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Review of user charging and demand management

Infrastructure WA

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Contents

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Executive summary

The economic rationale for user charging

A user pays model is an appropriate approach for the public road network

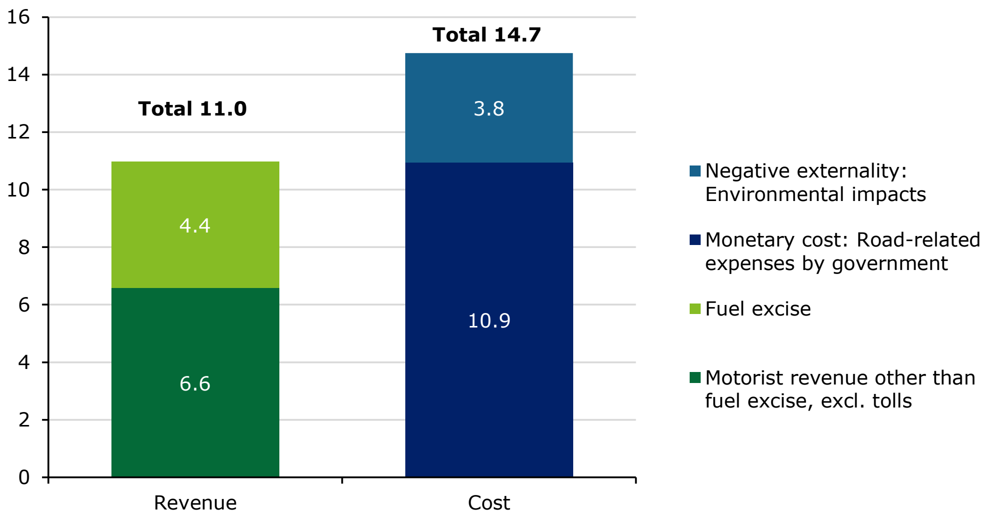
The public road network is characterised by economists as a **common good**. Technically speaking, it is rivalrous in that each additional user imposes costs on the next user (in the form of congestion) but it is non-excludable in the sense that governments lack feasible means of restricting road use to certain cohorts of drivers. Public roads, like all common goods, should be funded through a **user charge** to provide an efficient price signal to users and adequately resource infrastructure provision.

User charges should be set to offset the costs of road provision

The use of the public road network should be priced according to each user's proportional impact on the cost of road use. That includes the direct cost to governments of road provision, as well as negative externalities imposed on society at large, including the cost of accidents, environmental impacts and congestion.

Australian governments spent around $28.9 billion on road-related expenditure in 2018-19, including investment in new road projects, expanded capacity, maintenance and repair,[1] equating to around 10.9 cents per kilometre travelled on the road network.[2] In addition to the direct financial cost of road provision, road vehicle use also generated an estimated $10.0 billion in negative environmental externalities in 2018-19, around 3.8 c/km (Figure A).[3] Environmental externalities include air, water and noise pollution as well as upstream and downstream costs (such as those associated with vehicle construction).

Figure A: Road-related revenue and costs, 2018-19, cents per kilometre

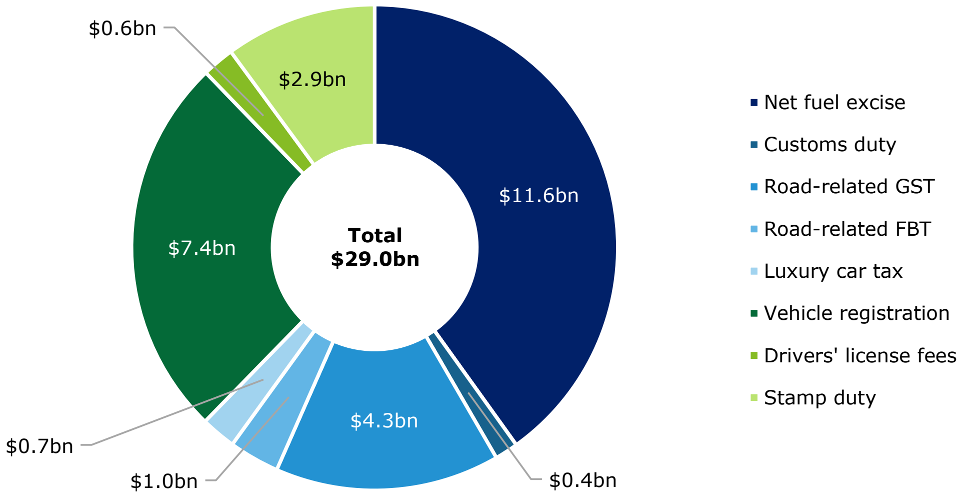


Source: Deloitte Access Economics; BITRE; Austroads

Current road-related revenue is not aligned with a user pays model

In 2018-19, Australian governments collected around $29.0 billion in road-related revenue (excluding income from toll roads), of which $11.6 billion (37 per cent) was attributable to net fuel excise tax, which is the only source of revenue resembling a user pays model (Figure B).[4] On average, total road-related revenue equated to 11.0 cents per kilometre, of which 4.4 cents per kilometre was paid in fuel excise.

Figure B: Road-related revenue, 2018-19



Source: BITRE

Fuel excise is a rudimentary approximation of a user charge, raising funds proportional to the consumption of an input to road use (i.e. fuel) rather than road use itself. Over time, improvements in fuel efficiency have meant that users of internal combustion engine (ICE) vehicles have paid a declining amount of fuel excise relative to the number of kilometres driven.

More critically, the rise of electric vehicles (EVs) and other zero-emissions vehicles means that the link between road use and government revenue will be substantially weakened over time. Implementing a user pays model will, therefore, underpin the sustainability of road-related revenue in the coming decades.

In the short term, a user charge for EVs only could partly fill the gap in road-related revenue from avoided fuel excise. In the long term, as fuel efficiency continues to increase and the share of EVs in the Australian vehicle fleet grows, a road user charge could apply to all vehicle users.

Potential user charging mechanisms

This study explores several alternative approaches to user charging:

- **Distance-based user charges:** A per-kilometre price on road use, measured either through in-vehicle devices that record kilometres travelled or through user self-reporting of odometer readings. This type of user charge can be extended to involve other variables such as vehicle **mass** and the **location**, **time of day** and **day of the week** on which the travel occurs. Distance-based charges for EVs implemented in Oregon and Utah, and proposed in Victoria, are discussed within, as is New Zealand's system of distance-based charging for all vehicles that avoid paying fuel excise.

- **Cordon charges:** A price on travel into a prescribed cordoned area, such as the central business district of a major metropolitan area. Cordon charges are designed to discourage road use within the cordoned area and are often complemented by incentives for greater uptake of public transport and measures to prohibit or penalise the use of high-emissions vehicles within the cordoned area. The impact on congestion of cordon charges in place in Singapore, London, Stockholm and Milan are reviewed.

- **Parking levies:** A cost on private and public non-residential car bays within a prescribed area, designed to slow the growth in or reduce the supply of car bays to discourage driving into inner cities. The existing **Perth Parking Policy** is discussed and shown to correspond with limited growth in private parking supply and increasing the public transport mode share. Schemes in Melbourne and Sydney are shown to be relatively less effective.

- **Toll roads:** A cost to use specific roads or road segments. In the Australian context these are predominantly operated by private toll concessionaires. The feasibility of implementing toll roads in WA is considered in the context of their relative merit to other user charging mechanisms, and community attitudes to toll roads.

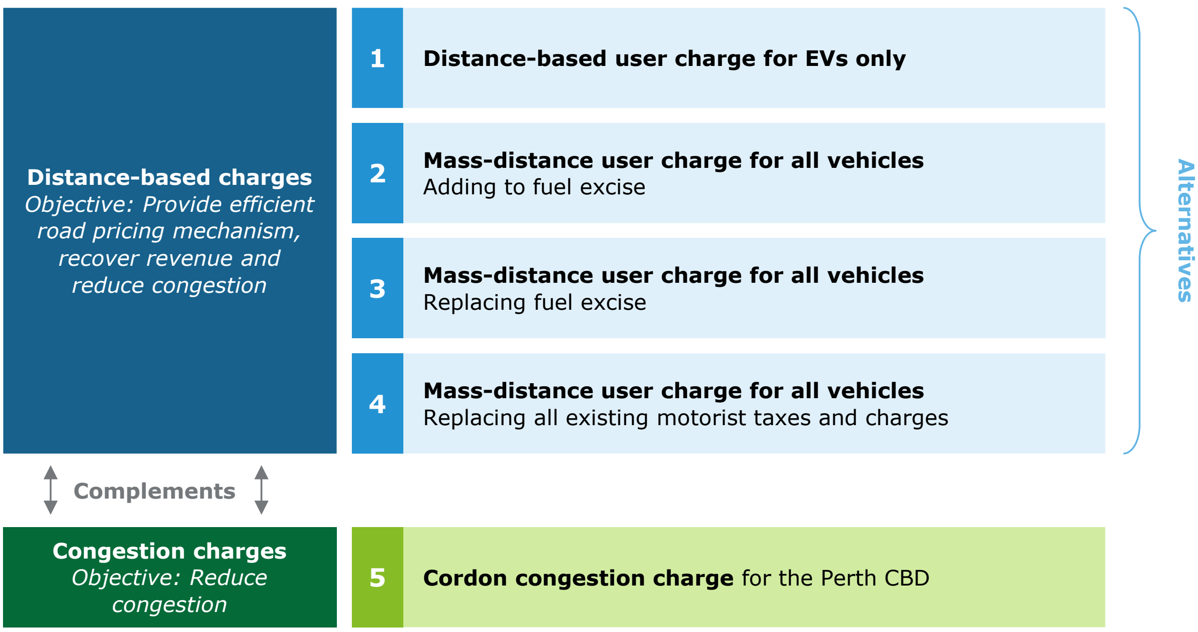
Options for road user charges in Western Australia

Based on the review of mechanisms implemented locally, in other Australian jurisdictions and overseas, and in the context of the economic rationale for a user pays model, a series of potential options for implementing road user charges in WA is discussed in this report.

Four options for distance-based user charging are proposed, varying by whether they apply to EVs only or all vehicles, and whether they are implemented to complement or replace fuel excise and other motorist taxes. A cordon charging option is proposed to target congestion reduction, which could be implemented as a complement to a distance-based user charge.

Potential options identified are shown in Figure C.

Figure C: Options for implementing road user charging in Western Australia



Source: Deloitte Access Economics

Each option is explored in terms of the factors that may influence its pricing and **considerations for implementation**, including how variables such as distance travelled and potential investment in infrastructure required.

Options are not necessarily mutually exclusive, and aspects of the various distance-based charges will converge over time as the EV share of the vehicle fleet increases. Further, congestion charging models can be applied over distance-based charging mechanisms to provide price signals for mass, distance, time and location.

For each of the four distance- and mass-distance-based charges, the per-kilometre charge would be set based on recovering each vehicle type's contribution to the average **social cost of road use**, and the **revenue measures** being replaced under each option.

Under **Option 1**, a distance-based user charge for EV users would only approximately offset the average per-kilometre direct financial cost of road provision incurred by government. This would bring EV users' per-kilometre payments in line with ICE vehicle users, but could be discounted to provide a net overall incentive for EV uptake.

Under **Option 2**, a mass-distance charge would be applied to all vehicle users on top of existing fuel excise. This would offset both the direct financial cost of road provision incurred by government, and each vehicle type's relative contribution to negative environmental externalities from road use.

Under **Option 3**, fuel excise would be replaced altogether with a mass-distance user charge for all vehicle users, with EV users paying a lower rate than ICE vehicle users.

Under **Option 4**, all motorist taxes and charges would be replaced with a mass-distance user charge, with EV users paying a lower rate than ICE vehicle users.

Indicative pricing for the cordon congestion charge under **Option 5** would need to consider many factors, including the share of vehicle movements and total congestion cost that occurs within the defined cordoned area. In 2018-19, the estimated cost of road congestion in the Greater Perth area was approximately $10.0 billion.[5] Only a portion of this cost could be recoverable through a cordon charge on the Perth CBD; for example, it would not impact heavy vehicle congestion on highways outside of the CBD.

Cordon congestion charges can also be expensive to implement and operate, relative to a distance- or mass-distance based charge. In London and Milan, for example, around 40 to 50 per cent of annual gross revenues from cordon charging schemes is spent on operating costs.

Other potential user charging mechanisms were explored, including an expanded **parking levy** scheme and the use of **private toll roads**. Expansion of the existing Perth Parking Management Area or implementation of similar parking management schemes in other areas was found to have little merit as a road pricing mechanism relative to the introduction of a mass-distance user charge, and little merit as a congestion management tool relative to a cordon charging system.

Private tolls implemented on segments of the road network were found to be effective at reducing congestion and providing faster journeys within the tolled zone, but were found to be neither an effective means of raising revenue for governments nor an effective congestion management tool at the network level. In some cases, the use of toll roads was found to increase congestion on neighbouring or alternative roads.

User charging could be paired with demand management mechanisms to address congestion

Separate from the question of securing future funding for road network provision and developing an efficient user pays model, congestion on the road network could also be reduced through non-infrastructure solutions.

This study also explores a series of travel demand management (TDM) initiatives that focus on altering travel behaviour on the demand side, rather than investment on the supply side of the road network.

Several initiatives are already in place in Western Australia, including the Your Move travel behaviour change program. Additional TDM initiatives may be necessary as alternatives to additional capital investment in the road network, including consideration of carpooling incentives, high occupancy vehicle (HOV) lanes on major roads, and addressing regulatory and other barriers to micro-mobility services being operational in WA.

TDM initiatives can influence users' behaviour to deliver more efficient outcomes, delaying or removing the need for investment in new or expanded capacity.

The time for change

The rise of EVs has exposed long-standing issues with the existing system of road taxes and charges in Australia. EVs present a platform for change because they will cause a significant and widening gap between revenue raised from fuel excise and the cost of road provision over time.

EVs currently account for only a small share of the Australian vehicle fleet, but this is projected to increase rapidly over the next decade. Therefore, it may be prudent to implement EV user charges sooner rather than later, so that these charges are in place before the ‘natural’ uptake of EVs accelerates in coming years. That would mean that an individual consumer’s purchase decision is not marginally impacted by the introduction of a user charge later.

Governments could further use the opportunity presented by EVs to undertake broad reform of road-related revenue measures, to ensure that revenue raised from each road user adequately reflects the social cost of that user’s travel behaviour. More comprehensive reform will require greater coordination between states, territories and the Commonwealth and more challenging legislative and regulatory change, but could nonetheless be the objective.

1 Context

1.1 Purpose of this study

Infrastructure Western Australia (IWA) has asked Deloitte to prepare a short research study on transport user charging and demand management mechanisms. The purpose of this study is to support IWA in preparing the inaugural State Infrastructure Strategy (SIS), specifically regarding potential non-build infrastructure responses relating to transport.

IWA is seeking to develop an evidence base to inform its decision-making on potential user charging and/or demand management mechanisms for the Perth metropolitan and broader Western Australian transport systems.

The inaugural SIS will be issued for public consultation by the end of June 2021. The development of the SIS will need to consider a broad range of sector-specific and cross-sectoral infrastructure issues.

In addition to new infrastructure projects and programs, the SIS will also consider non-build solutions and issues which may include policy, regulatory, pricing, technology, procurement, skills and governance issues. The IWA Board has identified transport infrastructure as one such opportunity to consider whether non-build responses may be appropriate for inclusion in the SIS.

The SIS will primarily focus on infrastructure that is fully or partly funded by the State Government. In this context, IWA must also consider sources of revenue to fund transport infrastructure, and how future developments in transport systems – such as the increasing significance of electric vehicles (EVs) – will impact those revenue streams.

1.2 Limitations

This paper considers a broad range of user charging and demand management mechanisms, examining the economic motivation, impacts on transport system user costs and experience and examples of implementation in WA and other jurisdictions. The extent to which each mechanism has been explored was limited by several factors:

- **Timing** – This work was completed in a three-week period in April 2021, with a significant focus on a desktop review of existing documentation.
- **Stakeholder engagement** – Due to the short timeframe, consultation with stakeholders to source additional information or test key findings was not undertaken.

1.3 Structure of this report

Chapter 2 explores the economic rationale for user charging and provides an overview of the current state of road user taxes, fees and charges in Australia.

Chapter 3 explores specific mechanisms for road user charging transport systems, including short case studies of implementation in WA, other Australian jurisdictions and overseas.

Chapter 4 explores several mechanisms for travel demand management and road congestion reduction that do not involve direct user charging, including short case studies.

Chapter 5 sets out potential options for implementing road user charging in Perth and WA.

2 The economic rationale for user charging

2.1 When users should pay

Classifying different aspects of transport systems according to economic principles helps determine how governments should optimally fund, and recoup costs for, transport infrastructure and services. The economic efficiency of the transport network can be improved by better aligning price signals with the social costs of its use.

Goods and services can generally be categorised according to whether they are rivalrous and/or excludable:

- **Rivalrous** goods are those where one person's consumption decision limits or reduces another person's consumption opportunities. An apple is rivalrous because it can only be consumed once, while a television program is non-rivalrous because each additional person's viewing has no impact on any other person.
- **Excludable** goods are those for which consumption can feasibly be restricted or prevented. Watching a film in a cinema is excludable because a ticket is required, while watching a public fireworks display is non-excludable because a person cannot feasibly be prevented from watching.

Meeting none, one or both criteria gives rise to four categories of goods and services:

- **Public goods** are non-rivalrous and non-excludable; for example, national security is a public good because one person benefiting from the provision of national security does not impact benefits to any other person, and it is not possible to exclude a person from benefiting from national security.
- **Club goods** are non-rivalrous but excludable; subscription television and streaming services are examples of club goods in that there is a fee required to access them, but one person's use of the service does not impact other users' experience.
- **Common goods** are rivalrous but non-excludable; for example, fish in the ocean that can be harvested by anyone (non-excludable) but there is a finite quantity such that one person's overconsumption will limit another person's opportunity to consume (rivalrous).
- **Private goods** are both rivalrous and excludable. A car is a private good because there is a cost to the user to attain it and it can only be used to transport a finite number of users at a time.

Generally, **a user pays model is not advisable in the provision of public goods (e.g. national defence)**. Because public goods are non-rivalrous, users will benefit from their provision whether they pay for it or not; and because they are non-excludable, there is no incentive for any one person to opt into paying for a public good. Governments, therefore, bear the full cost of providing public goods like national security, and could fund them through broad, equitable sources of revenue (Box 2.1).

Box 2.1: Public goods in transport provision

Much of the auxiliary infrastructure associated with the transport network can be considered **public goods** – for example, signage and streetlights. Information about the transport network is also a public good, such as Transperth's Journey Planner or Main Roads' published alerts about traffic disruptions and road closures. There is no way to prevent a user from benefiting from any of these (non-excludable) and each user's consumption has no impact on other users (non-rival). A user pays model would not be advisable to fund the provision of these services.

In contrast, **a user pays model is advisable for the consumption of common goods (e.g. the road network).** Because such goods are rivalrous, each user's consumption limits consumption opportunities for other users. If the common good is provided 'free', the user has no incentive to temper their consumption and the good is at risk of being overconsumed or depleted altogether. Levying direct charges on users better aligns the beneficiaries of a good or service with those who pay for it (Box 2.2).

Box 2.2: Metropolitan roads as common goods

In most transport systems, metropolitan roads are planned, built and maintained by government. In the absence of a toll system, metropolitan roads are **non-excludable** because governments cannot feasibly restrict access to the road network for any individual user. However, they are **rivalrous** because each additional user adds to congestion levels, resulting in less efficient traffic flow and slower journeys for each subsequent user.

On this basis, metropolitan roads should be funded through a user charge but this principle is not applied in many jurisdictions. While governments levy charges on aspects of road use – such as the consumption of fuel, registration of vehicles and licensing of drivers – these are neither directly related to road use, nor do they cover the full cost to government of building and maintaining the road network.

2.2 How much users should pay

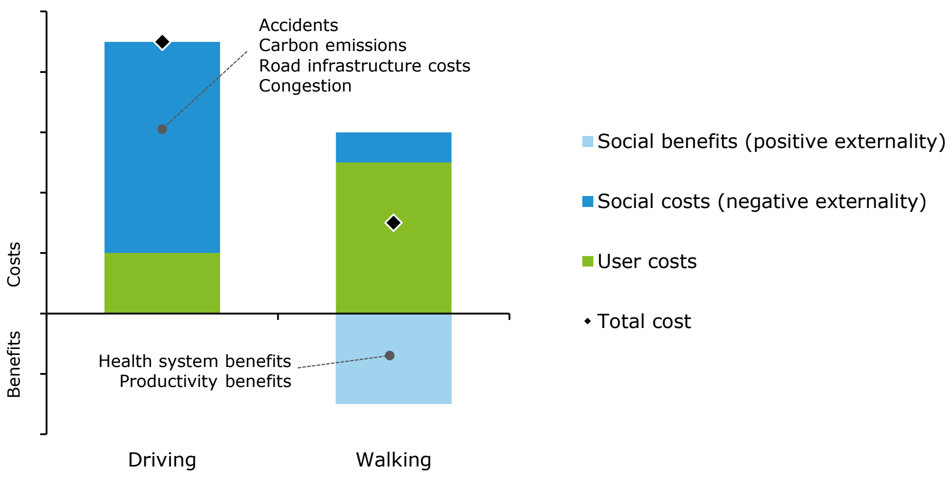
For markets to operate efficiency, pricing should reflect the full cost of providing a good or service. That includes both the direct cost incurred by the user, and other costs borne by society that may not be perceived by the user.

