



Potential for electric bike use in Melbourne

Background report for Transport Strategy Refresh

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Executive Summary

The global electric bicycle (e-bike) market has grown substantially in the last decade. E-bikes represent the largest, most rapid uptake of alternative fuelled vehicles in the history of motorisation. E-bike owners ride more often, and farther than other cyclists and are able to better maintain speed with less effort. E-bike ownership reduces car use to an even greater extent than regular bicycles.

Australia's harmonisation of e-bike regulation, which broadly equates to European standards, coupled with growing market interest, has resulted in a flourishing local e-bike sector. This report examines international research on e-bikes; who uses them, for what purpose and the impact they can have on transport outcomes. This provides the basis for an exploration of the potential of e-bikes to assist Melbourne in meeting its transport and wider strategic objectives. E-bikes for personal travel, as well as commercial applications, such as last kilometre freight and food delivery are explored in this report.

E-bikes offer the user quicker travel time, with less effort. E-bikes have been found to lessen some of the common barriers to conventional bikes, including the ability to overcome topographical challenges, physical limitations of the rider and arriving at work without perspiring. Moreover, e-bike owners report that being able to ride with greater loads (e.g. children or groceries) opens up greater possibilities for cycling, including replacing some car use.

E-bike riders cycle more frequently than conventional bike users and each trip is significantly longer than conventional bike journeys. E-bike users also report replacing car trips more often, helping to reduce congestion, emissions, parking pressure and other negative impacts associated with urban car use.

'I use my e-bike to commute because I don't need special clothing or showers and I don't get as sweaty on hills or as tired from the ride'

E-bike owner

In 2017, Australian e-bike sales doubled compared to the previous year, with an estimated 25,000 – 30,000 e-bikes sold.

While the increasing availability and presence of e-bikes should be welcomed, there are some potential issues that will need to be addressed. This includes possible speed differences between e-bike riders and those on conventional bikes. This may represent overtaking issues on narrow parts of the network. Additionally, the burgeoning food delivery market may have (anecdotally) a higher prevalence of throttle-controlled e-bikes (which do not require pedalling and can, illegally, provide propulsion greater than 25km/h). Their concentration in some parts of central Melbourne may cause some pedestrian access issues.

A number of studies have found that e-bike owners report that they feel a sense of joy when using their e-bike.

Research suggests that the main barriers to a greater take up of e-bikes relate to a higher purchase price, theft concerns if having to park on the footpath, battery range and the safety associated with riding on streets without adequate bicycle infrastructure. Recent City of Melbourne commissioned research found a very strong market preference for bike lanes that offered physical protection from motor vehicles.

E-bikes offer several important benefits to assist the City of Melbourne achieve its wider objectives. Many of these relate to the added value proposition e-bikes offer. Female representation in cycling participation is much lower than their 51% of the population and e-bikes have been found to reduce this gender imbalance. At peak times, the road and public transport network is at capacity, and therefore e-bikes provide an opportunity to lower capacity constraints currently impacting the road and public transport network. As Melbourne continues to grow, this congestion is widely expected to become more pronounced. The ability of e-bikes to shift trips from motor vehicle and public transport hold the following specific benefits in addition to congestion reduction:

- Road safety improvements
- Transport emissions reduction
- Physical activity benefits
- Reduction in transport costs
- Improved travel time reliability.

Understanding the potential for e-bikes

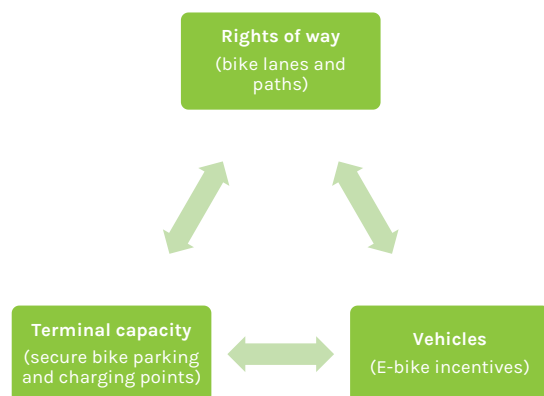
A brief analysis was undertaken to assess the potential for e-bikes to contribute to growing the number of people accessing the City of Melbourne by bike. Focusing solely on the journey to work, e-

bikes have the potential to substantially increase the number of people accessing City of Melbourne workplaces by bike. A high-level analysis suggests e-bikes are capable of increasing daily ridership by between 2,000 and 6,000 people, for the journey to work alone. This is the equivalent to adding between 2 to 6 new High Capacity Metro Trains servicing the peak each day.

E-bikes also hold great potential to reduce negative impacts associated with last kilometre freight delivery. The density of small parcel freight delivery in central Melbourne lends itself to e-cargo cycles. These vehicles are currently experiencing a surge of activity in European cities. E-cargo cycles offer an important opportunity to reduce the congestion and emissions caused by small parcel delivery in the City of Melbourne and assist in efforts to create car free, vibrant spaces within central Melbourne.

What the City of Melbourne can do

This report has found that the encouragement of e-bikes (including e-cargo cycles) supports the City of Melbourne's wider strategic ambition. A greater use of e-bikes will help the City of Melbourne achieve its ambition to become a connected, creative eco-city. Every mode of transport consists of three elements (rights of way, terminal capacity and vehicles), as shown below. For Melbourne to maximise the potential e-bikes offer, it will be necessary for different levels of government to work together to create environment that encourages e-bike use, targeted at substantial improvements in the bicycle network (rights of way), more opportunities for secure bike parking and charging (terminal capacity) and incentivising e-bike purchase.



Vehicle recommendations include:

1. Hold e-bike 'Come and Try' days through partnerships with e-bike retailers. This will help people gain a better understanding of what it is like to ride an e-bike, which has been shown to increase people's willingness to buy and use one.
2. Introduce an e-bike purchase subsidy, which may require a lobbying approach to either state or federal government. The City of Melbourne may need to partner with other capacity city local governments for a combined submission.
3. Encourage the use of salary sacrificing programs for work related e-bike purchase
4. Work with other agencies to explore the merits and risks of boosting power output for e-cargo bikes, from 250W, while still maintaining the regulated 25km/h maximum speed limit.

Rights of way recommendations include:

5. Spearhead the development of a costed *Network Development Plan* for protected bicycle infrastructure across Greater Melbourne, in cooperation with other LGAs. This must also include a forecasting model of its use, to enable a cost benefit analysis.
6. Widen the bike network to enable a more comfortable riding environment and e-bike riders to safely overtake slower riders. The uptake of more cargo cycles will also require bicycle infrastructure of greater width.
7. Increase the permeability of City of Melbourne streets to cycling relative to motor vehicles.

This will boost the competitive advantage of sustainable modes such as e-bikes, while also creating opportunities for enhanced street vibrancy.

Terminal capacity recommendations include:

8. Improve bicycle parking, including partnering with commercial parking garages for the creation of secure, publicly accessible bike parking with the opportunity for charging e-bikes. The Planning Scheme must also be updated to one parking spot per bedroom. The type of bicycle parking will also need to change to accommodate e-bikes, including more horizontal parking and easier access to power points for charging.
9. Create a *Last Kilometre Freight Distribution Hub* to assist the logistics industry in shifting to more appropriately sized vehicles for making last kilometre parcel delivery in central Melbourne.
10. Conduct an examination of the costs, risks and benefits of current and future e-bike food delivery in the City of Melbourne.
11. Work with the commercial delivery industry to create a better understanding of current delivery practices and explore the potential for undertaking last kilometre freight with e-cargo cycle.

1. Introduction

E-bikes have achieved substantial technical advances in the last decade, making them more affordable and reliable. The ever-expanding range of models, and types of bicycles offering an electric version has resulted in significant growth in both ownership and usage.

E-bikes have been identified as playing an increasingly significant role in the development of a low carbon, healthy transport system (Jones, Harms, & Heinen, 2016). Commercially available e-bikes originated in Japan in the early 1980s (Rose, 2012), but technological and cost factors limited market attractiveness until the early 2000s (Jamerson & Benjamin, 2013). Improved battery and motor technology, as well as economies of scale improvements have meant e-bikes can now travel longer distances, are faster, and are more affordable.

E-bikes have the potential to act as a compelling alternative for short to medium distance motor vehicle and public transport trips. By maintaining speed with less effort, e-bikes appeal to a broader range of the population. This is an important issue because cycling is not currently enjoyed equally by all members of the community. Women, older age groups and those living beyond 7km from central Melbourne are all significantly underrepresented in

cycling. Cycling has the potential to benefit a much greater spectrum of the community, and e-bikes should be seen as a catalyst for this, combined with high quality, protected bicycle infrastructure.

In the US, e-bike sales achieved a 25% annual growth rate in 2017 (Nisensen & Crowther, 2018). Commentators estimate 35 million e-bikes were sold in 2015 alone, with forecasts the annual number of e-bikes sold, will more than double by 2035 (Jamerson & Benjamin, 2017a).

The growth of e-bike sales over the last decade makes it the largest and most rapid uptake of alternative fuelled vehicles in the history of motorisation (E. Fishman & Cherry, 2015).

A wide variety of e-bikes are commercially available, with varying performance and design characteristics (Cherry, Weinert, & Xinmiao, 2009; Rose, 2012). There is a spectrum of e-bike designs, from bicycle-style e-bikes to scooter style e-bikes, as shown in Figure 1. This section provides brief definitions, characteristics, and operating performance of different variations of e-bikes.



Figure 1 Range of electric two wheelers

Source: Fishman & Cherry (2015)

The underlying technology of the bikes shown in Figure 1 is the same, with three main components: battery, controller, and motor. The distinctions are mainly related to performance (e.g. speed), cosmetic design, and two main control modes (throttle control or pedal assist). Most pedals on scooter style e-bikes (see image e in Figure 1) do not provide much function and are generally included for regulatory purposes.

The motor power generally ranges from 200W to 1000 W. The weight ranges from 20kg to 45kg, and the range can be as high as 150km on a single charge. Speeds are generally less than 45km/h and as will be discussed, in Australia, the motor cuts off assistance at 25km/h. The predominant European and North American bike designs include derivatives of Figure 1 (a), while China's market includes all styles of e-bike shown in Figure 1. In some Chinese cities, the vast majority of e-bikes fall in the style of vehicles shown in Figure 1(d)–(f), whereas those styles of e-bikes are relatively rare in North America and Europe.

A modern version of an e-bike is shown in Figure 2.



Figure 2 Modern e-bike

Victoria harmonised its e-bike regulation in 2012 (VicRoads, 2018), broadly aligning with the European standard. This has had the effect of widening the types of e-bikes sold in Australia and improved the quality of bicycle available. The current standard is 250W, and a motor cut off speed of 25km/h (200W for throttle controlled). There is continuing debate about changes to this regulation, with some arguing that speed rather than power output would enable cargo bicycles that required higher torque to benefit from a higher power output, while still adhering to the 25km/h

maximum speed. In New Zealand, the power limit is 300W and the maximum speed limit is the posted speed limit on the road.

In most countries, e-bikes that require pedalling to activate the motor (pedelecs) are legally classified

as bicycles. Regulations vary across countries, regions, and even between jurisdictions in the same urban area. A very brief synthesis of complex regulations is as follows, and is presented in Table 1.

Region	Motor Power Limit (W)	Top Speed (km/h)	Notes
United States	750	32	Operable pedals required. S-pedelecs are allowable above 32 km/h since they require human power. States are allowed to regulate use differently.
Canada	500	32	Electric power above 3 km/h.
Australia	250	25	Operable pedals required. Pedelecs allowed 250W power. Throttle e-bikes allows 200W power.
European Union (pedelec)	250	25	Pedelecs classified as bicycles.
European Union (powered cycles)	250-1000	25	Requires pedals. Generally throttle powered.
European Union (moped)	1000-4000	45	S-pedelec must weigh <35 kg. Motor power must be <4 times human power.
China	-	12	Pedals required, but often removed by consumer/retailer. Must weigh <45 kg. Cities can regulate use differently. Inconsistent enforcement of design standards.
Japan	250	24	Pedelec only, power tapers from 15-24 km/h.

Table 1 Main performance regulations of global e-bike markets

Source: Modified from Macarthur & Kobel (2014)

1.1 E-bike sales

Figure 3 provides an overview of estimated e-bike sales in different regions (excluding China). Europe is the dominant e-bike market. In fact, in the Netherlands in 2017, around 30% of all new bikes sold were e-bikes (Bike Europe, 2018). No systematic sales data has been

captured on e-bike sales in Australia (Johnson & Rose, 2013). Bicycle Industries Australia estimate that between 25,000 – 30,000 e-bikes were imported into Australia in 2017, which is approximately twice the number imported in 2016. It is not clear whether this estimate includes sales of conversion kits and online sales from overseas e-bike merchants.

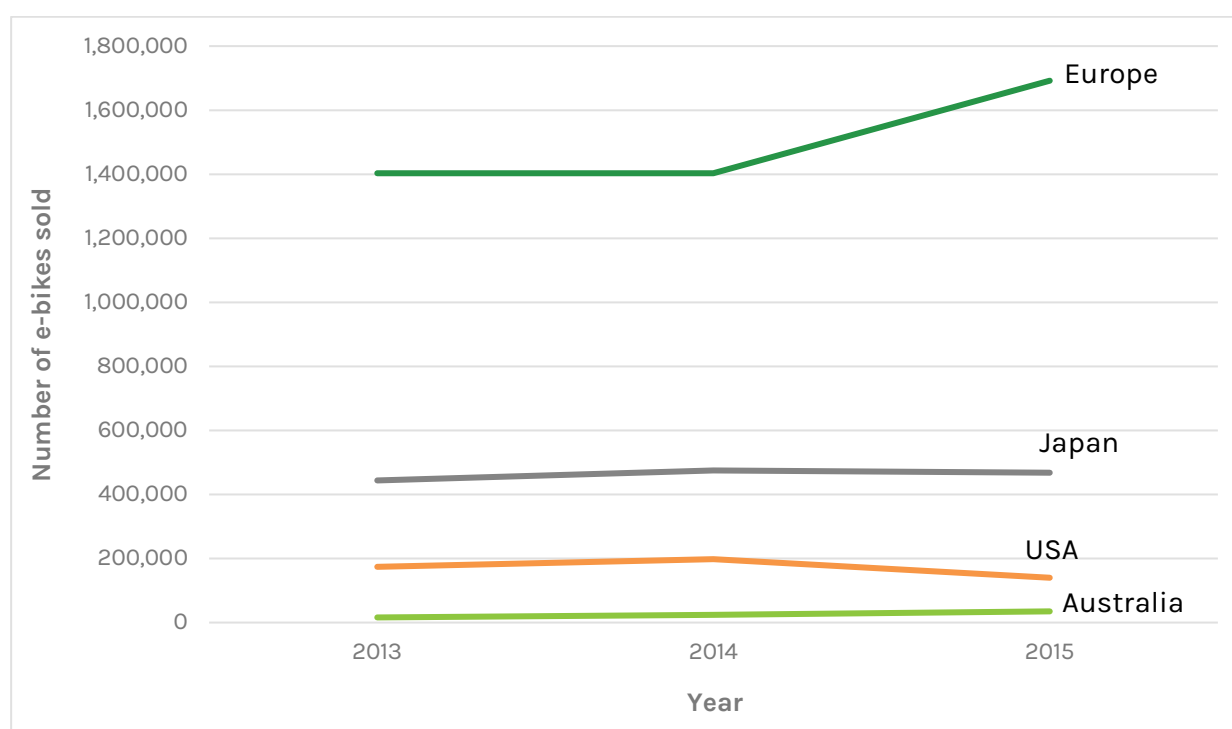


Figure 3 Estimated e-bike sales by region

Source: Jamerson & Benjamin (2017b)

Although it is unclear what methodology was used, Jamerson and Benjamin (2017b) provide forecast e-bike sales from 2015 to 2035 for Australia (Figure 4). This shows a dramatic increase from 2030 (adding an extra 300,000 e-bikes in the five years

to 2035). By way of comparison, there are approximately 1.2 million bicycles (of any type) sold annually in Australia. These figures should be used with caution, with particular concern regarding the 2035 figure.

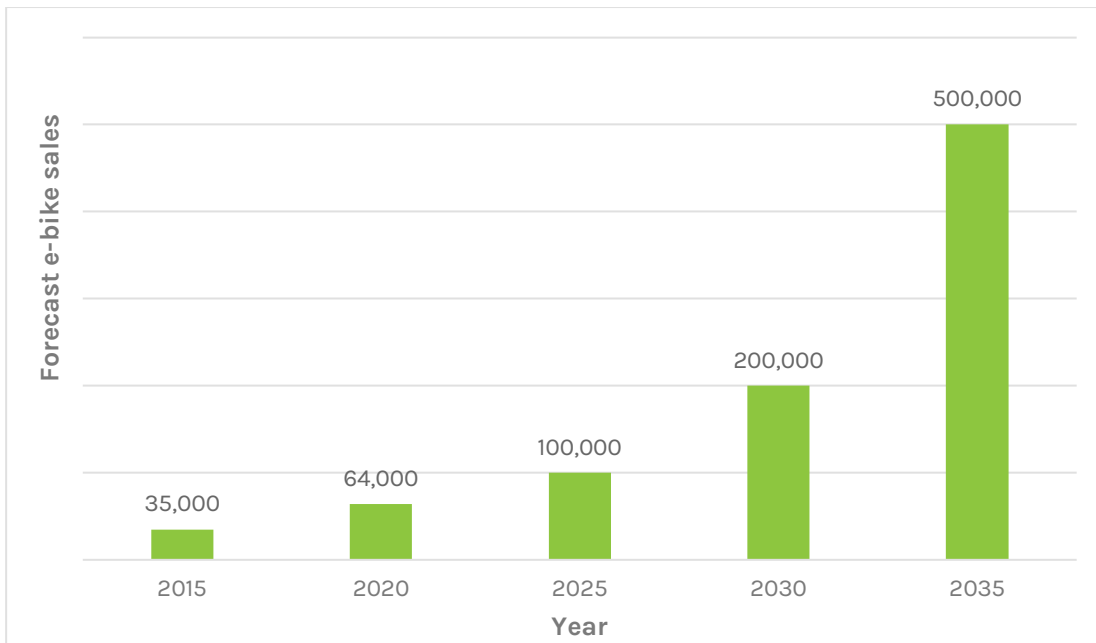


Figure 4 Australian e-bike sales forecast

Source: Jamerson & Benjamin (2017b)

2. E-bikes in Melbourne: Understanding the strategic alignment

E-bikes have the potential to boost cycling levels, and act as a compelling alternative for a proportion of trips currently using cars, vans or public transport within central Melbourne.

