Centre for Automotive Safety Research

# Networking access, substitution effects and design issues surrounding e-scooter use

CASR244

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# Report documentation

| REPORT NO. | DATE | PAGES | ISBN | ISSN |
|---|---|---|---|---|
| CASR244 | June 2024 | 53 | 978-1-925971-77-4 | 1449-2237 |

**Title**

Network access, substitution effects and design issues surrounding e-scooter use

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**Funding**

This research was funded via a deed with the South Australian Government

**Available From**

Centre for Automotive Safety Research; http://casr.adelaide.edu.au/publications/list

**Abstract**

E-scooters are an efficient and economical form of micro mobility that provide benefits to individual users for transportation needs as well as economic benefits through the gig economy. This form of micro mobility has the potential to improve public transport usage by facilitating first and last mile transport, replacing car trips and reducing congestion on the road transport network. The consequences of a fast-growing new transportation mode can also produce safety issues such as collisions involving vulnerable road users, as well exposing e-scooter riders to injury by road traffic in a transport system that has not matured to a level where micro mobility has been integrated effectively. This report considers the different legislative, policy frame works, benefits and issues that jurisdictions both overseas and within Australia have experienced with both private and shared e-scooters. Additionally, the report provides some insight into e-scooter safety performance, particularly braking considerations and emergency stopping distances, kinetic energy exposure and potential injury consequences with increasing vehicle impact speed for existing implementation scenarios.

**Keywords**

E-Scooter, safety, micro mobility

# Summary

E-scooters are an efficient and economical form of micro mobility that provide benefits to individual users for transportation needs as well as from a broader transport perspective. The rise in e-scooter use has been attributed to various factors ranging from personal convenience, environmental concerns and low operating costs (especially through rental/sharing schemes, and more recently e-privately owned e-scooters). E-scooters are also an attractive transport option in the gig-economy, such as in food delivery services. Public debates on e-scooters, especially in the media, have tended to occur in a polarised manner, i.e. either for or against their use, with mobility versus safety issues a strong area of contention.

There are different considerations relating to how e-scooters fit  within different legislative and policy frameworks both internationally and within Australia which has resulted in regulatory disparities with respect to definitions of e-scooters, accessibility of e-scooters (e.g., by age and by private ownership or shared e-scooter schemes), network access (e.g., allowances or non-allowance on footpaths, shared paths, bike paths, bike lanes, roads) and allowable network speeds.

While the National Transport Commission (NTC) considered that an e-scooter speed limit of 10 km/h on footpaths was appropriate for pedestrian safety, for bicycle paths and local roads, a maximum speed up to 25 km/h was regarded as safe and appropriate. Some Australian jurisdictions have adopted the NTC model while others have adopted higher limits on footpaths and lower speed limits on local roads. This has resulted in a non-harmonised approach nationally, but also highlights the importance of monitoring injury outcomes in e-scooter collisions to better inform speed management strategies that ensure the safety of pedestrians and e-scooter users.

Some jurisdictions have allowed use of hire scheme e-scooters only, while others have made allowances for private e-scooters, and each have resulted in various benefits and issues. Shared e-scooter schemes allow for geolocation-based control over individual devices by speed and location, mass and dimensional control, resulting in good compliance in network access and speed and energy control. Hire-schemes appear to be associated with levels of non-compliance with helmet usage, blood alcohol levels and single occupancy use of e-scooters. Additionally, ‘littering’ of hire scheme e-scooters due to poor and non-compliant parking behaviours are also problematic and result in injuries or potential injuries to pedestrians, particularly those with vision impairments. Regular discussions between hire scheme operators and government stakeholders have been found to assist with understanding the extent of these issues and provides for mechanisms to improve non-compliance.

The use of Private e-scooters on public networks is associated with higher single occupancy riding and increased helmet compliance and have the added advantage of not contributing to the e-scooter ‘litter’ problem. Additionally, private e-scooter use appears to be more aligned with the anticipated use of this micro mobility mode for first and last mile transport and for transport mode change, although the evidence suggests that the modal change is less likely to occur from motor vehicle use to e-scooter use, but more likely from active transport use to e-scooter use. This may be due to the infancy of private e-scooter use and that there is further scope for a motor vehicle transport modal change to private e-scooter use in the future. Issues relating to private e-scooter use have not all been positive, and despite regulatory requirements imposed upon private e-scooter users, compliant network access, travelling speed and alcohol control remains problematic within the transport environment, with active enforcement being difficult to put in effect, particularly as breaches of e-

scooter design or operational specifications (e.g., e-scooters that are capable of exceeding 25 km/h) fall under a category of an "unlicensed/uninsured vehicle" but is by no means equivalent in transport network risk to a genuinely unlicensed/uninsured motor vehicle. Similarly, issues relating to alcohol intoxication are hard to enforce as there are no mechanisms in place to allow random breath testing. Some jurisdictions have suggested that cooperation with police and active enforcement and education relating to speed and helmet use is beneficial and that consideration of legislative framework that will allow random breath testing of e-scooter riders (and bicycle riders) should be explored.

The consequences of this fast-growing new transportation mode has also produced issues such as new types of collisions involving vulnerable road users (such as pedestrians), as well as exposing e-scooter riders to injury by motor vehicles in the road traffic system that has not matured to a level where micro mobility has been integrated effectively. The burden of injury on the public health care system has been noted as being a growing problem, with inexperienced e-scooter users (first time users) as well as existing infrastructure that is not designed with e-scooter stability and usability in mind, anecdotally, resulting in a considerable number of loss of control and injurious collisions with the pavement, street furniture and from the e-scooter itself (particularly handle bar injuries).

At the higher level of injury severity, evidence from hospital reports indicate that non-compliant behaviours result in the majority of injuries. Alcohol intoxication and non-helmet use have been reported as being the biggest contributors to collisions resulting in more serious injuries, however, there has been no hospital evidence to inform whether these are more likely to occur on share scheme e-scooters or private e-scooters. Some share scheme operators have introduced "sobriety tests" to attempt to reduce drunk e-scooter riding, as well as other collision avoidance technology.

The prevention of e-scooter collisions is dependent on the reaction time of e-scooter riders (which is impaired by alcohol) as well braking performance of e-scooters. The overseas literature indicates that braking performance differs considerably based on type of braking system (e.g., disc brakes, drum brakes or foot brakes) as well as how the braking system is operated, with concerns being raised around braking configuration and user operation, consistency across devices and hand signal operation with brake coordination and throttle control. Generally, disc brakes were considered as providing better braking performance, front wheel brakes were more efficient and so the most easily accessible brake mechanism (e.g., the left brake hand trigger) in an independent braking system should operate the front brake. Ideally, a combined anti-lock braking system (or derivative) operating from a single brake trigger would be optimal for the most effective braking performance.

In a second phase of this research project, a series of tests were undertaken using a common commercially available e-scooter to measure the braking performance at different speeds and compared to the braking performance of a bicycle under the same conditions. The braking performance of the bicycle was superior to that of the e-scooter, with the bicycle producing higher decelerations and shorter stopping distances. Given the similarities in network access for these two transport modes and stability issues with e-scooters, mechanisms to ensure good braking performance of e-scooters should be strongly encouraged.

Kinetic energy modelling was also undertaken, and e-scooter speed was a more significant factor in kinetic energy exposure rather than mass of e-scooters. Consequently, under a system of energy management within the transport system, e-scooter speed management should be prioritised over e-scooter mass, particularly if increases in mass specifications will result in improved braking systems, improved suspension systems or systems that enhance safety of e-scooter riders and other road users. From the kinetic energy modelling and with reference to pedestrian fatality risk curves, it is quite evident that low speed environments (less than or equal to 50 km/h) are safest for e-scooters if they are required to mix with motorised traffic, however, some consideration could be given to network access to 60 km/h roads where bicycle lanes of sufficient width exist. It was uncertain as to whether the minimum passing distance (MPD) laws applicable to cyclists across Australia would apply to e-scooter riders on roads, however, mechanisms to ensure these MPD laws apply to e-scooters should also be adopted. Similarly, for e-scooter allowance on footpaths, consistency with bicycle laws is desirable. Additionally, there was suggestion that lighting on devices should not just be so that e-scooters are visible, but also for path illumination for the benefit of the riders, particularly on footpaths and shared paths at night, where they may be inadequate street lighting.

The e-scooter landscape is changing rapidly and there is considerable diversity internationally and nationally. Growth in use appears to occur too rapidly for legislative reform to meet the growth in demand and use. Consequently, it is important for South Australia to monitor any developments that occur with e-scooter technologies and safety improvements as well as monitoring jurisdictions that are more mature in their adoption of e-scooters and have appropriately made legislative and policy reforms.

There is a distinct lack of detailed information regarding e-scooter crashes and incidents. It is important that systemic monitoring and review of e-scooter incidents and injury mechanisms be performed to provide a feedback loop for the refinement of policy and improvement of safety. Ideally some level of crash investigation will help inform on systems issues such as e-scooter design and safety features, infrastructure compatibility, rider competency and other risk factors.

There is considerable scope for the consideration of scooter design and performance parameters and ideally this issue first needs to be dealt with at the Commonwealth level, which potentially includes the regulation of the importation of e-scooters to ensure they meet the existing policy framework. Efforts to achieve this should continue as a high priority. Advancements in e-scooter safety features are inevitable and ideally the efficacy of these improvements should be verified with priority given to encourage the adoption of solutions that enhance braking, stability and technologies that improve user compliance.

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# 1. Introduction

E-scooters are becoming an increasingly common sight in cities and townships with the first rental schemes introduced in several countries, including Australia, around 2018 to 2019. The rise in e-scooter use has been attributed to various factors ranging across personal convenience, environmental concerns and low operating costs (especially through rental/sharing schemes, though many e-scooters now are privately owned). E-scooters are also an attractive transport option in the gig-economy, such as in food delivery services. Public debates on e-scooters, especially in the media, have tended to occur in a polarised manner, i.e. either for or against their use, with mobility versus safety issues a strong area of contention.

With a focus on safety implications, this report identifies from jurisdictional comparisons and research literature: (i) network access issues arising with e-scooter use, (ii) transport mode substitution effects, and (iii) e-scooter design issues.

This report firstly considers the vast number of different legislative, policy frame works, benefits and issues that jurisdictions both overseas and within Australia have experienced with both private and shared e-scooters. Additionally, the report provides some insight into e-scooter safety performance, particularly braking considerations and emergency stopping distances, kinetic energy exposure and potential injury consequences by vehicle impact speed within transport environment.

# 2. Network access issues

Network access issues were identified through jurisdictional comparisons and relevant research literature.

## 2.1. Australian jurisdictions

Access to the road network by e-scooter users is principally determined by how e-scooters are defined in jurisdictional legislation. Each Australian jurisdiction has developed its own rules for e-scooters based on the Australian Road Rules (ARRs) coverage relating to personal mobility devices, with the exception of the Northern Territory (NT), which has merely appended the ARRs to its regulations.

It can be seen from Table 2.1 (reviewed recently with representatives from each Australian jurisdiction except the ACT) that, while the ARRs classify e-scooters as personal mobility devices, some individual jurisdictions in developing their own applicable regulations based on the ARRs have applied different terminologies to either fit e-scooters within existing legislation, or to develop a new category altogether. For example, South Australia classifies e-scooters as electric personal transporters. In New South Wales and Queensland they are wheeled recreational devices, while Tasmania refers to them as eRideable devices. The laws relating to each of these definitions determine the nature and extent of network access by riders. Moreover, differences in the definitions create disparities across Australia.

Some jurisdictions permit e-scooter use on footpaths, shared paths and cycle paths. However, the ARRs also permit individual jurisdictions to allow travel on roads and road-related areas. Hence, Victoria, New South Wales (NSW), Queensland, Tasmania and Western Australia (WA) allow e-scooter travel on roads that are speed limited at 50km/h. However, South Australia (SA) New South Wales (NSW), Victoria and the NT have restricted travel to certain council areas, typically on a trial basis. By contrast, e-scooters may be ridden anywhere in WA, NT, Queensland and the Australian Capital Territory (ACT) (provided travel is on footpaths, shared paths, cycle paths, etc.). To date, SA, NSW and NT only allow scooters hired from a registered company to be ridden, whereas all other jurisdictions permit both privately owned and hired e-scooters to be ridden in public.

Whereas all jurisdictions (except NSW) have incorporated the e-scooter motor power limit of 200 watts in the ARRs, there is limited consistency across jurisdictions with regards to travel speeds which, in turn, affect the nature and extent of network access. The ARRs specify a 10km/h speed limit on footpaths, which NSW has adopted, yet Queensland has 12km/h, while SA, ACT, WA, Tasmania and NT all have 15km/h, and Victoria 20km/h. The same speed limits apply for shared paths, except for Tasmania and the ACT, where e-scooters can travel up to 25km/h. Where permitted, on bike lanes and on roads zoned at 50km/h, e-scooters can be ridden at up to 20km/h in Victoria and NSW, and up to 25km/h in Queensland and Tasmania. Both WA and the ACT also uniquely impose a speed limit of 10km/h when using pedestrian and other signalled crossings.

In line with the ARRs, all jurisdictions require helmets to be worn by riders and specify blood alcohol restrictions, but minimum age requirements vary. Under the ARRs, and in Queensland, NSW and WA, the minimum age is 16; in SA, NT and Victoria it is 18. The ACT and Tasmania allow e-scooter riders of any age, although those jurisdictions plus Queensland have special rules concerning children under 12 or so relating to adult supervision or speed limit. Most, but not all, jurisdictions have rules governing rider/e-scooter visibility at night, and bans on mobile phone use while riding.