Costs borne by society (and not the users) are **negative externalities.** In the case of driving an internal combustion engine (ICE) vehicle, these include emissions of greenhouse gases and other pollutants from the burning of fuel. The impact of emissions on climate conditions and air quality is unavoidably borne by society, and in the case of road transport, there is no cost recovery mechanism.

On the other hand, some activities generate **positive externalities**, where the full social cost of consumption is lower than the cost incurred directly by the user. Walking is an example of a transport mode that generates positive externalities. The user experiences a benefit in the form of lower risk of health complications, but society also benefits from lower health system costs because that user is less likely to require publicly funded medical services in future.[6]

Externalities are a sign of market failure, and provide an opportunity for government policy to improve efficiency. Users base their consumption behaviour only on costs that they perceive, which may be only a limited subset of all costs. For example, drivers often base their behaviour principally on the variable cost of fuel because it is incurred directly and on a regular basis. They may fail to consider direct costs that they consider fixed or unrelated to their travel behaviour (such as annual vehicle insurance or maintenance costs), indirect costs borne by society for which there is no direct financial impact on the user (such as carbon emissions from fuel consumption) and indirect benefits to society (such as reduced health system costs due to greater uptake of walking), illustrated in Figure 2.1.

Figure 2.1: Illustrative costs of driving vs. walking



Source: Deloitte Access Economics

Quantifying externalities is important for governments to accurately set prices for goods and services. There are two ways government can intervene to ensure prices are reflective of social costs:

- **Corrective taxes and charges** should be levied on activities that generate negative externalities, both to fund remedial action and to discourage that activity. This is the stated basis for so-called 'sin taxes' on consumption of goods with relatively high negative health system externalities like alcohol and tobacco, as well as taxes on carbon dioxide emissions.
- **Subsidies** should apply to activities that generate positive externalities, to encourage greater uptake and further reduce social costs. Public transport is highly subsidised in many jurisdictions because it generates positive externalities relative to other transport modes.

Externalities should be viewed relative to a set of feasible alternatives. Trains still contribute indirectly to greenhouse gas emissions by using electricity generated from fossil fuels, and buses still cause wear and tear on roads. But on both measures, the social cost of a public transport service is still lower than the total social cost of all passengers completing the same journey individually by car.[7]

2.3 Policy alignment with user pays model

There are two areas of misalignment between the current state of road funding in Australia and the economic rationale for a user pays approach outlined above:

- Most sources of road funding are either not related to road use, or weakly related through indirect channels such as the consumption of fuel
- While road funding approximately offsets direct government costs of road provision, current policy does not account for the cost of other negative externalities from road use, including greenhouse gas emissions and congestion.

In Australia, revenue is collected from motorists through several channels by the Commonwealth Government, state and territory governments, and operators of toll roads.

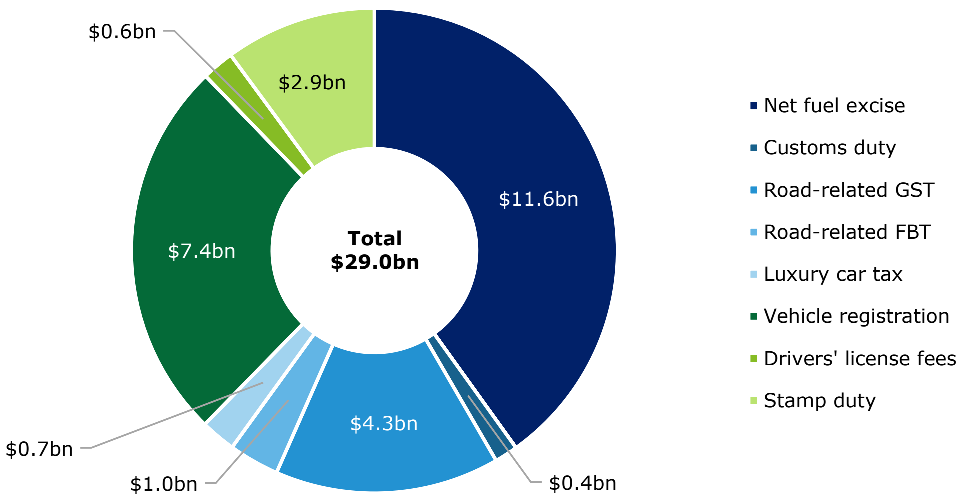
In 2018-19, motorists paid an estimated $29.0 billion in major road-related taxes and charges.[i] The Commonwealth collected around 62 per cent of this amount, the largest component of which was $11.4 billion in net fuel excise (total fuel excise less fuel credits repaid to business).

The Commonwealth collected a further $449 million in customs duty on imported vehicles, $4.3 billion in road-related goods and services tax (GST), $972 million in road-related fringe benefits tax (FBT) and $677 million in luxury car tax.

State and territory governments collected an estimated $10.9 billion in taxes, fees and charges from motorists. Motor vehicle registration fees accounted for around two-thirds ($7.4 billion) of this amount, with a further $620 million collected in drivers' license fees and $2.9 billion in stamp duty on motor vehicle transfers.

A summary of road user taxes and charges is provided in Figure 2.2.[8]

Figure 2.2: Road-related revenue, 2018-19, $ billion



Source: BITRE

In addition, motorists also paid around $2.5 billion for the use of toll roads in 2018-19, none of which occurred in Western Australia.

The sections that follow provide further detail on each of these charges, including an overview of the mechanism and an assessment of its consistency with the economic rationale described in Chapter 2.1.

2.3.1 Fuel excise

2.3.1.1 Overview

Fuel excise is levied by the Commonwealth on most consumer and commercial fuels and petroleum products. From 1 February 2021, the rate of excise for most fuels is $0.427 per litre, including for petrol and diesel; a lower rate applies to certain fuels such as liquefied petroleum gas (LPG) used in gas vehicles.[9]

Prior to 1959, revenue collected from fuel excise was formally hypothecated to fund investment in the road network.[10] Since then, fuel excise has instead added to consolidated revenue.

Rates of fuel excise have fluctuated over time, alternating between periods of gradual increase linked to indexation, and sharper, arbitrary increases where the primary objective is an increase in revenue.[11] For example, in 1986, to offset declining receipts from crude oil excise due to a global

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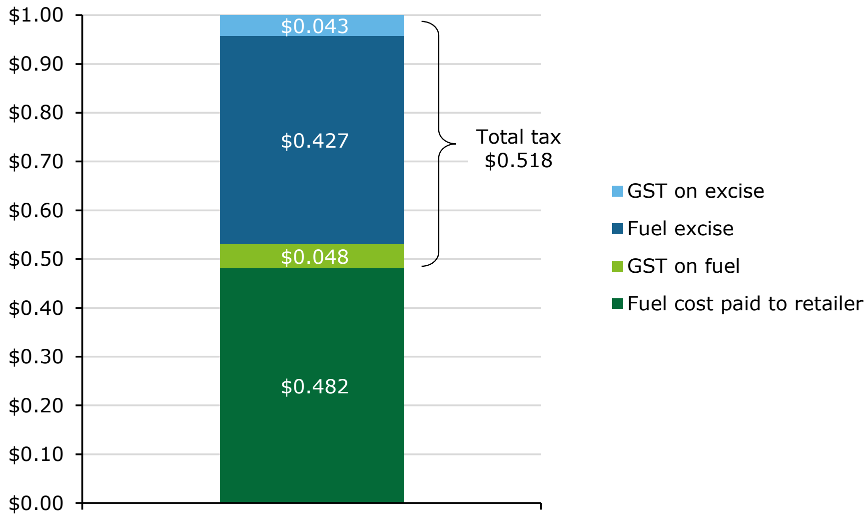
[i] Excludes fees and charges that raise relatively little revenue, such as permits for oversize vehicles and loads levied by states and territories.

decline in oil prices, the rate of petrol excise was increased from $0.104 to $0.239 (129 per cent) over six months.

Prior to 1997, state and territory governments levied franchise fees on fuel retailers. In 1997, a High Court determination relating to similar franchise fees for tobacco retailers found that such fees met the definition of an excise tax, which under the Australian Constitution can only be levied by the Commonwealth Government.[12] Consequently, as states and territories removed franchise fees on products including petrol, the Commonwealth increased the rate of petrol excise from $0.347 to $0.428 (23 per cent) and agreed to return the surplus excise revenue raised to the states and territories.

The excise amount is subject to GST levied at 10 per cent. For example, when a consumer pays $1 for a litre of petrol at the bowser, they are in fact paying $0.482 for the petrol itself, $0.048 in GST on the petrol, $0.427 in excise and $0.043 in GST on the excise (Figure 2.3). When the GST came into effect in 2000, the rate of excise was cut by 15 per cent (from $0.441 per litre to $0.375) to offset the impact of taxing fuel consumption twice.

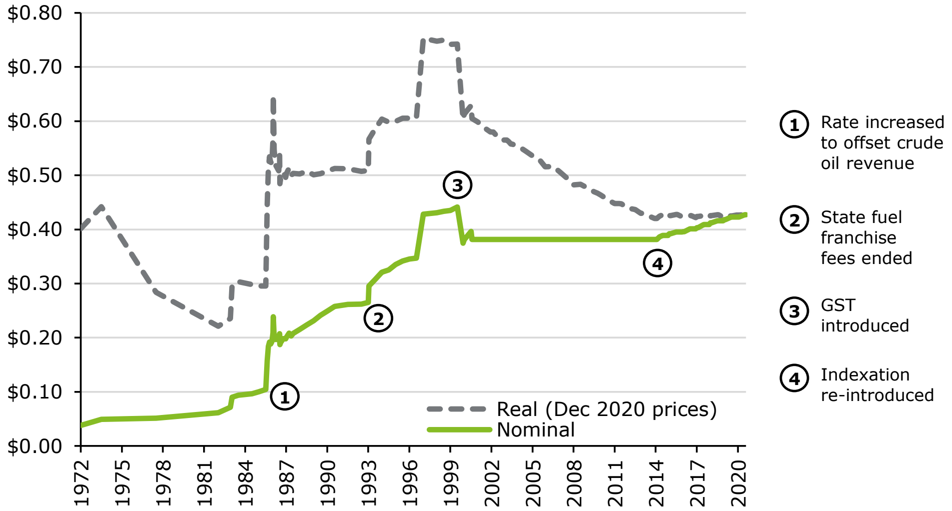
Figure 2.3: Components of $1 spent on 1 litre of petrol



Source: Australian Taxation Office

The excise rate on petrol went unchanged for 13 years between 2001 and 2014 at $0.381; diesel was taxed at a slightly higher rate of $0.401 until 2006, when it was lowered to match the rate on petrol. In 2014, the Commonwealth Government re-introduced the practice of indexing excise rates to the consumer price index (CPI) twice yearly (Figure 2.4).

Figure 2.4: Rate of petrol excise, $ per litre



Source: Australian Taxation Office; ABS

In real terms, the rate of fuel excise per litre has declined by around 30 per cent over the last 20 years due to the freeze on indexation from 2001 to 2014. The reintroduction of indexing to CPI has meant that the rate has remained approximately constant in real terms since 2014. However, in real terms, the amount of revenue raised has not kept pace with levels of vehicle use due to increasing fuel consumption (further discussed below).

In 2006, the Commonwealth introduced the Fuel Tax Credits Scheme (FTCS) to provide rebates to businesses to offset tax paid on fuel used in machinery, fixed plant and equipment, heavy vehicles used in any capacity, and light vehicles travelling on private roads or otherwise not on public roads.[13] A heavy vehicle is defined as having a gross vehicle mass (GVM) of more than 4.5 tonnes.

The FTCS provides a full refund for tax paid on fuels used for fixed plant and equipment, and vehicles that exclusively use private roads or otherwise do not use the public road network. This is consistent with the economic rationale for road user charging; if revenue collected from road vehicle fuel tax should be used to invest in the public road network (including offsetting wear and tear) then there should be no tax levied on machines and vehicles that do not use public roads.

For heavy vehicles that use public roads, part of the fuel tax credit is withheld as a 'road user charge' (RUC) which is intended to offset the additional wear and tear to the public road network caused by heavy vehicles. From 1 July 2020, the RUC is $0.258 per litre, reducing the available fuel credit for heavy vehicles using public roads to $0.169, or 40 per cent of the tax paid.[14] There are further adjustments to the available rebate for auxiliary fuels used by heavy vehicles on public roads (for example, fuel used to power a refrigeration unit fixed to a heavy vehicle).

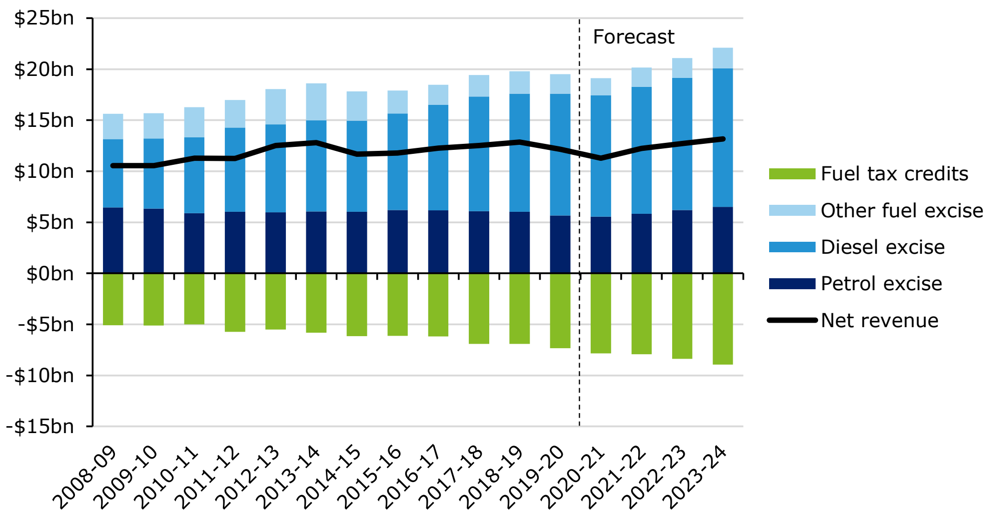
In 2020-21, the Commonwealth Treasury will collect a projected $19.1 billion in fuel tax revenue. The COVID-19 pandemic caused a reduction in road travel in the 2020 calendar year, in turn causing a reduction in the volume of fuel consumed and leading to a decline in fuel tax receipts of 1.4 per cent in 2019-20 and 2.0 per cent in 2020-21.[15]

Prior to the impacts of COVID-19, fuel tax had generally been a stable source of revenue for the Commonwealth Government, growing in line with road travel and fuel consumption and incorporating inflation by indexing the excise rate to CPI. Over the decade to 2018-19, fuel tax revenue grew at an annual average rate of 2.4 per cent per annum. Over the forward estimates period to 2023-24, receipts are projected to grow at 3.2 per cent per annum, on average.

Diesel is the largest source of fuel tax revenue, accounting for $11.9 billion (62 per cent) of projected receipts for 2020-21. Petrol is the next largest contributor ($5.6 billion or 29 per cent) with all other fuels and petroleum products contributing $1.7 billion (9 per cent).

In 2020-21, the Commonwealth will refund an estimated $7.8 billion in fuel tax revenue to businesses under the FTCS, leaving net revenue of $11.3 billion to be added to consolidated revenue (Figure 2.5).

Figure 2.5: Fuel tax revenue collected and credits paid, $ billion



Source: Commonwealth Budget Papers

The amount refunded under the FTCS has grown faster than the amount collected (averaging 3.3 per cent annual growth over the decade to 2018-19, compared to 2.4 per cent annual growth in fuel tax collected) and consequently the amount refunded has increased as a share of total receipts (from 32 per cent in 2008-09 to a projected 41 per cent in 2020-21).[16]

While no formal hypothecation mechanism exists, in practice the Commonwealth distributes net fuel tax revenue to state and territory governments in the form of grants and national partnership payments to fund road infrastructure. The GST collected on fuel excise implicitly forms part of the total GST pool, which the Commonwealth distributes to states and territories on an untied basis.

2.3.1.2 Economic rationale

In 2010, the *Australia's Future Tax System Review* (colloquially, the 'Henry tax review') described the current fuel excise system as inefficient, described its purpose as being to raise general revenue rather than fund provision of public roads, and found that it was not capable of functioning as an effective pricing mechanism for roads.[17] The system has largely gone unchanged since the 2010 review was completed.

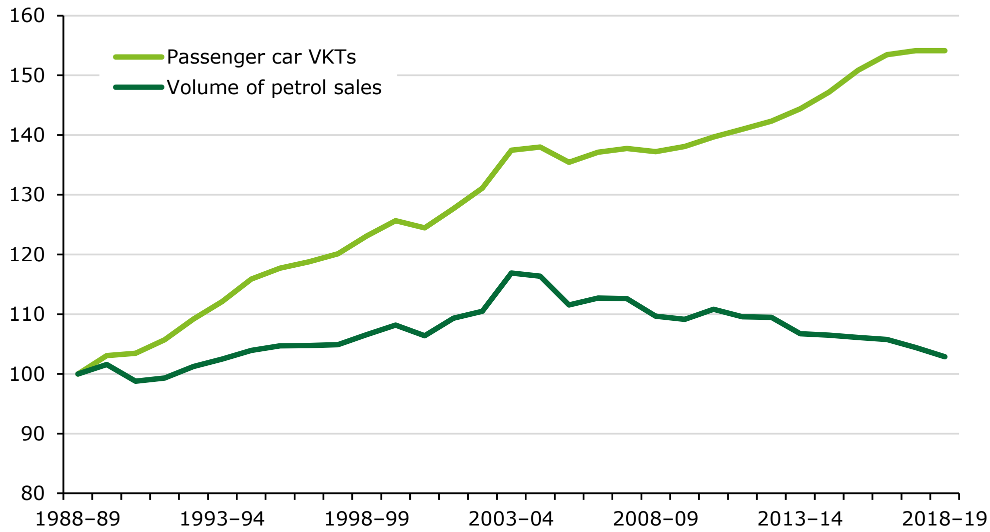
Despite its flaws, fuel excise is the closest proxy for direct, variable road user charging in Australia. But in the absence of a formal hypothecation mechanism, it fails to properly act as a price signal in the way that prices do in other markets. Users cannot adequately assess how the fuel tax they pay relates to the cost of road provision or their willingness to pay for road use; and providers cannot identify cases of under- or overinvestment based on users' response to prices.[18]

Moreover, fuel excise is a rudimentary measure that treats road use as being directly proportional to fuel consumption.

Increased fuel efficiency of road vehicles, enabled by technology improvements, has weakened the link between road use and fuel consumption. In 2018-19, the number of vehicle kilometres travelled (VKTs) by passenger cars on Australia's road network was 185.5 billion, having increased by more than 50 per cent from the 120 billion passenger car VKTs in 1988-89.[19] In contrast, around 16.1 billion litres of petrol were sold in Australia in 2018-19, just 3 per cent higher than in 1988-89 (Figure 2.6).[20]

This trend has likely made fuel excise more regressive, as owners of cheaper, older, less fuel-efficient vehicles pay a disproportionately high amount of fuel tax relative to their use of the road network. A user charge priced per VKT, rather than per litre of fuel, would address this problem.

Figure 2.6: Passenger car VKTs and volume of petrol sales, index 1988-89 = 100

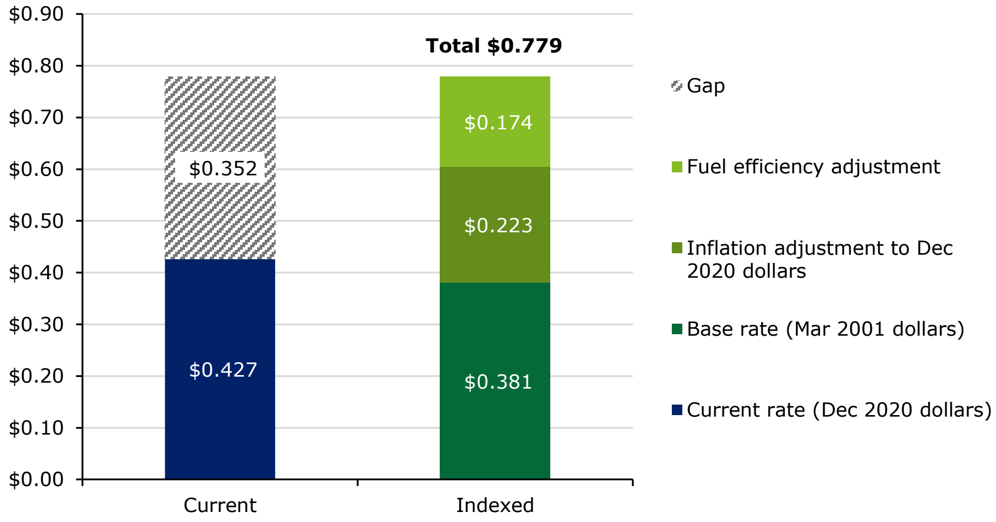


Source: BITRE

For fuel excise to function as a road pricing mechanism, it would need to be indexed to keep pace with road use (as measured by VKTs) rather than fuel consumption, as well as keeping pace with inflation.

For example, suppose that the excise rate of $0.381 per litre set in March 2001 (following the introduction of the GST) was considered an adequate baseline for the cost of road use. To both offset consumer price inflation and maintain the same rate per VKT (accounting for improved fuel efficiency) as it was in March 2001, the current rate would need to be increased from $0.427 to $0.779 per litre (Figure 2.7).