This section identifies the strategic alignment and support e-bikes may offer the City of Melbourne as it seeks to achieve its long-term objective of being a *‘sustainable, inventive and inclusive city that is vibrant and flourishing’*.

Every mode of transport relies on three elements (Shoup, 2010); rights of way, terminal capacity and the vehicles themselves (see Figure 5). This is critically important to identify because any policy intended to realise the potential for e-bike use in the City of Melbourne must be cognisant of each of these three elements.

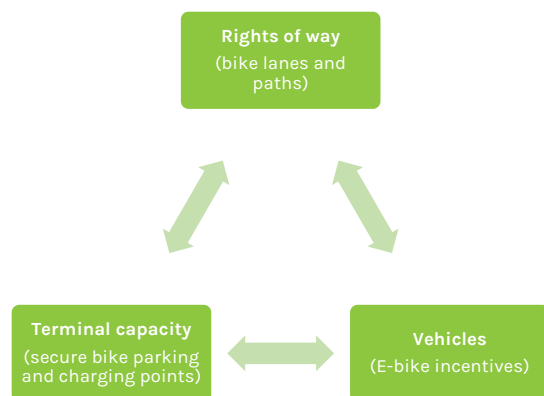


Figure 5 Three elements of the e-bike system

The Near Market report (see CDM Research & ASDF Research, 2017) identifies that the most common age bracket for those working in the City of Melbourne are those aged 35 – 49, and that this category has a higher use of the car as their only mode for travelling to work. Indeed, the Near Market report notes that *‘people stop riding to work when they hit their 50s’* (CDM Research & ASDF Research, 2017, p. 13). E-bikes, as will be shown in this report, have the effect of broadening the spectrum of age groups that see cycling as an option. The data presented in the Near Market report suggests that e-bikes might help to increase the number of central Melbourne workers arriving by bike.

The remainder of this section offers a brief review of the strategic alignment of existing policies and e-bikes.

2.1 Council Plan

The *Council Plan 2017 – 2021* is Council’s key strategic document. There are several important areas in which the strategic ambition of Council is supported through greater use of e-bikes, especially as a replacement of motor vehicle journeys.

The City of Melbourne’s strategic ambition to become a connected, creative eco-city will depend partly on the degree to which it can create an environment supportive of cycling. E-bikes are an effective way of helping to overcome the barriers preventing more people from cycling.

Melbourne is expected to grow from 4.5 million in 2015 to 7.9 million in 2051 (City of Melbourne, 2017). It is unavoidable that a more efficient use of available transport infrastructure will be required if Melbourne is expected to maintain its status as a liveable city given its current growth projections. *‘Doing more with less’* will become increasingly necessary and e-bikes are an excellent opportunity to realise the space efficiency benefits of cycling while avoiding some of the barriers that prevent more people from riding conventional bikes.

The eight goals that form the basis of the *Council Plan 2017 – 2021* (City of Melbourne, 2017) are:

1. A city that cares for its environment
2. A city for people

3. A creative city
4. A prosperous city
5. A connected city
6. A deliberative city
7. A city planning for growth
8. A city with an Aboriginal focus.

Many of the above goals have a direct relationship to transport and a greater use of the bicycle for every day trips.

2.2 Transport Strategy 2012

The City of Melbourne's 2012 *Transport Strategy* (which is currently undergoing a major refresh) outlines six key directions (City of Melbourne, 2012):

- Integrate transport and land use planning.
- Go anywhere, anytime public transport for inner Melbourne.
- Support public transport, walking and cycling as the dominant modes of transport in inner Melbourne.
- Develop high-mobility pedestrian and public transport streets in the central city.
- Make Melbourne a cycling city.
- Foster innovative, low-impact freight and delivery in central Melbourne.

The last two of the above points in particular hold direct relevance to e-bikes. The creation of a cycling city will be assisted by any measures that widen the appeal of cycling. As the literature in this report shows, encouraging the take up of e-bikes is a demonstrated measure that can be taken to grow the number of people who cycle on a regular basis. Moreover, e-cargo cycles are an excellent example that is being used in other cities to lower the impact of last kilometre freight delivery.

Figure 6 illustrates the mode split target set out in the 2012 *Transport Strategy*. The share of private car trips is targeted to drop from 39% (833,729 people) in 2009, to only 20% in 2030 (667,844 people). This represents a very significant challenge, but one that will need to be met in order to achieve the City of Melbourne's current commitment to become carbon neutral. By growing the appeal of cycling for more people, e-bikes can assist the City of Melbourne achieve the mode split targets set out in the *Transport Strategy*.

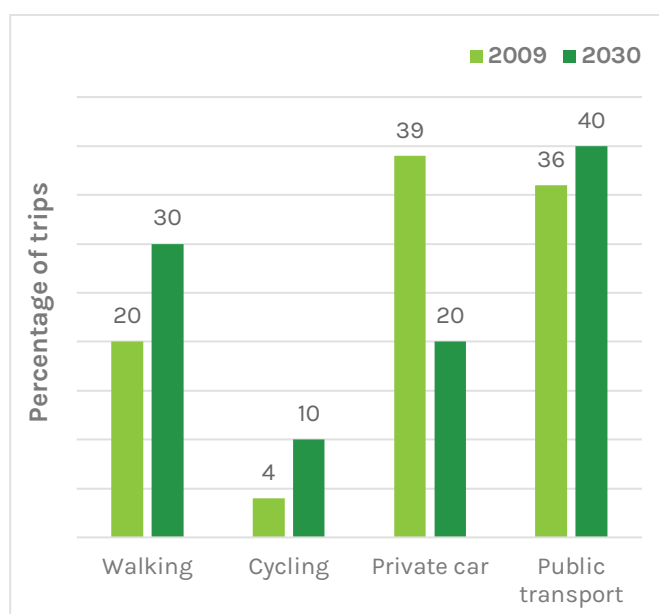


Figure 6 Percentage of trips by mode, weekday 2009 and 2030¹

Source: Taken from Figure 1.3 of the City of Melbourne's *Transport Strategy* (2012)

2.3 Bicycle Plan 2016 – 2020

The *Bicycle Plan 2016 – 2020* identifies the current and future role of cycling within the City of Melbourne. The target for 7% of all trips within the municipality to be by bicycle in 2020, and for this to increase to 10% by 2030 will be supported by the increasing availability of e-bikes. By allowing the rider to maintain speed with less effort, the City of Melbourne stands to enhance the effectiveness of

¹ NB: The figures shown in Figure 6 include those to, within and from the City of Melbourne.

its transport system through the encouragement of e-bikes.

The *Bicycle Plan* details the many benefits of cycling. Almost all the benefits known to be derived from the use of a conventional bike apply to the use of e-bikes (including health benefits, as will be shown in Section 3.6). The *Bicycle Plan* identifies the importance and benefits of electric and cargo bicycles as part of the shift towards lower impact forms of freight and other commercial purposes (City of Melbourne, 2016a).

2.4 Walking Plan

The City of Melbourne's *Walking Plan* identifies that pedestrian travel is the dominant and most important mode of transport within the municipality (City of Melbourne, 2014a). A growth in e-bikes may increase the average speed of bicycle travel and this impact must be managed carefully to preserve pedestrian amenity. Where there are known conflicts between the movement of people on bicycles and foot, the use of e-bikes could exacerbate this issue by potentially increasing the average travel speed.

2.5 Last Kilometre Freight Plan

The *Last Kilometre Freight Plan* (City of Melbourne, 2016b) was developed to improve the efficiency of the freight task, in order to enhance the productivity, liveability and sustainability of Melbourne. The Plan identifies that there are more than 10,300 delivery vehicles entering the central city on an average weekday and that the number of workers and businesses in the central city area has grown rapidly in the last decade to 2015.

A selection of key directions within the *Last Kilometre Freight Plan* are shown below (City of Melbourne, 2016b):

- Establishing current and future freight needs in local area plans.
- Considering the impact of public transport infrastructure and network changes on the function of freight.

- Encouraging freight innovations amongst local businesses and delivery industry.
- Supporting and adapting to new innovations, sharing information and maintaining clear lines of communication with our stakeholders.
- Regulating building and street design to support efficient servicing and delivery.

The role of cargo bikes is highlighted as an opportunity to boost the environmental performance of the last kilometre freight task. E-cargo cycles are considered particularly suitable to dense inner-city environments as they require less space and are easier to park than a larger vehicle (e.g. truck). Improvements to e-bike technology has meant that heavier loads can be carried by cargo bike.

The diversity and capability of modern e-bikes present an important opportunity for the City of Melbourne to fulfil many of the actions included in the *Last Kilometre Freight Plan*

The Plan identifies that a number of pilot projects will be funded by the City of Melbourne in order to foster freight innovation. Another Action within the *Last Kilometre Freight Plan* of relevance to e-bikes is the investigation of enhancing cycling infrastructure to encourage more freight tasks to be undertaken by cargo bike. Finally, using the Queen Victoria Market redevelopment as an opportunity to create a low impact vehicle freight hub was identified as a way of reducing the use of greenhouse emitting vehicles to deliver last kilometre freight.

The City of Melbourne's *Last Kilometre Freight Plan* contains many actions that have strong applicability to e-bikes. The maturity of the e-bike market represents a new opportunity for the City of Melbourne to implement many of the actions that

remain to be fulfilled from the *Last Kilometre Freight Plan*.

Council’s e-bike fleet

The City of Melbourne has had e-bikes as part of their Corporate Fleet since 2008. The number of e-bikes has increased and now includes 25 e-bikes, with most designated to branches, including:

- 9 e-bikes in corporate transport ‘pool’.
- 6 e-bikes used by Park Ranges and other 6 used by Maternal Child Health nurses to attend appointments with new mothers
- 2 e-bikes used by Animal Management for patrols
- 1 e-bike used by the Waterways team and another by Arts House.

E-bikes are typically replaced by the City of Melbourne every three years, to ensure the reliability of the fleet and to take advantage of the continually improving technology.

There has been a significant growth in the use of e-bikes by City of Melbourne staff in recent years, with 10% of all corporate fleet trips occurring on e-bike, compared to 2.5% in 2016 (a fourfold increase).

Box 1 City of Melbourne’s Corporate E-bike Fleet

2.6 Zero Net Emissions by 2020

Zero Net Emissions by 2020 was updated in 2014 and is the City of Melbourne’s strategy to become carbon neutral. There are a variety of mechanisms through which transport emissions can be lowered. A summary of the different pathways is shown in Figure 7, with e-bikes fitting into the ‘mode change’ category.

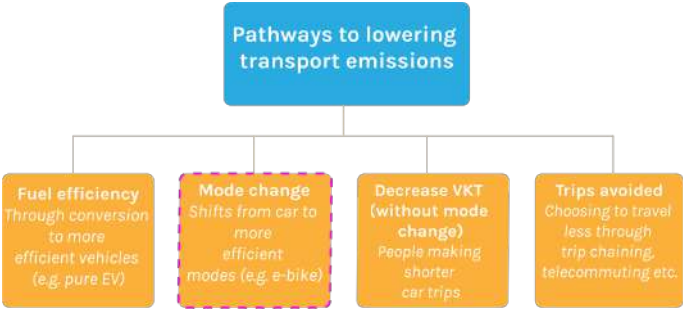


Figure 7 Pathways for lowering transport emissions

One of the focus areas of the Zero Net Emissions strategy is *transport and freight* and includes a target to ‘increase the percentage of all trips using low emissions transport from 51% in 2009 to 60% in 2018’ (City of Melbourne, 2014b, p. 4).

The cost and abatement potential of different categories are outlined in the Zero Net Emissions 2014 Update and show that ‘shifting to more efficient vehicles’ is among the most cost-effective measures to reduce emissions’ (on a \$/tCO₂-e basis). Figure 8 provides an illustration of the emissions intensity and space consumption of various modes of transport. While e-bikes are not specifically listed in Figure 8, their space requirements roughly equate to a conventional bicycle and consume a negligible amount of energy, per kilometre (Ji, Cherry, Bechle, Wu, & Marshall, 2012). The greenhouse gas emissions, per kilometre, for e-bikes cannot be represented in Figure 8, as it is too small (~6g CO₂ per km) This serves to highlight that two wheeled electric transport can assist the City of Melbourne achieve its growth projections in a manner that is both sustainable and reduces congestion when used to replace more space consumptive transport.

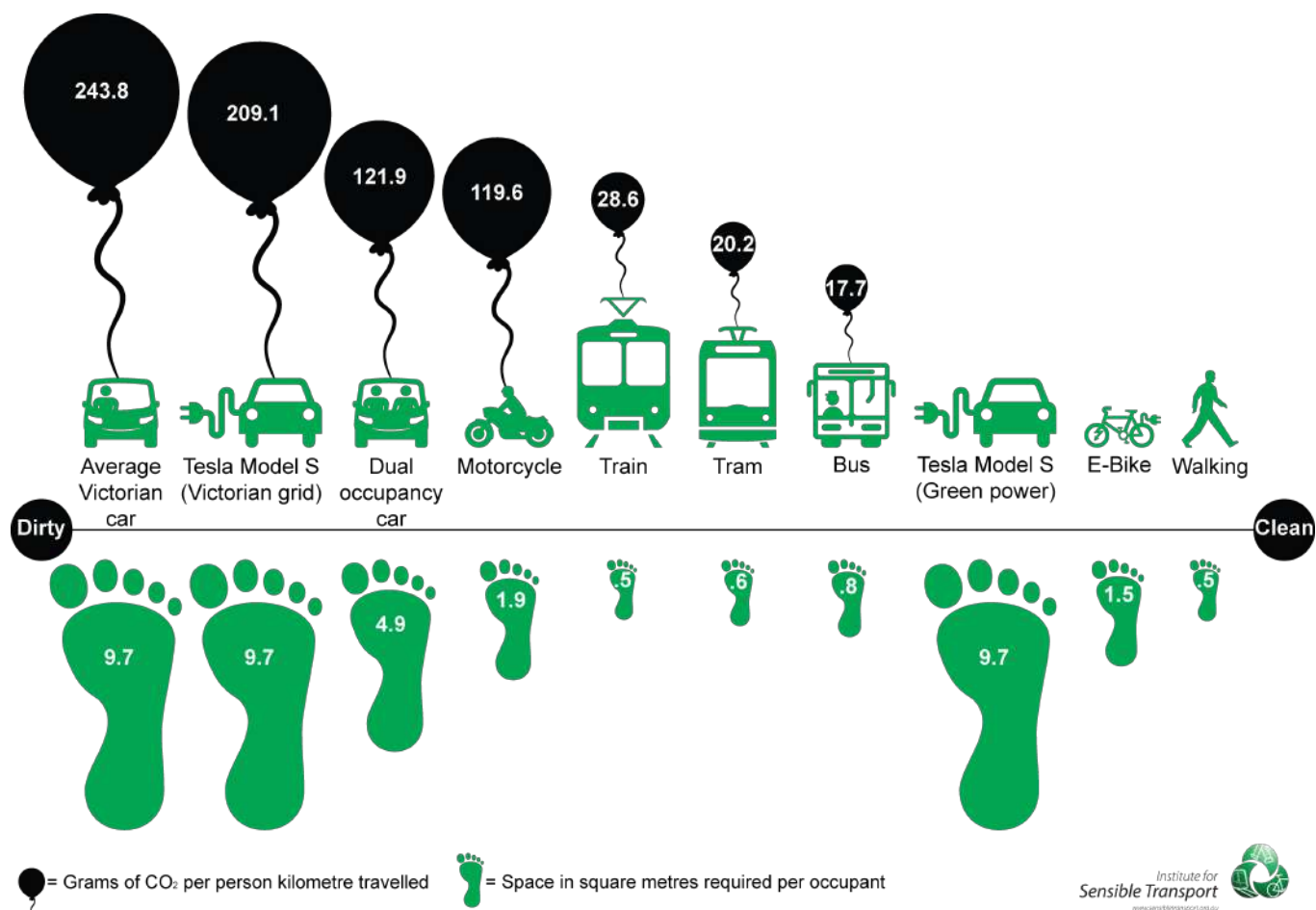


Figure 8 Emissions and space intensity, various modes

Source: Davies & Fishman (2018), commissioned by the City of Melbourne.

