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Regulations of E-Bikes in North America

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REGULATIONS OF E-BIKES IN NORTH AMERICA
A POLICY REVIEW

Report

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16. Abstract

Throughout the world, the electric bicycle (e-bike) industry is growing very quickly. The North American market has been somewhat slow to adopt this technology, which is still considered to be in the "early adopter" phase (Rose & Dill, 2011; Rose, 2011), but in recent years, this has begun to change. But as e-bike numbers increase, so too will potential conflicts (actual or perceived) with other vehicles and non-motorized devices, bicycles and pedestrians, causing policy questions to arise. Indeed, conflicting user groups are petitioning state legislatures and local governments for permission to operate legally on roadways and paths or to ban these devices.

Although some states, such as Oregon, Minnesota, and Pennsylvania, have created specific e-bike legislation, other states' legislation surrounding e-bikes is best described as nebulous. The confusion stems from the wide variety of devices and technologies on the market; perceived overlap of legal entities' jurisdiction over the device, which under certain circumstances can be either a consumer product or a motor vehicle; outdated laws and regulations; and inconsistency of terms. The purpose of this paper is to outline the different classifications of e-bikes—what they are and what they are not—and to help shed light on aspects of federal and state legislation of e-bikes. In addition, this paper explores the potential conflicts these regulations may cause for the adoption of this technology.

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DISCLAIMER

ERRATA

A correction was made to the first paragraph, second sentence on page 41. The sentence now reflects that e-bike speeds are slightly higher than standard bicycles. Maps were updated to reflect recent revisions in addition to correcting errors: Maryland introduced a law defining an *electric bicycle*, changing most maps; an error was corrected in Wisconsin—a driver's license is required (Figures 13 and 19); Hawaii was corrected to show both a driver's license and vehicle registration is required (Figure 19); Pennsylvania was corrected showing that *pedalcycles with electric assist* are not considered motor vehicles (Figure 18). Several numbers in the section *Analysis of E-Bike Laws* were updated based on the above changes (pages 17-21).

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REGULATIONS OF E-BIKES IN NORTH AMERICA: A POLICY REVIEW

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Throughout the world, the electric bicycle (e-bike) industry is growing very quickly. China's e-bike market has grown to an estimated 150 million units, and sales in European countries continue to rise (Hurst & Gartner, 2013). As reported by Bike Europe, e-bikes now account for 11 percent of market share in Germany, with more than 400,000 units sold in 2013 (Beckendorff, 2014). The North American market has been somewhat slow to adopt this technology, which is still considered to be in the "early adopter" phase (Rose & Dill, 2011; Rose, 2011), but in recent years, this has begun to change. Many sales estimates and projections show steady increases, with 2013 estimates ranging from 75,000 units (Hurst & Gartner, 2013) to 159,000 units (Jamerson & Benjamin, 2013) sold in the U.S. This makes it increasingly difficult to deem this technology a novelty. And for good reason: E-bikes may play a key role in addressing cities' transportation and public health issues by getting more people out of cars and onto bicycles–to get more people biking and biking more often. But as e-bike numbers increase, so too will potential conflicts (actual or perceived) with other vehicles and non-motorized devices, bicycles and pedestrians, causing policy questions to arise. Indeed, conflicting user groups are petitioning state legislatures and local governments for permission to operate legally on roadways and paths or to ban these devices.

Although some states, such as Oregon, Minnesota, and Pennsylvania, have created specific e-bike legislation, other states' legislation surrounding e-bikes is best described as nebulous. The confusion stems from the wide variety of devices and technologies on the market; perceived overlap of legal entities' jurisdiction over the device, which under certain circumstances can be either a consumer product or a motor vehicle; outdated laws and regulations; and inconsistency of terms. Unlike the European Union, the U.S. does not have one standard governing e-bikes. The E.U. directive—EN15194 standard—both defines a "pedelec" e-bike and legally classifies it as a bicycle. At the U.S. federal level, the Consumer Product Safety Commission (CPSC) and the National Highway Transportation Safety Administration (NHTSA) are charged with the safety and manufacturing regulations of such devices. They have agreed on a term, *low-speed electric bicycle*, that we commonly call an *e-bike*. The federal definition does not necessarily translate to states and cities,

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which have vastly differing and vague state laws and municipal codes, some of which have prohibited the use of some types of e-bikes on all public ways, like in New York City. Even colloquial conceptions of e-bikes are not standardized, ranging from a scooter-like vehicle (*scooter-style electric bike* (SSEB)) to a standard bicycle with a small hub motor (*bicycle-style electric bike* (BSEB)). The term *e-bike* is used primarily as a generic term in the U.S. to refer to most electric-assist bicycles. This does create some confusion because people in the U.S. and in other countries use the term *e-bike* for electric scooter-type devices, which have different regulatory requirements than bicycles.

The purpose of this paper is to outline the different classifications of e-bikes—what they are and what they are not—and to help shed light on aspects of federal and state legislation of e-bikes. In addition, this paper explores the potential conflicts these regulations may cause for the adoption of this technology.

METHODOLOGY

In the first part of the paper, terminology, we started from what we know about e-bikes. Having conducted e-bike literature reviews in recent months, we looked through several academic and online sources to determine how people use the term e-bike. From there, we developed a normative framework for addressing the standardization of e-bike terminology. We purposefully append broadly the term *e-bike* to the class of bicycles that have a small electric motor attached and simultaneously distinguish the term from similarly operating devices.

In the second part of our paper, legislation, we researched federal, state/provincial, and municipal codes. Many questions were answered through searching credible web sources and legal databases, such as LexisNexis. In addition, we contacted state departments of transportation (DOT), departments of motor vehicles (DMV), and state police. We corresponded with representatives from several state agencies as well as NHTSA, CPSC, and FHWA to ensure we have accurately interpreted the laws and definitions.

WHAT ARE E-BIKES?

Electric bicycles (e-bikes) are similar in geometry to human-powered bicycles but have a small electric motor that provides pedal assistance and allows riders to accelerate, climb hills, and overcome wind resistance more easily than manually powered bikes. They are part of a broader classification of *motorized bicycles*, which includes a range of bicycles with motors, from gasoline- and diesel-powered internal combustion engines, to even steam-powered engines. The modern electric variety of motorized bicycles emerged in the early 1980s in Japan as a way to make cycling easier for the elderly. By 2001, Japan had sold over 900,000 units (Rose & Cock, 2003). E-bikes can be generally divided into two categories: *bicycle-style electric bikes* (BSEB) and *scooter-style electric bikes* (SSEB).

The authors have chosen to use these two categories in order to group different e-bike styles and to facilitate the discussion in the report around federal, state, and local

definitions. Because the e-bike market is quickly changing and evolving, there is more of a spectrum of low-speed electric bicycles that range from more traditional bicycles to scooters than there are distinct classifications, all of which could be officially classified as an e-bike by the federal CPSC definition. As discussed in this report, the variety of e-bikes on the market have caused confusion for policymakers, the general public, retailers, law enforcement, media and other groups in understanding what an electric bicycle is and how it may differ from other devices, such as scooters, mopeds, motorcycles, bicycles, and Segways. We are hoping that by using *BSEB* and *SSEB*, it will help the reader understand the different broader categories of e-bikes on the market. In general, we use characteristics such as geometry, functional pedals, speed, additional safety components (e.g., headlights, mirrors, and turn signals) and motor type to describe BSEBs and SSEBs.

Bicycle-style electric bikes (BSEB)

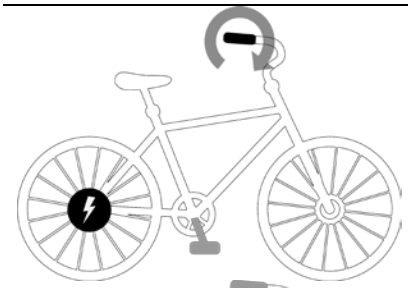
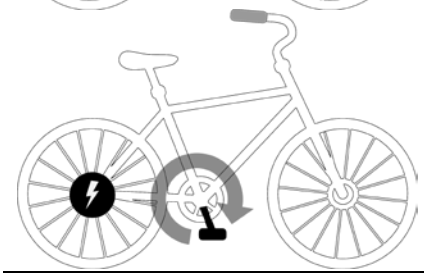
In North America, many terms are associated with the general classification of *bicycle-style electric bicycles* (BSEB), sometimes called *low-powered electric bicycles* or *low-speed electric bicycles*. In general, BSEBs have an electric motor powered up to 750 watts that goes slower than 20 miles per hour. These bikes have working pedals that are meant to propel the bicycle with or without the help of the electric motor.

BSEBs can be further divided into two broad categories: *powered bicycles* (PB) and *power-assisted bicycles* (PAB), or *pedelecs* (Table 1). The term *pedelec* is mostly used in Europe[3] and sometimes used in the U.S., but it is more of an insider's term and does not appear in the legal definitions. *S-pedelecs*, another common classification in Europe,[4] are bikes with motor power greater than 250 watts and can attain speeds up to 27.9 mph (European Parliament & European Council, 2003). In the U.S. this term is rarely used, and there are not many S-pedelec electric bikes on the market. In most cases, these types of bikes would potentially be classified as a *moped* or *motorized bicycle* in local jurisdictions.

[3] In 2009, the European Committee for Standardization (CEN) created a new standard for *electronically power assisted cycles* (EPAC), which are excluded from type approval by Directive 2002/24/EC. The new standard (EN 15194) specifies safety requirements and test methods for the assessment of the design and assembly of electrically power assisted bicycles and sub-assemblies (AFNOR, 2009).

[4] S-pedelecs ('S' for *schnell*, or "fast") usually require a license plate and insurance in Europe. In the U.S. the term refers to *speed pedelec*.

Table 1: Common alternative terms for two main categories of bicycle-style e-bikes.

	E-bike type	Alternative terms [a]
	Powered bicycle (PB, E-PB)	**Throttle-assisted bicycle**; electrically propelled bicycle (EPB); electric bike power-on-demand (POD); on-demand bikes; motorized bicycle
	Power-assisted bicycle (PAB, E-PAB)	**Pedal-assisted bicycle**; electrically assisted bicycle (EAB); pedal electric cycle (**pedelec**); electric pedal assist cycle (EPAC); human-powered hybrids

[a] Bold indicates more commonly used terms in North America.

Powered bicycles have a throttle on the handlebar that is often twisted with the wrist or thumb to engage the motor, similar to how a motorcycle or moped engages (Figure 11). Pedelecs do not have a throttle that propels the bike without pedaling; rather, the motor engages only when the operator pedals the wheels (Figure 2). Pedelecs include an electronic controller that stops the motor from producing power when the rider is not pedaling or when a certain speed—usually 20 mph—has been reached.[5] An electronic sensor, typically torque or cadence, detects changes in resistance or in the cranks and then engages the motor. This provides an extra boost when the bike accelerates or attempts to climb a hill. Some e-bikes can operate as both PB and PAB, such as Currie-Tech IZIP E3 Compact (Figure 3). In some regions, like the E.U., Japan, and some cities in China, powered bicycles are forbidden but power-assisted bicycles are permitted (Table 2).

Figure 1: A common throttle mechanism for powered bicycles. *Image source*: E-Republic.co.uk

[5] There are pedelecs that go faster than 20 mph, such as the Specialized Turbo and the Stromer Mountain 33 and Power 45.

Figure 2: Kalkhoff Sahel I8—a modern power-assisted bicycle (PAB) or pedelec. *Image source*: Kalkhoff-Bikes.com

Figure 3: Currie iZip E3—a hybrid PB/PAB folding electric bicycle. *Image source*: CurrieTech.com

Table 2: Comparison of e-bikes across regions globally, national level.

Region	Power limit	Top speed	PB	PAB	Other conditions
U.S.	750 W	20 mph	Yes	Yes	Operable pedals required
Canada	500 W	20 mph	Yes	Yes	Power assistance only above 2 mph
Australia	250 W [a]	No limit	Yes	Yes	Operable pedals required. Power (electric or IC) must be auxiliary, not the main source of power
E.U.	250 W	16 mph	No	Yes	Power assistance only when pedaling
China	No limit	12 mph	Yes	Yes	Inconsistent enforcement by region and/or city
Japan	250 W	15 mph	No	Yes	Max assistance at 9 mph declining to zero above 15 mph

[a] In Australia, PABs and PBs have different power outputs. PBs (*power-assisted pedal cycle*) are limited to 200W, while PABs (*pedalec*) are set at 250W.
Source: Rose, 2011, modified by authors.

Some of the latest developments in BSEBs are the motor-battery hub and encapsulated recumbent electric bikes. The Copenhagen Wheel from MIT SENSEable City Lab and the Smart Wheel from Flykly are two models of the hub technology, which is essentially a bicycle wheel with a self-contained motor and battery (Figure 4). No torque or cadence sensor is needed; instead, the device communicates with the operator's smart phone. The wheels' streamlined installation and ability to interface with smart phones brings great promise for this technology, especially for those who want to convert their own bikes.

Figure 4: Superpedestrian's Copenhagen Wheel—a wheel that converts a standard bicycle into a pedelec using a motor and battery in a self-contained hub. *Image source*: Superpedestrian.com

Encapsulated recumbent electric bicycles also challenge our conception of what an electric bicycle could be. The ELF from Organic Transit outfits a recumbent bicycle with an electric motor and places a lightweight material around the bike to shield the operator from the elements (Figure 5). Although bulky, it is only slightly wider than the handlebars of a standard bicycle.

Figure 5: Organic Transit's ELF, which is a *low-speed electric bicycle* as defined by CPSC, despite its bulk. *Image source*: OrganicTransit.com

Scooter-style electric bikes (SSEB)

While in the purest sense, e-bikes are bicycles with a small electric motor attached, the term has also been applied to scooters, mopeds and even motorcycles. These are called *scooter-style electric bikes* (SSEB). The distinction between BSEB and SSEB is of growing importance as more people start using e-bikes and as other emerging low-speed vehicles come to market. Because the term *e-bike* has been broadly used to refer to a varied class of vehicles, the general public is not clear of the differences, and policymakers are forced to make decisions on regulations that might not serve the overall needs of the public. It is important to note that we differentiate BSEBs from other vehicles based on the potential to be considered a bicycle—in geometry, weight, speed, and the ability to be pedaled. Furthermore, our report focuses on electric bicycles in the United States and Canada that meet the federal definitions described in our review of the legislation below.

Many people confuse electric scooters,[6] mopeds, and other SSEBs with BSEBs (usually powered bicycles).[7] Although electric mopeds may have pedals, they are more of an appendage than a functional necessity. In fact, these scooter-like vehicles often feature a platform on which the operator can rest his/her feet. The profile of these bikes ranges between a bulky bicycle and an Italian Vespa (Figure 6 and 7). Such bikes are quite common

[6] There is some confusion with the term *scooter*. We do not refer to *kick scooters*, devices typically ridden for recreation, consisting of a footboard mounted on two wheels and a long steering handle, propelled by resting one foot on the footboard and pushing the other against the ground (Figure 8).

[7] NHTSA defines the term *motor-driven cycle* as a motorcycle with a motor that produces five-brake horsepower or less. A motor-driven cycle is exempted from certain requirements of the FMVSS that apply to motorcycles (49 C.F.R. 571.3). NHTSA does not define the terms *motor scooter* and *moped*. These terms, therefore, have no relevance to the classification of a vehicle for the purpose of determining which FMVSS would apply to it.

in China (Weinert, Burke, & Wei, 2007). In some jurisdictions around the world and in the U.S., there is no legal difference between SSEBs and BSEBs.

