Local community benefits of Zero Emission Vehicles in Australia

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AUSTRALIAN CONSERVATION FOUNDATION

Prepared by Deloitte Access Economics Pty Ltd

Contents

Acronyms

Acronym	
ACCC	Australian Competition and Consumer Commission
ACF	Australian Conservation Foundation
BEV	Battery Electric Vehicle
BITRE	Bureau of Infrastructure and Transport Research Economics
BRT	Bus Rapid Transit
CARB	The California Air Resources Board
CO2	Carbon dioxide
EV	Electric Vehicle
FCEV	Fuel Cell Electric Vehicles
GHG	Greenhouse Gas
ICE	Internal Combustion Engine
LGA	Local Government Area
NPV	Net Present Value
NSW	New South Wales
PHEV	Plug-in hybrid electric vehicles
PPP	Public Private Partnership
QLD	Queensland
SA	South Australia
UK	United Kingdom
USA	United States of America
VAT	Value-added Tax
VKT	Vehicle Kilometres Travelled
VIC	Victoria
ZEV	Zero Emissions Vehicle

Executive summary

Leading the charge towards net zero emissions

This report was prepared by Australian Conservation Foundation (ACF) and incorporates research from Deloitte Access Economics to examine the potential benefits of a significant shift to Zero Emission Vehicles (ZEV) around Australia.

The modelling calculates the benefits of the shift to ZEVs by measuring four 'externality' types:

- Air pollution
- Green House Gas (GHG) emissions
- Noise pollution
- Water pollution.

While these are not the only benefits of ZEVs, they are likely to account for the majority of benefits and, are therefore, the focus of this report.

Scenario one assumes that current State and Federal transport and climate targets are fully implemented. For example, this includes State and Territory electric bus transition targets and net zero emission targets. It assumes ZEV uptake by 2030 in line with federal government projections.

Under scenario one, Australia has the potential to avoid future costs of approximately $232.6 billion (NPV* $2021) between 2022 and 2050.

Scenario two assumes a swifter transition to ZEVs among private cars than Scenario One. In this instance, all States and Territories adopt bus transition policies in line with NSW, and a net zero emissions target by 2045 in line with the Climate Targets Panel 2-degree scenario.

If Australia was to proceed along scenario two, there is the potential to avoid future costs of approximately $335.4 billion from adopting a more ambitious ZEV scenario to achieve net zero road transport emissions by 2045.

Scenario three increases the ambition of scenario two by bringing forward net zero to 2035 in line with the Climate Targets Panel 1.5°C scenario and adds significant improvements to zero emission public transport based on improved levels of service.

If Australia was to proceed along scenario three – characterised by a faster transition to 100% ZEV vehicles and increased public bus usage – there is the potential for even greater benefits to the Australian community. Under this scenario, achieving net zero road transport emission by 2035 could result in avoided costs of $491.6 billion.

A discussion of ZEV incentives introduced to accelerate the uptake and widespread adoption of ZEVs presents an overview of the domestic and international policy landscape. This includes best practice case studies across international jurisdictions, specifically Norway, and cities such as Beijing and San Francisco.

The modelling results have been presented at the local level through four case studies of Australian electoral divisions:

- The electoral division of North Sydney (NSW)
- The electoral division of Higgins (VIC)
- The electoral division of Ryan (QLD)
- The electoral division of Mayo (SA).

International experience and high-ambition policy options is considered in an analysis of range of potential policies likely to encourage ZEV uptake. They include:

- ZEV mandates: Requirement of vehicle manufacturers to sell a minimum number of ZEVs as a proportion of their overall sales in the country.
- Public transport: Complete upgrade of buses from internal combustion engines (ICEs) to ZEVs.
- Funding reform: Large scale hypothecation of Commonwealth fuel tax revenues towards ZEV infrastructure and subsidies and public transport.

Table i: Overview of the three scenarios considered in this analysis**

	Scenario one: A general scenario	**Scenario two:** A ZEV driven transition to net zero	**Scenario three:** A swift hybrid transition to net zero
Net zero in road transport emissions	2050	2045	2035
Private fleet ZEV share	26% by 2030	2030: 28% 2045: 100%	2035: 100%
Public transport (bus): ZEV share	Announced State commitments	2030: 100%	100% by 2027
Public transport (bus): mode share	Same as Base Case (–5%)	Same as Base Case (–5%)	2035: 10% 2045: convergence to trends seen in comparable best practice cities internationally

**Net Present Value: Present value of benefits less present value of costs*

***A social discount rate of 3% has been used*

Summary of results

Imagining a ZEV future

Maintaining our current approach to road transport could **cost Australia $865 billion** between 2022 and 2050.

- This is made up of the following costs to the community:
- Air pollution: **$488 billion** (56%)
- GHG emissions: **$205 billion** (24%)
- Noise: **$95 billion** (11%)
- Water pollution: **$76 billion** (9%).

Adopting more ambitious zero emission road transport scenarios has the potential to result in **significant reduction** in these costs.

Scenario one:

a gradual ZEV uptake:

$233 billion (NPV 2021) in avoided costs to the community.

Scenario two:

a ZEV driven transition to net zero:

$335 billion (NPV 2021) in avoided costs.

Scenario three:

a swift transition to net zero and increased share of public transport:

$492 billion (NPV 2021) in avoided costs.

1. Introduction

Structure of this report

This report incorporates insights from ACF, coupled with research from Deloitte Access Economics to analyse the local benefits of significant increases in ZEVs and public transport. This report is structured as follows:

Chapter two: provides an overview of both the domestic Australian and international policy landscape for ZEV uptake.

Chapter three: outlines the three scenarios modelled in this report and provides a high-level overview of the modelling methodology (more detail is provided in the appendix).

Chapter four: outlines the results of this analysis, including the relative avoided costs available to the Australian community under each scenario.

Chapter five: considers these results at the local level through four case studies of Australian electoral divisions.

Chapter six: provides an analysis of a range of potential policies that are likely to encourage ZEV uptake. It considers international experience and goes beyond policies that use cost levers for individuals, and high ambition policy options.

2. Background

2.1 Domestic policy overview

Australian State and Territory Governments are introducing a greater range of ZEV incentives to lower price differences between ZEVs and ICE vehicles as a means of encouraging ZEV uptake. A summary of current incentives across each of the State and Territory Government bodies is provided below.

Figure 2.1: Current ZEV incentives available across Australia

Northern Territory
ZEVs pay lowest registration fees in the small car category

Western Australia
$21 million Electric Vehicle Fund to build the world's longest network of EV charging stations
Target 25% of EVs in the State Government fleet by 2026
New lower rate EV tariff to encourage EV owners to charge between 11pm and 4am
EVs are exempt from the 10% on-demand (taxis, ride-sourcing, charter vehicles) transport levy which can add up to $10 to each journey

South Australia
Entire SA Government fleet to be electric by 2030
ZEV road user tax to be implemented from 2027
Investment in charging Infrastructure: 110 rapid highway charging stations installed across SA, 350 fast destination chargers in metropolitan centres by 2030-35

Tasmania
Stamp duty exemptions for two years on new and used ZEVs
Target for 100% of Government fleet to be EVs by 2030
Free registration for EVs purchased by car rental companies and coach operators for two years
Investment in charging infrastructure: $600,000 towards fast- and destination-charging stations in regional and tourism destinations

Victoria
$3,000 rebate for 20,000 ZEVs priced under $68,740
$100 registration discount for Zero or low emission vehicles
Low emissions vehicles do not attract the luxury car transfer tax rates
$19 million on charging infrastructure in regional areas
$10 million to replace 400 vehicles in the Government fleet with ZEVs by 2023
From 1 July 2021, a new user-pays charge is required for Victorian-registered ZEVs

Queensland
On 17 June 2021, the QLD Government announced the development of a new Queensland Zero Emission Vehicle (ZEV) Strategy
Reduced stamp duty for EVs
Reduced registration fees – EVs save between $71.45 and $606.85 compared to the ICE vehicles, depending upon the number of cylinders
Investment in charging network, including 49 fast charging locations across QLD

New South Wales
From September 1 2021, the first 25,000 buying an ZEV priced below $68,750 will benefit from a $3,000 rebate
From September 1 2021, NSW motorists buying an EV priced below $78,000 will have stamp duty waived (saving up to $3,000)
100% of the State fleet to be electric by 2030
$171 million investment in ZEV chargers, including $131 million on 'ultra-fast' chargers
ZEV road user tax to be implemented from 2027

ACT
Stamp duty exemptions on new EVs
Two years free registration fro new and used ZEVs (until mid-2024)
20% annual vehicle registration discount for ZEVs
Government has committed to providing households with interest free loans of up to $15,000 to assist with the upfront costs of investing in ZEVs – including second-hand ZEVs – and home ZEV charging infrastructure

2.2 International policy overview

This section provides an overview of ZEV incentives implemented in other jurisdictions internationally, and examples of best practice mechanisms used to accelerate the uptake and widespread adoption of ZEVs.

Comparison of international incentives

A summary of the range of policies that have been introduced across leading jurisdictions in terms of ZEV uptake is presented in the table below. Policy options range from consumer incentives, infrastructure deployment, building codes, zoning and parking concessions.

Table 2-1: Jurisdiction analysis on policy implementation

	ACT Australia	Oslo, Norway	Amsterdam, Netherlands	Los Angeles, USA	San Francisco, USA	London, England	Paris, France	Stockholm, Sweden	Beijing China
Building code changes	✔			✔					
Fuel efficiency standards			✔	✔	✔	✔	✔	✔	✔
Direct vehicle incentive (i.e. interest free loans or tax concessions)	✔	✔	✔		✔	✔	✔	✔	✔
Stamp duty/Registration discounts	✔		✔			✔			✔
Incentives for home and multi-dwelling chargers				✔		✔		✔	
Exemption from road toll	✔	✔							
Zero emission zones				✔	✔	✔			
Access to High Occupancy Vehicle (HOV) and bus lanes		✔	✔		✔			✔	
Free municipal charged parking		✔	✔		✔	✔		✔	
Subsidies for companies		✔				✔	✔		
Owners of ICE vehicles are charged additional taxes			✔		✔	✔		✔	✔
Compensation for scrapping of ICE vehicles		✔			✔		✔		✔
Electric Vehicle target		✔	✔	✔	✔		✔		✔
Phase out date for ICE vehicles		✔	✔			✔	✔	✔	
Electric bus transition policy		✔	✔	✔	✔				

Source: *Deloitte analysis*

2.2.1 Comparative review: **Norway**

Norway has been the most successful country in achieving ZEV market penetration, with the Norwegian Government having invested heavily in financial incentives and EV charging infrastructure.

It was the first country where the sale of electric cars had overtaken those powered by petrol, diesel and hybrid engines in 2020.

A snapshot of Norway including the extent of ZEV uptake across the country, existing charging infrastructure, and national targets is provided in the table to the right.

