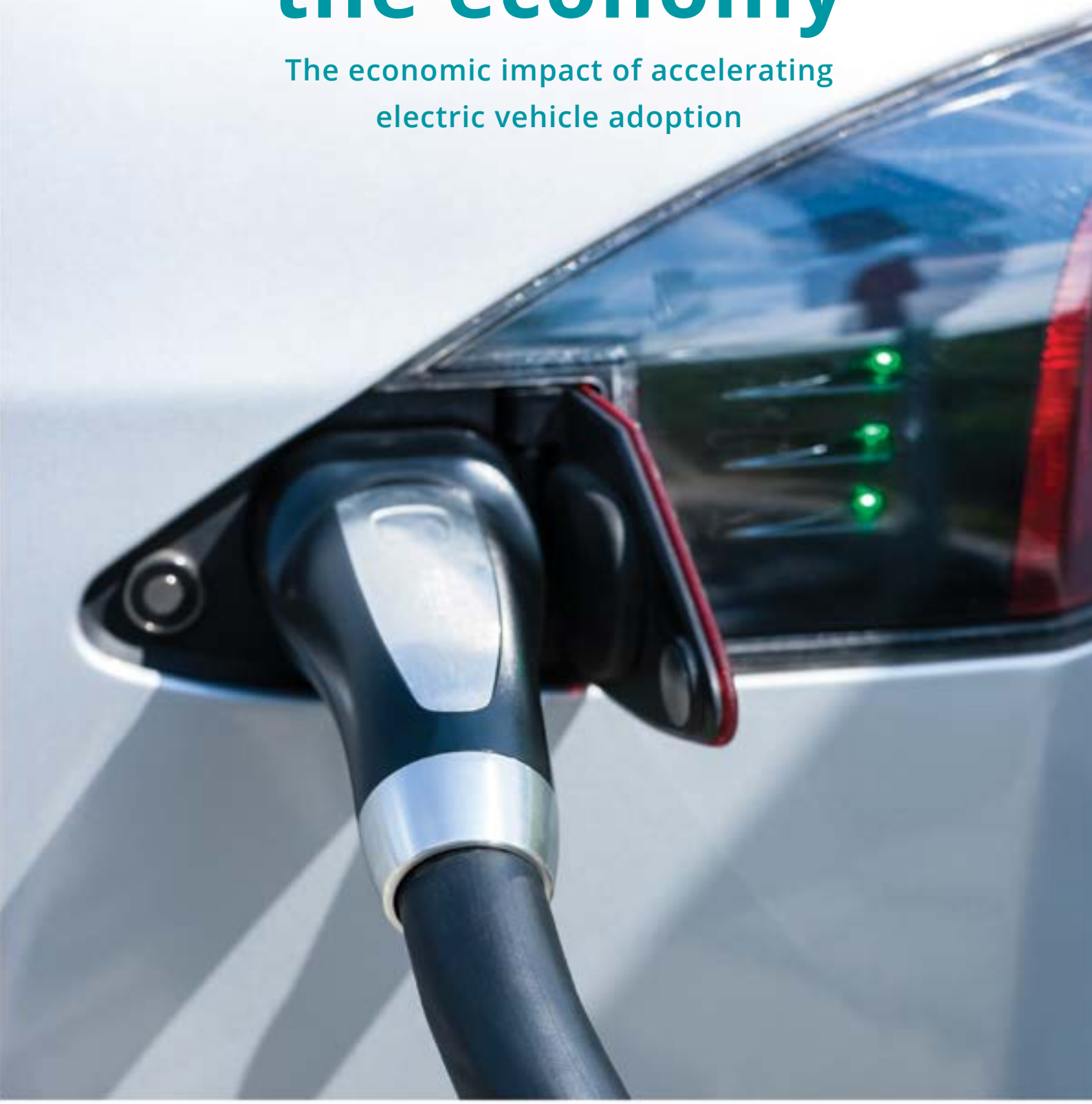
Recharging the economy

The economic impact of accelerating electric vehicle adoption



ELECTRIC VEHICLE COUNCIL

NRMA

pwc

St BAKER ENERGY INNOVATION FUND

About

Electric Vehicle Council

The Electric Vehicle Council is the national body representing the electric vehicle industry in Australia. Representing companies involved in providing, powering and supporting electric vehicles, our mission is to accelerate the electrification of road transport for a sustainable and prosperous Australia.

As the world's largest vehicle markets and companies set their course for a future where road transport is powered by zero emissions vehicles, the Electric Vehicle Council works to highlight the important role and opportunities for Australia in this global transition.

Working to overcome the current challenges in Australia's electric vehicle market through policy and industry development, the Electric Vehicle Council recognises electrification is a milestone in the future mobility ecosystem, enabling advances in sharing, connectivity and autonomy.

By bringing the Australian market up to speed with the global transition in road transport, we firmly believe Australian consumers and industry can be leaders in the future of mobility.

PwC

PwC was engaged by the Electric Vehicle Council (EVC), the NRMA and the St Baker Energy Innovation Fund to undertake an economic impact assessment of an electric vehicle (EV) growth scenario.

PwC is one of Australia's leading professional services firms, bringing the power of our global network of firms to help Australian businesses, not-for-profit organisations and governments assess their performance and improve the way they work. Having grown from a one-man Melbourne accountancy practice in 1874 to the worldwide merger of Price Waterhouse and Coopers & Lybrand in 1998, PwC Australia now employs more than 7,000 people.

Our people are energetic and inspirational and come from a diverse range of academic backgrounds, including arts, business, accounting, tax, economics, engineering, finance, health and law. From improving the performance of Australia's transportation systems, to performing due diligence on some of Australia's largest deals, and working side-by-side with entrepreneurs and high-net-worth individuals, our teams bring a unique combination of knowledge and passion to address the challenges and opportunities that face our community.

The NRMA

Better road and transport infrastructure has been a core focus of the NRMA since 1920 when our founders lobbied for improvements to the condition of Parramatta Road in Sydney. Independent advocacy was the foundation activity of the organisation and remains critical to who we are as we approach our first centenary.

From humble beginnings, the NRMA has grown to one of the largest tourism and travel companies in Australia, representing over 2.6 million Australians principally from NSW and the ACT. The NRMA provides motoring, mobility and tourism services to our Members and the community.

Today, the NRMA works with policy makers and industry leaders to advocate for increased investment in road infrastructure and transport solutions to make mobility safer and easier, provide access to affordable and efficient transport options, and ensure communities remain connected to business and employment opportunities. The NRMA is passionate about facilitating tourism and travel across the Australia, recognising the vital role travel plays in how Australians connect and recharge, and discover the country.

By working together with all levels of government to deliver integrated tourism and travel options we can give the community a real choice about how they get around. The NRMA believes that integrated transport networks, including efficient roads and cycleways, high-quality public transport and improved visitor facilities, are essential to solve the challenge of growing congestion and provide for the future growth of our communities.

St Baker Energy Innovation Fund

The St Baker Energy Innovation Fund is an active investor in a portfolio of early-stage companies that are developing disruptive products in the clean energy sector. These transformative companies are reshaping the energy industry by creating and optimising innovative products that improve performance, efficiency and sustainability.

The portfolio of companies includes:

Tritium: a leading developer of direct current super-fast electric vehicle chargers that are exported from its Brisbane headquarters to Europe and the USA. The company has grown substantially in the past three years and is supplying public-use chargers throughout Queensland as part of the electric vehicle super highway.

Fast Cities: is building a national, ultrafast electric vehicle charging network in order to catalyse the adoption of clean and efficient transportation in Australia.

ERM Power: founded by Trevor St Baker, ERM is Australia's fourth largest energy company, supplying electricity and energy solutions to business customers across Australia.

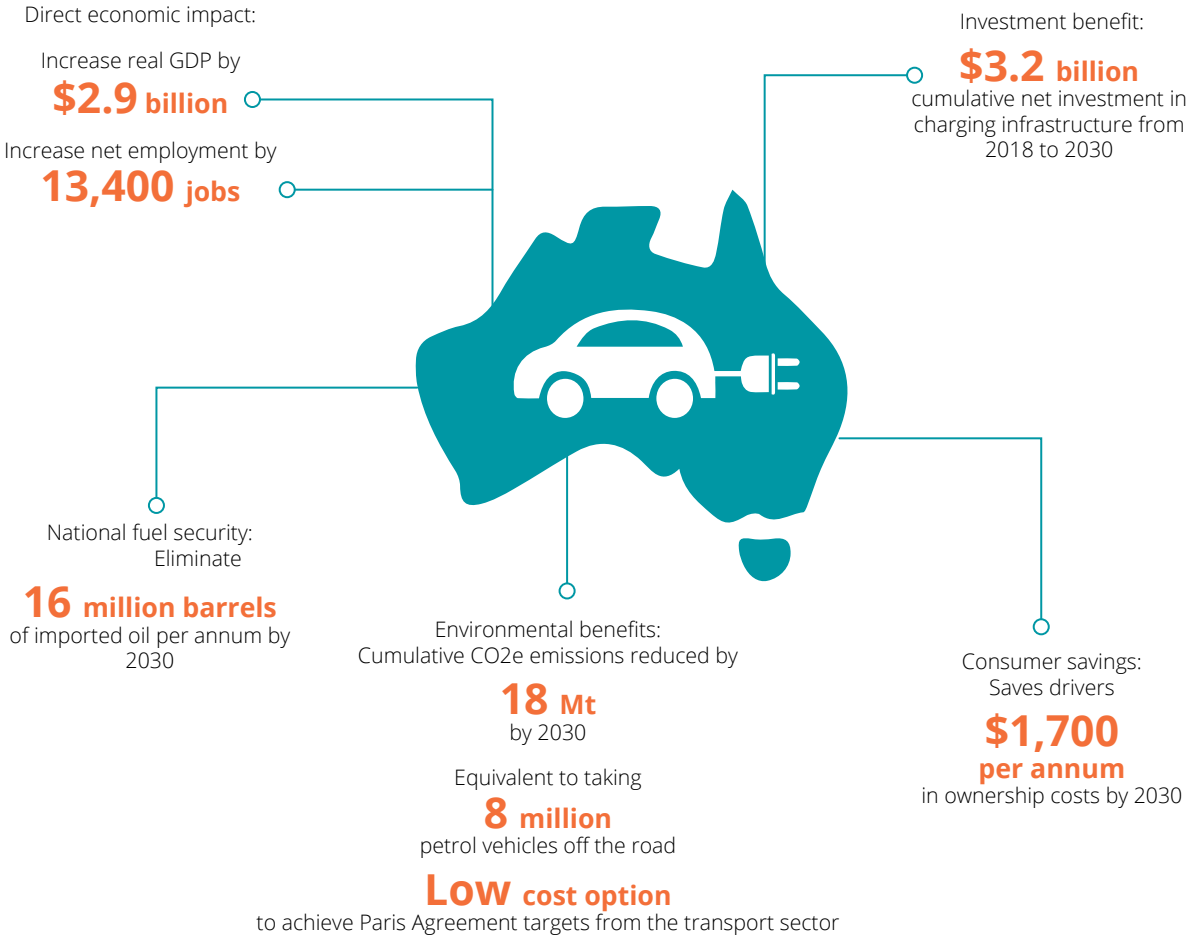
Contents

1. Key statistics

Economic Benefits of High EV Uptake in Australia

(Based on equivalent EV uptake to Norway – the current world leader)

Presented by EVC, NRMA and St Baker Energy Innovation Fund



Electric Vehicle Facts

Motorists can save
$810
to
$1400
per annum on vehicle ownership costs

Lower fuel costs: EVs save
7 cents per km
compared to internal combustion engines

10.3 years
to offset the upfront purchase of a Mitsubishi Outlander through fuel savings, (average ownership period is 10.1 years)