Electric mopeds straddle the line of being classified as *e-bikes* because of the semi-functional pedals (Figure 6). Several states in the U.S. do not distinguish between a moped and an electric bicycle/motorized bicycle, which is one cause for the confusion. Another cause may be that the term *bike* can mean both a *bicycle* and informally a *motorized cycle* (moped, motorcycle, etc.). Many states do not differentiate between fuel sources of these motorized cycles. The power of electric mopeds range from about 350 watts to 3,000 watts or more, and they can reach speeds of 20 to 35 mph. There are some moped-type e-bikes on the market that meet the federal definition of an e-bike set by the Consumer Product Safety Commission (CPSC) and by Transport Canada (Figure 6). These have caused confusion and frustration with both law enforcement officials and users of bike facilities because they look like a moped but have minimal restrictions.

Lastly, the term *e-bike* is sometimes confused with electric motorcycles. These vehicles can reach speeds of 50 or 60 mph. In North America, this category of electric bikes is not generally considered an e-bike because they are not primarily human powered.

Figure 6: Scooter-style electric bike (SSEB) with operable pedals. *Image source*: OkOkChina.com

Figure 7: Electric scooter has no pedals, which is not considered an "e-bike." *Image source*: Made-in-China.com

Figure 8: Razor E300 stand-up electric kick-style scooter. This style of kick scooter is <u>not</u> a *scooter-style electric bicycle* (SSEB). *Image source*: Razor.com

REVIEW OF NORTH AMERICAN LEGISLATION

When it comes to e-bike legislation in the United States and Canada, it is important to ground the reader in three focus areas: systems of governance; relevant regulatory bodies; and specific e-bike legislation. This section gives an overview of the federal systems in North America, noting that the federal government is generally responsible for setting standards and doesn't specify usage and licensing of vehicles. It is also important to recognize that municipalities are often "creatures of the state/province," which may not have the powers granted to them to enact ordinances governing e-bikes. This section also looks at the specific roles of federal bodies—what they do and do not have jurisdiction over. Lastly, we look at how each country defines e-bikes at the federal level and what that means for state/provincial governments.

United States

The 10th Amendment of the Constitution establishes the American system of federalism by reserving for the states those powers not delegated to the federal government. States are able to enact and enforce police powers—the inherent authority of the state to impose restrictions on individual rights for the betterment of health, safety, morality, and general welfare—to achieve their goals. This means they can levy property taxes, require driver's licenses and enact vehicle codes, in addition to numerous other powers.

The powers and roles of the federal and state governments are made clear by the U.S. Constitution; however, it is silent about the roles and powers of municipalities. This has resulted in 50 unique political and legal situations by which states delegate powers to municipalities and local charters. In some states, constitutional amendments give local jurisdictions the right to self-govern by enacting local laws that are consistent with both the state and federal constitutions. These are called Home Rule states. In other states, the authority of local jurisdictions is limited to only those powers expressly permitted under state legislation. These are called Dillon's Rule states. Home Rule and Dillon's Rule are not mutually exclusive.[8] Some states, like Michigan, can be a Dillon's Rule state but also have Home Rule. These states have typically loosened their constructionist stance on local government autonomy.

This framework is important when considering e-bike laws in the United States. First, it makes clear the ability for the federal government to establish agencies, such as the Consumer Product Safety Administration (CPSC), the National Highway Transportation Safety Administration (NHTSA), and the Federal Highway Administration (FHWA), and to remind the reader of the limitation of power. Secondly, as discussed later, the absence of a state law about e-bikes could tie the hands of municipalities in Dillon's Rule states when attempting to legislate the device.

Federal agencies: CPSC, NHTSA, and FHWA

Certain federal agencies are charged with ensuring the standardization and proper safety of products in the United States. CPSC handles consumer products, and its purview is limited only to the ***manufacture and first sale of consumer products***. Products that do not fall under the jurisdiction of CPSC include those specifically named by law to be under the jurisdiction of other federal agencies, such as firearms, motor vehicles, and food and drugs. When CPSC defines a device as a *consumer product*, it means the device must comply with all manufacture and product sales regulations set by CPSC that pertain to the device. This does not affect how states may decide to govern the ***licensing and use of*** consumer products, such as bicycles or all-terrain vehicles.

Similarly, NHTSA handles motor vehicles, and its purview is limited primarily to ***safety requirements of motor vehicles***. Through administering the Federal Motor Vehicle Safety Standards (FMVSS), NHTSA is able to impose requirements on the design, construction, performance, and durability of motor vehicles. In addition, NHTSA administers the vehicle

[8] States without Home Rule: Alabama, Delaware, Mississippi, Nebraska, Nevada, New Mexico, Oklahoma, Vermont, West Virginia and Wyoming.

identification number (VIN) system and standards for motor vehicle theft, fuel economy, manufacturer and importer licensing, and safety testing of motor vehicles and motorcycle helmets. When NHTSA defines a device as a *motor vehicle*, it means the device must comply with all regulations set by NHTSA that pertain to the device. This does not affect how states may decide to govern the ***licensing and use of*** motor vehicles, such as mopeds or passenger vehicles.

The key points to understand are that CPSC handles only the manufacture and first sale of consumer products, such as bicycles; NHTSA handles vehicle and safety standards of motor vehicles. When CPSC or NHTSA define a product or vehicle, the extent of the definition is limited only to the purview of their regulations. Thus, **states are free to govern the licensing and use of consumer products and motor vehicles as they wish**, insofar as states do not enact laws that reduce the manufacture/safety standards set by the federal agencies.

Finally, the Federal Highway Administration (FHWA) is a division of the U.S. Department of Transportation, and its primary role in the federal-aid highway program is to oversee federal funds used for design, constructing and maintaining the National Highway System (primarily interstate highways, U.S. routes, and most state routes). In addition, FHWA provides oversight and guidance for non-motorized trails and pedestrian walkways using federal transportation funds (23 U.S. Code § 217).

U.S. e-bike federal regulations

Having explained the extent to which the federal government can legislate both motor vehicles and consumer products, we now examine specific regulations of e-bikes at the federal level. In 2002, the U.S. Congress enacted Public Law 107-319, which amended the Consumer Product Safety Act by updating 15 U.S.C. Chapter 47 Section 2085 that establishes the requirements for low-speed electric bicycles, defined as:

> a two- or three-wheeled vehicle with **fully operable pedals**[9] and an electric motor of less 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**.

CPSC considers e-bikes that meet this definition to be standard bicycles for the purposes of manufacture and first sale at the federal level, and they must adhere to the requirements (for bicycles) set forth in 16 C.F.R. § 1512 (2014).

Public Law 107-319 also differentiates 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)].

[9] There is no guidance to describe what "fully operable" means. There are scooters and mopeds on the market that have pedals that can move the wheels but would prove very difficult to propel the device for any substantial distance or any distance at all.

A 2005 docket from NHTSA addressed the apparent incongruence between a motor vehicle and a low-speed electric bicycle by stating that NHTSA's interpretation is in coordination with that of CPSC: Low-speed electric bicycles are not motor vehicles (Federal Register, 2009). Thus, NHTSA defers to CPSC to regulate these products (Table 3) (Hansen, 2013).

Table 3: Matrix summary of regulatory bodies with jurisdiction over described e-bikes.

	Meets definition	**Does not meet definition**
Off-road	CPSC	Uncertainty of agency jurisdiction
Street-use	NHTSA defers to CPSC	NHTSA

However, we are left with a gray area for e-bikes that do not meet CPSC's definition of *low-speed electric bicycle* (i.e., e-bikes that go faster than 20 mph and/or are powered above 750 W). The bikes would then fall into the arena of NHTSA and would be defined as a *motor vehicle*. It is uncertain how NHTSA would classify these types of bikes, especially S-pedelecs, and what additional safety requirements would be added.[10] There is also lack of clarity in the regulatory definition for pedelecs that reach speeds greater than 20 mph. The Specialized Turbo has a top speed of 28 mph and is currently on sale in the U.S. Specialized interprets the federal regulations to mean that the 20 mph speed limit only pertains to a bike that is powered solely by the motor and can be ridden without any human power (Roberts, 2013). This interpretation potentially creates a second classification for low-speed electric bicycles and could cause additional policy-related questions for state and local municipalities.[11] For example, would a bike that could reach speeds of 28 mph be allowed on a separated bike path in the Boulder, CO or Toronto, Canada where the use of e-bikes in these areas is already in question?

As for the operation and licensing of e-bikes, states and local municipalities are responsible for regulating these products. As we will see, how states incorporate e-bikes into their vehicle codes varies greatly. Although states are delegated this task, one clause that often leads to confusion is part (d) of Public Law 107-319:

> d) This section shall supersede any State law or requirement with respect to low-speed electric bicycles to the extent that such State law or requirement is more stringent than the Federal law or requirements referred to in subsection (a).

When taken out of context, this clause might suggest that the "federal definition" of an e-bike takes precedent over any and all state laws pertaining to e-bikes. Since the "federal definition" considers *low-speed electric bicycles* to be standard bicycles, the assumption follows that states cannot impose more stringent restrictions on e-bikes and that CPSC's

[10] An e-bike powered in excess of 750 watts and capable of speeds above 20 mph may be considered a motor-driven cycle, as defined by NHTSA (49 U.S.C. § 30101, et seq.).

[11] The authors were not able to obtain any official interpretation from CPSC.

definition is *the definition* for all states. ***This common interpretation is wrong***.[12] Because Public Law 107-319 amends the Consumer Product Safety Act, the provision is limited to only the manufacturing and first sale of the product.

There is one area the federal government has established jurisdiction on the use of electric bicycles. In 23 USC Section 217, electric bicycles are permitted to be used on trails and pedestrian walkways that are built using federal funds where state or local regulations permit. Though this legislation still gives state and local regulations the final say, it does provide an opportunity for e-bikes to be considered for use in these areas with federally funded trails and walkways. In a particular sense, knowing where an e-bike is allowable becomes difficult to determine for the user and regulatory authorities, since a roadway, path or trail might be comprised of different funds throughout. To help clear up how this legislation can be applied, FHWA has created a framework for considering motorized use on non-motorized trails and pedestrian walkways (Federal Highway Administration, Office of Planning, Environment, and Realty, 2014).

An interesting aspect of the legislation is how it defines an electric bicycle as "any bicycle or tricycle with a low-powered electric motor weighing under 100 pounds, with a top motor-powered speed not in excess of 20 miles per hour," which was added to 23 USC 217 in Pub. L. 105–178, title I, § 1202(a), on June 9, 1998. Though this legislation predates Pub. L. 107-317, the federal agencies are faced with two different definitions, which is confusing and unnecessary.

Finally, as for use in the National Park System, e-bikes are not explicitly banned from use in national parks, but they would not be considered a bicycle. The National Park Service regulates the use of bicycles on park roads, in parking areas, and on routes designated for bicycle use (Federal Register, 2012). E-bikes would fall under the designation of *motorcycle* or *motor vehicle* and would be banned from use in areas for non-motorized use, such as paths and trails (36 C.F.R. § 4). The International Mountain Bicycle Association (IMBA) has called for different classifications of electric-assist/motorized mountain bicycles and mountain bikes (IMBA, 2010). Much of the mountain bike community would like to see e-bikes only used on legal off-highway vehicle (OHV) trails and roads. The belief is that e-bikes would lead to the deterioration of single-track trails and nature areas (Lockwood, 2014).

Canada

The federal system of Canada differs from that of the U.S. in that it recognizes two jurisdictions with political authority: the federal and provincial governments.[13] The federal and the provincial governments are both autonomous and interdependent; cooperation at the provincial-federal level is an essential feature of their interconnected relationship, and their roles cannot be neatly separated. To help rationalize both jurisdictions' authority,

[12] Michigan State Police issued the Field Update #26 stating this misconception that some retailers and operators have of the federal regulation.
http://www.michigan.gov/documents/msp/TSS_Field_Update_26_180953_7.pdf
[13] The territories are delegated powers to be exercised by Parliament.

Canada has several doctrines in place. While the federal government is delegated responsibilities to connect provinces and regulate commerce and transportation in the national interest, exclusive powers of provincial legislature are those that are inherently local. Such powers include municipalities, property rights, and taxation/spending.

The provincial-municipal relationship is quite different from the federal-provincial relationship. Provinces not only determine the specific powers delegated to municipalities, but they are also responsible for the very existence of municipalities. For example, the Local Government Act of British Columbia spells out what local governments are responsible for and what they can enact; the exception is the Vancouver Charter that established the City of Vancouver. Each province, however, has a unique relationship with its municipalities (for example, Vancouver Charter, SBC 1953, c 55).

Transport Canada and MVSR

Transport Canada is the federal department charged with developing transportation policies, regulations, and services in Canada. In 1971, Transport Canada established the Motor Vehicle Safety Act for creating safety standards for motorized transport, which enabled the legislation of Motor Vehicle Safety Regulations (MVSR). MVSR establish the Canada Motor Vehicle Safety Standards (CMVSS), which aim to set standards for safer vehicles. Provinces also have their own transportation departments to handle vehicle licensing, infrastructure planning and maintenance, and vehicle regulation. MVSR ensure proper standards for human safety are met, while province regulations address use, definitions and licensing, among others.

Canadian e-bike federal regulations

With a general understanding of the Canadian federal system and the powers of the provinces and federal government, let's look at exactly how Canada addresses e-bikes at the federal level. Transport Canada defines a *power-assisted bicycle* (PAB) in the MVSR (CRC, c 1038 (2)):

> "power-assisted bicycle" means a vehicle that:
>
> (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 watts** [0.67 horsepower] 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 [**19.9 mph**] on level ground [...].

Transport Canada has the power to define *power-assisted bicycles* for the purposes of setting safety standards. Although different from federal preemption, Transport Canada does not require licensing and registration for power-assisted bicycles. However, similar to the United States, the provinces reserve the authority to require licensing, define the vehicle, and add restrictions like age and helmet requirements. PABs in Canada are similarly defined to how low-speed electric bicycles are in the United States, the exception being that the maximum power output in Canada is 250 watts fewer than in the U.S. The federal definition in Canada includes both powered bicycles (throttle-assist) and pedelecs (pedal-assist).

STATE AND LOCAL REGULATIONS

As it relates to motor vehicles (including bicycles), states and municipalities are given the powers to authorize vehicular registration and licensing, as well as operator licensing. States also have the power to define vehicles under their corresponding vehicle codes. Although NHTSA, CPSC and FHWA have set definitions of e-bikes for their own provisions, these agencies' definitions do not weigh in directly to states' decisions. In the case of e-bikes, states can define what an e-bike is, whether the device requires operator licensing, where the device can be operated, and several other factors (e.g., need of helmet and age restrictions).

The National Committee on Uniform Traffic Laws and Ordinances (NCUTLO) is a private, non-profit membership organization made up of mostly state government and related transportation organizations, focused on providing uniformity of traffic laws and regulations through the creation of the Uniform Vehicle Code (UVC) (NCUTLO, 2000). The UVC acts as model regulatory framework on traffic safety issues that can be adopted by states. The intent is to create uniformity and consistency in state vehicle regulations. In the latest version of the UVC, there is no mention of electric bicycles, but it would probably classify them as mopeds.[14]

In 2012, the National Committee on Uniform Traffic Control Devices (NCUTCD)[15] appointed a task force to review the Rules of the Road as found in Chapter 11 of the millennial edition of the UVC, and to generate proposed amendments to these traffic laws as necessary to reflect the new engineering principles and applications as they appear in the current version of the Manual on Uniform Traffic Control (NCUTCD, 2012). The NCUTCD suggests

[14] S 1-154 Moped - A motor-driven cycle with a motor which produces not to exceed two-brake horsepower and which is not capable of propelling the vehicle at a speed in excess of 30 mph on level ground. If an, internal combustion engine is used, the displacement shall not exceed 50 cubic centimeters, and the moped shall have a power drive system that functions directly or automatically without clutching or shifting by the operator after the drive system is engaged.

