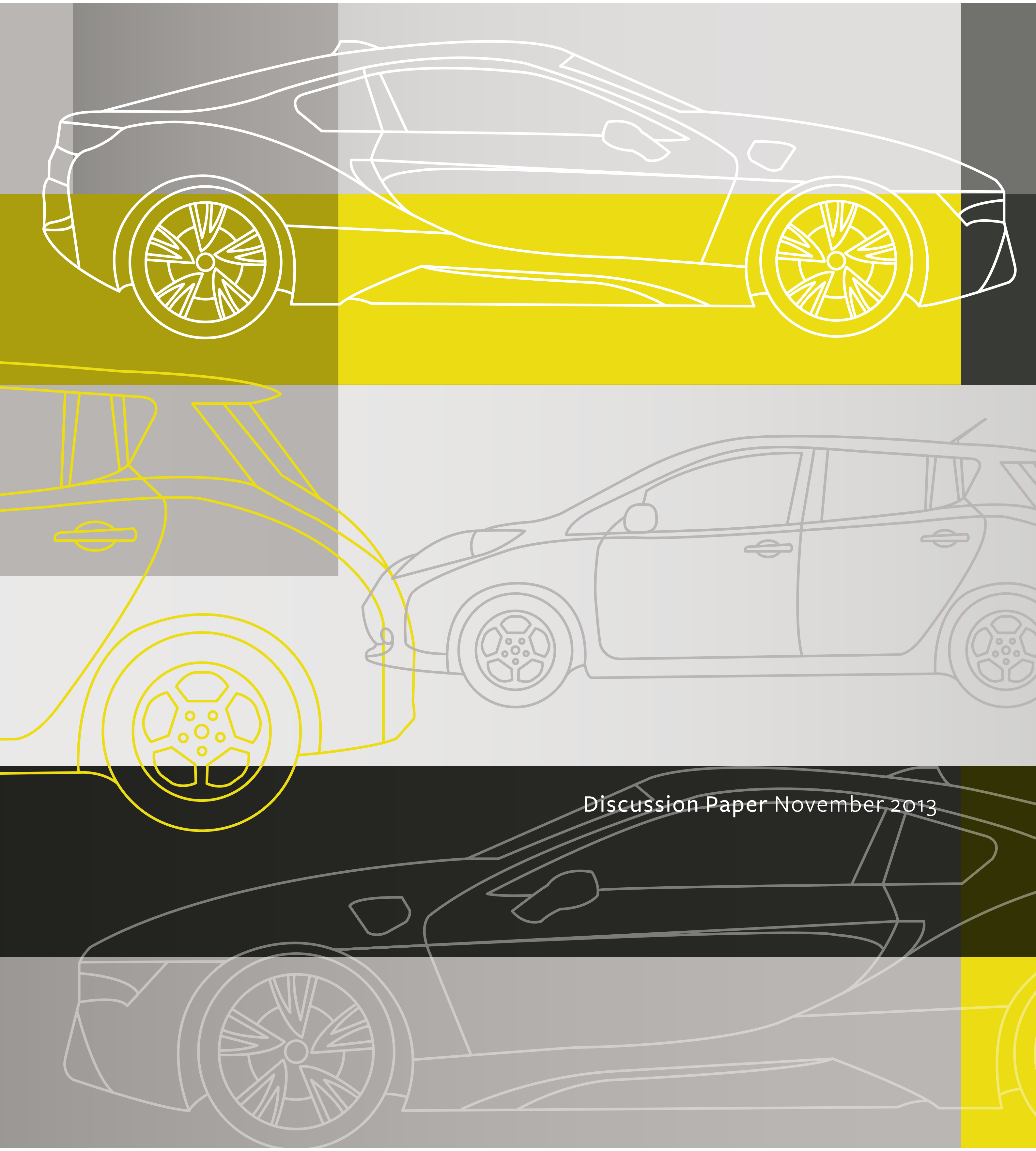
Energy Supply Association of Australia

Sparking an Electric Vehicle Debate in Australia



Discussion Paper November 2013

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Introduction

Cars defined the 20th century. The development, mass production and mass consumption of the car changed human society. It shaped the wars that were fought, the way cities developed and how people and goods were moved around. It spawned a vast network of roads that span continents and that still define most urban centres. The legacy of this infrastructure is immense. It means that as we look to alternative technologies to fuel more than a billion cars and trucks on the world's roads, the most efficient transport solutions are more likely to re-power these vehicles rather than replace them.

Internal combustion engines (ICE) have been used for the past century to power most cars and other transport vehicles. But the era of the ICE may be approaching its twilight. The move to look beyond petrol and diesel engine cars is being driven by a range of factors: energy security and questions over the adequacy of oil reserves, the cost of petroleum fuels and the international cartels that attempt to control the price and the need to reduce greenhouse gas and pollutant emissions from transport vehicles.

This paper explores the potential of plug-in electric vehicles (EV) to contribute to the transformation of transport vehicles in Australia. A second paper will consider the potential for natural gas vehicles. In Australia these energy systems have the additional advantages of an existing indigenous supply and established distribution networks. Transforming the 16.6 million vehicles that comprise Australia's transport fleet[1] will take time and require appropriate policy settings. This paper considers the key barriers and opportunities in delivering that transformation.