Relevant policies, incentives and critical success factors attributable to the Norwegian Government are summarised below:

At the national level

- No purchase/import tax or Value-added Tax (VAT)[1]: Drivers are exempt from both purchase tax and a 25% VAT on purchase when buying or leasing a new or pre-owned EV.
- No road traffic insurance tax: EV owners are exempt from paying annual road traffic insurance tax.

At the local government level

- Half price tolls: Charge of a maximum of 50% of standard toll prices on roads and ferries for EV owners.
- Half price parking: Charge of a maximum of 50% of the cost of standard parking for EV owners.
- Use of bus and taxi lanes: Access to bus and taxi lanes by EV owners.

The range of incentives introduced over time in Norway and the corresponding ZEV proportion of new sales is illustrated in Figure 2.2.

Critical success factors

- **Funding of national, regional or local initiatives created by counties and municipalities:** Funding of organisations such as Enova, and the creation of a framework for both the public and private sector to work within.

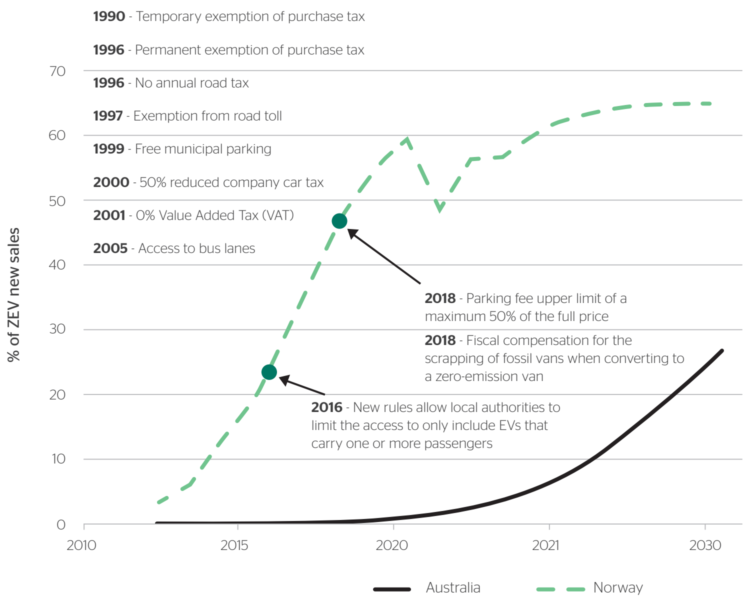
Table 2-2: Norway key statistics (2021)

Norway (2021)	Description
Current population	5.5 million
# of registered ZEVs	464,000
ZEV market share	54%
# of ZEV chargers	16,000
Charging stations per population (100,000)	1:291
National targets	Ban of sales of fossil-fuelled cars by 2025 Net zero greenhouse gas emissions by 2050

Source: *Electrive (July 2021)*

- **Significant investment in charging infrastructure:** Development of charging stations along major highways and investment in a national charging grid. For example, The Norwegian government has established fast-charging stations on every 50km on all main roads.
- **Comfort, safety and design:** New standards for ZEVs have been set in terms of range and speed.

Figure 2-2: Jurisdiction analysis on Norway's policy implementation with ZEV uptake



Source: *Brite (2020), Deloitte Analysis*

2.2.2 Comparative review: **Beijing, China**

Rapid uptake of ZEVs across Beijing can be attributed to high levels of government support including the implementation of policies that promote investment in infrastructure and incentivise buyers. More broadly, China accounts for nearly half of global EV sales.

Significant air pollution concerns have forced the city to look to cleaner technologies and alternatives to ICE vehicles, such as ZEVs. Increased demand for electric transportation has additionally seen a rise in the use of electric bikes and scooters and cheaper and more convenient alternatives.

A snapshot of Beijing, including the extent of ZEV uptake across the city, existing charging infrastructure, and broader national targets, is provided to the right.

Government policy initiatives, incentives and critical success factors attributable to the Chinese Government are summarised as follows.

At the Central Government level

- 20% ZEV passenger car share by 2025
- Exemption of ZEVs from consumption and sales taxes
- Waiving 50% of vehicle registration fees for ZEVs.

At the provincial and local government level

- Subsidies for manufacturers of longer-range ZEVs
- Free and preferential parking for ZEVs
- Provision of grants for technological innovation and subsidies for manufacturers of ZEVs.

Critical success factors

- **Leadership and political commitment.** High level of support from the government through incentive packages and regulatory legislative action. This has resulted in the increasing popularity of ZEVs among the public and changing consumer preferences.
- **Focused and flexible policy.** Rollout of subsidies and incentives in Beijing to encourage initial interest in ZEVs, and imposition of restrictions on foreign car sellers to collaborate with local manufacturers created a strong domestic market, leading to a rapid uptake of ZEVs. Promotion of policies to create a self-sufficient market will be shortly rolled out (e.g. reduction in subsidies).
- **Involvement of a wide range of stakeholders to change consumer preference and behaviour.** In the development of targeted policies, technological inputs from private and government-owned car and battery manufacturers have been incorporated, in addition to inputs from academic institutions studying the performance, acceptance and infrastructural requirements of ZEVs.

Table 2-3: Beijing key statistics (2021)

Beijing, China	Description
Current population	20.9 million
# of registered ZEVs	188,000
ZEV market share	4.4%
# of ZEV chargers	205,100
Charging stations per population (100,000)	1:981
National targets	• *Ban on sale of ICE vehicles:* End sales of conventional vehicles by 2030. • *Zero emissions vehicle mandate:* Each Chinese vehicle manufacturer and importer is required to make or import at least 12% EVs (2020). • Companies that fail to achieve the required percentages may purchase credits from companies that over comply.

Source: *He, Jin , 'How China put nearly 5 million new energy vehicles on the road in one decade', The International Council on Clean Transportation (28 January*

2.2.3 Comparative review: **San Francisco, United States**

San Francisco has been identified as a best practice comparator city for major Australian cities such as Sydney and Melbourne, based on similarities in terms of factors such as population, population density, GDP per capita and public transport mode share[2].

Amongst the cities across the United States, San Francisco ranks among the top in EV promotion actions, EV adoption, and public and workplace charging infrastructure[3].

A snapshot of San Francisco including the extent of ZEV uptake across the city, existing charging infrastructure, and broader national targets, is provided to the right.

Existing legislative requirements

A summary of San Francisco's ZEV legislated requirements is provided below[4]:

Commercial garage ordinance: Requires commercial parking lots and garages with more than 100 parking spaces to install EV charging stations in at least 10 percent of the parking spaces. Parking facility owners would be required to install the EV charging stations by January 1, 2023 and will be encouraged to work with EV charging providers to do so. The ordinance will apply to approximately 300 commercial parking facilities throughout the city.

Electric vehicle readiness ordinance: Starting January 2018, the city's electric vehicle (EV) readiness ordinance requires new residential, commercial, and municipal buildings, and major renovations, to have sufficient electrical infrastructure to simultaneously charge (at Level 2 charging) EVs in 20% of parking spaces provided.

Zero Emission Vehicle municipal fleet ordinance: The city's zero emission vehicle (ZEV) municipal fleet ordinance requires all light-duty passenger vehicles in the city fleet to be ZEVs by December 31, 2022. The ordinance will advance the city's commitment to reducing greenhouse gas emissions from light-duty vehicles while improving electric vehicle (EV) charging infrastructure at municipal facilities.

Table 2-4: San Francisco key statistics

San Francisco, USA	Description
Current population	900,000
# of registered ZEVs	10,000+
ZEV market share	26%
# of ZEV chargers	900
Charging stations per population (100,000)	1:100
National targets	• Electrification of light duty passenger vehicle fleet by 2022 • Roadmap for 100% electric vehicles by 2030 • Full electrification of vehicles on roads by 2040

Source: *Electric Vehicle Capitals: Cities aim for all electric mobility', The International Council on Clean Transportation (September 2020)*

Critical success factors

The city regularly engages in planning activities to ensure sufficient future charging installations, including the implementation of multi-stakeholder charging strategies.

The ordinance will advance the City's commitment to **reducing greenhouse gas emissions** from light-duty vehicles

2.2.4 Comparative review: **Bogota, Colombia**

The City of Bogota currently possesses the largest electric bus fleet in Latin America and provides a model for environmental protection through its fast-growing electrified public transport system.

The Colombian capital, a city of 8 million people, is part of the C40 Cities network – a group of almost 100 cities globally who are committed to delivering climate action plans designated to spur uptake of clean energy, boost adaptation to climate threats and ensure the 2015 Paris Agreement on climate change is acted upon[5].

Table 2-5: Bogota, Colombia key statistics

Botoga, Colombia (2021)	Description
Current population	8,000,000+
Area	478km^2 (urban area)[6]
# of electric buses	350
National targets	• Carbon-neutral by 2050[7] • Roll out of 1,485 clean buses by 2022

Progress toward net-zero

Bogota's target of rolling out 1,485 clean buses by 2022, accompanied by green and environmentally friendly charging stations, demonstrates the city's commitment to a transition to clean energy and sustainable development of zero-emission travel services. This will provide it with capacity to remove the old diesel and gasoline fleet and renew it with clean, electric buses.

Compared with diesel buses, the city's electric bus fleet reduces emissions equivalent to taking 42,000 cars off the road each year and keeping more than 94,000 tonnes of carbon dioxide out of the atmosphere each year.

The bus fleet will be supported be a large charging station located in the Fontibon district of Bogota, which is equipped with 56 double-gun electric chargers with a power of 150KW. Each bus takes 1.5 to 2.5 hours to fully charge, with a cruising range that exceeds 300 kilometres on a single charge, which can easily meet the buses' daily operating mileage of 260 kilometres[8].

TransMilenio

TransMilenio was established in October 1999 as the city's Public Transport Authority to alleviate heavy congestion in the capital and provide an efficient and cost-effective transportation system. It was created as a Public Private Partnership (PPP) to construct and operate the Bus Rapid Transit (BRT) system. In this instance, the public sector is responsible for the investment needed to develop the infrastructure, and the private sector for the system's operation and maintenance.

The Authority provides a BRT solution to 2.4 million passengers per day and serves the main arteries and points of interest of the city[9].

the city's electric bus fleet reduces emissions **equivalent to taking 42,000 cars off the road each year**

3. Future scenarios of **ZEV transport**

3.1 Future ZEV transport scenarios

Three ZEV scenarios

3.1.1 Overview

Three ZEV future uptake scenarios have been developed in conjunction with ACF. Each of these scenarios represent a more optimistic view of the future in terms of ZEV uptake across Australia.