[15] The NCUTCD is an organization whose purpose is to assist in the development of standards, guides and warrants for traffic control devices and practices used to regulate, warn and guide traffic on streets and highways. The NCUTCD recommends to the FHWA and to other appropriate agencies proposed revisions and interpretations to the Manual on Uniform Traffic Control Devices (MUTCD) and other accepted national standards.

new language for a definition of *electrically-assisted bicycle* and defining them as bicycles, with the same privileges:

> Every vehicle upon which any person may ride, and propelled by the operator, having two tandem wheels and an electric motor, 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.

The NCUTCD justified the changes to the UVC, because low-powered bicycles were becoming more common due to improvements in battery and motor technology. E-bikes are low-speed, quiet and non-polluting, which make the bicycles acceptable on paths. Though this definition is similar to the CPSC definition, it doesn't specify motor size, the requirement of working pedals, and doesn't seem to allow for three-wheeled bicycles.

Local municipalities have also started to look into regulating the use of e-bikes. Some notable cities include Boulder, CO; Eugene, OR; New York City, NY; Park City, UT and Toronto, ON. In these cases, the city has established, or is currently establishing, local regulations determining what is considered an e-bike and where e-bikes can and cannot be ridden. For Boulder and Eugene, the definition of an electric-assisted bicycle is consistent with state definitions. Toronto, on the other hand, has a definition more stringent than provincial law. Park City Council staff are proposing a more stringent set of restrictions and definition than Utah State Code.[16] These cities and others are highlighted in our analysis below.

Additionally, confusion occurs in the states and provinces that don't have specific e-bike regulation. Many of the U.S. states and Canadian provinces that are silent on the issue have regulations in place governing *moped*, *motorcycle*, *motorized bicycle*, *motorscooter*, *scooter*, and/or *motor-driven cycle*. By default, an e-bike would fall into these categories for areas that are silent on e-bike regulation.[17] This creates two types of problems for e-bike owners. First, they will have licensing and registration requirements that are stricter than necessary, including helmet and safety light requirements. These restrictions can be barriers to participating in cycling. In some cases, like in New York and New Jersey, the lack of a proper definition has created a problem whereby e-bikes are not able to be registered by state DMVs, even as mopeds, thus making them illegal. Secondly, if e-bikes are not considered *bicycles*, they can then be barred from use on bicycle infrastructure such as paths, bike lanes or sidewalks.

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[16] On May 29, 2014, Park City Council staff proposed recommendation for the use of electric assisted personal assistive mobility devices on city pathways and trails. The recommendations include edits to the municipal code to establish definitions, restrictions on use and a proposed pilot program to collect data on use on public pathways and trails (Park City Council, 2014)

[17] Some states have seemingly incompatible definitions for e-bikes, particularly when specifications for engine displacement (CCs—cubic centimeters) are used. However, a reference to engine displacement does not intrinsically take e-bikes out of such a definition. For example, a moped could be defined as a "device equipped with a motor with an engine displacement of less than 50 CC." Because e-bikes do not have any engine displacement, the displacement is indeed less than 50 CC.

ANALYSIS OF E-BIKE LAWS

For this section, the term "e-bike" is limited to those equipped with fully operable pedals and a motor of no more than 750 W (U.S.) or 500 W (Canada) that propels the bike at a maximum speed of 20 mph (U.S.) or 32 km/h (Canada).

The analysis below summarizes Appendix A, which attempts to catalogue the legal status of electric bicycles in all 50 states, Washington, D.C., and Canada's 13 provinces and territories. It is our first attempt at digesting 64 different regulatory situations for electric bicycles. While we took pains to identify the correct legislation for this table, we cannot guarantee its accuracy. For example, it is difficult to determine whether an area explicitly permits or prohibits operation of e-bikes on paths/sidewalks; some states also have multiple definitions for e-bikes. We invite readers to provide feedback with local knowledge they may have. Appendix A addresses the following regarding e-bikes:

1. State/provincial vehicle code definition that contains e-bikes
2. If it is essentially classified and treated as a bicycle
3. If the operator is required to have a license
4. If the e-bike is required to be registered
5. Minimum age of operation
6. Maximum power output
7. Maximum speed of operation
8. If pedals are required
9. If the state/provincial definition meets the federal definition
10. If a helmet is required
11. If e-bikes are allowed on paths
12. If e-bikes are allowed on sidewalks
13. References to code

Of the 50 states plus D.C., 30 do not have definitions that recognize e-bikes as a unique vehicle separate from mopeds or similar devices (Appendix A). Only 10 states have definitions that correspond to CPSC's definition of a *low-speed electric bicycle*. The terms used to identify e-bikes also vary, but the most common are *motorized bicycle* (12 states); *moped* (11 states); *electric-assisted bicycle* (seven states); *motor-driven cycle* (four states); and *bicycle* (four states). Several others are variations of these. Surprisingly, only three states, Maryland, Nevada and Texas, dodge the convoluted naming structure and identify e-bikes as simply *electric bicycles*, and five other states have some derivation of electric bicycle not mentioned above.

Based on various states' definitions and requirements, we determined whether electric bicycles as defined by CPSC were *rendered* bicycles—those regulatory situations that make the use of an e-bike analogous to a bicycle (Figure 13). We define this by whether a driver's license is required and whether the e-bike is required to be registered with a DMV. We found that in 24 states, e-bikes are treated essentially as bicycles; 27 states have more onerous requirements, such as vehicle registration, rider licensing, or require special equipment. At least 10 states consider e-bikes to be motor vehicles (Figure 18). Of the 24

states that treat e-bikes as standard bicycles, five include e-bikes in the very definition of *bicycle*.[18] Only 10 states have adopted a definition that is in line with the federal definition.

The following states are those without Home Rule: **Alabama**, Delaware, **Mississippi**, **Nebraska**, Nevada, **New Mexico**, Oklahoma, **Vermont**, **West Virginia**, and **Wyoming**. Out of these 10 states, the seven in bold do not have a definition that recognizes e-bikes as a unique vehicle (Figure 14). This overlap is surprising and has several implications for policy and responsive governance. For example, if a municipal corporation in Alabama wished to add its own definition of *electric-assisted bicycle* to its city ordinances, the city would encounter the issue of whether it has the authority to do so. Unless the authority to amend parts of vehicle code is expressly granted to the city, it cannot make rules about e-bikes that do not comply with state law. Although all Canadian provinces and territories do not have Home Rule, their delegations of power to local authorities often include those matters pertaining to bicycling.

Most states (44) impose a speed limit on e-bikes; 22 states limit e-bikes to 20 mph, 6 states to 25 mph, and 16 states to 30 mph (Figure 17). All but three of the 22 states that recognize e-bikes as a special vehicle set the maximum speed at 20 mph. As for engine output, only 33 states specify a maximum power output in a unit relevant to e-bikes—either horsepower or watts (Figure 9 and 16). However, 18 states do not accommodate electric motors in the vehicle's definitions and instead designate an internal combustion engine's maximum piston displacement (Figure 10). There is not a direct unit conversion between engine displacement (cc) and horsepower or watts, thus making the determination of classifying these bikes difficult to impossible.[19]

Considering the 22 states that recognize e-bikes as a unique vehicle, the particular definitions they set create a gap between what is allowed in the state and what CPSC requires in order to be considered a *low-speed electric bicycle* (Table 4). These states either have a higher allowable maximum speed (20 mph) or power output of the motor (750 W).

About half of all states (27) require an operator's license to ride an e-bike, but nearly three-quarters (38) do not require registration (Figure 12 and 19). This is consistent with the minimum age of operation; most states (36) have a minimum age, with 18 states requiring the operator be 16 years of age (Figure 11 and 15). In some states, like Alabama, Connecticut, and North Dakota, motor-driven cycles, motorized bicycles, or mopeds require an additional endorsement in order to be legally operated. The extent of this requirement varies. Some states, like Arkansas, require only an easily obtained certificate. Other states, such as Alaska, riders are required to obtain a motorcycle class license through a DMV-administered exam. In most other states, such as Tennessee, Hawaii, and Michigan, no additional endorsement beyond a standard operator’s license is required; the caveat is that these types of vehicles stay within some specified power range, typically less than 50 cc.

[18] These states include Delaware, Florida, Idaho, Montana and Pennsylvania.

[19] Conversion used in Appendix A: watts expressed in horsepower equivalent: 1 H.P. = 745 watts.

Table 4: States whose permitted speed or power for electric bicycles exceeds the CPSC definition of *low-speed electric bicycle*.

State [a]	Identity	Power	Speed
California	Motorized Bicycle	*1,000 watts*	20 mph
Georgia	Electric-assisted Bicycle	*1,000 watts*	20 mph
Indiana	Motorized Bicycle	50 cc	*25 mph*
Kansas	Electric-assisted Bicycle	*1,000 watts*	20 mph
Minnesota	Electric-assisted Bicycle	*1,000 watts*	20 mph
Mississippi	Bicycle with a Motor Attached	*no limit*	*no limit*
Montana	Bicycle	*2 HP*	*30 mph*
Nebraska	Moped	*2 HP*	*30 mph*
North Carolina	Moped	50 cc	*30 mph*
Oregon	Electric-assisted Bicycle	*1,000 watts*	20 mph
Texas	Electric Bicycle	*no limit*	20 mph
Virginia	Electric Power-assisted Bicycle	*1,000 watts*	*25 mph*
Washington	Electric-assisted Bicycle	*1,000 watts*	20 mph

[a] Only states that have a definition recognizing e-bikes as unique vehicles were considered

For adults, most states (41) do not require the rider to wear a helmet; however, for riders under a specified age limit, helmets may be required. This figure is consistent with state laws for bicycle helmets. As of April 2014, 22 states have codified into state law requirements for bicycle helmets—typically geared toward children—and 13 states have no helmet laws, even in any of their municipalities (Bicycle Helmet Safety Institute, 2014). Because some states view e-bikes as mopeds or motor-driven cycles, a motorcycle helmet meeting safety standards laid out by NHTSA may be required for adults.[20] In Louisiana, the operator may have an insurance policy of at least $10,000 in place of a motorcycle helmet. In other states, like California and Georgia, a bicycle helmet will suffice in place of a motorcycle crash helmet.

Of the 13 provinces/territories in Canada, only four do not have vehicle definitions that are relevant to e-bikes: New Brunswick, Newfoundland and Labrador, Northwest Territories, and Nova Scotia.[21] Only pedal-assist bicycles are permitted in Alberta and British Columbia, which is similar to how Europe and Japan structure their laws. Only Prince Edward Island, which calls e-bikes *motor-assisted pedal bicycles*, requires a driver's license to operate an e-bike. We could not confirm whether any province prohibited e-bikes on bike paths.

The question of where electric bicycles are permitted is complex. States can explicitly permit or prohibit operation of standard bicycles on sidewalks, paths, trails, etc. However, many states stay silent on where cyclists can ride. In vehicle code, vehicles are often prohibited from operation on sidewalks, and in many states, e-bikes are defined as vehicles. For standard bicycles, eight states ban their use upon sidewalks, and 21 states

[20] States with motorcycle-style helmet requirements include Alabama, Massachusetts, New Jersey, Nebraska, North Carolina, Tennessee, and West Virginia.
[21] The four provinces accounted for 6.7% of the population in 2011 (Statistics Canada, n.d.).

explicitly permit use on sidewalks. While four states have conditions when a cyclist can use a sidewalk, 18 states have either no law whatsoever or it is unclear (League of American Bicyclists, n.d.). But we have seen that e-bikes are not defined as bicycles under many states. Some states, like Oregon, have provisions that make e-bikes essentially bicycles but have additional restrictions on using electric-assist bicycles on sidewalks.

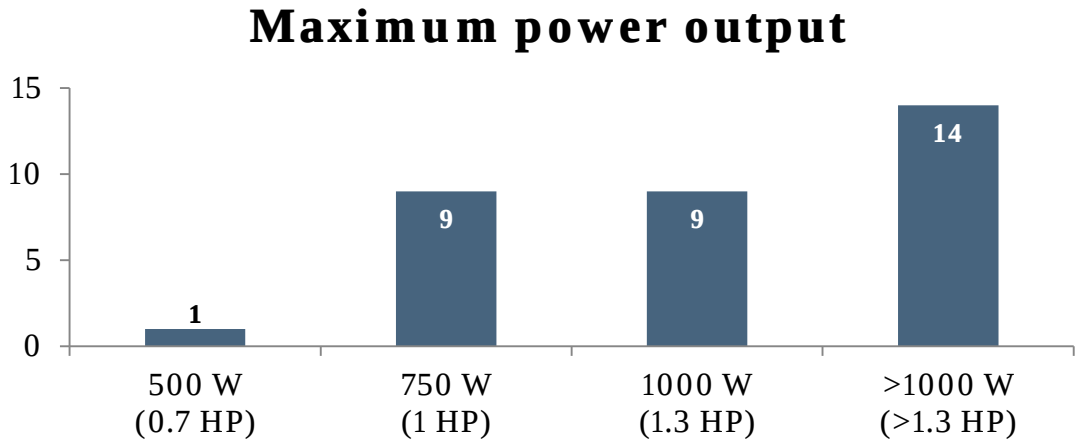

Figure 9: Number of U.S. states with specified allowable maximum output of an electric-bicycle motor. Horsepower was converted to watts. 1 horsepower = 745.7 watts. *N* = 33.

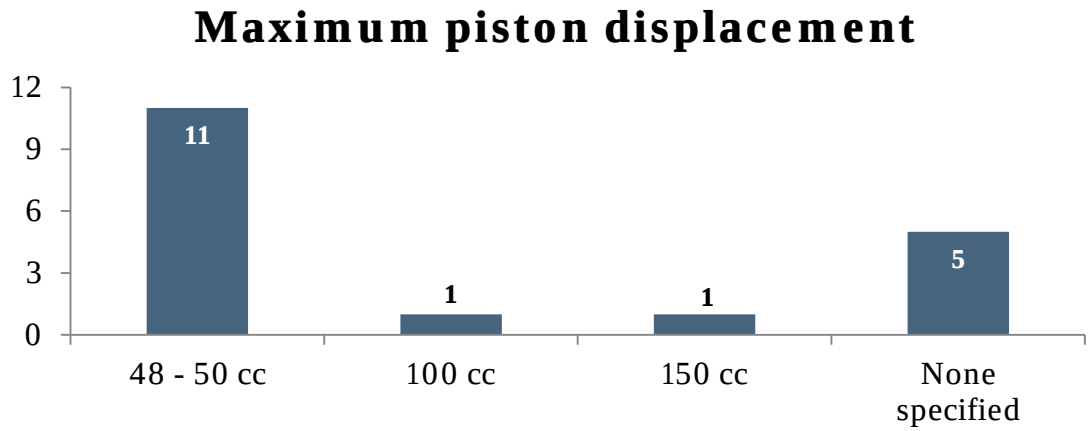

Figure 10: Number of U.S. states with specified maximum piston displacement by the identification under law. *N* = 17.