Food delivery e-bikes

The City of Melbourne has seen an influx of e-bikes to serve the food delivery market. Anecdotally, it appears that many of these bicycles are throttle controlled, rather than pedal assist e-bikes, meaning the motor is able to be engaged without the rider pedalling. Again, anecdotally, some of these delivery riders appear to be travelling beyond 25km/h and may be operating illegally. Their concentration in some parts of central Melbourne may cause some pedestrian access issues.



Performing food delivery via e-bike does provide significant benefit when compared to the use of internal combustion engines, from a climate change, noise pollution and air quality perspective.

It is recommended research be conducted in relation to:

- E-bike compliance with relevant laws
- Behaviour of riders in terms of safe riding behaviour
- Pedestrian access issues associated with the parking of e-bike delivery vehicles on the footpath.

The outcomes of this research may inform the development of a set of actions designed to encourage the safe use of e-bikes to perform food delivery in the City of Melbourne.

Box 2 E-bike food delivery - Understanding the issues

3. Literature review

This section provides a review of the e-bike literature, with a focus on user demographics and motivation, how e-bikes influence travel behaviour and barriers to use. E-bikes increase participation from underrepresented groups (e.g. women, older adults), and increase the distance people are willing to cycle. E-bikes are found to replace car trips to a greater degree than regular bikes, are ridden more frequently and for greater duration.

3.1 Demographics of e-bike users

E-bike users have higher incomes and are better educated than regular cyclists. E-bike users in Western countries tend to be older than riders of regular bicycles. E-bikes help address some of the known barriers to riding (e.g. hills, excessive physical exertion, journey time). Those who cycle infrequently were the most likely to report being interested in buying an e-bike. Women were more likely than men to report interest in buying an e-bike (A. Fyhri & Sundfer, 2014).

Millennial and Generation X survey respondents reported that their primary motivation for purchasing an e-bike was for it to be their *primary means of transport*. Older age groups were more likely to report *health reasons* as their main motivation (Ling, Cherry, MacArthur, & Weinert, 2017). Millennials and Generation X's also reported *saving time* and *environment* much more commonly than Baby Boomers as their motivation for purchasing an e-bike.

Females are under-represented in cycling participation in Melbourne (Pucher, Greaves, & Garrard, 2010) and e-bikes have been shown to boost female cycling levels (Macarthur, Harpool, Schepke, & Cherry, 2018), in part because they make it easier to carry shopping and children, both of which fall disproportionately to females (Heinen, 2011). Perhaps unsurprisingly, those living in a hilly environment are more likely to express interest in an e-bike (Ling et al., 2017). While Melbourne is not a hilly city, a large number of City of Melbourne workers do reside to the east of the central city (e.g. Kew) and these areas can be hillier than other

parts of Melbourne. E-bikes therefore represent an opportunity to boost cycling participation in these areas.

3.2 E-bikes influence on transport choice

When e-bikes are used as a replacement for motor vehicle trips, benefits arise through reductions in congestion, emissions, and improvements to health through physical activity and lowering local air pollution (E. Fishman & Cherry, 2015; Gojanovic, Welker, Iglesias, Daucourt, & Gremion, 2011; Rose, 2012). This section reviews research examining the impacts of e-bikes, in terms of changes in travel behaviour.

Interestingly, e-bikes are *unlikely* to lead to large reductions in conventional bicycle use, but rather attract people who were previously using other forms of motorised transport (A. Fyhri & Sundfer, 2014). In the largest study to date of North American e-bike owners, it was found that for utilitarian e-bike trips (e.g. to work, shopping), the majority were replacing trips formally undertaken by car (Macarthur et al., 2018). The study's authors concluded that '*...e-bikes make longer trips more feasible, as distance to destinations is a key deterrent to riding a standard bicycle. Thus, e-bikes could potentially serve as a practical means of transportation for people who live in the suburbs and have a longer commute*'.

‘...e-bikes make longer trips more feasible, as distance to destinations is a key deterrent to riding a standard bicycle. Thus, e-bikes could potentially serve as a practical means of transportation for people who live in the suburbs and have a longer commute’.

- Macarthur et al (2018)

E-bikes are especially useful for making longer (i.e. >10km), more complicated journeys (Jones et al., 2016). Most studies looking into the impact of e-bikes on reducing car use find that between 40% - 50% of e-bike trips replace a journey that would have otherwise be completed by car (Cairns, Behrendt, Raffo, Beaumont, & Kiefer, 2017). The degree to which e-bikes replace car trips can increase for the commute trip. This is especially important for the City of Melbourne, which is the largest single destination for commute trips within Victoria, and e-bikes are among the most space efficient modes of individual transport.

An evaluation of the first e-bike sharing program in North America found e-bikes to replace car trips for 11% of rides (Langford, Cherry, Yoon, Worley, & Smith, 2013). In other bike sharing programs that contain a mixture of regular and e-bikes, the e-bikes are used between 3 to 4 times as frequently as the regular bike share bicycles (E Fishman, 2017).

A study on US e-bike owners found replacing car trips was cited by almost 65% of respondents as one of their primary reasons for beginning to use an e-bike (MacArthur, Dill, & Person, 2014). In Australian research, 60% of respondents to an online survey cited replacing some car trips as a main motivation for e-bike purchase, followed by 49% who said they were motivated by being able to

ride with less effort (Johnson & Rose, 2013). Neither of those two surveys documents actual car substitution. One study found that when provided with an e-bike, study participants increased the proportion of trips done by bike from 28% to 48% (A. Fyhri & Fearnley, 2015).

The research to date on the impact of e-bikes on cycling and car use suggests that e-bikes facilitate more frequent cycling, and trips of greater distance.

A 2018 study of North American e-bike owners asked what mode of transport they are now replacing with e-bikes. Figure 9 shows two mode categories for which e-bikes are acting as replacement modes. *Active Transport and Transit* includes foot, standard bike, bike share, or public transport. *Automobile* includes any form of car use (e.g. private car, Uber, taxi or car share). The results show that e-bikes are most likely to be used as a replacement for a commute trip formerly done by car (45.8% of respondents), and active/transit (39.8%). This is pertinent to the City of Melbourne, which acts as the destination for over 600,000 trips on a typical weekday.

The data reviewed here suggests that e-bikes are likely to be of strong appeal for those with central Melbourne as their trip destination. While the potential of e-bikes to replace a car trip holds obvious appeal in terms of supporting the City of Melbourne's wider strategic ambition, the ability of e-bikes to create a compelling substitute in replacement of public transport is also beneficial. For peak hour services, shifting people to e-bikes is essentially like creating an extra seat on a crowded train or tram. Previous work has found that e-bikes can offer competitive travel times to public transport (Cairns et al., 2017). See Figure 24 for some Melbourne specific examples.

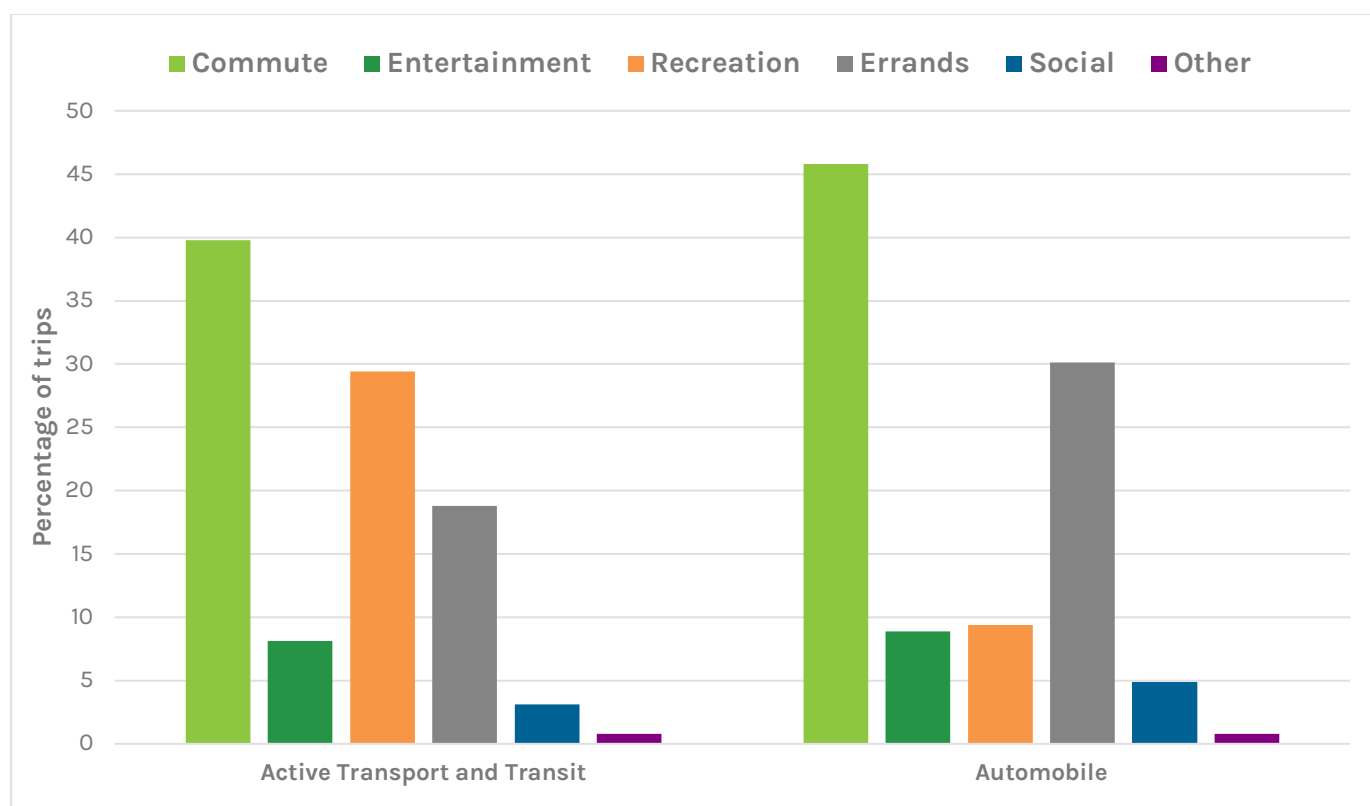


Figure 9 Modes replaced by e-bike

Source: Macarthur et al (2018)

3.2.1 Impact on Riding Distance and Frequency

A North American study found that the average e-bike trip was just under 14.9km (Macarthur et al., 2018). This is considerably longer than the average commute bike trip in Melbourne (almost entirely non e-bike), which is 6 – 7km. E-bikes have a major increase in the time spent cycling (Cairns et al., 2017). To some degree this may be a result of *self-selection bias* (i.e. people who agree to take part in an e-bike study and meet the researchers criteria may have a predisposition to greater use). Moreover, the novelty factor may cause an increase in riding that may ‘wear off’ over time.

People who own or are trialling an e-bike consistently ride further than the average trip distance for conventional bicycles. While there is some variation, in general, e-bike trips tended to be around 50% longer than conventional trips (Cairns et al., 2017).

e-bike trips are around 50% longer than conventional trips

E-bikes boost the frequency of riding (MacArthur et al., 2014). A large North American study that included a *before/after* component found that 55% of the sample indicated they rode weekly or daily prior to owning an e-bike and since e-bike ownership, 93% ride weekly or daily. Despite potential self-selection bias, or short-term novelty of e-bikes, this result would appear too large to discount entirely. A similar, updated study (Macarthur et al., 2018) found that when people purchase an e-bike, riding increases drastically. Using the results from over 1,500 e-bike owners, some 7% did not ride a bike as an adult prior to purchasing an e-bike, and 94% of them now ride either weekly or daily (Macarthur et al., 2018). Of those that *did* ride a conventional bike prior to the purchase of an e-bike, some 59% rode daily *prior* to

the purchase of the e-bike. This jumped to 91% riding weekly or daily once they had a e-bike. Almost 70% of respondents reported that they now ride for different purposes or to different destinations as a result of their e-bike. This is often related to being more able to ride up hills and for longer distance without feeling sweaty on arrival (Macarthur et al., 2018). As one respondent stated; *'I use my e-bike to commute because I don't need special clothing or showers and I don't get as sweaty on hills or as tired from the ride'* (Macarthur et al., 2018, p. 20).

When researchers have provided some participants with an e-bike, and had others act as a control group (no e-bike), the results have showed that the number of cycling trips increases significantly for those with the e-bike (A. Fyhri & Fearnley, 2015). The researchers found cycling trips increased from 0.9 to 1.4 per day and distances increased from 4.8km to 10.5km following the provision of the e-bike. The control group showed no increase. The increase among the e-bike group was greatest for women. The results are shown in Figure 10.

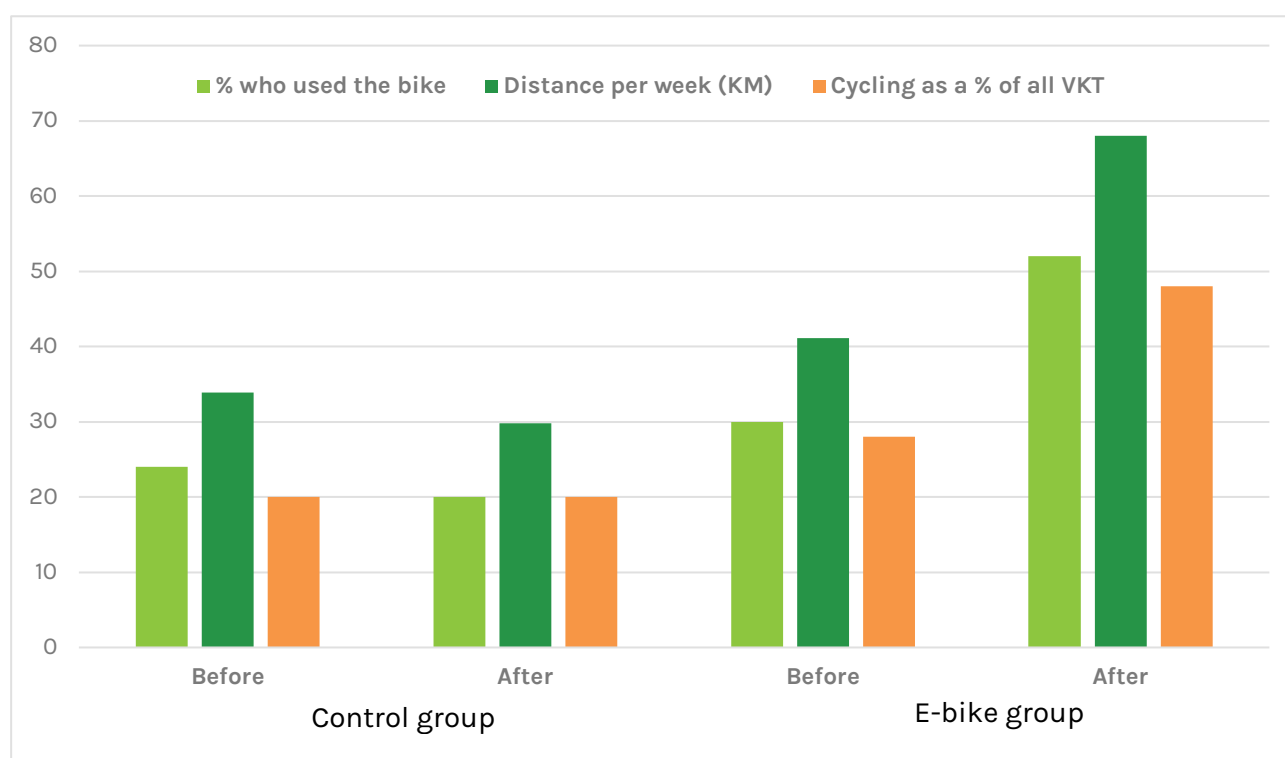


Figure 10 Bicycle use: E-bike vs control group

NB: VKT refers to Vehicle Kilometres Travelled

Source: Fyhri & Fearnley (2015)

The results shown in Figure 10 indicate that the provision of an e-bike has a strong impact on increasing bicycle use (both in terms of frequency of cycling and the total distance cycled). E-bikes were shown to replace trips formerly done by public transport and private car use. For the City of Melbourne, these results are important, as public transport and the road network are both at capacity during peak hour, and therefore e-bikes are likely to assist in lowering the pressure on both the public transport and road network.

Another study found riding distances varied considerably between the different bike types, with e-bike owners reporting significantly higher average daily travel distance (23.8km vs 19.6km). Importantly from a transport perspective, a greater proportion of e-bike trips were for utilitarian purposes (e.g. riding to work, errands) compared to those on conventional bicycles (Ling et al., 2017).

Cherry and Cervero (2007) found travel speed was between 10 - 15% higher for e-bikes than regular

bicycles, but mean travel times were similar, supporting literature on constant travel time budgets (Marchetti, 1994).²

3.3 Why people choose to ride e-bikes

People choose to ride e-bikes because they allow the rider to maintain speed with less effort (Popovich et al., 2014). This helps to overcome some of the most commonly cited barriers to traditional bike riding. Macarthur et al (2018) identify that there are three (somewhat overlapping) mechanisms through which e-bikes act to boost levels of cycling. E-bikes:

1. Attract people that may have a physical limitation, topographical challenge, or distance barrier
2. Enable longer trips
3. Enhance the perceived safety and fun of cycling.

A study that looked at the motivation of people purchasing e-bikes in the Netherlands and the UK revealed that e-bikes were commonly purchased due to a health condition that prevented the easy use of conventional bikes. E-bikes were seen as a way of maintaining the ability to cycle, in the face of changing household circumstance as well (e.g. children, other load bearing requirements or increasing travel distances). Moreover, the researchers found that e-bikes were also purchased by people that did not consider conventional bicycles a convenient option (Jones et al., 2016).