Electric cars have equivalent fuel costs of approximately 3 cents per kilometre, compared to 10 cents per kilometre for conventional cars.

Comparing electric cars with conventional cars

Significant advances in technology have created a new generation of electric cars that have the potential to surpass traditional petrol-driven cars on performance, safety, design and running costs. While the EV industry is still in its infancy, a number of high-end models offer impressive performance, thanks to an EV's highly efficient and responsive drive train. EV motors transfer energy instantly to the wheels, meaning they accelerate rapidly and don't need gears. However this level of performance is not as evident among smaller EVs, which are produced with smaller engines and batteries to reduce weight and cost. EVs can also exploit a lower centre of gravity in the car and advanced aerodynamics, due, in part, to the absence of the engine high up in a conventional car (which contributes to drag).

Fuel costs are typically the greatest ongoing cost associated with vehicle ownership. Of all engine types, battery EVs currently produce the lowest fuel costs per kilometre, according to analysis commissioned by the Victorian Department of Transport: battery EVs are estimated to incur an equivalent fuel cost of approximately $0.03 per kilometre, compared to an ICE at more than $0.10 per kilometre. Maintenance costs for an EV are also about 70 per cent of an ICE.

Electric cars – governments can play an important role in building critical mass

Electric car technology is becoming increasingly competitive with conventional vehicles. Twenty-first century EVs can exploit their technological advantages (performance, handling, safety, and lower operating costs) to offset their disadvantages (shorter range and higher up front cost). The more advanced EV markets, in California, Norway, and Japan, are already demonstrating strong demand by a growing section of the consumer market.

Passenger vehicles rely on adequate infrastructure for refuelling, maintenance and active and transparent markets for used vehicles. In other words, when a consumer buys a conventional car, they know how much it will cost to run and can rely on an established network of refuelling options around the country. Consumers know they have a range of different repair and servicing options, and have access to reliable information about its likely resale value. Most of these basic user expectations are not yet afforded to electric vehicle owners.

Measures to reduce this infrastructure gap for new entrant vehicles are crucial to allow them to compete with conventional cars. In California, the State Government has made a major commitment to stimulate an electric vehicle market. It has introduced a suite of measures that is helping create a critical mass of electric vehicles. This in turn has revealed new partners and commercial opportunities that exploit some of the key differences between EVs and conventional cars. The creation of a critical mass of vehicles in California is both reducing this gap and encouraging further entrants into the EV market, both as car buyers and support service providers.

Why governments should care about EVs – strategic advantages of electric vehicles

Any debate about the take-up of EVs is more than a discussion about one new consumer technology displacing an old one. Electric vehicles have the potential to deliver broader strategic and economic benefits beyond their direct impact on consumers. There are three main strategic benefits of electric vehicles: environmental, increased energy security and grid stability.

Environment

One of the fundamental differences between EVs and conventional cars is that electric cars enable consumers to eliminate greenhouse gas emissions from their vehicle use. This will vary depending on whether life-cycle emissions are assessed or just the emissions associated with refuelling the vehicle.

During the lifetime of a vehicle, EVs recharged using renewable electricity produce less greenhouse gas emissions than ICEs after just three years, a recent Victorian Government EV trial found.[2]

If fuel combustion alone is considered, even when the electricity used to charge EVs comes from a CO_2-emitting source, such as a coal or gas-fired powered plant, the net CO_2 production from an electric car can be lower than from a comparable combustion vehicle. An EV will emit around 22 per cent less CO_2 equivalent than new passenger vehicles. This will continue to improve as the electricity supply continues to decarbonise over time, and consumers are able now to purchase green power products which enable them to source electricity from low or zero emissions sources.

EVs also release almost no air pollutants at the place where they are operated. This removes key air pollutants from cities, improving air quality. EVs also create less noise than an internal combustion engine vehicle, whether it is idling or in motion.

Utilisation of the grid

Rising electricity prices have been a hot button subject of public debate in Australia. One of the key drivers has been the cost of recent re-investment in electricity networks and transmission systems. This multi-billion dollar infrastructure is built to manage large but short run spikes in energy demand. It is mostly under-utilised, particularly at night, when the majority of transport vehicles are garaged and also when the availability of wind energy is high. Utilising this spare overnight capacity is almost costless but would improve the efficiency and operation of the electricity network. In effect, with sensible incentives for users to charge at off-peak times, more than 500,000 EVs could be charged without requiring major new electricity infrastructure.[3]

Future generations of EVs may be capable of storing and releasing energy back into the grid at high times of demand. While this may be a future use of EVs, it is not possible with the existing range of EVs likely to be in the market until the end of the decade. It should be seen as a potential long-term benefit.

EVs release almost no air pollutants when they are driven.

Energy security

Oil is a finite and depleting resource. Oil prices have tracked in excess of $100 a barrel since 2011.[4] New extraction technologies will continue to extend the proven reserves of oil-based fuels, although this is likely to be at higher cost. By contrast, electric vehicles are not reliant on a specific source of energy. Any technology that can generate electricity can be used to power an EV. This means EVs have the ability to be fuelled by fully renewable energy sources.