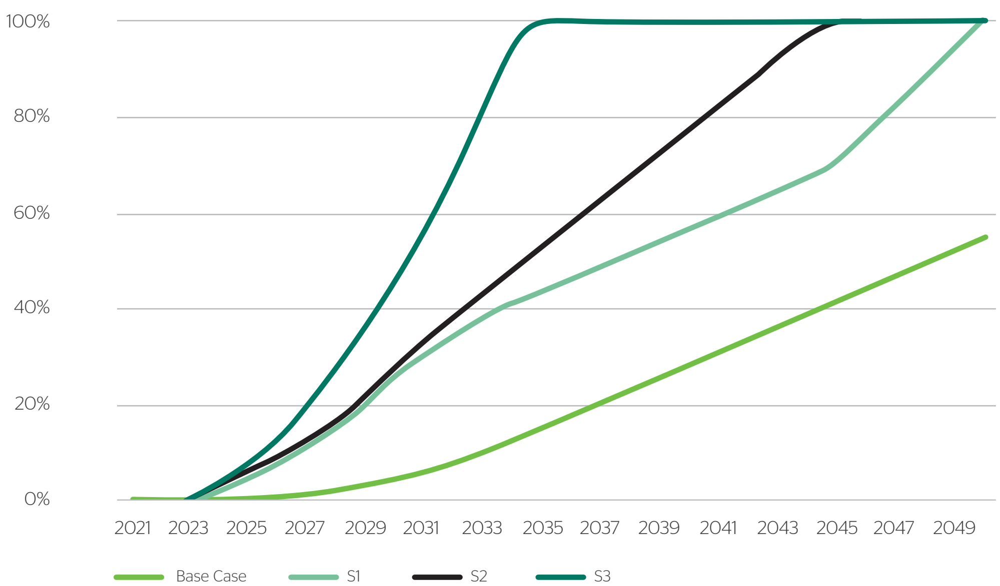
The base case is defined as a 'business as usual' situation with current ZEV uptake trends applied out to 2050.

The core assumption used in the three scenarios is summarised in the table below. Detailed descriptions of each scenario are discussed in the next section.

Table 3.1: Overview of the three scenarios considered in this analysis

	Base case	**Scenario one:** A gradual ZEV uptake	**Scenario two:** A ZEV driven transition to net zero	**Scenario three:** A swift hybrid transition to net zero
Net Zero in road transport emissions	na	2050	2045	2035
Private fleet ZEV share	55% by 2050	26% by 2030	2030: 28% 2045: 100%	2035: 100%
Public transport (bus only): ZEV share	Announced State commitments	Announced State commitments	2030: 100%	100% by 2027
Public transport (bus only): mode share	Around 5%	Same as Base Case (around 5%)	Same as base case (around 5%)	2035: 10% 2045: convergence to trends seen in comparable best practice cities (around 20%)

Figure 3.1: Private ZEV uptake rates across the three scenarios and the base case



3.1.2 Scenario one: Current policies and projections for electric vehicles

This is a general scenario, representing a more optimistic view of the future relative to the ‘Base case’. Scenario one is underpinned by a core assumption that 26% of the private vehicle stock will be ZEVs by 2030. Under this scenario, Australia is assumed to reach net zero emissions in passenger transport by 2050.

The uptake assumptions for private ZEV vehicles in Scenario One are as follows.

- A swift increase in the uptake of ZEVs in Australia, reaching 26% of vehicle stock between 2024 and 2030. This initial update is assumed to be concentrated to higher socio-economic groups.
- Between 2031 and 2045, the annual uptake rate ‘steadies’ as gradual improvements in battery technology reduces the relative cost of ZEVs.
- In the remaining five years to 2050, a rapid ‘catch-up’ in ZEV uptake is assumed as ZEVs reach price parity with ICE vehicles in order to reach a net zero emissions by 2050.

In terms of public transport (buses), current rates of bus mode share (around 5%) will be assumed throughout the projection period. This assumption is the same as what will be considered in the ‘Base case’.

Scenario one also considers current state/territory public transport targets for ZEV vehicles.

- NSW: An announced target of electrifying the public transport bus fleet by 2030 (i.e. 100% are ZEVs).
- VIC: An announced target for all public transport bus purchases to be ZEVs from 2025. This equates to around 100% of the fleet being ZEVs between 2030 and 2040.
- QLD: An announced target for all public transport bus purchases to be ZEVs from 2025. This equates to around 100% of the fleet being ZEVs between 2030 and 2040.
- ACT: An announced target that all buses on Canberra roads with be ZEVs by 2024.

3.1.3 Scenario two: Faster shift to electric cars and buses in line with best state policies

This scenario represents a higher uptake of ZEVs to achieve net zero emissions in passenger transport by 2045. This scenario is based on an ambitious shift to electric technologies and is underpinned by a core assumption that 28% of the private vehicle stock will be ZEVs by 2030. This assumption is aligned to ClimateWorks’[19] benchmark for ZEVs under a 1.5 degrees Celsius pathway scenario. Scenario Two assumed faster improvements in battery technology, increasing the transition to price party relative to Scenario one.

In terms of public transport (buses), current rates of bus mode share (around 5%) will be assumed throughout the projection period. This assumption is the same as what will be considered in the ‘base case’ and scenario one. Scenario Two assumes that all State/Territory governments achieve a 2030 target for ZEV vehicles in public transport (i.e. parity with NSW).

3.1.4 Scenario three: Ambitious shift to greater public transport mode share alongside a rapid shift to electric vehicles

This scenario represents a swift transformation to net zero emissions in passenger transport, underpinned by rapid cost reductions in battery technology and increased patronage on electric bus public transport. This scenario is underpinned by the core assumption that Australia will achieve net zero emissions in passenger transport by 2035.

In terms of public transport (buses), bus mode share will increase from around 5% to 10% by 2035. From this point, bus mode share in capital cities will converge to a mode share of around 20% - comparable to that of current day rates for ‘mega cities’ (i.e. London and New York) by 2045. This equates to around 20% bus mode share.

3.2 Modelling approach

An overview of the economic modelling approach

3.2.1 Overview

To gain a better understanding of the future landscape for land transport in Australia, Deloitte has designed a bespoke economic model. This model incorporates comprehensive data sets and calculations used to project land transport travel behaviour in Australia out to 2050.

The economic model takes a defined baseline year (i.e. 2020–21) and estimates future transport behaviour, based on econometrically estimated relationships with various economic variables, at a State/Territory level.

While the projections reported in this report can be considered 'likely scenarios' of the future, it should be noted that the results are dependent on the various assumptions and the quality of data used in the model.

The modelling methodology has been developed based on an approach applied by BITRE[10] in forecasting transport over the long run.

Some of the key economic variables used to project revenue and expenditure are:

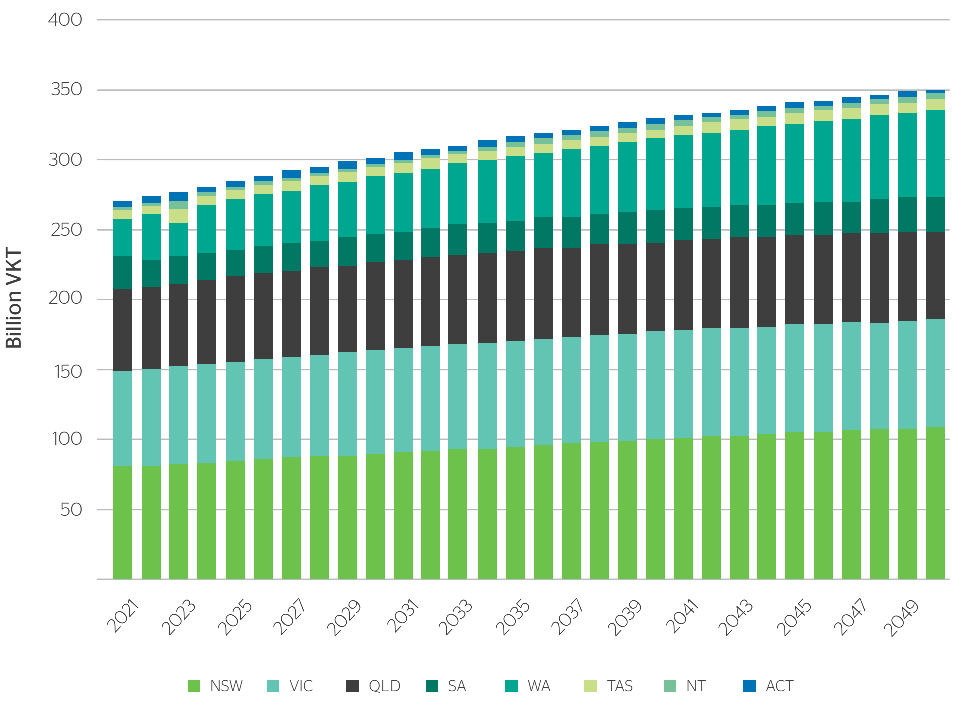
- Gross domestic/State product
- Population and household projections
- Passenger car units
- Freight task in billion tonne-kilometres
- Rate of fuel consumption
- Vehicle Kilometres Travelled (VKT) and vehicle stock.

3.2.2 Modelling externality costs to Australia

Deloitte's bespoke economic model estimates travel behaviour and VKT at the State and Territory level around Australia out to 2050 (Figure 3.2).

The next step in the modelling considers the three ZEV scenarios described in **Section 3.2**. Total VKT is disaggregated at between the relative share of ZEV and ICE vehicles under the ZEV uptake rates considered in each scenario.

Figure 3.2: Annual VKT (billion) between 2021 and 2050



3.2.3 Calculating negative externalities associated with road transport

Total ZEV and ICE vehicle VKT is separated between urban and regional areas at the Local Government Authority (LGA) level.

An urban area is defined by a population density of greater than 200 people per km squared. A regional area is defined by a population density of equal to or less than 200 people per km squared. Based on this urban/region classification, values of negative externalities for key impacts (summarised in the following section) of road usage are applied to VKT in each LGA. A negative externality is typically defined in economic terms as the concept of uncompensated impacts that affect consumer utility (i.e. wellbeing) and enterprise cost outside the market mechanism. In other words, the cost incurred to the community from each kilometre travelled while using an ICE vehicle.

The relative cost to the community, in each year, is calculated under the base case (i.e. business as usual) and each of the three scenarios. The relative annual avoided costs under each scenario are calculated by subtracting the costs incurred in each scenario relative to the costs incurred under the base case.

The total costs between 2022 and 2050 are discounted to a 'Net Present Value'* (i.e. a value in today's dollars) using a **social rate of time preference discount rate of 3%**.

Social discount rates are used to put a present-day value on costs (and benefits) that will occur in the future. In the context of climate change policymaking, they are considered very important for discussions out how much today's society should invest in trying to limit the impacts of climate change in the future[11].

Further details on the use of social rate of time preference discount rate is discussed in the Appendix.

**Net Present Value: Present value of benefits less present value of costs*

3.3 Modelling approach

An overview of the economic modelling approach

3.3.1 Negative externalities considered in this analysis

In order to consider the overall cost to the Australian community, several key externality types were considered for this analysis. The parameters summarised in Table 3.2 are used to place a dollar per kilometre travelled figure on the overall economic cost to the community.

Air pollution

Air pollution is predominantly a concern in urban areas. Urban air pollution is a complex mixture of gases, compounds and particles that can have direct adverse impacts on human health. These impacts include[12]:

- Respiratory diseases
- Asthma
- Heart disease
- Personal irritations and learning difficulties in children.