Lower maintenance costs:
$380
per annum on EV maintenance costs compared to
$750
per annum on internal combustion engines

Approximately
$70,000
to
$180,000
per electric vehicle fast charger installed

An average new internal combustion engine vehicle emits ~ 185g CO2/Km compared to an average new EV which emits
98g CO2/km
if charged via the electricity grid

The cost of recharging a vehicle's battery is
3 cents per km
compared to 10 cents per km for fuel

What Motorists Think

89%
of motorists want fast charging adjacent to motorways

11%
of motorists have decided to purchase an EV as their next car (23% in the 25-34 age bracket)

49%
would view government more positively if they progressed an EV fast charge network

63%
would view government more positively if the EV fast charge network was free

41%
of motorists will consider purchasing an EV as their next car (58% in the 18-24 age bracket)

Just
6%
would view government less positively if an EV fast charge network was wholly funded by government

The three largest barriers to EV uptake are:
65% say
Access to charging infrastructure
61% say
Purchase cost
59% say
Anxiety over the distance an EV can travel

80%
of motorists want fast charging in regional towns

94%
of motorists would be more likely to undertake a road trip with an EV if a charging network was in place

Motorist statistics derived from Member surveys conducted by the NRMA

2. Executive Summary

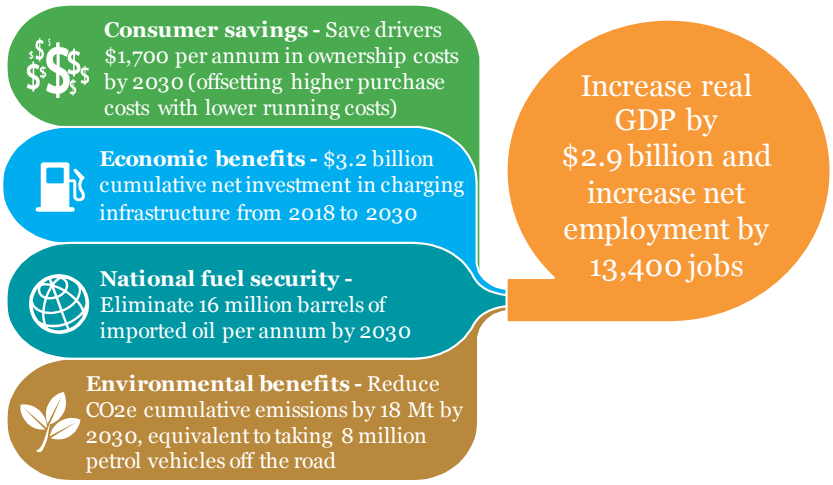
PricewaterhouseCoopers Consulting (Australia) Pty Ltd was engaged by the Electric Vehicle Council (EVC) , the NRMA and the St Baker Energy Innovation Fund to undertake an economic impact assessment of an electric vehicle (EV) growth scenario.

> ...the number of new BEV sales is assumed to reach 576,000 in Australia by 2030...

The scenario assumes Australia achieves a battery electric vehicle (BEV) growth rate similar to that of Norway. The scenario is referred to as AU 50@30 and assumes that by 2030, 57 per cent of new car sales will be BEV. As a result, the number of new BEV sales is assumed to reach 576,000 in Australia by 2030 from a baseline of 2,500 in 2017. In this analysis, BEVs do not include plug-in hybrid electric vehicles (PHEVs).[1] Unless otherwise specified, BEVs are referred to as EVs in this report.

This report's analysis does not specify the drivers of this high EV growth. It is adopted as a 'What if?' scenario to assess the economy-wide impacts including changes to gross domestic product (GDP) and employment.

Estimated benefits to be achieved by 2030 include ...



Context

Australia is committed to the Paris Agreement on climate change, with a 2030 target to reduce carbon emissions by 26 per cent to 28 per cent below 2005 levels.

In October 2017, the Turnbull Government announced its new energy policy, the National Energy Guarantee (NEG), which is designed to reduce emissions after 2020 when the Renewable Energy Target (RET) expires. New obligations for reliability and emissions reduction under the NEG will be agreed in 2018.

1 PHEVs are not considered in the modelling scenario as they are powered by electricity and fuel. PHEV propulsion is a mix of the internal combustion engine (ICE) and electric engine. The ICE is used to extend the driving range beyond battery capacity for longer distances and to recharge the battery itself. As such, the required ratio of public charging points to PHEVs is uncertain. As a conservative estimate, the charging infrastructure investment, which is an input to the economic model, is assumed to be driven by the uptake in BEVs only. For simplicity, BEVs are referred to as EVs in this report.

Australia's transport sector represents the third highest source of emissions.

Australia's transport sector represents the third highest source of emissions; its contribution in 2015 was 18.1 per cent of all emissions. Transport emissions are projected to rise by 6 per cent by 2020 driven by general economic growth.

Assuming the electricity sector meets its target emissions reductions, further contributions from transport and other sectors would be required to meet the overall national Paris commitment, as emissions from the electricity sector make up one third of total emissions.

This report considers EV uptake of light passenger vehicles. The impact of EV uptake of commercial and heavy vehicles has not been considered in this analysis. The Australian Bureau of Statistics (ABS) reports that commercial and heavy vehicles accounted for 41.5 per cent of total fuel consumption in 2016.[2]

Results and Implications

The economic impact of EV uptake between 2018 and 2030 under the AU 50@30 case is estimated to increase real GDP by $2.9 billion and increase net employment by 13,400 jobs, relative to 2016-17.

The economic impact of EV uptake between 2018 and 2030 under the AU 50@30 case is estimated to increase real GDP by $2.9 billion and increase net employment by 13,400 jobs, relative to 2016-17.

Table 1: Economic impact results

	2030
GDP impacts ($m, 2016-17)	2,900
Percent change in GDP	0.2
Employment impacts (jobs)	13,400

Source: PwC analysis, GDP impacts rounded to the nearest $million and job impacts are rounded to the nearest 100.

The economic impact of EV uptake was modelled through four channels. On a cumulative basis, between 2018 and 2030, the model inputs were:

- A net $3.2 billion capital injection in supporting infrastructure
- 18 million tonnes of emission reductions, equivalent to a $628 million tax cut
- $14 billion reduction in vehicle ownership costs (on a whole-of-life basis)
- $15 billion reduction in fuel imports

PwC's CGE modelling is based on Australia's EV uptake reaching 57 per cent of car sales by 2030. However, current forecasts by the Australian Energy Market Operator (AEMO) under a neutral EV growth scenario indicate EVs would account for just 10.4 per cent of vehicles on the road by 2030, compared to 20.8 per cent in this modelling scenario.

2 9208.0 Survey of Motor Vehicle Use, Australia, 12 months ended 30 June 2016 http://www.abs.gov.au/ausstats/abs@.nsf/mf/9208.0

Modelling in the 50@30 scenario assumes a higher growth forecast and hence there would need to be a change in the future trajectory of EV uptake for these economic impacts to be achieved.

Consumer preferences are affected by both economic and psychological factors. This strong EV growth scenario could potentially be realised in the event that:

- Technological advances are achieved to:
  - improve the cost parity of EVs
  - reduce the recharge time
  - extend the driving range
- Government support is extended to stimulate growth, for example by:
  - modifying vehicle emissions standards
  - support for rollout of EV charging infrastructure
  - establishing a national target for EV uptake (in a similar manner to the recent announcements by the UK, France, Germany, the Netherlands and India etc.)
  - providing financial incentives to EV owners
  - providing grant programs for private sector investment
  - investing in EVs as part of the government vehicle fleet (an initiative which has already begun with State Governments and local councils either individually or as part of the Climate Action Roundtable)
  - developing other policy programs.

A high EV growth scenario could also be supported with a shift in consumer preferences as a result of increased consumer education and the availability of new EV models.

A literature review of market surveys, interviews and trials identifies the importance of consumer awareness for EV uptake.[3] Consumer outreach and awareness activities can help to reduce consumer barriers related to understanding and awareness of EVs.

3 The International Council on Clean Transportation, Literature review of electric vehicle consumer awareness and outreach activities, March 2017

3. Introduction

Presented by EVC, NRMA and St Baker Energy Innovation Fund.

The transport sector is the skeleton on which the Australian national economy is built. Millions of people and tonnes of freight must move across the nation each day in the most time and cost effective manner.

Our island nation of wide open spaces requires goods and people to travel vast distances to markets both at home and abroad. The efficiency and global competitiveness of the Australian transport sector is therefore paramount to our economic strength.

Similarly, congestion greatly impacts the liveability of Australia's largest cities. Ask a Sydney-sider, Melbournian or any major city inhabitant their biggest gripe, and transport or congestion will usually top their list. Transport is also a talking point in the bush with petrol costs, a lack of infrastructure and limited choices major issues.

Transport costs are high and rising; the average Australian metropolitan household is spending $17,606 on transport per year. This accounts for 14.2 per cent of household income – more than four times the amount spent on utilities.

However, the sector is on the cusp of change. The rapid rise of artificial intelligence, connectedness, automation and alternative energy sources and their application to transport is redefining productivity in the sector and changing the way people travel.

Australia is among the top 20 nations for new car purchases, however the sector only represents 1.2 per cent of total car sales.

These changes offer the potential to re-energise Australian competitiveness and redefine liveability.

Despite the benefits of electric vehicles, and the inevitability of their mass arrival on Australian shores, the electrification of road transport requires concerted national leadership and close policy coordination from government.

The role of governments will be essential to manage potential impacts on the electricity grid, efficiently meet the need for new infrastructure and avoid wasteful duplication of effort. Like the mixed rail gauges of the 1900s, Australia faces the risk of mixed electric vehicle chargers in the 2000s.

Australia is among the top 20 nations for new car purchases, however the sector only represents 1.2 per cent of total car sales. Furthermore, of the 1,157,000 new cars purchased in

Australia last year, electric vehicles accounted only for around 2,200 of those vehicles.

As a result of the failure to embrace electric vehicles, consumers remain vulnerable to retail fuel prices, higher operating and maintenance costs, and a lack of retail transparency and competition. Meanwhile, emissions from the transport sector continue growing at the fastest rate within the economy, increasing more than 50 per cent between 1992 and 2010. This rate of transport sector emissions growth is more than twice the rate of growth in the European Union.

Australian adoption of electric vehicles is lagging

The failure of the Australian public to embrace electric vehicles can largely be attributed to three factors: relatively higher upfront costs, lack of available charging infrastructure, and anxiety over driving range.

While the transition to electric vehicles will eventually be forced by the market, governments have many levers to address shortcomings and bring forward the benefits.

Federal taxes like the Luxury Car Tax (LCT), Fuel Excise, Fringe Benefits Tax (FBT) and GST; state charges like Stamp Duty, Registration and Compulsory Third-Party (CTP); and local fees including parking permits and charges add to vehicle ownership costs.

Reform to incentivise the purchase of cleaner and safer vehicles will improve consumer choice and generate economic activity while reducing costs to governments from sectors like health care.

> Reform to incentivise the purchase of cleaner and safer vehicles will create jobs and economic activity, while also reducing costs to governments.

The creation of incentives for cleaner vehicles sets the market up to avoid shocks that will ultimately arise when upfront costs of electric vehicles fall below parity with internal combustion engines, expected around 2025.

Over the coming year, Nissan, Renault and Hyundai will join Tesla in introducing new electric vehicle models in Australia priced between $35,000 and $50,000. While a new car is not affordable for many Australians, the increased availability of vehicles at these prices will broaden the market, with fleet vehicles then entering the secondary market.

Action is required to support electric vehicle adoption

With an increased uptake of electric vehicles comes the need for charging infrastructure.

The availability of sufficient charging facilities and provisions within the electricity market will be essential to avoid consumer disruption and potential impacts on the power grid. A lack of charging locations to service specific journeys, emergence of queues at charging stations or grid impacts causing localised brown-outs (as has occurred in some locations in the UK) would quickly discourage electric vehicle uptake.