Table 2.1
Network access issues (Australian jurisdictions)

| Jurisdiction's laws as at April 2024 | Where e-scooters can be ridden | Speed limit & motor power limit | Age requirement | Other access issues |
|---|---|---|---|---|
| **Australian Road Rules** (ARRs), s.244A-S (2021);<br><br>Riders of e-scooters must obey rules for riders of wheeled recreational devices | Not on road or road related area (unless permitted in individual jurisdiction) | 10 km/h<br><br>200 watts | 16 + | -Must have lights and reflectors for night use |
| **Victoria**<br>Road Safety Road Rules 2017, s.2: relating to wheeled recreational devices;<br><br>Private e-scooters permitted<br><br>Hire e-scooters permitted (must have an agreement with a Council) | Shared paths, bike paths, bike lanes and roads with a speed limit 60 km/h or less but only in trials in City of Melbourne, City of Yarra, City of Port Phillip & City of Ballarat, Melton, Frankston, Bendigo<br><br>Not permitted on footpaths | 20 km/h<br><br>No power limits | 16+ | -Must have lights and reflectors for night use, single file only |
| **New South Wales**<br>NSW Road Rules s.240(2)(c) relating to wheeled recreational devices;<br><br>Private e-scooter use only permitted on private property | Shared paths, bicycle paths, roads zoned as <50km/h, but only in trial areas | 10 km/h on shared paths<br><br>20 km/h on, bicycle paths roads & bicycle lanes<br><br>No motor power limit | 16 + | -Must have lights and reflectors for night use |
| **ACT**<br>Section 244D to 244J in ACT Road Transport (Road Rules) Regulation 2017 | Footpaths, shared paths, cycle paths<br><br>Not permitted on roads or on-road bike lanes except on residential streets without footpaths | Footpaths – 15km/h<br>Shared paths, bike paths – 25km/h<br>Using a crossing – 10km/h<br><br>No motor power limit | Any age, but if <12 years need adult supervision | -Must have lights and reflectors for night use |
| **Tasmania**<br>Road Amendment (Personal Mobility Devices) Rules 2021 | Footpaths, shared paths, cycle paths<br><br>Local roads zoned at 50km/h or less with no dividing line, no median strip or no multiple lanes on one way road | Footpaths – 15km/h<br>Shared paths, bike paths & local roads 25km/h<br><br><45 kg | 16 or older<br><br><16 only permitted to use low powered e-scooters which do not exceed 200 watts or 10km/h | -Must have lights and reflectors for night use |

Table 2.1 (continued)
Network access issues (Australian jurisdictions)

| Jurisdiction's laws as at April 2024 | Where e-scooters can be ridden | Speed limit & motor power limit | Age requirement | Other access issues |
|---|---|---|---|---|
| **Queensland**<br>Transport Operations (Road Use Management—Road Rules) (Personal Mobility Devices) Amendment Regulation 2018 — Riders of e-scooters must obey rules for riders of personal mobility devices. | Footpaths, shared paths, separated paths, bicycle paths<br><br>Bike lanes on roads zoned at 50km/h or less<br><br>Bike lanes physically separated from other traffic<br><br>Local streets 50km/h or less and no dividing line | Footpaths, shared paths, road crossings – 12km/h;<br><br>Separated paths, bicycle paths – 25km/h (or less where signed)<br><br>Roads (inc. in bicycle lanes) – 25km/h, or less if speed limit less than 25km/h<br><br>No motor power limit<br><br>< 60 kg | 16+; but 12-16 if supervised by adult | -Must have lights and reflectors for night use, warning devices to be fitted |
| **Western Australia**<br>E-scooters defined as eRideable devices; WA Road Traffic Code 2000, Division 2 | Footpaths, shared paths, cycle paths<br><br>Roads zoned at 50km/h or less without a dividing line | Footpaths – 10km/h<br>Shared paths, bike lanes & roads – 25km/h<br>Using a crossing – 10km/h<br><br>No motor power limit<br><br>25 kg or less for private devices, 35 kg or less for hire devices<br><br>Speed limited to 25km/h on level ground | 16 +<br><br><16 only permitted to use low powered e-scooters which do not exceed 200 watts or 10km/h | -Must have lights and reflectors for night use, warning devices to be fitted |
| **Northern Territory**<br>ARRs as incorporated in NT Traffic Regulations 1999<br><br>Private e-scooter use only permitted on private property – if used on public road considered driving and un-registered/uninsured vehicle.<br><br>Shared e-scooters have an exemption until 2025 only Beam e-scooters | Footpaths, shared paths, cycle paths in City of Darwin only | Generally 15km/h, some áreas 12 km/h (slow zones), some time restrictions in certain areas, controlled by GPS and geofencing<br><br>No motor power limit | 18+ | -Must have lights and reflectors for night use and a warning device |

## 2.2. Overseas jurisdictions

Requirements for e-scooter use in overseas jurisdictions are summarised in Appendix 1. It can be seen that, just as in Australia, the overseas picture is one of diversity in e-scooter network access provisions ranging from city-restricted scheme trials in the United Kingdom, in some Canadian provinces and in some US states, to several European countries that allow e-scooters to be ridden basically anywhere that cycling is allowed.

Again, a major reason for this diversity is the variety in how e-scooters are classified in road traffic law. For example, European countries including Belgium, Austria, Switzerland, Greece, Sweden and Portugal treat e-scooters as bicycles in terms of their laws. On the other hand, the UK and Denmark treat e-scooters as mopeds, while New Zealand, Ireland, Italy and Japan (up to July 2023) consider e-scooters to be motorised vehicles that variously may or may not require registration and/or rider licensing. Jurisdictions that deem e-scooters to be mopeds or other motorised vehicles tend to allow riding on roads. Those defining e-scooters as a form of bicycle transport tend to permit riding on roads, bicycle lanes, shared paths and on pavements where bicycles are permitted on pavements. None of the jurisdictions in Table A1 restricts e-scooters to footpaths exclusively.

An associated factor contributing to the diversity is likely to be the increasing popularity of e-scooters over the last five years, which has outpaced the ability of legislation to keep up. In the United States, rental companies began by simply making e-scooters available on streets and waiting for the civic authorities to respond and/or regulate, if at all. Part of this trend was due to lack of clarity as to which authorities were responsible (Button, Frye & Reaves, 2020).

Many countries that initially exercised tight control over e-scooter use, along with those who have considerably relaxed initial restrictions, have experienced substantial public opposition to e-scooter use, mainly in relation to other road users who have been injured by riders and hire scooters left haphazardly on footpaths when the renting rider no longer needs one. In particular, e-scooter riding has become contentious in Ontario due to injury and insurance issues, and hired scooters have been banned in Montreal due to ‘littering’ of unused e-scooters. After imposing limits on rented scooter total numbers and restricting the number of rental schemes to three, the Parisian city authority is considering banning hired e-scooters after a recent poll found over 90% of residents opposed them, mainly on grounds of ‘littering’ and injuries caused. In response to such issues, Italy is examining calls for registration plates on e-scooters, compulsory insurance for all riders, helmets for everyone and a light driving licence. In Brussels, from 2024, the total number of rental e-scooters will be reduced by 62% to 8,000 and the number of rental schemes permitted to two. Reasons for the reductions are not clear, but as fines for abandoned e-scooters have increased (Micromobility Report, May 2023), littering of the devices may be behind the move.

Some countries have found much higher injury rates for e-scooter riders (and to other road users that the e-scooter riders collide with) than occur with bicycle riders and have reformed, or are considering reforming, their legislation as a consequence. Denmark tightened its laws when monitoring reports into its city trials found injury risk for e-scooter riders *seven* times that for bicycle riders. Similarly, Norwegian trials found the risk factor was *ten* times. Importantly, a German hospital data study found 74% of admissions for e-scooter injuries were *not* also reported to police, suggesting that incident data collected by police forces are likely to be underestimates of the true scale of the problem.

Overseas jurisdictions generally permit riding on footpaths (except for Belgium, Cyprus, Denmark, Netherlands, Norway, Slovenia and Spain; some US states; in Canada if aged over 14; and in Czech

Republic and Portugal if aged over 10). Countries that ban or restrict e-scooters on footpaths may well be concerned about injuries to pedestrians particularly. Some countries permit e-scooters on footpaths only below minimum speeds: below 6 km/h in, France, Italy and Japan.

As previously noted, e-scooter riding on shared paths and cycle paths is commonly allowed. Most countries that permit riding on roads generally limit the roads to those zoned at either 30 km/h or 50 km/h, and/or which have dedicated bicycle lanes.

Maximum permitted speeds for e-scooter riders tend to be either 20 km/h or 25 km/h although, as noted, lower speeds are required on footpaths in some countries. E-scooter motor power limits range from 250 watts up to 1000 watts. Some countries have no power limit, although some of these do have restrictions on the physical size of the motor. Interestingly, Spain appears to be unique in its Safe System perspective by examining minimum technical standards for e-scooters.

Some countries have no minimum age stipulated for riders: New Zealand, Czech Republic, Portugal, Finland and Sweden. Others do have a minimum age for riders: above 16 in most US states and Canada, United Kingdom, Japan, Belgium, Cyprus, and Netherlands; above 15 in Denmark, Greece, Norway and Sweden; above 14 in Bulgaria, Germany, Italy, Slovenia, Spain and Switzerland; above 12 in Austria, Belgium, France and Norway; and above 10 in Poland. Some countries have conditions imposed on their minimum ages: Austria requires a proficiency test, while the United Kingdom and Switzerland require a young rider to hold a provisional and a moped licence respectively. Denmark and Poland require young riders to be supervised by an adult. Other countries restrict young riders to maximum speeds (Italy, Greece and France) or to certain riding environments (Bulgaria and Spain).

## 2.3. Network access issues identified in the literature

A study across North American cities (Ma, Yang, Ma, Yang, Hu & Xie, 2021) explored different regulatory approaches. Of 156 cities, a majority of 39% had guidelines in place; 12% had a mixture of guidelines and specific laws; 30% had neither guidelines nor specific legislation; while 29 cities (19%) decided to ban e-scooters in public at the conclusion of their pilot programs. The cities imposing bans cited five main reasons for their bans:

- Operational concerns
- Safety concerns
- Nuisances for communities
- Hindering traffic and pedestrians
- Blocking people with disabilities, or blocking public infrastructure.

Across the cities providing guidelines and/or having specific legislation in place, there was considerable variation in relation to matters such as: areas where riding is / is not permitted, helmet wearing, age requirements, speed limits, geofencing, curfews and alcohol restrictions. While it seemed plausible that some of the substantial variation in regulatory approaches that was found could be explained by population size, demographic profile, climate and street infrastructure profile across the cities, these factors were not necessarily consistent with the content of guidelines generally. Two similar sized, neighbouring cities might have quite different approaches to e-scooter usage in their guidelines/regulations, leading to inadvertent law breaking when a rider is temporarily in a city with different riding requirements. Based on their findings, the authors suggested that authorities developing or improving their guidelines consider the following matters:

- Understanding the characteristics of users or potential users in their areas
- Clearly instructing riders as to where to ride and park
- Providing guidelines on how to share road spaces with others (including any rights of way)
- Setting appropriate speed limits for riding on different facilities
- Providing contact information in case of emergency incidents
- Exchanging lessons and experiences with other districts.

In a similar vein, Goodman, Witte, Stark and Frackelton (2019) conducted stakeholder interviews in nine US cities to identify emergent issues. Safety issues identified included tracking collision data and concerns about safety norms and rider behaviours. Regulatory issues included better organisation of parking and better definition of speed limits and their enforcement. Infrastructure design issues included attention to street facilities for e-scooters, separation from traffic, and pedestrian access and rights of way. Providing guidelines on how to share road spaces with others is vital. The survey by Comer, Apathy, Waite, Bestmann, Bradshaw, Burchfield and Embi, et al. (2020) of 561 Indiana residents found that riders and non-riders could not agree on the hazards e-scooters pose to pedestrians.

Queensland has released a *Personal Mobility Action Plan* to advance its policy and practice, including in relation to regulations. Network access actions in that plan include:

- increase use of geo-fencing to support no or slow riding in high-volume pedestrian areas
- establish an e-scooter parking working group to create clear rules for e-scooter parking to keep footpaths clear for pedestrians and people with disabilities.
- support efficient enforcement of devices that can travel faster than 25km/h
- investigate greater scope to allow personal mobility devices to be used in on-road bike lanes.
- advocate for all levels of government to accelerate the roll out of physically separated bike path infrastructure.

Geofencing means e-scooters are automatically slowed or halted according to their GPS coordinates, which delineate invisible, impassable barriers into neighbouring councils, parks, railway stations, canal or riverside paths, or in the vicinity of other designated public spaces. In Queensland, the rental company Lime has geofenced its e-scooters by limiting their maximum speed to 6km/h in certain inner city Brisbane high volume pedestrian streets (Gőssling, 2020). In some British e-scooter trials, at the behest of local authorities, rental companies are encouraged to geofence their e-scooters (Topham, 2023).

In 2020, the Euro Cities' Smart and Connected Mobility Working Group surveyed cities in Belgium, Germany, Hungary, Sweden, Portugal, Slovenia, Spain, Italy, Norway, Latvia, Bulgaria, France, Poland and Switzerland about their approaches, challenges and regulatory gaps in e-scooter policy and practice. Municipal approaches ranged through establishing legal obligations for riders and rental schemes, to self-binding or voluntary codes of practice and information exchange. Commonly reported challenges were:

- Overloading of public space.
- Protection of pedestrians.
- Insurance coverage.
- Reckless riding behaviour.
- Conflicts with pedestrians, cyclists and persons with limited mobility.
- Poor geofencing precision.
- Regulation and compliance with parking rules.

