FINAL REPORT

# Regulating Personal Mobility Devices

Economic Appraisal of regulatory settings for PMDs

*Prepared for*
*NSW Productivity Commission*

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THE CENTRE FOR INTERNATIONAL ECONOMICS
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# Summary

## Project objective

NSW Treasury has recently released a report on 'Regulating NSW's Future' which identifies challenges and opportunities for creating, modern, fit for purpose regulation. This was followed by the NSW Productivity Commission Green Paper in August 2020, which identified specific opportunities for smarter and more flexible regulation to support emerging technology. One proposed reform was to make micro-mobility work better through improved regulation of Personal Mobility Devices (PMDs), which at present are prohibited in New South Wales.

## Scenarios assessed

We have modelled three scenarios, which includes the base case (status quo) as well as two scenarios which permit the use of PMDs in NSW. The central growth scenario assumes an appropriate regulatory framework is put in place to enable PMD use, leading to a moderate growth in usage. In contrast, the high growth scenario assumes more barriers to higher uptake are removed, and this is achieved through broader policy support from Government which may include new infrastructure (Table 1).

### 1 Scenarios

| Scenario | Regulatory approach | Other changes |
|---|---|---|
| Status quo | Illegal to use (beyond private property) | na |
| Central growth | Legalised with an appropriate regulatory framework put in place | na |
| High growth | Legalised with an appropriate regulatory framework put in place | Growth which could be supported by factors including:<br>▪ External drivers<br>▪ Additional investment in infrastructure<br>▪ Broader policy support<br>▪ High availability of shared services |

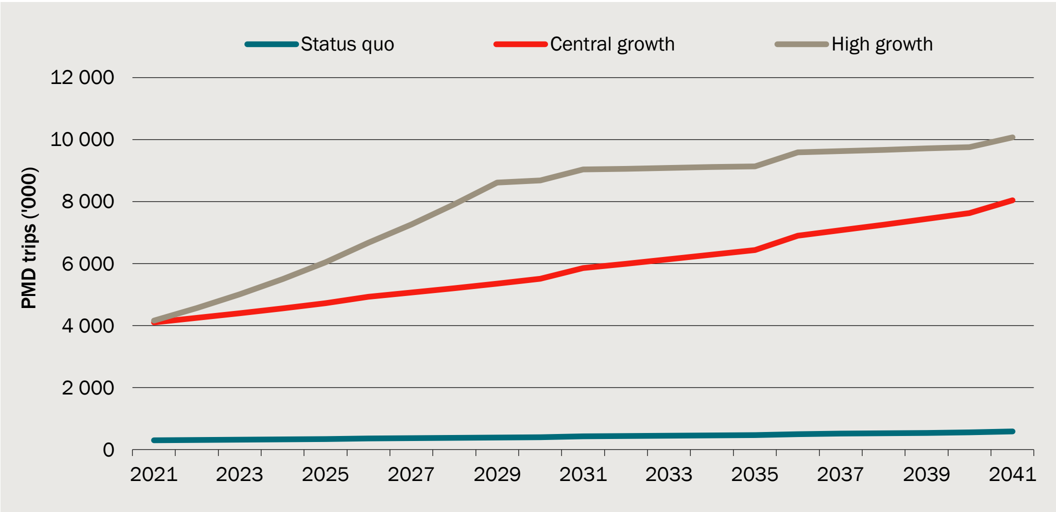
*Source:* NSW Treasury.

## *Expected uplift*

Under the status quo (base case), there are a small number of users who ride PMDs illegally. This amounts to around 300 000 trips per year (based on the assumption of 1 000 riders per business day) and increasing to 600 000 by 2041. The central growth scenario assumes a higher rate of penetration in the first year PMDs are legalised compared to the base case, leading to an uplift of around 4 million trips per year, increasing to 8 million trips by 2041. The high growth scenario achieves a faster rate of growth, however, which leads to a larger initial gap between this scenario and the central growth scenario, with around 10 million trips by 2041 (chart 2).

Across all scenarios, PMD trips include a mix of recreational use (31 per cent of trips) as well as use for transport purposes (69 per cent of trips).

**2 Annual PMD trips 2021–2041**




*Data source:* The CIE.

## Economic results

Overall, there are net benefits associated with regulating PMDs in NSW. PMDs lead to travel time saving benefits for those that use them, while also generating positive externalities in the form of reduced congestion and emissions due to reduced motor vehicle usage. The main offsetting disbenefits of PMDs are worse safety outcomes as well as negative health impacts from reduced walking, since PMDs largely replace walking trips.

The central growth and high growth scenarios both lead to net benefits relative to the base case, with net present values of around $58.3 million and $86.5 million, respectively. We have also quantified the outcomes associated with illegal PMD usage under the status quo (base case) relative to there being no usage, and this leads to a net present value of around $4.3 million. It should be noted that there is substantial uncertainty surrounding the level of base case PMD usage, and this uncertainty also extends to the results for the scenarios, since the scenarios are incremental to the base case. Sensitivity analysis has been performed on base case usage and still shows very large uplifts even when assuming substantially higher values of base case PMD usage (such as up to 1 million annual trips).

As there are very little direct costs associated with a change in regulation, the definition of the benefit-cost ratios becomes less meaningful. As such, we have focused on the quantification of net benefits as the main indicator of economic value.

### 3 Benefits and costs of each scenario

| Category | Status quo | Central growth | High growth |
|---|---|---|---|
| | $pv | $pv | $pv |
| **Benefits** | | | |
| Travel time savings | 3 662 704 | 49 520 616 | 70 835 659 |
| Vehicle operating cost savings | 1 240 056 | 16 810 705 | 23 746 790 |
| Decongestion benefits | 575 207 | 7 797 737 | 11 015 077 |
| Environmental impacts | 169 658 | 2 305 086 | 3 354 516 |
| Health benefits | -1 012 097 | -13 659 220 | -18 123 716 |
| Safety impacts | - 179 750 | -2 410 087 | -1 541 421 |
| Total benefits | 4 455 778 | 60 364 836 | 89 286 905 |
| **Costs** | | | |
| Enforcement costs | - 153 008 | -2 064 988 | -2 739 926 |
| Total costs | - 153 008 | -2 064 988 | -2 739 926 |
| **Net benefits** | **4 302 770** | **58 299 848** | **86 546 979** |

*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE.

## *Next steps*

This analysis provides a high-level indication that regulating PMDs in NSW will lead to a net positive change, although a more comprehensive analysis of the impacts will require a formal PMD trial in NSW. A trial will help eliminate some of the uncertainties around PMD uptake as well as the benefits and costs that are expected to occur, as thus far the analysis draws heavily on evidence from other Australian and overseas locations where PMDs have been legalised. More work must also be done on defining what an appropriate regulatory framework would look like in the NSW context, as the underlying assumptions of the analysis also draw from the outcomes resulting from rules and regulations put in place in other states and cities.

# 1 Introduction

This project considered the costs and benefits of changing regulation for Personal Mobility devices in NSW.

## Project objectives

NSW Treasury has recently released a report on 'Regulating NSW's Future' which identifies challenges and opportunities for creating, modern, fit for purpose regulation. This was followed by the NSW Productivity Commission Green paper in August 2020, which identified specific opportunities for smarter and more flexible regulation to support emerging technology. The objective of these reforms is to make micro-mobility work better through improved regulation of Personal Mobility Devices (PMDs), which at present are prohibited under the current arrangements.

## Purpose

This report sets out the methodology the CIE has used to conduct the cost benefit analysis (CBA) of the different scenarios for regulating PMDs and e-bikes in NSW. This draws extensively on the following guidelines.

- NSW Treasury Guide to cost-benefit analysis[1]
- TfNSW Principles and Guidelines for Economic Appraisal of Transport Investments[2]
- Australian Transport Assessment and Planning guidelines.[3]

CBA is a comprehensive and transparent appraisal technique that estimates the economic, environmental and social costs and benefits of a project or program in monetary terms[4]. This is done by identifying all the costs and benefits related to the program or project and valuing them in dollar terms for the purpose of understanding which option has the highest economic returns.

1 NSW Treasury - TPP17-03 NSW Government Guide to Cost-Benefit Analysis

2 Transport for NSW 2020, *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives*, version 2.0, November

3 https://atap.gov.au/

4 NSW Treasury - TPP17-03 NSW Government Guide to Cost-Benefit Analysis

## *Key steps in the CBA*

This study involves evaluating the economic viability of a range of alternative transport project options. In undertaking the CBA, we have used a structured approach based on the key steps in set out in box 1.1.

### 1.1 Key steps in a CBA

- **Articulating the decision that the CBA is seeking to evaluate**. For this analysis the CBA evaluates the various regulatory scenarios considered by NSW Treasury and determines which scenario is likely to result in the highest net benefit to society.
- **Establishing the base case** against which to assess the potential economic impacts of changes. The base case defined for this project is no government action beyond that already committed.
- **Quantifying the changes** from the base case resulting from the possible scenarios being considered. This focuses on the incremental changes resulting from the decision, such as changes in travel time by permitting the use of PMDs
- **Placing values on the changes** and aggregating these values in a consistent manner to assess the outcomes.
- **Generating the Net Present Value (NPV) of the future net benefits stream**, using an appropriate discount rate, and deciding on the Decision Rule on which to assess the different options. The best decision rule is to choose the scenario that has the highest net benefits.
- **Undertaking sensitivity analysis** on a key range of variables, given the uncertainties related to specific benefits and costs.

## *Framing of the CBA*

The reference group for this project is the community of NSW, which is composed of households, firms and the Government.

The scenarios generate a stream of benefits and costs over time. The CBA accounts for all relevant costs and benefits over the evaluation period to determine which scenario make this community better off (a net benefit) or worse off (a net cost). An evaluation period of 20 years starting in 2021 (the assumed date of a regulation change).

For the central case, future costs and benefits are discounted using a real social discount rate of 7 per cent per year. This means that a benefit today is worth 7 per cent more than a benefit next year. This is in accordance with TfNSW Principles and Guidelines for

Economic Appraisal of Transport Investments[5] and NSW Treasury Guide to cost-benefit analysis[6].

## *Decision criteria*

Two decision criteria are commonly used in CBA:

1 Present value of net benefits — this is the difference between the present value of benefits and costs. The greater the difference, the greater the return to society from investment in the project.

2 Benefit cost ratio (BCR) — this is a ratio of the present value of the project benefits to the present value of the project costs. Example BCR interpretation:
   - BCR of 0.5 — for every $1 of benefits, society must pay $2 in costs
   - BCR of 1 — for every $1 of benefits, society must pay $1 in costs
   - BCR of 1.5 — for every $1.5 of benefits, society must pay $1 in costs

Present value of net benefits has been used as the principle decision criteria to determine which of the various scenarios result in the highest net benefit to society.

5 Transport for NSW Principles and guidelines for economic appraisal of transport investment and initiatives – transport and economic appraisal guidelines

6 NSW Treasury - TPP17-03 NSW Government Guide to Cost-Benefit Analysis

# 2 Personal Mobility Devices

## Defining Personal Mobility Devices

Personal Mobility Devices (PMDs), such as electric scooters and electric skateboards, are typically small, portable, and designed to carry one person over short to medium distances[7]. PMDs are designed to meet the needs for 'micro mobility', which favours more individualised forms of personal transport which is less dependent on typical road and public transport infrastructure.