The costs of electric vehicle fast charging infrastructure are relatively small, with an install cost of between $70,000 and $180,000. The cost of establishing a fast charging network on Australia's circumnavigating Highway 1 – the longest highway in the world – could be less than $10 million.

State governments have a critical role to play in creating access arrangements that allow new infrastructure to be added to complement the existing networks.

However, access to suitable roadside sites and costly connections to the state-owned electricity grids are major inhibitors to establishing charging locations. State governments have a critical role to play in creating access arrangements that allow new infrastructure to be added to complement the existing networks. The determination of access to these assets is outside the control of the private sector.

The Australian Government also has a role to play.

$75 billion over the next 10 years has been committed to transport infrastructure; the Government is well placed to condition the provision of these funds to ensure that land adjacent to the national highway network is reserved for mid-journey charging.

Through the National Energy Guarantee, the Australian Government, the Australian Energy Market Commission and the Australian Energy Market Operator must plan to ensure dispatchable electricity is able to meet the needs of electric vehicle operations. The electricity needs of fast charging infrastructure cannot be overlooked in electricity planning, with some fast chargers requiring on-demand power similar to a factory or other industrial facility when in use. It is incumbent on the Australian Government to lead this transition.

Processes to plan, assess or construct electric vehicle charging sites are non-existent within most governments. The absence of information to allow the private sector to plan networks, as well as the lack of policy and procedures within government to consider proposals, means that progression is being significantly hampered.

Some state government initiatives are well-designed, such as the establishment of the Queensland Electric Super Highway, however others, while welcome and well-intentioned, have created a patchwork, leading to inconsistent policies and infrastructure across states.

Exemptions from stamp duty and registration costs, electric vehicle fleet targets, charging infrastructure investment and transitioning buses to electric propulsion demonstrates a strong willingness across borders to work together to drive new technology in road transport – but far better coordination is required.

The benefits of government intervention will be great.

Through electrifying the transport sector, enormous economic, national security, consumer and environmental benefits can be unlocked.

Indeed, Australia cannot afford to continue its trend of stagnant growth and uncertainty in its adoption of electric vehicles. With 92 per cent of our fuel being imported, our national security, balance of trade and the integrity of our nation's fuel security are threatened by an almost total dependence on imports.

An accelerated uptake of electric vehicles above a business-as-usual scenario to achieve 50 per cent market share of new light vehicle sales by 2030 would improve Australia's GDP in real terms by $2.9 billion and create 13,400 additional jobs.

The increasing uptake of e-mobility will also put households and businesses in a position to benefit greatly through lower transport costs. Under a high adoption scenario, fuel and maintenance costs for vehicles are expected to be up to 10 per cent lower by 2030.

Our hazardous reliance on fuel imports to move goods across the continent would be mitigated by eliminating the need for 16 million barrels of imported oil per year.

Australia is well positioned to capitalise from cheap and reliable energy. The transition of the transport sector to electrified propulsion offers the prospect of benefiting from this national advantage and accelerating the transition of the National Energy Market to the new generation of distributed power production and storage.

The complex interface between the transport and energy sectors during this period of significant change means a coordinated national plan across all levels of government gives Australia the best opportunity to align with the international adoption of these technologies.

Additionally, through a natural endowment of key minerals required for battery production, such as cobalt, lithium and other rare earths, Australia is well positioned to compete globally across the value chain of the burgeoning electric vehicle industry.

The benefits of change are clear – action is needed now

The benefits of an electric vehicle-led step change in the efficiency of the transport sector will be felt throughout the economy.

A national plan to embrace and support the transition to electric vehicles in the short-term is needed to drive initial sales and provide certainty for private sector investment in charging infrastructure.

Over the long-term, we need to make sure we are 'EV ready', planning for the integration of electric vehicles in our electricity, infrastructure, transport and planning systems.

Crucially, these changes are needed as the key enabler of other future mobility technologies such as connected and automated vehicles. We must ensure the policies, regulations and infrastructure are in place not only to support the electric evolution, but also the automated revolution. We need to ensure our policies and regulations are fit for purpose and do not slow or stagnate the pace of change.

With Australian automotive manufacturing ceased, there is no need to protect the status quo; there is a great opportunity to recharge the economy through innovative and exciting advancements in mobility.

PwC Analysis and Modelling

PwC was engaged by the Electric Vehicle Council (EVC) , the NRMA and the St Baker Energy Innovation Fund to conduct a high-level economic impact assessment of a high EV growth scenario, assuming a Norwegian rate of electric vehicle (EV)[4] uptake. Current forecasts by the Australian Energy Market Operator (AEMO) under a neutral growth scenario indicate EVs would account for 21 per cent of new vehicle sales by 2030, compared to 57 per cent under the scenario in this report.

Modelling in the 50@30 scenario assumes a higher growth forecast and hence there would need to be a change in the future trajectory of EV uptake for these economic impacts to be achieved.

4 Unless otherwise specified, Battery electric vehicles (BEVs) are referred to as EVs in this report.

Limitations

Economic impact estimates have been based upon an initial 'what if?' scenario assuming EVs account for an estimated 57 per cent of car sales in Australia by 2030. Given the high level nature of the analysis, this report does not account for the following:

- **EV uptake in Western Australia, Northern Territory and Tasmania** – while the modelling scenario considers the impact of EV uptake on all Australian states and territories, high EV growth rates have not been modelled for Tasmania or states outside of the National Electricity Market (NEM).
- **Additional benefits to public health** – vehicle travel generates a range of environmental externalities, in addition to carbon emissions, such as air, water and noise pollution. These external benefits have not been included in the CGE modelling.
- **Fuel security** – a reduced reliance on liquid fuel imports would improve Australia's fuel security and its resilience to global shocks.
- **Supply chain activation** – if the demand for EVs increases, there is potential to establish a new on-shore market in EV technology innovation and manufacturing capacity. Further research on supply chain activation and industry development, including the manufacture, reuse, recycling and disposal of EV batteries, is required.
- **Valuable storage capacity** – vehicle batteries will represent millions of storage units that can help to balance volatility in a renewables-powered electricity mix. According to a UBS study, the value of power storage to the grid operator is around AUD $320 per EV per annum (€200).
- It is recommended that further detailed analysis is undertaken to provide for a more tailored assessment of the economic impacts of electrifying Australia's transport sector based on the current and future structure of the industry.

Report Structure

The report proceeds in three sections:

- Description of the EV market in Australia, including the contribution of the transport sector to the Government's 2030 commitment under the Paris Accord.
- Assessment of the economic impact of the AU 50@30 EV growth scenario, in particular, the impact of:
  - investment in EV charging infrastructure (partially offset by a reduction in capital investment in areas such as the petrol fuel network)
  - emissions reductions and associated tax cuts
  - consumer savings as a result of lower vehicle ownership costs
  - reduced reliance on fuel imports.
- Description of the EV growth scenario in Norway used to define the AU 50@30 scenario for the economic impact assessment.

Methodology

The economic impact of EV uptake in Australia was assessed using a computable general equilibrium (CGE) modelling framework. CGE modelling was chosen as it is the preferred method of analysing the impact to changes in economic activity, such as investment and consumption, as it captures flow-on supply chain impacts to the wider economy. The economy-wide impact of EVs assesses the national impact of increased EV uptake in Queensland, New South Wales, Victoria, South Australia and the Australian Capital Territory from 2018 to 2030[5]. This is consistent with those states identified within the National Electricity Market (NEM) excluding Tasmania.

From the first year of sales in 2009 to 2017, the EV market share of new car registrations in Norway grew from 0.11 per cent to an estimated 21 per cent.

The scenario assumes the growth in EV market share of new car sales in Australia is equivalent to Norway's EV growth experience (historic and projected). From the first year of sales in 2009 to 2017, the EV market share of new car registrations in Norway grew from 0.11 per cent to an estimated 21 per cent. Applying the same historic growth profile and assuming Norway reaches its projected target for all new cars to be zero-emission vehicles by 2030, EVs would account for an estimated 57 per cent of car sales in Australia by 2030, referred to in this report as AU 50@30.

The impact is modelled through four channels over the period 2018-2030:

1. The net capital investment required for areas such as charging infrastructure to support EV uptake
2. Emissions reductions resulting from the transition to EVs and away from Internal Combustion Engine vehicles (ICEs)
3. Consumer savings resulting from lower vehicle ownership costs of EVs compared to ICEs
4. Reduction in reliance of fuel imports.

5 While the modelling scenario considers the impact of EV uptake on all Australian states and territories, EV uptake is not captured in Tasmania or states outside of the NEM .

Approach

1. The net investment of $3.2 billion required over the period 2018 to 2030 to support EV growth will stimulate economic activity in the short term. Net investment refers to the increased investment in EV charging infrastructure and the reduced investment in areas such as fuel infrastructure (ICE stock and infrastructure requirements reduce as consumers transition towards EVs).
2. Greenhouse benefits from a reduction in vehicle CO2 emissions is estimated to save $35 per tonne of CO2 abated[6]. Under the modelled EV growth scenario, 18 million tonnes of CO2 are estimated to be saved by 2030, providing a $628 million economic benefit to the economy. This is modelled by marginally lowering distorting taxes on factors of production thereby decreasing the cost of capital slightly.[7] Australia becomes more attractive to investors and allows after-tax wages to rise slightly without increasing costs of labour for business.
3. Total car ownership costs are assumed to reduce through lower maintenance costs and fuel costs. By 2030, each EV is estimated to save drivers $1,700 per annum in total ownership costs (savings are assumed to increase between 2018 to 2030 with an average saving of $810 per annum over the analysis period). These savings release resources into the economy that can be put to alternative productive uses. Increased spending power for workers combined with reduced or stable costs of labour for employers increases both consumer spending and employment.
4. The reduction in the reliance of fuel imports marginally improves the terms of trade of Australian businesses, in turn passing on benefits to consumers.

6 Cost assumptions for the social cost of carbon are outlined in Improving the efficiency of new light vehicles Draft Regulation Impact Statement, Department of Infrastructure and Regional Development, 2016, page 73. BITRE reports $35/per tonne of CO2 as a conservative estimate

7 Simulations of the Effects of Greenhouse Gas Mitigation Policies for the Australian Electricity Sector, Philip Adams, June 2016

4. Economic Impact Assessment

High EV growth boosts real GDP by $2.9 billion and supports 13,400 jobs by 2030

By 2030, EV uptake increases real GDP by approximately $2.9 billion, or 0.2 per cent, based on 2016-17 Australian GDP.

The number of net jobs also increases by 13,400 jobs relative to 2016-17 employment (Table 2). This net increase offsets job losses in industry sectors such as fuel resources and motor vehicle and parts manufacturing against job gains across the economy.

The benefits anticipated through EV uptake in Australia that were included in the modelling scenario are described below.

Table 2: Estimated economic impact of EV uptake

	2030
GDP impacts ($m, 2016-17)	2,900
Percent change in GDP	0.2
Employment impacts (jobs)	13,400

Source: PwC analysis, GDP impacts rounded to the nearest $million and job impacts are rounded to the nearest 100

Charging infrastructure stimulates investment in the short run and productivity in the long run.

1. Charging infrastructure stimulates investment in the short run and productivity in the long run.

The economic modelling assumes increasing investment in EV charging infrastructure and reduced investment in fuel infrastructure:

- Growing demand for EV charging infrastructure, battery materials and other related EV services is a relatively new sector of economic growth, potentially leading to higher incomes and an increase in jobs.[8]
- Reduced demand for fuel infrastructure is modelled to include reduced investment and lower incomes associated with this investment stream (it does not include financial losses associated with write-downs).

In the short run, the economy benefits from the build up of capital stock. Investment in the charging network boosts GDP during the construction phase as more labour and capital are demanded in the economy to build the new infrastructure.