The value of Australia's imports of crude oil, automotive and diesel fuel totalled more than $32 billion in 2011–12, even though Australia is one of the biggest exporters of energy in the world.[5] A shift to vehicles fuelled by domestic fuel sources such as electricity or natural gas would reduce this reliance on imported fuels and the risks of price vulnerability due to oil supply constraints.

Electric vehicles require unconventional thinking

Conventional combustion engine cars dominated the car market in the 20th century because they delivered fundamental benefits to consumers: they could travel large distances with increasing reliability at effective speeds with increasing levels of safety and comfort. All this was provided at an increasingly affordable price. While electric vehicles were more prevalent than ICEs early in the 20th century, their inability at the time to match many of these consumer benefits forced them out of the market.

To become a viable alternative in the consumer passenger vehicle market, EVs need to offer a competitive value and performance proposition. The new generation of 21st century EVs have clear advantages and disadvantages compared to ICEs. It is their ability to minimise the disadvantages and maximise the advantages that will determine the rate of uptake in this highly competitive consumer market.

It is possible, but unlikely, that EVs' pathway to success will be to simply try to replicate the properties of a conventional car. It is more likely that they will succeed where they can adapt and maximise the unique benefits of the technology.

> The Tesla Model S can accelerate to 100kmh in 4.4 seconds.

The benefits of removing the combustion engine in a car

The Tesla Model S is probably the most advanced all-electric passenger car production model in the world right now. It has been awarded a number of leading car awards in the US (including Motor Trend Car of the Year 2013 and Automobile Magazine 2013 Automobile of the Year) because of its superior performance and handling. Much of this relates to the ability of Tesla to maximise the benefits of removing a combustion engine from the design of a car.

Removing the engine and fuel tank from a car and replacing it with an electric motor and batteries has significant design consequences. First, the higher efficiency of an electric drive train means it can deliver power instantaneously to the wheels, dramatically improving acceleration; the Tesla Model S four-door saloon can accelerate to 100km/h in 4.4 seconds.

Second, handling and performance is improved by the removal of a heavy combustion engine relatively high up in the car, batteries low in the chassis and an electric motor between the rear axles. This also enables more aerodynamic body styling. The Tesla Model S has the second lowest drag coefficient of any production line car ever manufactured.[6]

Finally the absence of the combustion engine also allows for safer design, as there is more crumple room at the front of the car in the event of a head on collision and more capacity for strengthening the entire chassis of the car.

Addressing range anxiety

The notion of infrequent, long-range refuelling of cars has become the norm over the last century. It reflects the refuelling properties of fossil fuel engines. The inability of electric vehicles to replicate this experience has resulted in the perception of "range anxiety" by some consumers. These concerns are so acute that some major car companies developing electric vehicles have begun development of hybrid versions, reducing many of the innate benefits of an electric car in order to alleviate concerns over range.

Pure EVs are likely to have different refuelling properties to conventional cars. They will operate more like a mobile phone or other portable electric device. In developing EV markets, retailers are volunteering EV recharge facilities. Because of the relatively low cost of recharging, retailers value the time of the driver in their store more than the cost of the electricity provided to the car.

Some of the biggest barriers to EVs are driven by perceptions: most car journeys are well within the range of even the shortest range electric car, but anxiety about the shorter range is exacerbated because drivers still see refuelling as a weekly or monthly experience, rather than something done daily. Unrealistic tests are put on cars – like the ability to drive uninterrupted between two major cities – when most Australians fly these routes or drive inter-city rarely.

Policy enablers to reduce barriers to electric vehicles

Governments around the world have sought to accelerate the uptake of EVs through a range of measures. All US consumers have access to a federal income tax credit of $7500 for the purchase of an EV (for the first 200,000 EVs sold by each manufacturer). Other measures are applied at regional levels. Almost one-third of total EV sales in the US have been in California.[7]

California offers an additional rebate of $2500 for the purchase or lease of an EV, as well as exemptions from high occupancy vehicle lanes. Other incentives include:

- Tax credits to offset the cost of installing charging equipment
- Discounted vehicle registration fees
- Discounted or zero state sales tax
- Removing planning restrictions to enable EV charging equipment to be installed
- Insurance discounts

The Electric Power Research Institute (EPRI) has found that the combination of state incentives in California mean that the Nissan LEAF is US$11,000 less expensive to run over its lifetime than a comparable ICE vehicle.[8]

Policy options in Australia

The esaa is not advocating for any specific policies to be introduced in Australia. Rather, if EVs are seen to provide benefits for Australia, government involvement is likely to be important to help develop a critical mass of vehicles. This report simply seeks to encourage a discussion about how to encourage EV uptake. Potential options include:

- **Tax concessions for new electric vehicles:** EVs have a higher up-front purchase price but cheaper operating costs. This exposes them to costs such as luxury car tax, higher import duties and higher stamp duty, which further increase the sticker price of electric vehicles compared to a conventional car.
- **Planning for recharge:** Appropriate planning arrangements and regulations are needed to facilitate the recharging of EVs. Stakeholders in Victoria's EV Trial have reported that complex planning arrangements have made installing public recharging facilities more difficult.[9]
- **Infrastructure:** Governments could provide upfront capital or fixed revenue agreements to ensure infrastructure providers have the incentive to enter the Australian market – the first infrastructure will be fast charge inverters in households and at retail outlets.
- **Electricity tariff reform:** Enabling EV users to take advantage of Time of Use (TOU) tariffs will create incentives for them to recharge during off-peak times and exploit significant discounts available for electricity sold at these times. Eventually EVs could be used to augment the grid by utilising Vehicle to Grid (V2G) technology – delivering surplus battery-stored electricity back into the grid at times of peak demand.
- **Other:** In some overseas markets EV users are granted on-road privileges, such as access to transit lanes.