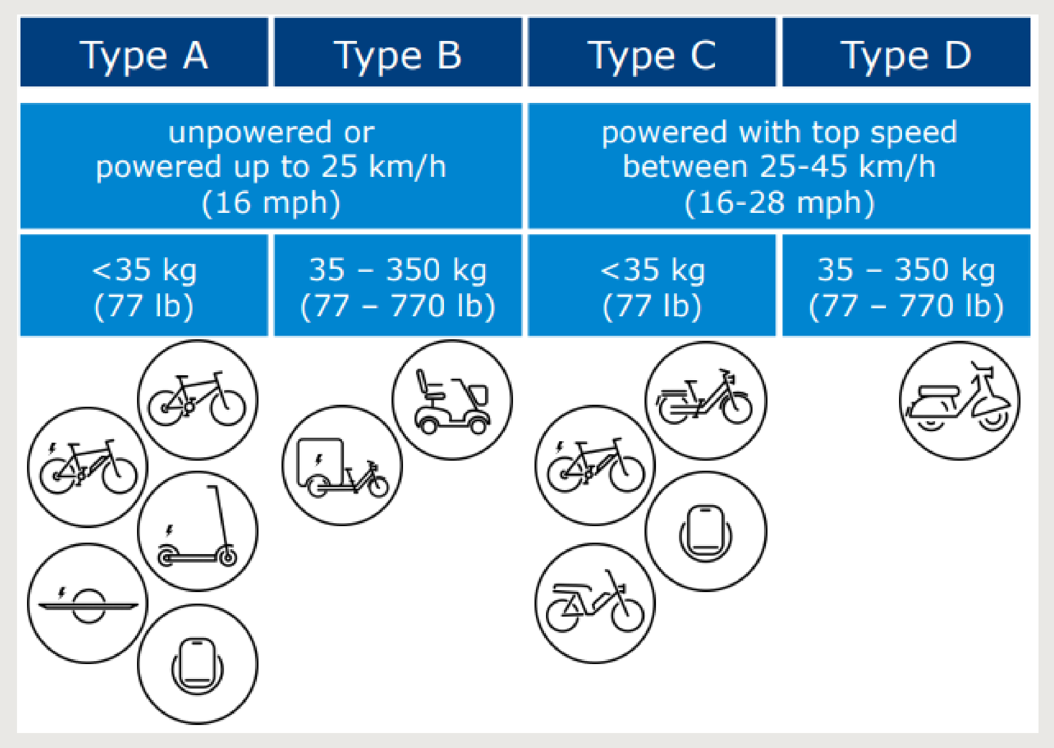
PMDs and Micro Mobility devices more broadly (of which PMDs are an emerging subset) vary in terms of their:

- Formfactor — the overall shape and size of the device
- Speed capabilities — how fast the vehicle can travel on various surfaces
- Maximum power — the overall strength of the motor (e.g., in watts)
- Weight — how heavy the vehicle is, excluding cargo and users

The International Transport Commission has outlined the various types of devices according to classes along these dimensions. Overall, it defines micromobility as the use of vehicles with a mass of less than 350 kg and a design speed of 45km/h or less. The various classes include: Type A micro-vehicles with a mass of up to 35kg and a power limit such that their maximum speed cannot exceed 25km/h. Other types include Type B, which have higher mass, Type C, which have higher speeds or Type D which has bother higher mass and speed (chart 2.1)

7 NTC: Barriers to the safe use of personal mobility devices, Decision Regulation Impact Statement, August 2020

**2.1 Types of micro-mobility devices**




*Data source:* International Transport Forum: safe micro mobility, p 15, 2020.

The PMDs considered as part of this study mainly fall within the Type A category (such as e-scooters). We will also analyse regulation that would enable some Type C devices such as more powerful e-bikes and speed pedelecs.

The National Transport Commission (NTC) has developed a proposed regulatory framework that focuses on the use of Type A PMDs, which has been referred to in order to inform how PMDs might be regulated in NSW.

### *National Transport Commission framework for PMDs*

As part of its Decision Regulation Impact Statement in August 2020, the NTC has proposed a regulatory framework for PMDs which sets out:

- The definition of a Personal Mobility Device in the Australian context
- Permitted access to roads, bike lanes and pedestrian infrastructure
- Speed limits

The definition of a PMD according to the NTC is set out in box 2.2.

### 2.2 Proposed regulatory framework for PMDs — National Transport Commission

A personal mobility device is a device that:

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

Category A (small, light devices)

- is not more than:
  - 1 250mm in length by 700mm in width by 1 350mm in height
  - 25kg when the vehicle is not carrying a person or other load.

Category B (optional — large, heavier devices)

- is not more than:
  - 700mm in length by 1 250mm in width by 1 350mm in height
  - 60kg when the vehicle is not carrying a person or other load.

The NTC considered a range of options regarding the types of infrastructure that PMDs would be able to access as well as different speed limits. The preferred approach outlined by the NTC includes:

- To permit the use of PMDs on most pedestrian infrastructure, including:
  - Footpaths
  - Shared paths
  - Separated footpaths (designed for the use of bicycles)
  - Bicycle paths
  - Local roads (50km/h or less, no dividing line or median strip and not a one-way road with more than 1 marked lane)
- Not permitted to travel at a speed faster than 10km/h on a footpath or shared path
- Not permitted to travel at a speed faster than 25km/h on a separated footpath (designated for the use of bicycles), bicycle path or local road.

# 3 Scenarios

We have been asked to model 3 scenarios, which include legalising PMDs in addition to a base case (table 3.1). The base case represents the status quo, in which PMDs remain prohibited to use beyond private property. The two scenarios allow the use of PMDs under an appropriate regulatory framework as well as the possibility for further policy support. Specifically, the two scenarios include:

- Central growth — legalises PMDs in NSW under an appropriate regulatory framework which governs the type of devices that can be used, where they may be ridden and at what speeds. This scenario enables a moderate growth rate to be achieved in the number of PMDs that are used.
- High growth — legalises PMDs in NSW under an appropriate regulatory framework but includes a higher take-up rate of PMDs due to other supporting factors such as additional investment in infrastructure, broader policy support and enabling high availability of shared e-scooter services. Under these settings, take-up of PMDs grows in line with expected global trends because there are less barriers to take-up.

### 3.1 Scenarios

| Scenario | Regulatory approach | Other changes |
|---|---|---|
| Status quo | Illegal to use (beyond private property) | na |
| Central growth | Legalised with an appropriate regulatory framework put in place | na |
| High growth | Legalised with an appropriate regulatory framework put in place | Growth which could be supported by factors including:<br>▪ External drivers<br>▪ Additional investment in infrastructure<br>▪ Broader policy support<br>▪ High availability of shared services |

*Source:* NSW Treasury.

# 4 Take-up of PMDs

## Status quo

While PMDs are prohibited to use outside of private property in the base case, there is some evidence (albeit anecdotal) that PMDs such as e-scooters are being used in public places across NSW. At present, there is a lack of quantitative data to help inform the current level of PMD usage, or what the likely uplift would be over time.

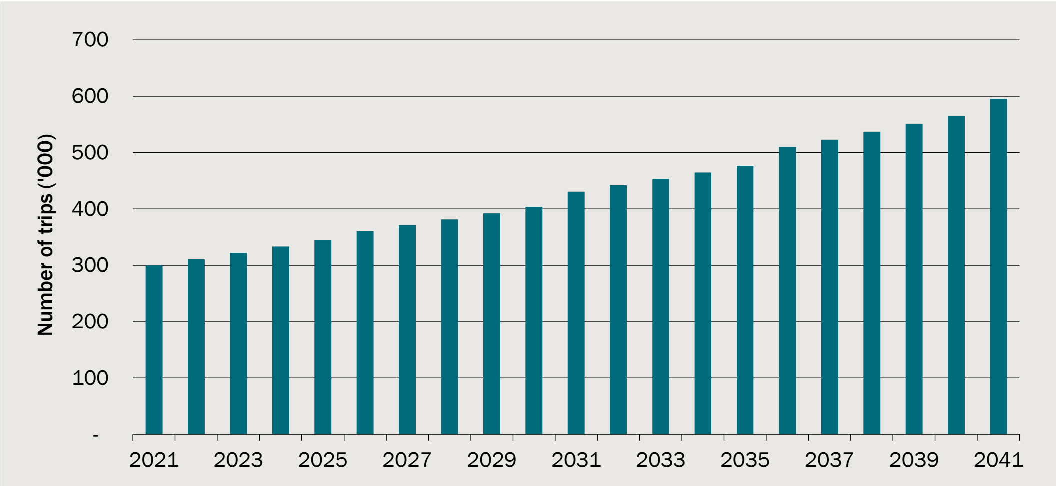
We expect that any usage would likely remain relatively small, at least compared to other modes of travel. As a starting point, we have assumed 1 000 daily PMD trips across metropolitan centres across NSW such as Sydney, Newcastle, Wollongong, the Central Coast and Blue Mountains. These trips are assumed to occur on business days, leading to around 300 000 trips per year (chart 4.1). Our choice of starting point is essentially guesswork due to the lack of any formal or informal information on PMD usage in NSW (although we have undertaken sensitivity analysis around the assumed base case usage). We assume that usage will increase over time, reflecting the fact that even under status quo conditions PMDs will become more popular.

While the global market size of e-scooters is expected to grow by 7.7 per cent per annum through to 2030[8], this reflects a level of uptake based on international markets which have high levels of support of devices such as e-scooters. We have calculated an alternate growth rate of 2 per cent for the status quo scenario[9]. This leads to around 600 000 trips per year by 2041.

8 Grand View Research forecasts that the market size of e-scooters will increases by 7.7 percent on a CAGR basis through to 2030 See https://www.grandviewresearch.com/press-release/global-electric-scooters-market

9 See technical appendix discussion on how 2 per cent was calculated

### 4.1 Status quo PMD usage




*Data source:* The CIE.

## *Central growth scenario*

Under a central growth scenario, PMDs become legal to use in NSW under an appropriate regulatory framework. This could be in the form of the approach developed by the National Transport Commission, which permits PMDs on pedestrian infrastructure such as footpaths as well as shared paths and bicycle lanes. This is similar to the way these devices have been legalised in other jurisdictions across Australia such as Brisbane and the ACT.

To inform the take-up rate in NSW on this basis, we used data on the number of e-scooter trips made in Brisbane since legalising the use of e-scooters in 2018. Within the first three months of the e-scooter trial, around 500 000 trips[10] were made in Brisbane. Pre Covid-19 levels of usage reached around 2 million trips per year in 2019[11] and with a population of 2.5 million people, this implies 0.82 trips per capita.

Applying this uptake factor to the population of major metropolitan centres across NSW[12] (which equates to around 5.3 million people) leads to an uptake of just over 4.3 million trips per year in the first year of regulated usage (assumed to start in 2021) (chart 4.2) (excluding the base case usage of 300 000 trips leads to an actual uplift of around 4 million trips per year). We have applied the same uptake rates to all metropolitan areas, although in practice this could vary (and in fact could be lower in less dense urban and metropolitan areas).

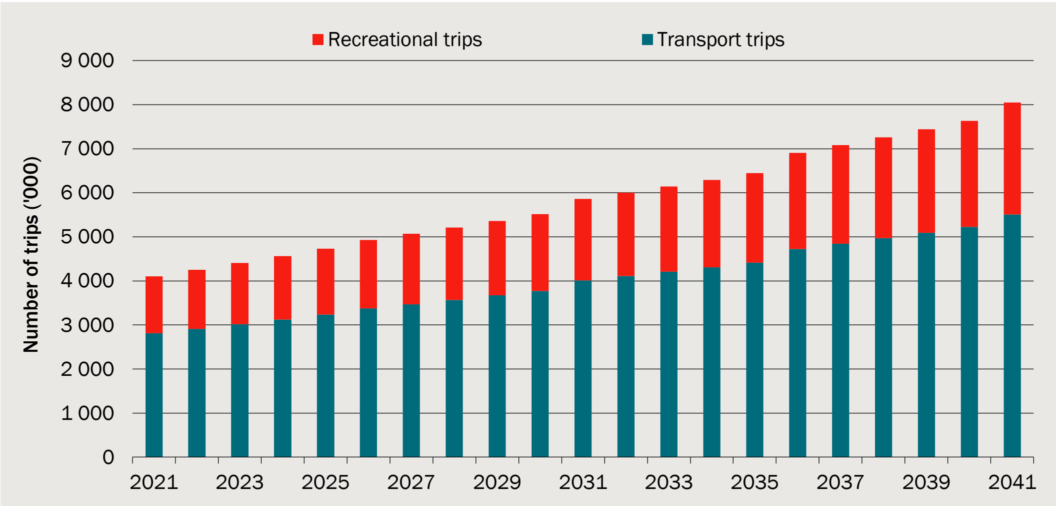
10 Centre for Accident Research and Road Safety, QUT, Illegal and risky riding of electric scooters in Brisbane, 2019

11 E-scooter usage declined during 2020 as a result of the COVID-19 pandemic, but have recently increased to pre pandemic levels at the end of 2019, https://www.brisbanetimes.com.au/national/queensland/brisbane-e-scooter-use-returns-to-pre-pandemic-levels-20210316-p57b6y.html

12 Including places such as Sydney, Wollongong, Newcastle, the Central Coast and Blue Mountains

Of the trips forecast, 31 per cent are for recreational purposes while 69 per cent are for transport purposes. Recreational trips would likely include a proportion of trips made by tourists, as recent research has shown that for shared e-bike schemes around a third of trips are made by tourists[13]. If a similar pattern emerged for PMDs, then we may expect a lower level of recreational usage in the first few years due to the COVID-19 pandemic leading to dramatically lower levels of international tourism.