ZEVs are assumed to reduce externalities associated with air pollution by 100% relative to ICE vehicles.

Greenhouse gas emissions

GHG emissions refer to the economic cost that would result from emitting one additional ton of greenhouse gases into the atmosphere. In this analysis, it is assumed that ZEVs are powered by renewable energy sources. This is a reasonable assumption given the high penetration and potential for home solar in Australia.

ZEVs are assumed to reduce externalities associated with GHG emissions by 100% relative to ICE vehicles.

Table 3.2: Cost of externality by ICE vehicle type to Australia (cents per VKT)

	Cars	Buses and coaches	Light commercial vehicles	Rigid (and other) trucks	Articulated trucks	Motorcycles
Urban						
Air pollution	3.37	37.90	7.56	16.50	65.00	1.69
GHG emissions	2.66	15.61	2.35	3.67	14.64	1.33
Noise	1.10	2.66	1.29	2.75	10.97	0.55
Water pollution	0.51	5.66	1.13	2.47	9.87	0.26
Rural & Regional						
Air pollution	0.04	na	na	0.16	0.65	0.02
GHG emissions	2.66	15.61	2.35	3.65	14.64	1.33
Noise	na	na	na	0.28	1.11	na
Water pollution	0.05	0.06	0.01	0.99	3.95	0.03

Source: *TfNSW , Economic Parameter Values (2020)*

Noise pollution

Noise pollution can be defined as unwanted sound in the environment. Long-term exposure to high environmental noise levels such as traffic, above 53 decibels (dB) can result in adverse health effects, such as[13]:

- Hearing loss
- Sleep disturbance
- Hypertension and cardiovascular disease
- Cognitive performance
- Mental health impacts.

Typically, average street level traffic from ICE vehicles is around 90 decibels at 3 meters, whereas ZEVs are around 20 dB. ZEVs are assumed to reduce externalities associated with noise pollution by 95% relative to ICE vehicles.

Water pollution

Water pollution includes organic waste or persistent toxicants run-off from roads generated from vehicle use. These include engine oil leakage and disposal, road surface, particulate matter and other air pollutants from exhaust and tyre degradation[14].

ZEVs are assumed to reduce externalities associated with water pollution by 50% relative to ICE vehicles.

3.3.2 Limitations

This modelling only considers the relative difference in 'avoided costs' for the above externalities between ZEVs and ICE vehicles. It does not consider the impacts of overall electricity generation or externalities beyond actual road transport.

The results presented in this report should be interpreted as relative difference (i.e. avoided cost) associated with switching from an ICE vehicle to a ZEV under each of the three scenarios.

Furthermore, the modelling assumes that travel behaviour returns to long-term trends post the COVID-19 pandemic and lockdowns have ceased to be a regular occurrence.

Further limitations of this modelling approach are discussed in greater detail in the Appendix.

ZEVs are assumed to **reduce externalities associated with noise pollution by 95%** relative to ICE vehicles

**Net Present Value: Present value of benefits less present value of costs*

4. Results

4.1 Overview **base case**

The current approach to road transport could cost Australia $864.9 billion between 2022 and 2050 in air, water and noise pollution, and GHG emissions.

4.1.1 Costs to the community under the base case

Under expected road usage patterns and current trends (i.e. business as usual) the Australian community is expected to incur a total cost of **$864.9 billion** (NPV $2021) between 2022 and 2050.

This made up of the following externality costs to the community:

- Air pollution: $488.2 billion (56%)
- GHG emissions: $205.4 billion (24%)
- Noise: $95.4 billion (11%)
- Water pollution: $75.8 billion (9%).

4.1.2 Jurisdictional breakdown

Considering this total cost at the jurisdiction level, NSW and VIC together account for 53% of the total cost to the community. This is primarily due to the relative size of the population in these states.

The cost per capita (2050 population levels) tells a slightly different story, with Western Australia leading at an average cost to Australia of $43,900 per person. These per capita costs reflect overall passenger car movements and the freight task of each state and territory.

Figure 4-1: Base case cost to the Australian Community by externality type (NPV $2021 billion)

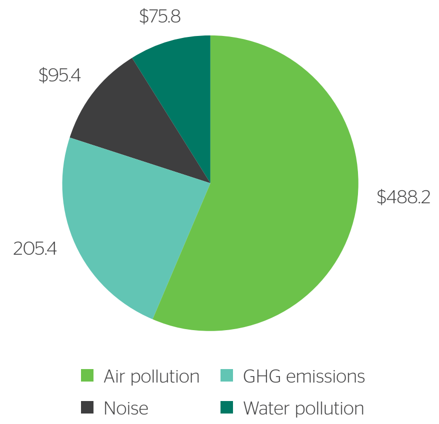


Figure 4-2: Total cost by jurisdiction under the case case between 2022 and 2050 (NPV $2021 billion)

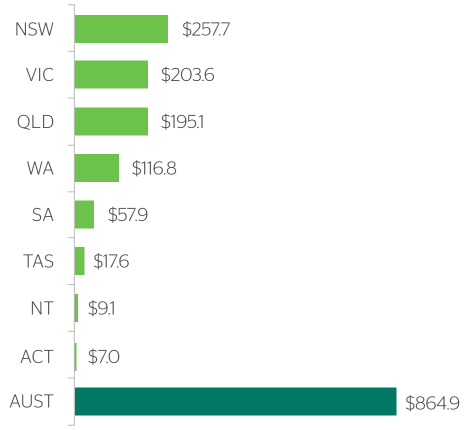
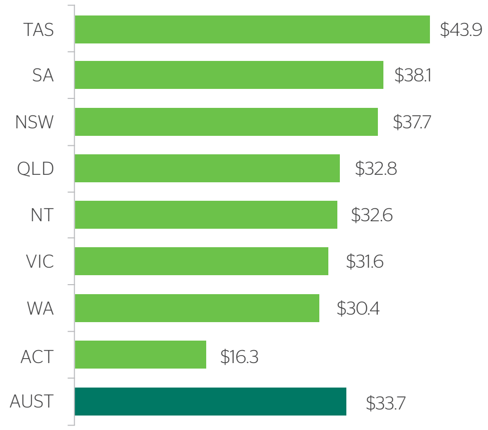


Figure 4-3: Per capita cost by jurisdiction under the case case between 2022 and 2050 (NPV $2021 thousand)



4.1 Overview **base case**

Passenger cars account for the largest share of road externalities in Australia

4.1.3 Breakdown by vehicle type

Of the **$864.9 billion** (NPV $2021) projected to cost the Australian community between 2022 and 2050 under the Base Case, passenger cars account for approximately **$319.9 billion** (37%). The combined freight task (light commercial vehicles, articulated trucks and ridged (and other) trucks) account for **$504.72 billion** (58%). Whereas buses (public transport and private coach) accounts for just 4.3% and motorcycles 0.3%.

Breaking down the results down by externality type, yields a slightly more nuanced story.

- The majority of **air** and **water pollution** can be attributed to **articulated trucks**, which cost the community a total of $159.4 billion (18%) and $26.1 billion (3.0%), respectively.
- **Passenger cars** are the leading cause of road **GHG emissions** and **noise pollution**, accounting for $112.9 billion (13%) and $42.8 billion (4.9%), respectively.

4.1.4 Urban and regional/rural areas

Unsurprisingly, there are stark differences between urban and regional / rural areas of Australia. This is primarily because:

- Higher population densities result in higher passenger and freight burdens
- Road traffic in densely populated urban areas has a greater community impact in terms air, noise, water and land pollution.

Overall, **urban road traffic** in Australia is projected to result in a **$817.0 billion** (94.5%) cost to the community between 2022 and 2050. Whereas regional / rural road traffic is projected to result in **$47.9 billion** (5.5%).

This primarily reflects the urban concentration of Australia, with the majority of the population living in urban areas of the country.

Table 4.2: Total cost by externality and vehicle type to Australia under the Base Case (NPV $2021 billion)

	Air pollution	GHG emissions	Noise	Water pollution	Total
Urban					
Cars	142.2	89.7	42.8	21.1	295.8
Light Commercial Vehicles	111.2	27.6	17.5	16.3	172.6
Articulated trucks	159.0	28.6	24.7	23.7	235.9
Rigid (and other) trucks	50.5	9.0	7.7	7.4	74.6
Buses and coaches	23.0	7.6	1.5	3.4	35.4
Motorcycles	1.3	0.8	0.4	0.2	2.6
Total	**487.2**	**163.2**	**94.6**	**72.0**	**817.0**
Regional & rural					
Cars	$0.4	$23.2	$0.0	$0.5	24.2
Light Commercial Vehicles	$0.0	$7.1	$0.0	$0.0	7.2
Articulated trucks	$0.4	$7.4	$0.6	$2.5	10.9
Rigid (and other) trucks	$0.1	$2.3	$0.2	$0.8	3.4
Buses and coaches	$0.0	$2.0	$0.0	$0.0	2.0
Motorcycles	$0.0	$0.2	$0.0	$0.0	0.2
Total	**$1.0**	**$42.2**	**$0.9**	**$3.8**	**47.9**
AUST	**$488.2**	**$205.5**	**$95.4**	**$75.8**	**864.9**

4.2 Overview **potential avoided costs to the Australian community**

Adopting more ambitious net zero road transport targets can yield substantial community benefits in avoided pollution and greenhouse gas emissions.

4.2.1 Scenario one

Under scenario one, Australia has the potential to avoid costs of approximately **$232.6 billion** (NPV $2021) between 2022 and 2050. This avoided cost is relative to the base case under this scenario, and is achieved from increasing overall ZEV uptake to achieve net zero road transport emissions by 2050.

4.2.2 Scenario two

If Australia was to adopt scenario two, there is the potential to avoid costs of approximately **$335.4 billion** from adopting a more ambitious ZEV scenario to achieve net zero road transport emissions by 2045.

In other words, by pushing forward the 100% ZEV target by five years, Australia could potentially avoid costs of an additional $102.9 billion relative to scenario one.

4.2.3 Scenario three

However, if Australia was to adopt scenario three – characterised by a faster transition to 100% ZEV vehicles and increased public bus usage – there is the potential for even greater benefits to the Australian community. Under this scenario, achieving net zero road transport emission by 2035 could result in avoided costs of **$491.6 billion**.

This is an increase of $156.2 billion relative to scenario two, and an increase of $258.0 billion relative to scenario one.