Another way of examining the reasons why people decided to purchase an e-bike is to look at current e-bike owners stated barriers to using a conventional bicycle (prior to their e-bike purchase). The results to this question are shown in Figure 11 and illustrate that riding up hills, distance, speed and physical limitations all featured as the most common reasons for limiting the use of conventional bicycles, prior to e-bike purchase.

² The Marchetti Constant is the observation that throughout history, people have maintained a similar duration of travel, even if the speed may have increased. On average, people generally travel for around 35 minutes each way between home and work.

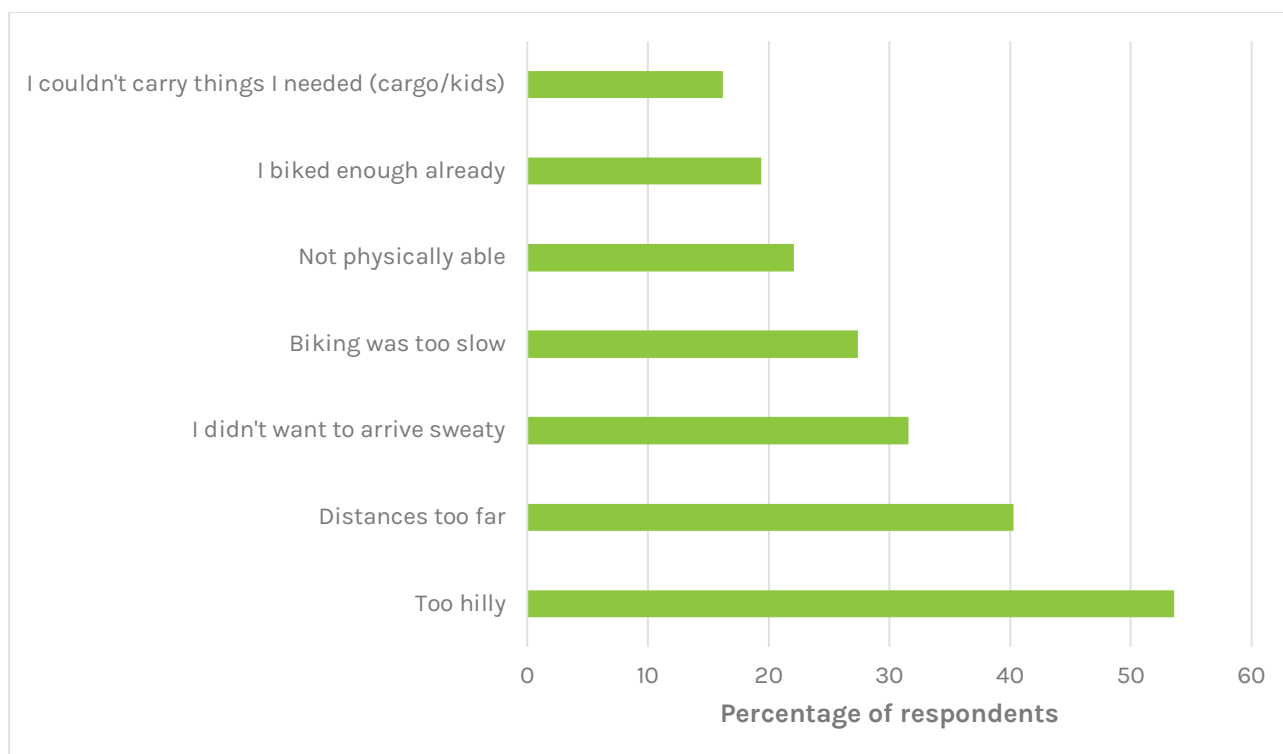


Figure 11 Barriers limiting conventional bike use according to e-bike owners

Source: Macarthur et al. (2018)

NB: Excludes safety concerns

Studies on the barriers to conventional bicycle use found that topography, distance and time constraints are consistent barriers (Heinen, van Wee, & Maat, 2010). E-bikes potentially mitigate against each of these factors. High temperatures, poor air quality, and precipitation can also push riders towards e-bikes instead of bicycles (Campbell, 2014). There is some evidence that e-bikes provide mobility to those with physical limitations that prohibit cycling (Langford, 2013; MacArthur et al., 2014; Rose, 2012). Results from an online surveys of 553 e-bike owners in North America (MacArthur et al., 2014) and 529 e-bike owners in Australia (Johnson & Rose, 2013) found the increased speed and reduced physical exertion are motivating factors for e-bike purchase, allowing riders to arrive at their destination in a comfortable state (Popovich et al., 2014).

A pertinent finding from North American research found 67% of riders said they often needed a shower after a conventional bike trip but only 26% did after an e-bike trip (MacArthur et al., 2014). This

is highly pertinent to the City of Melbourne given its function as the economic centre of Victoria. Over 600,000 workers have the City of Melbourne as their destination, providing an indication of the potential benefit from a cycling option that does not require showering or special clothing. Arriving without the need for a shower may be an important consideration for workers thinking about cycling.

67% of riders said they often needed a shower after a conventional bike trip but only 26% said they did after an e-bike trip

A consistent theme emerging from interviews with Californian e-bike owners is that the electrical assistance offered by e-bikes had made cycling fun again (Popovich et al., 2014).

An interesting finding to emerge from the literature is that once people had the experience of riding an e-bike, they were more willing to spend a greater amount of money to purchase an e-bike (see A. Fyhri & Fearnley, 2015). This may have implications for the City of Melbourne, from both a public awareness raising perspective, and in terms of providing an experience of riding an e-bike, which most people in Melbourne are yet to have.

...once people had the experience of riding an e-bike, they were more willing to spend a greater amount of money to purchase an e-bike

3.4 Barriers to e-bike use

Cost, battery range and a stigma associated with the assistance offered by the motor are three of the main reasons preventing more people from riding an e-bike. The other key barrier, which is the same as for regular bicycles, is the lack of protected bicycle infrastructure. This last barrier was highlighted in recent Near Market study into riding preferences (CDM Research & ASDF Research, 2017).

A North American study asked participants who did not own an e-bike what the key barriers to purchasing one might be. Overwhelmingly, 'expensive to purchase' was the dominant reason offered, with almost 4 in 5 respondents citing high purchase cost as the primary reason (Ling et al., 2017). The younger respondents were more likely to cite high purchase price as the key barrier.

Combined with the finding that young people use e-bikes more for transport purposes (see Macarthur et al., 2018) suggests that offering

pricing incentives for the purchase of e-bikes may be effective in promoting a greater take up of e-bike transport (similar to what Sweden and Oslo have begun doing, as identified in Section 4).

A study of e-bike owners in the Netherlands and the UK identified that battery life, the heaviness of the bicycle and a social stigma were limitations or negative aspects of e-bikes. A desire for the battery range to be longer was expressed, and some identified that a social stigma surrounds the use of e-bikes (a perception of 'cheating'), with their social network sometimes making jokes about their use of an e-bike (Jones et al., 2016), especially if the rider is relatively young (e.g. under 60 years of age). It is plausible similar attitudes exist in Melbourne, given that our cycling culture is broadly similar to the UK, and that a significant proportion of urban cycling is 'lycra' style cycling, in which the physical nature of the activity is more prominent than it is in, for example, northern European cycling. This is therefore possible that e-bikes, especially for younger people, are associated with a laziness, or 'cheating'. Paradoxically, the same attitudes do not extend to very short car trips, despite this activity being widespread and holding no physical activity benefit (unlike e-cycling).

Macarthur et al. (2018) asked e-bike owners how important various factors were when making their e-bike purchase. The results are presented in Figure 12 and reveal that the type of bike (e.g. upright style, cargo etc.), battery range and price were the most important considerations when making an e-bike purchase.

Bike type, battery range and price are the three most important considerations when making an e-bike purchase.

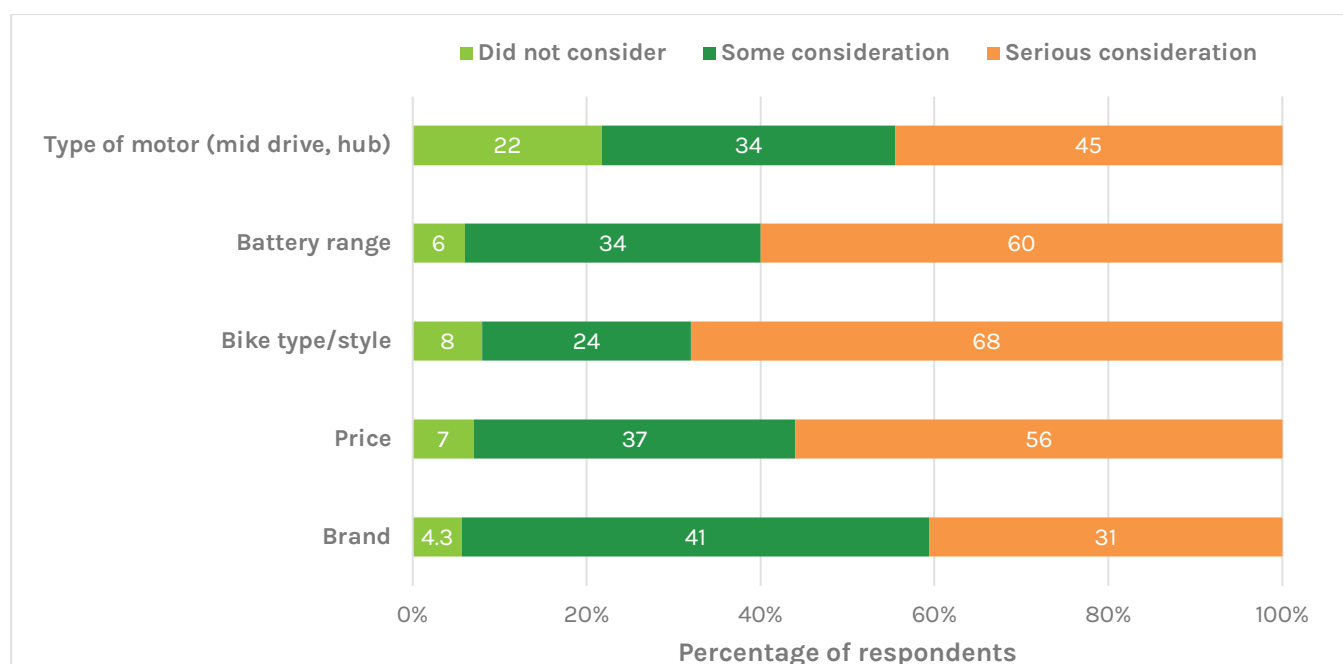


Figure 12 Considerations at time of purchase

Source: Macarthur et al. (2018)

3.5 Safety of e-bike riding compared to traditional bicycles

E-bikes are beginning to reach sufficient levels of market penetration to observe crash data in some European countries. Research shows that of the crashes that do involve an e-bike, they are no more severe than crashes on regular bicycles. Papoutsis et al. (2014) investigated hospitalisation data for e-bike riders in Switzerland. The authors investigated 23 crashes that were reported to the emergency department (ED). Just over one quarter of the reported crashes resulted in head injuries, with upper extremities being the second highest injured region. These results may be somewhat different in Australia, with helmet use mandatory. Interestingly, most of the crashes reported were as a result of being caught in a tram rail, not a result of motor vehicle collision. This is pertinent to the City of Melbourne, which is at the centre of the world's largest tram network. The authors found that crashes tend to be less severe in Switzerland than China, in part due to wider use of helmets and the relatively low number of e-bike crashes involving motor vehicles.

Schepers et al. (2014) compared the safety outcomes of e-bike and bicycle use in the Netherlands, using data from Emergency Departments, as well as surveys of cyclists without any known crash experience. In total, 294 e-bike and 1,699 bicycle crash victims were included in the study, as well as 791 e-bike users and 517 bicycle riders without any known crash involvement (control group).

After controlling for age, gender and the amount of cycling, e-bike use is associated with a fairly small increase in risk of Emergency Department treatment due to a crash, but that for those treated at an Emergency Department, e-bike users are no more likely than bicycle riders to be admitted to hospital; i.e. crashes are equally severe (J. P. Schepers et al., 2014).

The age group with the highest likelihood of Emergency Department treatment were those 65 years and older. Overall differences in safety outcomes were not dramatic between e-bike and bicycle riders.

3.5.1 Infrastructure considerations

E-bikes may trigger modal shift and this may have wider impacts on transport safety generally, particularly if the shift replaces motor vehicles (P. Schepers et al., 2015).

A study using in-depth interviews with e-bike owners in the Netherlands and the UK found that when using their e-bike, the speed of participants had to be moderated, in order to feel safe (Jones et al., 2016). For busy Dutch bicycle paths, e-bike users reported that they sometimes need to plan their route to reduce interactions with other users that would slow them down (Jones et al., 2016). Users also reported that they moderate their speed depending on the environment in which they are cycling. On open bike paths users felt comfortable to have maximum assistance (25km/h), while on congested, central city streets, it was necessary to ride at a speed consistent with the prevailing bicycle traffic speed.

Bicycle infrastructure quality has also emerged as an important element of perceptions of safety for e-bike users (Jones et al., 2016). Compared to their Dutch counterparts, participants from the UK reported that having to share the road with motor vehicles and the lack of a cohesive cycling network reduced their level of perceived safety and enjoyment. Interestingly however (and consistent with US findings), the extra speed with which people were able to travel *increased* perceptions of safety, as they reported being able to better keep up with motorised traffic flow; i.e. the speed differential was less (Jones et al., 2016). This finding is relevant to Melbourne, which lacks a coherent network of protected bicycle infrastructure. The findings from the Near Market study underlined the very strong preferences *would be* cyclists (i.e. not currently cycling) individuals had for protected bicycle lanes/paths (CDM Research & ASDf Research, 2017).

The Near Market study also asked people to rate their confidence riding on roads and paths (see Figure 13). Overwhelmingly, people said they were *cautious* (i.e. defined themselves as preferring off-

road paths or low stress roads and willing to take a longer route to get to a destination).

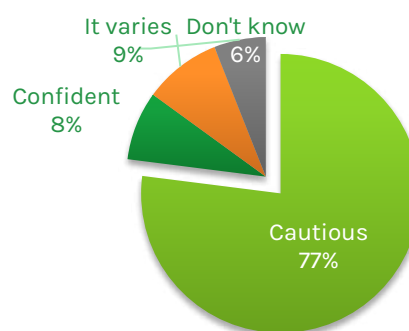


Figure 13 Cycling confidence

Source: CDM Research & ASDf Research (2017)

The findings presented in Figure 13 are important for the current project because it underlines the need for significant improvements in the bicycle infrastructure network across Greater Melbourne. Often this will require diversions, and more dramatic changes in topography, both of which are easier to do with the electrical assistance offered by an e-bike.

Finally, the Near Market report presented different riding contexts and asked respondents how confident they would feel in each riding situation. Overwhelmingly, bicycle lanes that are physically protected from motor vehicles was the preferred infrastructure (with 83% feeling confident or very confident).

3.6 Health impacts of e-bike riding

Several studies have emerged over the previous decade seeking to measure the impact of e-bikes on health. For the purposes of this review, the meaning of the term 'health' is restricted to improved health from increased *physical activity*.

The overwhelming, consistent theme to emerge from this body of research is that e-bike riding holds many of the physical activity benefits associated with regular cycling. In sum, e-bike riders have a metabolic workload of around 60 – 70% of a regular cyclist (on a per distance basis). As

shown previously, e-bike riders tend to ride longer, and more frequently than regular cyclists, meaning that much of the overall metabolic activity differences between e-bike and regular riding evaporates.

Simons, Van Es, & Hendriksen (2009) conducted a study in the Netherlands on 12 healthy, physically active subjects, who rode a 4.3 km route three times using an e-bike while measuring physiological performance. Key points of the study:

- First circuit was undertaken without any power assistance
- Second while the e-bike was on eco mode
- Final circuit was completed using the most electrical assistance.

The researchers measured physiological variables such as heart rate and oxygen consumption as well as power applied through the pedals. Results:

- All three-power settings provided a useful contribution to meeting minimum physical activity requirements.
- Even with electrical assistance, riders achieved the necessary physical activity intensity (between 3 - 6 Metabolic Equivalent of Task, or METs³) to help reduce the chance of sedentary lifestyle diseases.

Not surprisingly, riders under the most powerful assistance setting achieved a higher average speed, which had the effect of reducing overall riding time. While this does have the effect of reducing the duration of physical activity, previously cited evidence suggest that those riding e-bikes tend to spend more time on their bikes than if they did not have an e-bike available (MacArthur et al., 2014).

Gojanovic et al. (2011) set out to examine whether e-bikes were able to provide sufficient physical activity for the user to gain health benefits. Conducted in a hilly part of Lausanne, Switzerland, 18 sedentary participants (12 female) performed

four set trips at their own pace. The first trip involved a 1.7 km uphill walk, the second a predominately uphill 5.1 km trip on a conventional bicycle, an e-bike with a standard power setting and with a high-power setting. The walking and e-bike (high power setting) resulted in average METs of 6.5 and 6.1, respectively (no significant difference). The e-bike using the standard power setting and the traditional bike resulted in an average MET of 7.3 and 8.2, respectively. These results led the authors to conclude that e-bikes are effective in providing health enhancing physical activity in a topographically challenging environment.

e-bikes are effective in providing health enhancing physical activity

A study conducted by Sperlich et al. (2012) involved eight sedentary females and required them to cycle at their own pace along a 9.5 km route, once on an e-bike and again on a conventional bike (the order was randomised). Measures of physical exertion were lower when using an e-bike compared to a traditional bike, but the level of enjoyment and speed was higher. Despite the lower levels of physical activity recorded by participants on e-bikes, the energy expenditure was found to be within the range necessary for health enhancement. De Geus et al. (2013) found positive physiological changes in 20 people following a 6-week period of e-bike use.