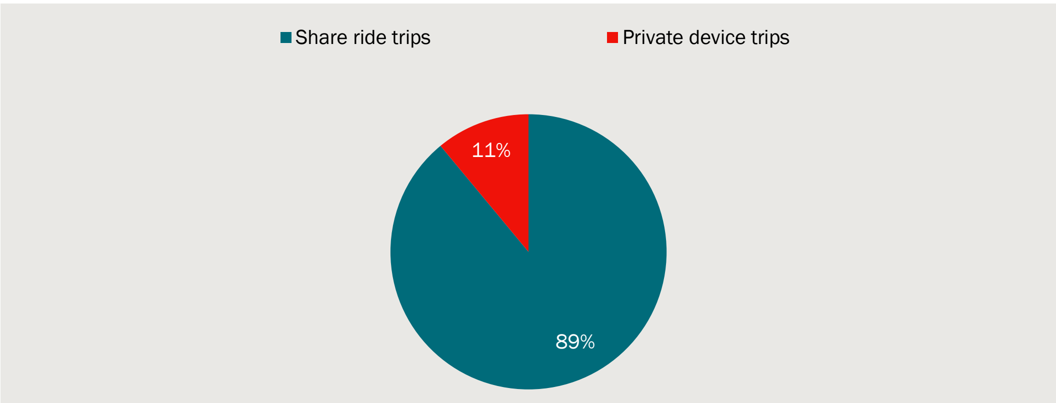
### 4.2 Total PMD trip uplift Central growth scenario




*Data source:* The CIE.

Data from Brisbane's e-scooter implementation also reveals that around 89 per cent of trips made on e-scooters were made on shared-devices made available by providers such as Lime and Neuron Mobility, while 11 per cent were privately owned devices. If PMDs are introduced in a similar fashion, then it could be reasonably expected that a similar pattern would emerge in NSW (chart 4.3).

### 4.3 Proportion of share ride trips and private device trips

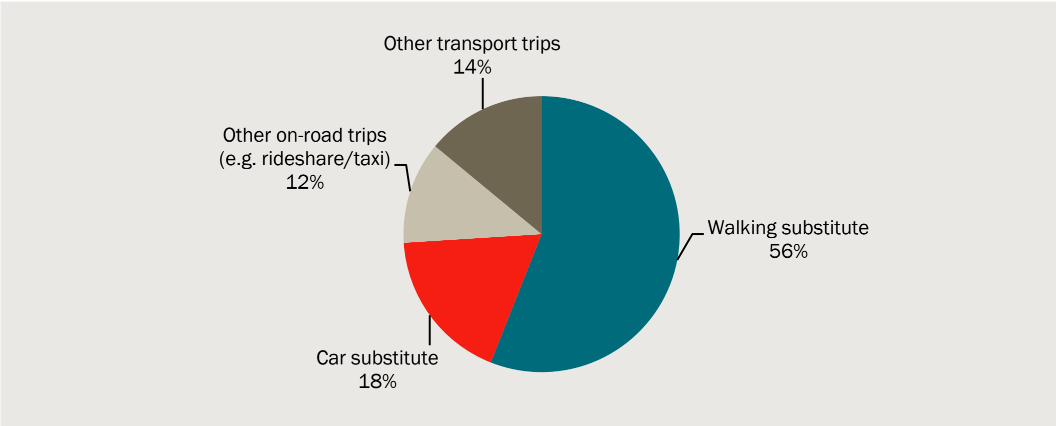



*Data source:* Use shares based on Centre for Accident Research and Road Safety, QUT, Illegal and risky riding of electric scooters in Brisbane, 2019.

13 Buning & Lulla, Visitor bikeshare usage: tracking visitor spatiotemporal behavior using big data, Journal of Sustainable Tourism 24 September 2020

Since PMDs are a new type of transport solution, the benefit pathways are specific to the substitution patterns and new use cases that they offer. Using data from mode substitution towards PMDs, in addition to our own modelling, we have found that the majority of new PMD trips that are made are those which replace walk trips (54 per cent). This is followed by road-based travel which includes driving cars (17 per cent) or other forms of road-based passenger trips such as ride-share and taxis (12 per cent) (chart 4.4)

### 4.4 Mode share for trips replaced by PMDs




*Data source:* Mode share data based on Shared e-bike and e-scooter Final Pilot report, Calvary 2020.

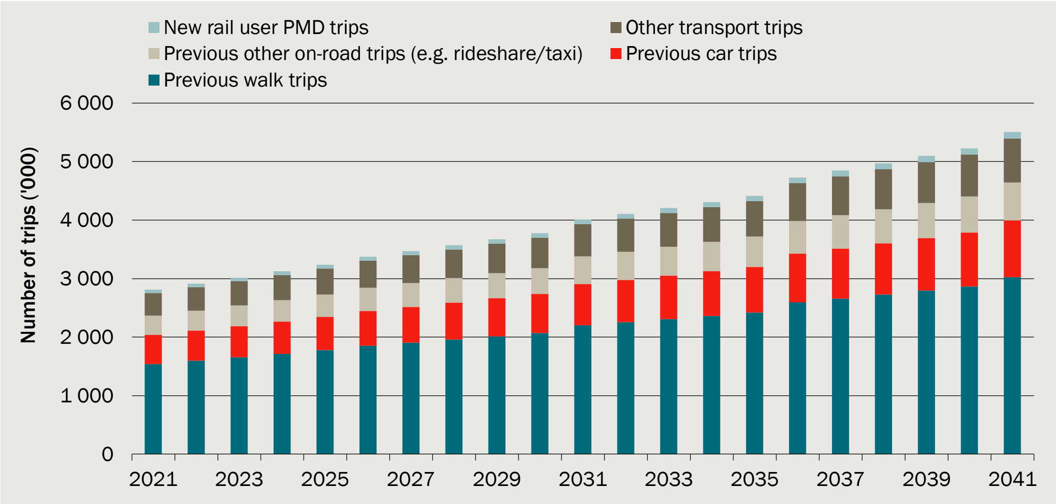
PMDs also provide a new way of solving the 'first and last mile' problem, by reducing access and egress costs associated with car parking. Part of the benefit of using PMDs therefore also include creating easier ways to use public transport services such as rail. By reducing the cost of accessing rail services, we would also expect an uplift in rail usage. We estimate an additional 57 000 rail users in 2021 due to PMDs lowering station access costs. It must be noted that the estimated number of trips made for rail access are for induced new users of rail. There is likely a large number of people using e-scooters to access public transport that were previously using other modes of access, such as walking or driving and are thus existing public transport users.

The patterns of PMD usage for transport based on these mode shares lead to 5.5 million transport trips by 2041, of which (chart 4.5)

- 3 021 000 would have been walk only trips
- 971 000 would have been car trips
- 647 000 would have been other road-based trips (e.g., ride-share or taxis)
- 755 000 would have been other modes
- 112 000 trips are to connect new rail users to train stations[14].

14 This is the number of new rail users that are induced to rail as a result of PMDs. This does not represent the number of PMD trips made to access public transport in total.

**4.5 Forecast transport based PMD trips — central growth**




*Data source:* The CIE.

## *High growth scenario*

The high growth scenario is one in which PMDs are legalised within an appropriate regulatory framework, but higher rates of take-up are made possible due to broader supporting factors such as infrastructure investment, Government policy or even changing attitudes towards micro mobility in general. Without being too specific on what the necessary conditions are to achieve higher growth we can specify what the growth level would likely be if barriers to PMD take-up were lowered.

We would expect that the take-up of PMDs in NSW would follow international trends in PMD growth based on other cities which have already adopted the technology. This would involve a strong growth in the market penetration rate of devices such as e-scooters to 2031 (in line with market forecasts of 7.7 per cent growth each year to 2031[15]), and more moderate growth beyond to 2041. Under these settings, PMD usage in Sydney grows from 4 million trips per year in 2021 to 10 million trips per year by 2041 (chart 4.6).

15 Grand View Research forecasts that the market size of e-scooters will increases by 7.7 percent on a CAGR basis through to 2030 See https://www.grandviewresearch.com/press-release/global-electric-scooters-market

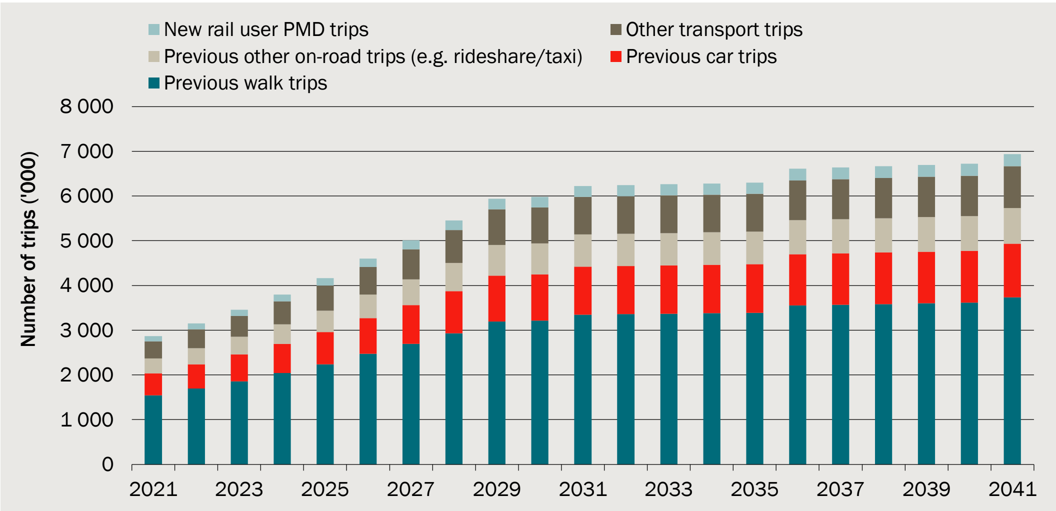
### 4.6 Total PMD trip uplift — high growth


*Data source:* The CIE.

The forecast usage includes 6.9 million transport trips on PMDs by 2041, of which (chart 4.7)

- 3 731 000 would have been walk only trips
- 1 199 000 would have been car trips
- 800 000 would have been other road-based trips (e.g., ride-share or taxis)
- 933 000 would have been previously other modes
- 276 000 trips which are made to connect new rail users to train stations.

### 4.7 Forecast transport based PMD trips — high growth




*Data source:* The CIE.

# 5 *Benefits and costs*

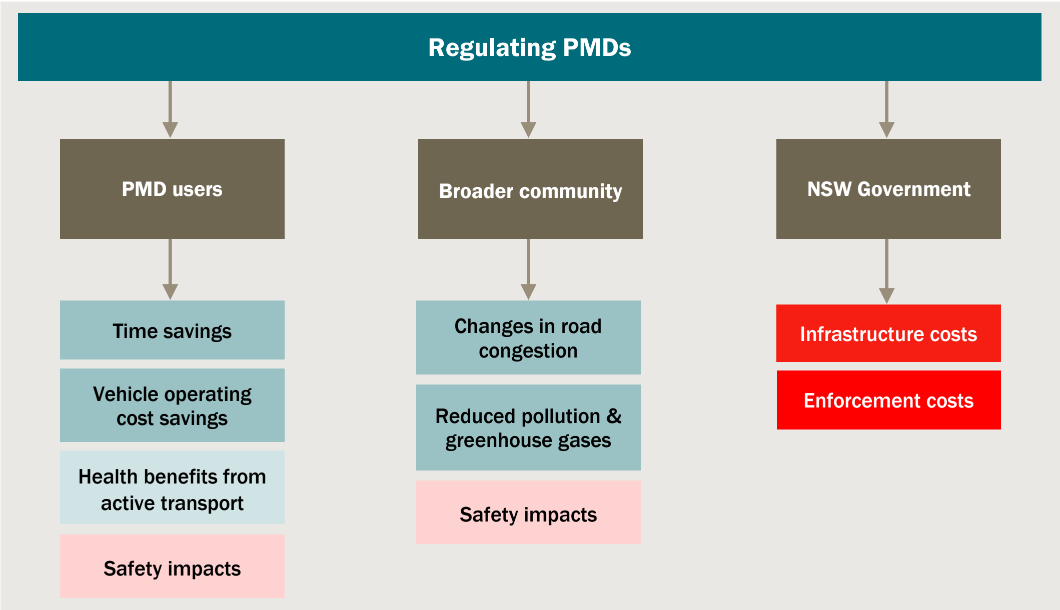
## *Benefit and cost pathways*

In order to analyse the net impacts of the scenarios to the community of NSW, we have considered a range of benefits. These benefits include:

- direct benefits — these are impacts on the users of PMDs which are driven by changes in regulation. In this case, direct benefits flow directly to these users in the form of travel time savings for instance.
- indirect benefits and positive externalities — these are impacts on third parties such as those not directly involved in the usage of PMDs, such as environmental impacts and reduced road congestion caused by people switching from cars to other modes of travel.