The most cited factor for the success of e-scooter management was early and continuous dialogue with scheme providers. This allows authorities and operators to establish mutual understanding and solve challenges through cooperation. Other cities mentioned the importance of regular dialogue with police authorities, limiting the total number of an operator's e-scooters within defined geographical areas, holding public debates and establishing procedures for handling complaints.

A case study of Paris's development of e scooter policy since the first rental schemes in that city in 2018 was undertaken by Latinopoulos, Patrier and Sivakumar, (2021). Initially, the provision was seen as a natural extension of pedal cycle sharing and electric car sharing schemes. In 2019, a Code of Conduct for e-scooters was promulgated, focussing on parking issues, hiring conditions, encouragement of helmet wearing, and powers given to local councils. Surveys and interviews conducted the following year found that trip reasons were balanced between recreational and purposeful needs. However, they added that, from their observational work, on roads with dedicated bike lanes e-scooter riders tend to travel in a queue (which can impede bicycle travel). On roads without bike lanes, riders tend to mingle among various vehicles, creating heightened safety risks for them as vulnerable road users. Furthermore, where footpath riding is allowed, the 50% of riders who said they prefer using footpaths tended to say it was because it was safer. Latinopoulos et al., (2021) suggest a possible solution for exploration is to increase the width of bicycle lanes on roads. However, the authorities' response to date has been to reduce overall exposure of e-scooters to the road system through caps on total numbers of devices. Network access issues arising from riders' collisions with pedestrians also feature in research literature.

***Issues for pedestrians***

Those pedestrians most prone to injury when struck by an e-scooter are young children, the elderly, those with vision/hearing problems and those distracted by mobile phones. Such pedestrians face financial burdens from hospitalisation and rehabilitation costs, taking time off work (Sikka, Vila, Stratton, Ghassemi, & Pourmand, 2019).

A study focussing on e-scooter rider interactions with pedestrians surveyed 3,385 respondents across Australia, Belgium, the Czech Republic, Norway and Sweden (Šucha, Drimlová, Rečka, Haworth, Karlsen, Fyhri & Slootmans, et al., 2023). Around 20% to 30% of riders rode on footpaths, regardless of whether this is permitted or not. Moreover, this proportion rode on footpaths at speeds greater than a walking pace. Interestingly, pedestrians reported seeing e-scooter riding on footpaths more often than riders said they did. Males were more likely to ride on footpaths, and younger riders compared to older riders more often rode on footpaths. In Australia, e-scooter riders reported slightly more near misses with pedestrians than they did for cars. Šucha et al., (2023) conclude that e-scooter riders and pedestrians are best separated in the interests of mobility and safety, unless riders on footpaths are restricted to a walking pace.

A literature review of psychosocial risk factors of e-scooter riders (Useche, Gonzalez-Marin, Faus & Alonso, 2022) concluded that individuals with the lowest levels of ability to perceive risks are more prone to engage in risky riding likely to increase their collision involvement.

From a systematic review of e-scooter usage from both transport planning and injury studies perspectives, Kazemzadeh, Haghani & Sprei (2022) noted that footpaths are relatively narrow, so e-scooter users tend to move close together. Moreover, pedestrians have a much slower speed than riders do, which poses difficulties in manoeuvring for either party, thus increasing the chances of conflict, especially in adverse weather conditions or poor illumination.

Citing Haworth, Schramm, and Twisk's (2021a) observational study in Brisbane, Kazemzadeh, Haghani & Sprei (2022) pointed out that 40% of the observed riders rode within one metre of a pedestrian. By contrast, in on-road contexts, e-scooter riders are extremely vulnerable by virtue of lack of protection and speed differential to motor vehicles.

***Decision of the National Transport Commission on personal mobility devices***

To better understand the key safety and regulatory issues associated with personal mobility devices (PMDs), the National Transport Commission (NTC) (2020) undertook extensive consultation and sought feedback from government, industry and community stakeholders. The NTC then developed and assessed four options for PMD access to road and path infrastructure and three speed approaches. The analyses conducted by the NTC (appended in the NTC report) included assessments of safety risks, access and amenity impacts, broader economic impacts, as well as compliance and enforcement challenges.

The NTC's analysis considered that the best approach to balance mobility and safety would be to permit PMDs that comply with the proposed regulatory framework (see Chapter 4 in present report) on footpaths and shared paths at a maximum speed of 10km/h, and on bicycle paths and local roads at a maximum speed of 25km/h. The NTC considered that permitting PMDs to travel up to a maximum of 10km/h on pedestrian infrastructure is an appropriate speed based on safety considerations for pedestrians. For bicycle paths and local roads, a maximum speed up to 25km/h is considered safe and appropriate and there is little justification to further restrict PMD speed in these areas.

A final assessment of that option affirmed the challenge of establishing a common national approach to permitting access of PMDs onto public roads and paths. Each variation of infrastructure access and speed approach results in trade-offs between the safety and enforcement challenges. The NTC assessed this option as providing the highest net benefit. It considered the benefits associated with PMD access, commercial opportunities and congestion reduction outweigh the costs associated with 'minor' increases in safety risks to pedestrians, compliance and enforcement challenges. Allowing PMDs to be used for their intended purposes with moderate restriction is likely to enable the achievement of close to their full potential economic benefits (e.g. commercial opportunities and congestion reduction).

The NTC also acknowledged that, to minimise the safety risks for this option, there will need to be a high level of compliance and clear enforcement with the proposed road rules. While there may be a variety of challenges with regulating variable speeds across different roads and paths, these difficulties, in isolation, should not offset the potential benefits of minimising PMD speed around pedestrians.

At the same time, the NTC acceded that the preferred approach would need to vary if an assessment were made at individual state and territory level. For instance:

- Jurisdictions with urban environments that tend to have wide, flat and sparsely used footpaths with limited local roads will tend to prefer use on footpaths with higher speed allowances (than 10 km/h); whereas
- Jurisdictions with urban environments that tend to have narrow, fractured footpaths relied on heavily for mobility by vulnerable users will tend to prefer options that more significantly restrict speeds on footpaths for PMD users, or even not allow access at all.

In relation to enforcement and compliance, the NTC noted some jurisdictions have already imposed age restrictions on the use of PMDs. For example, in Queensland a person must be at least 16 years old, or at least 12 years old if supervised by an adult, to be eligible to use a PMD.

To reduce enforcement challenges, the NTC recommended that children under the age of 16 years old be permitted to continue using e-scooters provided the scooters are incapable of travelling more than 10km/h on level ground.

## 2.4. Summary of identified network access issues

***Differences in definitions of e-scooters***

Laws relating to e-scooter definitions (e.g. electric transport devices) determine the nature and extent of network access by riders. Jurisdictional differences in the definitions create regulatory disparities across Australia.

***Differences in speed limits***

There is limited consistency across jurisdictions with regards to e-scooter travel speeds, generating differences in the nature and extent of network access.

***Age limit differences***

Age limits for public e-scooter riding in Australia range from over age 18 to no age restrictions.

***Restricted access to footpaths by pedestrians***

Several countries have experienced substantial public opposition to e-scooter use, mainly from other road users who have been injured by riders and hire scooters left haphazardly on footpaths when a renting rider no longer needs one. E-scooters are often ridden on footpaths at speeds greater than walking pace.

***Need for incident and injury data collection to inform network access***

Some countries have found much higher injury rates for e-scooter riders (and to other road users that the e-scooter riders collide with) than occur with bicycle riders. Such jurisdictions have reformed, or are considering reforming, related legislation as a consequence.

### *Effects of footpath widths*

Where footpaths are relatively narrow, multiple e-scooter users travel close together. Moreover, pedestrians have a much slower speed than riders, posing difficulties in manoeuvring and increasing the chances of conflict.

### *Engineering treatments for e-scooter riding locations*

Relevant engineering treatments include: increased use of geo-fencing in high-volume pedestrian areas; accelerating installation of separated (and if possible wider) bike path infrastructure; protection of pedestrians and those with restricted mobility, and providing scooter parking facilities at public transport hubs.

### *Extent of adoption/adaptation into South Australia of the NTC's preferred option*

The NTC considered that an e-scooter speed limit of 10km/h on footpaths is appropriate for pedestrian safety. Individual jurisdictions may adopt limits higher than that where footpaths are wide and are sparsely used. For bicycle paths and local roads, a maximum speed up to 25km/h is considered safe and appropriate.

# 3. Substitution effects

The United Kingdom permitted public e-scooter trials in 2020, and its national evaluation of the trials was published by the Department for Transport (DfT) in 2022. Monitored data included trip details (time of day, duration, distance), user survey data, local resident survey data, and data from stakeholder interviews.

There were over 14.5 million trips during the trial period, the average trip was 2.2 km, taking 14 minutes, which placed e-scooter use in between walking and cycling trips in terms of average distance, but of slightly shorter average duration than both. Users were predominantly male (71%) and under age 35 (74%). Users with a disability reported increased mobility. Other users said they preferred to use an e-scooter rather than drive or use public transport. Over the trial period, the proportion of trips taken for commuting to work reasons increased from 24% to 33%, while the trip proportions for enjoyment fell from 12% to 7% (other reasons included running personal errands, used for work and commuting to leisure facilities). The vast majority of trips (90%) occurred after morning peak times (7am to 10am).

During a series of in-depth interviews to probe further reasons for stated preferences to use e-scooters over other transport modes, riders cited time and cost savings, convenience and enjoyment as the strongest motivational factors for e-scooter use, with novelty waning as a factor over the trial period. A recurrent theme across the interviews was that e-scooters were seen by many female riders as safer than walking home at night.

Yan, Zhao, Broaddus, Johnson and Srinivasan (2023) have explored to what extent e-scooter sharing/rental schemes can enhance public transport use, thus reducing driving (and hence advancing safety through reduced car exposure to the road). Their surveys in Washington DC and Los Angeles have shown that many riders use e-scooters to connect with public transport and in doing so replace car trips, and that many riders save money through ‘e-scooter + public transit’ rental discounts (e.g. Scoot N’ Ride). This is convenient and cost-effective for the rental companies if they provide substantial scooter parking facilities at public transport hubs. The authors conclude by calling for better coordination between transit operators and e-scooter operators to enhance the benefits of such arrangements.

Another American study of travel behaviour patterns also had a basis of environmental concerns, but with safety implications (Vallamsundar, Jaikumar & Venugopal, 2022). E-scooter travel data collected during 2018 in a Texan city found that most riders were full time professional males aged 26 to 45 commuting to and from work. The factors most influencing e-scooters as the travel mode of choice were: trip length, connectivity with public transport, congestion and car parking issues. E-scooters had commonly replaced personal vehicle use and shared vehicle use travel modes, and had replaced walking to catch public transport.

In their Parisian e-scooter use study, Latinopoulos, Patrier and Sivakumar (2021) found that the majority of trips (on footpaths and bike lanes) lasted 11 to 20 minutes and a majority of surveyed riders (66%) had transitioned *from* using public transport or cars, leading the study’s authors to consider that e-scooter use can be a traffic calming measure in high vehicle environments, and particular so for peak period short trips that would otherwise be taken via vehicles.

## 3.1. Summary of identified substitution effects

***E-scooters as a preferred purposeful travel mode (e.g. for commuting)***

Riders often prefer e-scooters over other transport modes for reasons of time and cost savings, convenience, enjoyment, and for nighttime safety instead of walking. However, they may well choose riding to access and return from other travel modes such as public transport, as well as preferring e-scooters over driving and public transport generally.

# 4. Design issues

***NTC proposed regulatory framework for PMDs (including e-scooters)***

The NTC (2020) proposed regulatory framework for national adoption defines a personal mobility device (including an e-scooter) as a device that:

- has 1 or more wheels.
- is propelled by 1 or more electric motors.
- is designed for use by a single person only.
- has an effective stopping system controlled by using brakes, gears or motor control.
- when propelled only by the motor, cannot reach a speed greater than 25km/h on level ground.
- is not equipped with any sharp protrusions.

The NTC further distinguished between two device categories:

Category A (small, light devices) as not more than:

- 1250mm in length by 700mm in width by 1350mm in height.
- 25kg when the vehicle is not carrying a person or other load.

Category B - optional (large, heavier devices)

- 700mm in length by 1250mm in width by 1350mm in height.
- 60kg when the vehicle is not carrying a person or other load.

***Design issues research***

In Germany, Siebert, Ringhand, Englert, Hoffknecht, Edwards and Rötting, (2021) investigated the safety implications of the ergonomic design of e-scooters, particularly their braking systems. Braking systems vary across e-scooter manufacturers: for example, some models have brake controls on both the left and right handlebars (operable by either hand), while others have a single handle brake on the left handlebar coupled with a foot brake for either the front or rear wheel depending on the model.