In the long run, the overall benefit to the economy is attributable to productivity gains, reflecting a more efficient transport network which drives long-term economic gains.

8 The Path Forward – ClimateWorks 2016

Emissions reductions creates consumption and employment.

2. Emissions reductions creates consumption and employment.

An average new ICE vehicle emits roughly 185 gCO2/km compared to average new EVs which emit 98 gCO2/km if charged via the electricity grid. When charged via renewable energy sources, EVs emit zero emissions. As renewable energy represents an increased proportion of the electricity mix and battery capacity improves, EV emissions are estimated to fall to 58 gCO2/km.

While the major impacts associated with emissions are important fornon-economic reasons, they also have a positive effect on the economy. Since lowering emissions in the transport sector is cheaper than the cost of carbon[9], the cost of meeting Australia's Paris obligations through the budget process are lowered with a higher take up of electric vehicles. This is modelled by slightly lowering distorting taxes on factors of production.[10] This decreases the cost of capital slightly making Australia more attractive to investors and allows after-tax wages to rise slightly without increasing costs of labour for business. Increased spending power for workers combined with reduced or stable costs of labour for employers increases both consumer spending and employment.

Consumer savings increase productive use of resources.

3. Consumer savings increase productive use of resources.

BEVs currently have a higher purchase price relative to ICEs but the total cost of ownership for a consumer includes ongoing running and maintenance costs. However, BEVs have lower running costs over the life of the vehicle.

Lower maintenance costs – An electric motor (e-motor) is less complex than the combustion engine. In a modern e-motor, there are only three moving parts compared to over 100 moving parts in a combustion engine. EVs do not require a regular change of fluids such as engine oil and fewer parts are needed to be replaced over the car's life. According to AEMO, customers will spend $380 per annum on EV maintenance costs compared to $750 per annum for ICE vehicles.[11]

Lower fuel costs – The cost of recharging a vehicle's battery is 3 cents per km[12] compared to 10 cents per km for fuel.[13] The cost of recharging a vehicle's battery is further reduced if charged from domestic solar.

9 The cost of abatement using BEVs and PHEVs is estimated to be $3.93/tCO2e. See Modelling and analysis of Australia's abatement opportunities, Energetics, 2016, page 40. This is compared to the average cost of carbon of $35/tCO2e as used in BITRE modelling. See Improving the efficiency of new light vehicles Draft Regulation Impact Statement, Department of Infrastructure and Regional Development, 2016, page 73

10 Simulations of the Effects of Greenhouse Gas Mitigation Policies for the Australian Electricity Sector, Philip Adams, June 2016

11 Fixed annual maintenance costs, AEMO Insights, Section A.3.5, page 33

12 This is assuming no discounts are applied to the retail electricity price for consumers.

13 Based on the latest fuel efficiency of new ICEs/BEVs currently available on the market.

Lower maintenance and running costs for private vehicles release resources into the rest of the economy that can be put to alternative productive uses and the savings made by consumers can be diverted to other goods for consumption.

Reduction in fuel imports improves Australia's terms of trade.

4. Reduction in fuel imports improves Australia's terms of trade.

Australia has an opportunity to become less reliant on imported oil and fuel and diversify its energy portfolio. Reduced reliance on imported fuel reduces the overall need for Australia to export goods to maintain a given trading and investment relationship with the rest of the world. This again has benefits to consumers and also slightly improves the terms of trade for Australian businesses.

Electric Vehicle Benefits Excluded from PWC Modelling

Economic growth from supply chain activation

Current modelling assumes the 'shock' to the Australian economy from increased EV uptake will follow existing supply chain arrangements. As the uptake in EVs increases and provides a growth market on-shore for EV technology innovation and manufacturing capacity, there is an opportunity to further unlock the local supply chain and develop domestic skills and capabilities to service the local market (and export to the global market).

Vehicle batteries could represent millions of storage units to help balance volatility in a renewables-powered electricity mix.

Valuable storage capacity

BEVs provide storage capacity to the grid and can be powered with self-generated electricity (solar panels). Vehicle batteries could represent millions of storage units to help balance volatility in a renewables-powered electricity mix. Batteries can be charged and also discharged to stabilize the grid.

According to UBS, the value of power storage to the grid operator is around AUD $320 per BEV per year (€200), which accounts for 30-60 per cent of the annual electricity bill for the consumption of the BEV. The global value of EV storage available to utilities could be AUD $9.5 billion per annum.[14]

Fuel security

Although the CGE model factors in the economic impact on Australia's balance of trade as a result of reducing its dependence on fuel imports, the model does not quantify the potential improvement to fuel security and its resilience to global shocks.

14 UBS, Global Autos: What is the powertrain of the future?, Q-series March 2016, page 23

Public health benefits

Vehicle travel generates a range of environmental externalities, in addition to carbon emissions, such as air, water and noise pollution. The model does not quantify the potential benefits to community health and living standards from reducing these non-carbon emissions.[15]

Targeting the transport sector by encouraging the use of EVs presents an effective way to reduce carbon emissions

National Energy Guarantee

Australia has made an international commitment as part of the Paris Agreement to reduce carbon emissions by 26 per cent to 28 per cent by 2030 from 2005 levels.[16]

The Turnbull Government announced its new energy policy in October 2017, designed to reduce emissions after 2020. The National Energy Guarantee (NEG) contains two new obligations on electricity retailers. The first is to ensure there is sufficient electricity generation available to meet demand (the Reliability Guarantee). The second is to drive down the sector's greenhouse emissions (the Emissions Guarantee).

New obligations for reliability and emissions reduction will be agreed in 2018.

In 2015, Australia's transport sector represented the third highest source of emissions contributing 18.1 per cent.[17]

Transport's contribution to emissions

In 2015, Australia's transport sector represented the third highest source of emissions, with contribution to emissions of 18.1 per cent.[17] Transport is one of the strongest sources of growth in emissions. From 1990 to 2015 transport emissions rose over 55 per cent, averaging 2.2 per cent annually, with road transport accounting for roughly 85 per cent of all transport emissions.[18] This sector's emissions have been projected to rise 6 per cent to 2020, to reach 97 million tonnes (Mt) CO2e, driven by general economic growth.

Assuming the electricity sector meets its target to reduce emissions, further reductions will be required in transport and other sectors to meet the overall national Paris commitment, as emissions from the electricity sector represent only about one third of total emissions. With the cessation of domestic vehicle manufacturing, policy flexibility relating to transport has increased.

15 The combined economic cost to Australia of motor vehicle-related mortality and morbidity was estimated in 2005 by the Bureau of Transport and Regional Economics between $1.6 billion and $3.8 billion (central estimate $2.7 billion), Health impacts of transport emissions in Australia: Economic costs, Working Paper 63, 2005, p.xiv.
16 Australia's 2030 Emissions Reduction Target – www.environment.gov.au
17 National Inventory Report 2015 – www.environment.gov.au
18 PwC, National Energy Guarantee – A balancing act between emissions and reliability, October 2017, p.4

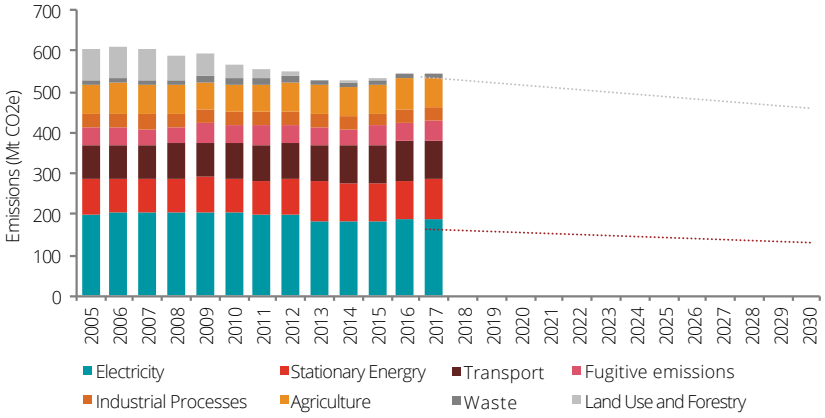
If higher emissions standards are required from the transport sector, there may be challenges for the automotive industry. But there will also be opportunities and benefits to the sector if incentives are provided to fast track the take up of EVs.[18]

According to the Climate Change Authority, "...relative to other sectors, vehicle efficiency improvements are some of the lowest cost opportunities to reduce emissions, delivering net savings to motorists because higher vehicle purchase costs can be more than offset through lower running costs."[19]

> "...relative to other sectors, vehicle efficiency improvements are some of the lowest cost opportunities to reduce emissions...
> *Climate Change Authority*

Figure 1 demonstrates the emission reduction required by each sector on a pro rata basis.

Targeting the transport sector by encouraging the use of EVs present an effective way of reducing carbon emissions thereby assisting Australia in meeting its international commitments.



Source: PwC, National Energy Guarantee – A balancing act between emissions and reliability, October 2017, page 3

Figure 1: Emissions by sector (Mt CO2e)

CGE modelling has been undertaken to assess the economic impact of a high EV growth scenario

Computable general equilibrium (CGE)

The total economic impact of EV uptake in Australia was assessed using a CGE modelling framework. CGE modelling is the preferred method of analysing changes to economic activity as it captures flow-on impacts to the wider economy. That is, it acknowledges that infrastructure spending will in turn impact other industries in the economy and accounts for the indirect effects of these changes.

19 Climate Change Authority, http://www.climatechangeauthority.gov.au/reviews/light-vehicle-emissions-standards-australia/opportunities-reduce-light-vehicle-emissions

Modelling scenario considered

The economy-wide impact of EVs assesses the national impact of increased EV uptake in Queensland, New South Wales, Victoria, South Australia and the Australian Capital Territory from 2018 to 2030.[20]

The impact is modelled through four anticipated changes or 'shocks' to the economy as a result of the potential EV uptake:

1. The net capital investment required for areas such as charging infrastructure to support EV uptake
2. Emissions reductions resulting from the transition to EVs and away from ICEs
3. Consumer savings resulting from lower vehicle ownership costs of EVs compared to ICEs
4. Reduction in reliance of fuel imports which slightly improves Australian businesses' international competitiveness.

The economic impact is assessed in terms of Australia's gross domestic product (GDP) although the EV uptake and carbon abatement is limited to states within the NEM (excluding Tasmania).

Modelling approach

A CGE model is a simplified representation of the complex nature of the economy based on Australian Bureau of Statistics (ABS) data and standard economic concepts. It is commonly applied by Australian governments to estimate the economic impacts of policies and projects on the whole economy. Total economic impact analysis includes indirect (flow-on) impacts in other sectors or regions of the economy. Indirect impacts include those backward linkages through the supply chain of industries, essentially supplier industries, to those industries and businesses directly affected by policies and projects.

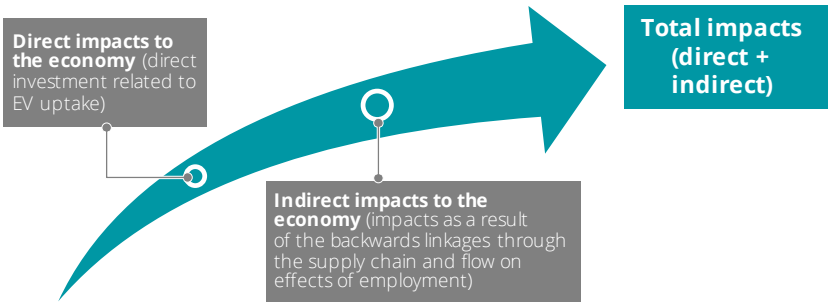


Figure 2: Total economic impact

20 Increased EV uptake was only considered in those states within the National Electricity Market (NEM) excluding Tasmania. National impacts will be understated given the exclusion of EV uptake from Tasmania, Western Australia, and the Northern Territory.