Chart 5.1 outlines the key benefit and cost pathways that we have identified as part of regulating PMDs in NSW. These are discussed in turn.

### 5.1 Benefit and cost types and pathways




*Note:* Red is cost and blue-grey is benefit. Light blue and pink are potential benefits or costs depending on the direction of changes.

*Source:* The CIE.

## *Travel time savings*

Travel time savings relates to the reduction in time spent making a trip from a given origin to a destination. The more time spent travelling, the greater the opportunity cost incurred on the traveller. Since PMDs are a new mode, the benefits that apply to people who switch to them vary depending on the previous mode used. The main groups of mode switchers include people who:

- **Switch from walking** — the majority of new PMD trips are made by users who previously made a walking trip. The benefit to these new users is the faster travel time made possible by faster speeds.
  - On average, a walking trip in Sydney takes 9 minutes, is a distance of 660 meters and is made at an average speed of 4.4 km/h[16].
  - In contrast, the average speed of an e-scooter in a metropolitan setting is around 7 km/h. This is below the maximum speed limits made possible (such as a 10km/h maximum speed on a footpath and a 25 km/h on a dedicated cycle lane), since various factors such as congestion and stop-start patterns caused by changing access types prevent maximum speeds from being realised at all times.
  - The average walking trip therefore would take over 5 minutes on an e-scooter based on these average travel speeds.
- **Switch from using cars** — according to the TfNSW cycling and micromobility SBC, 54 per cent of weekday car trips in Greater Sydney are less than 5 km, and on average around 3km in inner city areas[17]. There are travel time saving benefits associated with switching from short car trips to PMDs. While a car is capable of surpassing an average e-scooter speed of 7km/h and even e-scooter maximum speeds, the main benefits are instead associated with the 'last-mile' of car journeys, which is parking.
  - For instance, recent modelling from the Western Sydney place-based infrastructure compact by TfNSW[18] estimates a parking-based interchange penalty of 16.4 minutes for park and ride transport, 11.4 minutes for kiss and ride transport and 6.4 minutes for regular transport
  - We estimate a non-transport parking penalty as the difference between a park and ride and kiss and ride penalty, since using a PMD such as an e-scooter would reduce the need to park, but also offset the full benefit due to the need to either dock or carry the device. This leads to around an average time saving of 5 minutes by avoiding the need to park a car.
- **Switch from other road-based travel**, such as ride-share and taxis (in addition to other forms of travel).
  - For other road-based travel such as ride-share and taxi, we apply the same travel time saving uplift as those gained by car users

16 Based on data from Active Transport in Sydney, TfNSW 2010

17 TfNSW Cycling and Micromobility Investment Program, Strategic Business Case, 2019 p55

18 This was provided to us by TfNSW and includes a range of methodological reporting and parameter values

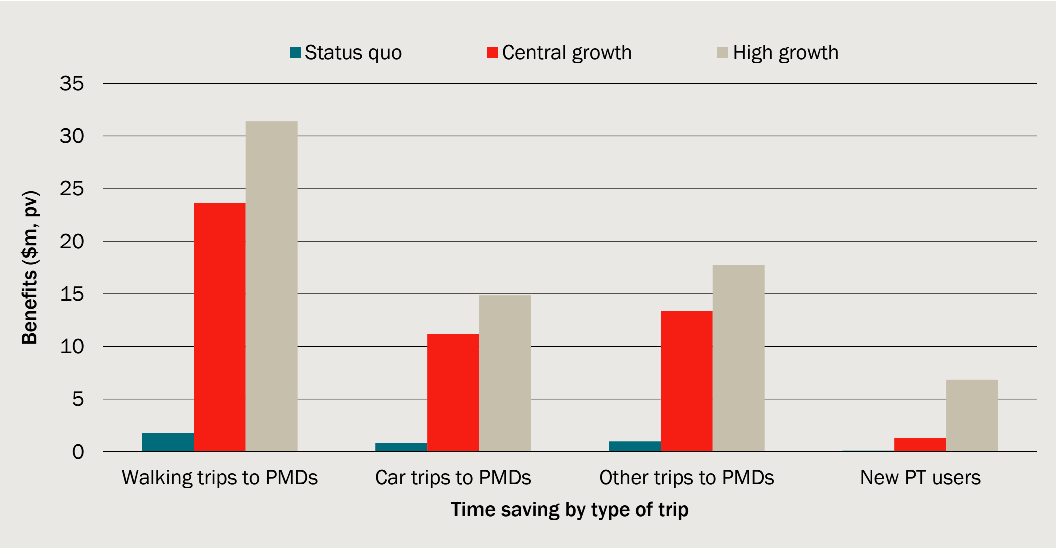
  - For other types of trips replaced (trips not specified in the mode share dataset to which we refer), we apply the time saving benefit gained by users who switched from walking
- **Start using public transport because of PMDs** — since devices such as PMDs reduce first and last mile transport problems, a subset of users may be induced towards using public transport (specifically rail) due to lower access costs.
  - Induced demand for rail would primarily replace car journeys
  - The benefit associated with switching from a car journey to a rail journey would be equal to the change in rail access costs, since this change would need to offset any change in travel times between using a car or a train to make a journey
  - For the central growth scenario, we set the access benefit as equal to the difference between a park and ride penalty (16.4 minutes) and a kiss and ride penalty (11.4 minutes), while in the high growth scenario we reduce the penalty to that of an ordinary transport interchange (6.4 minutes) to reflect the assumption of broader policy and infrastructure support from Government (such as providing e-scooter docks at stations).

The travel time saving benefits for each of the scenarios in present value terms are set out in chart 5.2. The benefits for the status quo are relative to no PMD usage, while the benefits for the central and high growth are relative to the status quo (base case). The benefits include:

- $3.7 million in travel time savings to be expected under the status quo, that is irrespective of any change in policy
- $49.5 million in additional travel time savings under the central growth scenario compared to the status quo
- $70.8 million in additional travel time savings under the high growth scenario compared to the status quo

A large portion of the travel time saving benefits are for people who switch from walking trips to PMDs.

### 5.2 Travel time saving benefits from PMDs



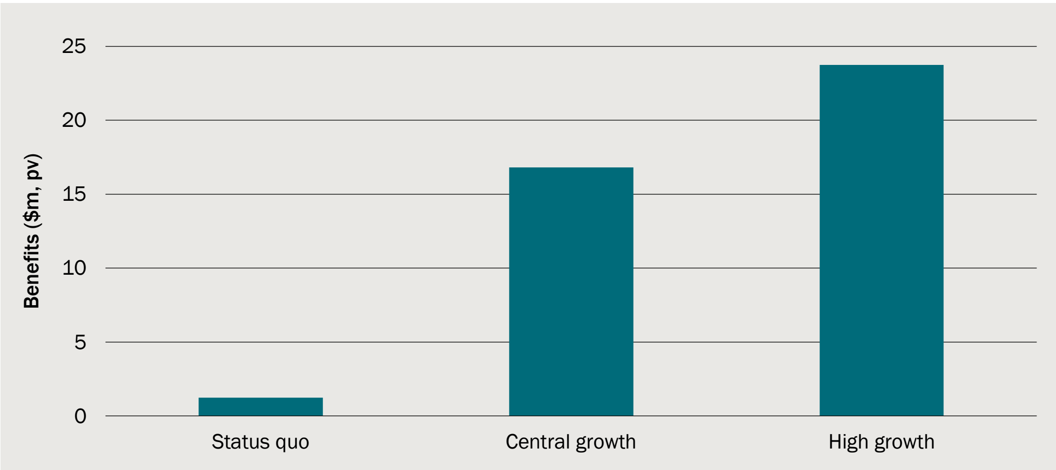

*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE.

## *Vehicle operating cost savings*

PMDs replace a number of car journeys, leading to benefits in the form of reduced vehicle operating costs for users who have stopped using cars in favour of PMDs. Vehicle operating costs refer to the costs of owning, operating and maintaining a motor vehicle, such as fuel and wear and tear of the vehicle. Across the scenarios, this leads to $1.2 million in benefits under the status quo, $16.8 million in benefits under the central growth scenario and $23.7 million in benefits under the high growth scenario. Vehicle operating cost benefits increase when there is greater substitution away from vehicles towards PMDs and public transport.

### 5.3 Vehicle operating cost savings



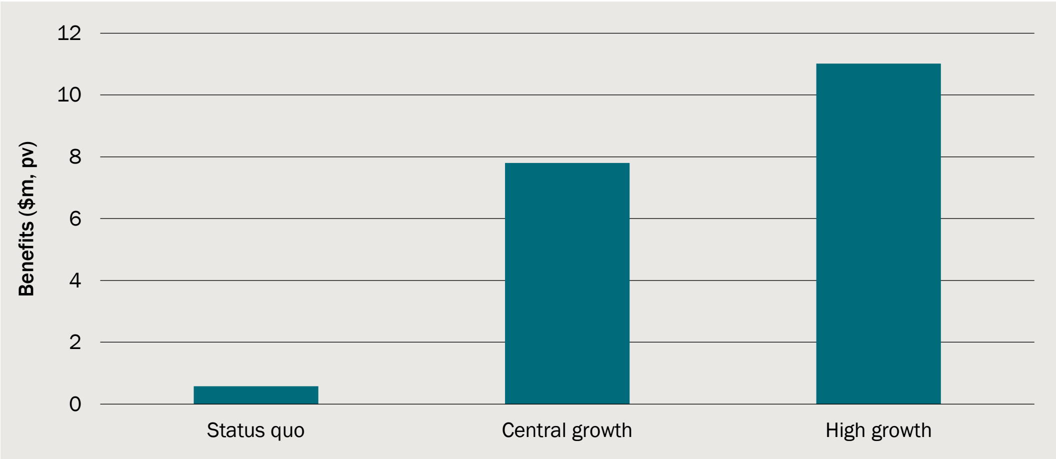

*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE.

## *Decongestion benefits*

Congestion is a negative externality caused by the number of road vehicles exceeding road capacity. This leads to reduced speeds and longer trip times for all road users. By legalising PMDs, users who switch from car travel to PMDs effectively reduce the number of cars on the road, leading to improved car journeys for other road users. Decongestion benefits from PMDs are around half a million under the status quo (that is compared to no PMD usage), $7.8 million under central growth and $11 million under high growth.

**5.4 Decongestion benefits**




*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE.

## *Safety impacts*

The safety impacts of legalising PMDs are net negative across the scenarios. The safety impacts include:

- Reduced road incidents due to less vehicles on the road — this is caused by car users switching to PMDs
- Increased accidents for PMD users — the use of PMDs themselves includes an inherent safety risk.

These is a range of evidence regarding the safety impacts of PMDs such as e-scooters, covering the rate of injury per trip, the severity of injuries, the type and place of injuries and the risk of fatalities. We have drawn from a range of studies to help inform the likely safety outcomes should PMDs be implemented in NSW.

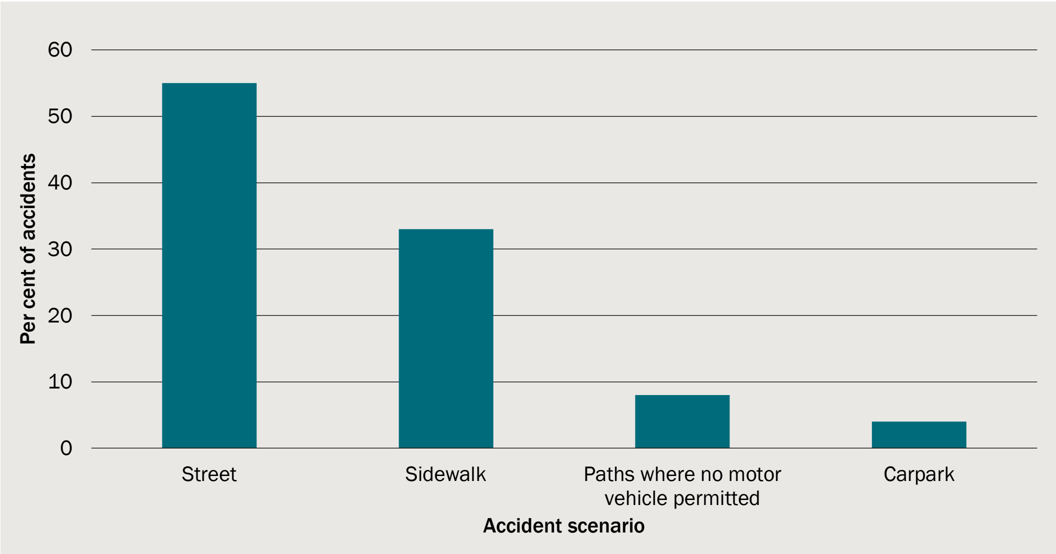
For instance, a comprehensive study by Austin Public Health, Texas, following the introduction of the devices in 2018[19] estimates an injury rate of 20 injuries per 100 000 trips, based on the 936 110 e-scooter trips analysed[20]. This study was limited to

[19] Dockless Electric Scooter-Related Injuries Study, Austin, Texas, Austin Public health 2019

[20] Ibid, p10

investigating only those injured e-scooter riders and non-riders who sought care at a hospital emergency department or had care provided by emergency medical services, however. Further, the safety regulations in Austin do not require the use of a helmet, whereas helmet usage would likely be mandatory in NSW (which would likely lead to lower incidence of serious head injury compared to the rates observed in Austin). The likelihood of injury was observed to be much lower overall when riders use dedicated infrastructure such as cycleways, however. (chart 5.5).