Figure 2.7: Indexing fuel excise rate for both consumer price inflation and fuel efficiency



Source: Deloitte Access Economics; BITRE; ABS

Notes: Inflation and fuel efficiency adjustments preserve the real rate of petrol excise per kilometre as at March 2001.

2.3.1.3 EVs and fuel excise

The increasing prominence of EVs threatens to break the link between fuel consumption and road use altogether. In addition to widening the disconnect between those who use the road network and those who pay for it, the rise of EVs poses a risk to the amount of fuel tax collected.

Several major economies have committed to ban the sale of ICE vehicles over the next two decades, including the UK by 2030, Japan and California by 2035, and France and Singapore by 2040.[21] No Australian jurisdiction has yet made such a commitment.

Australian new electric vehicle sales tripled in 2019 relative to the prior year. However, they represented just 0.6 per cent of total new vehicle sales. Australia lags most other advanced economies, with new electric vehicle sales representing between 2.5 and 5 per cent of total new vehicle sales across the developed world in 2019.[22]

Delayed investment in charging infrastructure and a lack of financial incentives in Australia have contributed to the slow uptake of EVs. In 2020, Australia had fewer than 2,500 public charging stations or about 100 stations per million population. In the same year, the Netherlands and Norway – recognised as global leaders in EV uptake – had 2,940 and 2,560 chargers per million people. Other regions in northern and western Europe averaged 250-500 public chargers per million people.[23] Lack of access to charging stations contributes to 'range anxiety' and a perception that EVs are not a like-for-like replacement for ICE vehicles.

Other countries where EVs represent a greater share of new vehicle sales have introduced significant incentives including tax breaks, stamp duty discounts and subsidies to overcome the high purchase price of EVs. In China, subsidies equivalent to US$12,000 are offered for BEVs and PHEVs. The Netherlands offers stamp duty exemptions and Norway grants a full exemption to the 25 per cent value-added tax for EVs. Some Australian states – including the ACT, Queensland and Victoria – offer discounts on stamp duty and registration. However, these incentives have been insufficient to accelerate EV uptake thus to date.

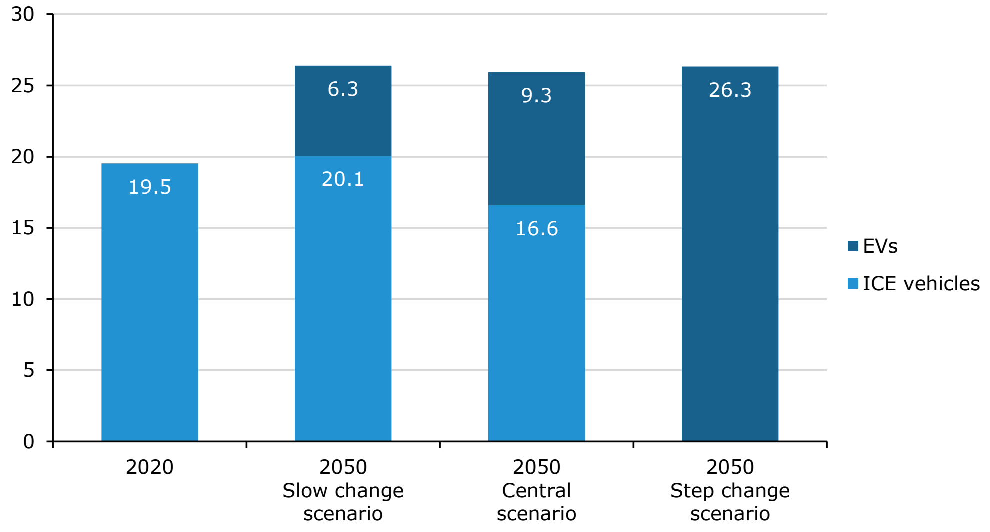
In 2020, global EV sales increased by 43 per cent and even faster growth is anticipated in the near future. Uptake is not likely to be linear, with EVs reaching a 'tipping point' of rapid mass adoption some time between 2023 and 2025 due to a fall in battery prices (globally, but not necessarily in every jurisdiction). Lithium-ion battery costs have been falling since 2010, driving the price of EVs towards parity with petrol and diesel models.[24]

Despite its relatively slow start, the CSIRO projects that electric vehicles could potentially account for around 40 per cent of Australia's vehicle fleet by 2050 under a 'central' scenario (assuming little to no policy change), around 9.3 million vehicles in a fleet of around 26 million.[25] That implies a decline in the number of ICE vehicles to around 16.6 million vehicles by 2050, from 19.5 million vehicles in 2020.[26]

In a 'step change' scenario developed by the CSIRO, electric vehicles could potentially account for close to 100 per cent of Australia's vehicle fleet; however, this would require significant policy change and rapid change in economic factors – for example, electric vehicles would need to achieve price parity with ICE vehicles by 2025,[27] compared to 2030 under the central scenario.

In a 'slow change' scenario – in which EV uptake is slower than planned and EV price parity is not achieved until 2035 – the CSIRO estimates there will be more than 6.3 million EVs on Australian roads by 2050, representing around a quarter of the vehicle fleet.[28] The number of ICE vehicles in 2050 would therefore be only slightly greater than in 2020 (Figure 2.8).

Figure 2.8: Australian road vehicle fleet (millions) – 2020 vs 2050 forecast



Source: BITRE; CSIRO

Even in this lower bound scenario, the declining share of ICE vehicles will result in a decline in fuel excise receipts. That decline will occur more rapidly under the CSIRO's central scenario for EV uptake, and much sooner under the step change scenario if the necessary policy and economic conditions change accordingly.

2.3.2 Other Commonwealth taxes on vehicle use

The Commonwealth levies several other taxes on motor vehicles and motorists in addition to fuel excise:

- **Customs duty** is payable on imported motor vehicles at a rate of 5 per cent of the customs value. The sum of the customs value of the vehicle, customs duty payable and any insurance and freight costs is the value of taxable importation (VoTI). GST is levied at 10 per cent of the VoTI.[29]

- Imported vehicles are also subject to **luxury car tax** where the value of the vehicle (inclusive of GST, but net of freight, insurance and customs duty costs) exceeds the luxury car tax threshold. The current threshold is $68,740 or $77,565 for fuel efficient vehicles, defined as any vehicle with fuel consumption not exceeding 7 litres per 100km (including electric vehicles).[30] Luxury car tax is levied at 33 per cent of the amount of the GST-inclusive value exceeding the threshold.

- **Road-related fringe benefits tax** generally includes FBT payable on employees' use of company vehicles or salary sacrifice arrangements involving employees' private purchase or lease of motor vehicles. FBT is levied at 47 per cent of the taxable amount, generally offset by deductions against corporate income tax and GST payable on the purchases and amounts subject to FBT.

- **Road-related GST** includes the GST payable on fuel excise, VoTI of imported vehicles including customs duty, and other road-related activities.

- Prior to 2018, the Commonwealth administered the **Federal Interstate Registration Scheme** (FIRS) to provide a single national registration system for heavy vehicles travelling on interstate roads. In 2017-18, its final year of operation, the FIRS raised around $70 million in revenue for the Commonwealth. From 1 July 2018 onward, responsibility for the registration of heavy vehicles travelling on interstate roads was shifted to state and territory governments.[31]

None of the Commonwealth taxes noted above act as a pricing mechanism for road use. Customs duty and luxury car tax relate to the number and value of motor vehicles, irrespective of any vehicle or motorist's actual use of the road network.

FBT is partly related to the volume of road use, insofar as employers can use a cents-per-kilometre method to determine the value of the taxable fringe benefit relating to the use of a company motor vehicle. However, FBT is intended to offset corporate and personal income tax that would otherwise be payable if the fringe benefit was paid to the employee as cash in their salary or wages. While partly determined by kilometres travelled, FBT is a tax on income rather than a charge for the volume of road use.

Road-related GST is partly related to road use in that it mainly comprises the GST levied on fuel excise. In that respect, it suffers from the same flaws as fuel excise explored in Chapter 2.3.1.2, including being at risk of shrinking as the share of EVs increases over time. Further, GST revenue is pooled and distributed in full to state and territory governments on an untied basis and cannot be directly linked to investment in the public road network.

2.3.3 State and territory fees and charges

2.3.3.1 Overview

State and territory governments levy a series of fixed charges on motorists and owners of motor vehicles. Charges levied by the Western Australian Government include, but are not limited to:

- Stamp duty on motor vehicle purchases
- Transfer fees
- Motor vehicle license (registration)
- Motor injury insurance
- Driver's license fees
- Vehicle inspection fees
- Permits for oversize vehicles and loads.

Generally, charges are fixed per driver/vehicle/instance, related to the tare mass of the vehicle (registration cost) or related to the value of the transaction (stamp duty). In 2020-21, WA Treasury estimates that the 'representative' household will spend around $928 on motor vehicle and driver charges, including:[32]

- Vehicle registration ($385)
- Recording fee relating to vehicle registration ($10)
- Driver's license ($88)
- Motor injury insurance ($404)
- Stamp duty paid on motor injury insurance ($40).

Note that the 'representative' household does not buy or sell any vehicles, which would cause them to incur further stamp duty or transfer fee costs.

In the 2020-21 State Budget, WA Treasury estimated that the State would receive more than $1.4 billion in motor vehicle-related charges in 2020-21, mainly consisting of a little under $1.1 billion in motor vehicle registration fees and $380 million in stamp duty receipts from vehicle transfers. Over the forward estimates period to 2023-24, total motor vehicle taxes are expected to grow at an annual average rate of 3.5 per cent.[33]

This amount does not include stamp duty paid on motor injury insurance (which is not separately reported from other insurance duty) or driver's license fee revenue. Driver's license fee revenue is likely to be substantially smaller than motor vehicle taxes; BITRE estimates WA driver's license fee revenue at just under $50 million in 2018-19.[34]

2.3.3.2 Economic rationale

Motor vehicle taxes represent a relatively stable source of taxation revenue for states and territories. In WA, motor vehicle taxes represent the third-largest source of taxation revenue (after payroll tax and stamp duty on property) and are projected to account for around 16 per cent of total taxation revenue in 2020-21.

Motor vehicle taxes are also resistant to trends identified in Chapter 2.3.1.2 relating to fuel efficiency and the increasing importance of EVs in the vehicle fleet, provided that state and territory governments continue to tax vehicles and drivers irrespective of the engine or vehicle type.

However, motor vehicle taxes and driver charges are not an efficient pricing mechanism for road use. There is no reliable relationship between the determinants of motor vehicle taxes and driver fees – such as the number of vehicles, drivers, vehicle mass or number of transfers – and actual road use.

State and territory governments are required to fund auxiliary aspects of the road system – including policing, road safety, justice and healthcare – that may not necessarily be determined by the volume of road use. For example, the cost to WA Police and the judicial system of enforcing road rules against an individual traffic offender is not necessarily related to the number of kilometres driven by that offender.

Many of these auxiliary functions are public goods that states and territories should fund using a broad-based taxation mechanism, rather than through user charging. It would not be feasible to apply a user charge to fund, for example, the full cost of WA Police enforcing road rules.

The existing regime for motor vehicle and driver charging could arguably perform the role of a broad-based taxation mechanism to fund these auxiliary road functions. However, they should be complemented by an efficient mechanism to fund the direct provision of the road network.

2.3.4 Road tolls

2.3.4.1 Overview

There are currently 22 toll roads in operation in Australia, representing just 300km of the country's 880,000km road network.[35] All toll roads are in NSW, Victoria and Queensland, with all but one toll road being within the Sydney, Melbourne and Brisbane metropolitan areas.

Most tolls in Australia are levied on a fixed basis; the user pays the same fee to use any segment of the toll road, irrespective of distance travelled, time of day, day of the week or congested conditions (Table 2.1). Since 2013, all toll roads in Australia have been cashless.

Table 2.1: Toll roads in Australia

Location	Toll road	Toll mechanism	Toll operator[ii]
Sydney	Sydney Harbour Bridge	Time/day dependent	TfNSW
	Sydney Harbour Tunnel	Time/day dependent	Tunnel Holdings
	Cross City Tunnel	Fixed	Transurban
	Lane Cove Tunnel	Fixed	Transurban
	Military Road E-Ramp	Fixed	Transurban
	M1 Eastern Distributor	Fixed	Transurban
	M2 Hills	Fixed	Transurban
	WestConnex M4 Motorway	Distance travelled	Transurban
	WestConnex M8 Motorway	Distance travelled	Transurban
	M5 East	Distance travelled	Transurban
	M5 South-West	Fixed[iii]	Transurban
	Westlink M7	Distance travelled	Transurban
	NorthConnex	Fixed	Transurban
Melbourne	CityLink	Distance travelled	Transurban
	EastLink	Distance travelled	Horizon Roads
Brisbane	Go Between Bridge	Fixed	Transurban
	Clem7	Fixed	Transurban
	Airport Link	Fixed	Transurban
	Legacy Way	Fixed	Transurban
	Gateway Motorway	Fixed	Transurban
	Logan Motorway	Fixed	Transurban
Regional QLD	Toowoomba Second Range Crossing	Fixed	Transurban

Source: BITRE; IBISWorld

Several toll motorways in Sydney and Melbourne use a distance-based approach, with the toll consisting of a flag fall plus a charge per kilometre travelled. For example, tolls on the M7 motorway are determined by the distance between the motorist's entry and exit points up to a maximum of $8.41 for small/light vehicles and $25.23 for large/heavy vehicles (equivalent to a 20km journey).[36] An additional fee of $0.75 is added to the amount payable for users who do not register their vehicle with Westlink's preferred toll retailer, incentivising users to do so.

The distance-based approach to tolling has become more common on Sydney toll roads. This has been the approach adopted on new toll roads since 2017, and the toll mechanism on the M5 South-West Motorway will shift from being fixed per vehicle to distance-based in 2026.

The Sydney Harbour Bridge and Tunnel are tolled based on direction of travel, time of day and day of the week. There is no toll payable when travelling northbound (out of the Sydney CBD). Tolls for southbound travel (into the Sydney CBD) range from $2.50 for weekend trips between 8pm and 8am, to $4.00 on weekdays during the AM and PM peak periods.[37]

All Queensland toll roads have a fixed cost for four vehicle classes, irrespective of distance travelled. Tolls are constant for all times of day and days of the week with the exception of the Go

[ii] References to Transurban include operators that are wholly- or majority-owned by Transurban or its consortium partners.
[iii] The M5 South-West toll mechanism will shift to a distance travelled approach in 2026.

Between Bridge, Clem7 and Legacy Way toll roads, which have a small peak/off-peak spread for heavy commercial vehicles only.

Australia's toll operators are projected to record $2.7 billion in revenue in 2020-21, down around 8 per cent from a peak of $2.9 billion in 2018-19 due largely to the impacts of the COVID-19 pandemic on road travel. Revenue is projected to grow at an annual average rate of 4.5 per cent over the next five years, as road travel resumes and the toll network expands due to the completion of several new toll roads.[38]

The toll road industry in Australia is highly concentrated. ASX-listed Transurban Group is the ultimate parent entity for toll roads and operators representing around 80 per cent of the market, including 100 per cent of Queensland toll roads, with estimated toll road revenue of $2.1 billion in 2020-21 across Australia.[39]

Victoria's EastLink tollway is operated by Horizon Roads Pty Ltd through its ConnectEast subsidiary, with estimated revenue of $339 million in 2020-21, while Tunnel Holdings Pty Ltd operates only the Sydney Harbour Tunnel toll with around $50 million in annual revenue.[40]

The NSW Department of Transport, trading as Transport for New South Wales (TfNSW), is Australia's only public sector toll operator. TfNSW directly operates the Sydney Harbour Bridge toll through its Road and Maritime Services (RMS) division. In 2020-21, RMS is expected to record around $155 million in toll revenue.

2.3.4.2 Economic rationale

Most toll roads in Australia were developed through public-private partnerships (PPP), and the primary purpose of allowing private operators to operate the toll concession has historically been to recover the private component of the initial capital cost. The motivation is chiefly financial rather than economic, with fixed tolls set based on projections of vehicle movements irrespective of economic or distributional impacts.

Tolls have not generally functioned to manage congestion. Indeed, historically, contractual arrangements between state and territory governments and private delivery contractors and toll operators prevented tolls from acting as a partial price on congestion by varying according to time of day or day of the week.[41]

More recently, the implementation of distance-based tolls more closely reflects a road user charge, with users paying according to their relative impact on road wear and tear. While not dynamically mass-based, such tolls are generally higher for heavy vehicles to account for their greater impact on roads. However, where such tolls have been implemented in Australia to date, they have not taken account of time of day or day of the week, and hence do not reflect congestion conditions.

3 User charging mechanisms

3.1 Overview

This chapter reviews a range of road user charging mechanisms implemented in Australian overseas jurisdictions. Four user charging mechanisms are explored in this chapter:

- Distance-based charges linked to the volume of road use
- Cordon charges linked to the location of road use
- Parking charges
- Tolls for specific road segments.

Distance-based and cordon charges are the main focus of the chapter, given that these mechanisms are relatively novel to the Australian context.

3.2 Distance-based user charges

3.2.1 Overview

Proposals for distance-based charges have become prominent in recent years in response to the rise in EVs.[iv] As outlined in Chapter 2.3.1, policymakers have traditionally viewed fuel excise as an indirect charge for road use. EVs implicitly avoid paying fuel excise,[v] and future fuel excise revenue will decline as the EV share of the vehicle fleet increases.

Distance-based charges recently introduced in other jurisdictions have typically taken the form of a fixed cost-per-kilometre charge levied on EVs only, while ICE vehicle drivers continue to pay indirectly for road use through fuel taxes. Other jurisdictions have implemented distance-based charges for vehicle classes irrespective of whether they use traditional fuels but have recently introduced lower rates for EVs.

In the simplest form, a direct user charge is linked only to the number of vehicle kilometres travelled (VKT). Other variables can be included that increase the complexity of the charging mechanism, but also increase the alignment between the beneficiaries of road network provision and those who pay for it:

- **Vehicle mass:** For each VKT, larger and heavier vehicles cause more road wear and tear than smaller, lighter vehicles.
- **Location:** Roads in major CBDs and inner metropolitan areas are more likely to be congested. A higher unit charge for highly congested roads could incentivise users to switch to public transport, while providing a (relative) saving to those driving in less congested areas, or change their travel patterns.
- **Time:** A complement or alternative to location, varying the charge by time of day and day of the week would help align the amount users pay with the social cost of congestion caused by their road use. Time-based charges could also help spread road use either side of conventional peak periods and encourage drivers to switch to public transport during periods of high demand, or change their travel patterns.

[iv] For the purpose of this discussion, EVs include battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), fuel cell electric vehicles (FCEVs) including those fuelled by hydrogen, and other hybrid electric vehicles (HEVs) that combine the use of an electric motor with a conventional internal combustion engine (ICE).
[v] PHEVs and other HEVs pay fuel excise on the volume of fuel they purchase, which would typically be substantially lower than a conventional ICE vehicle.

3.2.2 Considerations for implementation

3.2.2.1 Recording distance travelled

Accurately charging each road user requires the revenue collecting authority to be supplied with, or otherwise obtain, information from the vehicle's odometer. The means to do so largely exist already, albeit they vary in complexity.

Under the distance-based scheme proposed in Victoria, users are required to report odometer readings through their digital account with VicRoads. Supporting evidence is required to be retained by the user, although the format of this evidence is not specified in the legislation.

This self-reporting option is susceptible to underreporting and therefore underpayment of the charge. Suggested alternatives include requiring the user to submit a digitally timestamped photograph of their odometer instead, or policing potential fraud using software complemented by random, manual audits undertaken by the revenue collecting authority, like the way the ATO polices personal income tax returns.

The self-reporting option is also available under schemes implemented overseas, including in the US states of Utah and Oregon. However, both those states also offer mechanisms that require the use of a telematic device installed in the car – either with GPS technology, mobile internet technology or linked to the vehicle's onboard diagnostics system – which automatically collect and transmit travel distance information. These systems require less manual effort on the part of the user but have raised potential data sharing and user privacy concerns in some jurisdictions.

Such systems can also be configured to receive information directly from onboard computers in vehicles with built-in telematics capability (such as the Tesla Model 3), where the user authorises the vehicle manufacturer to enable this feature.

Under New Zealand's existing road user charge (RUC) system, users of vehicle types subject to RUC are effectively required to pre-pay their distance-based charge in advance, purchasing a 'distance license' in blocks of 1,000km. The distance license is required to be displayed on the vehicle dashboard. Each RUC vehicle must also be fitted with a 'hubodometer' (a distance-recording device) from an approved manufacturer; alternatively, users can install an approved electronic distance recorder with GPS or other telematic capabilities. The distance recorded on the hubodometer or electronic system is used to audit whether the user has exceeded the allowable distance on their distance license.

3.2.2.2 Recording mass

Extending the simple distance-based charge to include a mass component would be relatively straightforward in a Western Australian context. Vehicle mass is already recorded in the annual vehicle registration process, and users are accustomed to paying variable charges for vehicle registration based on vehicle mass. The mass-distance charge could take the form of tiered per-kilometre charges based on categories of vehicle mass, in the same way that the New Zealand road user charge works presently.

3.2.2.3 Recording location and time

Incorporating location and time variables into a distance-based user charge is more complex. Both variables require information unlikely to be recorded by the user or their vehicle and would likely need to be recorded by a telematic device with GPS or mobile internet capability.