The output of the model demonstrates the change in key economic variables (such as gross domestic product and employment) compared to a scenario without the policy change. PwC has considered changes to these key economic variables across 2018 to 2030 to demonstrate the short and longer term effects of EV uptake in Australia.

Modelling scenario assumes EV market growth rates align to Norway with Australia reaching 57 per cent of car sales by 2030

Norway's growth experience has been used to assess the economic impact of a high EV growth rate in Australia. This scenario is selected on the basis that:

1. Norway provides a real demonstration of EV growth potential with a high level of Government support.
2. While Norway has experienced above average EV growth rates, EV uptake is expected to accelerate globally over the next 10 years with key growth drivers including regulation and incentives.
3. Charging infrastructure in Norway must service disparate urban concentrations, and provides indicative ratios of charging infrastructure required in Australia to support EV uptake.

Estimated forecast sales of cars (all types)

Forecast numbers of cars on the road and annual car sales are based on AEMO's estimates for the NEM. Forecast data is available for the period under review, 2018 to 2030.[21]

> The Norwegian government has announced a plan for all new private cars, city buses and light vans to be zero-emission vehicles by 2025.[22]

While AEMO has also estimated forecast EV market share, the CGE modelling has assumed an alternative scenario based on a Norwegian EV growth rate (Figure 3), a world leader in EV uptake. As such, this analysis estimates the benefit to the Australian economy from following a similar path as Norway.

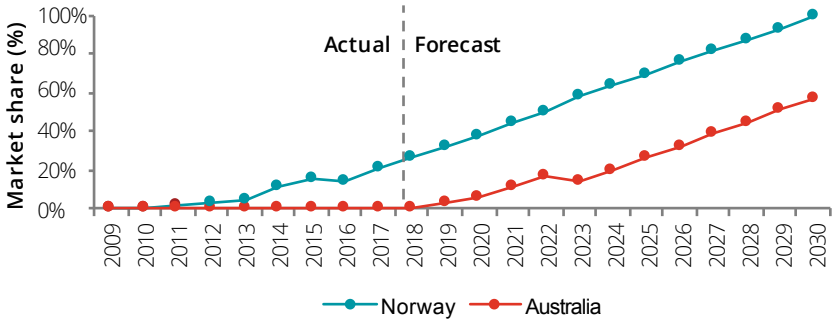
The Norwegian government has announced a plan for all new private cars, city buses and light vans to be zero-emission vehicles by 2025.[22]

As a conservative estimate, Norway's market share of new car sales is assumed to reach its target of 100 per cent by 2030. This puts Norway's growth in BEV market share at 6 per cent per annum from 2018 to 2030. For modelling purposes, Australia's market share is assumed to increase at the same rate as Norwegian growth rates. This means that by 2030, the BEV market share of new car sales in Australia will reach 57 per cent (50@30).

21 Electric Vehicles, AEMO Insights, 2016, Appendix B.1: EV Uptake
22 Electric Vehicle Policy in Norway, Climate Exchange, 2017

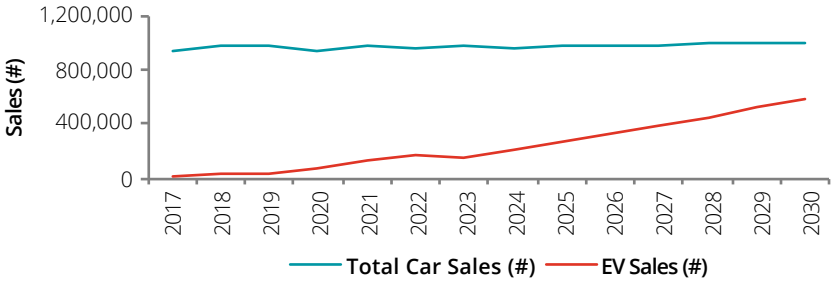
EV market share of new car sales

In 2009, BEV market share of new car registrations in Norway was 0.11 per cent. Within eight years, by 2017, this market share had grown substantially to 21 per cent.[23] Australia's BEV market share of new car sales in 2016 (0.07 per cent) is similar to Norway's market share in 2009.



Source: PwC analysis. Global EV Outlook 2017, International Energy Agency, 2017

Figure 3: Australian EV market share as benchmarked against Norway



Source: PwC analysis based on market shares (Global EV Outlook 2017, International Energy Agency, 2017) and car sales (Electric Vehicles, AEMO Insights, 2016)

Figure 4: Potential EV uptake in Australia, 2017 to 2030

Investment in charging infrastructure is needed to mitigate range anxiety for prospective EV purchasers

Charging stations to support EV uptake

A key question faced by policy makers and the private sector is how quickly to install EV charging infrastructure. While the majority of charging (90 per cent or more) is undertaken at home and work, public charging infrastructure is needed to mitigate range anxiety.

Charging infrastructure includes:

- Home chargers – most car makers recommend installing an EV charging station at home to improve recharging times
- Public chargers – level 2 chargers provide approximately 50 kilometres of range per hour and are the most common type

23 NPRA. Last updated: 31 December 2017. Numbers include passenger cars and light commercial vehicles. Published via https://elbil.no/english/norwegian-ev-market/

of EV charging for locations where vehicles are parked for more than one hour (work, shopping centres and hotels)
- Fast chargers – level 3 chargers can fully recharge an average vehicle in 20 to 30 minutes with various charge output (50kW, 150kW or 350+kW).

Varied international experience demonstrates that there is no consistent ratio of charging stations to EVs for benchmarking purposes. For example, the ratio of EVs to charging points in the Netherlands and China ranges from 0 to 10, whereas in the United Kingdom it generally ranges from 15 to 25.1.

Given this, the economic impact approach assumes:

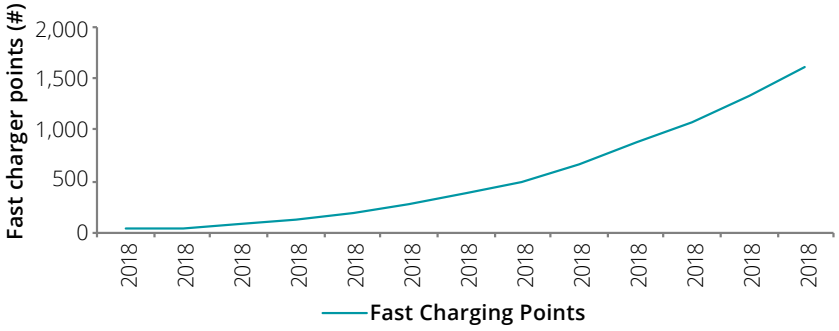
- 1 home charger is installed per EV
- Public (slow) charging infrastructure is installed according to a ratio of 19 EVs per charging point (based on the experience of charging ratios in Norway excluding fast chargers)
- 350kW+ fast chargers are capped at 1,000 units.

Over the period 2018 to 2030, it is assumed that 350+kW chargers increasingly account for a higher proportion of fast charger installations as technology in EVs continue to advance.

Table 3: Potential requirements for EV charging infrastructure in Australia

Number of	2018	2030
Electric vehicles	20,530	3,130,196
Home chargers	20,530	3,130,196
Public chargers	8,022	91,617
Fast chargers		
· 50kW	16	305
· 150kW	16	305
· 2 x 350kW+ Note 1	1	1,000

Source: PwC analysis. Data provided by EVC
Note 1: 2 x 350kW unit and costs represent one charging unit with 2 'heads' (points of charge) which allows for more efficient upgrade to 6 heads in future as required. 50kW and 150kW chargers represent costs for 1 'head' only.



Source: PwC analysis

Figure 5: Total fast charging points per year

Net investment in charging infrastructure provides a $3.2 billion capital injection from 2018 to 2030

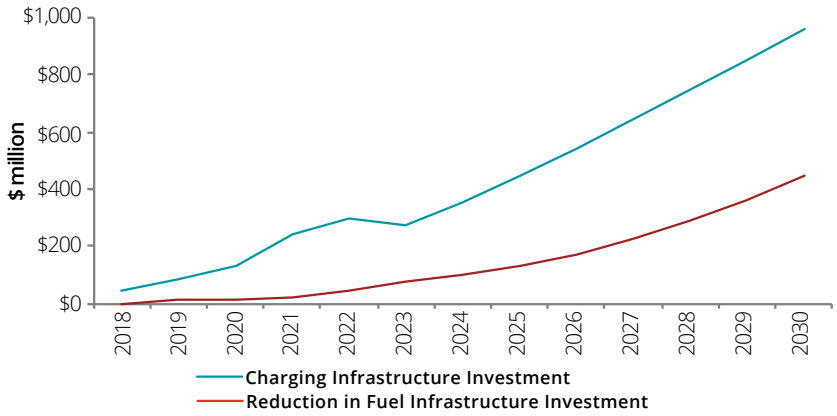
The model is 'shocked' to reflect changes resulting from the potential EV uptake in Australia based on the scenario AU 50@30. In this case four changes to the current economic environment were examined, as discussed below and detailed in the Appendix.

Change 1: Investment in EV charging infrastructure

Investment in infrastructure (Figure 6) was modelled under a two step process:

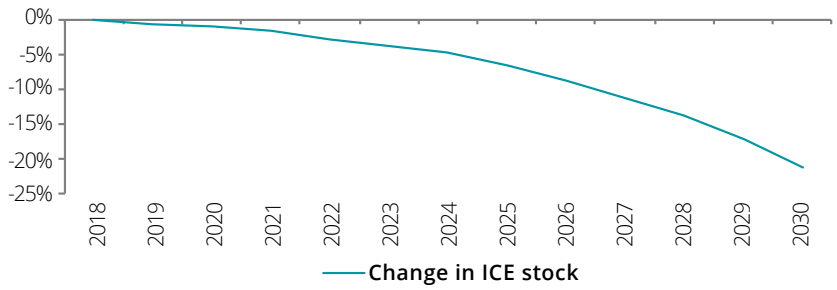
1. Investment in charging infrastructure, proportional to EV uptake rather than assuming that infrastructure is installed first
2. Reduction in investment in areas such as fuel infrastructure, proportional to the change in ICE stock (Figure 7).

The reduction in fuel infrastructure investment is an important consideration as to not overstate the EV investment impacts.



Source: PwC analysis based on cost data provided by EVC and publically available financial data on fuel capital expenditures

Figure 6: Infrastructure investment



Source: PwC analysis. Estimates are calculated as EV stock/total vehicle stock

Figure 7: Change in proportion of ICE vehicles to total vehicles on the road

Charging Station Costs

Capital costs associated with installing charging stations used in the model are outlined below. These costs may reduce over time.

Table 4: Charging Unit Costs

Charging Infrastructure	Unit cost
Home chargers	$1,500
Public chargers	$3,500
Fast chargers	
· 50kW	$62,500
· 150kW	$127,750
· 350kW+	$437,500

Source: Data provided by EVC. Estimated costs are for chargers and installation only. Discounts are applied to these costs to account for scale ie installing additional points at existing charging stations is less costly than initial build costs
Note: 350kW+ stations costs include two charging heads

Cumulative carbon emissions are estimated to reduce by 18 million tonnes by 2030 under a high EV growth scenario

Electric vehicles provide Australia with an opportunity to reduce emissions by a total of 18 million tonnes of CO2e between 2018 and 2030.

Change 2: Economic impact of emissions reductions

Electric vehicles provide Australia with an opportunity to reduce emissions by a total of 18 million tonnes of CO2e between 2018 and 2030.