Finally, Langford (2013) investigated the 19 users of a bicycle and electric bike sharing system in Knoxville, Tennessee, USA on a fixed 4.4 km hilly course using laboratory, GPS and onboard power meters to measure physical exertion. This research found that energy expenditure per unit time for e-bike trips is 11% less than that for regular bicycle trips and 8% more than for walking trips. Average

³ A physiological measure expressing the energy cost of physical activities and is defined as the ratio of metabolic rate (and therefore the rate of energy consumption) during a specific physical activity to a reference metabolic rate, set by convention to 3.5 ml O₂·kg⁻¹·min⁻¹

cruising speed for the three modes was 5.1 km/h for walking, 14.4 km/h for bicycle, and 16.4 km/h for e-bike. Walking trips, while requiring less energy per unit time, take longer to complete and, in this case, require a greater amount of total energy from the user, consistent with other active transport research (E. Fishman, Böcker, & Helbich, 2015). Considering the performance advantages of e-bikes over the course of the trips studied, the total energy demanded for e-bike trips was 21% less than required for regular bicycles trips and 62% less than for walking trips.

Overall, e-bikes provide a lower level of physical activity than traditional bikes, but still achieve measurable health enhancement.

Interestingly, there appears to be some added enjoyment experienced by e-bike users, although these are in experimental conditions, and it is not clear whether enjoyment levels are sustained when using an e-bike on a more consistent basis (i.e. without the novelty factor). However, the fact that those who have owned an e-bike for over 12 months continue to report higher riding levels than before they had an e-bike suggests some level of durability.

3.7 Environmental impacts of e-bikes

The environmental impacts of e-bikes are dependent to a large degree on the mode they replace (Cherry & Cervero, 2007). E-bikes that replace fully non-motorised modes (i.e. walking or conventional bicycle) result in a net negative impact on the environment. However, e-bikes are generally very energy efficient because of their light weight and electric drive technology, with

most e-bikes consuming less than 2kWh/100 km. This is about one tenth the energy consumption of a small electric car (Ji et al., 2012) and around 40 times less⁴ carbon dioxide (from power plants) than a standard car travelling the same distance (Ji et al., 2012).

E-bikes consume around 40 less CO₂ than a standard car travelling the same distance.

In perhaps the most comprehensive study of its type, Cherry et al. (2009) assessed the environmental impact of e-bikes in China and compared them with other, competing modes of transport, including environmental costs associated with vehicle production. The results indicate that e-bikes offer a considerable environmental improvement (in terms of most emissions) compared to car use and similar emissions intensity, on a per passenger kilometre basis, to that of bus travel. Moreover, the source of emissions is usually far from population centres, relative to conventional vehicles, so health impacts from conventional pollution are even lower than the emission factors suggest. In China, the health effects of emissions from power plants are lower by a factor of five compared to equivalent tailpipe emissions (Ji et al., 2012). Significant environmental gains occur where e-bikes are used as a replacement for motorised vehicles (Cherry et al., 2009).

Even where the power sector has among the highest emission factors such as China and Australia), emissions of CO₂ and other conventional pollution from e-bikes is relatively low. In countries where e-bikes are gaining popularity (e.g. Netherlands and Germany), their power sector emission factors are approximately half those of China and Australia (International Energy Agency, 2012), further reducing emission rates of e-bikes.

⁴ This will vary according to electricity generation factors and vehicle type.

The emissions of e-bikes are inconsequential and likely better than the set of alternative modes, even in large numbers and if the power sector is dominated by coal (e.g. Victoria).

3.8 The influence of e-bikes on rider confidence

A number of studies have found that people who ride e-bikes report that they feel safer than when riding a conventional bike (Macarthur et al., 2018). E-bike users note that they are more willing to take longer routes that avoid streets that feel dangerous and are better able to utilise shared paths and other routes that do not involve cycling in mixed traffic. Moreover, the assistance of the motor enables e-bike riders to take off faster from a standing start, helping to achieve a cruising speed that reduces the speed differential with motor vehicles. E-bike owners are eight times more likely to report that their e-bike helped them avoid a crash than they were to report that the e-bike contributed to a crash (Macarthur et al., 2018). The authors identified that *'Perceived safety plays an essential role in whether an individual is likely to ride a bicycle for a given trip; thus by enhancing one's sense of safety e-bikes could potentially tap latent demand for bicycling by encouraging those who may not feel safe on a standard bicycle'* (Macarthur et al., 2018, p. 6).

E-bike owners are eight times more likely to report that their e-bike helped them avoid a crash than they were to report that the e-bike contributed to a crash

Aside from rider confidence per-se, a number of studies have found that e-bike owners report that they feel a sense of joy when using their e-bike (Jones et al., 2016; Popovich et al., 2014). This increase in enjoyment may be one of the reasons e-bike owners ride more. This effect on increasing cycling participation may also, cumulatively, work

to reduce crash risk via the *Safety in Numbers* phenomenon (e.g. see Jacobsen, 2003).

Aside from rider confidence per-se, a number of studies have found that e-bike owners report that they feel a sense of joy when using their e-bike.

4. Best practice case studies

The benefits associated with e-bikes have led to a number of initiatives intended to boost their contribution to the transport and sustainability challenges faced by cities.

The most common method for encouraging the use of e-bikes is purchase price subsidy. Sweden and Oslo both have programs designed to incentivise e-bike purchase through direct subsidy and a number of other jurisdictions are planning similar programs, including the UK.

Many governments have subsidy programs for the purchase of electric cars. E-bike subsidy programs typically cost less than 8% of the typical dollar value of an electric car subsidy (Haubold, 2016). Put simply, a new electric car starts at prices that are over ten times the cost of a mid/high level electric bike, and thus represent a more fiscally conservative method for government to support the transition to electrified personal transport.

A report by the European Cycling Federation argued that subsidies are an effective method of boosting ownership and use (Haubold, 2016, p. 4):

‘In markets with low sales figures, a purchase subsidy of €500 (around 10% of the current purchase subsidies of electric cars in many European countries) could help to bridge the price gap to conventional bikes and facilitate market uptake of electric bikes (including low-powered as well as speed pedelecs⁵), which in turn have a high potential to achieve modal shift from car trips to cycling.’

4.1 Purchase subsidy programs

Subsidies for e-bikes are an effective method of boosting ownership levels, and the literature review found that e-bikes are much more likely to be used frequently and for longer trips than conventional bicycles. Moreover, recent large-scale surveys of e-bike owners showed that price is one of the most important considerations when making an e-bike purchase. In fact, of all the most important

considerations when deciding to purchase an e-bike, price is the only one that government have a level of control over.

4.1.1 Sweden’s e-bike subsidy

In 2017, Sweden created a subsidy program in which the purchaser of an e-bike is able to receive a 25% subsidy, for bikes up to €1,000. The program is budgeted for 2018, 2019 and 2020. The take up has been strong, with 40% of the annual €35 million depleted within the first 3 months of the program (Business Insider Nordic, 2018). Sweden’s EPA receives around 2,000 applications per week. Around 40% of surveyed Swedes reported that they would be interested in purchasing an e-bike (Business Insider Nordic, 2018). The subsidy is scheduled to end in 2020 (Electric Bike Report, 2018).

The 25% subsidy is on the purchase price and includes not just e-bikes but also electric mopeds, motorbikes, and electric powered mobility aids for those with a disability. Applications are only for Swedish residents aged 15 and over and restricted to one bike per person and year (Christofides, 2017). As the program is relatively recent, no data is available on the impact of the scheme, the demographics of applicants or other program outcomes.

⁵ Speed pedelecs are a type of e-bike with a maximum speed of 45km/h. In Europe, they are typically treated as a motor scooter rather than a bike, with the rider requiring a helmet and vehicle registration.

4.1.2 Oslo, Norway

In 2016 City of Oslo announced that it would provide a purchase price subsidy to overcome the price barrier, and encourage the uptake of e-bikes. The City now provides a €500 subsidy for residents who purchase an e-bike, as one part of a broader strategy of reducing car use. This subsidy can be doubled for the purchase of a cargo bike (Business Insider Nordic, 2018). The subsidy is only open to residents of Oslo. There is also a requirement for the recipients to respond to a questionnaire prior to their e-bike purchase (A Fyhri, Sundfer, & Weber, 2016).

The subsidy program had very strong uptake, with the quota of 1,000 applicants being reached within the first month of the subsidy announcement.

A study into the impact of the subsidy program was undertaken and used both the questionnaire data, and actual travel behaviour data recorded through the use of an App (Sense.DAT). Figure 14

provides an indication of the influence of different factors in the purchasing of an e-bike, using the responses from 830 people who had recently become e-bike owners. It shows that overwhelmingly it was the subsidy from the City of Oslo that influenced the purchasing decision.

...overwhelmingly it was the subsidy from the City of Oslo that influenced the e-bike purchasing decision

Media and peer recommendation was also found to be an important factor – both of which may have been influenced to some degree by the subsidy program itself which attracted a lot of media attention when it was announced.

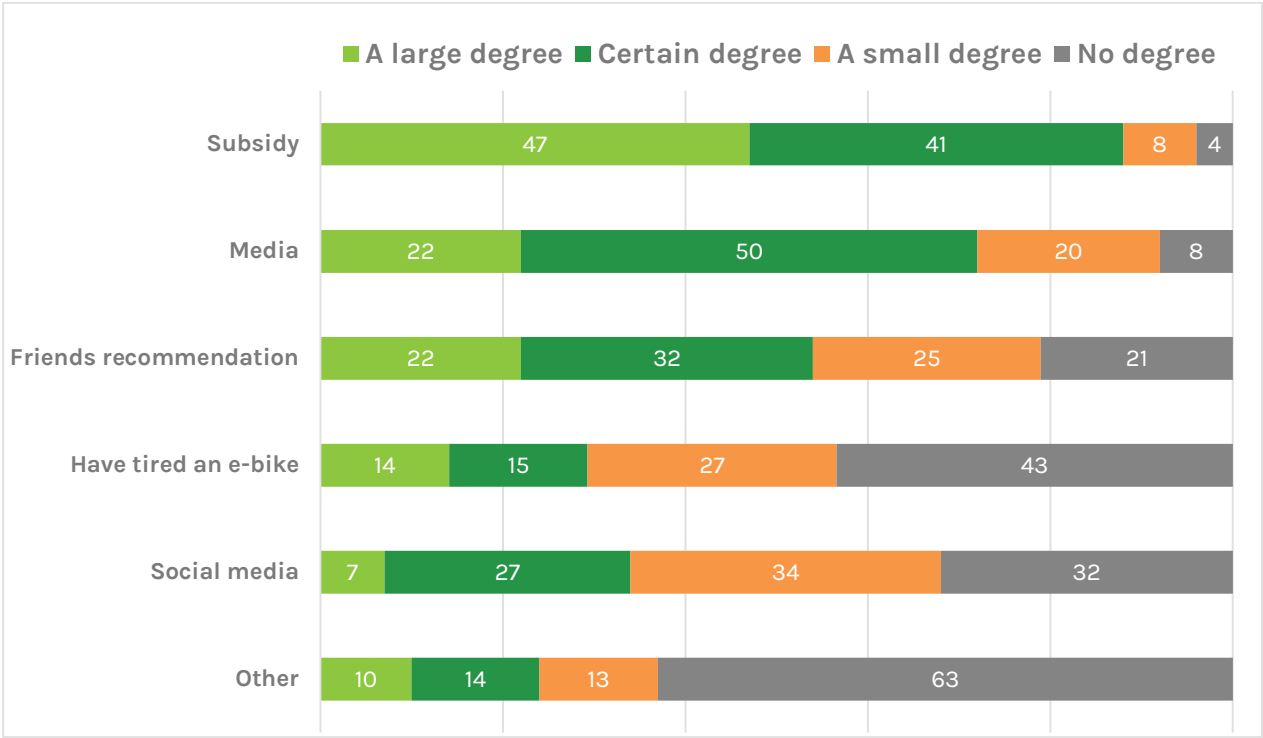


Figure 14 Factors influencing decision to purchase an e-bike (%)

Source: Fyhri et al (2016)

In terms of the influence that the e-bike purchase had on cycling activity, the study by Fyhri et al

(2016) found that for those taking advantage of the e-bike subsidy, their bicycle usage increased by

30% (in terms of trip frequency). This resulted in a reduction in walking, public transport and car use by 4%, 10% and 16% respectively. Prior to the purchase of an e-bike, the share of kilometres cycled was 17% and this increased to 52% after e-bike purchase.

As the City of Oslo has strong emissions reduction targets, an analysis was performed on the impact of the subsidy program on CO₂ emissions (A Fyhri et al., 2016). For each e-bike provided as part of the subsidy program, an estimated 87kg – 144kg CO₂ is avoided annually. This estimate does account for the fact that riding levels reduce considerably in the Norwegian winter. With milder winters, Melbourne could expect to have relatively smaller reductions in winter cycling, and thereby potentially larger reductions in CO₂ emissions.

For each e-bike provided as part of the subsidy program, an estimated 87kg – 144kg CO₂ is avoided annually.

4.1.3 United Kingdom

The United Kingdom currently provides a £4,500 subsidy for the purchase of a new electric car, and £8,000 for an electric van, with a budget of £1.5 billion for its *Ultra-Low Emission Vehicles Program* (to 2021). The government has recently begun to explore possibilities to extend incentives to e-bikes as well (e.g. see Reid, 2018). Scotland are preparing to launch a loan program to assist in reducing the barrier of upfront purchase price of e-bikes. At the time of writing the specific details are yet to be determined, but are expected to include £1.3 million from the Scottish Government (Scottish Government, 2018). The *Low Carbon Transport Loan Fund* will have a budget of £500,000 to provide interest free loans of up to £3,000 to assist both individuals and businesses with the upfront purchase of e-bikes, and e-cargo cycles (Scottish Government, 2018). An additional £700,000 will be distributed to local authorities and other public

agencies to scale up the adoption of e-bike use. Importantly, a further £100,000 will go towards an *E-bike Grant Fund*, with the objective of allowing members of the public to test e-bikes at authorised centres such as government advice centres and transport hubs (Scottish Government, 2018). As the earlier literature revealed, the experience of using an e-bike for the first time can have an important positive impact on people's perceptions of e-bikes and even boost their willingness to own an e-bike.

4.2 Freight and other commercial uses for e-bikes

Road freight has a major impact on central city transport systems and local amenity. Road freight makes up between 8 – 18% of vehicle movements and reduces road capacity by 30%, due to their frequent stops for pick up and deliveries (Nocerino, Colorni, Lia, & Luè, 2016).

Within the City of Melbourne, it is estimated that 15% of all CO₂ emitted by *on road transport* can be attributed to light commercial vehicles (Davies, Allan, & Fishman, 2018), which is broadly consistent with international averages (e.g. see Nocerino et al., 2016).

Electric assistance is considered especially important for the viability of cargo cycles, as it reduces the physical burden on the rider, which becomes increasingly important as payloads increase (Conway, Fatisson, Eickemeyer, Cheng, & Peters, 2011). Electrical-assistance also increases average vehicle speed, helping to boost its travel time competitiveness with conventional delivery vehicles. One Italian study found that for each kilometre in which an electric cargo cycle replaced a traditional delivery vehicle, between 45 – 370 grams of CO₂ were avoided (not emitted). Over the course of a day, this amounts to between 17 and 21kg of CO₂ (Nocerino et al., 2016), which, annually, would represent a saving of around 4.5 tonnes of CO₂, assuming 240 working days per year. To put this in context, this is roughly the equivalent of taking 1.3 average Victorian cars off the road.

The City of Melbourne has seen a substantial increase in the number of food delivery e-bikes over recent years (see Box 2). Recommendations to identify issues and maximise the contribution of this sector are offered in Section 6.4.

Considerable potential exists to transfer a portion of the freight task for small parcel delivery to low impact, electric cargo cycles. It has been estimated that between a fifth and half of all kilometres travelled by logistics firms that are currently done by internal combustion engine vehicles could be substituted with electric cargo cycles (Gruber, Ehrler, & Lenz, 2013). For European cities, it is estimated that half of all motorised vehicle trips involving goods transport, could be carried by bike or cargo cycle (Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015). It is unlikely this number is comparable to Greater Melbourne, due to lower density. For the City of Melbourne however, the congestion, parking difficulties and density factors mean that central Melbourne bears greater similarity to a European city than outer areas of Greater Melbourne, and offers a more favourable environment for e-cargo cycles.

4.2.1 DHL Cubicycles

DHL began introducing cargo cycles produced by the Swedish firm *Velove* into their European fleet in 2015. The cargo cycle accepts a loaded small container directly from a distribution warehouse or conventional van, reducing handling time. The cargo cycles receive power through the rider's pedalling and a 250W motor. The electric motor uses 6% of the electricity needed by a small electric van and a similar proportion of raw resources for its production (Velove, 2018).