The use of telematic devices installed in vehicles is relatively common in jurisdictions where distance-based charges apply to heavy vehicles (such as New Zealand). Such devices can record the location, time of day and day of the week of the vehicle's travel and transmit this to a system maintained by the revenue collecting authority. However, the requirement to use such devices has raised privacy and other concerns in some jurisdictions. For example, both the Victorian and SA Governments provided early assurance that no such devices would be mandatory in proposed user charging schemes in those states.

Location and time variables could be recorded using similar equipment used for cashless toll roads in New South Wales, Victoria and Queensland. For most toll roads in Australia, users link their vehicle's registration number to their account with the toll operator and payment occurs automatically. A similar system could be used to record kilometres travelled on the road network by location, time of day and day of the week – combined with previously registered vehicle mass information – to enable a full mass-distance-location-time charge. However, implementing this approach on a large metropolitan road network would require significant, costly investment in infrastructure on the part of the WA Government.

A potential alternative would be to combine a mass-distance charge with a cordon charge (discussed further in Chapter 3.3) so that the per-kilometre charge is simply raised or lowered depending on whether a user is driving within the cordoned area. This would approximate a mass-distance-location-time charge.

3.2.2.4 Impacts on EV uptake

The key motivations for exploring a direct user charge on EVs include ensuring a revenue stream to replace lost fuel excise revenue in the future, and establishing a more efficient price mechanism for road use than is provided by existing taxes, fees and charges.

There are environmental benefits from greater EV uptake and reduced consumption of fossil fuels in ICE vehicles. A direct user charge should be set such that it does not adversely impact the uptake of EVs.

Analysis undertaken by the University of Queensland suggested that the introduction of a 2.5 cents per kilometre EV charge could result in new EVs representing 40 per cent of new vehicle sales by 2050, rather than 65 per cent in a scenario where no charge applies.[42] However, this impact was modelled in a scenario in which no other incentives for EV purchases were provided, and it is not clear how this analysis treated the future of fuel excise or considered the impact on EV uptake of a user charge applied to all vehicles.

Many factors determine a user's willingness to purchase and use an EV rather than a conventional ICE vehicle. Studies have suggested that tax incentives to encourage EV uptake – such as discounts on stamp duty or vehicle registration fees – have little effect if consumers have low confidence in the underlying EV technology, such as being concerned about vehicle range or the availability of charging infrastructure.[43] For example, the number of new EV sales per capita was approximately the same in WA and NSW in 2019, despite NSW offering a concession for motor vehicle registration for EVs and WA offering no such concession.

If a marginal tax benefit has not necessarily had a material impact on supporting EV uptake, it may be the case that a direct user charge may not have an adverse impact, provided that the magnitude of the charge is appropriate.

Upfront costs to acquire an EV, rather than average running costs, appear to be front of mind for potential consumers. A survey conducted by the Electric Vehicle Council found that 71 per cent of respondents were discouraged from purchasing an EV due to upfront prices being higher than petrol or diesel vehicles.[44] Around four in five EV models available in Australia are priced at more than $60,000;[45] by comparison, the average new car purchased in WA in 2020 cost around $38,000.[46]

EVs are a relatively new product in the Australian vehicle market, with limited supply and high cost of acquisition relative to ICE vehicles. As supply expands and EV prices approach parity with ICE vehicles, it is likely that the rate of EV uptake will accelerate (as reflected in the CSIRO EV uptake scenario analysis, see Chapter 2.3.1.3).

Therefore, it may be prudent for governments to implement EV user charges sooner rather than later, so that these charges are in place before the 'natural' uptake of EVs accelerates in coming years. That would mean that an individual consumer's purchase decision is not marginally impacted by the introduction of a user charge later, when EV prices are falling.

Further, the impact of an EV user charge on a consumer's decision will be subject to the cost of running an ICE vehicle. If governments were to introduce a road user charge on all vehicles, and then offer a discount on this charge for EVs, then EV running costs would decrease relative to ICE vehicle running costs and an adverse impact on EV uptake would be unlikely.

For example, in 2019 the Illinois legislature passed a measure to set the annual motor vehicle registration charge at US$148 for ICE vehicles and US$248 for EVs, effectively imposing a US$100 EV tax. At the same time, the legislature doubled the rate of gasoline tax from US$0.19 to US$0.38 per gallon,[47] resulting in the average ICE vehicle user paying around US$150 in additional gasoline tax each year.[48] Despite the imposition of an additional charge on EV users, the average EV user was better off overall relative to the average ICE vehicle user.

Governments could consider similar or other methods to ensure EV users are not disadvantaged, relative to ICE vehicle users, when the charge is introduced. For example, a time-limited discount on a user charge could be provided to EV users who register their vehicle before a certain date. The total amount payable by an EV user could also be capped on a six-monthly or annual basis, at a level that would ensure no EV user pays more than the average ICE vehicle pays in fuel excise.

3.2.3 Case studies

Victoria

The Victorian Government is the only government in Australia to announce a **distance-based EV charge** to date. The South Australian Government announced a charge in its November 2020 budget, but subsequently delayed its introduction subject to industry consultation and monitoring of the Victorian implementation.[49] The NSW Government is investigating a similar scheme ahead of its 2021 budget but has not yet committed to doing so.[50]

From 1 July 2021, the Victorian Government will introduce a **2.5 cents per kilometre** charge for EVs. A lower 2.0 cent charge will be payable by PHEV users, acknowledging that these users still pay fuel excise for the ICE component of the hybrid engine, albeit less than conventional ICE vehicles. The charge does not account for vehicle mass, location, time of day or day of the week of travel.

The average Victorian car user travels around 13,000 kilometres per year, meaning that the average EV user would pay an additional **$330 per year** and the average PHEV user around $260 per year under this scheme.[51] The Government expects the tax will **raise $30 million over its first four years** of implementation, between 2021-22 and 2024-25.[52]

To measure distance travelled, users will be required to **submit odometer readings** at the same time that they pay their motor vehicle registration (on a quarterly, biannual or annual basis) through their existing account with VicRoads. Users must provide an initial odometer report within 14 days of the charge coming into effect on 1 July 2021. Failure to submit an odometer report risks the EV being deregistered.

The legislation established that odometer reports must be **accompanied by 'evidence'**, but the definition or format of this evidence was left to be determined through subsequent regulation.[53] It is unclear whether this includes information transmitted from an EV's onboard computer or user interface, or is limited to user-generated evidence such as a photograph of the odometer. The latter method runs the risk of evasion or underreporting; however, the legislation provides for penalties (including vehicle deregistration) for users who do so.

The Victorian Government – and the SA Government, in describing its proposed measure **– ruled out the use** of GPS, cellular or other telematic devices or systems in measuring users' distance travelled, opting for a self-reporting system instead.

While Victoria offers a $100 per year discount on motor vehicle registration costs for EVs (including PHEVs but excluding conventional HEVs) this is lower than the $260 to $330 per year additional cost payable by the average EV or PHEV user, respectively.

Acknowledging the role of 'range anxiety' in limiting consumers' willingness to purchase an EV, the Victorian Government announced a $25 million investment in EV charging infrastructure in its 2020-21 state budget, at the same time as announcing the EV user charge.

New Zealand

In New Zealand, only petrol and some automotive gas fuels are taxed through an excise tax. Vehicles not powered by these fuels – including diesel vehicles and EVs – instead pay a **distance-based road user charge** (RUC).

The RUC is levied in blocks of 1,000km, which are required to be purchased in advance by the user in the form of a 'distance license'. In addition to displaying the distance license on their dashboard, RUC users must also either fit a 'hubodometer' (a distance recording device calibrated to the vehicle's specific tyre size) to their vehicle, or install an electronic distance recorder in the vehicle with GPS or other telematic capability. The distance recorded on the hubodometer or electronic system is used to audit whether the user has exceeded the distance purchased under their distance license.

RUC rates vary by vehicle type and mass. The lowest rate applies to diesel-powered passenger vehicles with a mass less than 3.5 tonnes, paying NZ$76 per 1,000km (NZ 7.6 c/km). Rates are as high as NZ$435 per 1,000km (NZ 43.5 c/km) for a truck with four axles.[54]

Like Australia's fuel tax credits, refunds are offered on the NZ RUC for vehicles predominantly used off-road and for RUC vehicles powered by petrol or gas to cancel out any double-taxation.

In 2016, the NZ Government introduced its Electric Vehicles Programme (EVP), involving a range of measures to incentivise EV uptake and reach the Government's goal of 64,000 EVs on New Zealand roads by the end of 2021.[55]

One of the measures announced in the EVP was an **exemption to the RUC for light EVs**. This would save the average New Zealand EV user around NZ$600 per year in RUC. The exemption runs until 31 December 2021 or until EVs comprise 2 per cent of New Zealand's light vehicle fleet. An additional RUC exemption was introduced later for heavy electric vehicles including trucks and buses.

This mechanism **fails to function as a road user charge**, as EV users avoid contributing to road funding through both the RUC and fuel tax. However, the original RUC scheme – while functioning more like a user pays model – would likely have failed to incentivise EV uptake, by charging EV users the same rate per kilometre as diesel vehicle users.

When the exemption ends, the reintroduction of the RUC for EV users will restore its functionality as a user pays mechanism. At the same time, the NZ Government intends to lower all-in costs for EV users through complementary measures to ensure they are not paying the same, or more, as ICE vehicle users:

- EV users are eligible for a temporary reduction in ACC levies (New Zealand's compulsory insurance levy scheme paid as part of motor vehicle registration fees), saving each EV owner NZ$68 per year.
- The NZ Government has announced a **Clean Car Standard**, an emissions standard for imported vehicles, to come into effect in 2023. Importers will have to pay a penalty or purchase a 'credit' from another importer if they wish to import a vehicle with average emissions greater than the Standard.
- The Government has also announced, but not yet legislated, a **Clean Car Discount** scheme, under which consumers either receive a discount or pay a fee, based on the their vehicle's emissions rating. The scheme is intended to be self-funding, as revenue collected from levies on higher-emissions vehicles will be used to fund subsidies to lower-emissions vehicles. Different discounts and fees apply for new and used vehicles, as used vehicles tend to have a lower purchase price and a shorter remaining useful life, with savings of up to NZ$8,000 for new EVs and NZ$2,600 on used vehicles. The scheme is estimated to lower carbon emissions by 1.6 million tonnes CO_2e and result in lifetime fuel savings of around NZ$627 million or NZ$5,200 per vehicle.[56]

Oregon

Through the Road User Fee Task Force, established by the State Legislature in 2001, Oregon identified a **per-mile charging system as the best alternative to replace fuel excise** and undertook two pilot tests in 2006 and 2012 to gather feedback on different road charge options.[57]

In the 2006 pilot, there were 285 volunteer vehicles, **each installed with GPS devices**. Two service stations in Portland were created with **point-of-sale systems** used to collect data from the vehicles. Volunteers would go to one of these service stations to fuel their vehicles where a central reader would read the mileage from the GPS and calculate the amount payable by deducting the vehicle's last mileage reading from the current reading.

The **mileage fee was added**, and **gas tax deducted**, from the final amount payable. Different pricing zones were also established electronically via GPS and resulted in a 22 per cent decline in driving during peak hours.

Following feedback received from the first pilot, including the **concerns regarding GPS tracking**, the second pilot began in 2012 and tested four different road usage charging methods, from which the 88 volunteers could choose:

- GPS device
- Non-GPS device
- Flat fee (US$45 per month or US$135 for three months)
- Smartphone app.

Participants that didn't choose the flat fee were charged monthly at 1.56 US cents per mile. This system was deemed easy to use and was shown to be 97 to 98 per cent accurate when comparing mileage readings to the odometer. Vendors and participants also felt that this system helped to protect their privacy. The lessons learned in the two pilots were then used in the following phase of the program known as the 'OReGO Project'.

The OReGO Project started in 2015 and involved 5,000 participants driving light-duty vehicles. The charge program displays a technology-agnostic approach, where volunteers could be selective in the technology used to record their mileage. A mileage reporting device charging 1.5 US cents per mile travelled on public roads was installed; volunteers could choose between GPS or non-GPS devices. Refunds were offered on fuel tax paid and on private road travel in Oregon and out of state miles. In a 2016 survey, most citizens in Oregon agreed that a **mileage-based system for road usage charging was fairer** than other options presented.

The OReGO voluntary user charge is now available to all vehicle users in Oregon. Users enrol in the program by registering with an authorised account manager. The account managers offer different options for users to install **GPS devices**, **non-GPS devices**, or **self-report odometer readings**. Users pay **1.8 US cents per mile** travelled on Oregon roads.

Users enrolled in the program receive a credit for fuel tax paid (which in Oregon is levied at US$0.36 per gallon). The program is only open for light vehicle users, while vehicles with a mass of more than 26,000lb (around 11.8 tonnes) pay a separate **weight-mile tax**. In this sense, Oregon's system resembles a relatively efficient mass-distance user pays model.

As EV users do not pay fuel tax, Oregon introduced a further incentive to encourage EV users to opt into the user charge system. EV users will pay **lower registration fees** if they are enrolled in the program. Oregon drivers typically pay registration fees two to four years in advance and face registration fee increases expected in 2020 and 2022. The average EV user enrolled in the distance-based charge will pay an average of US$43 per year in vehicle registration, a **70 per cent saving** on the US$153 per year paid by EV users not enrolled.[58]

Utah

To ensure that EV users contributed toward the cost of road provision, Utah charges EV users an additional fee on top of their annual motor vehicle registration fee. In 2021, this additional fee is US$120 for fully electric vehicles. Acknowledging that hybrid vehicles pay some fuel tax, a lower fee of US$52 is payable by PHEV users and US$20 by HEV users.[59]

From 1 January 2020, the Utah Department of Transportation (UDOT) introduced a **distance-based road user charge** that EV users can opt in to. The user charge is an optional alternative to the additional annual registration fee; eligible participants can choose to either pay the distance-based charge of 1.5 US cents per mile, or pay the flat fee.

The **distance-based charges are capped** at the amount equivalent to the relevant flat fee, ensuring that no user is worse off by enrolling in the distance-based charge. The flat fee is equivalent to driving 8,000 miles per year under the distance-based charge; given the average Utah driver travels around double that per year,[60] this suggests the distance-based charge mainly benefits vehicle owners who seldom drive or drive short distances, relative to paying the annual flat fee.

As of January 2021, more than 3,600 users had voluntarily enrolled in the program, representing around 7 per cent of the 51,000 registered EVs and other alternative fuel vehicles in Utah.[61] UDOT contacted registered EV owners directly when the program was launched to invite them to participate.

The program provides alternative options for recording mileage:

- Users are required to download and install the prescribed smartphone app and use this app to **capture odometer photos** and transmit these to the authorised commercial account manager on enrolment and annually thereafter.
- For users whose vehicles have onboard diagnostics (OBD) technology, installation of a device with GPS and mobile network capability is required. The OBD device transmits mileage information to the smartphone app.
- For users whose vehicles have more advanced, built-in telematics capabilities (for example, the Tesla Model 3) the user can authorise the vehicle manufacturer to directly report their mileage information without needing to use the smartphone app.

All options require a network connection of some description and a digital account with the authorised commercial account manager. Users without an internet connection or smartphone are not able to enrol in the distance-based charge and must pay the annual flat fee.

Responding to potential user concerns around data sharing and privacy, UDOT assures participants that only anonymised, aggregated data collected from the OBD and telematic devices is provided by the commercial account manager to the state to calculate the tax payable. Location data is implicitly collected but not shared, as is individual driver behaviour data (such as travel speeds and braking behaviour).

Since January, participants recorded 2.1 million billable miles, generating a revenue of $32,000 at the charge rate of 1.5 cents per mile.[62]

The state intends to expand the distance-based charge to all users and vehicle types to **completely replace fuel tax** by the end of 2031.[63] However, raising the necessary level of revenue to offset fuel tax may be subject to advances in technology making it possible to expand the charge beyond a simple distance-based measure. UDOT has indicated it would also like to vary the charge by **location** or **time of day**, both to raise more revenue from users on congested roads and to encourage users to switch to public transport as an alternative mode.

3.3 Congestion charging

3.3.1 Overview

The proportion of Australia's population living in metropolitan areas has increased over time, growing from 40 per cent of the population to more than two-thirds over the last century. In Western Australia, the share of the population residing in the Greater Perth area is expected to reach 75 per cent by 2031.[64]

As cities grow in population size, so too does the issue of congestion in major CBDs and inner metropolitan areas.

On most metropolitan roads in Australia where congestion is a problem during peak periods, there is no price mechanism in place. Each additional user adds to congestion, resulting in higher marginal costs for the next user in the form of a longer, slower journey. Users incur no additional financial cost for driving on congested roads; instead, governments incur higher costs of additional investment required to increase road capacity to alleviate congestion.

A congestion charge is a price on congested road use, which offsets the social cost of additional investment in road capacity by imposing a financial cost on users. Users who wish to avoid the congestion charge can adjust their travel behaviour by driving at different times of the day or by switching to public transport or other modes of travel. This frees up road capacity for other drivers and reduces congestion.

Modelling undertaken by the Grattan Institute suggests that if drivers were charged to enter the Sydney CBD during peak periods, this would result in 3,000 fewer cars on Sydney's roads in peak periods, with 40 per cent fewer cars entering the CBD during the morning peak period. This would result in increases in average travel speeds of 11 per cent into the CBD in the morning and up to 20 per cent on sections of major congested roads.[65]

A congestion charge is not solely about raising revenue, and it is not clear that such a system, if implemented in Australian capital cities, could raise a sufficient amount to offset lost fuel excise revenue in the future.

For example, the London congestion charge raised around £147 million (AU$260 million) in 2018-19, net of costs of administering the system, an average of AU$18 per head of population in the Greater London metropolitan area. A similar scheme that eventuated in the same average revenue per capita in the Greater Perth area would raise around AU$37 million per year, equivalent to 3 per cent of WA's population share of current net fuel excise revenue.

If retaining overall levels of revenue were the objective, a congestion charge in the Greater Perth area would likely need to be complemented with other road user charges. However, a congestion charge can also function as a demand management tool, resulting in more efficient traffic flow and lower costs borne by government for investment in expanding road capacity in the future. In this sense, a congestion charge may have merit as a tool to influence users' travel behaviour irrespective of its effectiveness as a revenue measure.

3.3.2 Considerations for implementation

3.3.2.1 Congestion charge mechanism

Congestion charging can be implemented in various ways. Three typical systems are:

- **Cordon charging** where drivers pay to cross a boundary into (and at times out of) a cordoned zone such as a CBD
- **Corridor charging** where drivers pay to drive along an urban freeway or arterial road
- **Cordoned distance-based charging** where a distance-based charge similar to those outlined in Chapter 3.2 would apply only within the cordoned area on a per-kilometre basis.

Congestion charges can be fixed or variable. A flat charge could apply only on certain days and during times which reflect peak travel hours (e.g. 7am to 9am and 4pm to 6pm Monday to Friday). Variable charges could rise and fall based on the time of the day (e.g. a higher charge during peak periods and lower charge at other times of day), by vehicle size (being higher for heavy vehicles such as trucks) or by point of entry (e.g. a higher charge along the busiest thoroughfares).

The point of entry charge is more relevant to cordon congestion mechanisms, where vehicles are charged once they cross a geographic boundary that surrounds a certain area. In some jurisdictions, including London and Milan, vehicles are only charged a single toll per day, regardless of the amount of times entered and exited from the cordoned area. This tends to be less effective in accurately reflecting externalities.[66]

Congestion charges have been shown to be effective at reducing car driver trips within the cordoned area, encouraging people who would normally drive into the CBD to switch to more cost-effective transport modes to avoid congestion charges. If considering implementing a congestion charge in the Perth metropolitan area, the WA Government should consider the impact of mode-switching on public transport demand and whether improvements to public and active transport capacity – such as increasing the number and frequency of rail and bus services, providing additional park-and-ride spaces outside the cordon area and expanding safe and accessible bicycle and pedestrian infrastructure – is necessary.

To the extent that a congestion charge results in an overall reduction in road vehicle kilometres travelled and a switch to other transport modes, there may be future savings in financial costs of road maintenance incurred by government and reductions in negative externalities such as carbon emissions.

3.3.2.2 Technology

The technology used to implement a congestion charge would be similar to that used on private toll roads in Australia. Dedicated Short-Range Communication (DSRC) technology involves the use of overhead gantries to scan in-vehicle tags or transponders as vehicles cross the toll threshold. Automatic number plate recognition is also common and uses cameras mounted on gantries to capture images of number plates, which are converted to text using optical character recognition (OCR) software.[67]

Users could be encouraged to install the necessary telematic device or register their vehicle with the charging authority in advance, by offering a discount on the charge. This is common for private toll roads in Australia, where users who neither install a telematic device nor register their number plate pay a higher toll to cover the cost of the toll operator manually matching the captured number plate to the vehicle user’s address for billing.

3.3.2.3 Equity

Equity concerns exist as congestion charges are may disadvantage lower-income commuters who must dedicate a larger portion of their incomes to pay the congestion charge. These commuters may not be able to easily substitute away from using private vehicles if they live in areas where public transport infrastructure is less accessible, or services are less frequent, and where active transport is less feasible due to greater travel distance.

While a fixed cordon charge would apply equally to all users, a corridor charge or cordoned distance-based charge may also adversely affect lower-income commuters who are more likely to live further away from the CBD and other inner metropolitan employment centres.