Figure 4.4: Total cost to the Australian community (NPV $2021 billion)

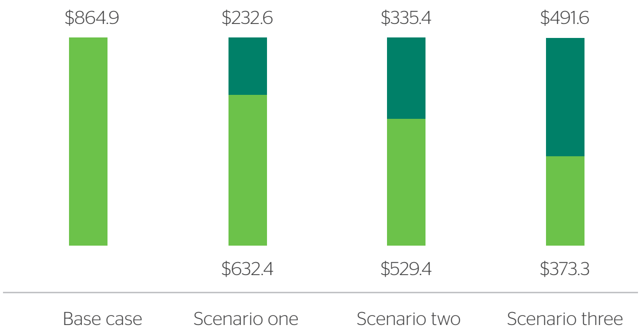
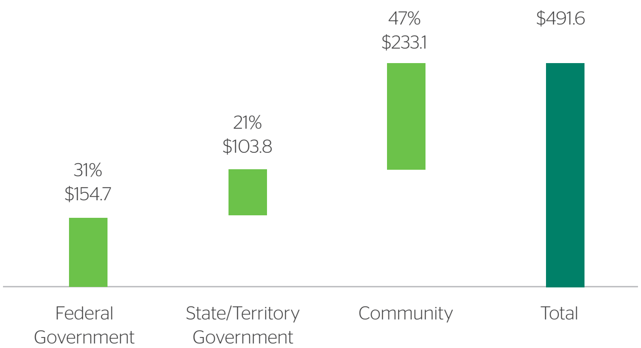


Figure 4.5: Avoided costs by jurisdiction under scenario three (NPV $2021 billion)



Note: Jurisdictional breakdown has been calculated based on relative cost burden (i.e. impact and expenditure).

Table 4.3: Avoided costs for the Australian community (NPV $2021 billion)

	Scenario one	Scenario two	Scenario three
Cost to the community			
Base case	$864.9	$864.9	$864.9
Scenario	$632.4	$529.4	$373.3
Total avoided costs	$232.6	$335.4	$491.6
Avoided cost breakdown			
Air pollution	$138.9	$200.3	$293.6
GHG emissions	$57.8	$83.3	$122.2
Noise	$25.1	$36.2	$53.0
Water pollution	$10.8	$15.6	$22.8

4.3 Scenario one

A potential avoided cost of $232.6 billion between 2022 and 2050.

If Australia were to adopt scenario one, there is the potential to avoid costs of **$232.6 billion** (NPV $2021) between 2022 and 2050 relative to the base case.

As can be seen in Figure 4.5, avoided costs to the Australian community begin to appear in 2024 as ZEV uptake diverges from the base case.

These avoided costs increase as total ZEV uptake approaches 26% in 2035 – as uptake increases in higher socioeconomic groups around the country. After this point, ZEV uptake slows somewhat despite improvements in battery technology. Under this scenario, ZEV vehicles remain more expensive compared to ICE vehicles – resulting in slower uptake rates post-2035.

Scenario one assumes that ZEV vehicles reach price parity with ICE vehicles towards 2045, after which ZEV uptake rapidly increases. After this point the avoided cost to the Australian community increase substantially as Australia approaches net zero road transport emissions by 2050.

4.3.1 Externality breakdown

As can be seen in Table 4.4, the majority of avoided costs are attributed to decreases in air pollution around the county. Avoided costs from reduced air pollution are projected to be $138.9 billion between 2022 and 2050 under Scenario One.

This is followed by avoided costs in reduced GHG emissions at $57.8 billion, noise pollution at $25.1 billion and water pollution at $10.8 billion.

Figure 4.6: Cost to the Australian community, 2021 to 2050 ($2021)

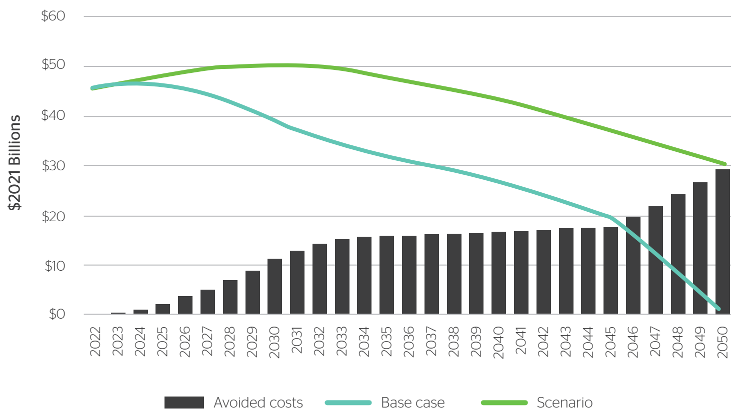


Table 4.4: Cost to the Australian community under scenario one (NPV $2021 billion)

	Base case	Scenario one	Avoided costs	Breakdown of avoided costs Federal Government	State/Territory Governments	Community
Air pollution	$488.2	$349.3	$138.9	$58.3	$36.1	$44.4
GHG emissions	$205.4	$147.6	$57.8	$0.0	$0.0	$57.8
Noise	$95.4	$70.4	$25.1	$10.5	$6.5	$8.0
Water pollution	$75.8	$65.1	$10.8	$4.3	$6.5	$0.0
Total	**$864.9**	**$632.4**	**$232.6**	**$73.1**	**$49.1**	**$110.2**

4.4 Scenario two

A potential avoided cost of $335.4 billion between 2022 and 2050

If Australia was to adopt scenario two, there is the potential to avoid costs of **$355.4 billion** (NPV $2021) between 2022 and 2050, relative to the base case.

Under scenario two, the Australian community could potentially avoid costs of an additional $102.9 billion, relative to Scenario One.

As can be seen in Figure 4.6, avoided costs to the Australian community begin to appear after 2025 as ZEV uptake increases, relative to the base case.

These avoided costs continue to increase as total ZEV uptake continues to accelerate after reaching 28% in 2035. This continued acceleration is due to assumed increases in battery technology (relative to the base case and scenario one) which accelerates price parity between ZEV and ICE vehicles over time.

Scenario two assumes that Australia reaches net zero road transport emissions by 2045 (five years earlier relative to scenario one). This essentially 'front-loads' the benefits to Australian – pushing forward the avoided costs to the community.

Avoided costs under scenario two peak in 2045 as Australia reaches net zero road transport emissions. After which the relative avoided costs begin to decline as ZEV uptake increases under the base case.

4.4.1 Externality breakdown

As can be seen in Table 4.5, the majority of avoided costs are attributed to decreases in air pollution around the county. Avoided costs for reduced air pollution are projected to be $200.4 billion between 2022 and 2050 under scenario two.

This is followed by avoided costs in reduced GHG emissions at $83.3 billion, noise pollution at $36.2 billion and water pollution at $15.6 billion.

Figure 4.7: Cost to the Australian community, 2021 to 2050 ($2021)

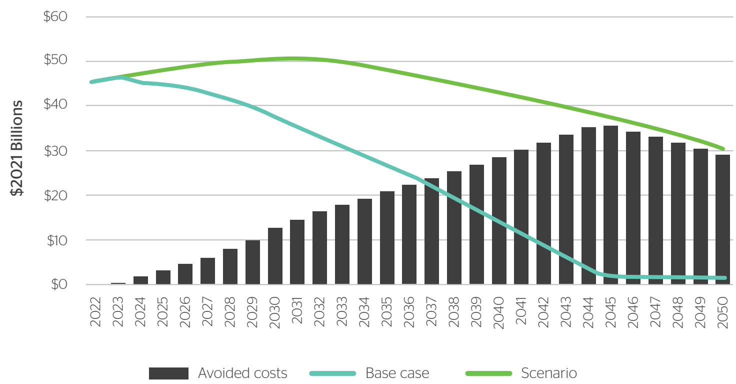


Table 4.5: Cost to the Australian Community under Scenario Two (NPV $2021)

	Base Case	Scenario Two	Avoided costs	Breakdown of avoided costs Federal Government	State/Territory Governments	Community
Air pollution	$488.2	$287.7	$200.3	$84.1	$52.1	$64.1
GHG emissions	$205.4	$122.2	$83.3	$0.0	$0.0	$83.3
Noise	$95.4	$59.2	$36.2	$15.2	$9.4	$11.6
Water pollution	$75.8	$60.3	$15.6	$6.2	$9.3	$0.0
Total	**$864.9**	**$529.4**	**$335.4**	**$105.5**	**$70.8**	**$159.0**

4.5 Scenario three

A potential avoided cost of $491.6 billion between 2022 and 2050

If Australia was to adopt scenario three, there is the potential to avoid costs of **$491.6 billion** (NPV $2021) between 2022 and 2050, relative to the Base Case.

Under scenario three, the Australian community could potentially avoid costs of $156.2 billion relative to scenario two, and an increase of $258.0 billion relative to scenario one.

As can be seen in Figure 4.7, avoided costs to the Australian community begin to rapidly appear after 2024 as ZEV uptake rapidly increases, relative to the base case. Assumed increases in the uptake of public bus transport also contribute to the avoided costs to the community. Under scenario three, there are less passenger cars on the road over time, as bus transit patronage increase to approximately 20% by 2045.

These avoided costs continue to rapidly increase as total ZEV uptake continues to accelerate over time. This acceleration is due to assumed rapid increases in battery technology (relative to the base case and scenario one and two) which rapidly accelerates price parity between ZEV and ICE vehicles over time.

Scenario three assumes that Australia reaches net zero road transport emissions by 2035 (ten years earlier relative to scenario two). Avoided costs under scenario three peak in 2035 as Australia reaches net zero road transport emissions. After which the relative avoided costs begin to decline as ZEV uptake increases under the base case.

4.5.1 Externality breakdown

As can be seen in Table 4.6, the majority of avoided costs can be attributed to decreases in air pollution around the county. Avoided costs as a result of reduced air pollution are projected to be $293.1 billion between 2022 and 2050 under scenario three.

This is followed by avoided costs as a result of reduced GHG emissions at $122.1 billion, noise pollution at $53.6 billion and water pollution at $22.8 billion.

Figure 4.8: Cost to the Australian community, 2021 to 2050 ($2021)

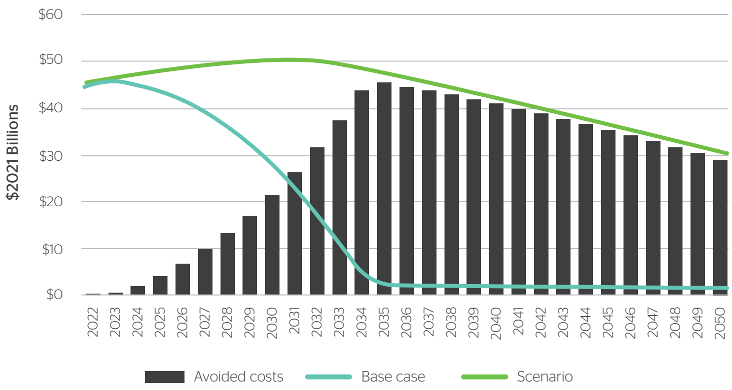


Table 4.6: Cost to the Australian community under scenario three (NPV $2021)

	Base case	Scenario three	Avoided costs	Breakdown of avoided costs Federal Government	State/Territory Governments	Community
Air pollution	$488.2	$195.1	$293.6	$123.3	$76.3	$93.9
GHG emissions	$205.4	$83.3	$122.2	$0.0	$0.0	$122.2
Noise	$95.4	$41.8	$53.0	$22.3	$13.8	$17.0
Water pollution	$75.8	$53.1	$22.8	$9.1	$13.7	$0.0
Total	**$864.9**	**$373.3**	**$491.6**	**$154.7**	**$103.8**	**$233.1**

4.5.2 Road fatalities avoided under scenario three

Unlike scenarios one and two, scenario three assumes an increase in the uptake of public buses as a transport alternative. Under scenario three, public bus patronage is assumed to increase over time to a maximum of around 20% mode share – with each public bus on the road at about 75% occupancy. Essentially, this results in fewer passenger cars on the road as commuters elect to take public transport as opposed to private vehicles.