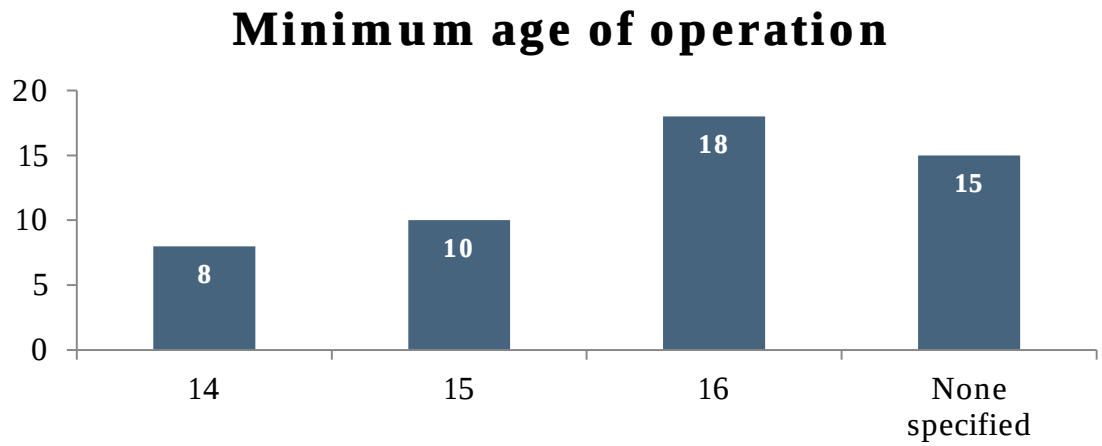

Figure 11: Number of U.S. states with specified minimum age of operator. *N* = 51.

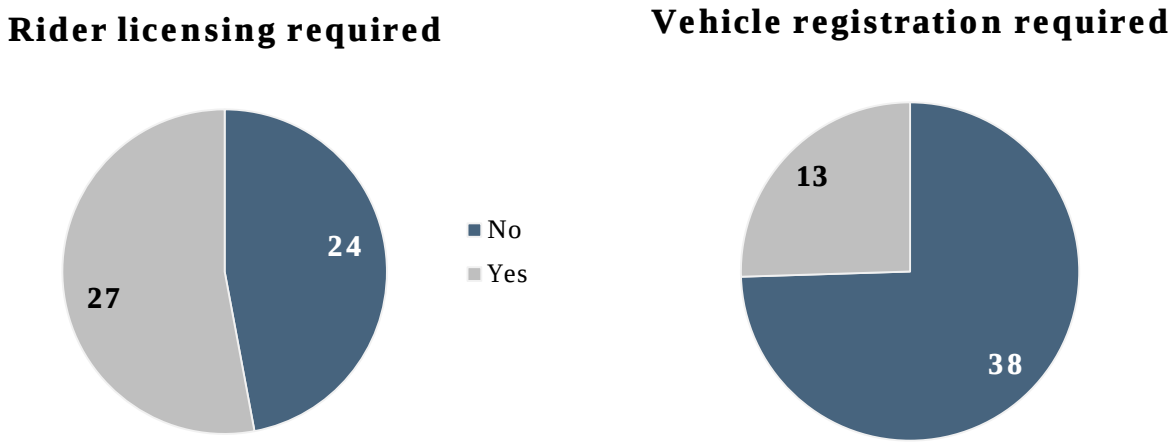

Figure 12: Number of U.S. states requiring rider licensing and vehicle registration for operation of electric bicycles. *N* = 51.

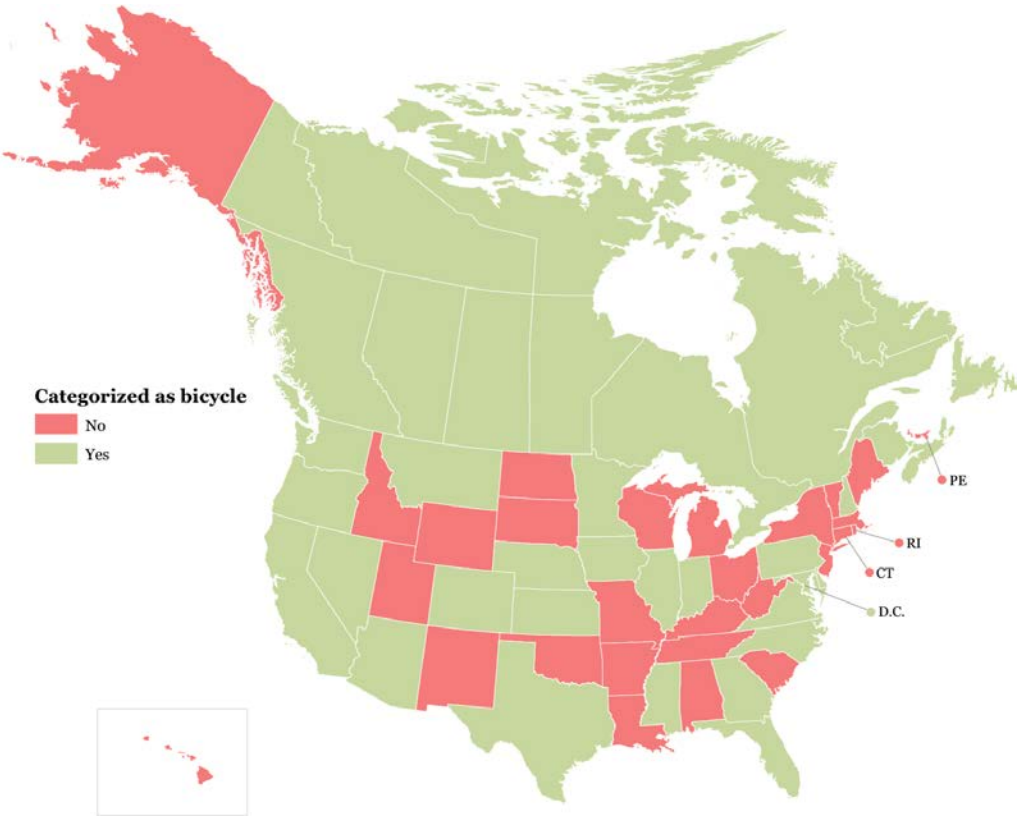

Figure 13: Areas where electric bicycles are classified essentially as standard bicycles, Canada and U.S., Nov 2014.

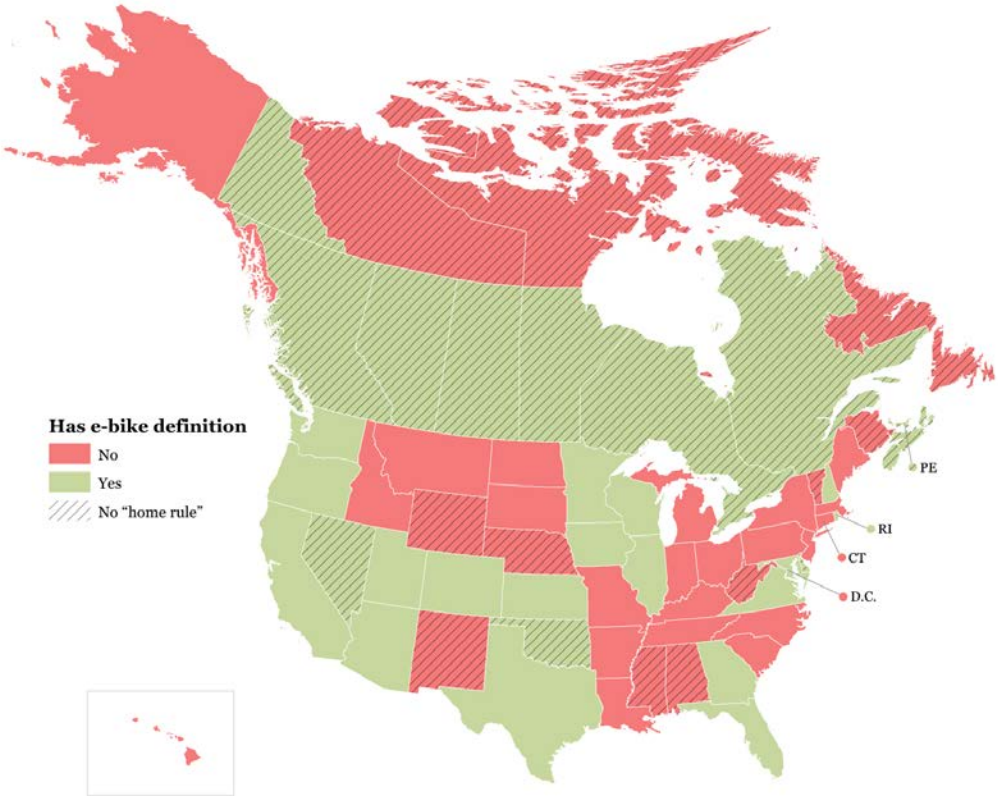

Figure 14: Codified definition that encompasses e-bikes by province/state with "home rule" areas un-hatched, Canada and U.S., Nov 2014.

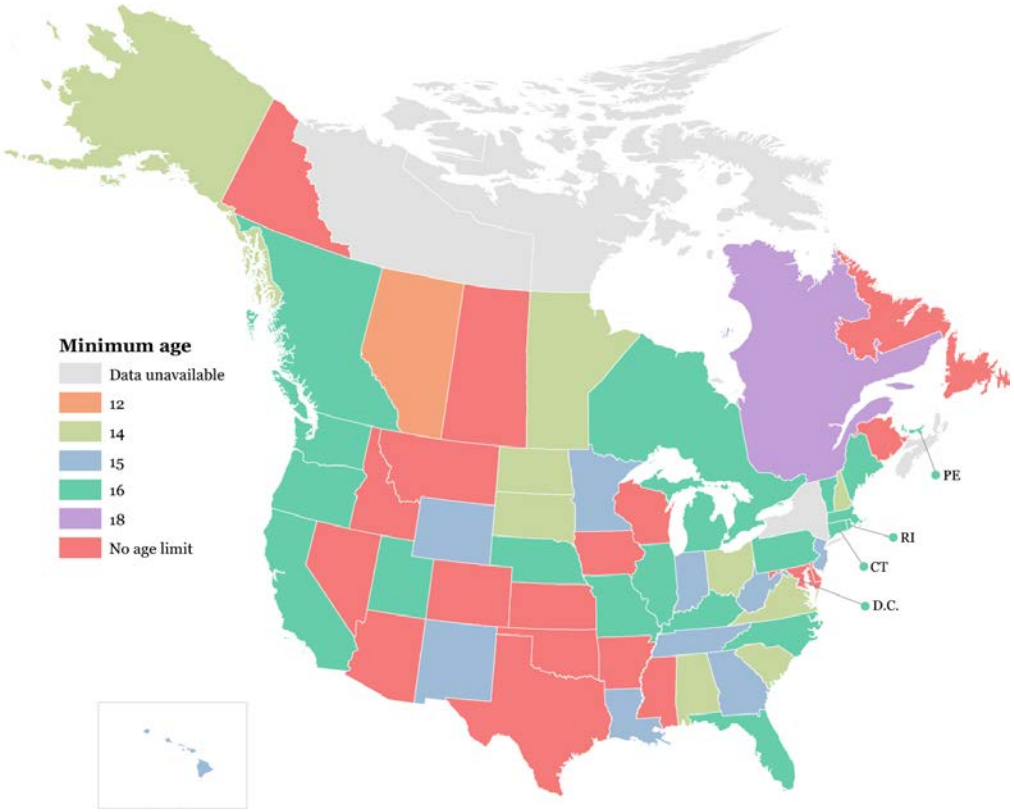

Figure 15: Minimum age of e-bike operation by province/state, Canada and U.S., Nov 2014.

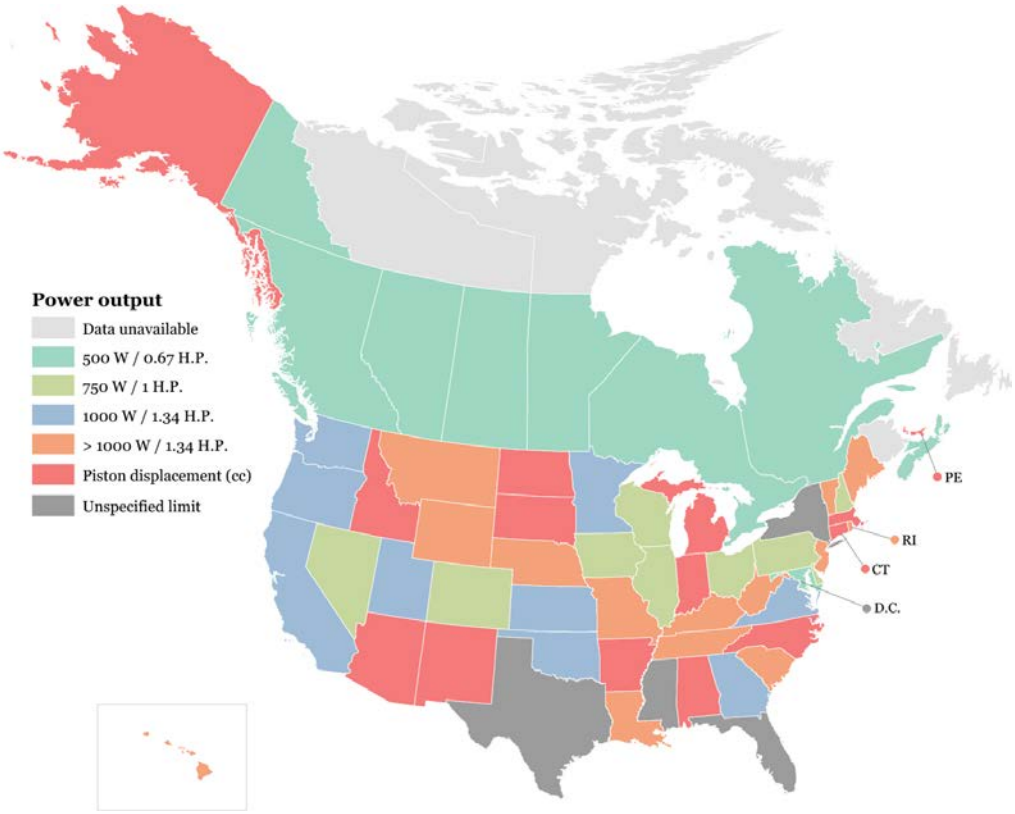

Figure 16: Maximum power output of e-bike motor by province/state, Canada and U.S., Nov 2014.

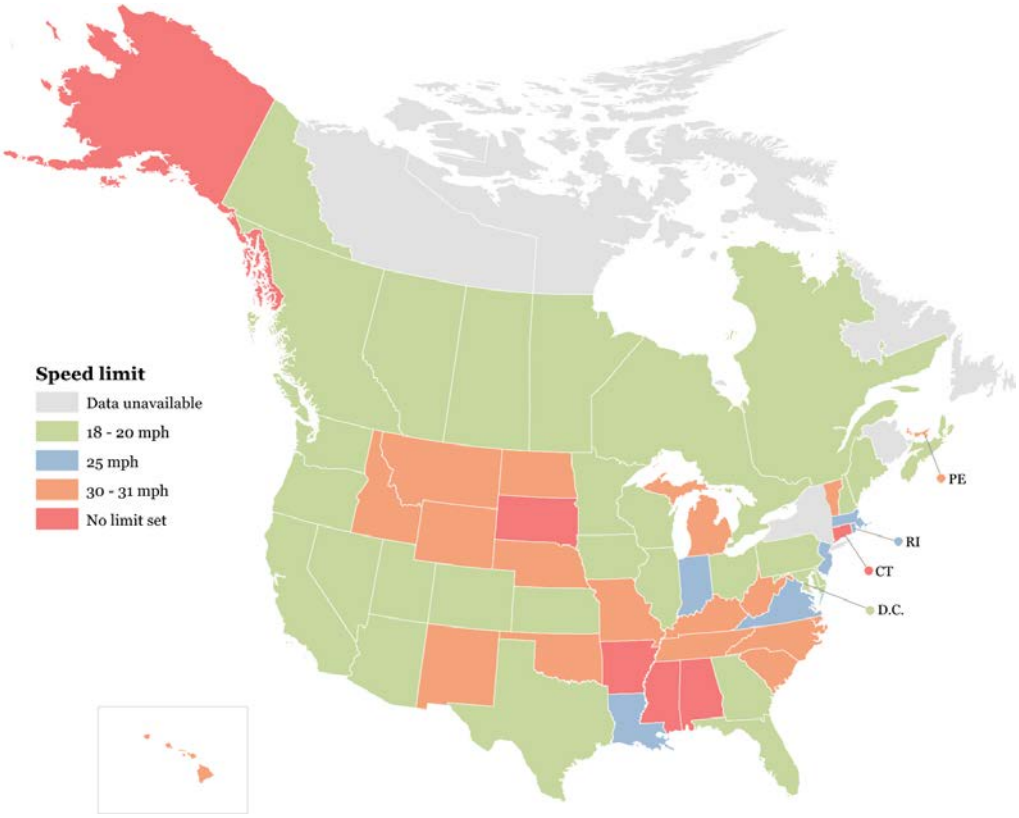

Figure 17: Maximum speed of e-bike operation by province/state, Canada and U.S., Nov 2014.