Over the 2020-2030 period, this would contribute 24 per cent of the Government's 76 MtCO2e reduction target.[24]

Modelling of emissions from ICE vehicles assumes:

- 2018 baseline of vehicle emissions of 185 gCO2e/km[25]
- ICE vehicle fuel efficiency improves to 152 gCO2e/km by 2030 under a business-as-usual scenario ie it does not assume potential changes to light vehicle emissions standards.[26]

24 ClimateWorks Australia and Future Climate Australia, Submission to the Vehicle Emissions Discussion Paper, April 2016, page 9
25 Tailpipe emissions - Light vehicle emissions standards—setting the right target, Climate Change Authority and Scope 3 emissions - National Greenhouse Accounts Factors, Department of the Environment and Energy, 2017
26 Light vehicle emissions standards—setting the right target, Climate Change Authority, Table 4.1, ICE fuel efficiency based on conversion rate: 1 g/km CO2 = 0.043 L/100km and represents the fuel efficiency of a new ICE vehicle (compared to average existing ICE of 10L/100km).

Modelling of emissions from EV vehicles assumes:

- 2018 baseline of vehicle emissions of 98 gCO2e/km
- EV emissions intensity improves to 58 gCO2e/km by 2030 assuming:
  - the NEM will achieve the emissions intensity targets aligned to Australia's Paris commitments. Indirect EV emissions from recharging will fall as the grid emission intensity falls.27
  - EV vehicle battery efficiency improves based on the release of existing EV models which will come available in Australia from 2021/22.28
- Given the uncertainties in forecasting battery technology improvements, there is no further assumption of improved efficiency beyond the existing EV models available from 2021/22.

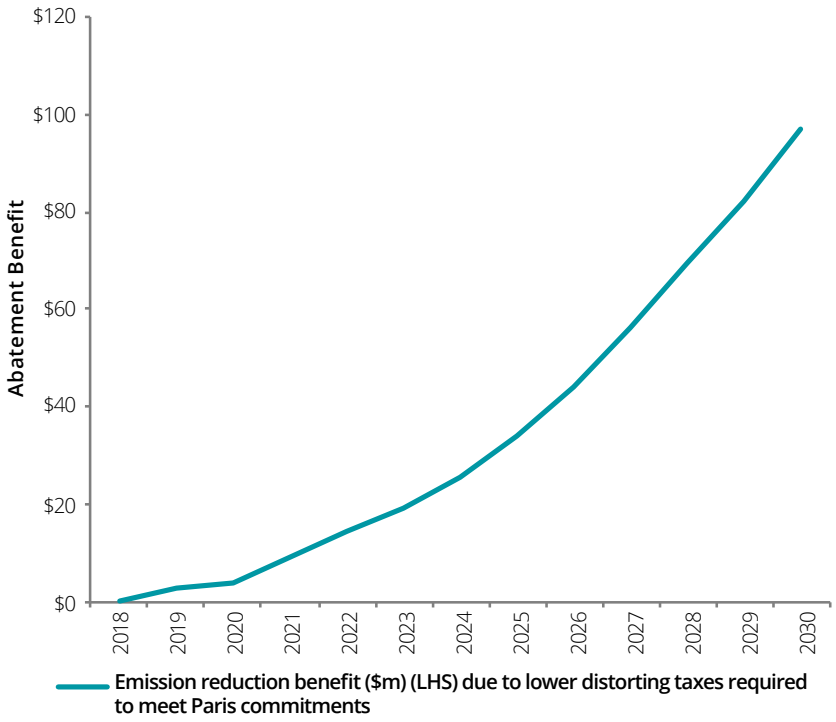
The assumptions underpinning the emissions reductions are considered reasonable to measure the economic impacts of transitioning to EVs. There are additional assumptions which could have been assessed. These are excluded either because of the forecasting uncertainties or because they would have a negligible impact on the economic modelling results. These include:

- Use of distributed energy to charge EVs - EV drivers may strategically choose to charge their vehicles using energy generated from solar panels and hence save electricity costs. It is not possible to robustly forecast estimates of distributed energy being used specifically for EV charging given the low levels of EV uptake in Australia. A conservative approach has instead been adopted to apply the overall NEM emissions intensity.
- Cradle to grave emissions from manufacture to disposal have not been assessed. The modelling measures the impacts to the Australian economy in response to Australia's decarbonisation efforts and excludes international manufacturing emissions.

A conservative estimate of $35/tCO2[29] abated has been used to estimate the economic benefit from a reduction in vehicle emissions. By 2030, the savings to the economy are estimated to be $628 million.

The savings are modelled by slightly lowering distorting taxes on factors of production (see Figure 8 overleaf), consistent with other Australian literature on modelling the impact of mitigation policies.[30]

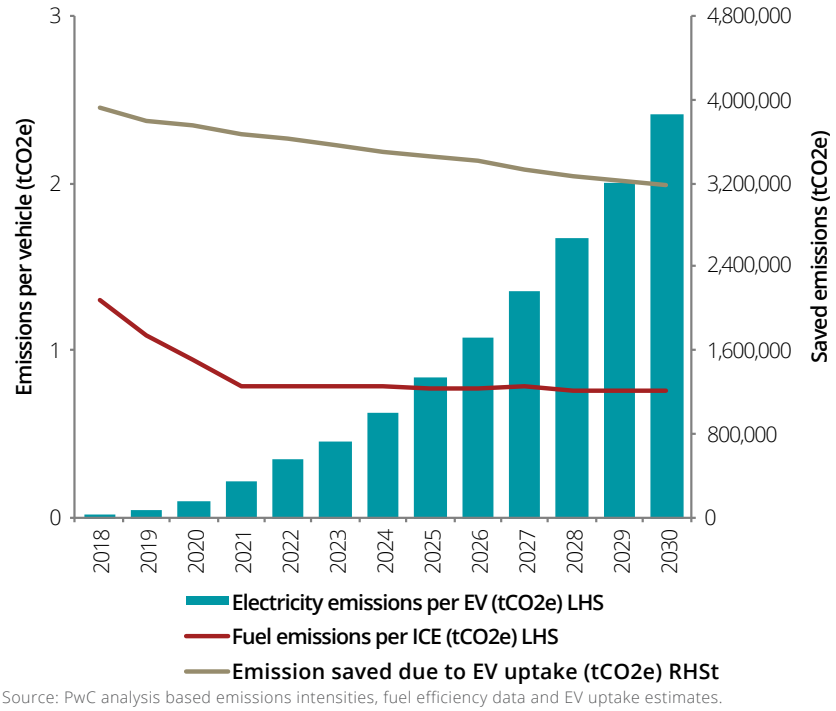
27 Modelling and analysis of Australia's abatement opportunities, Energetics, 2016
28 UBS, Global Autos, Q-series March 2017
29 Department of Infrastructure and Regional Development, Improving the efficiency of new light vehicles Draft Regulation Impact Statement, 2016, page 73
30 Simulations of the Effects of Greenhouse Gas Mitigation Policies for the Australian Electricity Sector, Philip Adams, June 2016



Source: PwC analysis. Economic benefit is calculated as abatement benefit of EVs x total emissions reduction.

Figure 8: Economic benefit of emissions reductions with lower abatement cost

Figure 9 shows the change in emission intensity of ICEs compared to EVs and the increase in emissions reduction overtime.



Source: PwC analysis based emissions intensities, fuel efficiency data and EV uptake estimates.

Figure 9: Fuel emissions per vehicle and forecast electricity emissions from the grid

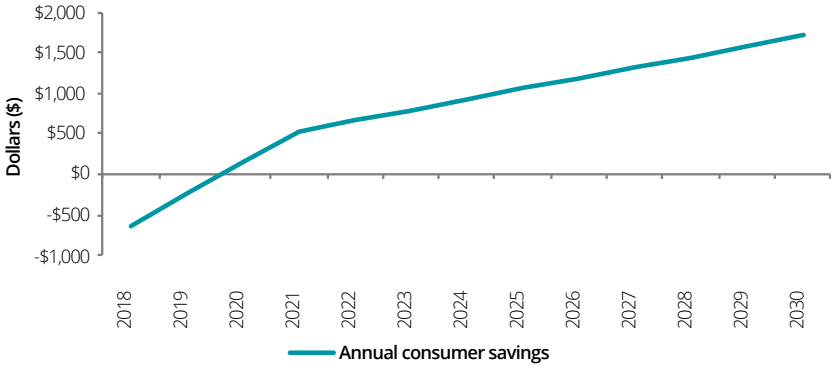
High EV uptake lowers vehicle ownership costs by $14 billion from 2018 to 2030 and reduces reliance on fuel imports

Change 3: Consumer savings

While the purchase price of EVs are higher relative to ICEs, EVs are less costly to maintain and run. Over a 10 year ownership period, UBS estimates the total cost of ownership to be A$5,000 less for EVs relative to ICEs by 2021 and A$11,000 less by 2025 as battery prices fall.[31]

Based on these estimates, Australian consumers are estimated to save $1,700 per annum by 2030. Total consumer savings over the entire period are estimated to reach $14 billion.

The impact of consumer savings was modelled through a productivity improvement of the vehicle fleet: consumers obtain the same level of output (car ownership) with fewer inputs (lower costs).



Source: PwC analysis based on petrol prices (Annual Retail Price Data, Australian Institute of Petroleum), NEM retail electricity prices (2016 Residential Electricity Price Trends, AEMO) and maintenance cost savings (Electric Vehicles, AEMO Insights, 2016).

Figure 10: Annual consumer savings for EV owners

Change 4: Reduction in fuel imports

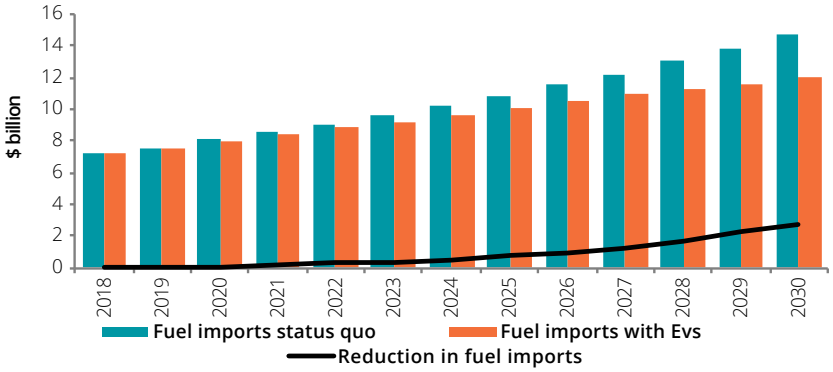
As EVs do not require fuel, this will have an effect on fuel imports which fall in proportion to the reduction in fuel consumption. This has benefits to consumers and also slightly improves the terms of trade for Australian businesses.

Given Australia imports 91 per cent of its fuel,[32] the estimated reduction in fuel imports totals $15 billion over the entire period to 2030.

31 UBS, Global Autos: UBS Evidence Lab Electric Car Teardown – Disruption Ahead?, Q-series March 2017. Total cost of ownership is based on UBS estimates for the European market. The cost inputs, including purchase price, maintenance, fuel and electricity costs, relative to local wages, are approximately on par for Europe and Australia. Hence, the total cost of ownership of BEVs and ICEs for the European market is assumed to provide a reasonable benchmark for Australia.

32 Australia's Transport Energy Resilience and Sustainability (Chapter 2), Senate Standing Committees on Rural and Regional Affairs and Transport, June 2015.

Fewer imports in turn require fewer exports to maintain Australia's balance of trade at its long run average. This change involved a shock to increase the price of exports such that the quantity of exports is reduced.



Source: PwC analysis based petrol imports (Net Supply of Energy, ABS), crude oil imports used for petrol (Australian Petroleum Statistics, 2016) and total imports (Australian National Accounts, ABS).

Figure 11: Fuel imports with and without EV uptake

Barriers to EV uptake currently limit Australia from achieving strong growth forecasts as per Europe and China

Electric vehicles on a global scale

Over 10 years, the number of EVs (BEVs and PHEVs) on the road has grown from 16,900 in 2006 to over 2 million in 2016. BEVs account for 1.2 million of the total electric car stock in 2016.[33]

> Over 10 years, the number of EVs (BEVs and PHEVs) on the road has grown from 16,900 in 2006 to over 2 million in 2016.