Governments at all levels can participate in establishing an Australian EV market. At a national level, there are issues such as import duties and luxury car taxes. State governments are able to influence planning restrictions, vehicle stamp duty, registration costs and potentially even preferential access on roads (such as transit lanes, or discounted tolls). While local councils are also able to enable charging infrastructure to be installed through planning arrangements as well as potentially offering dedicated EV parking spaces.

These are actions that cannot be taken in isolation. It will take a series of coordinated policies between government and industry in order to stimulate the EV market. The experience in the US, and California in particular, shows that the right combination of policy drivers can promote EVs and bring forward the potential.

Potential partners

There are a number of potential partners in the accelerated deployment of electric vehicles on Australian roads. Beyond car manufacturers, there is a range of key business partners who could mutually benefit from supporting increased uptake and scale of EV use in Australia. These include:

- Airlines (as consumers fly rather than drive longer distances).
- Hire car companies (increased use of hire cars for specialised journeys).
- Car share companies (using EVs in car share fleets).
- Retailers and shopping centres (provide recharge facilities while customers shop).
- Electricity companies (increased volume and improved grid utilisation).

It would take a series of coordinated policies between government and industry in order to stimulate the EV market.

Potential EV hotspots

A review of the Californian market for EVs identified key demographic and geographic trends common among early adopters of electric vehicles. These included distance from the CBD, availability of off street parking and households with two or more cars. Applying these metrics to Australian capital cities, this report has explored the prevalence of these conditions in the domestic market. Using data from the 2011 Census, the criteria assessed were: distance from CBD; proportion of separate houses (separate houses are used as a proxy for access to a garage or off street parking); proportion of households with 2 or more vehicles.

Based on this, a typical sample of the most highly suited EV suburbs in each capital city were:

City	Suburbs
Sydney	Baulkham Hills, Frenchs Forest, Kellyville, Menai, Terrey Hills
Melbourne	Balwyn North, Derrimut, Greensborough, Ivanhoe East, Point Cook
Brisbane	Bridgeman Downs, The Gap, North Lakes, Carindale, Upper Brookfield
Perth	Canning Vale, City Beach, Duncraig, Karrinyup, Nedlands
Adelaide	Aberfoyle Park, Athelstone, Beaumont, Crafers, Happy Valley
Hobart	Acton Park, Collinsvale, Howden, Tolmans Hill, Roches Beach
Canberra	Greenleigh, O'Malley, Fadden, Macarthur, Giralang

[1] ABS Survey of Motor Vehicle Use, June 2012.

[2] Victorian Government, 2013, *Creating a Market: Victorian Electric Vehicle Trial Mid-term Report*.

[3] AECOM (2012), *Impact of Electric Vehicles and Natural Gas Vehicles on the Energy Markets*.

[4] EIA, *What drives Crude Oil prices?* Last accessed 31 July 2013.

[5] Bureau of Resources and Energy Economics, 2013, Australian Petroleum Statistics No 202.

[6] Car and Driver, Tesla Model S review, January 2013.

[7] Electrification Coalition, *EV Market Outlook: State of the Plug-in Electric Vehicle Market*, July 2013.

[8] Electric Power Research Institute, *Total Cost of Ownership for Current Plug-in Electric Vehicles*, EPRI, Palo Alto, CA, 2013.

[9] Victorian Government, 2013, *Creating a Market: Victorian Electric Vehicle Trial Mid-term Report*.

1 Introducing the electric car

1.1 How they work

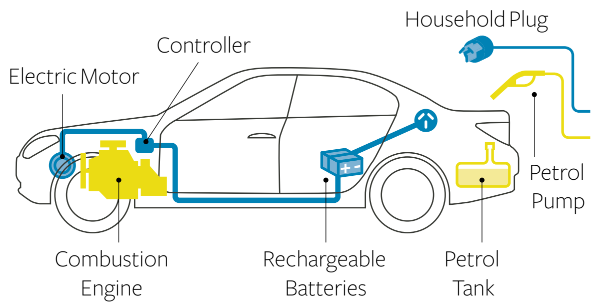
Electric vehicles are a developing technology. Consistent with most developing markets, car designers have developed a number of different drive trains to explore the trade-offs and benefits. Vehicle types fall into two broad categories:

- **electric** cars that draw power primarily from the electricity network and which may be augmented by other fuels, and
- **conventional** cars that are fuelled by fossil fuels but may use a hybrid electric drive train to improve the efficient use of that fuel.