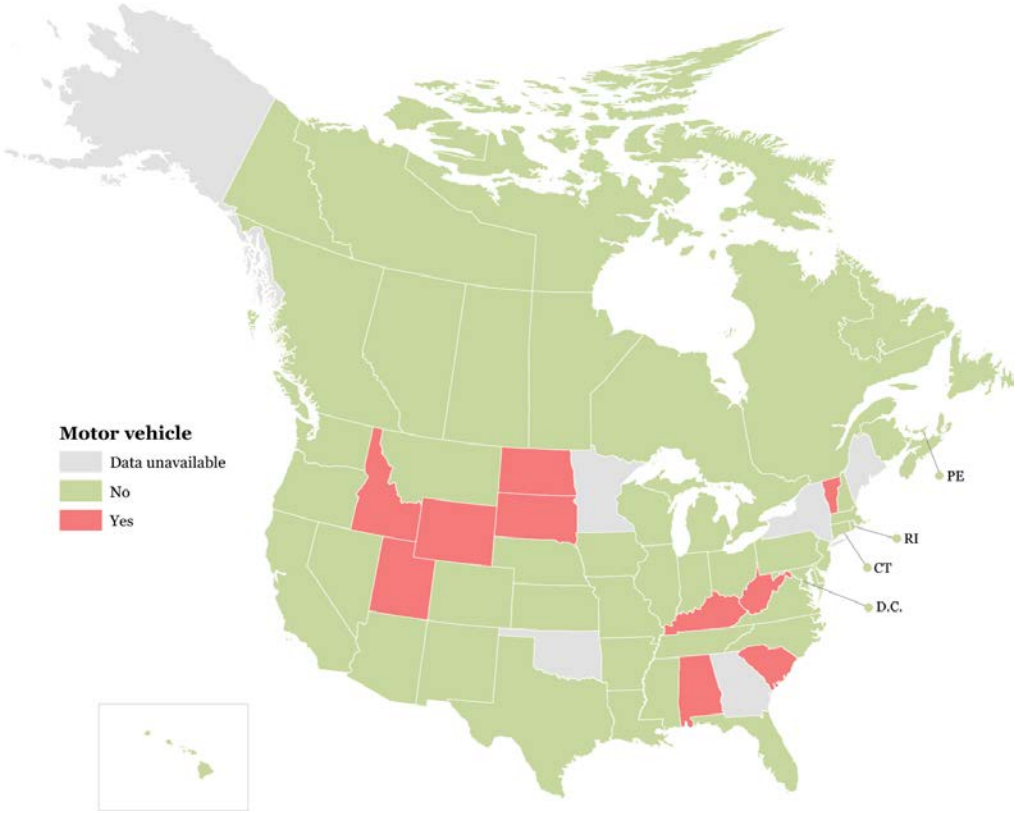

Figure 18: E-bikes considered "motor vehicles" by province/state, Canada and U.S., Nov 2014.

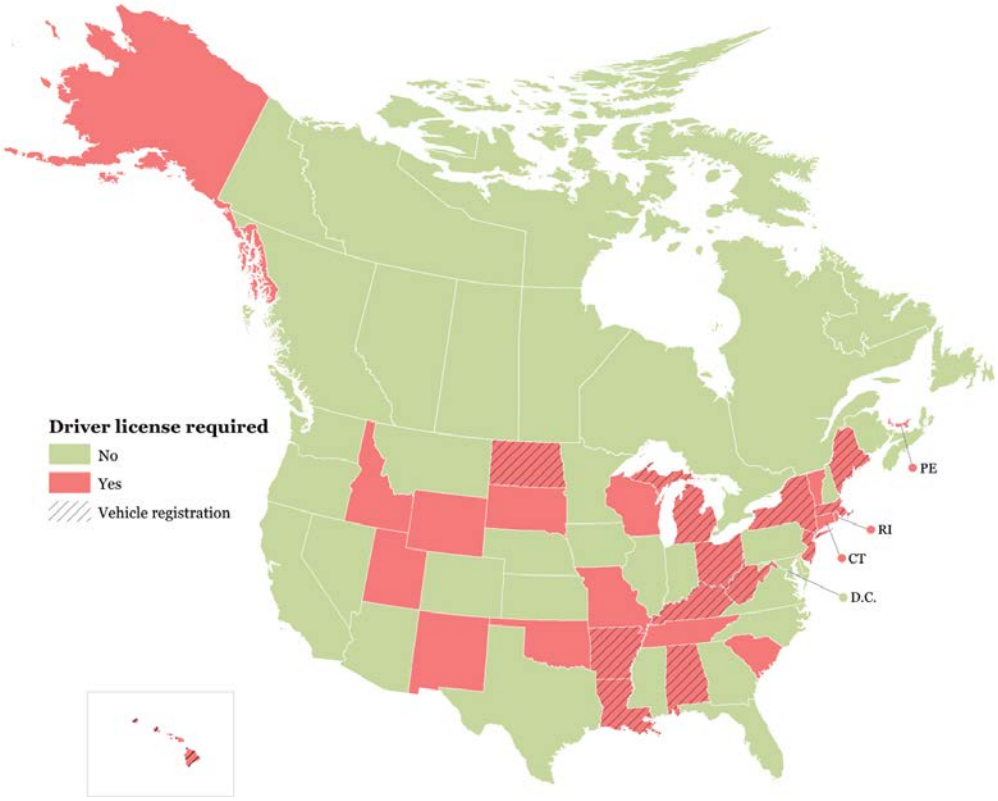

Figure 19: Provinces/states requiring operator license and vehicle registration for e-bikes, Canada and U.S., Nov 2014.

SPECIFIC EXAMPLES IN NORTH AMERICA

In the text below, we look at how some cities and states classify e-bikes under the law. It should be noted that in some locations, current laws are being proposed to amend vehicle code or local traffic ordinances, including Park City, Utah, Chicago, Nebraska and New York State.

Province of Ontario

Federal agency Transport Canada defined *power-assisted bicycles* (PABs) in 2000. In 2009, Ontario passed Bill 126, which amended the definition of bicycle to include PABs. It also adopted *power-assisted bicycles* into its Highway Traffic Act (HTA). This legislation came after a pilot project was launched in October 2006 that sought to evaluate the use of PABs on public roads, highways and in places where standard bicycles were allowed. The definition of PAB is under the current HTA (Highway Traffic Act, RSO 1990, c H.8):

> "power-assisted bicycle" means a bicycle that:
>
> (a) is a power-assisted bicycle as defined in subsection 2 (1) of the Motor Vehicle Safety Regulations made under the Motor Vehicle Safety Act (Canada),
>
> (b) bears a label affixed by the manufacturer in compliance with the definition referred to in clause (a),
>
> (c) has affixed to it pedals that are operable, and
>
> (d) is capable of being propelled solely by muscular power.

The same law also requires the operator to be 16 years of age or older and to wear a bicycle or motorcycle helmet, but no insurance, registration or operator's license is required. The pilot project in 2006 provided feedback from stakeholders on a range of issues, and one of the primary concerns was safety. Ontario responded by providing additional specifications for e-bikes, found in O Reg 369/09. One requirement is that the PAB's maximum weight is 120 kg (265 lbs) or less (Power-Assisted Bicycles, O Reg 369/09).

City of Toronto

Although Ontario has permitted the use of PABs on public thoroughfares since 2009, the province does not have jurisdiction over bicycle lanes and multiuse paths of municipalities. In Toronto, municipal code prohibits motor-powered vehicles from operation in bike lanes and shared paths. As e-bikes have become more popular, the need to address the incongruence between the spirit of the law and the ban itself has become more pressing. Following a staff report on PABs, City Council adopted the policy proposed therein with amendments in February 2014 (Toronto Transportation Services, 2013). The policy amended three municipal by-laws—parks, bike paths, and traffic and parking—by replacing the definition of *bicycle* with the following (Toronto City Council, 2014):

> **BICYCLE** – Includes a bicycle, tricycle, unicycle, and a **power-assisted bicycle** which **weighs less than 40 kg** [88 lbs.] and **requires pedalling for propulsion ("pedelec")**, or other similar vehicle, but does not include any vehicle or bicycle capable of being propelled or driven solely by any power other than muscular power.

Pedelecs will be permitted wherever bicycles are permitted, except on sidewalks. Transportation Services, in consultation with power-assisted bicycle riders and retailers, cycling groups, and the Toronto Police Service will monitor for the next two years the operation of power-assisted bicycles in conventional bicycle lanes in order to identify any safety concerns. Toronto regulation clearly defines pedelecs and e-scooters, but e-bikes that have throttle-only motors or throttle modes are not allowed. The MVSA defines a *power-assisted bicycle* as "***capable*** of being propelled by muscular power," but Toronto's definition "does ***not*** include any vehicle or bicycle ***capable*** of being propelled or driven ***solely*** by any power ***other than*** muscular power." So an e-bike similar to the Currie iZip E3 (Figure 3) may be illegal because it is capable of being propelled or driven by motor power only.

State of Colorado

Colorado is one of nine states that have incorporated aspects of CPSC's definition of low-speed electric bicycles into its vehicle code. The definition of *electrical-assisted bicycle* is found in Colo. Rev. Stat. § 42-1-102 (2013):

> "Electrical assisted bicycle" means a vehicle having two tandem wheels or two parallel wheels and one forward wheel, **fully operable pedals**, an electric motor not exceeding **seven hundred fifty watts** of power, and a top motor-powered speed of **twenty miles per hour**.

Colorado requires neither an operator's license nor vehicle registration. There is no minimum age of operation, and helmets are not mandated by state law. Colo. Rev. Stat. § 42-4-1412 (2013) lays out the proper operation of bicycles and other human-powered vehicles, including electrical-assisted bicycles. From left turns to operation on sidewalks, this clause contains a fair amount of language to make cyclists feel informed. One other noteworthy fact is that e-cyclists are forbidden from engaging the engine on bike and pedestrian paths under the same clause:

> 14. Except as authorized by section 42-4-111 [powers of local authorities], the rider of an electrical assisted bicycle shall not use the electrical motor on a bike or pedestrian path.

Another clause implies the power of local jurisdictions to impose further restrictions on e-bikes, such as the use upon sidewalks:

> 10. [...] (b) A person shall not ride a bicycle or electrical assisted bicycle upon and along a sidewalk or pathway or across a roadway upon and along a crosswalk where such use [...] is prohibited by official traffic control devices or local ordinances. [...]

In general, Colorado has been responsive and proactive to e-bikes by enacting these laws and establishing clearly the rules and responsibilities of riders.

City of Boulder, CO

Even though the state of Colorado has been responsive to developments in bicycle technology and their potential to reduce auto-dependency, the state still forbids road users from engaging the engine of *electrical-assist bicycles* on shared-use paths. In an effort to further the "complete streets" focus of the city's Transportation Master Plan (TMP), the City of Boulder announced a pilot program in August 2013 to allow e-bikes on multiuse paths, but not open-space trails (Boulder, CO, 2013). After a City Council unanimously approved the pilot in late October 2013, and from Feb. 7-Dec. 31, 2014, e-cyclists will be permitted to turn on the throttle of their e-bikes on designated multiuse paths.

State of New York

New York State has an outright ban on the use of e-bikes on any public thoroughfare. Dissenters are subject to arrest. Posted to their webpage on recreational vehicles, NYS DMV states (New York DMV, n.d.):

> **Motorized devices that cannot be registered in New York**
> You cannot register any of the motorized devices from the list below in NYS. You cannot operate these devices on sidewalks, public streets or highways in NYS. These devices are motor vehicles, but they do not have the correct equipment or design for operation on roadways. [...]
>
> **Motor-assisted Bicycle** - a bicycle to which a small motor is attached. A motor-assisted bicycle does not qualify for a registration as a motorcycle, moped or ATV and does not have the same equipment.

These devices are not allowed on any street, highway, parking lot, sidewalk or other area that allows public motor vehicle traffic. You are subject to arrest if you operate one of these motorized vehicles and do not have a registration, driver's license, inspection, insurance or correct equipment. The DMV cannot provide any information about operation of these devices on private property. Contact the local authorities and property owners.

It appears that New York State insists on having e-bikes registered using the VIN system. However, NHTSA, the federal agency responsible for issuing VINs, acknowledges the CPSC definition of low-speed electric bicycle, which is not a motor vehicle pursuant to 49 U.S.C. § 30102(a)(6). After all, bicycles are not provided a VIN by NHTSA. Many states assign VIN numbers to homemade vehicles and in other scenarios, but New York DMV refuses to assign a VIN to *motor-assisted bicycles*.

New York State Assembly and Senate have had various bills proposed over the years seeking to define *electric-assisted bicycles*.[22] The most recent bill is active in the 2014

[22] In the Assembly, Bills A00091-2001, A00588-2003, A00071-2005, A00189-2007, A02393-2009, A01350-2011, and A01618-2013 all sought to define *electric-assisted bicycle*. In each session, the Assembly voted nearly unanimously in favor of amendment, but the bills all died in the Senate through inaction.

session (A1618A-2013 and S390A-2013)[23] to amend the vehicle and traffic code in relation to the definition of electric-assisted bicycle and to bring New York in line with the CPSC definition. The bill's text does have one unique clause about use, where "no person less than sixteen years of age shall operate or ride as a passenger upon an *electric assisted bicycle*." This brings into question the use of electric cargo bikes that are used to carry small children.

New York City

New York City has an entirely different experience with e-bikes. The city's problem is that too many speeding messengers and food-delivery persons on e-bikes and e-scooters zoom down the crowded sidewalks, which poses a threat to pedestrians' safety (New York Office of Communications, 2013; Singer & Kilgannon, 2011). However, the city decided to make a sweeping ban on electric bicycles through Local Laws 2013/40 and 2013/41 (New York City, 2013a, 2013b).

Local Law 2013/40 defines *motorized scooter* to include powered bicycles (PB e-bikes):

> (a) [...] The term "motorized scooter" shall mean any wheeled device that has handlebars that is designed to be stood or sat upon by the operator, is powered by an electric motor or by a gasoline motor that is capable of propelling the device without human power and is not capable of being registered with the New York State Department of Motor Vehicles.

Local Law 2013/41 turns the focus toward *commercial* enterprises, stating:

> (k) A business using a bicycle for commercial purposes shall not possess any motorized scooter and shall not permit any employee of such business to operate such a motorized scooter on behalf of such business. A business using a bicycle for commercial purposes shall be liable for any violation of section 19-176.2(b) of this code committed by an employee of such business while such employee is operating a motorized scooter on behalf of such business.

Although New York City has recently doubled the fine for using motorized scooters on public thoroughfares. Power-assisted bicycles, which are not capable of propelling the bicycle *without* human power, seem to be exempt from this definition. But PABs are subject to state laws, and New York State still has a ban on any bicycle with a motor.