**5.5 Locations of safety incidents**




*Data source:* Dockless Electric Scooter-Related Injuries Study, Austin, Texas, Austin Public health 2019.

The city of Santa Monica designed a pilot program using a flexible regulatory approach that could be responsive to community needs as well as technological advancements[21]. This included daily monitoring of conditions, as well as program administrators that oversaw the program and could make adjustments based on community concerns and feedback from operators. Under these settings, Santa Monica found a lower accident rate (around 122 accidents in 2.7 million trips). Further, only 10 per cent of injuries were classified as serious. It is this kind of flexible approach to regulating PMDs which NSW would likely aim to model should it seek to regulate PMDs, and one which we have assumed for this analysis.

Finally, the International Transport Forum estimates that the average shared e-scooter risk of fatality ranges between 78 and 100 fatalities per billion trips[22]. This estimate is based on injury data collected by major global operators such as Lime.

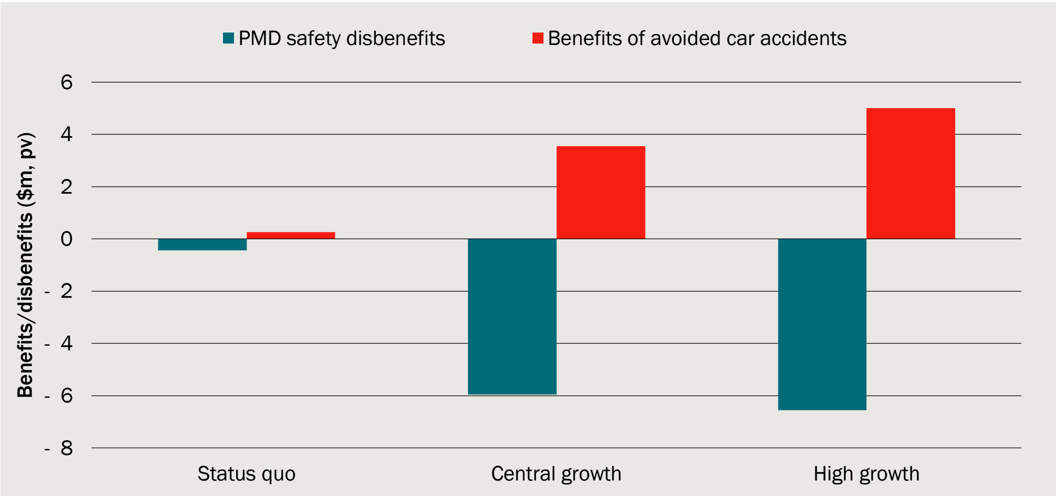
We have valued the safety impacts according to the severity of the injury (whether it was a major or a minor injury), and also accounted for the incidence rate and whether trips would occur on dedicated cycle infrastructure compared to shared spaces such as sidewalks and local roads. The safety impacts include (chart 5.6):

21 Santa Monica Shared Mobility Evaluation, 2019, p4

22 ITF Safe Micromobility, p22

- -$180 thousand in safety disbenefits (-$441 thousand in disbenefits from PMD usage and $261 thousand in avoided road accidents) under the status quo scenario
- -$2.4 million in safety disbenefits (-$6.0 million in disbenefits from PMD usage and $3.6m in avoided road accident benefits) under the central growth scenario
- $1.5m in safety disbenefits (-$6.5 million in disbenefits from PMD usage and $5.0m in avoided road accident benefits) under the high growth scenario
  – The high growth scenario assumes a degree of improvement in safety outcomes due to there being greater support from Government on implementing PMDs (e.g., through public education, improved signage or infrastructure). Specifically, a proportion of the uplift in usage (around 20 per cent) benefit from safety conditions akin to those observed in Austin, where there were dedicated cycle paths and signage to improve safety (leading to lower rates of accidents)

**5.6 Safety impacts**




*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE.

## *Health impacts*

The health impacts of PMDs such as e-scooters is an emerging field of research. At present, TfNSW provides active transport benefit parameters for cycling and walking only, and these benefits are quite large:

- $1.22 per kilometre for cycling relative to using a car or public transport
- $1.83 per kilometre for walking relative to using a car or public transport

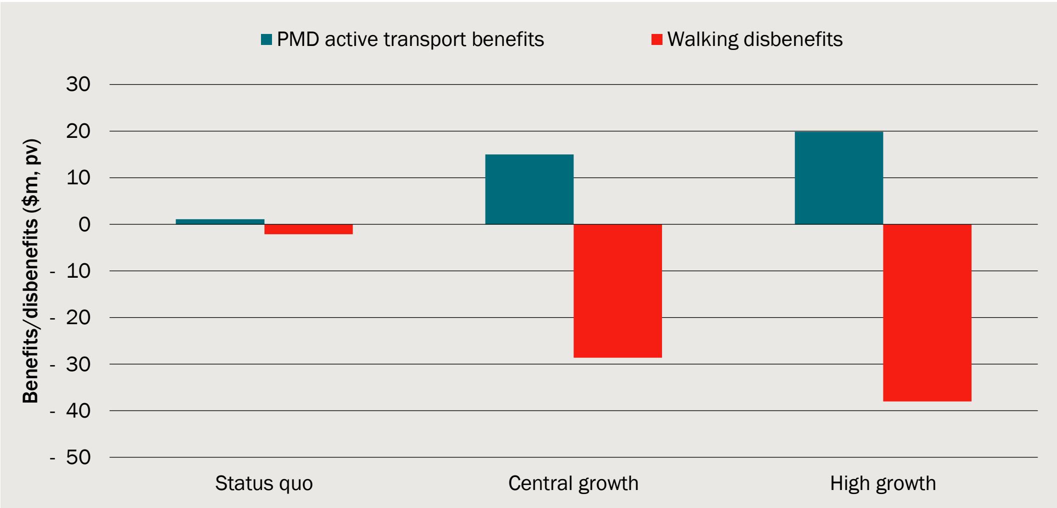
Electric scooter providers attribute the use of e-scooters as being similar to that of a low-intensity workout as the level of physical activity is lower compared to other modes such as walking and cycling. The stabilisation requirements of standing on an e-scooter puts positive demand on the muscles around the stomach and legs and is thus a more active form of transport compared to riding in motor vehicles[23]. For the purposes of this analysis, we have assumed half the benefit associated with cycling per kilometre travelled. These active transport benefits apply to previous trips which were not active.

There are also a large proportion of trips that PMDs replace which were previously active transport trips. Specifically walk trips, which are over half of the trips that PMDs replace. Since using an e-scooter is less physically demanding compared to walking, there are also disbenefits associated with replacing walk trips.

Because PMDs largely replace walking, the net health impacts of PMDs are negative (chart 5.7):

- -$1.0 million in disbenefits under the status quo (relative to no PMD usage)
- -$13.7 million in disbenefits under the central growth scenario ($14.9m in active transport benefits from PMD usage is offset from $-28.6m in lost benefits from walking)
- -$18.1 million in disbenefits under the high growth scenario ($19.8m in active transport benefits from PMD usage is offset by -$37.9m in lost benefits from walking)

**5.7 Health impacts**




*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE.

## *Environmental externalities*

There are both positive and negative impacts of increased PMD usage on the environment. These include:

- The benefits of avoided greenhouse gas emissions and other forms of pollution associated with less motor vehicle usage
- Negative environmental impacts of the PMD devices themselves. These mainly relate to the electricity used to charge the devices, as well as any other incidental negative

23 See https://www.pureelectric.com/blogs/news/does-an-electric-scooter-keep-you-fit

externalities associated with the collection and distribution of devices (such as in shared e-scooter schemes)

To value the benefits associated with avoided vehicle usage, we refer to TfNSW economic parameters on environmental externalities. Specifically, those relating to air pollution, GHG emissions, Noise, Water pollution, Nature and Landscape and urban separation (table 5.8).

### 5.8 Externalities for avoided vehicle usage

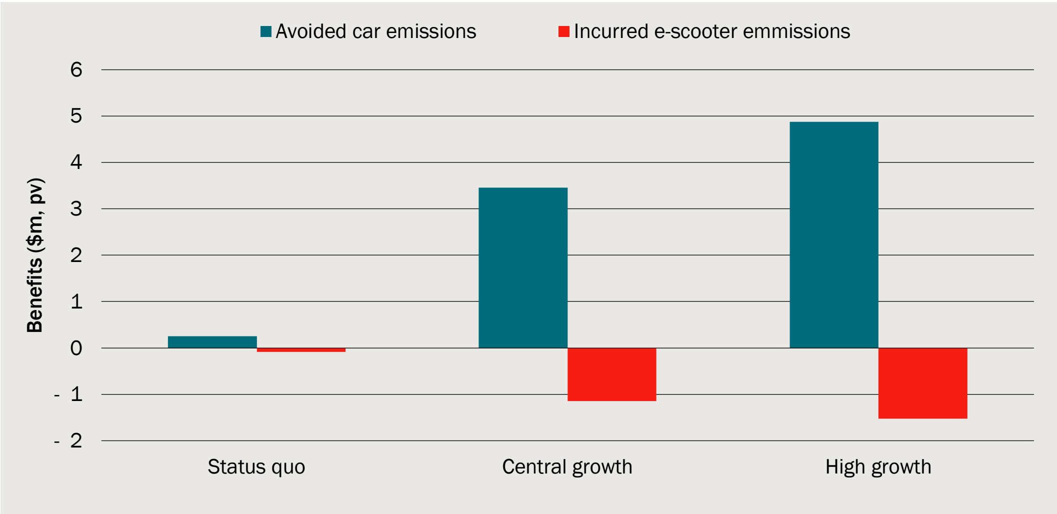
| Externality | $/vkt |
|---|---|
| Air pollution | 0.03 |
| GHG emissions | 0.03 |
| Noise | 0.01 |
| Water pollution | 0.01 |
| Nature and landscape | 0 |
| Urban separation | 0.01 |
| **Total ($2020)** | **0.09** |

*Note:* Individual parameter values are $2019, total has been price updated to $2020 using CPI
*Source:* TfNSW Economic parameters 2019

To measure the negative environmental impacts of PMDs, we refer to an estimate of C02 emissions of 62 grams per kilometre travelled[24] which accounts for the costs of charging and collection and distribution of the devices. This is equivalent to around 24 per cent of the value of car-based emissions.

Overall, there are net positive environmental externalities to PMD usage (chart 5.9) of $2.3m under the central growth scenario and $3.4m under the high growth scenario. This is on top of existing usage under the status quo (which leads to around $170 000 in benefits compared to no PMD usage).

### 5.9 Environmental externalities




*Data source:* The CIE.

24 Are e-scooters polluters? The environmental impacts of shared dockless electric scooters 2019

## *Enforcement costs*

Part of the costs incurred by the state of NSW after permitting PMD use will be the costs associated with enforcing rules. Specifically, the costs associated with riders that violate the rules as well as costs that relate to share rider schemes such as illegal parking and abandonment of e-scooters.

Findings from the e-scooter trial in Santa Monica between 2018 and 2019 pointed to 929 violations of the rules, resulting in 299 citations being written from 2.67 million trips. 1 200 devices were also impounded as a result of illegal parking that led to blocking access for people with disabilities, parking in the street or slow operator response time to collect devices[25].