Conversely, high costs associated with driving into the CBD during peak periods – including parking costs – may mean that lower-income commuters are less likely to incur the congestion charge. Analysis undertaken by the Grattan Institute suggests that most commuters driving during peak hours in the CBD tend to have higher incomes, and that higher-income earners tend to drive further.[68]

Offsetting measures may be required to accompany the introduction of a congestion charge for vulnerable or other disadvantaged cohorts. For example, people with a disability may be required to commute to the CBD during peak hours by car because alternative modes of transport are inaccessible.

3.3.3 Case studies

Singapore

In 1975, Singapore introduced an Area Licence Scheme (ALS), a timed **cordon charge** payable by vehicles that entered a 2 square-mile central business area between 7:30am and 9:30am Monday to Saturday, except for buses, motorbikes and police vehicles. All vehicles were required to buy a special licence to enter the cordoned area, priced at US$1 per day or US$20 per month. Parking fees within the cordoned area were also doubled. The ALS resulted in a **20 per cent reduction in congestion**.[69]

The ALS was later replaced in 1998 by an Electronic Road Pricing (ERP) scheme, which Singapore uses to this day. This ERP system is fully automatic and is in effect from 7am to 8pm from Monday to Saturday. The **charge varies according to the location and type of vehicle**. To reflect congestion in real time, it also varies according to the **route taken**, **time of day** and **direction of travel**.

To charge road users, an in-vehicle unit (IU) transponder is required to be fitted to the vehicle's dashboard with a smartcard inserted that stores the user's pre-purchased credit. These devices have visual displays and audio signals which inform the driver about deductions made or low balance. Charges are collected electronically at more than 50 charge points across the city and are variable, up to US$3 per charge. Overhead gantries are used at these charge points and can detect the vehicle type and the congestion at specific times. When a vehicle with an IU passes under the gantry, the variable congestion charge is deducted from the smartcard. Vehicle users who fail to install an IU are penalised with a fine of US$50 and those with insufficient funds are charged US$6. This technology allows for the **efficient identification** and charging of multiple vehicles at full freeway speeds. It is estimated that there are 300,000 daily pricing transactions.

Other complementary measures were implemented to discourage car use, coinciding with the introduction of the cordon charge. This includes an **increase in parking fees** within the cordoned area, increase in the number and frequency of public transport services, high vehicle occupancy lanes and more than 15,000 park-and-ride spaces created outside the cordoned area.

Since its introduction, Singapore has experienced a reduction in vehicle traffic and an increase in average speeds within the cordon area. Bus and train ridership have increased by 15 per cent and carbon emissions have fallen by 10 to 15 per cent within the inner city. The ERP system has also produced an estimated **annual net revenue of US$100 million**, which the government has used to support public transport and street safety.[70]

London

Since 2003, London has implemented a **cordon-style congestion charge** which covers a 21 square kilometre area in central London. Normally, a flat rate of £11.50 (around AU$20) is charged to drivers who enter the area between **7am and 6pm on weekdays**. In the wake of the COVID-19 pandemic, the charge has been extended to apply between 7am and 10pm, seven days a week (excluding Christmas Day) and increased to £15.00 (AU$27), to ensure London's economic recovery is not 'restricted by cars and congestion'.

Drivers who do not pay in advance or on the day of their travel face a higher charge of £17.50 (AU$31) and have three days to pay, otherwise they face a fine of £160 (AU$290). Motorbikes, mopeds, bicycles, emergency services, taxis, minicabs and most drivers with a disability are exempt from the charge. **Residents** within the congestion area receive a 90 per cent discount.

Since the cordon charge was introduced, London has experienced a reduction in congestion and noise, an increase in average speed, better air quality and public health. By 2011, **bus ridership reached a 50-year high** and **bicycle trips increased by 79 per cent** relative to 2001 levels.

Studies have also found that this charge has led to a **reduction in the number of serious and fatal car accidents** in the congestion zone as well as a reduction in bicycle accidents.[71] It has also proven to be successful as a funding source for future transportation enhancements. During its first 10 years, the congestion charge raised gross revenue of £2.6 billion (AU$4.7 billion) with 46 per cent of revenue (£1.2 billion or AU$2.2 billion) reinvested into transport infrastructure.[72]

To encourage polluting vehicles to become cleaner and improve air quality, an **Ultra-Low Emission Zone** (ULEZ) and **Low Emission Zone** (LEZ) were introduced. The LEZ covers most of Greater London while the ULEZ is in place in central London only. Vehicles must meet strict emission standards to enter the zone free of charge. For instance, in the ULEZ vehicles that do not conform to these standards will face a daily charge (additional to the congestion charge) of £12.50 (AU$22) for cars, motorbikes and vans or £100 (AU$180) for trucks, buses and coaches.[73]

Both low emission zones have shown to be effective, with the ULEZ resulting in a **20 per cent reduction in emissions** and **9,400 fewer cars** entering the ULEZ zone every day.[74] The introduction of the LEZ resulted in a **30 per cent reduction** in journey time delays and **15 per cent reduction** in the number of vehicles within the zone, when it was first introduced.

Users of **electric and plug-in hybrid cars** are offered a greater incentive, with a 100 per cent discount to the congestion charge. This also applies to passenger vehicles with nine or more seats.[75]

The congestion charge is applied using **automatic number plate recognition** technology. The system comprises overhead gantries mounted with cameras at all entrance points, pavement markings and street signage. There are 197 camera sites which monitor every lane of traffic at entry and exit points and are used to photograph number plates as a vehicle enters or leaves the charging zone.

Potential privacy concerns are addressed by not storing vehicle information. Once the congestion charge has been paid – or if the vehicle is exempt from paying the charge – the image is deleted from the system within two days. Images are only kept on record for vehicles with outstanding charges but are deleted once these charges have been paid.[76]

Stockholm

Stockholm's **cordon congestion charge** takes advantage of the limited number of bridge crossings into central Stockholm. This congestion charge was implemented in 2007 following a six-month trial in 2006. Travel time reliability increased, and **public transport usage** also increased by 4 to 5 per cent. In September 2006, a few months after the trial ended, a referendum was held in which the majority of Stockholm residents **voted to make the congestion charge permanent**.

Congestion charges tend to be viewed unfavourably by the public, as they ask people to pay for road access hitherto enjoyed for free. This was observed in Stockholm, where the proposed congestion charge had very limited public support prior to the trial in 2006, with almost 70 per cent resident opposition. As a result of the effectiveness of the trial in reducing congestion, public attitudes about congestion charging began to change and **support rose during and after the trial period**.[77]

Currently, the charge is in operation between **6:30am and 6:30pm weekdays**, with no charge on public holidays, the day before public holidays or during the month of July (a full month of school holidays in Stockholm). The congestion tax was increased in 2016 for the first time since its introduction, with the largest increase applied to the two highest peak periods (7:30am to 8:30am and 4pm to 5:30pm) from SEK 20 (AU$3.00) to SEK 35 (AU$5.40)

Currently, the amount charged depends on the time of day, with the highest peak period cost per passage being SEK 35 (AU$5.40). Some vehicles are exempt from any charges including emergency services vehicles, motorbikes, vehicles with a disabled driver and military vehicles.

The congestion charge covers a 35 square kilometre area that is equipped with **overhead gantries**, **cameras at all entrance points**, pavement markings and street signage. **Automatic number plate recognition technology** has been implemented where vehicles are registered automatically by cameras that photograph number plates at control points. The owner of the photographed vehicle is then sent a **monthly invoice** for the total charge which must be paid at the end of the month. These payments can be made by mail, online or by direct debit.

Other complementary measures were implemented to **discourage car use** in central Stockholm. This included an increase in the number and frequency of public transport services, 2,800 additional park-and-ride spaces created outside the cordoned area and investments in bicycle and pedestrian infrastructure.

Since its introduction, the Stockholm congestion charge has led to a **20 per cent reduction in traffic** to and from the cordon area and a **30 to 50 per cent reduction in journey time delays** caused by congestion.[78] Vehicle miles travelled have decreased by 14 per cent in the cordoned area and 1 per cent outside the cordon. The increase in charges implemented in 2016 also led to an **additional 5 per cent reduction** in traffic congestion.

The congestion charge has resulted in positive environmental outcomes, with reductions of carbon dioxide and nitrogen oxide reported within the cordoned area and a 2.5 per cent reduction of greenhouse gases outside the cordon. Air pollution modelling suggests that this will lead to **20 to 25 fewer premature deaths per year** in Stockholm's inner city and 25 to 30 fewer premature deaths each year in the metropolitan area.

The charge has also been successful in raising significant revenue for the government, with net revenue amounting to an estimated SEK 1.3 billion (AU$200 million) each year.[79]

Milan

In 2008, Milan implemented a **cordon pricing scheme** called "Ecopass" where all vehicles entering the city centre between 7:30am and 7:30pm on weekdays paid a cordon charge. This charge varied according to the **vehicle's emission class** and cost up to €10 (AU$16) per day.

A referendum was conducted in 2011, asking citizens whether they would be in favour of a scheme which limited traffic and increased the uptake of low-emission vehicles in the city centre. Almost **80 per cent voted in favour** of such a measure. As a result, in January 2012, Ecopass was replaced with a congestion charge called 'Area C'.

Area C represents a limited traffic zone of 8.2 square kilometres, which is 4.5 per cent of the Milan municipality area. Vehicles entering this area between **7:30am and 7:30pm on weekdays** (only until 6pm on Thursdays) are charged a **flat daily fee of €5 (AU$7.80)**, which allows for unlimited entrances and exits during the time of charge. Some vehicles are exempt from any charges including mopeds, motorbikes, electric cars, taxis and vehicles with disabled drivers.

Vehicles failing to meet minimum emissions standards – including petrol vehicles of fuel rating 'Euro 0' and diesel vehicles of fuel rating 'Euro 0—3' – are **prohibited access to the area**.

Residents are permitted 40 free entrances each year after which any additional entrances will cost €2 (AU$3.10). All motorists have until midnight of the following day to pay the charge, otherwise face a fine of up to €80 (AU$125).

Automatic number plate recognition technology has been implemented. The system consists of 43 toll entrance gates (seven of which are reserved for public transport vehicles) which are controlled by an electronic system of cameras that read the licence plates of vehicles entering Area C.

Since the introduction of both Ecopass and Area C, the Milan municipality area has experienced a **reduction in congestion**, an **increase in average travel speeds** and **better air quality**. Between 2007 and 2011, traffic volumes and road accidents fell in the cordoned area by 16.2 per cent and 21.3 per cent, respectively. During this same period, the number of high-emissions vehicles travelling in the cordoned area fell by 48.1 per cent, while the number of low-emissions vehicles increased by 478 per cent.

These effects were amplified once Area C was implemented in 2012, with a further reduction in traffic and road accidents of 30.1 per cent and 23.8 per cent respectively. **Public transport use**, measured by the number of passengers exiting subway stations inside the cordoned area, **increased by 12.5 per cent** and the average speed of public transport increased by 11.8 per cent.

The cordon charges have resulted in positive environmental benefits for the Milan metropolitan area. The Ecopass scheme reduced the area's total PM10 particulate emissions by 15 per cent. These emissions were reduced by an additional 18 per cent within the first year of the Area C system being implemented.[80]

The Area C system raises an estimated €30 million (AU$47 million) annually, with annual operating costs of around €14 million (AU$22 million).[81] Under the enabling legislation for the scheme, all net revenues are reinvested to promote public transport and sustainable mobility in Milan.

3.4 Parking levies

3.4.1 Overview

Parking levies are applied to off-street private and public car parking spaces in some major cities in Australia within prescribed areas. The levies are state government charges intended to reduce congestion by increasing the cost of parking in CBD areas.

Levies are payable by car park providers, including employers who provide parking spaces to employees at no cost to the employee. They are not efficient mechanisms for road user pricing, as revenue is raised from those who park in the CBD irrespective of distance travelled on the public road network. Further, they are largely hidden from road users' perspective as the cost is incurred directly by the car park provider, not the user.

In some cases, revenue raised from the levy is hypothecated for investment in public transport infrastructure or promotion of public and active transport modes. In the WA case, the revenue must be spent within the prescribed area to which the levy applies.

3.4.2 Considerations for implementation

The effectiveness of parking levies on CBD congestion is not conclusive. Analysis undertaken by the Grattan Institute suggests there is a limit to their usefulness given they do not apply to through-traffic in CBD areas, as parking levies have no impact on users whose journeys pass through the prescribed area but do not park within it. Through-traffic accounts for one-third of morning peak period vehicle travel in the Melbourne CBD and around 40 per cent of traffic in the Sydney CBD.[82]

While not necessarily effective as a means of congestion management, there are some potential benefits from parking levies including the generation of a revenue stream that can be hypothecated to fund sustainable transport initiatives within the area in which the levy applies, as is currently the case in Perth.

The WA Government has a parking levy in place for the Perth CBD, East Perth, West Perth and Northbridge (the Perth Parking Management Area, PPMA). If it were desired to increase the provision of sustainable transport initiatives within the PPMA, this could be effected either by expanding the PPMA boundary (increasing the number of parking spaces to which the levy applies) or increasing the levy per bay, increasing the amount of hypothecated revenue raised.

For example, the PPMA is currently bounded by Thomas Street to the west and the Swan River to the south and east. The area could be extended westward to take in the Subiaco activity centres, south-west to Nedlands and Crawley (including the University of Western Australia and QEII medical precincts), east to take in the Burswood activity centre or south across the river to the South Perth commercial and leisure precinct. Travel to each of these localities contributes to congestion in the CBD – for example along Thomas Street/Loftus Street or the Mitchell Freeway/Mounts Bay Road interchange – but is currently excluded from the PPMA.

Increasing the cost of parking in central areas, either through extending the PPMA or increasing the levy, may require an offsetting increase in the number or frequency of public transport services. As revenue raised from the levy is hypothecated for spending within the PPMA, additional revenue raised could be applied, for example, to extending the Transperth Free Transit Zone (FTZ) to the full extent or a larger extent of the expanded PPMA.

The WA Government could also explore the implementation of a similar scheme and levy in other activity centres that experience local traffic congestion but are outside the Perth CBD – for example, the Stirling and Joondalup CBDs.

3.4.3 Case studies

Perth

The Perth Parking Policy involves the management of parking within the Perth Parking Management Area (PPMA) which includes Perth CBD, East Perth, West Perth and Northbridge. Under the Perth Parking Management Act (1999),[83] **all non-residential parking bays** within the management area are licensed and **subject to an annual levy**.

There are currently around 52,000 fee-liable bays: 28 per cent of which are short-stay on-street public bays; 17 per cent are long-stay public bays; and 55 per cent are tenant bays. Annual levies for each type of parking bay amount to $1,038, $1,124 and $1,169 respectively. Motorcycle bays, loading bays and ACROD parking bays are exempt from the levy.

Money raised through this parking levy (around $30 million per year) is **reinvested within the PPMA** and spent to deliver services including the free Central Area Transit (CAT) bus service and bus and rail services within the Transperth Free Transit Zone (FTZ). This revenue also aids in funding transport projects and new or improved services that help to **reduce the need for cars** within the PPMA. This includes the construction of bus lanes, the provision of cycle paths and lanes and improvements to pedestrian infrastructure.

The implementation of the Perth Parking Policy has been effective at limiting the number of non-residential parking spaces in the central Perth area. The number of non-residential parking bays **declined by 8 per cent** between 1999 and 2012, and in 2019 the number was approximately the same as in the mid-1990s.[84] That is despite the number of employees working in the CBD increasing by 40 per cent over the same period.

In the mid-1990s, around 50 per cent of CBD employees commuted to work by driving a car. The implementation of the Perth Parking Policy has reduced that to around one-third, with public transport overtaking car driving as the mode of travel for the majority of CBD employees.[85]

Melbourne

The Victorian Government introduced a **congestion levy** in 2005, with the objective of reducing traffic congestion in inner Melbourne and encouraging motorists to use public transport instead. The annual levy is applied to all off-street private and public car parking spaces in two prescribed areas: Category 1 (including the Melbourne CBD, Docklands, MCG and Crown precincts) levied at $1,480 per bay; and Category 2 (including North Melbourne, Fitzroy, the University of Melbourne precinct and Southbank) levied at $1,050 per bay.[86]

The levy is payable by the car park owner (in the case of private bays) or the authorised operator (in the case of public bays). Like the Perth scheme, residential bays, loading bays, disabled bays and some other bays – including hospital patient and visitor parking – are exempt. Revenue from the scheme (around $100 million per year) is not hypothecated.

The levy has been successful at limiting growth in the number of car bays within the prescribed areas. The number of commercial off-street parking bays has **declined** since the levy was introduced, and growth in private non-residential bays – such as those provided by an employer for use by employees at no cost – has **slowed**.

While the levy has had a direct impact on the number of parking bays, its impact on traffic congestion within the CBD is less apparent. An evaluation undertaken by Monash University found that while the **public transport mode share has increased** since the levy was introduced, it is difficult to attribute the incremental effect of the parking levy versus other improvements to public transport services over the same period.[87]

Sydney

A **parking space levy** (PSL) was introduced by the NSW Government for the Sydney CBD in 1992, to address traffic congestion in central Sydney. Revenue raised from the PSL (around $100 million per year) is hypothecated for reinvestment in public transport infrastructure and services within Sydney.

The PSL is currently levied at two rates for two sets of prescribed areas: the Category 1 rate ($2,490 per year) applies to bays in Sydney CBD and North Sydney; and the Category 2 rate ($880 per year) applies to Bondi Junction, Chatswood, Parramatta and St Leonards.

Relative to schemes in Perth and Melbourne, the PSL covers a much greater area including activity centres and business districts outside of Sydney's central CBD, such as Parramatta, to address local traffic congestion in those areas. The Category 1 rate that applies to the Sydney CBD is also much higher than levies in Perth and Melbourne.

Like the Perth and Melbourne schemes, some bays are exempt including residential parking, mobility bays, delivery and service bays and parking for emergency services vehicles. The two category areas cover around 100,000 bays in total, of which around 80 per cent are liable for the levy.[88] Importantly, the PSL does not apply to public car parks.

The PSL has not been found to be effective at either reducing the number of parking bays in the prescribed areas or reducing traffic congestion. Studies attribute this to the concessions offered relative to other schemes (such as not applying the levy to public car parks)[89] and mixed effectiveness of complementary schemes to promote alternative transport modes, finding that the PSL has had '**little or no impact on car use**'.[90]

3.5 Toll roads

3.5.1 Overview

Tolls are collected from motorists to use a certain road or road segment. They are implemented for financing or revenue generation purposes to help the government or private investor recoup the costs associated with the construction and maintenance of roads. The primary motivation for tolls is to offset financial costs, rather than to function as a price proportional to road use or as a congestion management mechanism.

Tolls partially support demand management, regulating vehicle volumes for a certain stretch of road by pricing its access. However, tolls tend to fail to account for demand for beyond the entry and exit points of the tolled segments, relocating or redistributing congestion rather than truly addressing it by reducing overall car demand.

Toll roads do tend to result in lower levels of congestion, manifesting in reduced journey time delays and higher average travel speeds, on tolled road segments. The use of toll roads in Australia is almost exclusively to finance a road project or expansion that the government would not otherwise have been able to fund.

3.5.2 Considerations for implementation

Different charging methods for toll roads used in Australia include:

- **Time/day-based charging**: Tolls either apply only during certain times of day and days of the week, or vary according to time and day
- **Distance-based charging**: Road users pay a toll proportional to the distance travelled on the toll road, based on their entry and exit points.
- **Fixed toll**: Tolls apply for use of any segment of the toll road, irrespective of distance travelled, time of day, day of the week or congested conditions.

The toll payment can also vary according to the vehicle type and size, with larger vehicles such as trucks, buses and trailers charged more due to the greater amount of road wear and tear caused.

3.5.2.1 Technology

Automated toll-paying is now the preferred system for tolling in most countries. Automatic license plate recognition (ALPR) technology is commonly used and is sometimes accompanied with dedicated short-range communication (DSRC).

ALPR is based on images taken of license plates by cameras installed on gantries or poles, which are then processed to identify a vehicle by its number plate. A key issue with ALPR technology is the reliability of images which can be reduced due to light reflections or dirty or damaged plates. This leads to manual checking of these images which add significant processing costs.

DSRC technology involves the use of in-vehicle units (IU) which communicates with gantry-mounted equipment at checkpoints to charge the road user. An advantage of this technology is that it is efficient in identifying and charging multiple vehicles at full freeway speeds.[91]

3.5.2.2 Equity

Equity concerns exist as tolls are likely to disproportionately impact people who use roads less regularly, such as interstate visitors. Tolls are also likely to disadvantage low-income commuters who are less likely to live in the CBD and must dedicate a larger portion of their incomes to pay the toll.[92]

If considering the implementation of toll roads in WA, the State Government could introduce discounts or special conditions for particular cohorts to offset this burden. For example, in Japan the government grants international visitors unlimited use of designated expressways within a particular coverage area and set number of days.[93]

3.5.2.3 Community response

The feasibility of introducing tolled segments to WA's road network should be considered in the context of long-standing community and bipartisan opposition to tolls.

The proposed Perth Freight Link project, including the extension of Roe Highway to Stock Road (Roe 8) and then Stirling Highway (Roe 9), was set to be WA's first toll road, with heavy vehicle users charged a toll to use the new freight infrastructure. The project prompted significant community opposition – largely around the potential adverse environmental impact of the project, but also to the prospect of further toll roads being introduced in the State if successfully implemented on Roe Highway.[94]

A previous proposal to build and fund an express connection from the Graham Farmer Freeway to Perth Airport was not pursued largely because it relied on a private toll to recoup the private component of the construction cost.[95]

3.5.3 Case studies

Sydney – WestConnex

WestConnex is the largest transport infrastructure project in Australia. Upon completion, WestConnex will provide 30 kilometres of continuous motorway, including 22 kilometres of tunnel which will link west and south-west Sydney to the city and airport.

