic Model: B'Twin Elops 940 Classic Electric Bike: https://www.decathlon.co.uk/elops-940-e-classic-electric-bike-shimano-steps-id_8379382.html
Commuter Model: Coboc SEVEN Vesterbro: <https://www.coboc.biz/en/product/seven-vesterbro/>
E-Mountain Bike: Trek Powerfly LT 7 Plus: https://www.trekbikes.com/gb/en_GB/bikes/mountain-bikes/electric-mountain-bikes/powerfly/powerfly-long-travel/powerfly-lt-7-plus/p/23260/
Folding e-bike: Tern Vektron S10: <https://www.ternbicycles.com/bikes/472/vektron-s10>
Fat tire: Bulls Monster E FS: <https://www.bullsbikes.com/product/monster-e-fs-3/>

TABLE 4:
Pedelec: 2019 KTM Macina Fun XL 10 CX5: <http://www.flidistribution.co.uk/2019-ktm-macina-fun-xl-10-cx5>
Powered Cycles: Revolution X: <http://hi-powercycles.com/revolution-x/>
3-wheeled moped: Yamaha Tricity 125: <https://www.yamaha-motor.eu/kv/kv/products/scooters/urban-mobility/tricity-125/>
Light Quadricycle: Renault Twizy: <https://www.renault.co.uk/vehicles/new-vehicles/twizy.html>





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