DHL Express has introduced bicycles in more than 80 European cities in 13 European countries to date, including 14 Cubicycles in seven cities. Cubicycle couriers cover 50km per day on average.

Up to 125kg can be carried by the cargo cycle. In terms of operation, a standard van typically travels to a central city area, where the repacked containers are loaded onto the cargo cycles for last kilometre delivery. The containers match the dimensions of a standard shipping pallet and their height has been designed to be low enough for other cyclists to see over it.



Figure 15 DHL couriers using cargo cycles, Utrecht

While the DHL pilots are yet to be completed, early results suggest that productivity varies from 0% improvement (i.e. same number of parcels delivered per hour as conventional small vans) through to 100% improvement (twice as many parcels delivered per hour). Marijn Slabbekoorn is the operations manager with DHL's GoGreen program and was interviewed as part of the current project. During this discussion, it was revealed that DHL's cargo cycles can often deliver their parcels 2 – 3 times as quickly as a van on the same route. Generally, around 15 parcels can be delivered per hour using an e-cargo cycle. An e-cargo cycle could travel up to 60km per route and were capable of carrying two batteries to extend the distance travelled.

Mr Slabbekoorn reported that one of the key reasons e-cargo cycles are competitive with traditional delivery vans in the Netherlands is the

quality of the bicycle infrastructure network. There is also a support attitude from businesses and consumers to the delivery of goods via cargo bike.

For DHL, they recognise that as cities in the Netherlands move towards restrictions on polluting vehicles (due for implementation in 2025), clean, low impact delivery will become essential.

CEO of DHL Express Europe, John Pearson reports that 'DHL Express has already replaced up to 60% of inner-city vehicle routes in some European countries with cargo bicycles, and we expect that the City Hub and Cubicycle will both help us to accelerate this approach in other markets over the next 3-5 years' (Erlandsson, 2017).

The three most important measures government can take to boost the level of cycle freight deliveries are:

1. Completing a cohesive network of protected bicycle infrastructure
2. Restrict motor vehicle access and delivery for polluting vehicles
3. Assist in creating suitable handover points where goods can be shifted from larger vehicles to last mile e-cargo cycle delivery vehicle.

E-cargo cycles – key numbers

- Capacity for up to 300kg of cargo
- Battery range of ~50km
- Uses ~6% of an electric van
- Purchase price of \$4,000 - \$12,000
- Around twice as many deliveries can be made per hour in congested, dense inner cities (compared to standard vans)
- Power output can be compliant with existing legislation (250W max.)

- Improved bicycle infrastructure, with consideration for the needs of larger, slower e-cargo cycle freight. In practice, this means building wider bike lanes and paths (see Section 6.2 within *Recommendations*), and for protected infrastructure, designing it with the flexibility for a bike to exit and return from the protected section of the bike lane relatively easily.
- Avoid on road bi-directional bike lanes where possible, as large e-cargo cycles make it difficult for passing cyclists to overtake easily.
- Ensuring legislation does not prevent cargo cycles from parking on the footpath to make or pick up deliveries, but with safeguards to protect pedestrian amenity.
- Consider changes to e-bike power output, such that motors are able to provide more than 250W, but still adhere to a speed limit of 25km/h (see Section 6.1.4 in *Recommendations*).
- Support the development of urban freight consolidation centres which can serve to warehouse parcels for a short period prior to e-cargo cycle delivery. This typically needs to be located on the edge of the central city (see Section 6.3.2 in *Recommendations* for more information).

4.2.2 Last mile freight in Portland

B-Line is a last mile freight delivery initiative in Portland, Oregon. B-Line is intended to increase the sustainability of the delivery system. Established in 2009, it works at a Business to Business level, primarily for food delivery, as well as office supplies. It has contracts with major office suppliers to deliver office consumables.

Their vehicles are capable of holding 317kg of cargo and typically, a route will take 1.5 hours and include between 6 – 15 deliveries. They are time competitive with standard delivery vans in commercial centres in which there is a relatively short distance between deliveries. In high rise buildings however, their competitiveness with vans lowers, as these buildings typically have dedicated space for delivery vans and there are multiple deliveries within the same building.

Key recommendations B-Line consider important for government to implement to boost e-cargo cycle contribution to last mile freight include:

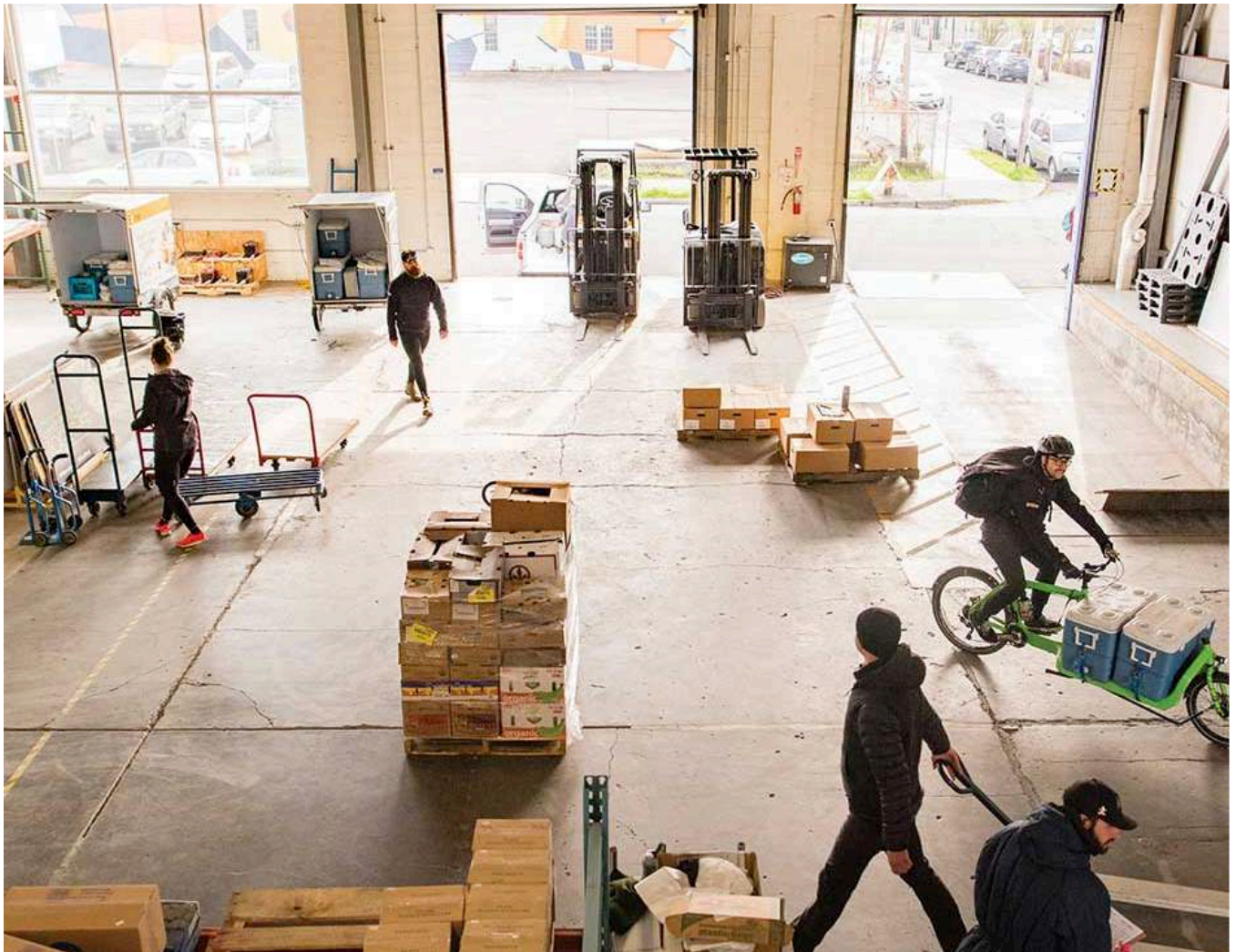


Figure 16 Distribution warehouse in central Portland

5. Understanding the potential for e-bikes in the City of Melbourne

E-bike use has grown strongly in a number of countries over recent years, including Australia. This section provides a brief analysis of the potential for e-bikes to grow the number of people accessing central Melbourne by bike.

5.1 Analysis of existing travel behaviour

The following series of charts are offered to develop a picture of how people currently access central Melbourne. This provides a base level of

information necessary to estimate the potential for greater numbers of people cycling through the use of e-bikes. Figure 17 identifies that in 2015-16, there were over 635,000 daily trips to the City of Melbourne (all purpose), with 28,670 being ridden. The overwhelming majority of these bicycle trips are expected to have been conventional bicycles.

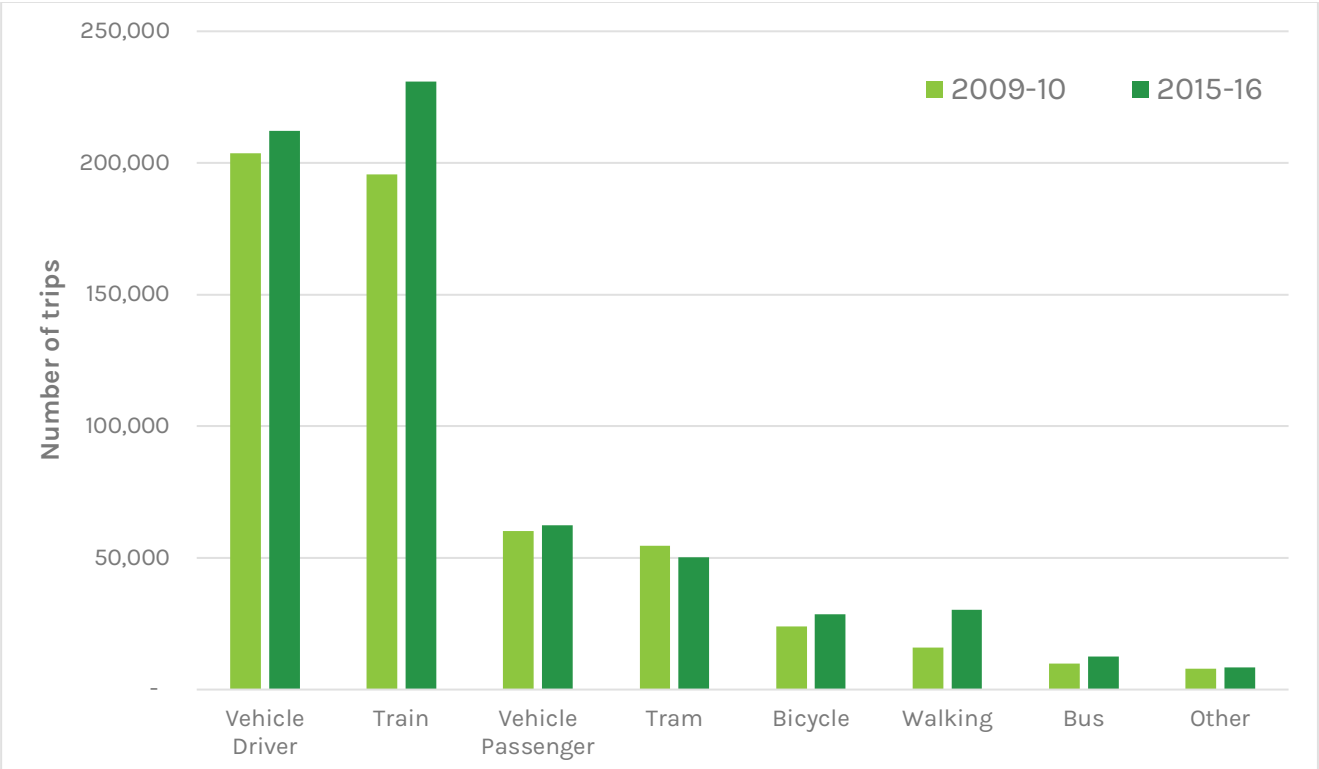


Figure 17 Weekday trips to the City of Melbourne
Source: Sift Research (2017)

The residential location of those that work in the City of Melbourne is concentrated in the inner and middle suburbs of Greater Melbourne (see Figure 18). The evidence from previously cited studies suggest that an e-bike increases the average trip distance by around 50%, and commute trips generally have a raised tendency for amplifying trip

distance (Cairns et al., 2017). This means that increasing the attractiveness of e-bikes (e.g. through subsidy or/or improved infrastructure) could provide a significant boost in the number of City of Melbourne workers arriving by bike.

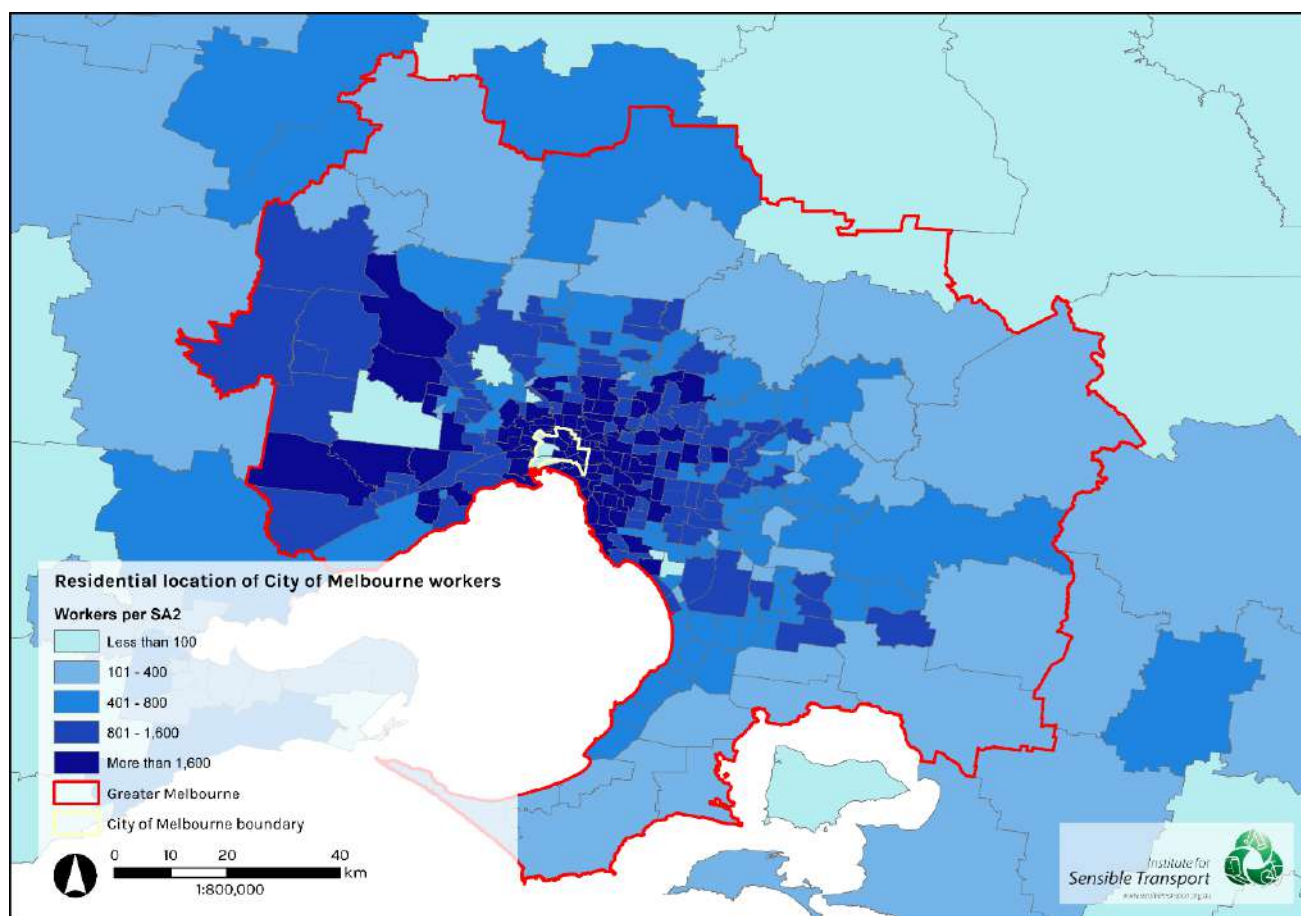


Figure 18 Residential location of City of Melbourne workers

Source: Australian Bureau of Statistics (2017)

5.2 Potential to grow cycling through e-bikes

In order to assess the potential for growing the number of people commuting to central Melbourne through the use of an e-bike, it is necessary to identify existing travel behaviour. Overall, there were 271,890 people who travelled to the City of Melbourne for work from within 20km of the GPO (2017). The bicycle mode share of these workers was 4.8%. This section provides a high-level analysis of the potential of e-bikes to grow the number of people accessing the City of Melbourne for work⁶ by bicycle.

The potential number, and location of e-bike users has been modelled using existing data available from the 2016 ABS Census. The number of City of Melbourne workers by residential SA1 was analysed using GIS software. This was used to determine the number of workers at 1km distance bands from the GPO, and the number who rode to work (also determined as a mode share percentage). This data was used to produce Figure 19, which shows that peak commuter cycling participation occurs between 4km to 6km from the GPO (with around 11% mode share). Of the 271,890 people who work in the City of Melbourne (and attended work on Census day), 13,165 commuted by bicycle.

⁶ It is important to recognise that the journey to work only constitutes around 18% of all trips, and there will of course be many non-work trips that could also be completed by e-bike.