The authors made field observations of nearly 3,000 e-scooter trips, followed up with surveys of 156 riders. A clear effect was found of braking system design, with significantly more riders using the left handle brake than the right hand one (or foot brake, depending on scooter model). The authors considered that such a preference for the left hand brake can be detrimental to braking of either the front or rear wheel. Moreover, in the survey, only one third of riders could identify the type of braking system present in the hired e-scooter they had last used. The authors consider that, for e-scooter renters, brake placement and operation will need to be remembered for a range of scooter models as a universal mental model will be incorrect for some scooter models. This could create confusion for many renters, exacerbated by front and rear brakes producing different brake forces, resulting in possible inadequate brake force when brakes are applied. Additionally, the need for continuous operation of a thumb-activated throttle control on the right handlebar could impede successful activation of the right hand brake lever. The authors go on to suggest that, given the higher efficiency of front wheel braking, manufacturers of e-scooters should couple the left hand brake control with the front wheel brake. They should also investigate colour coding and tactile sensing of handlebar brake controls to better indicate which brake lever operates the front wheel brake, and which the rear wheel brake.

In Britain, Eyers, Parry and Zaid (2022) examined the safety of 21 used e-scooters that had been donated mainly from rental companies for research purposes. Two particular capabilities were examined in detail: acceleration and deceleration. This was while noting that many e-scooters are manufactured with three speed mode choices for riders: Eco (economy), Drive (regular riding), and Sport (fast riding), often selected by repeat pressings of the power button. Most of the scooters had both an electronic brake and a mechanical back-up brake. It was found that:

- The average acceleration capability across all the e-scooters was 2.8 metres per second per second (SD = 1.1).
- The strongest predictor of acceleration capability was motor size, with 500 watt devices having a mean acceleration around 2 metres per second greater than that of the 250 to 350 watt scooters.
- Increases in mass of riders produced inconsistent variations to acceleration.
- The effect of tyre pressure variation on acceleration was inconsistent.
- All devices were found to over-state their peak speed. Where fitted, speedometer readings over-stated true speeds by 2.5 km/h to 5km/h, and peak speeds were found to be between 1.5 and 11km/h lower than the manufacturer's stated maximum values.
- Deceleration or braking rates across the sample were more consistent. The mean result for the whole sample was 3.4 metres per second per second (SD = 0.5).
- Scooters with disc brakes produced slightly higher decelerations than drum brakes and decelerations were greatest overall when using foot brakes.
- Wheel lock up was delayed or prevented when the rider was weighted (e.g. carrying loads, a backpack or a passenger), resulting in lower average deceleration rates.

In tests of manoeuvrability, it was found surface bumps up to 40mm in height could be negotiated without destabilising the rider. Ability to negotiate higher bumps without destabilisation depended on the rider's skill, which was largely the case with swerve manoeuvres. Destabilisation could also occur through throttle controls tending to be on the right side handlebar, meaning that when riders have to give a turn hand signal they have to take their hand off the throttle control, resulting in deceleration and possible destabilisation as a consequence.

In addition, assessment of the e-scooter sample highlighted a number of maintenance issues which may be encountered among privately owned devices. More than 50% of the scooters had brakes or steering in unserviceable condition, and 40% had broken or missing rear mudguards, often resulting in loss of the rear light assembly. Tyre maintenance was a common problem, with an average under-inflation of pneumatic tyres of 55% observed.

The report's authors considered that the above technical findings, while needing confirmation through examining a larger sample, provide a point of reference when investigating and reconstructing e-scooter collisions.

The ETSC has issued a set of recommendations for e-scooter design capabilities directed at member countries' governments (ETSC, 2023b). These include:

- Manufacturers should fix a maximum 20 km/h speed limited for private e-scooters.
- Shared e-scooter providers, while limiting top speed to 20 km/h, should also enforce lower speeds, for example in pedestrian zones, through using GPS technology.
- E-scooters should have a maximum rated power of 250 watts.
- Anti-tampering mechanisms should be included by the manufacturer for privately owned e-scooters and by the operator for shared e-scooter schemes; tampering with speed control mechanisms should be prohibited by law.
- Set a minimum wheel size of 30.5 cm for both private and shared e-scooters.
- Set a requirement for independent front and rear wheel braking devices for both private and shared e-scooters.
- Set a requirement for independent front and rear lights on private and shared e-scooters; indicator lights should be considered due to the difficulties of using hand signals while riding.
- Require an audible warning device on all private and shared e-scooters.

A Euro Cities report (ETSC, 2023c) noted that, as e-scooters have small wheel diameters and small lower stability relative to bicycles, this results in higher sensitivity of the e-scooter to the smoothness of various riding surfaces. Consequently, where footpaths have uneven surfaces, riders are more likely to prefer to ride on roads instead.

The European Transport Safety Council (ETSC, 2023b) noted that e-scooters are designed, on average, for a maximum carrying capacity of 100kg. It added that, as studies show that adult e-scooter riders suffer abdominal injuries as a result of shock from the handlebars in a collision, it could be implied that child passengers, standing in front of the rider, are at additional risk of head injury from impact with the stem and handlebars. Furthermore, it noted, the profile of adult e-scooter rider head injuries is more similar to motorcyclist head injuries than to cyclist head injuries.

The ETSC (2023b, p.32) went on to note that few member countries permitted riding on footpaths, largely this is because, "…pedestrians, especially the elderly and those who are visually impaired, are at risk of harm from vehicles sharing the same space". In fact, a study has found three-quarters of pedestrians struck by an e-scooter were either between ages 0 to 14, or over 60 years (Siman-Tov, Radomislensky, Israel Trauma Group & Peleg, 2017). Additionally, a high percentage of collisions occur the first time a rider uses an e-scooter, perhaps because e-scooters handle in a different way to pedal cycles, which many people are already familiar with.

Queensland's *Personal Mobility Action Plan* advocates for the Commonwealth Government to review importation requirements for e-scooters to limit non-compliant devices being imported into Australia.

Kelly (2022) notes anecdotal evidence that, while shared (rented) e-scooters have a fixed speed limit set in them, with privately owned e-scooters, speed limitation settings can easily be de-activated.

## 4.1. Summary of identified design issues

***Differences in acceleration capabilities and speed readings***

- The average acceleration capability across 21 used e-scooters was 2.8 metres per second per second, but with some noticeable variability (SD = 1.1).
- The strongest predictor of acceleration capability was motor size, with 500 watt devices having a mean acceleration around 2 metres per second greater than that of the 250 – 350 watt scooters.
- Increases in mass of riders produced inconsistent variations to acceleration.
- The effect of tyre pressure variation on acceleration was inconsistent.
- All devices were found to over-state their peak speed. Where fitted, speedometer readings over-stated true speeds by 2.5 km/h– 5km/h, and peak speeds were found to be between 1.5 and 11 km/h lower than the manufacturer's stated maximum values.
- There is anecdotal evidence that, while shared (rented) e-scooters have a fixed speed limit set in them, with privately owned e-scooters, speed limitation settings can easily be de-activated.

***Deceleration differences and different e-scooter braking systems***

- Braking systems vary across e-scooter manufacturers: some models have brake controls on both the left and right handlebars (operable by either hand), while others have a single handle brake on the left handlebar coupled with a foot brake for either the front or rear wheel depending on the model.
- Riders' general preference for the left hand brake can be detrimental to braking of either the front or rear wheel.
- E-scooter renters may need to remember brake placement and operation for a range of scooter models.
- However, such a universal mental model will be incorrect for some scooter models, creating create confusion for many renters, exacerbated by front and rear brakes producing different brake forces, resulting in possible inadequate brake force when brakes are applied.
- A need for continuous operation of a thumb-activated *throttle* control on the right handlebar could impede successful activation of the right hand *brake* lever.
- Given the higher efficiency of front wheel braking, manufacturers of e-scooters should couple the left hand brake control with the front wheel brake.
- They should also investigate colour coding and tactile sensing of handlebar brake controls to better indicate which brake lever operates the front wheel brake, and which the rear wheel brake.
- A high percentage of collisions occur for first time e-scooter riders, perhaps because e-scooters handle in a different way to pedal cycles, which many people are already familiar with.
- Deceleration or braking rates across a sample of 21 used e-scooters produced a mean of 3.4 metres per second per second (SD = 0.5).

- Scooters with disc brakes in the sample of 21 produced slightly higher decelerations than drum brakes and decelerations were greatest overall when using foot brakes.
- Also in that sample, wheel lock up was delayed or prevented when the rider was weighted (e.g. carrying loads, a backpack or a passenger), resulting in lower average deceleration rates.

***Effects of e-scooters' small wheel size***

- As e-scooters have small wheel diameters and small lower stability relative to bicycles, this results in higher sensitivity of the e-scooter to the smoothness of various riding surfaces. Consequently, where footpaths have uneven surfaces, riders are more likely to prefer to ride on roads instead.

***Handle-bar injury issue for adult riders***

- Adult e-scooter riders suffer abdominal injuries as a result of shock from the handlebars in a collision; furthermore, the profile of adult e-scooter rider head injuries is more similar to motorcyclist head injuries than to cyclist head injuries.

# 5. Field testing for braking performance

The ability of a vehicle to brake effectively in an emergency situation is crucial for the safety of the rider and other road users. Small reductions in brake performance can lead to large changes in impact speed, and increased risk of serious injury. Eyers et al., (2022) examined 21 used e-scooters (in the UK) and found that mean deceleration of the scooters tested was 3.4 m/s/s.

To provide further insights, a series of brake tests were conducted on an economical and popular entry level e-scooter that was available for purchase in Australia and comparisons were made with a bicycle under the same speed conditions.

## 5.1. Test equipment

An instrumented back pack was constructed consisting of a high-accuracy Global Positioning System (GPS) with Inertial Measurement Unit (IMU) integration and power source. The VBOX 3i + IMU system was used to accurately capture the position and acceleration (to a resolution of 0.01 g) of the rider. The backpack, power source and recording equipment weighed 11.6 kg and is shown in Figure 5.1.

The e-scooter used was a Segway Ninebot D28U with 10-inch pneumatic tyres (set to the rated pressure of 50 PSI), 300-watt front wheel motor with eBrake and rear cable drum brake both which engaged with a single brake lever, the e-scooter mass was 15.3 kg. A bicycle was also tested as a comparative and familiar transport mode. The bicycle was a Polygon Heist 5 hybrid bike with 29-inch pneumatic tyres (set to the rated pressure of 65 psi) with independently actuated hydraulic front and rear disc brakes. The rider height was 184 cm with a total mass of 91.6 kg with the instrumented backpack.

Figure 5.1
(a) Instrumented backpack (b) Instrumented backpack fitted to e-scooter rider.

## 5.2. Test Method

Testing was undertaken on a privately owned carpark consisting of an asphalt surface with an area of approximately 60 by 60 metres. The backpack was securely fitted to the rider and the VBOX 3i + IMU was switched on. Riding was undertaken in a figure 8 configuration on the bicycle to initialise the IMU. Orange traffic cones were placed at the location where braking was to begin and be contained within as shown in Figure 5.2.

Figure 5.2
Testing the e-scooter and bicycle braking performance.

Each test consisted of accelerating to the desired speed and maintaining the desired speed up until the braking start point. At the braking start point brakes were applied to the full extent without initiating wheel lock up. Prior to the commencement of each set of brake tests, the Vbox was activated to record, and the file number was noted. Recording was halted at the end of each set of tests.

Three tests were conducted for each of the following scenarios resulting in a total of 45 brake tests:

1. 5 km/h, 10 km/h, 15 km/h, 20 km/h and 25 km/h with high e-scooter regenerative braking
2. 5 km/h, 10 km/h, 15 km/h, 20 km/h and 25 km/h with low e-scooter regenerative braking
3. 5 km/h, 10 km/h, 15 km/h, 20 km/h and 25 km/h – bicycle braking

At the end of all testing, all Vbox files were downloaded from the device and catalogued into a digital folder system.

The Vbox data was recorded at 100 Hz and contained the following details for each test:

- Date
- Time
- Latitude
- Longitude
- Velocity
- Acceleration (deceleration)

Each file was then processed in the following way. First the data relevant to each individual test was isolated by finding periods where the velocity increased to the approximate test speed, held steady, and then suddenly decelerated to stationary (the light blue shaded area in Figure 5.3). The point within these periods where the deceleration of the test device began to increase was then identified. The speed of the device at this point was recorded as the 'initial test velocity'. The ADR 31 mean deceleration formula was then used to calculate the average deceleration of the test device between 80% of the initial velocity and 10% of the initial velocity. This process is discussed in detail in Mackenzie, van den Berg & Elsegood (2020). Additionally, the peak deceleration, the stopping distance within the steady state deceleration period and total stopping distance (to when the tested device came to rest i.e., less than 2 km/h or 0.56 m/s) was also calculated for each test.

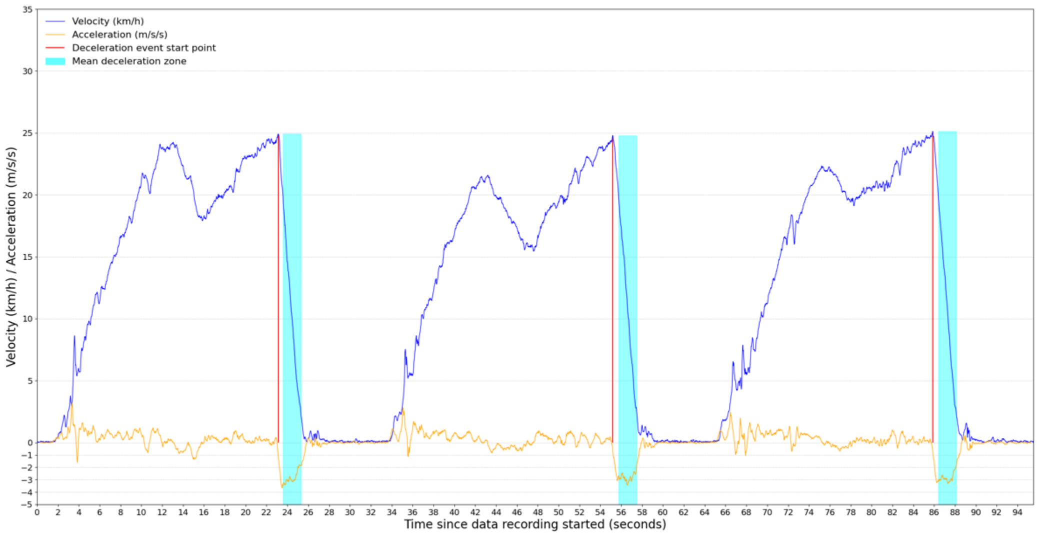


Figure 5.3
An example of the graphical output from brake testing.