> ### Box 1.1: EVs defined
>
> There are broadly three different energy systems powering transport vehicles: electricity, conventional petrol or diesel, and natural gas. The latter will be discussed in another paper.
>
> **Electric**
>
> **PEV: Plug-in electric vehicle –** electricity is drawn from the grid and stored inside in-build battery packs in the vehicle, which has no other engine or fuel tank.
>
> **PEV Swap: Plug-in electric vehicle (with battery swap) –** a PEV with the ability to swap the electric battery as a type of refuelling.
>
> **PHEV: Plug-in hybrid vehicle –** a vehicle driven by an electric drive train and fitted with an internal combustion engine (ICE) where the battery can be charged either from the grid or by the ICE.
>
> **Conventional**
>
> **ICE: Internal combustion engine vehicle –** uses fossil fuel combustion to power the in-build engine. Liquid petroleum gas (LPG) vehicles are included in this category.
>
> **HV: Hybrid vehicle –** combines and electric engine with an ICE to increase fuel efficiency but is fuelled only by petrol or diesel. This includes Series Hybrid (the engine charges the batter and an electric motor drives the vehicle), Parallel Hybrid (engine and motor work together to power the drivetrain), and Power-split Hybrid (both the engine and electric motor can work together or separately).

Figure 1.1: Schematic diagram of an electric car compared to an internal combustion engine car

Difference between an internal combustion engine and an electric engine



Source: Victorian Department of Transport, Differences to conventional cars[10]

1.2 History of electric vehicles

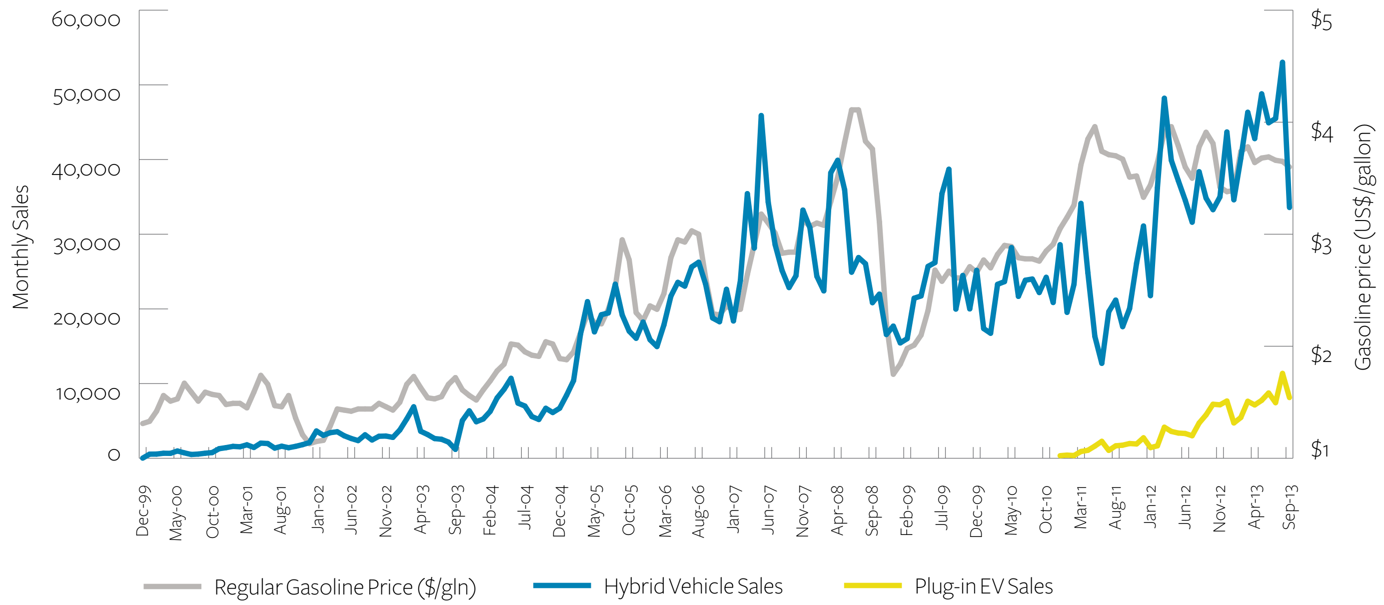
Electric vehicles (EVs) emerged in parallel to conventional cars over the last century.[11] They evolved from a fleet of New York electric taxis in the 1890s. By the end of the 19^{th} century, EVs had outsold traditional Internal Combustion Engine (ICE) vehicles. EVs enjoyed continued success until the 1920s, when improving road networks extended the potential travelling range of cars and crude oil markets expanded, giving ICE vehicles a range advantage over EVs.

The market for EVs then narrowed to specialised, short-range vehicles including golf carts and some delivery vehicles. Electric engines were used extensively for large-scale transport systems like trains, where supply could be continuously provided, thus avoiding range and storage limitations. But for most of the 20^{th} century EVs were effectively absent from the growing passenger vehicle market.

It wasn't until the late 20^{th} century that the first mass-produced electric car was built by General Motors. It was a concept car called the Impact released in 1990, and GM went on to manufacture and lease around 1000 EV1 electric cars in the US. GM was unsatisfied with the cost and performance of the cars, and subsequently recalled and destroyed them in 2002.