Figure 19 Cycle commuters to the City of Melbourne: Residential distance from GPO

Knowing that the average e-bike users' travel distance is higher than a person cycling on a conventional bike, we increased the overall mode share of cycling for trips between 5km and 16km from the GPO, by between .5% and 2% (shown in Table 2). This lengthens out the 'tail' of commuter cycling participation, increasing the average distance from approximately 6.2km to around 6.8km, with 2,444 additional people estimated to commute to central Melbourne through the use of an e-bike. This new distribution is shown in Figure 20.

The average commute distance of e-bike users, under this projection, is 9.8km. This is approximately 58% further than current commute cycling⁷ distances, and in line with what the literature has found to be an average increase due to the assistance provided by the electric motor.

Table 2 Estimated cycling mode share increases by distance

Distance	Existing cycle mode share	Increase
5 km	11.7%	0.5%
6 km	10.6%	1%
7 km	7.4%	1.5%
8 km	6.4%	1.5%
9 km	4.3%	2%
10 km	3.4%	2%
11 km	2.8%	2%
12 km	1.8%	2%
13 km	1.1%	1.5%
14 km	1%	1%
15 km	0.7%	1%
16 km	0.6%	0.5%

⁷ While there will be some cyclists who commuted to the City of Melbourne with an e-bike at the 2016 Census, overwhelmingly, these trips would have occurred on conventional bicycles.

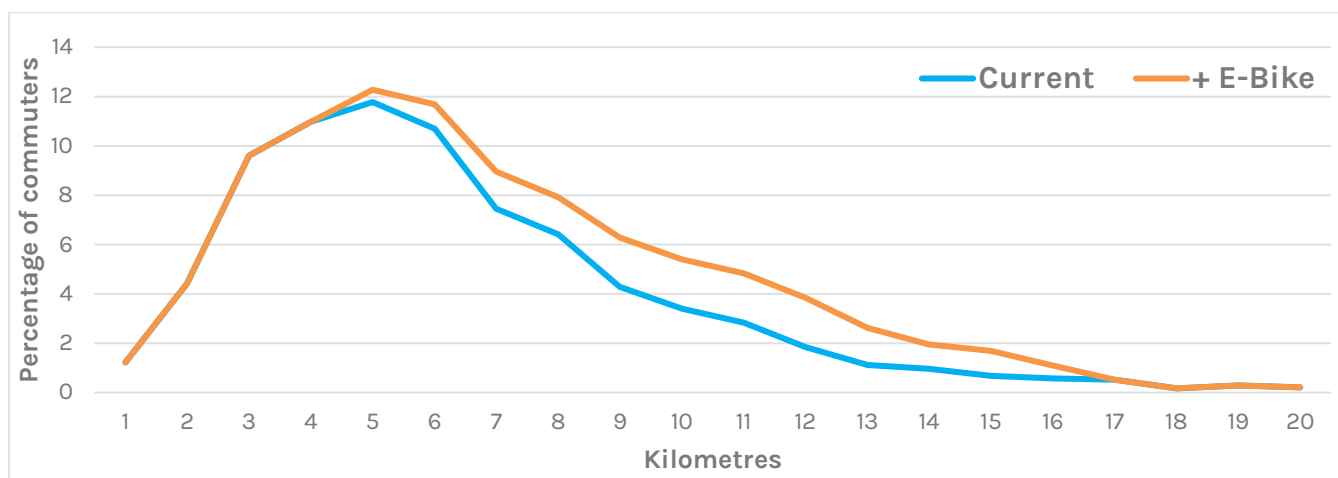


Figure 20 Comparing current and current + e-bike cycling to central Melbourne

It is important to recognise that as an early, exploratory activity, there are no time frames or specific mechanisms through which the ‘+ E-Bike’ scenario shown in Figure 20 is expected to be reached. However, as the Near Market report (see CDM Research & ASDF Research, 2017) identifies, the very strong preference of people who regularly access central Melbourne is for *protected* bicycle infrastructure. The development of a network of protected bicycle lanes across Greater Melbourne (see Section 6.2 in *Recommendations*) would substantially boost the number of people of people expected to access central Melbourne by bike.

The residential location of these potential new cyclists has been calculated in two different methods. The first, shown in Figure 21, is to increase cycling participation by the rates shown in Table 2, across distances *evenly*. The second

method, as shown in Figure 22, is to calculate the percentage rise in cycling participation based on existing participation rates. This second method produces an estimated impact from e-bikes that reflects a stronger spatial similarity with cycling origins as they were from the 2016 Census. While both methods will show the same total increase in cycling participation, and the same increase at each distance interval, the location within those distance bands is different. A strength of the first method is that it is not reliant on existing cycling patterns, and may therefore include potential cycling increases in areas where topography is not favourable to conventional cycling (i.e. hilly areas). However, it may also include potential cycling increases in areas where cycling infrastructure is either unavailable or perceived to be unsafe. The second method is stronger in this regard, as it apportions cycling increases to areas known to have relatively high commuting cycling participation.

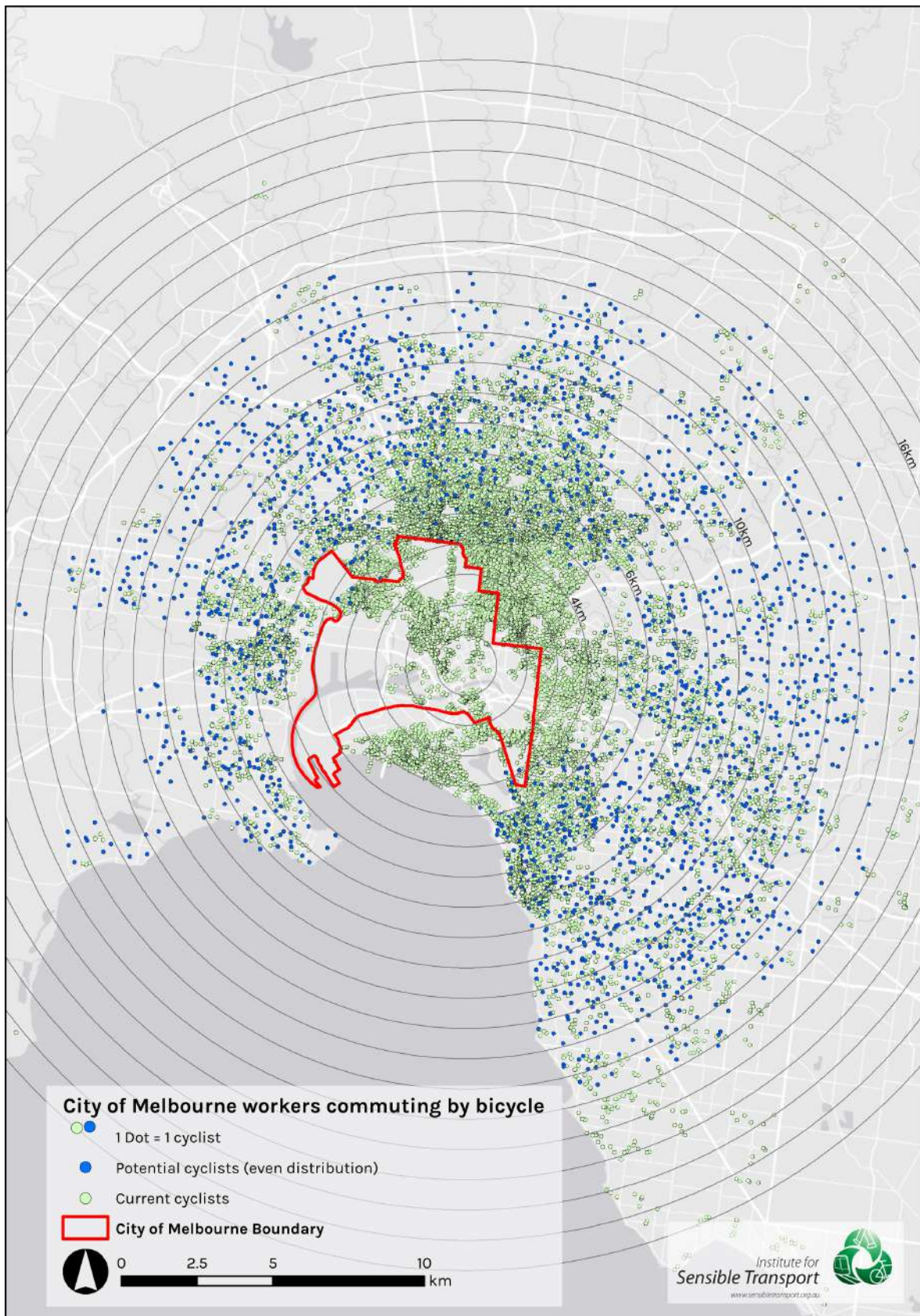


Figure 21 Current and potential commuting by bike

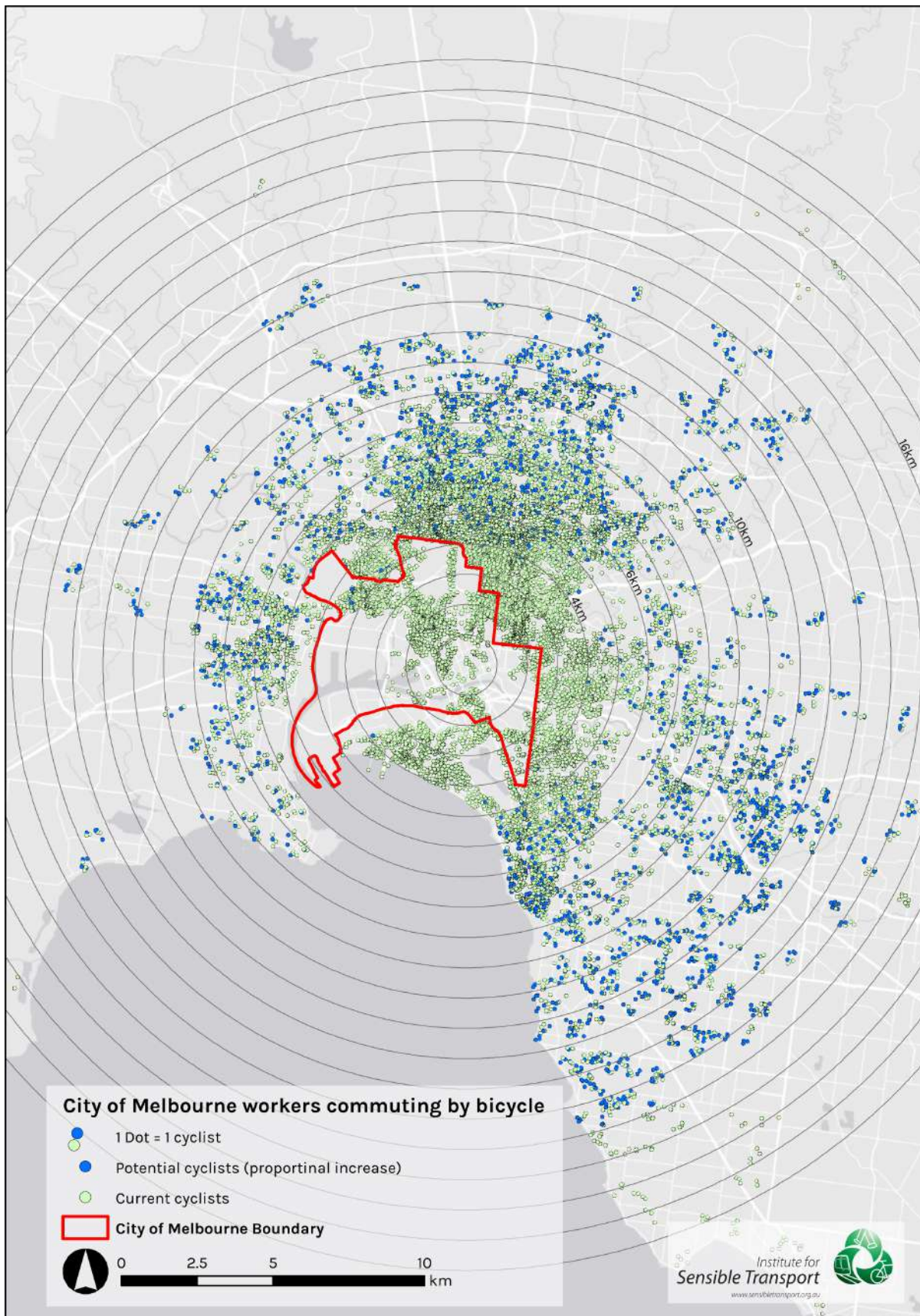


Figure 22 Current and potential cycling participation (proportionately increased)

Another approach to building an understanding the potential to grow the number of people accessing central Melbourne by bike (via e-bike) is to examine how many people are currently making this trip using non-cycling modes. Figure 23 shows the number of people who accessed the City of Melbourne with a mode of transport other than the bike on Census day 2016. This is broken down using distance bands from the GPO. A pertinent finding from this analysis is that the most common distance bands for those commuting into the City of Melbourne by non-bike modes are just outside the average cycling distance, but within the typical range for e-bike trip distances. As highlighted earlier, it is common for e-bike trips to be approximately 50% longer than conventional bike journeys. Almost 40,000 people currently access the City of Melbourne for work that live 7 – 8 km from the GPO. Over 155,000 people employed within the City of Melbourne boundary live between 7 and 14 km of the GPO. Attracting even 5% of this market to e-bikes would result in an extra 5,782 commuting to central Melbourne by bike. This is the equivalent of adding almost 3 extra lanes onto the Monash Freeway.

Over 155,000 people employed within the City of Melbourne live between 7 and 14 km of the GPO. Attracting even 5% of this market to e-bikes would result in an extra 5,782 commuting to central Melbourne by bike.

While this section has focused on the journey to work, it is important to recognise that 4 in 5 trips made in Melbourne are for purposes other than the commute and e-bikes will of course have a role in these trips as well. Finally, as will be described in Section 6.2, a high-quality bicycle network across Greater Melbourne will be essential to maximise the uptake and benefits of e-bikes; in particular for carrying greater loads, to assist with school runs, shopping and other duties people find difficult to do on a regular bicycle.

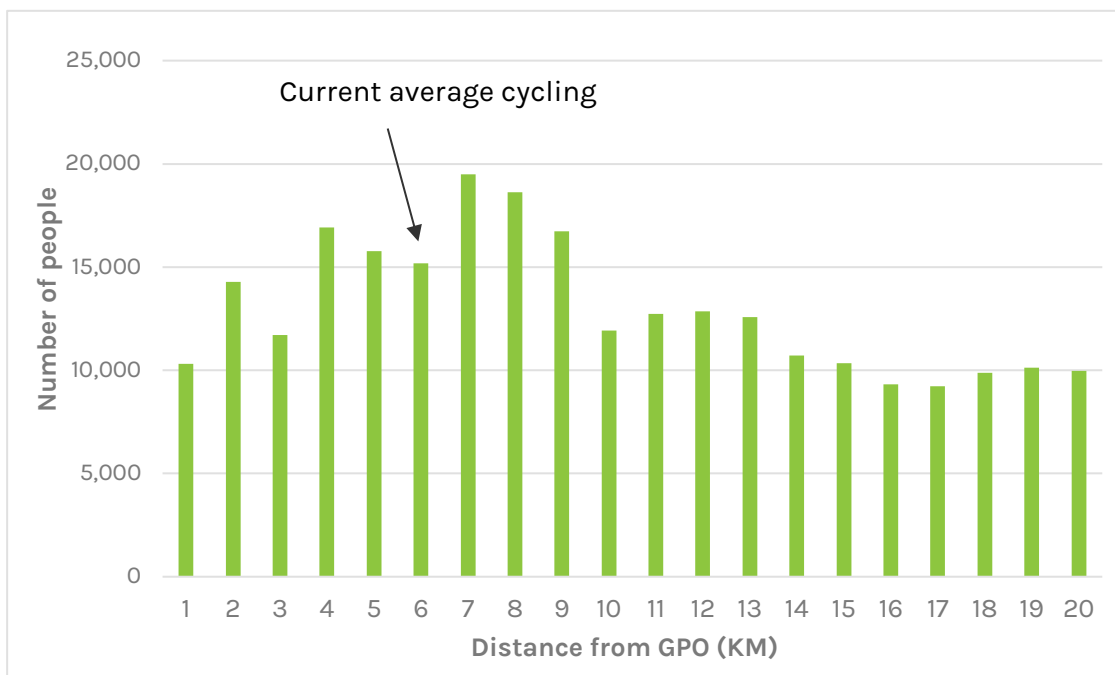


Figure 23 Non-cycling commute trips to the City of Melbourne

Source: Analysis by Institute for Sensible Transport, based on 2016 Census data (Australian Bureau of Statistics, 2017)

5.3 Potential impact on journey times

A simple exercise has been undertaken to illustrate potential changes in journey travel times from three different areas of suburban Melbourne into the Melbourne GPO. This is shown in Figure 24. Elwood, Malvern and Preston were chosen because they are common origins for those working within the City of Melbourne and are around 10km from the GPO, which is just outside typical riding distances for those currently travelling to central Melbourne by bike. These times are based on the suggested journey duration using the Google Maps directions feature. These suburbs are also generally within 32 minutes e-bike travel time to the GPO.

This was the average duration people said they were willing to spend travelling to the city in the survey conducted as part of the Near Market study (CDM Research & ASDf Research, 2017). In each of the three cases, the centroid of the suburb was used as the origin, and the Melbourne GPO as the destination. The trips were set for an arrival time of 9am on a Wednesday. Due to uncertainty regarding congestion, the car travel time was offered with a wide margin of error, which varied from 22 minutes, through to 65 minutes. E-bikes was assumed to travel at an average speed of 20km/h. In sum, e-bikes provided the most reliably quicker mode in all instances.