Using these data and applying violations on a per trip basis to the estimated uptake in NSW, we can calculate the expected enforcement costs over time. To value the cost associated with enforcement activity, we refer to data from the NSW Bureau of Crime Statistics and Research (BOCSAR). BOCSAR estimates on average 1.62 hours is spent by NSW police responding to traffic related incidents (although this is within the context of alcohol related traffic incidents)[26]. We use this as a benchmark for police time spent responding to incidents with PMDs and value this time by the average hourly rate for a police constable[27].

This leads to:

- $2.1 million in enforcement costs under the central growth scenario
- $2.7 million in enforcement costs under the high growth scenario

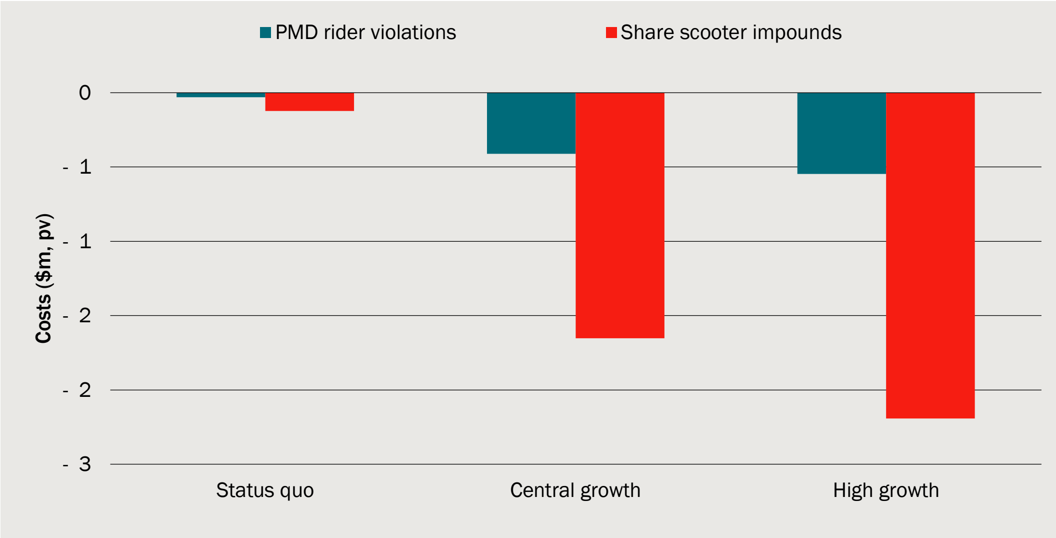
We also estimate costs of around $153 000 under the base case, although there is a lack of evidence of significant enforcement activity taking place for current illegal usage of PMDs in NSW (chart 5.10).

25 Shared Mobility Pilot Program Summary report, November 2019, p6

26 NSW Bureau of Crime Statistics and Research, National Drug and Alcohol Research Centre USNW, National Drug research institute Curtin University: Estimating the short-term cost of police time spent dealing with alcohol related crime in NSW, p17

27 Specifically a Constable level 2, assuming 40 hours of work time per week, see https://www.police.nsw.gov.au/recruitment/the_career/general_duties/working_conditions#:~:text=The%20NSW%20Police%20Force%20offers,carer's%2C%20sick%20and%20compassionate%20leave.

### 5.10 Enforcement costs




*Data source:* The CIE.

Enforcement costs could be higher depending on the additional resources that might be required to police PMD usage. There would likely be a large proportion of rule breaking that would go undetected. For instance, in Brisbane, research from the Queensland University of Technology Centre for Accident Research and Road Safety observed ride-share scooters user behaviour. It was found that 45 per cent of people using e-scooters were riding illegally, due to either not wearing a helmet, riding in prohibited places or carrying a passenger[28].

## *Benefits and costs not quantified*

### *Infrastructure costs*

There is likely to be an infrastructure cost associated with supporting the rollout of PMDs across NSW. This would specifically relate to the high growth scenario, since to achieve high take-up of the devices, additional infrastructure may be beneficial (such as cycling lanes).

We have not been explicit on the nature of these infrastructure requirements, as this would require a more in-depth analysis by transport planners and active transport experts. It is worth noting, however, that TfNSW has undertaken a strategic business case into cycling and micro mobility. That document sets out the costs and benefits associated with investing in over 5 500 km of new cycling and micro mobility infrastructure (referred to as the Principle Bicycle Network).

The nature and level of investment specified in the strategic business case is beyond the scope of what this project considered, however, and thus we have not attempted to identify or apportion any specific part of the PBN as being relevant to regulating PMDs.

28 Centre for Accident Research and Road Safety, QUT, Illegal and risky riding of electric scooters in Brisbane, 2019

The costs, however, are significant, at around $4.3m per lane kilometre for various bike infrastructure within inner and CBD areas across Sydney (table 5.11).

It is important to consider PMD regulation against the backdrop of any evolution in active transport infrastructure.

#### 5.11 Unit cost estimates for new micromobility infrastructure

| Cost per km inner and CBD areas Sydney | Unit cost |
|---|---|
| | $m/km |
| Painted Bike lane | 0.8 |
| Separated path | 9.9 |
| Shared path | 5.5 |
| Off-road separated | 7.4 |
| Bike Boulevard | 0.9 |
| Various | 1.3 |
| Average | 4.3 |

*Note:* $2019.

*Source:* TfNSW Cycling and Micromobility investment program SBC, p117.

### *Value of recreational e-scooter usage*

The analysis thus far has focused on the transport-related benefits of PMDs. 31 per cent of all PMD trips, however, are for recreational purposes. There would likely be a private benefit associated with recreational use. To estimate this impact, ideally, we would need to understand willingness to pay for both shared and private e-scooter trips so that a consumer surplus can be estimated. Research on this is lacking, and we have not been able to value recreational benefits at this stage.

### *Producer surplus of PMD operators*

By legalising PMDs in NSW, PMD operators such as those that provide shared e-scooter schemes (e.g. Lime and Neuron Mobility) will be able to establish business across metropolitan areas. These operators would receive some level of producer surplus from trips that are made on shared e-scooter schemes, which is an economic benefit. The surplus per trip at this stage is not able to be determined without further insight into the cost and revenue structure of operators in a NSW setting. Further, e-scooter operators are typically foreign owned companies and so there is also the question as to what extent surpluses generated by these companies is a benefit to the NSW community.

# 6 E-bikes

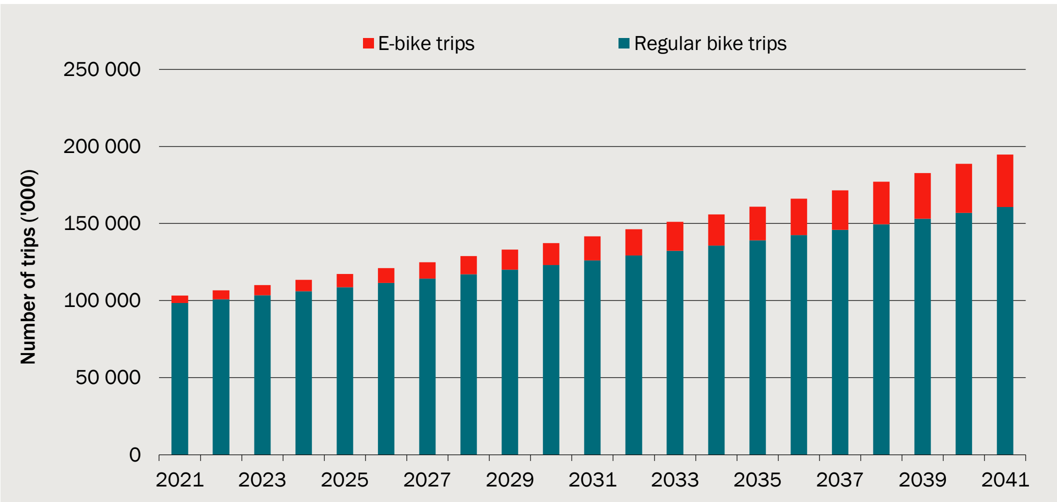
E-bikes are an example of a type of powered micro mobility device that are currently legal to use in NSW. The current regulation stipulates that the electric motor assisted bikes cannot exceed 25km/h before the electric motor must cut out, meaning to go faster than 25km/h requires human effort. Another consideration for more flexible regulation surrounding micromobility devices could be increasing the power limit beyond 25km/h to a higher threshold such as 45km/h, thereby enabling assistance at higher speeds.

## Forecast e-bike uplift

The TfNSW strategic business case on cycling and micromobility estimates around 100 million cycle trips per year, increasing to 334 million by 2056 under base case conditions. This implies a compound annual growth rate of 3.51 per cent, leading to under 250 million bike trips by 2041. This also reflects e-bike growth, which is expected to form an increasing share of all cycle trips over time.

Using an e-bike penetration formula derived from the cycling and micromobility SBC demand report[29], we can estimate the take-up of e-bikes into the future. This increases the share of e-bike trips from 4.7 per cent in 2021(~4.8 million trips) to 17.6 per cent in 2041 (~34 million trips) (chart 6.1).

**6.1 Bicycle and E-bike trips forecast**




*Data source:* The CIE.

29 Cycling Investment Program Strategic Business Case Demand Report, Final, 2019 p67

## *Impacts of raising the power limit*

As part of our consultation with TfNSW, we were informed that the impact of increasing e-bike power assistance limits would be nuanced. Specifically:

- The current power limit of power assisted pedalling at 25km/h is not a hard constraint to speed — the cap simply removes motor assisted pedalling beyond 25km/h, however the rider may go faster than this speed if they are willing or capable of doing so using human effort (although this would depend on the strength of the rider and the weight of the bike, since e-bikes with motors are heavier than regular bicycles).
- Speed is of minor importance to overall cycling-based mobility — while raising the power limit would enable reaching a higher maximum speed with less effort from the rider, this does not guarantee a travel time saving. This is because network conditions and infrastructure play a major role in the duration and reliability of a journey. While the maximum speed may increase, average speed would not (it would be mitigated by more stop-start patterns due to disconnected cycle infrastructure and the impacts of the broader road network where cycling is sharing road access).
  - Further to this point, the formal TfNSW guidelines on transport economic appraisal also state that no travel time cost or benefit should be applied to cycling[30]. This is because TfNSW considers cycling and walking to be slower compared to other modes. Further, it considers travel time saving to be of minor importance in the decision to take up cycling.
- Faster maximum speeds would lead to safety disbenefits due to the higher propensity for accidents.

Based on this, we have not attempted to estimate travel time saving benefits resulting from increasing the power limit on e-bikes. Instead, the most likely implications on e-bike users resulting from faster power assisted speeds may be on safety. Research on e-bike safety outcomes is mixed. The main uncertainties on e-bike safety relate to:

- whether there is an increased frequency of accidents on e-bikes at faster speeds
- whether the severity of any injury is greater at faster speeds

Studies from the Netherlands, which are considered world leaders for e-bike usage due to being early adopters[31], found in 2015 that half of the crashes that occurred on e-bikes were of the same event types experienced by regular pedal cyclists, while the remainder were due to events contributed to by the e-bike itself (such as speed and user error).

In terms of crash outcomes, analysis of hospital data from the Netherlands found no significant differences in terms of crash outcomes between pedal bike users and e-bike users[32]. In contrast, in countries where power and speed limits on e-bikes are more poorly enforced (such as China, where it is estimated that over 70 per cent of e-bike riders

30 TfNSW Economic parameter values 2019, p42

31 Cycling Investment Program Strategic Business Case Demand Report, Final, 2019 p67

32 Safety implications of e-bikes, p5

exceeded the speed limit[33]), evidence points to more severe injuries[34]. This would seem to indicate that faster speeds lead to worse safety outcomes.

A more recent survey of e-bike usage patterns and accidents from the Royal Automobile Club of Victoria (RACV) found that of the unsafe events that occur on e-bikes, 15.6 per cent were related to the fact that an e-bike itself was being used, compared to the remainder being circumstances that any type of bike might encounter. Of the e-bike specific factors leading to an unsafe event or accident, 22 per cent were related to speed, while others were due to surface conditions or rider error. This suggest that should maximum speeds be increased on e-bikes, there will be a proportion of trips that will be directly impacted negatively in terms of safety.

TfNSW economic parameters state an average annual number of crashes on bicycles (all types) at 629 per year[35]. This is based on injuries reported by the TfNSW/RMS Centre for Road Safety and includes minor injuries, moderate injuries, serious injuries, and fatalities. This primarily applies to incidents which were identified by or reported to NSW police, or for which there are records from health data collections. This would likely underestimate the number of minor injuries which go unreported, although these would likely also be of less economic significance (e.g., a skin abrasion would cause minimal economic impact compared to an injury requiring medical attention).