WestConnex comprises of three stages, delivered in six projects over a 10-year period. These projects include the widening the M4 Motorway and constructing tunnels to create a M4-M5 link. To fund WestConnex, the government uses taxation revenue and **road tolls**.

Tolling on WestConnex is **distance-based**, with motorists being charged only for the section of the motorway they use. Heavier vehicles pay up to three times the amount light vehicles pay to reflect the greater wear and tear caused. The toll for using the full length of WestConnex is **capped at $10.06**.

All of Sydney's tolls roads are cashless, and motorists require an electronic tag or pass to pay the toll. Tags are placed in the vehicle and emit an audible alert when the motorist passes through a toll point, reflecting a deduction made to the tag balance. Passes are a temporary toll payment system where the motorist's **number plate is recorded** into the system and then matched by a camera when passing a toll point.

Given WestConnex is still under construction, modelling techniques have been used to estimate its effectiveness in reducing traffic and congestion. A report published by SGS Economics & Planning creates a model to better understand the impacts of WestConnex and finds that the **project will be largely ineffective** at addressing broader traffic congestion in inner metropolitan Sydney. It finds that the project is unlikely to improve access to the Sydney CBD due to other channels and routes contributing to congestion, and the lack of available parking. The modelling suggests Sydney's congestion will worsen with or without the WestConnex project.

The toll could also have **adverse effects** on neighbouring or adjoining parts of the road network. Traffic flows on Parramatta Road are estimated to **increase by more than 20 per cent** as vehicles avoid paying the toll on the M4 and M4 eastern extension.[96] This creates additional problems for roads seen as alternatives to toll roads, including greater noise, safety issues and wear and tear on roads that are not designed to handle the increased volume of vehicles.

Brisbane – Go Between Bridge

The Go Between Bridge is a 300m **toll bridge** that opened in 2010 and connects Brisbane's northern, western and southern suburbs. It connects Merivale and Cordelia Streets in South Brisbane to Coronation Drive and the Inner City Bypass in Milton. The bridge features two separate bicycle and pedestrian paths and is an alternative to the William Jolly Bridge.[97]

Tolling on the bridge is a **flat fee** with rates distinguished by vehicle class where **heavier vehicles are charged more** than light vehicles to reflect the greater wear and tear caused. All vehicles are charged a single flat fee except heavy commercial vehicles. For these vehicles, charges range from $8.74 if travelling during off-peak hours (8pm-5am) and $9.88 during peak hours (5am-8pm).[98]

The bridge uses a free-flow tolling system with electronic tag and video matching payment options. Electronic tolling devices installed in the southern end of the bridge communicate with **in-vehicle electronic tags** or use **number plates** to charge the motorist. When a vehicle passes the tolling point, the system either detects the tag and deducts the toll from an account or will capture a photograph of both the front and back number plates and bill the registered vehicle owner.

The Go Between Bridge has so far been **largely unsuccessful at reducing congestion** and has been **operating well below capacity**, generating little revenue. In 2016, the bridge was estimated to carry 14,000 vehicles per day. These numbers have been declining recently, with daily traffic estimated at a low 11,000 per day in 2019.[99]

Further, with the closure of the Victoria Bridge in January 2021, motorists have been using the William Jolly Bridge (which is toll-free) more heavily than the Go Between Bridge. This is despite the Brisbane City Council offering $100 subsidies for residents using the Go Between Bridge. Since the toll bridge is only 300m, many motorists **cannot justify paying the toll** to travel such a short distance. This has led to an **increase in congestion** on neighbouring and alternative roads, causing delays for motorists crossing the river and in streets surrounding the William Jolly Bridge.[100]

RAC Queensland has called on Transurban, the toll operator, to **introduce variable toll fees** that offer return trip and off-peak discounts to motorists and encourages the extension of the $100 incentive to include all motorists and not just locals. Historically, the RACQ has also recommended the Go Between bridge toll be removed altogether.[101]

4 Travel demand management mechanisms

4.1 Overview

Travel demand management (TDM) initiatives are those that deliver positive outcomes for transport systems – such as reduced congestion, more efficient use of existing assets and infrastructure, and improved reliability – without requiring significant capital investment in new or expanded transport infrastructure.

Given finite fiscal capacity, governments typically seek to prioritise maximising existing infrastructure – a principle that extends to the road network. Like energy assets, road infrastructure is relatively inefficient because demand is concentrated at certain points in the day, but by its nature capacity is provided at all times of the day.

Investment in new road or rail infrastructure and services increases the capacity (supply) of the transport network and is usually undertaken to ease congestion in peak periods. On road networks, expanded capacity typically cuts congestion and improves journey times in the short term, but benefits tend to taper over time. This is attributed to induced demand: as supply increases, so does demand, and a net overall increase in the number of road users eventually absorbs spare capacity.

A US study refers to this phenomenon as *the fundamental law of road congestion*, finding that the number of car user VKTs increases proportionally to the number of available lane kilometres when the road network is expanded, resulting in no net material reduction in congestion.[102] Other studies of drivers' propensity to respond to additional available capacity show that even for large-scale network expansions, the increase in traffic volumes offsets almost all of the congestion benefits of increased capacity.[103]

TDM initiatives instead address the demand side of the transport system, using promotion and awareness campaigns, pricing and regulatory tools to encourage drivers to shift their travel behaviour, reducing or delaying the need for expensive new capital investment.

This chapter reviews several TDM mechanisms in use in WA, other Australian jurisdictions and overseas, including:

- Carpooling systems
- High-occupancy vehicle lanes
- Promoting working from home
- Promoting staggered working hours
- Travel behaviour change programs
- Micro-mobility
- Mobility as a service.

4.2 Carpooling systems

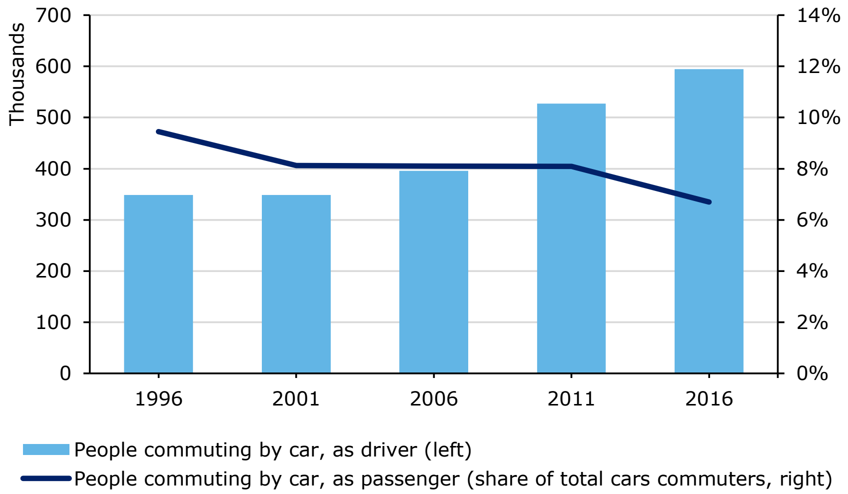
4.2.1 Overview

Driving remains the dominant mode of transport for Australians, representing more than 80 per cent of annual passenger kilometres travelled in major cities.[104] According to the 2016 Census, 69 per cent of the Australian working population (more than 6.5 million people) commuted to work by driving a car and only 5 per cent (fewer than 0.5 million people) travelled as a car passenger on Census day.[105]

Between the 1996 and 2016 Censuses, the number of people travelling to work in Greater Perth by driving a car increased by around 2.7 per cent per year. That contrasts to just 0.8 per cent annual growth in those who travel to work as car passengers, and also outstripped the 2.3 per cent annual growth in the Greater Perth population.[106]

As a share of all people who commute to work by car in Greater Perth, car passengers declined from 9.4 per cent in 1996 to 6.7 per cent in 2016 (Figure 4.1).[107] The declining share of car passengers implies that the number of vehicles on the roads is increasing faster than the number of people travelling on roads. This results in greater congestion, slower average travel speeds and longer journey times in capital cities.

Figure 4.1: Number of people commuting by car driver and passenger, Greater Perth



Source: ABS Census of Population and Housing 1996—2016

Carpooling is a potential approach to reducing the number of cars on the road by increasing the average occupancy of each vehicle, based on the shared use of a private car between two or more occupants with a common destination. As carpooling eliminates the need for each car occupant to drive in a separate vehicle, it can potentially deliver a reduction in user costs (such as fuel costs and journey time delays) as well as social benefits including reduced environmental costs and road wear and tear.

This section discusses carpool systems, while infrastructure such as carpool lanes are discussed in the following section as a type of high occupancy vehicle lane.

4.2.2 Considerations for implementation

Carpooling may be an informal arrangement organised between individuals or organised through online marketplaces and ride-matching websites. Current examples include Hophop Ride, Carpool World, Coseats and Rideshare. Generally, models will differ depending on how demand and supply are matched and depending on the breadth of user access.

Table 4.1 outlines the types of online carpool models made available through ride-matching apps and sites. Generally, models will differ depending on how demand and supply are matched and depending on the breadth of user access.

Table 4.1: Carpooling models

Model characteristic	Model options
Matching	• Fixed: ride-matching is based on a pre-defined group, route or zip code • Dynamic: on-demand carpooling which adapts to meet real-time demands and organises optimal routes accordingly.
Accessibility	• Open network: every user in the system can be matched to any other user for rides • Private network: matched users are travelling to and from the same place (e.g. same workplace, school, university).

Source: Deloitte Access Economics

The most common online carpooling model is one based on an open network with dynamic matching, where users are matched with unknown members of the public. UberPool is perhaps the most prominent example of this model in operation. Riding with unknown members of the public presents obvious security concerns, which can create a barrier to uptake. However, ride-sharing apps have begun using reputation systems that flag problematic users to address such issues.

Carpooling provides more efficient use of road capacity relative to individual private car travel, but less so than public transport services. Nonetheless, it can fill an important gap as a first- or last-kilometre connection where public transport services are unavailable or operate infrequently. This includes travel to and from public transport stations in the absence of a bus connection, and incentives could be provided to encourage carpooling over individual car travel (for example, discounts for carpool use of park-and-ride facilities).

Carpooling is likely to be most effective as a substitute for individual car travel during peak periods for patrons on their daily commute with consistent origins and destinations. Pooled ridesharing services (such as UberPool) have features that would cater to this type of traveller, for example by directing users to pick-up points selected to ensure a smooth ride but which may require the user to walk to get there; and providing maximum time limits for the user to arrive at the pick-up point, after which the driver is instructed to leave.

Outside of peak periods, where road utilisation is well below capacity and car demand is likely to be more concentrated among users with distinct destinations (such as business users travelling to meetings), carpooling is not likely to be perceived as a competitive alternative to individual car travel by users.

In some carpooling arrangements – such as those organised among students at the same university campus or employees at the same workplace – the lack of flexibility and reliability can limit uptake. Carpooling can make it difficult to accommodate every rider's origin or destination and may not be flexible enough to adapt to changes in work schedules and daily routines. Riders lose their freedom of mobility and delays are more likely to occur since journey times are reliant on the punctuality of all car occupants. Carpooling can be an unreliable transport mode since other users may not follow through on the agreed-upon ride. Further, if there is an insufficient number of users on online ride-matching apps or sites, the system may not find a suitable match.

Users' perceptions of comfort and security may also influence their willingness to use a carpooling service. While individual car travel imposes high social costs and represents the least efficient use of road capacity, it provides a relative guarantee of comfort and security for the user. In Western Australia, taxi, rideshare and public transport services are highly regulated, with measures such as mandatory in-vehicle cameras in taxis and the presence of security officers on public transport services providing a level of comfort for users. Research has shown that a potential sense of feeling 'trapped' in a car with an uncomfortable co-passenger can act as a deterrent to carpooling services, especially among women.[108]

4.2.3 Case studies

Washington DC Pool Rewards Program

The Pool Rewards project was a commuter incentive pilot program undertaken by Commuter Connections in 2010 to encourage carpooling in the Washington DC metropolitan area. Eligible participants could receive US$2 per day (US$1 each way) to carpool to work over a 90-day pilot period. The maximum incentive was US$130 in exchange for going online, logging travel information and completing surveys about the experience.

The pilot resulted in a **decrease of 298 daily car trips** based on logged passenger trips and a **reduction of vehicle miles** travelled by more than 9,000 miles (around 14,500 kilometres) each day. A follow-up survey conducted in 2011 found that **93 per cent of participants continued carpooling** after the pilot ended.

In 2011, more than 70 per cent of project participants identified Pool Rewards as a 'valuable motivator to get them out driving alone and into carpools, to and from work.' The encouraging results and positive feedback led to the project being extended.[109]

Participants were surveyed in 2012, 2013, 2014 and 2017. Pool Rewards participants registered during the 2015-2017 and 2018-2020 periods were surveyed in 2017 and 2020. The survey revealed that 87 per cent of these participants continued to use an **alternative transport mode** and only 13 per cent had returned to driving alone to work.[110]

In 2012, the program was extended to include vanpools (carpooling for vehicles with five to 15 passengers) which were eligible to receive an ongoing $200 per month incentive. Between 2015 and 2017, the vanpool program resulted in 233 fewer daily vehicles on the roads and a reduction of more than 8,500 daily vehicle miles travelled.

Washington DC is an example of complementing carpool systems with high-occupancy vehicle (HOV) lanes. Express lanes for high-occupancy vehicles on the I-66 motorway are currently under construction and expected to open in 2022. An additional US$100 is offered for commuters who create a three-person carpool on I-66, beyond the current US$130. The purpose of the program is to provide an additional incentive for commuters to alter their travel behaviour.[111] Additional journey time savings from the use of HOV lanes, in addition to financial incentives provided under the Pool Rewards program, are likely to support greater uptake of carpooling.

Perth (QEIIMC) TravelSmart

QEII Medical Centre has launched a TravelSmart program that aims to reduce congestion and make the best possible use of the finite number of car parking bays available on campus. The program encourages staff to use their cars less and share their journeys through carpooling.

Perth (QEIIMC) TravelSmart

Incentives offered to carpoolers include offering support for ride-matching and providing dedicated and discount parking.

An electronic carpooling register is used to match carpooling partners together, although there is an opportunity for applicants to choose their potential partner using the Public Carpooler Register. Matching occurs according to the information provided by each user, which includes days of travel, work start and finish times and the suburb the person lives in. Once matching occurs, each person is contacted separately for consent to exchange information and if agreed upon, contact details are exchanged.

Car parking bays in QEIIMC are guaranteed so long as two or more employees arrive in the same vehicle. One electronic carpooler permit, which is issued to each group, must be displayed on the parked car. Carpooling permit holders are given a Smart Parker (SP) account with one corresponding SP swipe card per group which holds funds to pay for parking. The card is used to access and exit the designated car park by swiping the card at the reader on the intercom machines.[112]

In 2012, an online survey was conducted where employees answered questions about their use of different transport modes. Results from this survey revealed that 11 per cent of respondents carpooled (approximately 700 employees), which is substantially greater than the level of carpooling among all commuters without access to such a program.[113]

4.3 High occupancy vehicle lanes

4.3.1 Overview

A high occupancy vehicle (HOV) lane, also called a carpool lane, is an exclusive lane reserved for vehicles carrying a driver and one or more passengers such as carpools, vanpools and buses. These lanes are typically provided on major freeways and highways and identified as '2+' or '3+' (the minimum number of occupants required to drive in the lane).

HOV lanes are a tool of demand management as they encourage greater car occupancy, thereby reducing the number of vehicle trips. Restrictions as to who can access HOV lanes limit road demand and can provide travel time savings along a corridor when compared to adjacent general-purpose lanes, which are more likely to be congested.

Construction of an additional HOV lane would likely result in lower levels of congestion, as travel time savings incentivise drivers to form carpools or choose a transport mode with a higher occupancy such as buses, to bypass more congested lanes. This reduces the number of vehicles on the road, leading to less congestion, lower direct user costs (such as fuel consumption and journey time delays) and lower social costs of road use, including environmental externalities and road wear and tear.

HOV lanes are particularly useful in jurisdictions where funding for road network expansions is limited, or where a lack of physical space prevents the expansion of capacity through additional lanes. However, the inability to expand the road network by providing additional lanes may mean that an HOV lane can only be created by converting a general-purpose lane; that could worsen congestion conditions, where only a proportion of drivers will take up HOV modes and remaining users compete for a reduced level of capacity on remaining general-purpose lanes.

Uptake of HOV lanes could be incentivised with complementary measures supporting the use of HOV modes, such as increased frequency of bus services with shorter journey times on HOV lanes; or financial incentives to enter into carpooling arrangements, such as the Pool Rewards scheme in Washington DC discussed above.

4.3.2 Considerations for implementation

There are multiple ways HOV lanes can be implemented, including:

- Converting existing general-purpose lanes into an HOV lane for all or part of the day

- Adding an additional inside or outside lane to an existing road
- Converting an existing bus way or bus lane into an HOV lane
- Allowing dual-use HOV cars and buses in an existing bus lane.

HOV lanes are usually located next to general-purpose lanes and may be separated by a physical barrier or by non-physical means such as lane marking and special traffic signs.

Enforcement of HOV lanes is crucial to ensure that vehicles accessing these lanes are complying with occupancy requirements. Legislation would need to be introduced to allow infringements to be issued to individuals who use HOV facilities with fewer than the required number of occupants. However, surveillance is costly and also diverts police resources away from potentially more significant public safety matters.

Technology can also be used for enforcement, such as through the use of gantry-mounted cameras to assess vehicle occupancy. This can be difficult to do in practice, as cameras may not be able to accurately identify vehicle occupancy, depending on the shape of the vehicle and orientation of seating. Use of other technologies – such as telematic devices that link to a vehicle's built-in sensors for the number of buckled seatbelts or weight sensors in each seat would require substantial user uptake to be effective, and are not precise ways of measuring compliance with HOV lane rules.[114] Roadside detection measures, such as the use of infrared systems, have shown to be effective in some conditions, but tend to be less effective at high speeds or in high vehicle volume conditions.[115]

Underutilised HOV lanes can also be converted into high occupancy toll (HOT) lanes, which allow vehicles that do not meet the occupancy requirements to pay a toll to use the lane. Tolls on HOT lanes could be varied so that they are higher during peak driving times. Highway capacity is used more effectively under this arrangement as drivers who are willing to pay the toll shift to underutilised HOV lanes and away from congested general-purpose lanes.

HOT lanes have shown to be equitable as households at all levels of income benefit.[116] High-income users tend to value their time more highly and are therefore more likely to pay the toll in exchange for faster and more reliable trips. Low-income drivers can forego paying the toll but also benefit as non-tolled roads are less congested as a result of HOT lane uptake.

4.3.3 Case studies

New Jersey I-80 and I-287 HOV Lanes

New Jersey has previously operated HOV lanes on two interstate motorways, I-80 and I-287. In 1998, New Jersey closed two HOV lanes on these motorways and reopened the lanes to all vehicles due to **low utilisation levels** and **high violation rates**. Both lanes had a 2+ occupancy requirement and operated only during peak periods.

The I-80 HOV lane opened to traffic in March 1994. This lane was reserved for buses, vanpools and 2+ carpools during peak periods and in the peak direction of travel only. At all other times, lanes were available to general purpose traffic. The I-80 lane was used extensively with more than 1,000 vehicles per lane-hour.

The I-287 lane opened in January 1998. A 2+ vehicle-occupancy requirement applied during peak travel hours. This HOV lane was **underutilised**, with fewer than 400 vehicles per lane-hour, which did not help to alleviate high levels of congestion on general purpose lanes.

After substantial public and media scrutiny, the New Jersey Department of Transport reviewed the use of the lanes. The review focused on whether the lanes induced people to carpool, whether the minimum use levels of 700 vehicles per lane-hour were met, and whether they helped to reduce the existing level of congestion in the corridor.

The review found that only the HOV use levels on I-80 had been met and **neither HOV lane resulted in mode shifts to carpools**, rather the HOV volumes represented spatial shifts from

New Jersey I-80 and I-287 HOV Lanes

adjacent facilities. The review also concluded that opening the lanes to all traffic would not adversely impact air quality levels.

Violation rates were also high. On the I-80 HOV lanes, these ranged from 4.7 per cent to 21.5 per cent depending on the level of enforcement. Violation levels were higher on the I-287, with rates ranging from 5 per cent to 75 per cent.

After the closure of both HOV lanes, traffic flow improved initially on both freeways, however, congestion continued to be a problem during peak hours and at specific locations. Further, while HOV lanes improved journey times and speeds for motorists between entries and exits on the motorway, this resulted in **long queues at exit ramps** along the corridor as congestion built up on adjoining arterial roads. [117]

Virginia I-66 HOV Lane

The Northern Virginia I-66 motorway extends west from downtown Washington DC. The HOV lane originally was reserved for vehicles with at least three occupants but was changed to vehicles with at least two occupants due to **public criticism that the HOV lane was underutilised**. This produced a 60 per cent increase in lane utilisation and a reduction in lane use violation.[118]

The HOV lane is reserved for buses, motorcycles, emergency vehicles and 2+ carpools during peak periods in the peak direction of travel. Single-occupant vehicles also have an option of paying a toll to use the HOV lane in the peak direction during peak hours.