In 1995 Toyota then adapted the electric drive train in its concept petrol-electric hybrid car the Prius for the Tokyo Motor Show that year. It went on sale in 1997, with more than 3.6 million Prius cars sold worldwide to date. In 2012 Toyota launched a plug-in Prius hybrid.

Figure 1.2: Oil prices and petrol-electric hybrid and plug-in electric car sales, US, 1999–2013



Source: Argonne National Laboratory Light Duty Electric Drive Vehicles Monthly Sales Updates

By February 2012, global hybrid vehicle sales exceeded 5 million.[12] This growth has been driven by rising fuel prices at the start of the 21st century, government subsidies and tougher fuel efficiency standards in key markets like the US. It has resulted in increased competition in the petrol-electric hybrid market. The US now has 38 hybrid vehicle products in the market, compared to just two in 2000.[13]

1.3 Lessons from the leading markets

Around 180,000 plug-in electric vehicles (PEVs) have been sold globally, most in the last two years[14] with strongest sales in the US, Japan and Europe. But the market is in its infancy: plug-in electric vehicles still only represent around 0.2 per cent of the global car fleet.

The recent emergence of mass market electric vehicles is the result of a convergence of key factors: sustained increases in the cost of fossil fuels; innovation in electric motor and storage technology; the strategic decision by some car companies to take a more aggressive and pro-active approach to electric car development. These trends are making mass market electric vehicles increasingly affordable.

The promise of lower or zero emissions from the car and reduced reliance on fossil fuels is one of the key marketing strengths of EVs. Sales of hybrid vehicles, and more recently EVs, have increased with rising fossil fuel prices.[15] Most existing government support mechanisms for EVs underscore their environmental performance. National tax credits for EVs up to $7500 per car are granted under the Energy Improvement and Extension Act, while California augments these with its Clean Vehicle Rebate Project. Furthermore, there are similar incentives in other states.

The US is the biggest EV market, with sales in excess of 120,000 plug-in electric cars since 2008. The Chevrolet Volt is the market leader with more than 40,000 cars sold, followed by the Nissan LEAF (30,000), the Toyota Prius plug-in (16,000) and the Tesla Model S (12,000). Around 39 per cent of all plug-in electric car sales are in California. The US EV market is also being driven by more stringent vehicle emissions standards, the availability of locally manufactured vehicles such as the Tesla and Chevrolet Volt, and the growing penetration of public recharging infrastructure. Nissan was able to reduce the price of its LEAF EV by US$6000 (AUD$6450) after transferring production from Japan to the US with support from the US Department of Energy.[16]

Japan has the second largest plug-in EV market with around 45,000 cars sold.[17] It is also second behind Norway in terms of share of new passenger vehicle sales with almost 1 per cent of new car sales being EVs. This is led by increasing sales of the Toyota Prius in the plug-in hybrid market and sales of the Nissan LEAF in the battery EV market. In 2012 Japanese consumers bought nearly 16,000 PEVs.[18] The Japanese government provides incentives of up to 1 million yen (AUD$10,800) for EVs and provides additional incentives of up to 1.5 million yen (AUD$16,200) per charger towards the cost of EV charging units.[19]

Norway is one of the leading European markets for plug-in EVs, driven by high petrol prices (around AUD$2.50/L)[20] and incremental sales tax based on vehicle greenhouse gas emissions. The Norwegian Government exempts PEVs from the 25 per cent sales tax on vehicles and congestion charges as well as giving EVs access to bus lanes.[21] In the third quarter of 2012, EVs made up over 3 per cent of new passenger vehicle sales in Norway. This is currently the highest share in the world.[22]

1.4 Plug-in electric vehicle market development

The plug-in electric cars market is still in its infancy. A handful of models are available in market, while most leading car manufacturers have one or more models in production or development. The market has split into pure electric cars and plug-in hybrid cars, which are augmented by a combustion engine either to power the drive train or recharge the battery.

The leading pure electric production line cars (PEV) to date have been the Tesla Roadster (2008, now discontinued), Mitsubishi i-MiEV (2009) and the Nissan LEAF (2010). Tesla began deliveries of its four-door hatchback Model S in 2012, while Honda released its all-electric version of the Fit/Jazz in the same year.

The leading production line plug-in hybrid (PHEV) vehicles to date have been the F3DM produced by Chinese car company BYD auto (2010, now discontinued), the Chevrolet Volt (2010, sold in Australia as the Holden Volt), the Toyota Prius plug-in hybrid (2012), the Volvo V60 plug-in hybrid (2012) and the Ford Fusion Energi (2013). Aside from the Volt, these cars were plug-in adaptations of existing hybrid vehicles.

As with any emerging market, there have been positive and negative surprises. Sales of the smaller pure electric cars have been well below initial projections, with Nissan reportedly investing a billion dollars in the development of the LEAF, but to date has "only" sold around 75,000 cars worldwide. Sales have been held back by the EV's relatively high sticker price, limited performance and limited range. The i-MiEV initially went on sale for $48,000 in Australia, while the Nissan LEAF was initially priced at around $51,000 (it is similar in many respects to an electric version of its $18,000 Tiida compact car). Both companies have subsequently discounted these prices to help lift sales.