Based on these data and recent statistics on e-bike usage patterns, on average in the current year:

- 29 of these accidents would occur on e-bikes
- Of these 29 e-bike accidents, 5 accidents (15.6 per cent) occurred due to the fact an e-bike itself was being used, while the remainder would have occurred on any type of bike
- 1 e-bike accident occurred due to speed being a problem (22 per cent of e-bike specific accidents)

Should the regulations be changed to enable faster maximum speeds on e-bikes, we could reasonably conclude that based on evidence from countries with faster speeds, accidents caused by e-bikes may be more severe. Chart 6.2 presents the safety costs expected under baseline e-bike usage, as well as under the scenario where the power limit is increased to enable faster maximum speeds. If the consequence of increasing the power limit only increased the severity of e-bike speed related injuries, then safety costs would increase from $4.2 million in present value terms to $4.5 million. If increasing power limits also increases the incidence of e-bike speed related injuries, then the cost increases to $5.6 million, which is a 32 per cent increase[36].

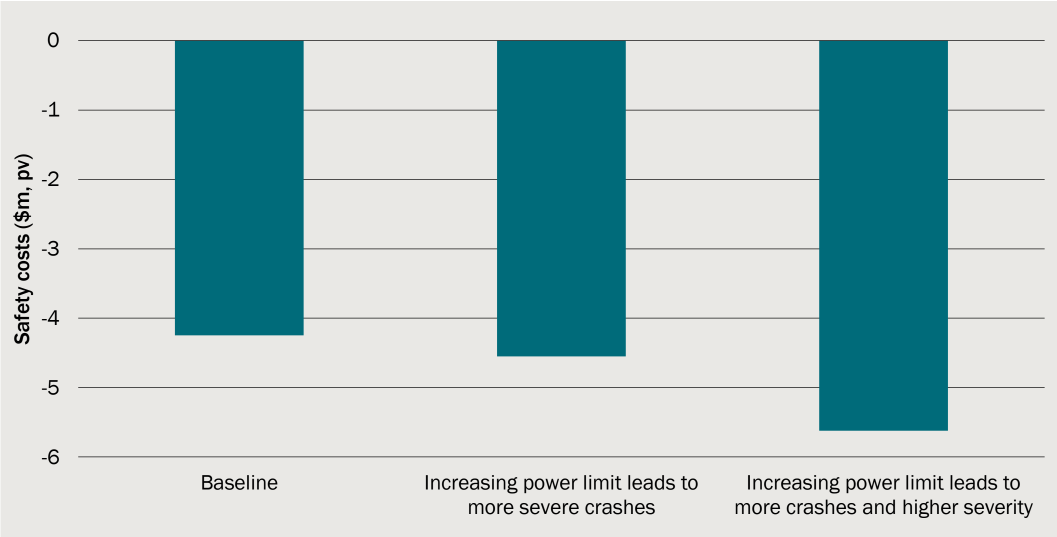
33 Safety implications of e-bikes, p5

34 Safety implications of e-bikes, p5

35 TfNSW economic parameters p42. Based on Centre for Road Safety data: https://roadsafety.transport.nsw.gov.au/statistics/interactivecrashstats/nsw.html?tabnsw=3

36 This assumes that all speed related injuries on e-bikes become severe injuries

### 6.2 Safety impacts of increasing power limit on e-bikes




*Data source:* The CIE

## *Illegal high-powered e-bikes*

Even under current regulatory settings, advancements and changes in technology and user behaviour creates new challenges that must be met. For instance, it is possible today to exceed the speed and power limits on e-bikes due to the way the legal framework is set up for e-bikes. While the rules do not permit power assisted speeds beyond 25km/h in public places, there is no such limit on private property. This means that there is no restriction on the supply and modification of e-bikes (which primarily come from overseas) in NSW. While it is not known precisely how many high powered or modified devices are in use on streets in NSW, mechanics at one Sydney based bike shop estimate that up to 10 per cent of e-bikes that go through their workshop have been illegally modified, allowing them to travel at speeds greater than the limit of 25km/h[37]. This highlights the need for regulation to be able to adapt and respond to technological advancements and changes in user behaviour.

37 https://www.theguardian.com/lifeandstyle/2019/nov/06/e-bike-surge-in-popularity-in-australian-cities-but-experts-warn-of-risks

# 7 Cost benefit analysis results for PMDs

The results of the cost benefit analysis are presented in table 7.1. Overall, there are net benefits associated with PMD usage in NSW, this includes $4.3m in benefits that occur regardless of any change in regulation and applies to illegal PMD usage. This rests on an underlying assumption of the level of PMD usage under the status quo scenario, however, and thus involves a degree of uncertainty (which has also been subject to sensitivity analysis). Relative to the status quo, the benefits resulting from regulating PMDs leads to a substantial uplift, of $58.3 million under the central growth scenario and $86.5 million under the high growth scenario in net present value terms.

The largest benefit categories are travel time savings, and these are largest for people who switch from walking trips to PMD trips. There are also positive externalities associated with avoided motor vehicle usage, including decongestion, and reduced environmental negative externalities.

These benefits are partially offset by the negative impacts on health and safety. PMD usage leads to slightly worse active transport outcomes overall, due to less people making walking trips. PMDs also involve a safety risk, although this risk is somewhat reduced under the high growth scenario due to the in-built assumption that broader policy and infrastructure support will lead to more trips taking place in places that are less prone to accidents (such as cycleways). The overall safety risk of PMDs between the base case and the central growth scenario are the same, although in reality there may be higher safety risks associated with PMD usage outside of a formal regulatory framework, due to there being no safety requirements (such as helmet use) for those that choose to ride prohibited devices. Finally, there are also costs incurred by the Government to enforce the rules regarding PMD use, and this will involve the use of police on streets responding to incidents.

There may be other costs associated with the scenarios, particularly the high growth scenario, which assumes broader policy support. Costs representing any large upfront or ongoing expenditure for things such as infrastructure for example, have not been included in this analysis. If for example the 5,500 km cycle path network is extended across Sydney, PMD's would be able to utilise that network. Since there is no significant cost outlay associated with a change of regulation aside from increasing policing activity, we only present the net benefits of the scenarios rather than benefit cost ratios[38].

38 A benefit cost ratio specifies the economic benefit per dollar of cost. The lack of significant economic outlay associated with a regulation change muddies the definition of a BCR in this context.

### 7.1 Cost benefit analysis results

| Category | Status quo | Central growth | High growth |
|---|---|---|---|
| | $pv | $pv | $pv |
| **Benefits** | | | |
| Travel time savings | 3 662 704 | 49 520 616 | 70 835 659 |
| Vehicle operating cost savings | 1 240 056 | 16 810 705 | 23 746 790 |
| Decongestion benefits | 575 207 | 7 797 737 | 11 015 077 |
| Environmental impacts | 169 658 | 2 305 086 | 3 354 516 |
| Health benefits | -1 012 097 | -13 659 220 | -18 123 716 |
| Safety impacts | - 179 750 | -2 410 087 | -1 541 421 |
| **Total benefits** | **4 455 778** | **60 364 836** | **89 286 905** |
| **Costs** | | | |
| Enforcement costs | - 153 008 | -2 064 988 | -2 739 926 |
| **Total costs** | **- 153 008** | **-2 064 988** | **-2 739 926** |
| **Net benefits** | **4 302 770** | **58 299 848** | **86 546 979** |

*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE.

## *Conclusions and next steps*

Overall, the analysis has shown that, at a high level, there are net benefits associated with regulating PMDs in NSW. PMDs lead to travel time saving benefits for those that use them, while also generating positive externalities in the form of reduced congestion and emissions due to reduced motor vehicle usage. The main offsetting disbenefits of PMDs are worse safety outcomes as well as negative health impacts from reduced walking, since PMDs largely replace walking trips.

The estimated impacts of PMDs have drawn from evidence from other places where PMDs have been legalised. This includes other Australian cities such as Brisbane, as well as cities overseas. This means there is an inherent degree of uncertainty surrounding what the true impact of regulating PMDs would be in the NSW context, since the level of uptake and the benefits and costs could be different in NSW.

This uncertainty particularly relates to defining what an appropriate regulatory framework would be for NSW. The different growth paths for the scenarios modelled do not include any explicit link between the growth assumptions and any specific features of a regulatory framework. By drawing on evidence from other jurisdictions to inform the impact analysis, the results mirror to some extent the regulatory settings of these other places. In reality, the regulatory approaches that have been implemented elsewhere may not be workable in NSW, and so the underlying assumptions surrounding benefits and costs may also not be applicable to the NSW context. Defining an appropriate regulatory framework for NSW is an area where more work is needed.

Finally, to measure the impacts of regulating PMDs comprehensively and accurately in NSW, a formal PMD trial would need to be conducted. This would need to be implemented with cooperation from major share e-scooter providers, as shared devices would likely form the bulk of PMD usage. A key focus of the trial would be the collection of relevant data, and this would include geospatial data which can trace where trips take place and at what times. This would help inform transport planners understanding of PMD usage patterns and assist in the rollout of any supporting infrastructure. Information on safety should also be a primary focus, so that the rate of injuries as well as the type of injuries can be determined. Feedback should be gathered from the broader community, including non-PMD users, as this will assist in the understanding of the general public perception of PMDs and identify any other positive or negative externalities that PMDs generate.

# 8 Sensitivity analysis

This chapter presents a set of results under alternate assumptions. These are set out in turn.

## Different base case PMD usage assumptions

This scenario assumes status quo PMD usage of 1 million trips per year. Increasing base case starting point usage to 1 million trips (compared to 300 000 trips in the core results) still leads to substantial uplifts under the central growth and high growth scenarios. This would indicate that even operating within a large margin of error for the base case, there is confidence that the net benefit uplifts are large (table 8.1).

### 8.1 Results with different base case PMD assumptions

| Category | Status quo | Central growth | High growth |
|---|---|---|---|
| | $pv | $pv | $pv |
| **Benefits** | | | |
| Travel time savings | 12 209 012 | 41 181 725 | 62 848 922 |
| Vehicle operating cost savings | 4 133 521 | 14 092 117 | 21 176 655 |
| Decongestion benefits | 1 917 356 | 6 536 705 | 9 822 906 |
| Environmental impacts | 565 526 | 1 945 128 | 3 025 044 |
| Health impacts | -3 373 655 | -11 297 662 | -15 762 158 |
| Safety impacts | - 599 168 | -1 953 764 | -1 229 961 |
| **Total benefits** | **14 852 592** | **50 504 249** | **79 881 408** |
| **Costs** | | | |
| Enforcement costs | - 510 026 | -1 707 970 | -2 382 908 |
| **Total costs** | **- 510 026** | **-1 707 970** | **-2 382 908** |
| **Net benefits** | **14 342 566** | **48 796 280** | **77 498 500** |

*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE.

## Different discount rates

Specifically, modelling the results using a 3 per cent and 10 per cent discount rate (charts 8.2 and 8.3). As expected, net benefits are higher with a lower discount rate, and lower using a 10 per cent discount rate. In both circumstances, net benefits are still positive.

### 8.2 Results at 3 per cent discount rate

| Category | Status quo | Central growth | High growth |
|---|---|---|---|
| | $pv | $pv | $pv |
| **Benefits** | | | |
| Travel time savings | 5 246 484 | 70 933 697 | 102 550 859 |
| Vehicle operating cost savings | 1 776 266 | 24 079 778 | 34 378 923 |
| Decongestion benefits | 823 931 | 11 169 535 | 15 946 850 |
| Environmental impacts | 243 019 | 3 301 822 | 4 856 431 |
| Health impacts | -1 449 735 | -19 565 568 | -26 238 235 |
| Safety impacts | - 257 476 | -3 452 227 | -2 231 561 |
| **Total benefits** | **6 382 489** | **86 467 037** | **129 263 267** |
| **Costs** | | | |
| Enforcement costs | - 219 169 | -2 957 904 | -3 966 671 |
| **Total costs** | **- 219 169** | **-2 957 904** | **-3 966 671** |
| **Net benefits** | **6 163 319** | **83 509 133** | **125 296 596** |

*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE.