## 5.3. Results

The results of the brake tests are shown in Table 5.1 for the e-scooter with high regenerative braking (HRB) and Table 5.2 for the e-scooter with low regenerative braking (LRB). There was very little difference in the mean deceleration with the HRB across all the test speeds (2.869 m/s/s) compared to the mean deceleration for the LRB (2.788 m/s/s). Additionally, there was also very little difference in the mean peak deceleration with the HRB across all the test speeds (3.367 m/s/s) compared to the mean peak deceleration for the LRB (3.255 m/s/s). However, there was slight improvement in the average braking distances (0.45m less) for the e-scooter with HRB compared to LRB at the highest initial speed of 25 km/h. The bicycle brake testing results (Table 5.3) produced better average braking deceleration across all speeds of 4.379 m/s/s and 5.159 m/s/s for mean deceleration and peak deceleration respectively, and correspondingly shorter braking distances compared to the e-scooter.

Table 5.1
Brake testing results for the e-scooter under high regenerative braking.

| Target Speed (km/h) | Actual Speed (km/h) | Mean Deceleration (m/s/s) | Peak Deceleration (m/s/s) | Braking Distance (m) |
|---|---|---|---|---|
| 5 | 6.938 | 1.923 | 2.454 | 0.755 |
| 5 | 5.582 | 1.088 | 2.444 | 0.768 |
| 5 | 5.926 | 2.254 | 2.512 | 0.647 |
| 10 | 11.012 | 2.516 | 3.634 | 1.3 |
| 10 | 10.037 | 2.531 | 3.349 | 1.259 |
| 10 | 9.827 | 2.194 | 2.926 | 1.543 |
| 15 | 15.693 | 2.639 | 3.709 | 2.894 |
| 15 | 15.216 | 2.667 | 3.657 | 2.871 |
| 15 | 15.265 | 2.609 | 3.298 | 3.597 |
| 20 | 20.016 | 3.063 | 3.851 | 4.915 |
| 20 | 19.959 | 2.849 | 4.004 | 4.823 |
| 20 | 19.558 | 3.034 | 3.893 | 4.583 |
| 25 | 25.351 | 3.038 | 3.496 | 8.169 |
| 25 | 24.843 | 2.72 | 3.689 | 7.947 |
| 25 | 24.967 | 3.036 | 3.592 | 7.845 |

Table 5.2
Brake testing results for the e-scooter under low regenerative braking[1].

| Target Speed (km/h) | Actual Speed (km/h) | Mean Deceleration (m/s/s) | Peak Deceleration (m/s/s) | Braking Distance (m) |
|---|---|---|---|---|
| 5 | 6.481 | 2.163 | 2.596 | 0.94 |
| 5 | 6.381 | 1.819 | 2.296 | 0.951 |
| 5 | 6.642 | 2.05 | 2.423 | 0.749 |
| 10 | 10.456 | 2.293 | 3.083 | 2.156 |
| 10 | 10.512 | 2.011 | 3.292 | 1.552 |
| 10 | 10.003 | 2.193 | 3.352 | 1.427 |
| 15 | 14.819 | 2.506 | 3.437 | 2.832 |
| 15 | 14.876 | 2.414 | 3.895 | 3.293 |
| 20 | 19.164 | 3.04 | 3.671 | 4.963 |
| 20 | 19.652 | 2.891 | 3.694 | 4.421 |
| 20 | 19.829 | 2.715 | 3.386 | 5.659 |

[1] Due to a technical issue, only data for 2 tests at 15 km/h were able to be analysed.

| | | | | |
|---|---|---|---|---|
| 25 | 24.914 | 2.812 | 3.669 | 7.803 |
| 25 | 24.798 | 2.813 | 3.454 | 8.798 |
| 25 | 25.13 | 2.838 | 3.323 | 8.697 |

Table 5.3
Brake testing results for the bicycle.

| Target Speed (km/h) | Actual Speed (km/h) | Mean Deceleration (m/s/s) | Peak Deceleration (m/s/s) | Braking Distance (m) |
|---|---|---|---|---|
| 5 | 5.024 | 1.771 | 2.443 | 0.324 |
| 5 | 4.933 | 1.481 | 2.371 | 0.255 |
| 5 | 5.048 | 1.949 | 2.721 | 0.5 |
| 10 | 10.825 | 3.943 | 5.329 | 1.015 |
| 10 | 11.006 | 3.822 | 5.099 | 1.292 |
| 10 | 10.826 | 3.221 | 3.892 | 1.437 |
| 15 | 15.873 | 3.784 | 4.523 | 3.118 |
| 15 | 16.219 | 4.538 | 5.456 | 2.236 |
| 20 | 15.348 | 4.523 | 5.065 | 2.055 |
| 20 | 21.455 | 4.337 | 4.773 | 4.658 |
| 20 | 20.467 | 4.125 | 5.067 | 3.712 |
| 25 | 21.995 | 3.561 | 3.959 | 5.453 |
| 25 | 27.802 | 4.665 | 5.339 | 6.464 |
| 25 | 26.262 | 4.497 | 5.054 | 6.288 |

Plots (and polynomial trend lines) for each test speed and corresponding braking distance are shown for each vehicle in Figure 5.4. Further, Figure 5.5 shows the braking distance equation of motion [Braking distance = (Initial Velocity)$^2$/(2 x deceleration)] plotted against speed, for the average deceleration derived from the LRB tests. This is compared to the LRB test data and polynomial trend line. The equation of motion correlates well with this deceleration and suggests that once a deceleration value is calculated through testing, the equation of motion can be used to determine braking distance at different initial velocities.

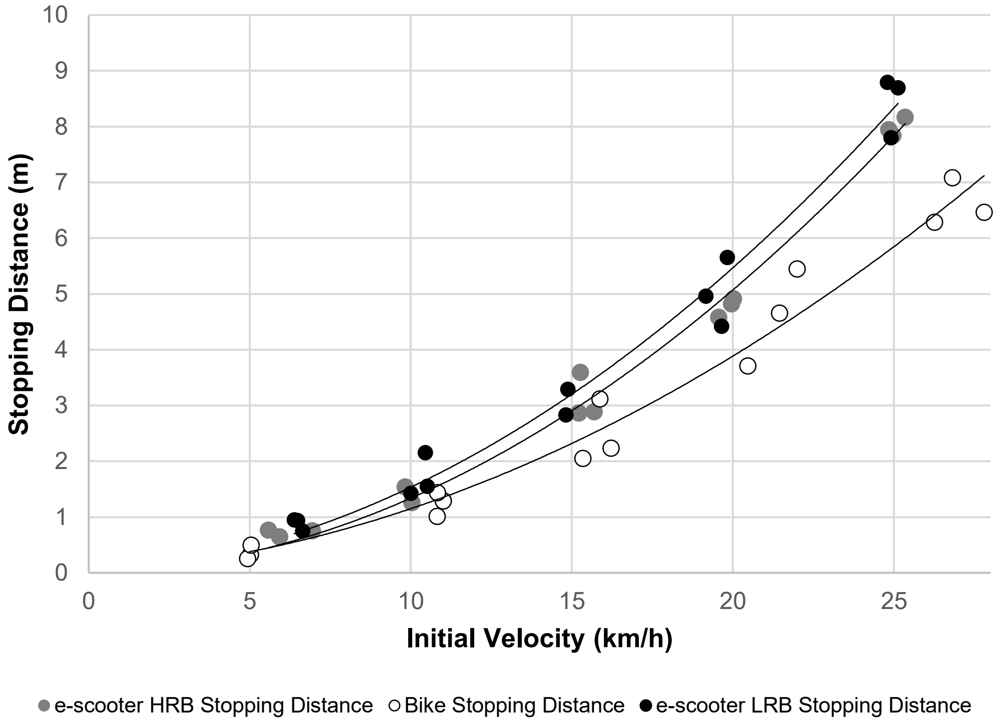


Figure 5.4
Initial velocity and corresponding total stopping distance for each test device (and second order polynomial trend lines).

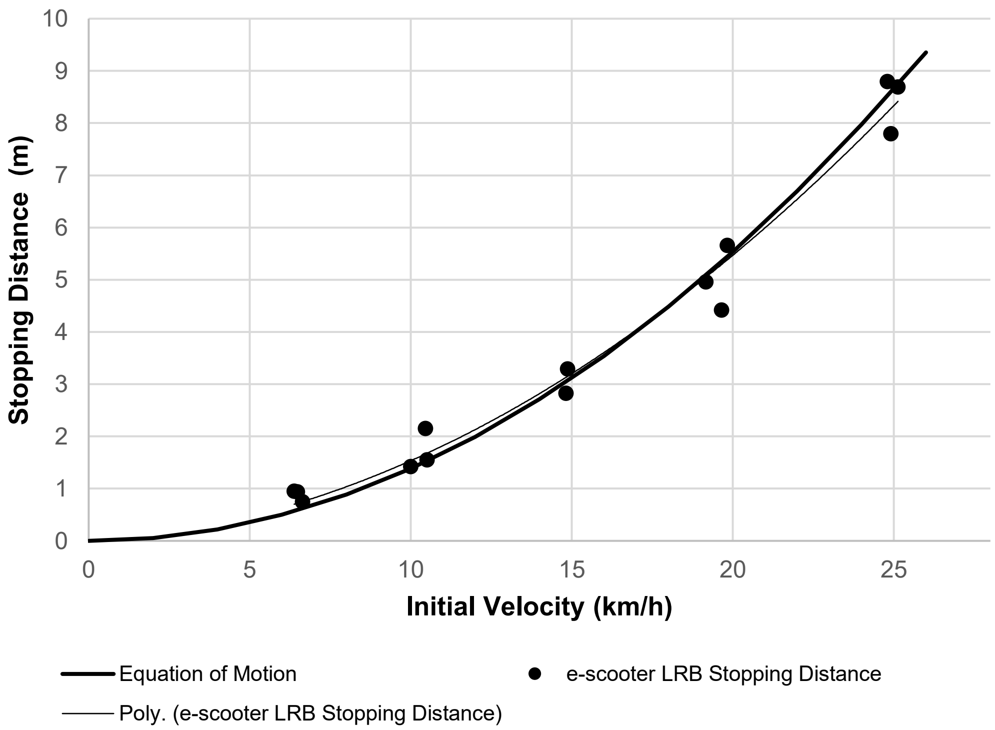


Figure 5.5
Calculated braking distances based on equation of motion using average deceleration from LRB e-scooter tests, compared to actual stopping distances from LRB e-scooter test.

The differences between total stopping distance for an e-scooter and bicycle for the same initial speed is demonstrated in Figure 5.6. If a bicycle and an e-scooter are both travelling on the footpath at 15 km/h and the rider reacts and then brakes, the bicycle will come to a complete stop in 6.1m whereas the e-scooter requires 7.3 m to stop. When the bicycle has come to a complete stop, the e-scooter still requires another 1.2 m of stopping distance, and with reference to Figure 5.5, the e-scooter will still be travelling at around 9 km/h. If both vehicles are travelling at 10 km/h initially then under the same reaction/braking scenario at the point the bicycle has stopped the e-scooter will still be travelling at around 6 km/h.

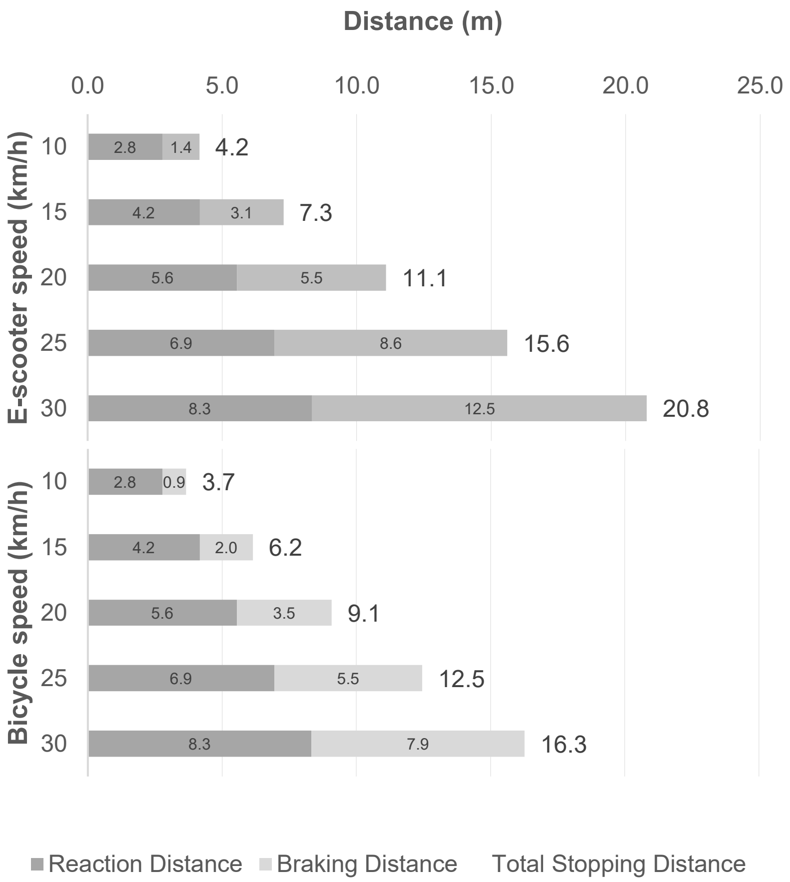


Figure 5.6
Demonstration of reaction distance, braking distance and total stopping distance for an e-scooter and bicycle at the same initial speeds.