By contrast the Tesla Model S has entered the US car market at a higher pricing point, starting at around $70,000, but offers greater driving range, a larger and more upmarket vehicle and better performance. It is now reportedly outselling leading brands like Porsche and Volvo in California. With production now passing around 20,000 cars a year, there is a two-to-three month waiting list for the Model S in the US.[23] Tesla's total sales in the US are still smaller than the Chevrolet Volt and the Nissan LEAF.[24]

Most major car companies now have an electric car in development or production, with many offering both pure and hybrid electric. Most of these cars are reported to have small initial production runs, targeted at release in leading US EV states like California and Oregon.

Essentially there are four entry points for new plug-in electric vehicles: small city commuter cars; high performance/high cost vehicles; all-electric cars; or plug-in hybrids. Plug-in hybrids improve range and "normalise" the EV car experience, but they tend to compromise the EV's greatest strength, and also add production costs from supplying two separate drive train systems. So far, pure EV cars remain significantly more expensive in the commuter car market, without noticeable performance benefits. Tables 1.1 and 1.2 outline the PEVs and PHEVs under development or production by major car companies.

Table 1.1: PEV models under development or in production by major car companies

Make	Model	Range (kms)	Price (USD)	Release date	Notes*
BMW	i3	160	42,275	Late 2013	Range extender hybrid version also available adding two cylinder petrol engine. *Australian release in mid-2014.*
Fiat	500e	140	32,500	On sale (US only)	Unspecified test run available only in California sold out mid-2013.
Ford	Focus Electric	120	39,200	On sale (US only)	Based on the Ford Focus. Active liquid cooling to manage heat. *Possible Australian release in 2014.*
Honda	Fit EV	132	37,415	On sale (US only)	Based on Honda Jazz.
Chevrolet	Spark EV	60	26,685	Late 2013 (US only)	Compact city car.
Kia	Venga	140	TBA	Late 2013	Scheduled for release in US and Europe.
Mercedes Benz	SLS E-Cell	250	TBA	2013	Luxury super-car EV with all-wheel drive expected price above $500,000.
Mercedes Benz	B-class E-cell	185	TBA	2014	Uses Tesla drive-train under contract.
Mitsubishi	i-MiEV	100	29,125	On sale	*Available in Australia* for $29,990.
Nissan	LEAF	120	28,800	On sale	*Available in Australia* for $39,990.
Nissan	Esflow	240	TBA	TBA	Concept high performance sports car based on Iconic Z class.
Renault	Fluence ZE	185	34,000	On sale in Europe and Israel	First electric car with battery swapping capacity – future uncertain with demise of Better Place.
Renault	Zoe Expression	210	27,250	On sale in Europe	Renault has indicated Zoe will not be sold in Australia without government support.
Renault	DeZir	160	TBA	TBA	Luxury two seat sports coupe aimed at performance car market
SAAB	9-3 ePower	200	TBA	2014	Based on 9-3 wagon. Developed by Chinese-Japanese consortium National Electrical Vehicle Sweden, which bought Saab Automobile from bankruptcy.
Smart	ED	100	25,750	2010	Small volumes sold in Europe and the US. Third generation released this year.
Tesla	Model S	250	62,400	On sale (US only)	Top of the range Tesla S model claims range of 480km. *Australian release in 2014.*
Toyota	RAV4 EV	160	49,800	On sale	Second generation using licensed Tesla drive-train. Release only in California.
Volkswagen	Golf Blue e-motion	150	TBA	Expected 2013	EV version of popular Golf model under development since 2010.

**Note: No planned Australian release unless stated.*

Source: CPIEVC

Table 1.2: PHEV models under development or in production by major car companies

Make	Model	Electric only range	US price (USD)	Release date	Notes*
Audi	A3 e-tron	50	52,000	2014	All-electric version also under development. *Australian release in late 2014.*
BMW	i8	35	300,000	2014	Lightweight 4-seat luxury sports car. *Australian release in late 2014.*
Ford	Fusion Energi	34	38,700	On sale (US only)	Plug-in hybrid version of the Ford Mondeo.
Honda	Accord Plug-in	21	39,780	On sale (US only)	
Chevrolet	Volt	60	39,145	2012	Largest selling plug-in electric car in the US. Won 2011 North American Car of the Year and 2012 European Car of the Year. *Available in Australia* as the Holden Volt for AUD$59,990.
Mercedes Benz	B-class E-cell PLUS	100	TBA	2014	Hybrid version of the B-class E-cell with 3-cylinder turbo engine added to electric drive train.
Mitsubishi	PX-MiEV	50	TBA	TBA	Seen as a possible replacement to the Outlander SUV.
Peugeot	HX1	35	TBA	TBA	Highly styled six-seater concept car with low roof for reduced drag.
Suzuki	Swift PHEV	20	24,900	TBA	Scheduled for US/Japan release in 2013.
Toyota	Plug-in Prius	25	32,000	On sale in US, Europe and Japan	Plug-in conversion of Toyota's successful hybrid car. *Australian release in 2014 or 2015.*
Volvo	V60 Plug-in	50	75,000	On sale in Europe	Plug-in diesel-electric hybrid version of V60 station wagon.