### 8.3 Results at 10 per cent discount rate

| Category | Status quo | Central growth | High growth |
|---|---|---|---|
| | $pv | $pv | $pv |
| **Benefits** | | | |
| Travel time savings | 2 914 889 | 39 409 984 | 55 783 638 |
| Vehicle operating cost savings | 986 874 | 13 378 460 | 18 700 783 |
| Decongestion benefits | 457 767 | 6 205 671 | 8 674 460 |
| Environmental impacts | 135 019 | 1 834 456 | 2 641 708 |
| Health impacts | - 805 457 | -10 870 415 | -14 272 569 |
| Safety impacts | - 143 051 | -1 918 019 | -1 213 881 |
| **Total benefits** | **3 546 041** | **48 040 137** | **70 314 138** |
| **Costs** | | | |
| Enforcement costs | - 121 768 | -1 643 379 | -2 157 713 |
| **Total costs** | **- 121 768** | **-1 643 379** | **-2 157 713** |
| **Net benefits** | **3 424 273** | **46 396 758** | **68 156 425** |

*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE.

## Higher risk of injury on PMDs

This scenario uses an alternate risk of injury parameter compared to the main results. While the main results use data from Santa Monica and the ITF on crash and fatality rates, this sensitivity uses data from Austin Public Health, which estimates 20 injuries per 100 000 trips.

Under this assumption, safety disbenefits are substantially larger, at $21.1 million under the central growth scenario and $21.4 million under the high growth scenario. Net benefits are still positive under both scenarios, although lower compared to the core results (table 8.4).

### 8.4 Results with higher risk of injury on PMDs

| Category | Status quo | Central growth | High growth |
|---|---|---|---|
| | $pv | $pv | $pv |
| **Benefits** | | | |
| Travel time savings | 3 662 704 | 49 520 616 | 70 835 659 |
| Vehicle operating cost savings | 1 240 056 | 16 810 705 | 23 746 790 |
| Decongestion benefits | 575 207 | 7 797 737 | 11 015 077 |
| Environmental impacts | 169 658 | 2 305 086 | 3 354 516 |
| Health impacts | -1 012 097 | -13 659 220 | -18 123 716 |
| Safety impacts | -1 568 210 | -21 148 698 | -21 432 060 |
| **Total benefits** | **3 067 317** | **41 626 224** | **69 396 266** |
| **Costs** | | | |
| Enforcement costs | - 153 008 | -2 064 988 | -2 739 926 |
| **Total costs** | **- 153 008** | **-2 064 988** | **-2 739 926** |
| **Net benefits** | **2 914 310** | **39 561 237** | **66 656 340** |

*Note:* Present value and net present value figures discounted with a real 7 per cent discount rate. Values are in $2020, unless stated otherwise (i.e. nominal values).

*Source:* The CIE

# A Technical Appendix

## Estimating PMD scenario growth rates

To inform the take-up rate in NSW (and specifically Sydney), we used data on the number of e-scooter trips made in Brisbane since legalising the use of e-scooters in 2018. Within the first three months of the e-scooter trial, around 500 000 trips[39] were made in Brisbane. Pre Covid-19 levels of usage reached around 2 million trips per year in 2019[40] and with a population of 2.5 million people, this implies 0.82 trips per capita.

Applying this to the population of major metropolitan centres across NSW[41] (~5.3 million people) leads to an uptake of just over 4.3 million trips per year in the first year of regulated usage (assumed to start in 2021) (excluding the base case usage of 300 000 trips leads to an actual uplift of around 4 million trips per year) We have applied the same uptake rates in other metropolitan areas such as those in Sydney, although in practice this could vary (and in fact could be lower in less dense urban and metropolitan areas).

This starting value was then grown over time by an appropriate growth rate. These include:

- The high growth scenario — a growth rate of 7.7 per cent per year to 2031 is forecast for the global e-scooter market. We assume this value as a high value which is made possible with reduced constraints to growth, since without any barriers uptake will increase in line with international trends in NSW.
  - The starting penetration rate of 0.81 trips per capita increases to 1.47 trips per capita to 2031, and then is assumed to have reached a maturity point. Beyond this point, total trips increase in line with population growth at this same penetration rate.
- The central growth scenario — only part of the global growth in PMDs is applied in this scenario, since there will still be some barriers to uptake in a 'regulation only' change. We assume under this scenario, that the penetration target of 1.47 trips per year is not reached until much later (2051), which implies a growth rate of 2 per cent per year

39 Centre for Accident Research and Road Safety, QUT, Illegal and risky riding of electric scooters in Brisbane, 2019

40 E-scooter usage declined during 2020 as a result of the COVID-19 pandemic, but have recently increased to pre pandemic levels at the end of 2019, https://www.brisbanetimes.com.au/national/queensland/brisbane-e-scooter-use-returns-to-pre-pandemic-levels-20210316-p57b6y.html

41 Including places such as Sydney, Wollongong, Newcastle, the Central Coast and Blue Mountains

- Status quo — the base case usage starts at an assumed value of 300 000, which is a much lower base compared to the scenarios. We apply the same growth rate of 2 per cent per year to this base.

## *Estimating induced rail usage*

To estimate the increase in rail demand, we apply a demand elasticity of 0.03 as recommended by BITRE[42]. This reflects the average elasticity for demand of public transport with respect to car ownership. We have used this elasticity to reflect the 'last-mile' access improvement associated with using a PMD to access a rail station compared to the alternative, which is a park and ride-based rail access journey.

In terms of the overall base at which to apply the elasticity, we target the subset of the rail-usage population that are 'in-range' of being induced to rail. That is, a PMD would only be able to induce a trip in a short distance to the station (up to 5km), which is where most rail trips are made from. We then target the relevant subset of the rail usage population to which the benefit would be applied to, which is park and ride trips (around 8.3 per cent of rail trips) (table A.1). The elasticity is applied to this base as a way to weight the overall improvement in access time for rail as a whole.

**A.1 Proportion of rail trips that are in scope for PMD inducement**

| Distance from rail station | Proportion rail trips | Proportion Park and Ride trips |
|---|---|---|
| Up to 1km | 63.7 | 1.0 |
| 1.01-2km | 17.9 | 2.6 |
| 2.01-5km | 11.9 | 4.7 |
| 5.01-10km | 4.3 | 2.3 |
| 10.01-20km | 1.7 | 1.1 |

*Source:* Train statistics 2014

The rail access improvement is applied as a percentage reduction in the average generalised cost of rail travel. In reality, the generalised cost of rail as a mode is origin-destination specific. We have assumed the following cost components for the typical rail trip in Sydney

42 BITRE Table 1D03 average elasticities for demand of public transport https://www.bitre.gov.au/sites/default/files/2019-11/tedb-table1d03.pdf

### A.2 Rail generalised cost components

| Component | Minutes |
|---|---|
| Time to station | 5.0 |
| Interchange penalty (parking) | 16.4 |
| Wait time | 10.0 |
| In-vehicle time | 30.0 |
| Egress | 5.0 |
| Fare | 15.5 |
| Total time | 81.9 |

*Note:* Interchange penalty for parking comes from a provided technical document on Western Sydney placed based infrastructure from TfNSW.

*Source:* The CIE

### *Example calculation*

An example of the elasticity calculation is set out as follows:

- Average generalised time to rail under status quo — 81.9 minutes, for people within 5km of a train station
- Status quo interchange penalty for a park and ride access — 16.4 minutes
- Interchange penalty using a PMD to access the station — 11.4 minutes
  - This leads to an improvement of 5 minutes in overall generalised rail cost
  - Interchange penalty reduction represents a 6.1 per cent fall in generalised cost of rail relative to a park and ride rail trip
- Using an elasticity of demand of 0.03, multiplied by the 'price' fall in rail cost of 6.1 per cent, leads to an increase in rail demand of 0.18 per cent
  - This reflects an improvement in park and ride generalised cost, rather than the generalised cost for all rail trips, and so the impact is weighted/applied to the share of rail trips that are park and ride and within 5km of a train station
  - 0.18%* 31.1 million = 57 000 additional trips in 2021

## *List of parameter values and assumptions*

Table A.3 lists the parameter values and assumptions that underly the analysis.

### A.3 Parameter values and assumptions

| Parameter | Value | Source |
|---|---|---|
| Value of travel time | $17.72 | TfNSW Economic parameters (price updated to $2020) |
| Base case usage rate | 300 000 trips starting in 2021 (1 000 per week day) | CIE |
| PMD Trips per capita | 0.82 in the first year | Shared e-Bike and e-Scooter Final Pilot Report - Calgary, CIE calculations |

| Parameter | Value | Source |
|---|---|---|
| Growth rate PMDs penetration rate status quo | 2% per year | CIE adjustments to numbers based on forecast global growth for PMDs, Grand View Research E-scooter Market growth and trends, Feb 2020 |
| Growth rate PMDs penetration rate central growth | 2% | CIE adjustments to numbers based on forecast global growth for PMDs, Grand View Research E-scooter Market growth and trends, Feb 2020 |
| Growth rate PMDs penetration rate high growth | 7.7% to 2031, constant thereafter (growth in trips increases in line with population at a fixed rate beyond 2031) | Based on forecast global growth for PMDs, Grand View Research E-scooter Market growth and trends, Feb 2020<br>Population growth based on DPIE forecasts |
| Walking substitute rate | 54% | Shared e-Bike and e-Scooter Final Pilot Report - Calgary |
| Car substitute rate | 17% | Shared e-Bike and e-Scooter Final Pilot Report - Calgary |
| Other on-road trips (e.g., rideshare/taxi) substitute rate | 12% | Shared e-Bike and e-Scooter Final Pilot Report - Calgary |
| Other transport trips substitute rate | 14% | Shared e-Bike and e-Scooter Final Pilot Report - Calgary |
| Average walk time per trip | 9 mins | Active transport in Sydney: Walking, 2010 |
| Average walk distance per trip | 660 meters | Active transport in Sydney: Walking, 2010 |
| Average walking speed | 4.4km/h | CIE calculation |
| Median speed escooter | 7.07km/h | Exploratory analysis of real time escooter trip data Washington DC |
| PMD injury rate | 122 per 2.67 million trips | Shared mobility pilot program summary report, Santa Monica, November 2019 |
| Proportion major injuries | 10% | Shared mobility pilot program summary report, Santa Monica, November 2019 |
| Proportion minor injuries | 90% | CIE assumption based on Shared mobility pilot program summary report, Santa Monica, November 2019 |
| Value of major injury | $13,474 | Investigating the costs of major and minor cylcing crashes in Tasmania Australia |
| Value of minor injury | $681 | Investigating the costs of major and minor cylcing crashes in Tasmania Australia |
| Base case bicycle trips 2018 | 100 000 000 | TfNSW cycling and micromobility investment program p146 |
| Bicycle growth rate | 3.22% per year | Implied growth rate under the base case from TfNSW cycling and micromobility investment program |
| E-bike uptake rate | 0.006407*(year - 9)-12.844 | Formula from TfNSW cycling and micromobility investment program demand report |

| Parameter | Value | Source |
|---|---|---|
| PMD rider citations/fines | 299 per 2.67 million trips | Shared mobility pilot program summary report, Santa Monica, November 2019 |
| Impounded PMDs per trip | 1200 per 2.67 million trips | Shared mobility pilot program summary report, Santa Monica, November 2019 |
| Hourly cost of police enforcement | $37/hour based on Salary constable level 2 at $76388/year at 40 hours per week | NSW Government website[43] |
| Enforcement time per PMD incident | 1.62 hours | BOCSAR Estimating the short-term cost of police time spent dealing with alcohol-related crime in NSW, 2007, p19 |
| Decongestion benefits | $0.19/km (price updated to $2020 using CPI) | TfNSW Economic parameter values June 2020 |
| Road safety benefit | $87581/mvkt | TfNSW Economic parameter values June 2020 |
| Vehicle operating costs | 41.5c/vkt | TfNSW Economic parameter values June 2020 |
| Environmental externalities | 8.52c/vkt | Sum of air pollution, ghg emissions, noise, water pollution, nature and landscape and urbans separation - TfNSW Economic parameter values June 2020 |
| e-scooter environmental cost | 2.06 c/vkt – based on calculation that e-scooters pollute 24% as much as cars (62g of c02 per km relative to 257g of c02 per km) | Are e-scooters polluters? The environmental imapacts of shared dockless electric scooters, 2019<br>TfNSW Economic parameter values June 2020 |
| Health benefits | Cycling benefit $1.23/km<br>Walking benefit $1.84/km<br>e-scooter benefit $0.61/km | TfNSW Economic parameter values June 2020, CIE assumption of half of cycle benefits for e-scooter use |

*Note:* Unless specified, dollar values (e.g. value of travel time) have been escalated to $2020 using CPI.

*Source:* The CIE.

43 https://www.police.nsw.gov.au/recruitment/the_career/general_duties/working_conditions#:~:text=The%20NSW%20Police%20Force%20offers,carer's%2C%20sick%20and%20compassionate%20leave.

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