State of Michigan

While New York City has a clear stance on e-bikes, Michigan's law is ambiguous toward electric bicycles. The problem here is that Michigan vehicle code definitions are completely irrelevant to electric bicycles, but those definitions still govern the use and requirements for e-bikes.

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[23] Progress on the bill can be viewed at http://open.nysenate.gov/legislation/bill/S390A-2013 and at http://assembly.state.ny.us/leg/?bn=A01618&term=2013.

The Traffic Services Section of the Michigan State Police released Field Update 26 in 2006, which claimed that electric bicycles meet the state's definition of both *motor vehicle* and *moped* (Michigan State Police, 2006). Michigan Department of Transportation (MDOT) defines a *motor vehicle* at Mich. Comp. Laws § 257.33 (2013):

> "Motor vehicle" means every vehicle that is **self-propelled** [with exceptions].

And *vehicle* is defined under Mich. Comp. Laws § 257.79 (2013):

> "Vehicle" means every device in, upon, or by which any person or property is or may be transported or drawn upon a highway, **except devices exclusively moved by human power** [and other exceptions].

MDOT defines a *moped* at Mich. Comp. Laws § 257.32b (2013):

> "Moped" means a 2- or 3-wheeled vehicle to which **both** of the following apply:
> (a) It is equipped with a motor that **does not exceed 100 cubic centimeters piston displacement** and cannot propel the vehicle at a speed greater than 30 miles per hour on a level surface.
> (b) Its power drive system does not require the operator to shift gears.

Furthermore, mopeds must be registered with the Michigan Secretary of State and outfitted with headlights, turn signals, a horn, and brake lights, among other specifications. Applicants seeking to register their e-bike as a moped must provide a VIN number or allow the Secretary of State to assign a VIN.

Field Update 26 has two problems. First, because some e-bikes, specifically PABs, are not *self-propelled*, MDOT's definition of *motor vehicle* doesn't adequately include this hybrid, *assistive* technology. It is unclear whether there is any distinction between PBs and PABs under Michigan Comprehensive Laws. Second, the scope of MDOT's definition of *moped* would appear to be limited in scope to vehicles with internal combustion engines because it specifies a maximum cubic centimeter piston displacement (cc). E-bikes do not have an internal combustion engine specifically because they are electric, which makes irrelevant the specification for piston displacement. This ambiguity makes it seem as though e-bikes *cannot* be mopeds because they do not meet both of the specifications (a and b) of *moped*. However, e-bikes are in fact equipped with a motor that does not exceed 100 cc because there is *no* piston displacement.

State of Oregon

Oregon is one of several states that have specifically codified e-bikes into law. Oregon Department of Transportation (ODOT) defines an electric-assisted bicycle at Or. Rev. Stat. § 801.258 (2013):

> Electric-assisted bicycle means a vehicle that:
> 1. Is designed to be operated on the ground on wheels
> 2. Has a seat or saddle for use of the rider

3. Is designed to travel with not more than three wheels in contact with the ground
4. Has both **fully operative pedals** for human propulsion and an electric motor
5. Is equipped with an electric motor that
    a. Has a power output of not more than **1,000 watts**
    b. Is incapable of propelling the vehicle at a speed of greater than **20 miles per hour** on level ground

ODOT has even elucidated any potential ambiguity in its definition of a moped, at Or. Rev. Stat. § 801.345 (2013):

> Moped means a vehicle, including any bicycle equipped with a power source, other than an electric assisted bicycle as defined in ORS 801.258 (Electric assisted bicycle) or a motor assisted scooter as defined in ORS 801.348 (Motor assisted scooter) [...]

Furthermore, Or. Rev. Stat. § 814.405 (2013) establishes electric assisted bicycle as a bicycle under law:

> **Status of electric assisted bicycle.**
> An electric assisted bicycle shall be considered a bicycle, rather than a motor vehicle, for purposes of the Oregon Vehicle Code, except when otherwise specifically provided by statute.

The state does have some exceptions on the operation of e-bikes. Or. Rev. Stat. § 814.410 (2013) forbids using e-bikes on sidewalks. Or. Rev. Stat. § 807.020 (2013) sets the requirement of age at 16.

City of Eugene, OR

Home to the University of Oregon, the city of Eugene has a slightly different stance on e-bikes than ODOT. In 2005, Ordinance No. 20340 (2005) made several amendments to Eugene Code (E.C.) regarding motorized transportation devices. The city lumps all vehicles with any motor into one definition at E.C. 5.010:

> **Motorized transportation device.**
> Any vehicle that is not propelled exclusively by human power, including but not limited to, an **electric assisted bicycle** (when not being operated by human propulsion), an electric personal assistive mobility device, a moped, a motor assisted scooter, a motor vehicle, a motorcycle, a motorized skateboard, any similar vehicle that operates without human propulsion.

Ordinance No. 20340 (2005) also made it illegal to operate an e-bike on an off-street bike path at EC 5.160:

> **Unlawful Use of Motorized Transportation Device.**
> 1. No motorized transportation device may be operated on any city owned off-street bicycle or pedestrian path or trail, unless exempt. A motorized transportation device

> is exempt from this provision if it is used as a mobility aid by a person with a mobility impairment, used by a person with express permission from the City, or used by a City employee or agent in the course of City business.

The ordinance emerged at a time when the city saw an increase in several newer forms of motorized transportation, from gas-powered scooters to electric bicycles. The problem was that many residents who enjoyed walking along off-street nature trails felt that these new motorized devices detracted from the experience and beauty of the natural scenes along the trails. Among the worst were motorized scooters, which emitted noxious fumes and were a noisy nuisance. Residents reported their concerns to the city, and the conversation followed local police. The police department felt it would be too difficult to discern one type of motor from another for the purposes of enforcement. The city thus re-classified all vehicles with a motor as a *motorized transportation device* and forbid their operation on trails. Although cyclists can still pedal their e-bike down bike and pedestrian paths, they are forbidden to engage the motor.

There are efforts in the making to change this law, which are being spearheaded by Lee Shoemaker, Eugene's Bicycle and Pedestrian Coordinator. In November 2013, Shoemaker helped host an open house to hear public comments on a proposal to allow electric-assisted bicycles to be operated on off-street, shared-use paths. Although there were 15 yeas and five nays, some of the comments reflected a lack of understanding about what an e-bike is and how it is used (Personal correspondence, 2013). One commenter even voiced concern over fumes and noise, which suggests she/he anticipated a gas-powered engine. In July 2014, City Council voted to allow e-bikes on off-street bicycle and pedestrian paths/trails.

DISCUSSION

A scan of the regulations and definitions used for e-bikes shows the vastly differing terms and requirements for electric bikes. It is clear how easily confusion can arise. First, there is a perceived contradiction between the federal "definition" and how state bodies classify and govern the use of e-bikes. Second is the general lack of e-bike-specific definitions at the state level for most states, which tend to lump e-bikes into classifications such as *moped* or *motorized cycle*. When definitions do exist, they are often inappropriate, convoluted or inconsistent with information available on DOT and DMV websites. Lastly, there is sometimes contention between how states define and govern e-bikes and how municipal governments do so within their jurisdictions.

Confusion at federal level

Some of the clauses used regarding e-bikes by CPSC and NHTSA have led individuals to think that the federal rules "supersede" state laws. As discussed above, these rules are limited only to safety standards of manufacture because the regulatory bodies' jurisdictions do not extend beyond the purview of their roles as standard-enacting federal agencies.

Despite this separation of powers, it is common to find e-bike dealers and distributors encouraging their customers to print what they see as the "federal definition" and carry it

with them when they ride in case of any run-ins with police officers.[24] Although a copy of P.L. 107-319 might be convincing to a less-informed police officer, this interpretation demonstrates a lack of understanding of federal law, the role of certain federal agencies, and the interaction of federal law with state law. This also places a burden on dealers and distributors, who may not have the (legal) resources to parse through convoluted clauses. More importantly, however, it highlights the defensive and proactive approach riders must engender in order to establish themselves and their vehicle as a legitimate and properly regulated mode choice.

There is also the question of e-bikes not meeting the definition set by CPSC and NHTSA. Not all possible forms of e-bikes are encompassed by the federal definition, and new forms of transportation continually emerge. Firstly, what if an e-bike isn't manufactured and first sold as a *low-speed electric bicycle*, as defined by CPSC? Research recently completed by Portland State University surveying existing e-bike users in North America shows that 52 percent of e-bike owners converted their standard bicycle to an electric-assist bicycle (MacArthur, Dill & Person, 2014). These e-bikes were first purchased as a bicycle and later outfitted with an electric motor. Thus, CPSC is limited in its capacity to regulate the technology.

Secondly, there is a potential that e-bike manufacturers claim their products are not primarily for use on public thoroughfares. We did not find any legislative framework that would cover such e-bikes, as NHTSA does not regulate off-road vehicles such as ATVs or low-powered scooters/skateboards. The result is that manufacturers can produce non-standard e-bikes that may or may not be street legal, depending on the locality. Our analysis of how states define e-bikes discovered that 23 states set a maximum power output of 1,000 watts or greater (1.34 horsepower), which is above the 750-watt (1-horsepower) limit set by CPSC. Is this a safety standard that CPSC shall supersede, or does it qualify the device as something that's no longer a *low-speed electric bicycle*?

These scenarios present a problem because the law does not articulate clearly the various types of e-bikes and the way people currently use them. This creates uncertainty for manufacturers and distributors, as well as potential costly lawsuits for operators using non-standard bicycles on public thoroughfares.

Confusion at state level

As we have seen, the classification and identification of e-bikes varies widely by state (and, to a lesser extent, the Canadian provinces). An e-bike could be a bicycle, a moped, a motorized bicycle, a motor-driven cycle, a motorcycle, a motor vehicle, have its own definition, or none of these. But what about those states that have no definition of an e-bike? Certain states such as New Jersey, Michigan and New York (and others) do not allow for any middle ground between bicycles and motorcycles. The capability of motorized propulsion is enough for any two-wheeled vehicle to fall under motorcycle/moped

[24] Examples of dealers, distributors and manufacturers who advise patrons incorrectly about P.L. 107-319 are numerous, and include PAElectrics.com, High5Scooters.com, ShockingRides.com, and ScooterCatalogue.com, among others.

classification. The issue in such states is the lack of deference given to low-powered vehicles that do not require strict regulation.

Other states have more focused legislation that complies with the main premise of the federal definition, yet differs in several aspects (Table 4 above). Virginia, for example, requires pedals, an electric motor, and has legislation specifically designed to meet the requirements of the electric pedal assisted bicycle; however, the maximum speed and power exceed federal limits. Other states, like Texas, may meet the power and speed requirements, but do not require functional pedals or an electric motor. The issue in these states is whether that state recognizes the e-bike or simply uses existing moped laws, which are not tailored to the needs of cyclists.

There is also the question of the subtle distinction between "human powered" and "*solely* human powered" when defining bicycles and vehicles. The way Colorado amended its definition of bicycles in 2009 following House Bill 1026—the same bill that provided the definition of *electrical-assisted bicycle*—has implications for how other states' definitions of *bicycle* might actually encompass e-bikes. H.B. 1026 amended the definition of *bicycle* by striking the word "solely" from before "human powered" (Colorado Legislature, 2009):

> 10. "Bicycle" means ~~every~~ a vehicle propelled ~~**solely**~~ by human power applied to pedals upon which ~~any~~ a person may ride having two tandem wheels or two parallel wheels and one forward wheel, all of which are more than fourteen inches in diameter.

Because legislators intentionally deleted the requirement that the bicycle be exclusively human powered in the same bill they added the definition of e-bike to, this implies that bicycle-like devices which might have a motor or other assistive device to propel the bike, including electrically assisted bicycles, are indeed bicycles. Unless otherwise stated, wherever a law applies to a bicycle, it would apply to an e-bike, too.

Does that mean, then, that in states that omit the phrase "solely/exclusively [human powered]" when defining the term *bicycle*, e-bikes are considered to be bicycles? Finding the answer is something that may baffle even the most adept vehicle code attorneys. It partly depends on how other terms, like *motor vehicle* and *vehicle*, are defined, as well as the type of e-bike in question (i.e., throttle- vs. pedal-assist), as in the city of Toronto. If the motor disengages when the cyclist stops pedaling, then the device could arguably be "human powered." Whether this would stand in court is beyond the scope of this paper.

For the 20 states that do have definitions that are relevant to e-bikes, several have conflicting information. Taking the Colorado example further, when H.B. 1026 amended several codes, the definition of motor vehicle was amended as follows:

> 58. "Motor vehicle" means any self-propelled vehicle ~~which~~ that is designed primarily for travel on the public highways and ~~which~~ that is generally and commonly used to transport persons and property over the public highways; ~~but~~ except that the term does not include [...] **vehicles moved solely by human power** [...]

The legislature took time to amend bicycle to include *electrical-assisted bicycle* through striking the word "solely," but did not do the same for *motor vehicle*. So are e-bikes motor vehicles in Colorado? The city of Broomfield, CO, has a different take on the definition. Their website claims that *electrical-assisted bicycles* are not defined as motor vehicles and thus do not require a driver's license (Broomfield official website, n.d.):

> **Are riders of electrical assisted bicycles required to have a driver's license?** NO. Colorado Revised Statute 42-2-103 requires that the operator of a motor vehicle, including motorcycle and low-power scooter, obtain a driver's license. **Electrical assisted bicycles are not considered or defined as a motor vehicle and no license is required.**

The city of Broomfield may very well be providing the correct interpretation, but this highlights the contradictory nature of e-bike laws.

The significance of "solely [human powered]" hinges on the states of Utah and Oklahoma, which have an identity for electric bicycles but do not classify the device consistently relative to other states. In Utah, the classification is cyclical: an *electric-assisted bicycle* is defined as a *moped*, which is defined as a *motor vehicle*. However, the definition of *bicycle* includes *electric-assisted bicycle*, and Utah Code § 41-6a-102 (34)(b) (2013) states that a *motor vehicle* "does not include vehicles moved solely by human power." As a *bicycle*, is an *electric-assisted bicycle* allowed in bicycle lanes or sidewalks? As a *motor vehicle*, is the operator required to be licensed? The law is contradictory and creates considerable confusion for the cyclist who seeks to be compliant.

Oklahoma is similarly unclear. *Electric-assisted bicycles* are defined as bicycles, and they are allowed on multi-use paths, bicycle lanes and sidewalks. They do not require registration, and there is no minimum age. However, e-cyclists are required to have a driver's license to operate an *electric-assisted bicycle*. Again, a *motor vehicle* is any self-propelled vehicle except those moved solely by human power in Oklahoma (Okla. Stat. tit. 47 § 1-134, 2013), so does that include *electric-assisted bicycles*? If so, how are these motor vehicles permitted to operate on sidewalks, especially considering they are allowed to reach speeds of up to 30 mph?

The need for uniformity of state e-bike regulation is clear. Several states seem to have laws that are appropriate and proportional yet fall short by requiring helmets, age restrictions, and licensing and registration of the vehicle and rider. For many e-bike advocates, the ideal situation would apply legislation to bicycles and low-speed electric bicycles equally, providing riders of low-speed electric bicycles the same rights and restrictions as the standard cyclist. But this equivalence is something still in question by the general public, policymakers, some bike and pedestrian advocates, and public safety officials.

What constitutes an e-bike?