# 6. Kinetic energy considerations

Kinetic energy is one of the most important determinants of impact severity. Pedestrian survival curves have been well established for pedestrian collisions (Rosén and Sander, 2009) however there is limited research on the relationship between speed and injury tolerance where collisions involving e-scooters, bicycles and pedestrians are concerned. In lieu of this, kinetic energy provides a simplistic and practical way to frame safety and performance considerations in the context of this report.

## 6.1. Energy on public roads up to 60km/h

The kinetic energy of a moving object is related to both the speed and mass of that moving object and is expressed in the following way:

Kinetic Energy = 0.5 x mass x velocity squared

While mass is important, energy is most sensitive to the velocity and small changes can result in large changes in overall energy. The unit of measurement of energy is in Joules (J) and is commonly expressed in kilojoules (kJ).

In the context of the current transport system, the kinetic energy of an 80 kg person with a walking speed of 5 km/h (1.39 m/s) is around 80 J (0.08 kJ). A motor vehicle with a mass of 1,400 kg moving at 10 km/h in a shared space has kinetic energy of around 5,400 J (5.4 kJ). The same motor vehicle travelling at 25 km/h (e.g., travelling at speed limit within a school zone) has a kinetic energy of around 34,000 J (34 kJ). In terms of energy equivalents, the 1,400 kg vehicle would have to be travelling at just over 1 km/h to have the same kinetic energy as the walking pedestrian.

Figure 6.1 shows the relationship between kinetic energy and speed for two different vehicle masses for speeds less than 25 km/h. This would cover situations where pedestrian protection is prioritised such as within school zones or road works.

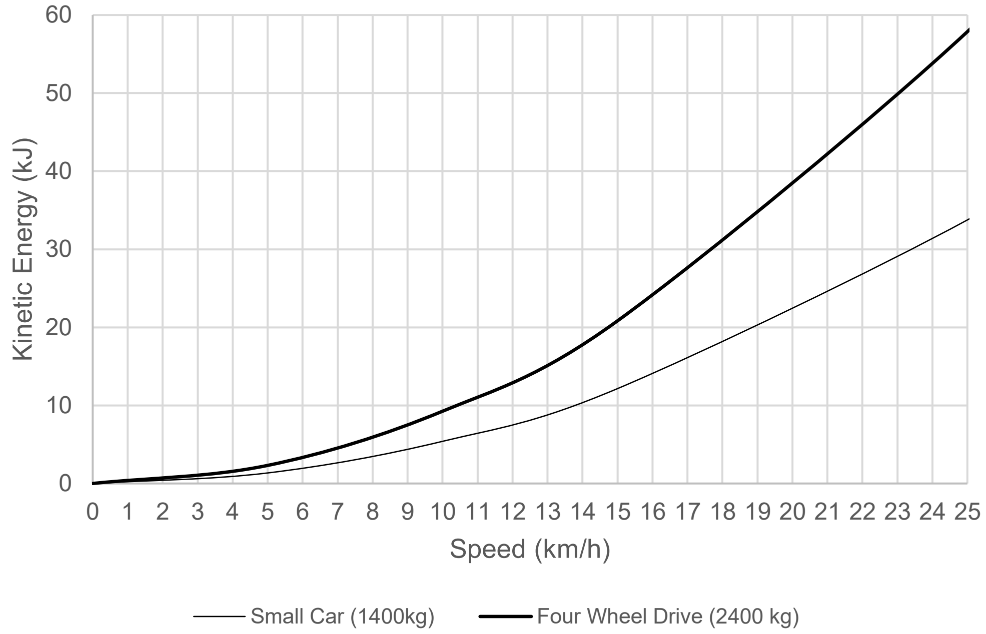


Figure 6.1
The relationship between kinetic energy and speed for two different mass vehicles for speeds under 25 km/h.

On higher speed roads, as the road hierarchy becomes more focussed on traffic movement, the kinetic energy within the system increases considerably. Figure 6.2 demonstrates the increase in kinetic energy with increasing speed, for three different mass vehicles, that are commonly seen on roads with these speed limits.

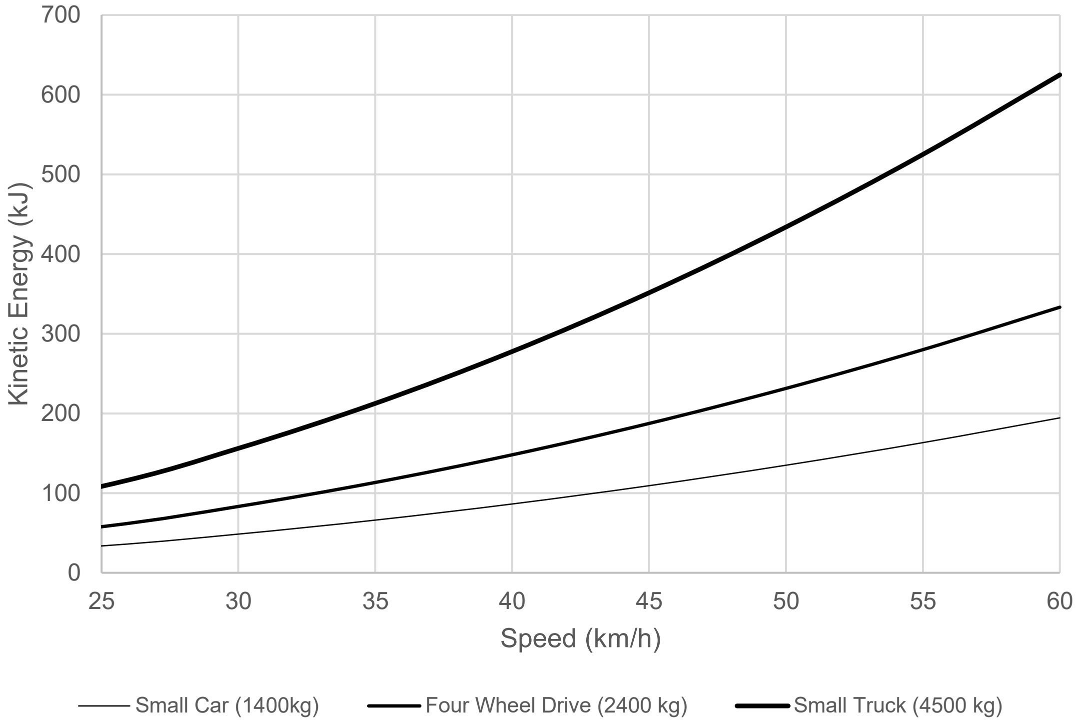


Figure 6.2
The relationship between kinetic energy and speed for two different mass vehicles for speeds 25 km/h to 60 km/h.

Figure 6.1 and 6.2 demonstrate the energy within the traffic system that cyclists are currently exposed to, and that e-scooter riders would also be exposed to if they were permitted on certain roads zoned 60 km/h or less.

## 6.2. Energy related to existing e-scooter legislation

The NTC parameters are used as the frame of reference: e-scooter mass between 25 kg and 60 kg, maximum speeds between 10 km/h to 25 km/h and a rider mass of 80 kg. Figure 6.3 shows the kinetic energy curves for four different e-scooter masses and increasing e-scooter speed from 5 km/h to 15 km/h for a rider weighing 80 kg (the kinetic energy exposure that currently exists within a policy framework that allows e-scooter use on footpaths).

Figure 6.4 shows the kinetic energy curves for four different e-scooter masses (with an 80 kg rider) and increasing e-scooter speed from 15 km/h to 40 km/h, where e-scooter speed greater than 25 km/h (greyed out) would be considered outside of the NTC framework or any current jurisdictional policy/legislative framework, but is shown as there is anecdotal evidence that some e-scooters are capable of speeds greater than 25 km/h.

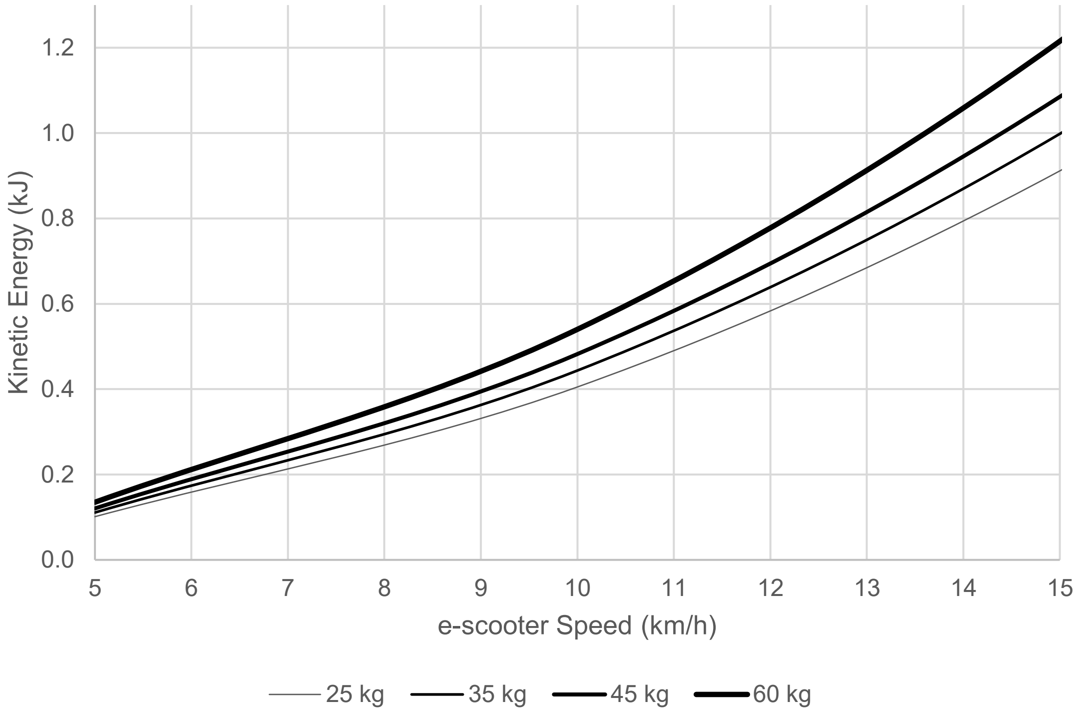


Figure 6.3
Change in kinetic energy for four different e-scooter masses and increasing e-scooter speed from 5km/h to 15 km/h assuming an 80kg rider.

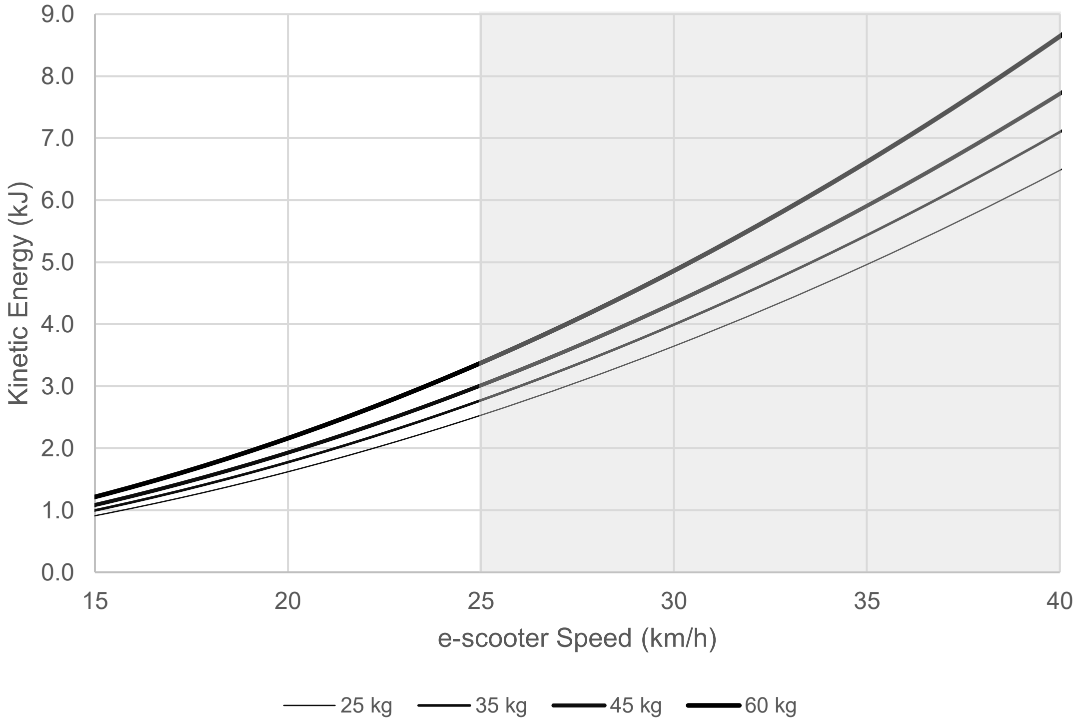


Figure 6.4
Change in kinetic energy for four different e-scooter masses and increasing e-scooter speed from 15 km/h to 40 km/h assuming an 80kg rider (greyed area shows speeds beyond the NTC guidelines).