From 2015 to 2019, the total number of people moving inbound on the I-66 during the morning peak increased by 1.2 per cent, while the **number of vehicles decreased by 2.7 per cent** indicating a higher share of trips made by public transport and HOV.

In 2019, approximately 23.7 per cent of inbound weekday morning peak-hour trips on the I-66 were made by HOVs, representing an increase in the HOV mode share of 1.2 percentage points since 2015. Average vehicle occupancy increased modestly from 1.52 to 1.54 persons per vehicle along the I-66 over the same period.[119]

In 2008, a research team worked with the Virginia State Police to assess the impact of enforcement on violation rates. The team collected violation rate data prior to the enforcement, immediately after enforcement and nine days after enforcement. A data collection team manually observed the HOV lane where, during morning and afternoon peaks and for 45-minute intervals, the number of violators was counted while the total vehicles were also counted. The team found that **enforcement had no effect on the violation rate** – the rate actually increased slightly following enforcement from 25.5 per cent (prior to enforcement) to 27 per cent (day after enforcement) and increased again, to 28 per cent (nine days after enforcement).[120]

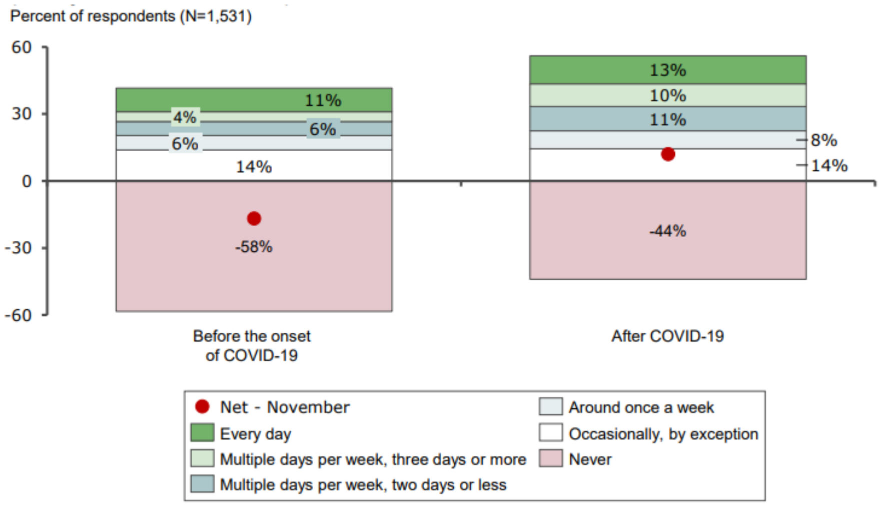
4.4 Working from home

4.4.1 Overview

Increased uptake of working from home (WFH) could be a viable demand management mechanism, relieving pressure on the road network from commuting to and from workplaces during peak periods.

The broad uptake of WFH has expanded considerably through the COVID-19 pandemic. In February 2021, an estimated 41 per cent of Australian workers worked from home at least one day per week, compared with 24 per cent before March 2020.[121] Based on survey data collected in November 2020, Infrastructure Australia estimated that the proportion of workers who wished to work from home at least once per week has grown from 27 per cent prior to the onset of COVID-19 to 42 per cent post-COVID-19, an increase of 15 percentage points (Figure 4.2). The driving factors were increased lifestyle flexibility and uncertainty about the resolution of COVID-19.[122]

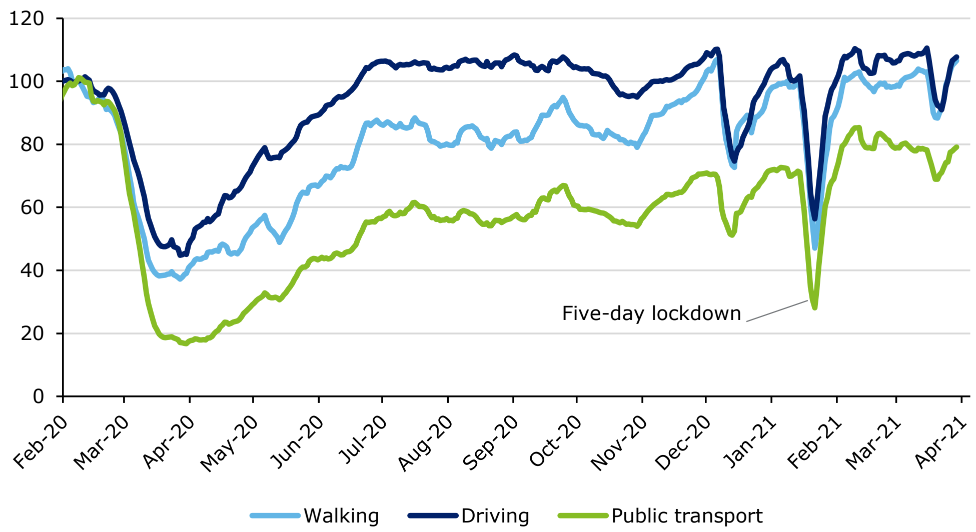
Figure 4.2: Intention to work from home, before vs during COVID-19



Source: Infrastructure Australia

With more people working from home and commuters fearing the possibility of contracting COVID-19, the recovery in public transport demand has not been as strong as private vehicle demand even as pandemic lockdown measures have subsided. For example, in mid-April 2021 in the Greater Perth area, Apple navigation data suggests that the number of journeys taken by driving and walking was around 10 per cent and 9 per cent higher than the pre-COVID baseline (based on mid-February 2020 data), while the number of public transport journeys was still around 19 per cent lower than pre-COVID levels (Figure 4.3).

Figure 4.3: Navigation requests by mode, Greater Perth area, index 100 = mid-February 2020



Source: Apple Mobility Reports

Businesses have embedded new operating models and 'ways of working' during COVID-19 which are likely to be sustained beyond the pandemic, supporting more flexible working in the future, potentially providing a means of reducing the cost of CBD office accommodation and amenities provided to employees.

The Commonwealth Government has also accommodated the greater uptake of WFH by creating a new shortcut method to claim home office expenses from personal taxable income. Using the shortcut method, taxpayers can claim deductions of 80 cents per hour worked from home for the 2019-20 and 2020-21 tax years. This represents an increase of 28 cents per hour from the fixed-rate shortcut method (52 cents per hour worked from home) in place before the pandemic.

As a certain degree of WFH is likely to become 'the new normal' even after the pandemic has subsided, demand for public transport services and infrastructure is likely to remain subdued relative to pre-COVID transport demand. That is partly because those working from home enjoy a benefit equal to savings in travel costs (including journey time) that they would otherwise incur.

For example, a study of COVID-19 impacts on WFH in the Greater Sydney area estimated that employees' annualised journey time costs for car and public transport travel were reduced by around $5.6 billion based on the observed uptake of WFH to May 2020, representing more than 50 per cent of pre-pandemic journey time costs.[123] While around $1.2 billion of that amount was due to reduced employment hours or job losses, there were still $4.4 billion in annualised savings to users who were working the same hours each week but were no longer commuting to do so.

That is likely an upper estimate, as May 2020 represented the peak of lockdown measures in many jurisdictions and there has been a resumption in commuter travel both by car and public transport over subsequent months. However, it indicates the scale of journey time savings enjoyed by employees who take up WFH, which may serve as an incentive for workers to continue working from home (at least partially) even after the pandemic has subsided. This is particularly true for users whose individual travel costs are higher due to longer journey times or who are required to transfer between multiple modes to complete their journey.

While promoting WFH could be an effective congestion management mechanism insofar as it reduces overall transport demand, this has not been reflected in empirical evidence observed in the Perth metropolitan area to date. Car demand appears to have grown to exceed pre-COVID levels despite the greater uptake of WFH. This is likely the result of a series of factors, including:

- Other incentives reducing the overall cost of car travel, such as free or reduced-price parking
- A perception that commuters have a higher likelihood of contracting COVID-19 on public transport
- Increased expenditure on vehicles, given that outlays on various forms of recreational activity and holidays have been curbed as a result of COVID-19
- Ease of car use outside of peak periods, as some workers split their day between working from home and working from their office.

This suggests that the promotion or encouragement of WFH may not be effective at addressing road congestion while these other factors persist.

There are some potentially negative impacts of WFH on CBD economies, with service industries largely catering to commuting employees during the working week. A study conducted in August 2020 suggested that reduced CBD demand due to WFH would reduce the output of the Sydney CBD by around $10 billion (or 7 per cent of the pre-pandemic projected level).[124]

The impact of WFH on CBD economies is closely linked to the vacancy rate for commercial accommodation. As firms put WFH arrangements into place on an ongoing or permanent basis, they may be able to reduce their accommodation need or defer planned expansions to house their full complement of employees at one time. A Property Council survey found that the Perth CBD commercial vacancy rate had increased from 17.6 per cent in January 2020 to more than 20 per cent in February 2021,[125] and is likely to worsen as additional commercial accommodation space comes online later in 2021.

This raises the potential for conflicting policy objectives. While encouraging WFH could be explored as a policy lever to manage congestion levels on the road network, it could also reinforce negative impacts on CBD economies resulting from the uptake of WFH. Other jurisdictions appear to be moving in the opposite direction; for example, the Victorian Government has issued directions for public servants to return to work in the office in greater numbers, in part to restore lost demand in the Melbourne CBD economy.[126]

4.4.2 Case studies

Allianz Insurance UK

In 2013, Allianz Insurance UK recorded approximately 4,300 employees working across 25 different sites with the head office located in Guildford, England. As a part of its employee benefits package, Allianz Insurance offers flexible working arrangements including home or remote working and has been awarded one of the Top Employers for Working Families in 2011 and 2012.

Allianz has identified three main reasons for providing flexible working arrangements including:

- To offer flexibility to workers that may be needed at home such as mothers, and allow them to be more productive
- To attract and retain valuable employees in a competitive marketplace
- To achieve a diverse workforce which is a high priority for Allianz.

In its flexible working documentation, Allianz also mentions the following benefits from flexible working:

- Can help support clients' needs around the clock
- Improved employees' morale (lower absence levels, lower turnover and higher commitment)
- Improved employees work-life balance
- Decreased strain from commuting.

Allianz has various flexible working arrangements including home or remote working, job sharing, compressed hours, term-time working, split shifts and career breaks and sabbaticals. Under a home or remote working arrangement, employees have the option of choosing full-time or occasional homeworking. Full-time homeworking involves employees being officially assigned to work outside the Allianz office either at home or at different sites. Typically, these employees go to the office only once a month. Occasional homeworking is permitted by line managers on a case by case basis where employees have the option of working in the office or from home.

In a report published in 2013, it was estimated that there were 650 to 700 employees who are full-time homeworkers in the UK, which represents up to 16 per cent of the Allianz Insurance UK workforce. As working from home arrangements are informal and agreed on a case by case basis by line managers, the number of occasional homeworkers is difficult to monitor and therefore, hasn't been recorded.

Allianz states that its Human Resources department tries to ensure that employees under flexible working arrangements are treated fairly during appraisal or promotion. As a result, there is no difference in monitoring methods for homeworkers and office-based workers: 75 per cent of performance evaluation is based upon 'what' has been achieved (e.g. employee's output) and 25 per cent is based on 'how' this has been achieved such as through client focused work (e.g. feedback forms) or people focused work (e.g. line manager appraisal of teamwork skills).[127]

4.5 Staggered working hours

4.5.1 Overview

For this discussion, staggered working hours refer to employees working more or less the same hours from the same location, but starting and finishing work at staggered times of the day; this is distinct from other flexible working arrangements that may reduce the number of hours worked, or the location of work. Staggered working hours have not been widely implemented in Australia, despite the increasing popularity of other flexible working measures including WFH.

Encouraging staggered working hours can be used as a mechanism to alleviate traffic congestion and public transport crowding during peak periods. While the volume of travel demand is more or less the same, the staggering of start and finish times mean that travel is spread on either side of conventional peak periods. There are benefits to the efficiency of transport system management and potential cost savings for the government from wide uptake of staggered working hours; for example, investment in road capacity could be set to meet a lower level of peak demand and the frequency and capacity of rail services during peak periods could be reduced.

Incentives could be offered, for example, to encourage employees to commence work before 7am and finish before 4pm. If workers or groups of workers start and finish work at different times, this would result in a smoothing of demand which permits traffic to flow more consistently, public transport to be less crowded and roads to be less congested.

Evidence of policy measures to support staggered working hours is limited. Responsibility for catering to staggered working hours largely rests with private employers in industries where it makes sense to do so, namely those with high concentrations of employees in the CBD and other congested areas whose work is not contingent on the time of day. The State Government could explore areas where it could do so directly, such as staggered work hours for public sector employees or staggered 'shifts' in the State school system (noting that travel to and from school is a significant contributor to peak period demand).

Also, promotion of public transport travel outside of peak periods could involve peak-spreading of fares or incentives for park-n-ride users who arrive and park before a certain time of the day.

4.5.2 Case studies

Honolulu, Hawaii - The Staggered Work Hours Demonstration Project

The Staggered Work Hours Demonstration Project was conducted in downtown Honolulu, Hawaii in 1988 over four weeks. Office hours for certain employees were shifted 45 minutes later from 7:45am-4:30pm to 8:30am-5:15pm to alleviate morning peak congestion in the city. There were approximately 4,000 participants, representing 7 per cent of the downtown workforce.

Participation was **mandatory for all public sector employees** and those who did not participate required approval through a formal exemption process. Participation by private sector employees was voluntary and unlike public sector employees, these workers were not restricted to the 8:30am-5:15pm time allocation and could change their work hours to an earlier or later schedule.

Travel times and speeds were monitored on three major corridors – Mililani, Hawaii Kai and Kailua – leading into downtown. These measurements were taken two dates before (February 3 and 7) and two dates during (March 2 and 16) the project.

The project resulted in **average travel time savings of 3 to 4 minutes**, or up to **9 per cent of the average commute** of 45 minutes. However, these effects were not uniform. Workers who shifted from 7:30am to an earlier schedule (private sector workers) benefitted the most and experienced an average travel time saving of 4 to 8 minutes. **Non-participants generally benefitted more than participants** since participants shifted out of the peak travel intervals. Their average travel time savings ranged from 2 to 7 minutes.

Some participants experienced more congestion, struggled to find a parking space and were unable to use their regular express bus services as they ended at 5pm. Workers who had flexible working arrangements before the project suffered the most. Workers who shifted from earlier hours (before 7:30am) experienced the greatest disruption to their schedules, worse travel conditions and had the longest commutes. Since these workers shifted into peak traffic times, this resulted in localised congestion issues at some sites.

Private sector employees reported favourable attitudes towards the project, while public sector employees generally had a negative view of the project. These contrasting attitudes reflect their

Honolulu, Hawaii - The Staggered Work Hours Demonstration Project

different experiences; the project was not compulsory for private-sector workers and they had more flexibility in adjusting their commute to avoid congestion. However, voluntary staggered work hours were perceived positively by all.[128]

Singapore – COVID-19 measures

As a result of COVID-19, employers in Singapore have been **encouraged to stagger start times** and allow flexible work hours to spread out staff and reduce crowding of employees at common spaces or near the workplace.[129] Lunch, other breaks and finish times will be staggered as well. These measures came into effect in early April 2021 to facilitate a safe return to working from an office environment.

The government has proposed staggering start times such that at least half of all employees arrive at the workplace at or after 10am. For instance, Cayman Group Holdings has two start times; some employees start at 8:30am and finish at 4:30pm to 5pm, whilst other employees start at 10:30am and leave between 6:30pm and 7pm.[130]

The staggering of start times would allow more employees to avoid peak-hour travel, reducing congestion on public transport and roads.

4.6 Travel behaviour change and other awareness-raising programs

4.6.1 Overview

Travel behaviour change programs use information, education, incentives and other marketing-based approaches to encourage and assist people to reduce their dependence on private vehicles and increase physical activity through voluntary adaptations in their travel habits and patterns.

This promotion of alternative transport modes, such as cycling and walking, to carry out habitual trips in every day routines is associated with positive outcomes in the form of lower pollution, reduced frequency of accidents and greater health and wellbeing outcomes.

Rather than building new infrastructure, travel behaviour under this approach is changed through informing and motivating people to alter their behaviour, with a focus on reducing information asymmetries related to active transport modes and providing individual support. The Perth Your Move programs (see case study below) offer integrated services to households, schools and workplaces, while also providing self-help services to these groups through regular contact, coaching and materials. The intensive integrated services to targeted areas help people to achieve their active transport goals through providing tailored information and resources as well as personalised coaching and feedback on progress.[131]

4.6.2 Case studies

Perth – The Your Move Program

Your Move is a free program run by the WA Department of Transport (DoT) that supports individuals, schools and workplaces to **substitute their private vehicle use** for **walking**, **riding** or catching **public transport**. This program has been implemented in the City of Cockburn, the City of Wanneroo, the Town of Victoria Park and the Town of Bassendean.

Your Move Wanneroo ran from February to November 2015 and encouraged more than 10,500 households to reduce their car use and increase their physical activity levels. During this time DoT implemented a range of strategies including:

Perth – The Your Move Program

- Distributing welcome packs containing maps, active transport information, cycling and walking routes, local sport and recreation options, a backpack and a water bottle
- Providing coaching and education sessions where participants were offered free training sessions, bicycle education classes and personal phone coaching to help them plan and work towards personal activity goals
- Issuing 545 Smartrider cards with credit to promote public transport usage
- Installing active transport infrastructure including 43 bus stop information modules, 20 bicycle racks and repair stations and 800 wayfinding signs.

Your Move Wanneroo was successful in promoting physical activity: 59 per cent of participants achieved their physical activity goals and 8 per cent of participants moved from being insufficiently active to meeting recommended physical activity guidelines. The program also resulted in an average increase in physical activity of 9 minutes per person per day.[132] Some 73 per cent of participants stated that the project changed their lives for the better.

Victoria – TravelSmart program

TravelSmart was a Victorian government initiative in operation from 2001 to 2012, which aimed to reduce car dependency and **encourage low-cost and environmentally friendly transport modes** such as walking, cycling, public transport and carpooling. Programs were conducted at various schools, universities, hospitals and other workplaces with over 150 travel plans developed across more than 38 funded projects.

TravelSmart Workplaces was designed to help employers to minimise the impact of work-related travel through a range of strategies such as green transport plans. These plans incorporated biannual staff travel surveys which assisted employers to assess the travel patterns of staff and to measure progress towards sustainable travel objectives.

TravelSmart Schools was a curriculum-based program for children in grades five and six that encouraged healthy and sustainable travel to school. Materials that promoted the benefits of physical activity and raised awareness of the environmental impact of car travel were distributed.

TravelSmart Communities was a program that encouraged members of local communities to 'identify sustainable transport solutions that meet their travel needs for family commitments and social activities.' The program involved contacting residents within a specific area and providing them with information specific to their needs.

TravelSmart achieved **positive shifts in behaviour** towards sustainable modes of transport. For instance, a 2012 review commissioned by DoT of 134 projects found that 85 per cent reported a shift towards more sustainable travel options. A further 65 per cent reported reduced car use, 35 per cent reported increased public transport usage, and 49 per cent reported increased cycling. However, funding for the program was discontinued in 2012.[133]

4.7 Micro-mobility

4.7.1 Overview

Micro-mobility refers to small, lightweight vehicles that carry one or two passengers and are driven by users. These include bicycles and scooters. Usually, they are used to travel short distances and can be either human-powered or electric. Electric micro-mobility vehicles also tend to operate at (or are capped at) low travel speeds.

This form of transportation can be privately owned or made available through a shared fleet. Over time, different versions of sharing schemes have been developed, from public bikeshare systems to dockless bikeshare and e-scooter fleets. Dockless vehicle-sharing has been particularly useful in increasing the flexibility of one-way trips as users who have ended their trip can leave their vehicle anywhere or within a certain geofenced area.

Micro-mobility vehicles can help to fill gaps in public transport routes by offering attractive solutions for first- and last-kilometre connectivity. They can facilitate inter-modal transfers and provide convenient and cost-effective methods of transport for short trips to and from public transport stations. Further benefits of micro-mobility include reduced usage of private vehicles, lower levels of pollution and reduced noise and congestion.

4.7.2 Considerations for implementation

There are regulatory barriers in Australia that constrain broader uptake of various micro-mobility options. For example, in Victoria, road rules are restrictive and prohibit the use of e-scooters. Under the current law, scooters cannot travel on footpaths faster than 10 kilometres per hour or operate with a power output of more than 200 watts. The fine for an illegal device in Victoria is $826.

Similarly, in Western Australia many e-scooters and e-skateboards are outlawed on public roads and paths.[134] However, other states have revised regulations recently. For instance, beginning December 2019, residents in the ACT were permitted to use e-mobility vehicles and ride at a maximum speed of 15 kilometres per hour on footpaths and up to 25 kilometres per hour in all other permitted locations.[135] This has facilitated the growth of the 'Neuron' and 'Beam' scootershare systems in Canberra.

As micro-mobility vehicles are driven on roads, existing infrastructure can be used, however, some modifications such as cycle lanes, ramps, parking facilities, storage and docking stations are typically needed.

Some micro-mobility vehicles, particularly electric devices, are subject to criticism for creating or adding to congestion, being carelessly discarded, creating obstacles for people with disabilities and increasing the risk of collisions between motorised vehicles and pedestrians. There have also been concerns from the public and authorities regarding the safety of e-scooter users. As of February 2020, there have at least been 29 e-scooter related deaths worldwide and several reports of injuries, with a proportion of these occurring due to a software glitch in Lime e-scooters which caused irregular braking.[136]

Generally, studies show that people who are younger, upper income, single and male tend to be the biggest users.[137] However, the dockless nature of micro-mobility vehicles within a geofenced boundary can lead to unequal distribution of these devices, leaving communities further from CBD areas without access – areas that generally have the largest need for last kilometre solutions.