The confusion at the state and federal levels can be attributed partially to the ambiguity of the laws. The definition laid out by CPSC covers three requirements: speed, power and pedals, though there is no consensus or details on the meaning of "functional pedals." States and provinces often include these same requirements. What are not specified is size, weight, geometry and assistance ratios, leaving an incredible amount of flexibility in the law. Manufacturers have taken advantage of that flexibility by supplying the market with vehicles that—though technically *low-speed electric bicycles* (U.S.) or *power-assisted bicycles* (Canada)—look nothing like a bicycle. Indeed scooter-style electric bicycles (SSEBs) that meet the federal and state/provincial definitions often don't require a driver's license and vehicle registration, which makes them a popular alternative to higher-powered mopeds, scooters and motorcycles,[25] particularly for those people who have never been licensed or who have lost their license because of DUIs or other reasons. This raises several questions. What makes an e-bike an *e-bike*? Can we reasonably expect law enforcement to become aware of all forms of e-bikes in order to carry out the law? Can the existing framework enable policymakers to write the most appropriate legislation for the use of e-bikes?

The concerns raised here are not hypothetical, and one case in Oregon helps to illustrate the tension caused by SSEBs and law enforcement. In 2011, Springfield Police stopped and cited rider Paul McClain six times for operating a motor vehicle without a driver's license (McCowan, 2011b). McClain's license was revoked several years earlier for operating a motor vehicle without insurance. The last citation, issued by Officer Michael Massey on March 24, 2011, caused McClain to argue in court *pro se* that his vehicle was no motor vehicle at all, rather a fully compliant *electric-assisted bicycle*. Indeed, the vehicle met ***most*** of the requirements fitting the definition of electric-assisted bicycle under Or. Rev. Stat. § 801.258 (2013). The outward appearance struck the officers as more of a moped than an electric bicycle. One officer felt that if you're not pedaling the bicycle, it becomes a motor vehicle under law (McCowan, 2011a). The "e-bike" was, after all, a scooter-style electric bicycle (Figure 20). The case made its way to District Court, where Senior Judge Raymond White ruled that, due to a missing pedal, the vehicle was rendered a *motor vehicle* under Or. Rev. Stat. § 825.005 (9) (2013). McClain was found guilty of operating a motor vehicle on a suspended license.

[25] Though this paper tries to show the differences between electric bicycles and other devices, such as scooters, mopeds, etc., and the need for specific recognition for e-bikes in state regulations, the authors recognize that these other devices are important transportation vehicles and should be promoted where appropriate.

Figure 20: Photograph of McClain's scooter-style electric bicycle with a broken pedal. The imprint reads *XL500W*, which corresponds to an EW-600 model of manufacturer Electric Wheels. *Image source*: Officer Michael Massey, Springfield Police, edited by authors.

This case is more complex than initial observation and lends itself well to other cases in which an individual was operating an e-bike without a grant of driving privileges. It had potential to set a precedent as to what constitutes an e-bike and whether operating an e-bike on a suspended license was forbidden. But what would have happened if the pedals had been fully operable? Or what if the pedals were removed and stored under the seat, as one Ontario man did in 2012 (R. v. Pizzacalla, 2013 ONCJ 31). In this case, which landed in provincial court, the judge ruled in favor of the defendant, wherein a "defective or incomplete" *power-assisted bicycle* did not inherently elevate to the status of a motor vehicle. Some kinds of e-bikes may push the intent of the law. But the question of whether it is still appropriate on bicycle infrastructure is still open to debate. As more vehicles emerge that push the extent of the law, the need to draw a line between motor vehicles and electric bicycles will grow.

The question of whether riders with suspended driver licenses are allowed to operate e-bikes is another area of uncertainty. In Oregon, Or. Rev. Stat. § 807.020 (2013) specifies that although no driver's license is required, the operator must be *eligible for* a license:

> **Exemptions from requirement to have Oregon license or permit.**
> A person who is granted a driving privilege by this section may exercise the driving privilege described without violation [...] A grant of driving privileges to operate a motor vehicle under this section is subject to suspension and revocation the same as other driving privileges granted under the vehicle code. [...] The following persons are granted the described driving privileges:
> 1. [...] A person is **not granted driving privileges** under this subsection:
>   a. If the person is under the minimum age required to be eligible for driving privileges under ORS 807.060 (Eligibility); [or]
>   b. **During a period of suspension or revocation** by this state or any other jurisdiction of driving privileges or of the right to apply for a license or driver permit issued by this state or any other jurisdiction; [...]

14. A person may operate a bicycle **that is not an electric assisted bicycle** without any grant of driving privileges.
15. A person may operate an electric assisted bicycle **without a driver license or driver permit** if the person is 16 years of age or older.

In extended correspondence with the Oregon Department of Motor Vehicles, they stated that the legality of riding an e-bike with a suspended license is left up to law enforcement and the courts, and that the DMV does not provide information on whether law enforcement or courts can cite/convict people. Essentially, some law enforcement agencies will cite and convict while others will not. This does not lend confidence to riders who have been convicted of DUIs.

While some may argue the revocation of a license is both punitive and remedial, others might argue the fines and other sanctions associated with DUI convictions are the punitive portion; the revocation is remedial for the sake of public safety. Following the latter argument, if e-bikes are similar to standard bicycles in terms of potential for inflicting harm, does the remedial function of license revocation have any relevance for e-bikes?

IMPLICATIONS

More people participating in cycling can help alleviate environmental, traffic and public health concerns. More manufacturers producing electric bicycles can help increase and diversify the economic base of cities across the nation and provide family-wage jobs. If we want the benefits of cycling and of an emerging industry, it is important to have a standardized definition and uniform regulation of e-bikes at state and federal levels. E-cyclists should be able to cross borders without fearing harassment, confusion or penalties. Manufacturer's should feel confident about expanding their markets and not have to worry about the legal status of their product. The need for standardization is pressing, and policymakers must determine the appropriate requirements for e-bikes.

Unclear legislation and a lack of agreement about what exactly constitutes an e-bike is cause for uncertainty over the proper and legal use of e-bikes. What, then, are the ramifications of that uncertainty?

E-bikes are not mopeds and should have their own regulations

E-bikes are neither mopeds nor scooters. Although e-bikes are typically heavier than the average bicycle due to the battery and motor, these components are becoming lighter and lighter, which brings them more in line with standard bicycles than devices that weigh several times more. Moreover, the maximum possible speed of electric bicycles pales in comparison to that of mopeds, scooters and motorcycles. We learn early in school that kinetic energy varies directly with mass and velocity squared and that force is the product of an object's mass and acceleration. The mass and maximum velocity (and hence acceleration) of an e-bike are significantly lower than a moped or motorcycle. Assuming the risks of bodily harm are a major component in the formation of vehicle legislation, why do 24 states lump electric bicycles in the same category as mopeds or scooters? What kinds of issues does this create?

Recall the distinction between bicycle-style electric bikes (BSEB) and scooter-style electric bikes (SSEB). These broad categories provide us with conceptual frameworks for considering e-bikes, which exist on a spectrum rather than a rigid classification. But this is imprecise for policy making and legislation, particularly when dealing with bicycle infrastructure. Do the definitions of e-bikes need to be made clearer to either broaden or narrow the interpretation? Or does a multi-criteria analysis of e-bikes need to be implemented, which accounts for the differences in speed, functional pedals, weight, geometry, function, power, etc.? The Volkswagen concept e-bike, *Bik.e,*[26] is an electric velocipede—that is, it has no pedals but is similar in geometry and weight to a standard bicycle. Another example is the SOLARped,[27] which has four wheels and a top cover. Many of the definitions of e-bikes limit bikes to two or three-wheeled devices. It is arguable that such devices are suitable for bicycle infrastructure, but the lack of operable pedals or the geometry raises questions about how to classify them.

One issue is a clear gap between the prescribed safety requirements for electric bicycles and the actual risk posed to the safety of e-bike riders and others. Additional requirements discourage the (legal) use of electric bicycles, which is one way to allow a broader participation in cycling. In states like Michigan, the additional requirements are particularly onerous: a headlight that illuminates objects at least 100 feet ahead; a horn audible from at least 200 feet away; a tail light; a brake light; a rear-view mirror; a permanently mounted seat; and handlebar geometry. Some states may require DOT FMVSS 218 approved helmet which would make bicycling difficult and excessive for bicycling speeds. Without even considering the cost imposed on the consumer for bringing an e-bike into compliance, how does the state of Michigan view these requirements as necessary for safe operation? Indeed, if the requirements *are* considered necessary for safe operation, why aren't they required for standard bicycles, which are more similar to e-bikes than e-bikes are to mopeds? The point is that definitions and requirements of vehicles should be based on factual safety considerations that take into account the vehicle's weight and speed.[28]

Incidental to the safety gap is another issue: liability. Draconian rules may seem incredulous to e-bike cyclists, who react by thinking the law doesn't apply to their bicycle. A Michigan resident might read the definition and requirements of a moped and believe it impossible for brake lights and a fixed seat to be required of their electric bicycle. This belief is consistent with reports of e-bike distributors claiming that CPSC's definition of *low-speed electric bicycle* "supersedes" states' definitions (see footnote 24). But in reality, the consequences for disobeying these requirements can be severe. It leaves the operator exposed to the risk of expensive lawsuits in the event of an accident, particularly if it involves a pedestrian. It also leaves the cyclist with little recourse for accidents where the

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26 Electric Bike by Volkswagen Auto China 2010: https://www.youtube.com/watch?v=sXhhWXw9V7A

27 http://store.rhoadescar.com/SOLARped_c_16.html

28 Regulating the power output of electric motors is an indirect way to control safety, usually measured in (brake) horsepower or watts. As the vehicle weight (or weight of rider) increases and the power output remains constant, the maximum achievable speed decreases, which in turn affects kinetic energy.

cyclist was not at fault, for their case may be more easily dismissed if they were operating non-compliant equipment.

It's not just inconvenience and financial risk that result from conflating e-bikes with scooters and mopeds under law. Another issue is that the true parameters for safe operation are not communicated to e-bike users. Although e-bikes can be more similar to bicycles than they are to scooters, they are indeed not bicycles. Relative to bicycles, specific locations may need to impose more stringent regulations on e-bikes. For example, in a city that has frequent interaction between cyclists and pedestrians, a valid concern is that pedestrians might see a bicycle not being pedaled and think it is slowing down. In reality, it could be an e-bike being accelerated via the throttle. Such a city might dutifully permit only pedal-assist bicycles (PABs) and prohibit throttle-assist e-bikes (PBs), as Toronto and European countries have done. However, implicit in lumping e-bikes with scooters and mopeds is the assumption that there are no divergent safety considerations beyond what is stated in the law. These nuances can only be appreciated when e-bikes are fully recognized as a vehicle separate from mopeds and scooters.

E-bikes should be given (most of) the same rights as bicycles

In addition to the issues caused by the lack of standardization of electric bicycle definitions and requirements, the manner in which e-bikes ought to be used brings up other concerns. Where should they be permitted or prohibited from operating, and how fast should they be set at? What kind of burden do electric bicycles place on bicycle infrastructure? Is there a difference between PBs and PABs that should be acknowledged by policies? Does it matter if an e-bike has pedals? As more people start to participate in biking, situations will arise that will require the answers to these questions.

Devices that go faster than 20 mph probably do not belong in bicycle lanes and shared-use paths. But it's an open debate about where e-bikes belong if they travel slower than 20 mph, and it is especially debatable and contentious if they don't look like a standard bicycle (i.e., they are SSEBs). However, in general, the design of shared-use paths[29] accommodates electric bicycles. The American Association of State Highway and Transportation Officials (AASHTO) specifies a 14-mph minimum and a 30-mph maximum design speed for shared-use paths in their bicycle facilities guide, with a generally sufficient design speed of 18 mph (AASHTO, 2010). The mean speed of cyclists in one study was 11 mph, with a standard deviation of 3.7 mph—the 85th percentile was 14 mph (Landis, Petritsch & Huang, 2004). Only 1 percent of bicyclists observed exceeded 20 mph (ibid). This is mostly consistent with AASHTO's performance criteria for upright adult cyclists on paved level terrain, which ranges from 8-15 mph; physically fit cyclists can reach speeds of 30 mph or higher (AASHTO, 2010). If low-speed electric bicycles are not allowed to be on bicycle infrastructure because of their speeds, it does create additional safety issues if they are forced into vehicle traffic lanes.

[29] A shared-use path is defined as, "a bikeway physically separated from motor vehicle traffic by an open space or barrier and either within the highway right-of-way or within an independent right-of-way. Shared-use paths may also be used by pedestrians, skaters, wheelchairs users, joggers, and other non-motorized users. Most shared-use paths are designed for two-way travel," (AASHTO, 2010).

These standards and statistics show that shared-use paths meeting AASHTO standards can easily accommodate e-bikes. Although reports of actual e-bike speeds are sparse in the literature, one study documenting an electric-bike sharing system showed that both the average speed and maximum speed of e-bikes were slightly higher (approximately 3 mph) than standard bicycles (Langford, 2013). This is consistent with anecdotal evidence of e-bike speeds. There is a design-cost tradeoff between the quality and efficiency of the pedal chain drive and the inclusion of electrical components, such as the motor, battery and sensors. The weight and inferior chain-drive components of e-bikes requires more physical exertion to attain speeds higher than the maximum motor output relative to standard bicycles. This means that the variance of e-bikes' speed is likely lower than standard bicycles. One study in Sweden showed a much lower variance of e-bike speeds compared to standard bicycles, though reported average speeds were higher (Dozza, Werneke & Mackenzie, 2013). Transportation planners and policymakers must evaluate their bicycle facilities to determine if electric bicycles ought to be permitted. However, in order for planners and policymakers to rationally evaluate the potential impact of e-bikes on their facilities, more robust data on e-bikes must be available. Manufacturers must test the speed, weight and other characteristics of their e-bikes and publish their results. Simultaneously, transportation researchers ought to collect on-the-ground data for e-bikes to help determine the true differences between e-bikes and standard bicycles.

Another concern planners must face is whether there is a meaningful difference between PBs (pedaling not required) and PABs (pedaling required), and whether the presence of pedals has any impact on where the device can and cannot be used. In British Columbia and Toronto, PABs are permitted while PBs are classified as a higher order vehicle (BC Reg 151/2002; Toronto, Ontario, City Council, 2014). Although the European Union also extends leniency to PABs while imposing more restrictions on PBs, most other places in North America do not distinguish between the two types. SSEBs are often PBs, but the degree to which a rider can effectively propel the bicycle using the pedals is questionable.

There is no legislation in place that imposes requirements on how effective the pedals must be. There are philosophical arguments about "cheating" by operating SSEBs and PBs in bicycle lanes without pedaling. There are also arguments about whether operators of SSEBs and PBs would be safe in traffic if they were prohibited from bike lanes, paths and trails. Policymakers and planners must consider the safety of PBs and SSEBs mixing with cyclists, pedestrians and other path users. But they must also think about climate change goals and how privileging PBs and SSEBs to use bicycle infrastructure would still encourage more people to get out of their car and onto a more efficient vehicle.

The federal governments of the United States and Canada have provided a framework for states and provinces with regard to e-bikes. Policymakers must now work to incorporate the federal law into local statutes. More populous provinces have been successful at adopting the federal law, but only nine of 51 U.S. states have amended their vehicle code to accept CPSC's definition. The question of what kinds of bicycles we wish to see in our transportation facilities, such as protected lanes, shared used paths, sidewalks and trails, remains open to debate.

CONCLUSION

Electric bikes are here to stay. The federal government did its part in providing a framework definition of the low-powered electric bicycle. However, the widely disparate statutes and codes, some of which were discussed in this paper, leaves the public all but confused about their legal rights and duties when using electric bicycles. While some states like Oregon readily accept the burgeoning technology, other states such as Michigan are behind in developing regulations. If we are to meet our goals of reduced emissions and VMTs for the next 30 years, policymakers must readily provide a place for e-bikes in codified law. Alas, until we have a common understanding of "e-bike," this will be a difficult road to travel down.