Official sales data from China, the US, Europe, Japan and Canada shows BEVs and PHEVs accounted for 1.7 per cent of new car sales in 2017 in those markets;[34] Australia sits at 0.1 per cent.[35]

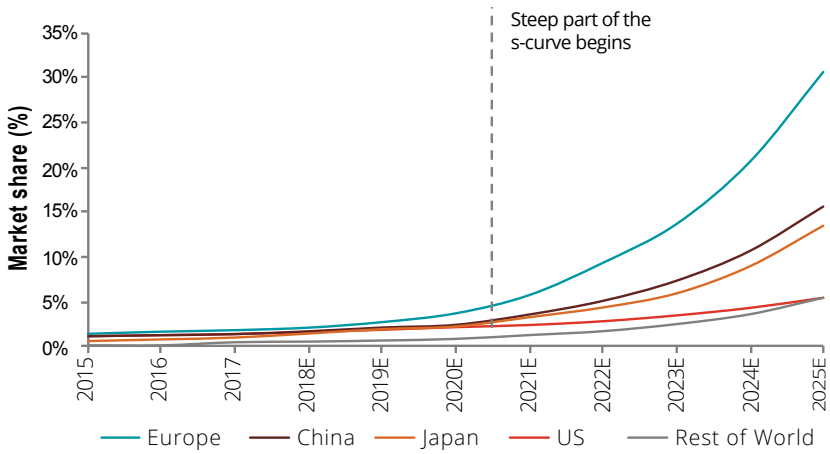
Forecast EVs, as a proportion of new car sales, is estimated to reach 9.2 per cent by 2025 which includes a penetration rate of 18 per cent in Europe.

33 International Energy Agency, Global EV Outlook, 2017, Tables 4 and 5, p.49.
34 Source reference provided by Macquarie Bank - CEIC, hybridcars.com, EAFO, Matthew Klippenstein, other national data, Macquarie Research, January 2018
35 Proportion calculated based on number of EVs sold (Climate Works Australia, The state of electric vehicles in Australia, 2017.) and total car sales (AEMO Insights, Electric Vehicles, August 2016)

Barriers to EV uptake in Australia

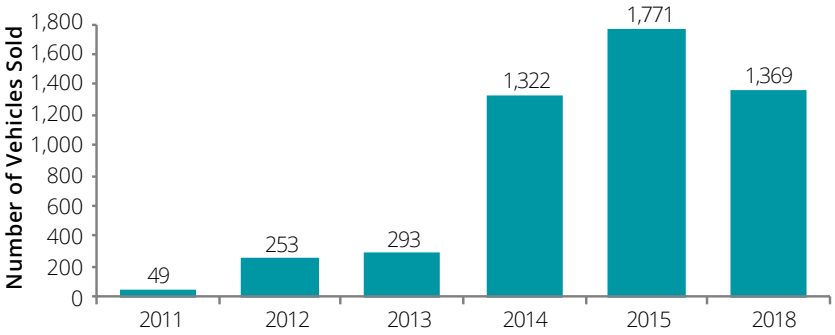
Figure 13 shows EV sales from 2011 to 2016. Some strong initial growth has been tempered recently. A number of barriers inhibit wider EV adoption in Australia, such as:

- **Lack of charging infrastructure** – requiring initial investment.
- **Recharge time** – consumers not willing to wait an hour or more to recharge.
- **EV model availability** – a lack of affordable models in Australia, with some of the most popular models in Europe and the US not available.
- **Consumer knowledge/awareness** – some consumers are not aware of the low-carbon emission options available when purchasing a new car.
- **Range anxiety** – consumers fear they are not able to travel long distances and reliably.



Source: UBS, Evidence Lab Electric Car Teardown – Disruption ahead?, May 2017

Figure 12 EV penetration to accelerate over the next ten years



Original source V-Facts (2017); Electric Vehicle Council industry engagement as reported in ClimateWorks Australia, The state of electric vehicles in Australia, 2017

Figure 13 EV sales in Australia, 2011 to 2016

5. EV Growth

Government policy support can stimulate EV growth

Overseas Government policy supportive of EVs

Figure 14 provides an overview of the actions of Governments around the world in promoting electric vehicle market uptake.

All the countries listed:

- Provide support for research and development
- Provide long-term efficiency standards for manufacturers
- Provide funding for an EV charging network
- Actively reach out to consumers to educate them on the benefits of owning an electric vehicle
- Maintain a carbon pricing scheme (USA's carbon pricing is state-based).

Policy direction for Australia

Australia has multiple policy options available to increase the penetration of EVs into the market. Some policies that could be undertaken include:

Light vehicle CO2 emissions standards – Australia is one of the few remaining developed countries without light vehicle standards. Standards apply in 80 per cent of the global automotive market.[36]

Tax rebates, stamp duty discounts or direct subsidies – all countries that are leading the market share of electric vehicles sales have some type of financial incentive such as those listed.[37]

Grant programs – to encourage the private sector to expand the electric vehicle charging station network and other complementary infrastructure across the country.[38]

> Australia is one of the few remaining developed countries without light vehicle standards. Standards apply in 80 per cent of the global automotive market.[36]

36 International Council on Clean Transportation (2015)
37 The Path Forward – ClimateWorks 2016
38 EVC Submission to Ministerial Forum – EVC 2017

Area	Action	China	France	Germany	Japan	Netherlands	Norway	United Kingdom	United States (excl. California)	California
Global Market Share	Vehicle sales in 2014 (million vehicles)	22	2.2	3.3	4.0	0.5	0.2	2.6	14	1.7
	Vehicle manufacturing in 2014 (million vehicles)	22	1.7	5.7	10.0	<0.1	<0.1	1.6	11	<0.1
	Percent of 2014 global electric vehicle sales	17%	4%	4%	10%	5%	6%	5%	19%	19%
Vehicle Manufacturer	Research and development support	X	X	X	X	X	X	X	X	X
	Long-term efficiency standards	X	X	X	X	X	X	X	X	X
	Incentive provisions within efficiency regulations	X	X	X		X	X	X	X	X
	Cumulative sales goal	X	X	X		X	X	X	X	X
	Vehicle deployment requirements									
	Vehicle production subsidy	X								
Consumer Purchase	Vehicle purchase subsidy (tax credit)									X
	Vehicle purchase subsidy (rebate)	X			X			X		
	Vehicle purchase tax exemption					X	X		/	
	Vehicle fee-bate scheme		X					X		
	Government fleet vehicle purchasing preferences		X		X			X	X	X
	High fuel price and greater fuel savings		X	X		X	X	X		
Consumer Use	Annual vehicle fee exemption			X	X	X	X	/	/	
	Discounted/fee electric changing				X	X	X	/	/	X
	Preferential lane (eg bus, HOV lane) access			/		X	X		/	X
	Reduced roadway tax or tolls			X	X	X	X	X		
	Preferential parking access		/	/		/	/	/	/	/
Fuel Provider, Infrastructure	Carbon pricing scheme	X	X	X	X	X	X	X	/	X
	Low carbon fuel incentive for electricity providers							/		X
	Public charging network funding	X	X	X	X	X	X	X	X	X
	Home charging equipment tax incentives		X						/	/
Consumer Awareness	Public outreach activities to educate on consumer benefits	X	X	X	X	X	X	X	X	X

Source: The International Council on Clean Transportation, 2015
Note: California is a leader in EV uptake and is included separately for comparison. "X" denotes national program; "/" Signifies smaller local or regional program. Note that USA has a carbon pricing scheme at a state level, signified by "/".

Figure 14: Summary of government EV promotion actions

Over 10 years, Norway has become a leader with EV market share growing from 0.11 per cent to 21 per cent of car sales

Government support for EVs in Norway

Norway provides a real demonstration of EV growth potential with a high level of Government support.

In order to curb the transport sector's environmental impact, the Norwegian Government implemented a number of policies to decarbonise passenger transport.

Norway has a more ambitious CO2 emissions target for new vehicles; 85 g/km by 2020 compared to the EU-wide target of 95 g/km by 2020.

In 2016, the Norwegian market share for battery electric vehicles (BEVs) was 15.7 per cent and 13.4 per cent for plug-in hybrids (PHEVs), 29.1 per cent in total.

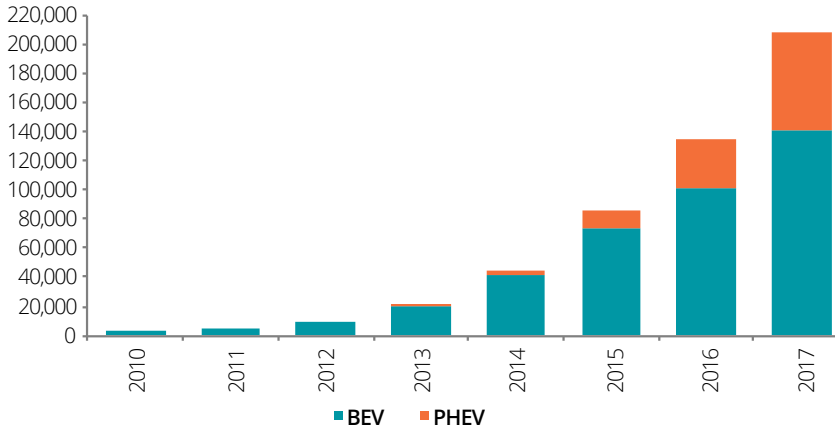
The Norwegian Government provides incentives for electric vehicles including:

- Target for all new private cars, city buses and light vans to be zero-emission vehicles by 2025
- Direct incentives such as tax exemptions
  - progressive vehicle registration tax based on CO2 emission values
  - exemption from VAT (which normally adds 25 per cent of a vehicle's list price to the total cost) for BEVs
  - reduced taxes on company BEVs.

As a result, the cost of purchasing an EV for private use is lower than a comparable conventional car.

- Indirect consumer incentives include such benefits as:
  - free access to toll roads
  - free parking
  - access to bus lanes
  - free charging at public charging stations
  - reduced ferry rates

Indirect incentives are estimated at approximately AUD $3,400 (~16,000 kroner)per year for a BEV owner.



Source: NPRA. Last updated: 31 December 2017. Numbers include passenger cars and light commercial vehicles. Published via https://elbil.no/english/norwegian-ev-market/

Figure 15: Electric Vehicle Fleet in Norway

Charging infrastructure in Norway must service disparate urban concentrations

Geographic dispersion of population

As at 2017, Norway has a population of 5.4 million living in 990 urban settlements. Norway has:

- A low population density with approximately 81.5 per cent of the population concentrated in urban areas (Australia's geographic size significantly exceeds Norway but it has a relatively similar demographic dispersion with its population concentrated in urban areas; 90 per cent of the population live in urban areas39 with 67 per cent living in a capital city40)
- A heavy reliance on cars, with 90 per cent of all motorized passenger kilometres travelled in cars.

Investment in charging infrastructure

In 2009-2010, the Norwegian Government provided financial support for the construction of charging stations with approximately AUD $11 million (~50 million kroner), which were used to subsidize public charging points with up to AUD $5,700 per point (30,000 kroner).[41]

In 2015, Enova introduced a support scheme with aims to cover the Norwegian main roads with fast charging stations every 50 kilometres.

In 2013, Enova supported fast charging infrastructure with AUD $1.3 million (~ 6 million kroner).

More recently, in 2015, Enova introduced a support scheme with aims to cover the Norwegian main roads with fast charging stations every 50 kilometres. Enova is a public enterprise (formerly known as Transnova) which is funded by the public Energy Fund and is overseen by the Ministry of Petroleum and Energy.

The economic impact assessment assumes public (slow) chargers are installed in Australia according to the ratio of chargers to EVs in Norway. Fast chargers are assumed to reach 1,000 by 2030.