This transition to public bus transport results in an additional avoided cost of approximately $0.9 billion (less than 1% of the total avoided cost under Scenario Three). This is essentially due to the fact that most of the benefits associated with ZEV uptake in public buses is achieved before Australia reaches 20% bus mode share.

While this figure is relatively small, it does have the potential benefit of reduced road fatalities, as less people are assumed to be using private passenger vehicles.

In 2020-21, there were 1,148 recorded road fatalities. This equates to around 5.4 deaths per VKT billion travelled on Australian roads. Applying these figures to the reduced passenger vehicle travel under scenario three, there could be approximately 2,624 road fatalities avoided between 2022 and 2050, by transitioning commuters to public bus transport and away from passenger vehicles.

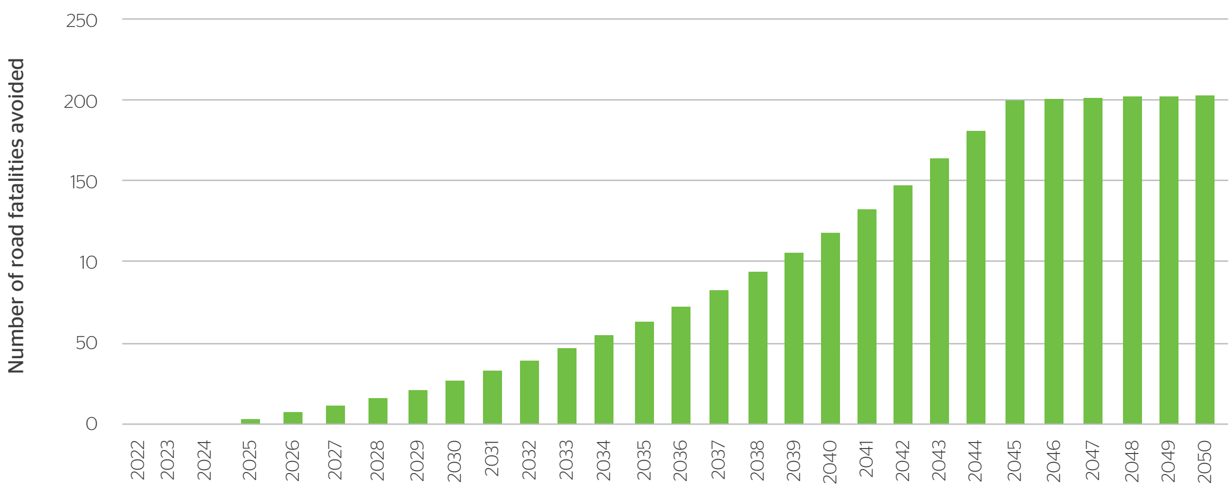
A potential avoidance of over 2,600 road fatalities between 2022 and 2050

The expected avoidance of road fatalities in passenger vehicles under scenario three on an annual basis is shown in Figure 4.8. Avoided road fatalities is projected to increase over time as bus patronage increases. Specifically, it shows that the number of road fatalities avoided will stabilise around 2045 as Australia reaches around 20% mode bus share.

Table 4.7: Avoidance of road fatalities in passenger vehicles under scenario three

Jurisdiction	Persons (2022 to 2050)
NSW	760
WA	606
VIC	461
QLD	445
SA	151
NT	116
TAS	67
ACT	18
AUST	2,624

Figure 4.9: Figure 4.9: Road fatalities avoided under scenario three, 2021 to 2050

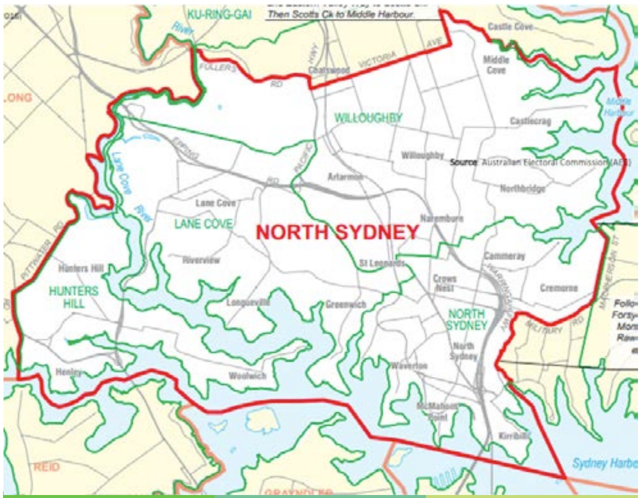


5. Case studies of **electoral divisions**

Case study:
The electoral division of North Sydney (NSW)

If people opted to take the bus as opposed to their private vehicles, this could enable the community of North Sydney to avoid environmental costs of over **$58 million** across 30 years under scenario one.

- **An inner metropolitan area situated in the NSW capital city and consisting of well-established built-up suburbs.**
- **Population: 178,820 people in 2020 over an area of 53km².**



Scenario one	Scenario two	Scenario three
$2.3 billion in total avoided costs by reaching net zero by 2050.	$3.3 billion in total avoided costs by reaching net zero by 2045.	$4.8 billion in total avoided costs by reaching net zero by 2035.

Cost to the community	Description	Potential avoided cost ($ billion) by scenario		
		One	Two	Three
Air pollution	Urban air pollution is a complex mixture of gases, compounds and particles that can have direct adverse impacts on human health, such as: • Respiratory diseases • Asthma • Heart disease • Personal irritations • Learning difficulties in children	$1.26	$1.79	$2.52
GHG emissions	GHG emissions from vehicle use directly contribute to your personal carbon footprint.	$0.53	$0.76	$1.08
Noise pollution	The average street level traffic is around 90 decibels. Noise pollution can be defined as unwanted sound in the environment . Long-term exposure to high environmental noise levels such as traffic, above 53 decibels can result in adverse health effects, such as: • Hearing loss • Sleep disturbance • Hypertension and cardiovascular disease • Cognitive performance • Mental health impacts	$0.25	$0.37	$0.54
Water pollution	Water pollution includes organic waste or persistent toxicants run-off from roads generated from vehicle use. These include engine oil leakage and disposal, road surface, particulate matter and other air pollutants from exhaust and tyre degradation.	$0.23	$0.37	$0.68

Case study:
The electoral division of Higgins (VIC)

If people opted to take the bus as opposed to their private vehicles, this could enable the community of Higgins to avoid environmental costs of over **$48 million** across 30 years under scenario one.

- **An inner metropolitan area situated in the VIC capital city and consisting of well-established built-up suburbs.**
- **Population: 178,952 people in 2020 over an area of 39km^2.**

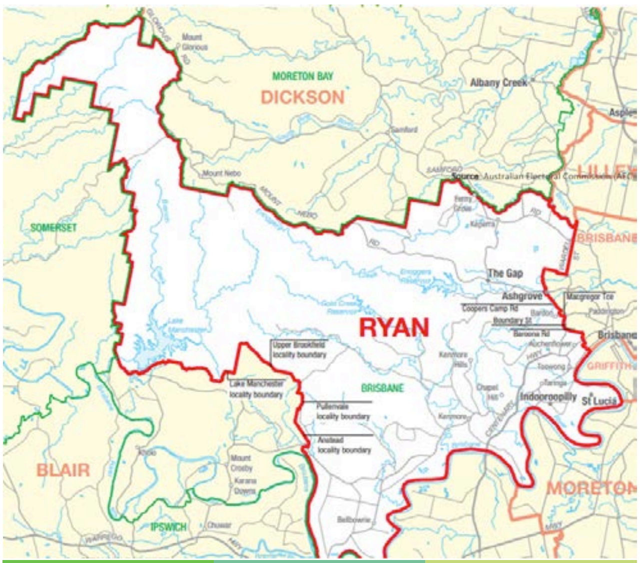
Scenario one	Scenario two	Scenario three
$1.9 billion in total avoided costs by reaching net zero by 2050.	$2.7 billion in total avoided costs by reaching net zero by 2045.	$4.0 billion in total avoided costs by reaching net zero by 2035.

Cost to the community	Description	Potential avoided cost ($ billion) by scenario		
		One	Two	Three
Air pollution	Urban air pollution is a complex mixture of gases, compounds and particles that can have direct adverse impacts on human health, such as: • Respiratory diseases • Asthma • Heart disease • Personal irritations • Learning difficulties in children	$1.05	$1.48	$2.09
GHG emissions	GHG emissions from vehicle use directly contribute to your personal carbon footprint.	$0.44	$0.63	$0.89
Noise pollution	The average street level traffic is around 90 decibels. Noise pollution can be defined as unwanted sound in the environment . Long-term exposure to high environmental noise levels such as traffic, above 53 decibels can result in adverse health effects, such as: • Hearing loss • Sleep disturbance • Hypertension and cardiovascular disease • Cognitive performance • Mental health impacts	$0.21	$0.31	$0.45
Water pollution	Water pollution includes organic waste or persistent toxicants run-off from roads generated from vehicle use. These include engine oil leakage and disposal, road surface, particulate matter and other air pollutants from exhaust and tyre degradation.	$0.19	$0.31	$0.57

Case study:
The electoral division of Ryan (QLD)

If people opted to take the bus as opposed to their private vehicles, this could enable the community of Ryan to avoid environmental costs of over **$67 million** across 30 years under scenario one.

- **An outer metropolitan area situated in the QLD capital city and containing large areas of recent suburban expansion.**
- **Population: 168,984 people over an area of 370km².**



Scenario one	Scenario two	Scenario three
$2.6 billion in total avoided costs by reaching net zero by 2050.	$3.8 billion in total avoided costs by reaching net zero by 2045.	$5.6 billion in total avoided costs by reaching net zero by 2035.

Cost to the community	Description	Potential avoided cost ($ billion) by scenario		
		One	Two	Three
Air pollution	Urban air pollution is a complex mixture of gases, compounds and particles that can have direct adverse impacts on human health, such as: • Respiratory diseases • Asthma • Heart disease • Personal irritations • Learning difficulties in children	$1.46	$2.07	$2.92
GHG emissions	GHG emissions from vehicle use directly contribute to your personal carbon footprint.	$0.62	$0.88	$1.25
Noise pollution	The average street level traffic is around 90 decibels. Noise pollution can be defined as unwanted sound in the environment . Long-term exposure to high environmental noise levels such as traffic, above 53 decibels can result in adverse health effects, such as: • Hearing loss • Sleep disturbance • Hypertension and cardiovascular disease • Cognitive performance • Mental health impacts	$0.29	$0.43	$0.63
Water pollution	Water pollution includes organic waste or persistent toxicants run-off from roads generated from vehicle use. These include engine oil leakage and disposal, road surface, particulate matter and other air pollutants from exhaust and tyre degradation.	$0.27	$0.43	$0.80

Case study:
The electoral division of Mayo (SA)

If people opted to take the bus as opposed to their private vehicles, this could enable the community of Mayo to avoid costs of over **$15 million** across 30 years under Scenario One.