4.7.3 Case studies

Hangzhou, China - Hangzhou Public Bicycle

China's first successful bicycle-sharing scheme was launched by the Hangzhou Public Transport Corporation in May 2008 and was called 'Hangzhou Public Bicycle'. The local government designed this scheme to cover the last-kilometre journey from the public transport stop to the user's destination or vice-versa. The launch of this program involved an investment of CNY 180 million (US$26.35 million) from the government.

In May 2008, Hangzhou had 61 bike sharing stations with 2,800 bicycles. The number of bicycles and stations have been increasing each year with over 3,500 stations and 84,100 bicycles recorded as of May 2016. On average, 310,000 people use the service every day, with the peak daily volume reaching 448,600.[138]

Hangzhou Public Bicycle uses smart-card technology, touch-screen kiosks, automated check-in and check-out of bicycles and distinguishable bicycle docking stations. Radio frequency identification is also used to track bicycle information and cameras at docking stations are used to monitor and prevent theft or vandalism.

A smart card, which is integrated with Hangzhou's public transport system, is used to pay for the bicycles. The first hour is free of charge, followed by incremental pricing that discourages use for long periods: the second hour costs CNY 1 (US$0.15), the third hour costs CNY 2 (US$0.30) and each hour beyond this costs CNY 3 (US$0.44).

This system has been successful in facilitating new forms of travel behaviour amongst residents as bike sharing supports one-way trips and inter-modal transfers. A survey was conducted in Hangzhou between January and March 2010 where separate questionnaires were issued to bike sharing members and non-members. The survey found that 70 per cent of bike sharing members used the service at least occasionally and 30 per cent used it regularly as part of their commute.

Bike sharing has also been attractive to car owners, with 78 per cent of car owner respondents stating that they used bike sharing for trips previously taken by car. Further, about 50 per cent of car households used bike sharing to substitute bus transit. 60 per cent of 'carless' households substituted walking and 20 per cent substituted taxi trips with bike sharing.[139] These modal shifts suggest that bike sharing acts as both a competitor and a complement to existing public transport and other transport modes.

Brisbane – Lime Scooters Trial

In 2018, Brisbane was the first Australian city to trial 500 electric Lime scooters. Previously in Queensland, scooters could not travel faster than 10 kilometres per hour or operate with a power output of more than 200 watts. However, these rules were adjusted for the trial, allowing e-scooters to travel at a maximum speed of 25 kilometres per hour. E-scooters could only be used on footpaths, not on roads or in cycle lanes, and riders must wear helmets.[140]

Users need to download the Lime app, scan a QR code on the chosen scooter and pay $1 to unlock it. The user then pays $0.38 per minute to ride. To encourage responsible parking behaviour, riders must submit a photograph on the app of their parking attempt for Lime to review. If the rider has parked their e-scooter poorly multiple times, Lime will suspend their account.[141]

During the first three months of the trial, more than 500,000 e-scooter trips were taken.

Brisbane – Lime Scooters Trial

In June 2019, the Brisbane City Council approved 250 e-scooters from Neuron Mobility whose e-scooters contain geofencing technology that informs the rider when they are entering prohibited or dangerous areas. The vehicle also uses GPS-enabled parking indicators on the handlebar display to help users find a designated parking zone.

To date, Lime and Neuron are the only two e-scooter companies approved by the Brisbane City Council. Lime has obtained approval for 400 e-scooters whilst Neuron has been approved for 600 e-scooters.

4.8 Mobility as a Service (MaaS)

4.8.1 Overview

Mobility as a service (MaaS) allows transport users to plan, book and pay for different types of mobility services using a single app or digital platform. It integrates end-to-end trip planning, booking, electronic ticketing and payment services across different modes of transportation.

MaaS combines multiple transport modes such as car and ride share, with public and active transport options. Apps and other digital platforms consider real-time conditions throughout the network and the users' preferences to offer an array of possible transport options and combinations. Users can either pre-pay for the service as part of a monthly subscription or pay as they go using a payment account linked to the service.

4.8.2 Considerations for implementation

A diverse range of players need to cooperate for MaaS systems to be efficient and successful including mobility management firms, telecommunications providers, payment processors, public and private transportation providers and local authorities in charge of transportation and city planning.[142]

The creation of MaaS systems tends to be more efficient and successful when providers that offer different services and possess different skillsets collaborate. For instance, UbiGo (see case study below) collaborated with Stockholm Public Transport to offer subscription services across their combined networks, allowing for a superior end-to-end journey service and offering free taxis if public transport was delayed for over 20 minutes.

Because MaaS relies heavily on technology, it requires widespread uptake of smartphones on 3G/4G/5G networks, high levels of connectivity, secure, dynamic and up-to-date information on travel options, schedules and updates and cashless payment systems.

Access to trusted mobility advisors which link the services of private and public transport operators, arrange bookings and facilitate payments through a single gateway is key for MaaS systems. Further, access to real-time travel information and updates is required for the multimodal mobility services to identify and offer the best route.

Any new transport system should consider evolving community values and goals. As concern over climate change and sustainability increases among the public, MaaS will likely drive and deliver behavioural changes and help incentivise more sustainable transport modes.[143]

In the future, MaaS offerings are likely to include driverless technology, which has been tested in several jurisdictions including Singapore, Tokyo and China (although several barriers to future take-up currently exist including the regulation of safety, liability, data use and privacy).

4.8.3 Case studies

Berlin – Jelbi

In 2019, the multimodal mobility app 'Jelbi' was created and introduced by the Berlin Public Transport Authority (BVG) and Trafi (a MaaS solution leader). The aim was to provide an attractive alternative to private car usage and contribute to the reduction of greenhouse gas emissions in the city.

Jelbi integrates all public transport and shared mobility options into a single app for Berlin residents to find, plan, book and pay for their trips. Transport modes available include public transport (bus, tram, subway, S-Bahn), electric scooter, bike, car and ridesharing modes. When planning and booking, users can also compare prices and expected travel times.

The app helps its users in assistance planning and route discovery and also offers real-time public transport information and shared mobility vehicle location and availability. The integration of these services into one app eradicates app-jumping and makes transport more accessible.

Part of 'Jelbi' involved the installation of mobility hubs next to subway stations and in neighbourhoods to help users find cars, bicycle and scooters. To date, more than 200,000 people have downloaded the application. It is expected that in the future, additional mobility services will be made available on the app.[144]

Sweden – Gothenburg MaaS

In November 2013, Sweden launched a six-month MaaS pilot project to test an **app-based travel service** in Gothenburg. The pilot involved 195 participants across 83 households who, through the app 'UbiGo', held a monthly subscription to their desired combination of, and amount of credit for different transport modes including public transport, carpool, hire car, taxi and bike.

The minimum subscription was set at 1200 SEK (AU$184) per month in prepaid credit per household, where any unused credit was refunded to participants at the end of the trial. Participants were given the option of setting their car aside during the project and if they did so, they would be compensated economically to reflect the loss of value to the car.

To access these services, the UbiGo traveller logged into the app to activate tickets, make bookings and access already activated tickets (i.e. to show ticket controllers). Each participant received a smartcard which could be used to check out a bicycle or unlock a booked car. UbiGo travellers were **rewarded for using eco-friendly modes** of transport available on the app and accumulated points based on reduced kilograms of CO_2 emissions, which were exchanged for other goods and services provided by sponsors such as tickets to public attractions and gift cards.

At the end of the trial, participants reported **decreases in private car use** and increases in alternative transport mode use particularly car sharing and use of buses and trams. Changes in travel behaviour were reported by **64 per cent of the participants**, with many participants citing changes in their pre-trip planning. Participants' attitudes also changed; participants became less positive about private car use and more positive towards alternative modes over the course of the trial.[145]

5 Options for implementation

5.1 Overview

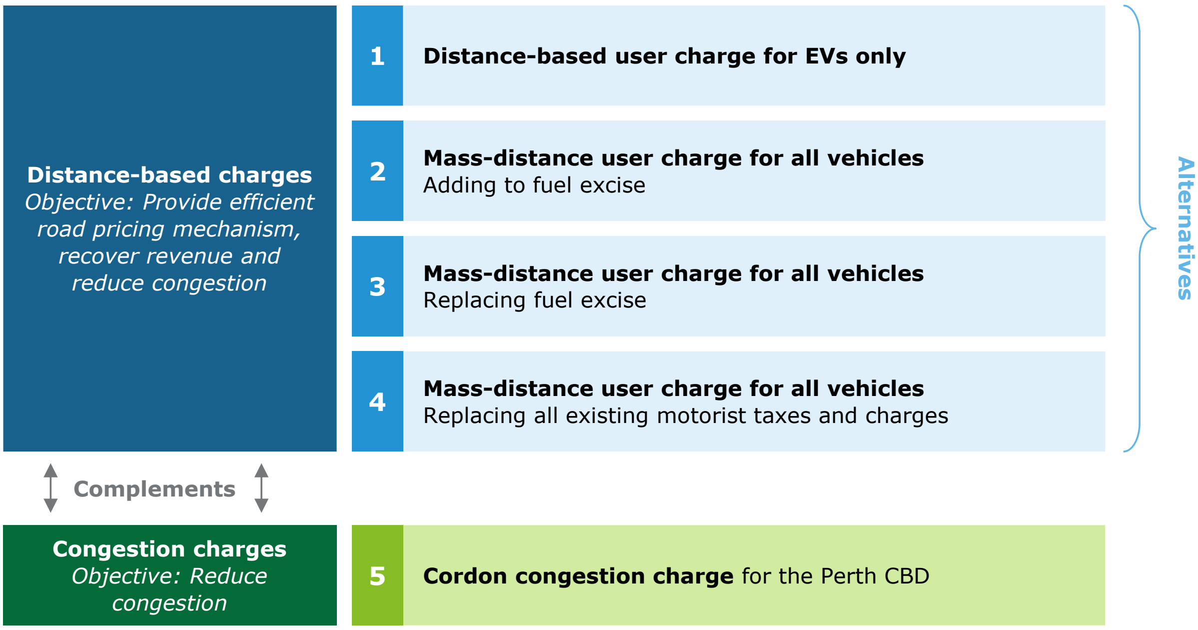
This chapter outlines a series of options for IWA to support its consideration of road user charging in Western Australia in the SIS.

Four options for distance- or mass-distance-based user charges are identified, varying in their scope (applying to EVs only or all vehicles) and scale (based on the level of costs and lost revenue they are intended to offset). These options also vary in whether they can be implemented by a state government independently, or require coordination with other states and territories and the Commonwealth.

Options for implementing charges and other mechanisms for congestion management are also set out in this chapter. These are complements, rather than alternatives, to distance- or mass-distance-based user charges.

A summary of options is provided in Figure 5.1.

Figure 5.1: Options for implementing road user charges in WA



Source: Deloitte Access Economics

5.2 Option 1: Distance-based charge for EVs only

5.2.1 Description

Under Option 1, a distance-based user charge would be introduced for EVs (including other zero- and low-emissions vehicles). The charge can either be a fixed rate per kilometre for all EVs or take the form of a schedule with different fixed rates per kilometre according to vehicle type and mass combinations.

Given that most vehicle EVs in Australia are light passenger vehicles, the impact of adding a vehicle type-mass variable is likely to be marginal and proceeding with a fixed rate for all vehicles may be simpler and easier to implement. Discounts can be provided for PHEVs and other HEVs that will continue to pay fuel excise, consistent with the Victorian approach.

5.2.2 Implementation considerations

An appropriate technological solution is needed to implement road user charging. This could be achieved independently using vehicle owners' existing accounts with the Department of Transport (DoT), with self-reporting of kilometres travelled (supported by photographic evidence of odometer readings) submitted annually when users pay their motor vehicle registration.

Overseas jurisdictions have tended to partner with third-party commercial providers who administer the self-reporting through a smartphone app or enable automated reporting through the installation of telematic devices or connection to vehicles' onboard diagnostics. This option may be more costly, and take longer to implement, than self-reporting through DoT given the relatively small number of existing EV users in Western Australia.

To avoid large, sharp increases in future, the charge would be indexed regularly to either CPI or a more representative price index for governments' direct cost of road provision (such as a producer price index for construction).

If opting for this simple distance-based charge for EVs only, it would need to be introduced relatively soon. As outlined in Chapter 2.3.1.3, given relatively low levels of EV uptake to date, levying an additional charge on a small number of users now, would allow future EV users to factor the charge into their purchase decision. From the perspective of future EV users, the charge will likely be more than offset by the 'natural' decline in EV prices (relative to ICE vehicle prices) as technology improves and EV component costs fall.

Temporary or one-off complementary incentives for EV users could be implemented to coincide with the introduction of the distance-based user charge, such as a reduction in motor vehicle registration fees for existing EV users and/or a discount on stamp duty paid on future EV purchases.

5.3 Option 2: Mass-distance charge for all vehicles

5.3.1 Description

Under Option 2, a mass-distance charge for all vehicles, including EVs and other zero- and low-emissions vehicles, would be introduced.

The charge would be levied on a per-kilometre basis in the same way as Option 1; however, given the wide variance in vehicle types and masses across the whole vehicle fleet, this charge would need to include a mass-based element to account for heavy vehicles' relatively greater impact on road wear and tear. This could take the form of a limited set of vehicle categories defined according to vehicle mass and vehicle type (e.g. based on the number of axles).

5.3.2 Implementation considerations

Implementation of a mass-distance charge for all vehicles could occur using similar processes and technology as for Option 1. Irrespective of the odometer reporting mechanism used, the appropriate rate by vehicle type and mass category could be applied based on information supplied in the motor vehicle registration process.

The implementation of Option 2 would impact virtually every vehicle user, including commercial and public sector fleet vehicles. There is likely to be a greater range of challenges and potential adverse impacts (for example, equity concerns) than for Option 1.

Consequently, Option 1 could be implemented in the short term to introduce a distance-based charge for EVs only, transitioning to Option 2 (a mass-distance charge for all vehicles) in the medium term.

5.4 Option 3: Mass-distance charge to replace fuel excise

5.4.1 Description

Under Option 3, all state and territory governments and the Commonwealth Government would collaborate to introduce a nationally consistent mass-distance charge for the full vehicle fleet. The charge would coincide with the removal of fuel excise and would be set to raise an equivalent amount of revenue currently raised by fuel excise (net of fuel tax credits).

The mass-distance charge would function like Option 2, with fixed per-kilometre charges applied for different categories of vehicles determined by a vehicle's mass and other characteristics (e.g. number of axles).

5.4.2 Implementation considerations

This option provides for a more efficient road pricing mechanism, greater relative incentive for EV uptake and resolves the issue of indexing the ICE vehicle charge to a measure of fuel efficiency, relative to Option 2.

The more efficient mechanism could have positive equity impacts, with users of older, less fuel-efficient vehicles who drive relatively fewer kilometres paying less overall.

Achieving national coordination to completely replace fuel excise with a mass-distance charge presents a substantial challenge, relative to Options 1 and 2. That is evident in the relatively little progress made on road pricing over the last decade: The Henry tax review recommended the replacement of fuel tax with a more efficient 'user pays' mechanism in 2010, and further recommended that the Council of Australian Governments (COAG) appoint a single institution to lead nationally consistent road tax reform.[146]

In the very long term, the outcomes of Option 3 are the same as Option 2; assuming that ICE vehicles eventually disappear from Australia's vehicle fleet altogether, the difference between the two options is simply a question of whether ICE vehicle users continue to pay fuel tax plus an additional charge in the meantime (Option 2) or whether fuel tax is replaced earlier (Option 3).

5.5 Option 4: Mass-distance charge to replace all motorist taxes and charges

5.5.1 Description

In addition to its findings on the inefficiency and unsustainability of fuel excise, the Henry tax review found that other mechanisms for raising revenue from motorists – including vehicle registration and stamp duty – were highly inefficient and should be phased out.[147]

Under Option 4, all such taxes and charges would be phased out and replaced by a mass-distance charge. This represents a more efficient road pricing mechanism than the other options explored, by replacing revenue sources linked to fuel consumption and the number of vehicles and drivers with a single per-kilometre charge.

5.5.2 Implementation considerations

Option 4 is the most efficient road pricing mechanism of the options explored, converting all existing motorist taxes and charges into a mass-distance charge that aligns motorists' use of the road network with their contribution to funding it.

However, it also requires the greatest level of coordination between governments to implement substantial legislative and regulatory reform. In addition to implementation challenges explored under Option 3, it also entails the removal of a range of other Commonwealth taxes as well as having all state and territory governments agree to the removal of stamp duty on motor vehicles, motor vehicle registration fees and other charges.

Option 4 is most consistent with the principle of a 'user pays' model for the road network, and most consistent with the recommendations of the Henry tax review for the reform of road revenue measures in Australia.

5.6 Option 5: Cordon charge for Perth CBD

5.6.1 Description

Under Option 5, a cordon charge for the Perth CBD would be introduced, setting the cordoned area based on analysis of congested conditions on key roads and origin-destination analysis of journey endpoints.

The cordoned area could be set to discourage motorists from travelling into the CBD, rather than functioning as a corridor charge or toll on certain road segments. For example, the cordon charge would target commuters who have access to public transport services to commute into the CBD and can be encouraged to complete the same journey using a different mode, by imposing a penalty for driving into the CBD.

The 2019 Australian Infrastructure Audit estimated the cost of road congestion in the Greater Perth area at around $1.5 billion in 2016 and projected that this would increase to $3.6 billion by 2031.[148] This cost represents the volume of hours of journey time delay caused by congestion, monetised using perceived values of time for private and business passenger car users and commercial vehicles.

The cordon charge would need to consider distributional impacts and ensuring that it is fairly applied to the appropriate cohorts of road users. For example, freight vehicle congestion on highways outside of the Perth CBD is likely a significant contributor to the total Greater Perth congestion cost, but unlikely to be addressed through a cordon charge for the CBD.

The cordon charge could apply during specific periods of the day (e.g. morning and afternoon peak periods) and on days of the week necessary to manage congestion. It could also vary according to vehicle type and mass, with heavy vehicles subject to a higher charge to offset their greater impact on road wear and tear.

Like the Milan and London models, the cordon charge could be tiered so that EVs and other zero-emissions vehicles pay a lower charge to drive within the cordoned area than conventional ICE vehicles.

5.6.2 Implementation considerations

Implementing a cordon charge would likely require significant investment in infrastructure, including gantries mounted with electronic detection systems (if the charge is applied using in-vehicle tags) and/or cameras (to capture number plate images) so that charges can be applied based on vehicle movements at each entry point.

This initial investment, and the annual operating costs of administering the system, would likely be significant. In the London and Milan systems, around 40 to 50 per cent of annual gross revenue from the cordon charging schemes is spent on operating costs.

The scope of the charge would need to be set to align with the objective of reducing road vehicle congestion in the inner metropolitan area. This is complicated, for example, by major river crossings in the CBD catering to north-south through-traffic, most notably the Narrows Bridge. A blanket charge applied to the CBD segment of the Mitchell and Kwinana Freeways would penalise motorists whose journeys begin and end outside of the CBD, as well as those commuting to the CBD.

The cordon charge could function as a complement to the distance-based and mass-distance charges outlined in the preceding options. The two charges in tandem would approximate an efficient mass-distance-location-time price for road use.

5.7 Other options

5.7.1 Parking management

Expansion of the Perth Parking Management Area or implementation of similar parking management schemes in other areas has little merit as a road pricing mechanism relative to the introduction of a mass-distance user charge, and little merit as a congestion management tool relative to a cordon charging system.

In comparison to both types of charges, increasing the cost of commercial parking spaces skews the alignment between road users and road funders to focus heavily on those who commute into the CBD to park. It ignores the impact of road use and congestion resulting from through-traffic in the parking management area. In other major metropolitan areas, through-traffic has been found to account for around one-third to 40 per cent of morning peak period CBD traffic; these users would essentially get a 'free ride' under a system that targeted commuters who park in the CBD.

There may be other merits to raising the cost of CBD parking – for example, to reduce the number of parking bays to unlock alternative land use opportunities – but these are not necessarily complements or alternatives to a more efficient road pricing mechanism.

5.7.2 Toll roads

While private toll roads may be effective at providing users with faster journeys, the purpose of the private tolling arrangement is generally to attract private investment in a road infrastructure project that would not otherwise have been affordable by providing a financial incentive to the private investor through a secure, long-term toll concession.

Private tolls implemented on segments of the road network are effective at reducing congestion and providing faster journeys within the tolled zone, but they take no account of congestion impacts on neighbouring roads or the un-tolled road segments beyond the entry and exit points. Consequently, at the network level, they are neither an effective means of raising revenue for governments nor an effective congestion management tool.

Given the historical and bipartisan opposition to private toll roads in the Western Australian community – and their lack of merit as a road pricing mechanism relative to a mass-distance and cordon congestion charge – an option for the introduction of private toll roads in WA has not been explored.

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Limitation of our work

General use restriction

This report is prepared solely for the internal use of Infrastructure WA. This report is not intended to and should not be used or relied upon by anyone else and we accept no duty of care to any other person or entity. The report has been prepared for the purpose of supporting Infrastructure WA in preparing the inaugural State Infrastructure Strategy, specifically regarding potential non-build infrastructure responses relating to transport. You should not refer to or use our name or the advice for any other purpose.

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