39 Trading Economics, 2016 urban population according to the World Bank collection of development indicators, https://tradingeconomics.com/australia/urban-population-wb-data.html,

40 Australian Bureau of Statistics, 2016 census, http://www.abs.gov.au/AUSSTATS/abs@.nsf/mediareleasesbyReleaseDate/A42AA95414E2A89FCA2581480009B6F2?OpenDocument

41 Charging infrastructure experiences in Norway - the worlds most advanced EV market, EVS30 Symposium, 2017

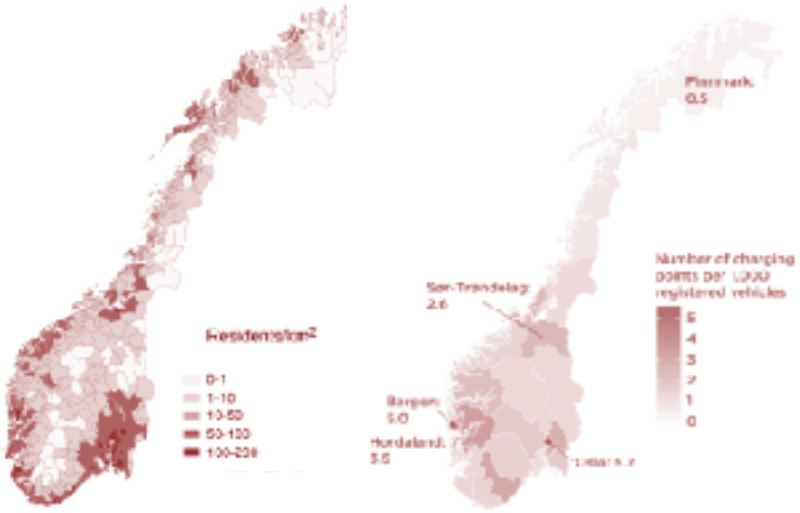


Figure 16: Population density map and number of charging stations per 1000 vehicles

Norway's growth rates are aggressive but EV forecast sales are nevertheless accelerating globally

EV sales will accelerate globally in next 10 years

EV sales are expected to grow as EVs become more affordable with mainstream models due to be launched. UBS estimates that the total cost of ownership of EVs is almost comparable with ICE cars in Europe today thanks to lower EV component and maintenance costs and higher fuel prices for ICE cars. UBS forecasts that EV (BEV + PHEV) penetration rates in new car sales will reach around 30 per cent in Europe and 14 per cent in China by 2025.[42] The scenario modelled by PwC for Australia assumes a BEV penetration rate of 27 per cent by 2025.

AEMO has also published forecasts for BEV + PHEV sales specific to Australia. The Neutral and Strong scenarios are modelled in Figure 17. EVs account for 27 per cent of car sales in 2025 under the 'Strong' scenario where EV sales initially increase due to higher oil prices and a decline in the cost of EVs and battery storage. Sales further accelerate due to the introduction of a carbon price on petrol (2020) and a fleet wide greenhouse gas emission standard (2022).

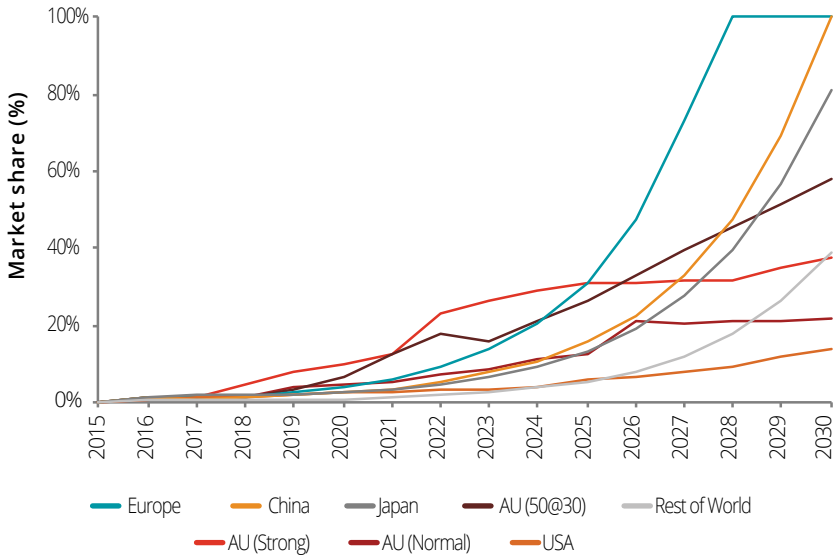
Australia's market share of BEVs under Norwegian growth rates - AU 50@30 - represents 57 per cent market share at 2030 and is comparable to AEMO's Strong scenario in 2021 and 2025. AU 50@30 then outpaces the AEMO Strong scenario but is still potentially conservative compared to European targets of 100 per cent EV sales by 2025.

42 UBS forecasts assume about 40 per cent of all EVs sold will be PHEVs and 60 per cent BEVs. As BEVs become more competitive, PHEV share is expected to drop below 20 per cent by 2025

Although the scenario modelled for Australia is aggressive, the forecast trend in EV market share across Europe and globally is nevertheless disruptive – the degree of disruption is likely to be dependent on Government mandates, purchase incentives, CO2 regulation and the relative cost of fuel (electricity vs petrol/ diesel).

To date, a number of Governments have announced plans to phase out petrol and diesel cars including:

- UK Government has announced plans to halt the production of new petrol and diesel cars by 2040. By 2050, all cars will need to have zero emissions
- French Government will ban sales of petrol and diesel cars by 2040
- Norway plans to phase out diesel and petrol cars by 2025
- The Netherlands are targeting for all new cars to be emissions free by 2030
- Germany's Bundesrat passed a resolution to ban ICE vehicles starting in 2030[43]
- India aims to be 100 per cent EV nation by 2030
- China will set annual EV sales targets starting in 2019.



Note: EV uptake in Europe is estimated to reach 100 per cent by 2027, prior to the proposed timeframes for Government bans of ICE sales eg French Government to ban ICE sales by 2040. This based on the accelerated growth rates from 2020-2025. Refer to sources and methodology below.

Source: Europe, US, China and Global forecasts to 2025 sourced from UBS, Evidence Lab Electric Car Teardown – Disruption ahead?, May 2017. UBS forecasts available to 2025. PwC assumed growth rate to 2030 based on 2020-2025 forecast CAGR. AU (Normal) and AU (Strong) sourced from AEMO Insights, Electric Vehicles, August 2016, Appendix B.1: EV Uptake. AUS (50@30) is BEV market share under Norwegian trend growth.

Figure 17: EV share by region (% of total car sales)

43 https://www.weforum.org/agenda/2017/09/countries-are-announcing-plans-to-phase-out-petrol-and-diesel-cars-is-yours-on-the-list/ September 2017

Appendix

Modelling Inputs

	Qualitative Effect	ShocK
Capital investment	Electric vehicle charging infrastructure increases in proportion to the number of EVs on the road. The cost of constructing charging infrastructure was provided by EVC. This capital expenditure is modelled as an increase in total investment.	Increase investment by the size of capital expenditure from 2018 to 2030. Over the period total investment amounts to $5.6 billion.
	Investment in charging infrastructure is offset, to some extent, by reduced spending in areas such as fuel infrastructure investment, which accounts for the lower incomes these assets would generate. However, the economic modelling does not account for financial losses associated with fuel infrastructure write downs. Capital expenditure from Caltex (Australia's only locally-owned and listed fuel company) and the company's market share in the fuel retailing industry, is used to identify investment in fuel infrastructure in Australia (approximately $2.7 billion per annum). Fuel infrastructure investment is reduced by the proportion of ICE vehicles replaced by EVs i.e. in 2018 this is 0.05 per cent of $2.7 billion, where 0.05 per cent represents the number of ICEs no longer on the road in that year.	Reduce investment in fuel infrastructure from 2018 to 2030 in proportion to the reduction in ICE vehicles. Over the period the total reduction in investment amounts to $2.4 billion. Net investment (EV infrastructure investment - ICE infrastructure investment) over the period amounts to $3.2 billion.
Tax cut	Consistent with Australian government modelling, estimated greenhouse benefits from a reduction in vehicle emissions of $35/tCO2 abated is kept constant over the analysis period.1 Under the modelling scenario, 18 million tCO2 are estimated to be saved by 2030, creating a $628 million economic benefit. Consistent with an Australian CGE impact study on the impact of mitigation policies2, the impact is modelled by slightly lowering distorting taxes on factors of production.	Reduce taxes on labour and capital from 2018 to 2030. Over the period the personal income tax rate is 0.03 per cent lower and the company income tax rate is 0.02 per cent lower.
Productivity Improvement	Vehicle ownership cost savings allows the economy to maintain the fleet of cars (output) at lower costs (inputs). This translates into a productivity gain in the private transport industry (where the car fleet is located) by the size of savings relative to the size of the industry.	Vehicle ownership cost savings are negative in 2018 ($630 per annum) but increase positively to $1,710 per annum by 2030 ie $810 per vehicle per annum on average over the period. The average increase in productivity between 2018 and 2030 is 2.1 per cent.
Reduce export demand	Fuel imports are expected to fall by the change in fuel consumption. Less fuel imports require fewer exports overall to maintain Australia's long term ratio of foreign debt to GDP. The shock increases the price of exports such that exports fall in line with imports to maintain Australia's trade balance.	Increase the price of exports between 2018 and 2030. Over the period the export price is 0.04 per cent higher on average.

Modelling Outputs

	Output
Gross domestic product	The change in real gross domestic product (GDP) is calculated with reference to 2016-17 Australian GDP.
Jobs	The net change in jobs is calculated relative to 2016-17 employment. The number of net jobs accounts for job losses in some industry sectors which are offset against job gains across the economy. Productivity gains in transport and lower demand for fuel and refining make for reduced employment in those sectors, but for increased employment in other sectors. The lower cost of transport in the economy flows through as lower costs for industries, which employ more people as they expand in response. The lower costs for individuals leaves them more disposable income to spend on other goods and services.

Glossary

Acronym	Description
AEMO	Australian Energy Market Operator
AUD	Australian dollar
BEV	Battery electric vehicle – powered only by energy stored in batteries with batteries charged by plugging into the grid
CGE	Computable general equilibrium
CO2e	Carbon dioxide the equivalent is used to describe how much global warming a given type and amount of greenhouse gas may cause, using functionally equivalent amount or concentration of carbon dioxide as the reference
EVC	Electric Vehicles Council
ICE	Internal combustion engine vehicle – represents the majority of private vehicles, powered by a standard internal combustion engine using petrol, diesel or gas
NEG	National Energy Guarantee
NEM	National Electricity Market
PHEV	Plug-in Hybrid Electric Vehicle – combines both an ICE with an electric engine. Electrical energy is stored in batteries by plugging into the grid. Vehicle propulsion is a mix of the ICE and electric engine, but is predominantly powered by the electric engine. The ICE is used to extent driving range beyond battery capacity for longer distances and to recharge the battery itself.
PwC	PricewaterhouseCoopers Consulting (Australia) Pty Ltd.
RET	Renewable Energy Target

Comments and Queries

Mr Behyad Jafari
Chief Executive Officer
Electric Vehicle Council
Email: Behyad.Jafari@electricvehiclecouncil.com.au
Web: electricvehiclecouncil.com.au

Mr Robert Giltinan
Senior Policy & Public Affairs Advisor
The NRMA
Email: Public.Policy@mynrma.com.au
Web: mynrma.com.au

Mr Mark Thomson
Partner
PwC
Email: Mark.Thomson@pwc.com
Web: pwc.com.au

Mr Rodger Whitby
Chief Executive Officer
St Baker Energy Innovation Fund
Email: RWhitby@stbenergy.com.au
Web: stbenergy.com.au