## 6.3. E-scooter speeds on footpaths

Evidence on injury mechanisms for low speed e-scooter collisions is not yet established and further monitoring and studies are required. Theoretically, a speed limit of 10 km/h would provide the safest environment for e-scooter riders and pedestrians and this has been selected by one other jurisdiction and recommended by the NTC. Increasing this speed to 12 km/h as adopted by Queensland or 15km/h as is currently adopted in SA (and three other jurisdictions) is likely to result in marginal safety performance differences when considered in the context of the broader operating conditions, including:

- The benefits of harmonisation with other schemes nationally
- A likely absence of speed enforcement or difficulty conducting enforcement
- A lack of ability of GPS to differentiate footpaths from road traffic lanes
- A potential lack of speed indication on some models of e-scooters
- User perceptions regarding the allowable speed limits and the desire to select a footpath over a road environment for travel
- A likelihood that some hire scooter designs will evolve with improved braking and collision avoidance performance into the future
- Concerns from pedestrians and cyclists

There can be a perception that the speed range of 10 to 15 km/h is very low and possibly comparable to pedestrian walking speeds. By way of comparison, (Figure 6.5) Austroads (2020) guidance for pedestrian walking speed to cross the road is 1 to 1.2 m/s (3.6 to 4.3 km/h). Therefore, e-scooter speed restrictions in the range of 10-15 km/h are approximately three to five times higher and the argument for higher speeds on this basis is unfounded.

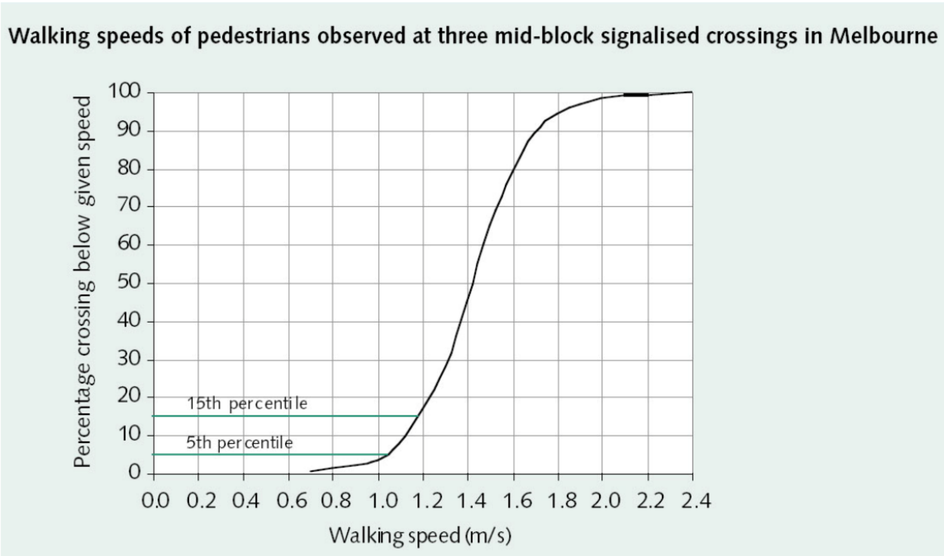


Figure 6.5
Walking speeds of pedestrians (Austroads, 2020).

## 6.4. Discussion

E-scooters are a relatively new mode of transport within the transport system, and currently operate in South Australia on footpaths or shared paths in particular local Government areas under share scheme trials. Speeds under the trial are limited to 15 km/h and the mass of e-scooters limited to 25 kg producing a maximum energy potential of just under 1000 J when ridden by an 80 kg person.

While a speed limit of 10 km/h would provide the safest environment for e-scooter riders and pedestrians from an energy management perspective (without excessive compromise of e-scooter mobility), most jurisdictions have adopted higher footpath speed limits, but not exceeding 15 km/h. Given the lack of information on injury mechanisms and outcomes for low speed e-scooter collisions further monitoring and studies are required.

If e-scooters are permitted to share the road with motor vehicles, they are exposed to much higher energy levels due in part to their increased speeds (up to 25km/h) and most significantly interaction with motorised vehicles.

While there are no published relationships associating energy, speed or recreational devices (bicycles and e-scooters) with injury tolerance, the established pedestrian survivability curves for collisions with passenger cars are provided here as a point of reference in Figure 6.6 (Rosén and Sander, 2009).

At a vehicle impact speed of 25 km/h the pedestrian fatality risk is approximately 1%. As vehicle impact speed increases to 40 km/h, 50 km/h and 60 km/h the pedestrian fatality risk increases to 3.5%, 8.3% and 18.2% respectively. The protection offered by helmets will also improve impact survivability. Whether considering energy or impact speed, it is evident that the exposure of e-scooter riders to high volume, higher speed roads should be avoided and segregation and high-level helmet enforcement remain as the preferred policy option.

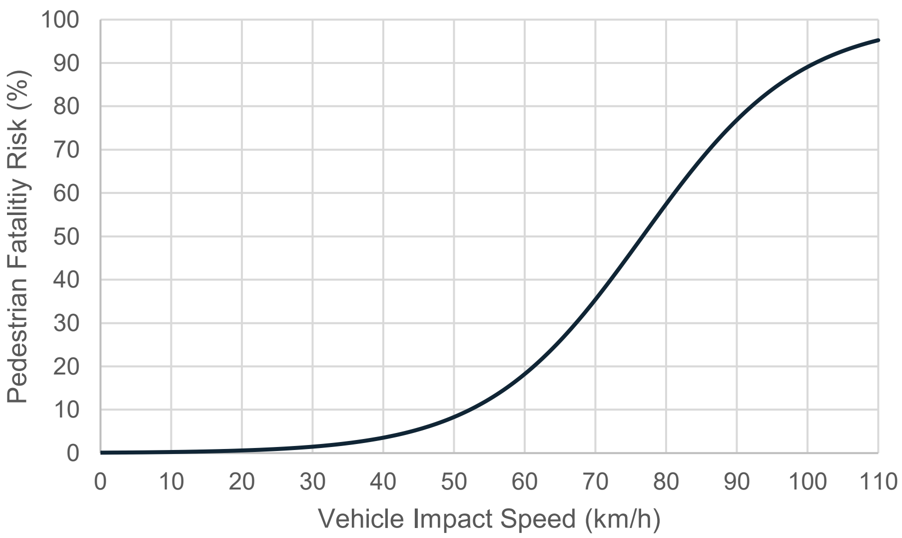


Figure 6.6
The relationship between pedestrian fatality risk and vehicle impact speed (Rosén and Sander, 2009).

# 7. Discussions with Australian jurisdictions

Representatives from Transport departments in each State and Territory within Australia were contacted for commentary regarding e-scooters within their individual jurisdictions. Note that private and shared scheme usage varies across Australia and comments are contextualised accordingly.

The questionnaire template used for feedback and interviews is included in Appendix 2.

A summary of the feedback is provided in the following sections.

## 7.1. Shared e-scooters

Opinions regarding shared e-scooter use within most jurisdictions were consistent. The benefits of the shared scheme included:

- Using embedded GPS, share scheme operators could apply geofencing parameters to the devices to ensure they could only operate designated areas and operation time could also be restricted.
- Speed limiting features were applied to the devices using GPS and geofencing which meant that speed regulations had forced compliance.
- Device mass and size limits could also be specified.
- Shared scheme operators provided incident reports, trip, and distance data, and met with jurisdictional representatives to ensure any issues could be reviewed, discussed and resolved.
- Some shared e-scooter devices were being improved with technology to detect pedestrians to reduce conflicts, provide better stability and improved braking systems.
- As a phone application was required to unlock and use a shared e-scooter some operators had introduced cognitive sobriety tests to reduce incidences of intoxicated people using shared e-scooters.
- The public seemed to accept their use.

There were also issues with shared e-scooter schemes:

- There was considerable non-compliance with mandatory helmet requirements.
- There was frequent non-compliance with operation of e-scooters while under the influence of alcohol.
- Anecdotally the outcome of the alcohol use and helmet non-use occasionally being e-scooter rider crashes and injuries. While most injuries were not serious, non-helmeted head injuries were often serious.
- The burden of injury on the public health system has increased.
- There were also frequent occurrences of the non-compliant behaviour of two people sharing one e-scooter.
- Shared e-scooters that were inappropriately “parked” were considered a nuisance/litter and a trip hazard/mechanism for injury particularly for those with impaired vision.

- Differences in regulations between jurisdictions often led to confusion for interstate visitors (e.g. some jurisdictions allow footpath use, some jurisdictions do not permit footpath use.)

## 7.2. Privately owned e-scooters

Feedback on privately owned e-scooters was also consistent, however there were slight differences in policy settings. The benefits of private e-scooter use included:

- Reasonably good mandatory helmet compliance.
- No issues with parking or street litter.
- Usage was better aligned with the aspirational ideas of e-scooters as a transport mode, used as a start of, and end-of-trip transport mode.
- Appeased the public enthusiasm/will for these devices.

There were also multiple issues with privately owned e-scooters:

- Considerable difficulties in enforcing regulations relating to private e-scooters. Most jurisdictions define an e-scooter with respect to specifications such as allowable mass, speed limitation requirements or power ratings, and use of any devices that are non-compliant are considered “unregistered/uninsured” vehicles. The consequence of operating an “unregistered/uninsured vehicle” is a significant offence type, but also presumably falls outside of the originally intended scope of that offence type. Consequently, police are both reluctant to enforce the private e-scooter specifications, as there are inherent difficulties for police to test devices, and they are reluctant to expiate given the significant difference in risk footprint between genuinely unregistered/unlicensed vehicles and non-approved e-scooters.
- Limiting the actual speed of devices and discrepancies with regulations and design specifications. For example, in Victoria, as part of the e-scooter definition, e-scooters must not be able to exceed 25 km/h, however the maximum permissible speed while on e-scooters in Victoria is 20 km/h.
- Unregulated e-scooter sales and importation into Australia. The consequence of this is a large variation in private e-scooters on the transport network that are potentially non-compliant, with no current mechanism to alleviate this issue.
- Speeding and other illegal behaviours. Some jurisdictions indicated that a considerable proportion of the severe injuries (and fatalities) derived from e-scooter usage were the result of illegal behaviours on private e-scooters, particularly speed and alcohol.
- Use of private e-scooters in areas not permitted, for example some private e-scooters were noted to be ridden on roads that exceeded the speed limit requirements of e-scooters for the particular jurisdictions or ridden on footpaths when not permitted.

## 7.3. Issues common to shared and private e-Scooters

Other issues that were highlighted or were noted, that were not specific to either private or hire scheme e-scooters included:

- Lighting concerns and that requirements for lighting only related to being visible to other network users, but there was no requirement for lighting for visibility of network users. For example, there was concern that at night some e-scooters were incapable of lighting footpaths or footpath users, and consequently presented higher collision risks to pedestrians at night.

- No jurisdiction had a policy or requirement in place specifying a minimum level of braking performance, only that that there had to be a functioning brake system.
- There was inconsistency for network access between jurisdictions, some allowed footpath use, some banned footpath use.
- Some jurisdictions considered e-scooter riders as pedestrians, some wanted to align them more with bicycles, some considered them in a separate category of “e-rideable”. However, when the e-scooters were non-compliant with the individual jurisdictional definition of an e-scooter, they defaulted as being an unregistered/uninsured vehicle, a category in which it was not aligned with at all.
- Jurisdictions had inconsistencies with mass specifications, and some had different masses dependent on whether they were privately owned or part of a hire-scheme but there were some jurisdictions that considered aligning specifications with each other.
- Jurisdictions also had inconsistencies in speeds designated for different networks.

Despite guidelines written by the NTC, jurisdictions have adopted different measures, so there is not a consistent approach to e-scooter usage. However, most jurisdictions shared many similar issues and required multi-jurisdictional support to influence the national regulatory processes. This made resolving important issues such as regulating the specifications of imported e-scooters much more difficult.