- **A rural area of SA.**
- **Population: 170,529 people over an area of 9,135km².**

Scenario one	Scenario two	Scenario three
$0.6 billion in total avoided costs by reaching net zero by 2050.	$0.9 billion in total avoided costs by reaching net zero by 2045.	$1.3 billion in total avoided costs by reaching net zero by 2035.

Cost to the community	Description	Potential avoided cost ($ billion) by scenario		
		One	Two	Three
Air pollution	Urban air pollution is a complex mixture of gases, compounds and particles that can have direct adverse impacts on human health, such as: • Respiratory diseases • Asthma • Heart disease • Personal irritations • Learning difficulties in children	$0.33	$0.48	$0.67
GHG emissions	GHG emissions from vehicle use directly contribute to your personal carbon footprint.	$0.14	$0.20	$0.29
Noise pollution	The average street level traffic is around 90 decibels. Noise pollution can be defined as unwanted sound in the environment . Long-term exposure to high environmental noise levels such as traffic, above 53 decibels can result in adverse health effects, such as: • Hearing loss • Sleep disturbance • Hypertension and cardiovascular disease • Cognitive performance • Mental health impacts	$0.07	$0.10	$0.14
Water pollution	Water pollution includes organic waste or persistent toxicants run-off from roads generated from vehicle use. These include engine oil leakage and disposal, road surface, particulate matter and other air pollutants from exhaust and tyre degradation.	$0.06	$0.10	$0.18

6. Policy analysis

6.1 Overview

This section provides an analysis of a range of potential policies that are likely to encourage ZEV uptake.

It considers international experience and goes beyond policies that use cost levers for individuals, including ambitious policy options.

The three policy options include:

These policies may be used to identify practical next steps towards implementation, and to map the implications of different policy levers including how they affect different stakeholders and potential barriers to implementation.

ZEV mandates

Requirement for vehicle companies to adhere to a **minimum share of ZEVs** as a proportion of their overall sales

Public transport

Complete **upgrade** of buses from ICEs to ZEVs and increased share of travel by public transport due to **more electric buses** servicing more areas regularly

Funding reform

Large scale hypothecation of Commonwealth **fuel tax revenues towards ZEV and public transport** infrastructure and subsidies

6.2 ZEV mandates

A ZEV mandate is a form of regulation that requires vehicle manufacturers to sell a minimum number of zero emission vehicles as a proportion of their overall sales in the country.

ZEV mandates provide for an effective policy to achieve game-changing greenhouse gas reductions from transport, and play an important role in overcoming a critical barrier to large-scale electrification.

Governments in leading auto markets globally have announced aggressive electrification goals with many targeting a 100% electric vehicle share in the 2020-2050 timeframe.

Insufficient model options – particularly affordable models – can deter consumers from purchasing ZEVs even after adequate emphasis on consumer incentives and charging infrastructure, illustrated by the case study.

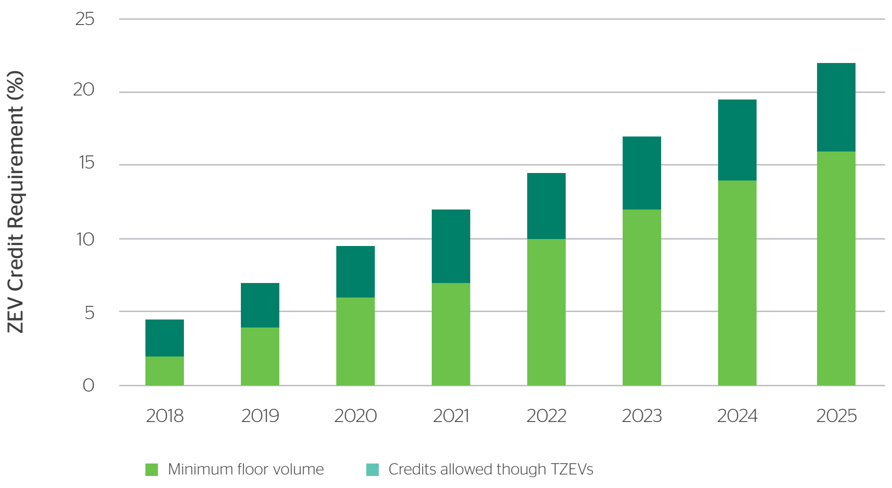
Case study: **California, USA**

California has been implementing ZEV mandates since 1990 and is the U.S. market leader in ZEV deployment, whereby ZEV mandates are implemented at the state level. Currently with a market share more than four times the country's average, it has more than 30 ZEV models on the market. In comparison, only a small fraction of this figure is available for the rest of the United States.

The California Air Resources Board (CARB) adopted the Advanced Clean Cars (ACC) program which includes increasingly stringent ZEV mandates. Manufacturers classified as 'large-volume manufacturers' and 'intermediate-volume manufacturers' are subject to fulfilling a certain ZEV percentage requirement, ranging from 4.5% in 2018 to 22% in 202510. Credits are awarded upon the delivery of a ZEV for sale in California.

Figure 6.1 summarises the total ZEV percentage requirement applicable to intermediate- and large-volume manufacturers, including the minimum floor volume applicable to large-volume manufacturers.

Figure 6.1: ZEV percentage credit requirements in California's ZEV mandate program from 2018 onwards



Source: *Overview of Global Zero-Emission Vehicle Mandate Programs, The International Council on Clean Transportation*

Key program elements of the California ZEV mandate have been summarised below[15]:

- **Applicability of ZEV mandate to manufacturers:** Manufacturers are classified based on their volume status for each compliance year. Volume status for the compliance year is calculated as the annual average of the manufacturer's sales in California in the previous three years.
- **ZEV percentage requirement:** The California mandate requires manufacturers to meet credit-based requirements, not direct market-share targets.
- **Types of ZEVs eligible to earn credits:** Pure ZEVs (BEVs, FCEVs), Transitional ZEVs (PHEVs that meet certain criteria), and a few less-prevalent technology types.
- **Credit allocation:** Eligibility for Pure ZEVs and Transitional ZEVs provided.
- **Banking, trade, and transfer:** Relating to the banking or trade of excess credits to other manufacturers.
- **Interlinkage of ZEV targets with greenhouse gas regulations:** Relating to matters where manufacturers exceed their corporate average greenhouse gas targets.
- **Penalties:** $5,000 per ZEV credit deficit.

6.3 A focus on public transport

As emissions from private motor vehicle use rise, encouraging greater use of public transport and reducing the emissions-intensity of vehicles are effective actions that cities can take to cut emissions.

Cities can lead the shift to ZEVs by focusing on the vehicles they have the most influence over, particularly its public transport network.

Approximately one-third of greenhouse gas emissions from C40 cities[17] come from transport, with traffic being the biggest source of air pollution – globally responsible for up to one quarter of particulate matter in the air.

Electric buses, for example, provide an attractive option for cities as they deliver improved air quality, noise reduction, and their total cost of ownership being cheaper than polluting alternatives. Cities including Los Angeles, Seattle, Copenhagen, Amsterdam, Guangzhou, and Nanjing have already set targets to fully transition their fleets to electric by 2030 or sooner and have started the procurement and operation of e-buses.

Bus Rapid Transport

The C40 Bus Rapid Transit (BRT) Network was established to support C40 cities' efforts to develop successful BRT programs, incorporating infrastructure, technology, scheduling, and financing solutions.

BRT is a high-quality bus-based transit system that delivers fast, comfortable, and cost-effective services at metro-level capacities. It does this through provision of dedicated lanes, with busways and iconic stations ideally aligned to the centre of the road, off-board fare collection, and fast and frequent operations.

Research from EMBARQ, Social, Environmental and Economic Impacts of Bus Rapid Transit Systems (2013), examined global evidence as well as four in-depth case studies of BRT systems in Bogotá, Colombia; Mexico City, Mexico; Johannesburg, South Africa; and Istanbul, Turkey. It concluded that BRT improves quality of urban life in five ways:

1. **Travel time savings**
2. **GHG and local air pollutant emissions reductions**
3. **Traffic safety improvements**
4. **Increased physical activity**
5. **Meeting other social aims.**

Below. Coal mine. *Photo.* Steve Morfi / Shutterstock

Case study: **Rio de Janeiro TransOeste BRT**

The first BRT corridor, the TransOeste located in the west side of the city, was launched in June 2012. It commenced operations with 40 kilometres of exclusive, segregated corridors, 36 stations, and new articulated and standard buses. The following year, the TransOeste BRT line grew to 56 kilometres of exclusive lanes and 58 stations, transporting now up to 185,000 passengers per day.

This example shows how a BRT corridor can provide a high capacity transit solution for a city, enabling municipal authorities to increase liveability, mobility, and sustainability. Furthermore, while BRT is often compared to metro lines in terms of service and operations, they can cost between ten to hundreds of times less. They can additionally be delivered much more quickly, as demonstrated in Rio de Janeiro.

$490 million to encourage households to buy electric vehicles through tax cuts and incentives

NSW Zero-Emissions public transport

In December 2020, NSW committed to transitioning its entire bus fleet of 8,000 to zero emissions transport by 2030. The rollout has since commenced with 120 electric buses expected in 2021, including some being manufactured locally.

The state has additionally set a target for all Sydney trains and NSW TrainLink rail to run on zero emissions electricity by 2025.

In its electric vehicle strategy, the state has outlined a fleet of measures to fast-track electric transport, including:

- $490 million to encourage households to buy electric vehicles through tax cuts and incentives
- New charging infrastructure for public and private electric vehicles
- A target to transition the NSW government's passenger vehicle fleet to fully electric by 2030
- Support for local councils and businesses to buy electric vehicles.

The NSW government has also emphasised the health, environmental and social benefits of shifting travel from private vehicles to public transport, walking and cycling.

6.4 National transport funding reform

Large-scale hypothecation of Commonwealth fuel tax revenues towards ZEV infrastructure and subsidies.

Over recent years, the uptake of fuel-efficient vehicles has driven a rapid and terminal decline in fuel excise revenue – currently making up a major source of funding for our roads. With EVs set to become a 'dealership mainstay' over the next decade, this will result in less money to pay for transport investment. The need for Australian governments to reform funding models for transport infrastructure, particularly for ZEVs, is therefore critical.

Infrastructure

Infrastructure assets have a significant influence on Australia's greenhouse gas emissions. ClimateWorks Australia has estimated approximately 70% of Australia's greenhouse gas emissions are either directly attributable to, or influenced by, physical infrastructure assets[18].

Infrastructure assets built today will still be operating in 2050 – when the nation is expected to reach net zero emissions under the Paris Climate Agreement. Despite this, emissions reductions in line with targets are not effectively prioritised in infrastructure planning, design, procurement and operations across sectors.