There is much confusion in North America as it relates to the definition of e-bikes but also in how they are governed. Part of the problem has been due to the fact that this is a new industry with low market penetration, so the general public is not aware of the differences in technology. This directly translates into how policy is written and developed. The other issue has been the industry's inability to differentiate their products from other devices, such as mopeds, scooters and motorcycles. Part of the issue in New York City and the recent ban of e-bikes is due to poorly written state and local regulations, but it is also an issue of clearly defining the difference between scooters and e-bikes. It is now the responsibility of the consumers, the industry and interested parties to educate policymakers in each state to change definitions and regulations related to e-bikes.

There is currently no known published research or market data showing how the general public perceives electric bikes in the U.S. This includes both how people define an electric bike and the differences between electric bikes and scooters, mopeds, motorcycles and traditional bicycles, and how and where these bikes should be used. To develop national statewide policy, this type of information is extremely important in crafting both appropriate policies but creating buy-in by the public in how these bikes should be used. In recent reviews of blogs, many people believe that a typical e-bike will go faster than a bicycle. This might be the case of average speed and under certain conditions, but many road bicycles can reach speeds far greater than 20 mph. Understanding how e-bikes fit into the transportation system and interact with other vehicles, bikes and pedestrians can add to the discussion.

This can be accomplished through groups like the Light Electric Vehicle Association (LEVA). The LEVA represents the strategic interests of light electric vehicle retailers, dealers, distributors, manufacturers and suppliers to promote the development, sale and use of LEVs worldwide. The LEVA has developed a legal regulation policy document, which includes definitions for e-bikes and suggested use regulations for states to adopt (LEVA, 2011). The LEVA and other e-bike advocates should work with organizations that have interest in how e-bikes are defined and legislated, such as the National Bicycle Dealers Association, the League of American Bicyclists, the Association of Pedestrian and Bicycle Professionals, International Mountain Bicycling Association, AAA, and the American Association of Motor Vehicle Administrators.

Finally, it is important to reach out to the general public to ensure a common understanding what e-bikes are and how they differ from mopeds. This can be done through media outreach and events that help reach a better understanding. How print and online media discuss e-bikes can greatly shape perception of the devices. For example, on May 14-15, 2014, in Crystal Springs Resort, NJ, there was an e-bike and outdoor technology media event called Charged Up (http://www.interbike.com/events/electric-bike.htm). The event was aimed at non-endemic consumer and technology print, broadcast and online media. Invited journalists were exposed to the advancements and functionality of e-bikes, portable power, safety and fitness gear, along with innovations in wearable technology.

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Appendix A: Electric bicycle laws by state/province.

Area	Identity	Bicycle?	License?	Registration?	Age	Power	Speed	Pedals?	Federal?	Helmet?	Paths?	Sidewalks?	Law references
Alabama	Motor-Driven Cycle	N	Y	Y	14	150 cc	--	N	N	Y	N	N	Ala. Code § 32-1-1.1 (2013); § 885-1-1-.05; 32-5A-245; 32-12-41
Alaska	Motor-Driven Cycle	N	Y	N	14	50 cc	--	N	N	N	N	N	Alaska Stat. § 28.90.990
Arizona	Motorized Electric Bicycle	Y	N	N	--	48 cc	20	N	N	N	Y	Y	Ariz. Rev. Stat. § 28-2516
Arkansas	Motorized Bicycle	N	Y	Y	--	50 cc	--	N	N	N‡	N	N	Ark. Code § 27-20-101; § 27-20-106
California	Motorized Bicycle	Y	N	N	16	1000 W	20	Y	N	Y	N	Y	Cal. Veh. Code. § 100-680-406; 21207.5 & 21209; 24016; 21212
Colorado	Electrical Assisted Bicycle	Y	N	N	--	750 W	20	Y	Y	N	N*	Y	Colo. Rev. Stat. § 42-1-102 (28.5); § 42-4-1412; § 42-4-111
Connecticut	Motor-Driven Cycle	N	Y	N	16	50 cc	--	N	N	N‡	N	N	Conn. Gen. Stat. § 248-14-1 (52); § 248-14-286
D. C.	Motorized Bicycle	Y	N	N	16	--	20	Y	N	N	N	N	D.C. Code § 18:99-01; § 50:1501.01-03; D.C. Act 19-658
Delaware	Bicycle	Y	N	N	--	750 W	20	Y	Y	N‡	Y	Y	Del. Code tit. 21 § 1-101 (2); tit. 21 § 41
Florida	Bicycle	Y	N	N	16	--	20	Y	N	N	Y	Y	Fla. Stat. § 322.01; § 316.003
Georgia	Electric Assisted Bicycle	Y	N	N	15	1000 W	20	Y	N	Y	Y	N	Ga. Code § 40-1-1 (15.5); § 40-6-294; § 40-6-351; § 40-6-352
Hawaii	Moped	N	Y	Y	15	1491 W†	30	N	N	N‡	N	N	Haw. Rev. Stat. § 14:249-1; § 17:286-81; § 17:291C-194
Idaho	Moped	N	Y	N	--	50 cc	30	N	N	N		Y	Idaho Code § 49-114; § 49-721; § 49-1428
Illinois	Low-Speed Electric Bicycle	Y	N	N	16	750 W	20	Y	Y	N‡		N	625 Ill. Comp. Stat. 5/1-140.10; 625 ILCS 5/11‑1516
Indiana	Motorized Bicycle	Y	N	N	15	50 cc	25	N	N	N‡		N	Ind. Code § 9-13-2-109; § 9-21-11-12
Iowa	Bicycle	Y	N	N	--	750 W	20	Y	Y	N	Y	Y	Iowa Code § 321.1
Kansas	Electric Assisted Bicycle	Y	N	N	--	1000 W	20	Y	N	N	Y	Y	Kan. Stat. § 8-1489
Kentucky	Moped	N	Y	Y	16	1491 W†	30	N	N	N‡		N	Ky. Rev. Stat. § 187.290 (5); § 189.285
Louisana	Motorized Bicycle	N	Y	Y	15	1119 W†	25	N	N	Y		N	La. Rev. Stat. § 32:401 (19); § 32:198; § 32:190
Maine	Motorized Bicycle	N	Y	Y	16	1119 W†	20	N	N	N‡		Y	Me. Rev. Stat. tit. 29-A § 101-1 (41); tit. 29-A § 11; tit. 29-A § 19; tit. 29-A § 2063
Maryland	Electric Bicycle	Y	N	N	--	500 W	20	Y	Y	N	Y	N	Md. Code, Com. Law § 11-117.1; § 21-1200
Massachusetts	Motorized Bicycle	N	Y	Y	16	50 cc	25	N	N	Y	Y*	Y*	Mass. Gen. Laws ch. 14, §§ 90-1B~E; ch. 14 § 90-1
Michigan	Moped	N	Y	Y	16	100 cc	30	N	N	N‡	N	N	Mich. Comp. Laws § 257.32b; § 257.79; § 257.33; § 257.4
Minnesota	Electric-Assisted Bicycle	Y	N	N	15	1000 W	20	Y	N	N	Y	Y	Minn. Stat. § 169.011 (27); § 168A.03; § 160.263
Mississippi	Bicycle with a Motor Attached	Y	N	N	--	--	--	N	N	N	Y*	Y*	Op. Atty. Gen. No. 2007-00602; Op. Atty. Gen. No. 2011-00095; Miss. Code § 63-3-103
Missouri	Motorized Bicycle	N	Y	N	16	2238 W†	30	N	N	N		N	Mo. Rev. Stat. § 301.010 (36); § 300.347; § 307.180; § 307.195
Montana	Bicycle	Y	N	N	--	1491 W†	30	Y	N	N	Y	Y	Mont. Code § 61-8-102; § 61-1-102; § 61-8-608
Nebraska	Moped	Y	N	N	16	1491 W†	30	Y	N	Y	Y	Y	Neb. Rev. Stat. § 60-122; § 60-638; § 60-6,279
Nevada	Electric Bicycle	Y	N	N	--	750 W	20	Y	Y	N	Y	N	Nev. Rev. Stat. § 484B.017; § 484B.777; § 484B.117; § 483.090
New Hampshire	Electrically Powered Bicycle	Y	N	N	14	750 W	20	Y	Y	N‡		N	N.H. Rev. Stat. § 259:65
New Jersey	Motorized Bicycle	N	Y	Y	15	1119 W†	25	N	N	Y	N	N	N.J. Rev. Stat. § 39:1-1; § 39:3-10
New Mexico	Moped	N	Y	N	15	50 cc	30	N	N	N‡		N	N.M. Stat. § 66-1-4.11; § 66-1-4.2; § 66-5-2
New York	Motor-Assisted Bicycle	N	Y	Y	--	--	--	N	N	N	N	N	N.Y. Veh. & Traf. Law § 102; § 123
North Carolina	Moped	Y	N	N	16	50 cc	30	N	N	Y		N	N.C. Gen. Stat. § 105-164.3; § 20-4.01 (27) d1; § 20-140.4
North Dakota	Motorized Bicycle	N	Y	Y	14	50 cc	30	Y	N	N		N	N.D. Cent. Code § 39-01-01 (48); 39-06-14.1
Ohio	Motorized Bicycle	N	Y	Y	14	745 W†	20	Y	Y	N‡		N	Ohio Rev. Code § 4501.01(L); § 4511.521; § 4511.711
Oklahoma	Electric-Assisted Bicycle	N	Y	N	--	1000 W	30	Y	N	N	Y	Y	Okla. Stat. tit. 47 § 1-104; tit. 47 § 11-805.2; tit. 47 § 11-1103
Oregon	Electric Assisted Bicycle	Y	N	N	16	1000 W	20	Y	N	N	Y	N	Or. Rev. Stat. § 801.258; § 814.405; § 814.410; § 807.020
Pennsylvania	Pedalcycle with Electric Assist	Y	N	N	16	750 W	20	Y	Y	N		Y*	Senate Bill 997; 75 Pa. Cons. Stat. § 102; 75 Pa.C.S. § 3525; 75 Pa.C.S. §3703
Rhode Island	Electric Motorized Bicycle	N	Y	N	16	1491 W†	25	Y	N	N‡	Y	Y	R.I. Gen. Laws § 31-1-3; § 31-3-2.2; § 31-19.1.1

Appendix A: Electric bicycle laws by state/province.

Area	Identity	Bicycle?	License?	Registration?	Age	Power	Speed	Pedals?	Federal?	Helmet?	Paths?	Sidewalks?	Law references
South Carolina	Moped	N	Y	N	14	1491 W†	30	N	N	N‡		N	S.C. Code § 56-5-165; § 56-1-1720
South Dakota	Moped	N	Y	N	14	50 cc	--	N	N	N‡		N	S.D. Codified Laws § 32-3-1; § 32-20-1; § 32-5-1.2; § 32-26-21.1
Tennessee	Motorized Bicycle	N	Y	N	15	1491 W†	30	N	N	Y		N	Tenn. Code § 55-8-101; § 55-9-302
Texas	Electric Bicycle	Y	N	N	--	--	20	N	N	N	Y	Y	Tex. Trans. Code §541.201 (24); §541.202 (4); §551.106
Utah	Electric Assisted Bicycle	N	Y	N	16	1000 W	20	N	N	N	Y		Utah Code § 41-6a-102
Vermont	Motor-Driven Cycle	N	Y	N	16	1491 W†	30	N	N	N		N	Vt. Stat. Ann. tit. 23 § 4 (45)
Virginia	Electric Power Assisted Bicycle	Y	N	N	14	1000 W	25	Y	N	N	Y	Y	Va. Code § 46.2-100; § 46.2-903; § 46.2-908.1; § 46.2-906.1
Washington	Electric Assisted Bicycle	Y	N	N	16	1000 W	20	Y	N	N	Y	N	Wash. Rev. Code § 46 4-169; § 46 61-710; § 46 4-320; § 46 37-530; § 46 16A-080; § 46 20-500
West Virginia	Moped	N	Y	Y	15	1491 W†	30	Y	N	Y		N	W. Va. Code § 17C-1-5a; § 17C-15-44
Wisconsin	Motor Bicycle	N	Y	N	--	750 W	20	Y	Y	N	Y*	Y*	Wis. Stat. § 340.01 (30); § 346.02 (4); § 346.79 (5); § 343.05(3)(c)
Wyoming	Moped	N	Y	N	15	1491 W†	30	Y	N	N‡	N	N	Wyo. Stat. § 31-5-102(xxi); § 10.32.160; § 31-5-115 (o); § 31-1-101
Alberta	Power Bicycle	Y	N	N	12	500 W	20	Y	Y	Y			Alta Reg 304/2002; Alta Reg 122/2009; RSA 2000, c T-6; Alta Reg 320/2002
British Columbia	Motor Assisted Cycle	Y	N	N	16	500 W	20	Y	Y	Y	Y	N*	BC Reg 151/2002; RSBC 1996, c 318, Part 1 & Part 3
Manitoba	Power-Assisted Bicycle	Y	N	N	14	500 W	20	Y	Y	Y		N	CCSM c H60
New Brunswick	Bicycle	Y	N	N	--					Y		Y	RSNB 1973, c M-17
Newfoundland	Bicycle	Y	N	N	--					N		N	RSNL 1990, c H-3
Northwest Territories	Bicycle	Y	N	N	--					N		N	RSNWT 1988, c M-16
Nova Scotia	Bicycle	Y	N	N	--	500 W	19	Y	Y	Y	Y	N	RSNS 1989, c 293
Nunavut	Bicycle	Y	N	N	--					N		N	RSNWT (Nu) 1988, c M-16
Ontario	Power-Assisted Bicycle	Y	N	N	16	500 W	20	Y	Y	Y	Y*	Y*	RSO 1990, c H.8; O Reg 369/09
Prince Edward Island	Motor Assisted Pedal Bicycle	N	Y	Y	16	50 cc	31	N	N	Y	Y	N	RSPEI 1988, c H-5; PEI Reg EC642/75
Quebec	Power-Assisted Bicycle	Y	N	N	18	500 W	20	Y	Y	Y	Y*	N	CQLR c C-24.2; CQLR c V-1.2, r 4.1; CQLR c P-9, r 25
Saskatchewan	Electric Assist Bicycle; Power Cycle	Y	N	N	--	500 W	20	Y	Y	Y	Y*	Y*	SS 2004, c T-18.1; Motorcycle handbook
Yukon	Electric Power-Assisted Bicycle	Y	N	N	--	500 W	20	Y	Y	N		N*	RSY 2002, c 153

Area: Which state or province in the United States or Canada?
Identity: Under which definition in vehicle code does an electric bicycle fall?
Bicycle: Is it essentially classified and treated as a bicycle?
License: Is a driver's license required to operate an e-bike?
Registration: Is the e-bike required to be registered with the state/province?
Age: What is the minimum age of operation of an e-bike?
Power: What is the maximum power output permitted?
Speed: What is the maximum speed of operation permitted?
Pedals: Are fully functional pedals required for operation?
Federal: Is the state/provincial definition in line with the federal definition?
Helmet: Is a helmet required for operating an e-bike?
Paths: Are e-bikes permitted on shared-use paths and trails?
Sidewalks: Are e-bikes permitted on sidewalks?
Law reference: What is source of this information?

-- = Limit not specified under law
= Information unclear/inconsistent
"Bicycle" = allowed on bicycle paths and no license/registration required

† Horsepower expressed in watts equivalent; 1 hp = 745 watts
Different than maximum speed capability, though most areas see this as the same

‡ Age requirement; those under a certain age are required to wear a helmet
* Restrictions apply (engine cannot be engaged, local ordinances prohibit use, etc.)
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