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# Appendix 1 – Overseas jurisdictions

| Jurisdiction (as at April 2023) | Where e-scooters can be ridden | Speed limit & motor power limit | Helmet requirement & Age requirement | Other access issue |
|---|---|---|---|---|
| **United Kingdom**<br><br>(e-scooters fall under moped legislation) | Trial city locations only | 25 km/h<br><br>500 watts | Helmet *not* required<br><br>16, but must have a provisional licence | - No passengers |
| **New Zealand**<br><br>(e-scooters fall under low-powered vehicles not requiring registration or a driver's licence) | Footpaths, shared parts & roads (but *not* in a bicycle lane on a road, as these are reserved for cyclists) | No speed limit<br><br>No power limit | Helmet *not* required<br><br>No min age | A rider on a footpath must 'operate the device at a speed that does not put other footpath users at risk' |
| **United States**<br><br>(No Federal law, but state laws vary state by state) | Generally: shared paths, cycle paths, but not footpaths<br><br>Roads at 50 km/h & where cycling is permitted | Generally 20-25 km/h<br><br>750 watts | Generally, helmet is required<br><br>Generally 16+ | - State by state variation in specific rules such as no night riding; but commonly riding with care and attention to other road users' needs<br>- A comprehensive state by state guide is provided by Unagi (2023) |
| **Canada**<br><br>(No national law, but provincial laws vary province by province, including what vehicle category e-scooters fall under) | Generally: shared paths, cycle paths, but not footpaths (unless aged <14)<br><br>Roads at 50 km/h & where cycling is permitted | Generally around 30 km/h<br><br>Power limits not specified | Generally, helmet is required<br><br>Generally 16+ | Variation in acceptance / rejection of e-scooters across provinces (e.g. contentious in Ontario due to injury & insurance issues, and hired scooters have been banned in Montreal due to littering) |
| **Japan**<br><br>(new rules from 1 July 2023) | Footpaths & shared paths (6km/h only)<br><br>Roads where cycling is permitted | 20 km/h<br><br>600 watts | Helmet *not* required (previously it was required)<br><br>16+ | - Footpath riders must have green flashing lights on e-scooters<br>- *Prior to July 2023, e-scooters treated as motorised bicycles, hence helmet required |

| European jurisdiction (as at April 2023) | Where e-scooters can be ridden | Speed limit & motor power limit | Helmet requirement & age requirement | Other access issue |
|---|---|---|---|---|
| **Austria**<br><br>(e-scooters treated as bicycles in law) | Footpaths (if permitted by local council)<br><br>Shared paths, cycle paths<br><br>Roads where cycling is permitted | 25 km/h<br><br>600 watts | Helmet only if aged <12<br><br>12+ yrs, but from age 9 if pass ability test | - Government is considering min age of 14, a 20km/h limit & mandatory helmets<br>- No passengers<br>- Must have lights and reflectors for night use |
| **Belgium**<br><br>(e-scooters treated as bicycles in law) | Shared paths, cycle paths<br><br>Roads where cycling is permitted | 25 km/h<br><br>No power limit | Helmet *not* required<br><br>16+ (raised from 12+ in July 2022) | - No passengers<br>- BAC – as for car<br>- Brussels to cut shared e-scooters by 62% and limit schemes to 2 from 2024 |
| **Bulgaria** | Footpaths, shared paths, cycle paths<br><br>Roads where cycling is permitted | 25 km/h<br><br>No power limit | Helmet only if aged <18<br><br>14+ for footpaths & shared paths, but 16+ for roads | - No passengers<br>- Must have lights and reflectors for night use |
| **Czech Republic**<br><br>(e-scooters treated as bicycles in law) | Footpaths only if aged <10<br><br>Shared paths, cycle paths<br><br>Roads where cycling is permitted | 25 km/h<br><br>250 watts | Helmet only if aged <18<br><br>Min age not specified | - No passengers<br>- Zero BAC – same as for car |
| **Cyprus**<br><br>(e-scooter legislation being considered) | Shared paths, cycle paths<br><br>Road use is being proposed | Proposal for 15 km/h<br><br>No power limit | Helmet requirement being considered<br><br>16+ | - Proposal for no passengers<br>- BAC <0.05 proposed |
| **Denmark**<br><br>(e-scooters treated as mopeds in law) | Under 5 year trial: Shared paths, cycle paths | Proposal for 20 km/h<br><br>No power limit | Helmets now mandatory (Jan 2023)<br><br>15+ (must be accompanied by adult if aged <15) | - Lights & reflectors<br>- No passengers |

| European jurisdiction (as at April 2023) | Where e-scooters can be ridden | Speed limit & motor power limit | Helmet requirement & age requirement | Other access issue |
|---|---|---|---|---|
| **Finland**<br><br>(e-scooters treated as bicycles in law) | Footpaths, shared paths, cycle paths / lanes | 25 km/h<br><br>1000 watts | Helmet is required<br><br>No age minimum | |
| **France**<br><br>(e-scooters treated as bicycles in law) | Footpaths (where permitted), shared paths, cycle paths<br><br>Roads where cycling is permitted | 25 km/h (but 6 km/h on footpaths where permitted)<br><br>No power limit | Helmet *not* required<br><br>12+ | Parisian city authority is considering banning hired e-scooters after a poll found 90% of residents opposed them, mainly on grounds of them being left anywhere on footpaths and injuries caused |
| **Germany** | Footpaths (where permitted), shared paths, cycle paths<br><br>Roads where cycling is permitted | 20 km/h<br><br>500 watts | Helmet *not* required<br><br>14+ | -Government seeking to raise min age to 15 |
| **Greece**<br><br>(e-scooters treated as bicycles if >6 km/h, but pedestrians if <6 km/h) | Footpaths, shared paths, cycle paths<br><br>Roads where cycling is permitted | 25 km/h for ages 15+, but 6 km/h for ages 12-14<br><br>No power limit | Helmet required<br><br>15+ (but see speed limit note) | |
| **Ireland**<br><br>(e-scooters treated as motor vehicles in law) | Unclear | Speed limit not specified<br><br>Power limit not specified | Helmet is required<br><br>15+ (but see speed limit note) | -E-scooter riders required to hold a driver's licence |
| **Italy** | Footpaths, shared paths, cycle paths<br><br>Roads zoned at 50 km/h or less | 20 km/h, but 6 km/h in pedestrian areas<br><br>500 watts | Helmet required only if under 18 yrs<br><br>14+ | -Lights & reflectors at night, dayglo jacket if poor visibility<br>-Government is considering calls for registration plates on e-scooters, compulsory insurance for all riders, helmets for everyone and a light driving licence |

| European jurisdiction (as at April 2023) | Where e-scooters can be ridden | Speed limit & motor power limit | Helmet requirement & age requirement | Other access issues |
|---|---|---|---|---|
| **Netherlands**<br><br>(e-scooters treated as mopeds in law) | Only areas where approved mopeds can be ridden (i.e. roads) | 25 km/h<br><br>No power limit | Helmet *not* required<br><br>16+ | |
| **Norway** | Roads | 20 km/h<br><br>No power limit | Helmet required only if <15 yrs<br><br>12+ | -Government is considering treating e-scooters as motor vehicles in response to research finding 10X injury risk compared to bicyclists |
| **Poland** | Footpaths, shared paths, cycle paths<br><br>Roads zoned at 30 km/h | 20 km/h<br><br>No power limit | Helmet *not* required<br><br>10+ (but adult supervision if aged <10) | -Cycling proficiency certification if aged 10 to 18 |
| **Portugal**<br><br>(e-scooters treated as bicycles in law) | Footpaths (only for children <10 yrs), shared paths, cycle paths<br><br>Roads where cycling is permitted | 25 km/h<br><br>1000 watts | Helmet *not* required<br><br>No minimum age | -BAC >0.05 |
| **Slovenia** | Cycle paths<br><br>Roads where cycling is permitted | 25 km/h<br><br>No power limit | Helmet required only if aged <18<br><br>14+ | |
| **Spain** | Cycle paths<br><br>Roads where cycling is permitted | 25 km/h<br><br>1000 watts | Helmet required<br><br>14 to 16 yrs, depending on city | -not allowed in tunnels<br>-Government is considering minimum technical standards for e-scooters |
| **Sweden**<br><br>(e-scooters treated as bicycles in law) | Footpaths, shared paths, cycle paths<br><br>Roads where cycling is permitted | 20 km/h<br><br>250 watts | Helmet required only if aged <15<br><br>No minimum age | |
| **Switzerland**<br><br>(e-scooters treated as bicycles in law) | Footpaths, shared paths, cycle paths<br><br>Roads where cycling is permitted | 20 km/h<br><br>250 watts | Helmet *not* required<br><br>14+ | Moped licence required for 14-16 year olds |

# Appendix 2 – Jurisdictional e-scooter questionnaire

Name:

Organisation:

Jurisdiction:

| |
|---|
| *Note – consideration is being given to both fleet only and private ownership scenarios so please clarify this context if relevant in your responses.* |

**Q1. Can you please confirm the details of current practice in your jurisdiction are correct according to the included table (below).**

*Do you envisage any significant changes or refinement of your existing policy in the next 5 years?*

**Q2. Are there any access issues that your organisation is dealing with. Which of these have been resolved and which remain unresolved?**

*These might include:*

- *Use of e-scooters on roads, bicycle lanes, shared paths, footpaths?*
- *Is road environment/locality also a factor – e-scooter use on wide suburban footpaths vs busy CBD streets?*
- *Speed limit settings where e-scooters are permitted to operate.*

**Q3 Are there any emergent issues that your organisation is dealing with. Which of these have been resolved and which remain unresolved?**

*This includes:*

*Any new devices entering the market that may not be captured under your existing framework.*

**Q4. Do you have any data, evidence or information on the interaction between e-scooter users and other road users and whether the experience has been positive or otherwise?**

**Q5. How has your organisation determined what devices are suitable to be permitted for use?**

*For example:*

*Is it based on design and performance criteria?*

*If relevant:*

*Is the NTC Decision Regulation Impact Statement adequate for your current policy response?*

*Do you have any concerns that extend beyond the NTC heavy and light categories (e.g. braking, wheel size, weights etc)?*

| |
|---|
| National Transport Commission (2020), Barriers to the safe use of personal mobility devices, Decision Regulation Impact Statement, NTC, Melbourne. https://www.ntc.gov.au/sites/default/files/assets/files/NTC-Decision-RIS-PMDs.pdf |

**Q6. What do you consider to still be the largest gaps in knowledge or policy setting at present?**

**Q7. Are there any additional comments you would like to contribute?**

Network access conditions (Australian jurisdictions) - DRAFT

| Jurisdiction's laws as at April 2023 | Where e-scooters can be ridden | Speed limit & motor power limit | Age requirement | Other access issues |
|---|---|---|---|---|
| **Australian Road Rules** (ARRs), s.244A-S (2021);<br><br>Riders of e-scooters must obey rules for riders of wheeled recreational devices | Not on road or road related area (unless permitted in individual jurisdiction) | 10 km/h<br><br>200 watts | 16 + | -Must have lights and reflectors for night use |
| **Victoria**<br>Road Safety Road Rules 2017, s.2: relating to wheeled recreational devices; | Shared paths, bike paths, bike lanes and roads with a speed limit 60km/h but only in trials in City of Melbourne, City of Yarra, City of Port Phillip & City of Ballarat<br><br>Not permitted on footpaths | 20 km/h<br><br>200 watts | 16+ | -Must have lights and reflectors for night use, single file only |
| **New South Wales**<br>NSW Road Rules s.240(2)(c) relating to wheeled recreational devices;<br><br>Private e-scooter use only permitted on private property | Footpaths, shared paths, bicycle paths, roads zoned as <50km/h, but only in trial areas | 10 km/h on footpaths & shared paths<br><br>20 km/h on roads & bicycle lanes<br><br>No motor power limit | 16 + | -Must have lights and reflectors for night use |
| **ACT**<br>Section 244D to 244J in ACT Road Transport (Road Rules) Regulation 2017 | Footpaths, shared paths, cycle paths<br><br>Not permitted on roads or on-road bike lanes except on residential streets without footpaths | Footpaths – 15km/h<br>Shared paths, bike paths – 25km/h<br>Using a crossing – 10km/h<br><br>No motor power limit | Any age, but if <12 years need adult supervision | -Must have lights and reflectors for night use |
| **Tasmania**<br>Road Amendment (Personal Mobility Devices) Rules 2021 | Footpaths, shared paths, cycle paths<br><br>Local roads zoned at 50km/h or less with no dividing line, no median strip or no multiple lanes on one way road | Footpaths – 15km/h<br>Shared paths, bike paths & local roads 25km/h<br><br>200 watts (16 +) | 16 or older<br><br><16 only permitted to use low powered e-scooters which do not exceed 200 watts or 10km/h | -Must have lights and reflectors for night use |

Network access conditions (Australian jurisdictions) - DRAFT

| Jurisdiction’s laws as at April 2023 | Where e-scooters can be ridden | Speed limit & motor power limit | Age requirement | Other access issues |
|---|---|---|---|---|
| **Queensland**<br>Transport Operations (Road Use Management—Road Rules) (Personal Mobility Devices) Amendment Regulation 2018 — Riders of e-scooters must obey rules for riders of wheeled recreational devices. | Footpaths, shared paths, separated paths, bicycle paths<br><br>Bike lanes on roads zoned at 50km/h or less<br><br>Bike lanes physically separated from other traffic<br><br>Local streets 50km/h or less and no dividing line | Footpaths, shared paths, road crossings – 12km/h;<br><br>Separated paths, bicycle paths – 25km/h (or less where signed)<br><br>Roads (inc. in bicycle lanes) – 25km/h, or less if speed limit less than 25km/h<br><br>No motor power limit | 16+; but 12-16 if supervised by adult | -Must have lights and reflectors for night use |
| **Western Australia**<br>E-scooters defined as eRideable devices; WA Road Traffic Code 2000, Division 2 | Footpaths, shared paths, cycle paths<br><br>Roads zoned at 50km/h or less without a dividing line | Footpaths – 10km/h<br>Shared paths, bike lanes & roads – 25km/h<br>Using a crossing – 10km/h<br><br>No motor power limit<br><br>25 kg or less<br><br>Speed limited to 25km/h on level ground | 16 +<br><br><16 only permitted to use low powered e-scooters which do not exceed 200 watts or 10km/h | -Must have lights and reflectors for night use |
| **Northern Territory**<br>ARRs as incorporated in NT Traffic Regulations 1999<br><br>Private e-scooter use only permitted on private property | Footpaths, shared paths, cycle paths in City of Darwin only | 15km/h<br><br>No motor power limit | 18+ | -Must have lights and reflectors for night use |