The provision of infrastructure represents a major subsidy to fossil fuel industries in Australia. Governments spend significant amounts of money on ports, railways, pipelines, power stations and other infrastructure that assists the production, transport and consumption of fossil fuels. While the users of this infrastructure often pay to use it, and the management bodies may return surplus money to the government that owns the asset, the acceptance of risk and up-front costs by government-owned entities provides benefit to industry and imposes costs on the community[19].

BITRE reported in 2020 that public spending on roads relative to public transport over time as averaged a ratio of 80:20 respectively[20]. This has raised concerns where such spending exacerbates Australia's over-reliance on private vehicles.

While infrastructure assets do not have direct control over emissions from vehicles or how energy is produced or consumed, there is potential for transport infrastructure to support the uptake of low and zero emissions transport (such as ZEVs or public transport) and for energy distribution and transmission networks to enable the increased connection of renewable electricity generation and energy storage technologies.

Subsidies

In the budget year FY 2020-21, fossil fuel subsidies cost the Commonwealth government $10.3 billion, with the largest subsidy being the Federal Fuel Tax Credit Scheme. Beyond tax concessions, the government spent $1.4 billion on measures that assisted coal and gas industries, making it cheaper for them to export fossil fuels to the rest of the world.

The reform and elimination of such subsidies will be important for Australia to facilitate and re-direct public spending toward sustainable solutions including the incentivisation of cleaner vehicles and modes of travel, building public transport infrastructure and potentially subsidies[21].

Case study: **New Zealand**

In 2021, the New Zealand government announced the proposed Clean Car Programme to support the nation's efforts in meeting carbon neutral targets by 2050. It comprises of two pillars[22]:

1. Clean Car Standard: Focuses on influencing vehicle supply by regulating CO2 targets

2. Clean Car Discount: Focuses on influencing vehicle demand with rebates for low CO2 emission vehicles (from 1 July 2021) and introducing fees for moderate-high CO2 emission vehicles (from 1 January 2022).

Specifically, the Clean Car Discount will reduce the costs for New Zealanders to purchase electric and low emission vehicles. The initiative is anticipated to prevent up to 9.2 million tonnes of carbon dioxide emissions and will help with the upfront cost of making the transition, returning up to $8,625 for users.

Case study: **California, United States**

The California Climate Investments programs uses funds raised through its emissions trading scheme to fund climate solutions, including many in the transport sector which support reduced air pollution.

Its 2021 Annual Report indicated funds have so far been directed toward projects including[23]:

- 700+ transit projects (including low carbon transport, public transport and active transport, high speed rail, and intercity rail)
- 330,000 rebates for zero emission private vehicles.

6.5 Comparison of major ZEV metrics

The introduction of Government subsidies to accelerate ZEV uptake ranges from additional public charging infrastructure, discounts on upfront and operational costs, and travel concessions to attract new users.

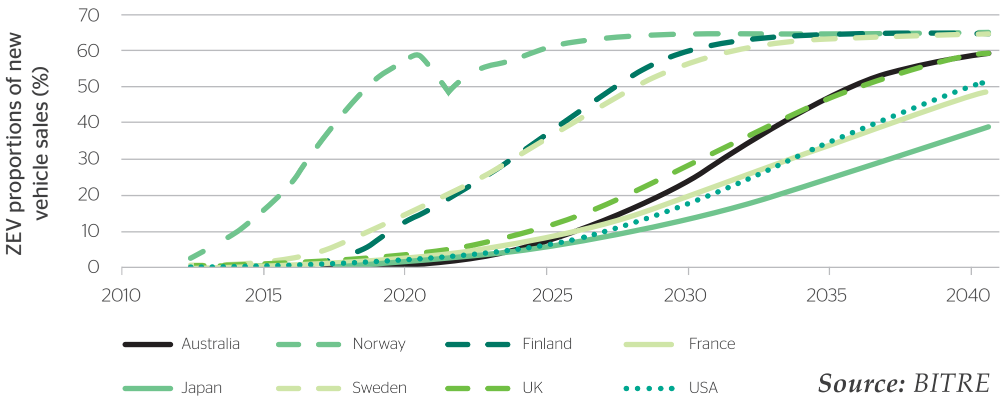
Research has shown the following metrics can be used as a benchmark to evaluate initiatives such as the rollout of public charging infrastructure:

- ZEV proportion of new sales
- ZEVs per million population
- Public chargers per million population
- ZEVs per public charger.

Several international jurisdictions have implemented a range of mechanisms to increase ZEV uptake, depending on region.

A summary of a key metric – the ZEV proportion of new vehicle sales – across a number of jurisdictions is shown in the figure below.

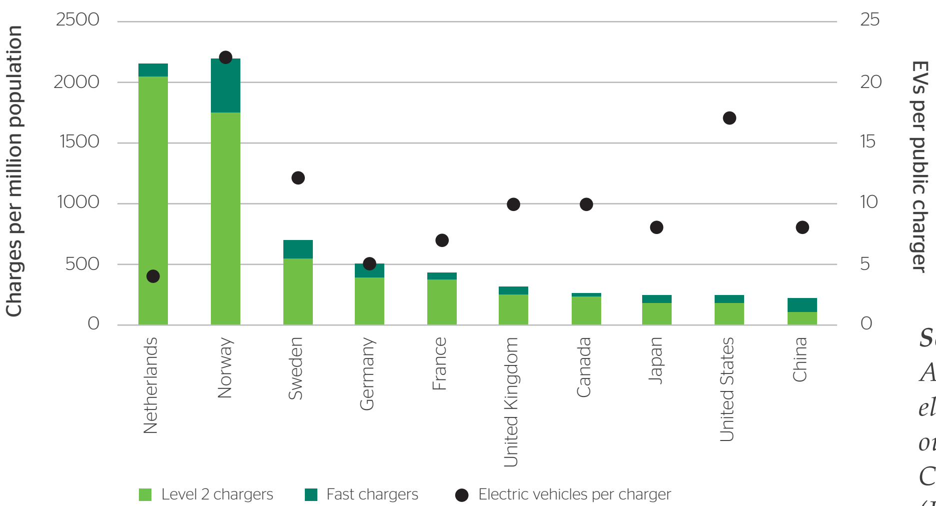
Figure 6.2: ZEV uptake across leading adopters across the world



Source: *BITRE*

The metrics in the figure below provide a benchmark to relatively gauge the activities of leading nations:

Figure 6.3: Public chargers per million population and ZEVs per public charger



Source: *Driving a green future: A retrospective review of China's electric vehicle development and outlook for the future, International Council on Clean Transportation (January 2021)*

6.6 Summary

Evidence indicates significant potential benefits to Australia from increasing the uptake of ZEVs. Given recent experience, however, Australian consumers will be unlikely to create the shift necessary to generate these benefits alone.

The following table presents a summary of policies that are likely to encourage ZEV uptake. They consider international experience and goes beyond policies that use cost levers for individuals. While ambitious, they will act as a strong catalyst for change and have exhibited encouraging outcomes in other jurisdictions.

TABLE 6.1: Summary of policy options

Policy	Description	Examples
ZEV mandates	Requirement for vehicle companies to adhere to a minimum share of ZEVs as a proportion of their overall sales	• California, USA – Implementation of ZEV mandates since 1990
Public transport	Complete upgrade of buses from ICEs to ZEVs and increased share of travel by public transport due to more electric buses servicing more areas regularly	• Rio de Janeiro, Brazil – TransOeste BRT, C40 Bus Rapid Transit (BRT) Network
Funding reform	Large scale hypothecation of Commonwealth fuel tax revenues towards ZEV and public transport infrastructure and subsidies	• New Zealand – 'Clean Car Programme' • California, USA – 'California Climate Investments' program

Endnotes

Endnotes

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Appendix 1: Choice of discount rate

The results presented in this analysis have been discounted to a ‘Net Present Value’ (i.e., a value in today’s dollars) using a **Social Rate of Time Preference** (SRTP) of 3% in real terms. Discount rates are used to put a present-day value on costs (and benefits) that will occur in the future.

The literature on discount rates is a constantly evolving and remains contested. However, in recent years Australia guidelines have diverged from international practices. There are two established approaches to deriving discount rates for economic policy appraisals[1]:

- The SRTP approach seeks to estimate the rate at which society is willing to trade present for future consumption.
- **Social Opportunity Cost** of capital approach (SOC), based on a weighted average cost of capital. The most common way to determine the value of a discount rate under the SOC approach is to estimate a benchmark rate of return to private capital investment in the economy.

These approaches start from very different premise and can (and generally do) lead to very different answers. Current Australian Cost-Benefit Analysis guidelines recommend a SOC approach with a central rate of 7% (with a lower bound of 3% and a higher bound of 10%). Whereas international agencies now tend to recommend discount rates in line with the SRTP approach[1].

In this context, the UK Green Book recommends a SRTP rate of 3.5% in real terms. This rate includes “a 1% allowance for catastrophic risk which is excluded to give the risk-free component of 2.5%”[2]. The US Office of Management and Budget[3] recommends using both a 3% and a 7% rate, however leading research has advocated for lower rates, in light of recent trends in the long-term bond rate. A survey of 197 economists, found an average long-term SRTP discount rate of 2.25%, with 92% being comfortable with of a rate between 1% to 3%[4].

In the context of climate change policymaking, especially over long-term time horizons, the choice of discount rate is important in discussions out how much today’s society should invest in trying to limit the impacts of climate change in the future. In light of the international literature and the objectives of this report, the lower bound of 3% as recommended by Australian guidelines[5] has been used in this analysis.

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Appendix 2: Limitations of this analysis

It should be noted, that while the findings presented in chapters four and five this report are considered to be likely scenarios, they are dependent on the various underlying assumptions and data sources used in the modelling. Variation to major assumptions, will have an impact on the results presented in this analysis. For example, as this analysis is scenario based, so any variation of the ZEV uptake scenarios represented in chapter three will yield different results.

The modelling only considers the relative economic costs associated with "road transport" (i.e., transport by rail is excluded) between ICE vehicles and ZEVs. It does not consider broader costs of transport outside the externalities categories (noise, GHG, air and water) considered in the report. Furthermore, the modelling assumes similar performance of private ZEV and ICE vehicles in these 'other' areas such as safety. The modelling also assumed that transport behaviour remains the same before and after the acquisition of a ZEV.

The results are dependent on VKT projections at the State and Territory level. These projections provide an indication of the likely travel patters between passenger and freight vehicles out to 2050. This modelling only disaggregates VKT by one class of light vehicle, four classes of heavy vehicles and motorcycles.

Based on this urban and region classifications, values of the cost of the four negative externality categories associated with road usage are applied to VKT assigned to each Local Government Area in Australia. These results have been broken down to the SA1 level and then reaggregated to an electorate level for the case studies presented in chapter five. As a consequence, the results presented in chapter five are inherently dependent on the assumptions associated with transport usage and behaviour at the initial LGA level.

Governments in leading auto markets globally have announced aggressive electrification goals with many targeting a 100% electric vehicle share in the 2020-2050 timeframe.

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