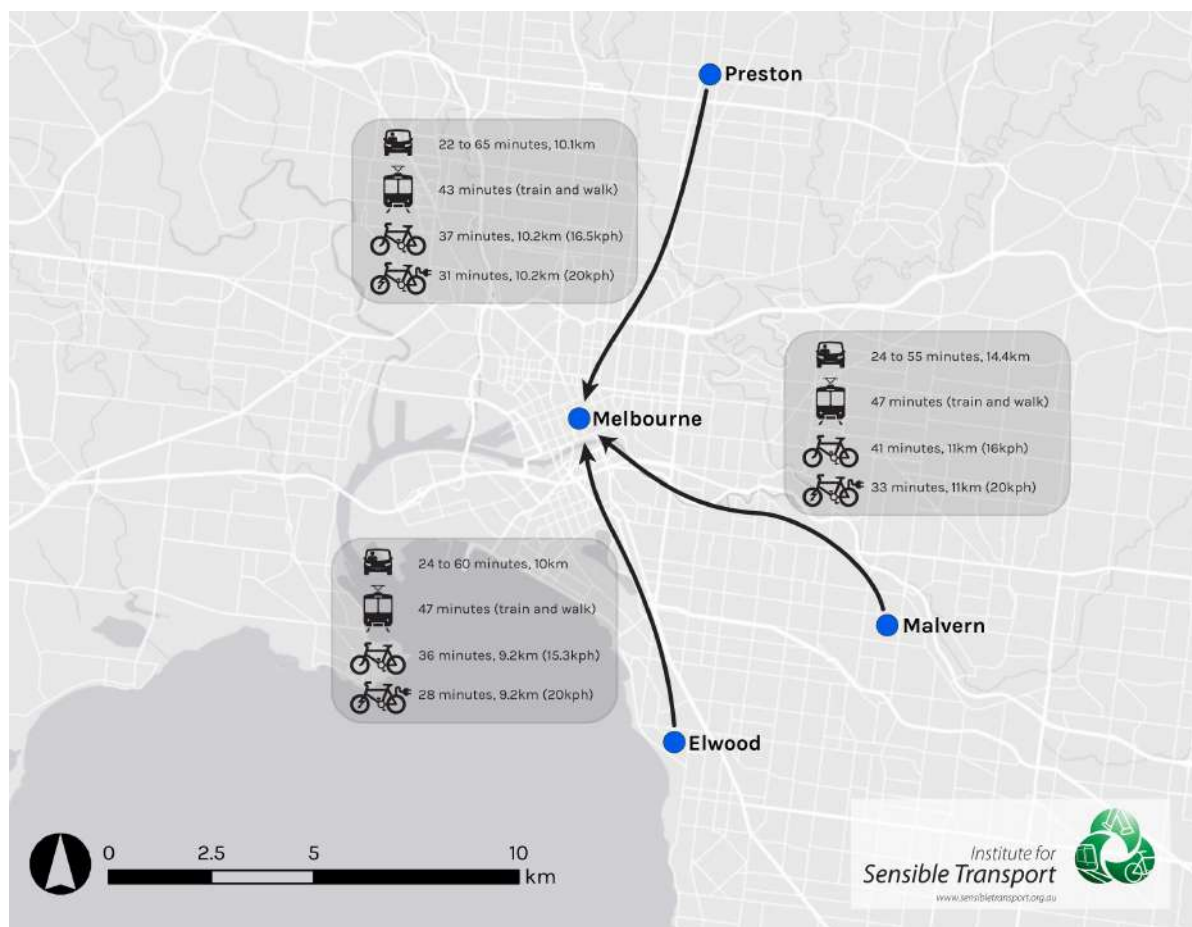


Figure 24 Journey time comparison

6. Recommendations

E-bikes are among the most energy and space efficient forms of transport and are experiencing rapid growth. E-bikes are an efficient method of assisting the City of Melbourne achieve its wider strategic objectives. E-bikes can act as a catalyst for the City of Melbourne to realise its ambition to be a sustainable, inventive and inclusive city that is vibrant and flourishing'. However, to maximise the potential of e-bikes, some important actions will require implementation, across different levels of government.

As identified at the beginning of this report, every transport mode contains three elements; 1) *rights of way*, 2) *terminal capacity* and 3) the *vehicle* as shown in Figure 5. To achieve strong growth in the use of a particular mode of transport, it is necessary for the provision of each of the elements to be of a high quality. In the case of e-bikes, the *rights of way* will include a cohesive network of wide, smooth bicycle paths and protected on street lanes. *Terminal capacity* relates to parking, and for e-bikes, this often requires higher levels of security, and the ability to charge the battery. *Vehicles* are of course the e-bike itself. The quality, reliability and battery range has improved significantly over the past two decades, which helps to explain the substantial growth in e-bike use. Governments in other countries are beginning to introduce subsidies to assist people overcome the barrier presented by their higher price.

The following set of recommendations are grouped together based on the three elements of the e-bike transport system to which they relate, as identified immediately above and in Figure 5.

6.1 The Vehicle

6.1.1 Recommendation 1.1: Hold 'Come and Try' days

E-bikes have the potential to appeal broadly across different market segments. This includes

- Office, retail and hospitality workers who may benefit from more easily arriving without the need for a shower or special clothing
- Families needing to carry children

- Shoppers with heavy items (e.g. Victoria Market customers).
- Small parcel delivery workers
- Students.

Providing an opportunity for all members of the community to experience riding an e-bike is a measure the City of Melbourne can take at minimal expense and will serve to boost the community's understanding of e-bikes, bringing them one step closer to becoming an owner and regular user.

The City of Melbourne should:

- Collaborate with adjoining councils to hold a combined event/s
- Identify a suitable location, that may include:
 - at least a 100m of open pathway, in a car free location.
 - some topographical variation to give the rider an indication of the assistance available when riding uphill.
 - good car access/parking, and accessible by public transport.
- Identify and approach three experienced, reputable e-bike retailers. These retailers should have a location in inner Melbourne as this may make it easier for servicing in the future, should bike purchases be made during or following the event. The retailers will also need to be chosen based on the types of bicycles they offer, with an objective of showcasing a wide variety of bicycle types (e.g. step through frame, flat bar road bike, mountain bike, fold up, cargo cycle, long tail).

6.1.2 Recommendation 1.2: Subsidy

The City of Melbourne should explore approaches for the creation of an e-bike subsidy program. The City of Melbourne may be too small to offer the subsidy programs that have been implemented in Sweden, Oslo and the UK, however it could encourage the State Government to introduce such a scheme. Additionally, it is understood the Australian Government may be considering what Commonwealth assistance may be provided to boost Australia's take up of electric vehicles. There is a compelling case to include e-bikes within any future federal subsidy for electric vehicles. The City of Melbourne (perhaps in conjunction with other capital city local governments) should consider lobbying for the inclusion of an e-bike subsidy.

6.1.3 Recommendation 1.3: Salary sacrificing programs

There are a number of Australian businesses that run programs to encourage e-bike use through salary sacrificing and leasing schemes (e.g. see <https://www.e-stralian.com.au>). The City of Melbourne may wish to investigate what capacity it has to promote such schemes, both internally, as well as through its links with the business community in central Melbourne.

6.1.4 Recommendation 1.4: Boosting power for e-cargo cycles

The current maximum power output for an e-bike is 250W, with a maximum speed of 25km/h. The heavier loads e-cargo cycles are required to carry mean that a higher power output is warranted, while still adhering to the existing speed limit. This would enable e-cargo cycles to be more commercially viable without jeopardising safety. The City of Melbourne should work with VicRoads and other relevant agencies to explore the merits and risks associated with a lifting of the power output for e-cargo bikes.

6.2 Rights of way

The countries with the strongest uptake of e-bikes have generally done more to create a cohesive

network of high quality bicycle lanes and paths (e.g. Netherlands). While these bicycle networks have been developed prior to societal and government interest in e-bikes, they now serve as an essential element in facilitating the growth of e-cycling (CROW, 2017).

As this report has demonstrated, e-bikes are effective in reducing some of the known barriers to cycling (e.g. hills, distance, heavy perspiration). E-bikes cannot however overcome a hostile riding environment. As the Near Market study demonstrated (see CDM Research & ASDF Research, 2017), a lack of *protected bicycle infrastructure* is preventing people from riding into the City of Melbourne for work. It is therefore necessary to substantially increase the quality and coverage of the bicycle network. Specific considerations include:

6.2.1 Recommendation 2.1: Expanded bicycle network

Melbourne's bicycle network remains immature and the absence of separated, connected, high quality routes becomes more pronounced further from central Melbourne. As highlighted earlier, *rights of way* are a critical element in the effectiveness of a mode of transport, and until the bicycle network matches the expectations of potential users, the contribution e-bikes are able to make to assist Melbourne meet its transport challenges will be constrained. The *Bicycles for Everyday Transport Discussion Paper* (City of Melbourne, 2018) identified that when protected bicycle lanes are provided, 83% of people feel confident to cycle, compared to only 22% for a regular painted lane.

Develop a costed *Network Development Plan* for protected bicycle infrastructure across Greater Melbourne, in led by the City of Melbourne, and with the cooperation of other LGAs. The Network Development Plan should include a forecasting model that includes population growth and the boost in ridership from enhanced infrastructure. A full Cost Benefit Analysis (CBA) should be conducted, using a recognised \$/km impact for

each additional kilometre cycled. The methodology should be consistent with Victorian and National guidelines. A set of scenarios (high, medium and low) for ridership should be included, as well as the implications of a ‘do nothing’ (Business as Usual) scenario, in terms of consequences for congestion, emissions, transport costs, safety and liveability.

The expansion of the bicycle network will require strong cooperation between Melbourne local governments, as well as the State Government. The creation of a network that meets the expectations of potential users will assist those seeking to ride both conventional bikes and e-bikes. Ultimately, such a network will provide the step change necessary to create a diversified transport system

that lowers the car dependence threatening Melbourne’s liveability.

6.2.2 Recommendation 2.2: Widen the bike network

The width of bike lanes and paths on high demand bike routes will need to be increased to enable safer overtaking and greater carrying capacity. E-bike riders generally travel between 20km/h and 25km/h, whereas many conventional cyclists will often travel at a slower speed. In order to reduce potential conflict and delay, it will be necessary to provide widths capable of allowing safe overtaking. While this will vary based on context, the minimum future dimensions for high demand bike routes is indicated in Figure 25.

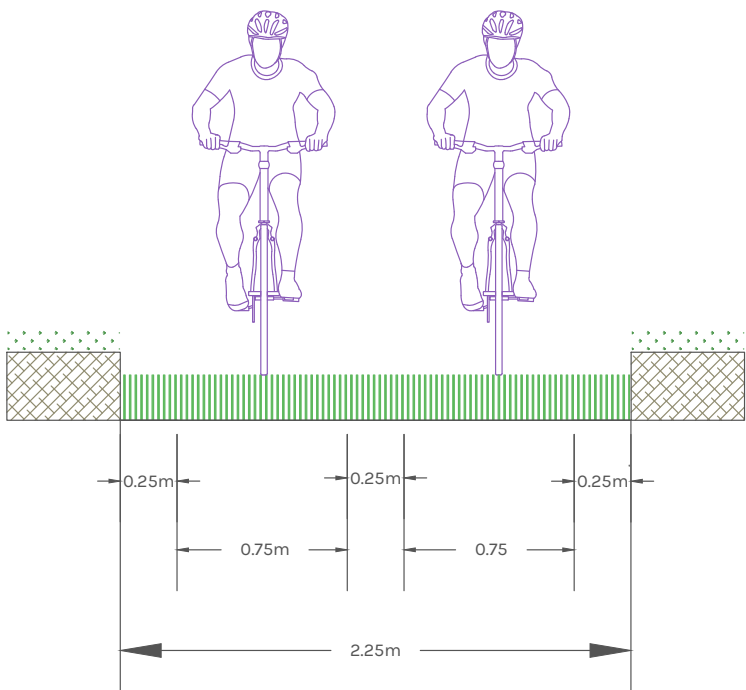


Figure 25 Double width protected bike lane

Source: Created by Institute for Sensible Transport using data contained in CROW Manual (CROW, 2017)

Many e-cargo bicycles/trikes are wider and slower than other bicycles and infrastructure design should allow for safe overtaking possibilities. For protected bicycle infrastructure, it may be

necessary to make these semi-permeable, to facilitate over taking.

Bi-directional protected lanes may cause conflict between oncoming bicycle traffic due to the width

consumption of some of the larger e-cargo freight bikes. Bi-directional lanes should only be used once all other options have been considered.

6.2.3 Recommendation 2.3: Increase the cycling permeability of central Melbourne relative to motor vehicles

Travel time competitiveness is a critical determinant of transport choice. Increasing the permeability of central Melbourne for sustainable modes, and reducing the road network's facilitation of motor vehicle movements will boost the take up of e-bikes. For e-cargo cycles in particular, it is unlikely the industry will adopt the innovations seen in many Northern European cities without the implementation of restrictions on internal combustion engine delivery vans.

6.3 Terminal capacity

6.3.1 Recommendation 3.1 Improve bicycle parking

This report found that e-bike users require enhanced bicycle parking. This is partly due to the extra cost of an e-bike, and the desire for a more secure location than parking on the street (Jones et al., 2016). E-bike users also identified that the ability to charge their battery while parked at a secure parking location increases the ease with which they are able to use their e-bike (Jones et al., 2016). The City of Melbourne should work with commercial parking garages to identify opportunities for retrofitting a small portion of existing car parking bays to secure bicycle parking, and include electric charging facilities.

The Victorian Planning Provisions (Clause 52.34) requires amendment, to boost the amount and type of bicycle parking in new developments and major refurbishments. Currently only one parking space is required per five dwellings. This limits bicycle ownership. This should be increased to one bicycle parking spot per bedroom.

E-bikes will almost always require horizontal rather than vertical parking, and therefore wall mounted parking facilities are unlikely to be useful for e-bike

parking. The Clause should stipulate that vertical parking cannot constitute more than a third of the bicycle parking. For new developments, wall sockets should be provided to enable the charging of e-bikes.

6.3.2 Recommendation 3.2: Create a Last Kilometre Freight Distribution Hub

Last kilometre freight distribution hubs are critical to the success of lowering heavy, internal combustion engines vehicle movements in central Melbourne. The City of Melbourne's Last Kilometre Freight Plan (see City of Melbourne, 2016b) contained numerous actions pertaining to the need for a distribution hub, without any noticeable progress. To follow through on the implementation of the Last Kilometre Freight Plan and take advantage of new advances in e-cargo cycles, the City of Melbourne should accelerate efforts to create a *Last Kilometre Freight Distribution Hub*. In essence, this would act as a transfer point where freight operators transfer parcels from larger vehicles into smaller e-cargo cycles, for the final leg of their journey.

Creating a freight transfer hub on the edge of central Melbourne will allow the City of Melbourne and the freight industry to pilot a scheme for lowering the impact of last kilometre freight. The next steps should include:

- Liaise with key industry bodies and firms with a large interest in small parcel, central Melbourne freight delivery regarding the new Transport Strategy and the future of freight delivery
- Gauge the interest, issues and opportunities the freight industry envision in the creation of a *Last Kilometre Freight Distribution Hub*
- Identify measures that the City of Melbourne can take to increase the attractiveness for industry actively participating in a *Last Kilometre Freight Distribution Hub* to transfer parcels to e-cargo cycle.
- Identify costs and risks associated with leasing a suitably sized and located distribution hub to create a trial program intended to enable the

industry to boost the use of e-cargo cycles for central Melbourne deliveries.

- Identify the costs and risks associated with the bulk purchase of a fleet of e-cargo cycles. Potentially offered through a leasing arrangement, the program would act as a catalyst for reform of last kilometre freight practice, helping to lower emissions and congestion associated with large, internal combustion engine vehicles undertaking last kilometre delivery. Through a bulk purchase of e-cargo cycles, the City of Melbourne will be able to actively support the policy objectives in various strategic commitments (e.g. Last Kilometre Freight Plan in Section 2.5).

- Average number of parcels in a small delivery van when leaving distribution warehouse.
- Frequency distribution of parcel weight (e.g. 20% less than 1kg, 20% 1kg - 4kg, 20% 4kg etc...).
- Average distance between deliveries (for central Melbourne).

By understanding the key metrics of central Melbourne freight practices, the City of Melbourne will be in a stronger position to provide the industry support necessary to lower the negative impact associated with last kilometre freight.

6.4 E-bike food delivery

As identified in Box 2, there are currently a substantial number of e-bikes being used in the City of Melbourne for food delivery. More data is needed regarding potential safety issues associated with current practices. It is recommended research be conducted in relation to:

- E-bike compliance with relevant laws
- Behaviour of riders in terms of safe riding behaviour
- Pedestrian access issues associated with the parking of e-bike delivery vehicles on the footpath.

The outcomes of this research may inform the development of a set of actions designed to encourage the safe use of e-bikes to perform food delivery in the City of Melbourne.

6.5 Improved data on freight

Prior to embarking on measures designed to boost the use of e-bikes for small parcel delivery, the following industry data would be useful, in order to gauge the potential for transferring some delivery capacity from vans to e-cargo bike:

- Average delivery rate (i.e. deliveries per hour), for central Melbourne.

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