**Note: No planned Australian release unless stated.*
Source: CPIEVC

California has emerged as the most competitive EV market in the world.

Total EV sales have grown but have also under-performed some forecasts, as consumers struggle with the higher sticker prices but conflicted consumer benefits.

This is clearly an immature market. Volumes remain relatively small compared to the total volumes of the car market. There is evident uncertainty by major car companies about which drive train and which segments of the market are likely to be the most successful. There is growth in EV markets, particularly where there are increased volumes, more infrastructure support and increased competition.

While Nissan made a decisive (and expensive) investment decision to develop its LEAF EV, most car companies appear to be taking a more defensive approach. The dominant strategy is based on producing small volumes of EVs derived from existing ICE models, coupled with the development of more exotic concept cars put on display at car shows and on websites. This maximises the brand benefits of technical innovation and future thinking, without yet committing to the large-scale production of these vehicles.

1.5 The California experiment

In the US, California accounts for 32 per cent of total electric vehicle sales.[25] This exceeds the state's share of US population (12 per cent). The California Plug-In Electric Vehicle Collaborative estimates that more than 48,000 plug-in EVs have been sold in the state.[26] The California EV market has been accelerated by a range of factors: a strategic approach to accelerating EV market development by the State legislature resulting in a comprehensive suite of measures, a large consumer market with a track record of incubating and supporting new technologies and as the home state to the world's leading pure-electric vehicle car company, Tesla. Table 1.3 shows the top 10 EV states in the US.[27]

Table 1.3: Highest level of EV sales in the US by state

State	% of total EV sales	EV charging stations
California	32	1362
Florida	6.6	388
Washington	5.7	360
Texas	4.3	482
New York	3.5	228
Ohio	3.1	84
North Carolina	3.1	161
Illinois	3.1	216
Tennessee	2.9	302
Hawaii	2.9	128

Source: Edmunds.com

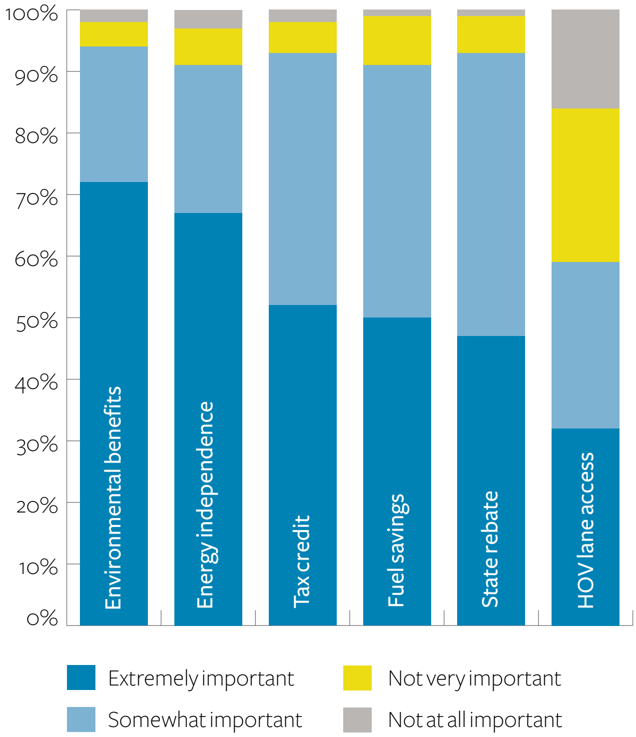
As a result there are signs that California has emerged as the most competitive EV market in the world. Most major car companies are launching their first small volume editions of PEVs in California such as the Fiat 500 or Toyota RAV4 EV. These are known as 'compliance cars'; cars only available in California in order to meet the state's zero emissions vehicle requirements.[28] There is some evidence of increased price competition in the California EV market.[29]

California's Plug-in EV Driver Survey showed that 94 per cent of EV owners also own a conventional car and 90 per cent live in a detached home, which suggests they are likely to be able to recharge in their home garage.[30] Demographic information suggested these early adopters were older, higher income consumers with higher levels of education. The survey found: 52 per cent of EV owners had a postgraduate degree; almost three-quarters were over the age of 45 and 47 per cent had an income of more than $150,000 (compared to 15 per cent of conventional vehicle buyers).

The survey also gave some indication as to people's motivation for purchasing an EV. The biggest drivers were environmental performance and energy independence. These results can be found at Figure 1.4.

The development of competition and critical mass in the EV market is accelerating the development of support infrastructure. By May 2013 there were more than 1200 recharging stations available in California and nearly 6000 across the US. Some of these new recharge facilities are provided at low cost or free of charge by retail chains including Walgreens, Kroger, IKEA, McDonald's, Target and Kohl's.

Figure 1.3: Key drivers for purchasing EV, California 2013



Source: CCSE

1.6 The Tesla effect?

While most EVs are being built by existing car manufacturers, the notable exception is pure electric start-up Tesla Motors. Tesla was established in 2003 by Elon Musk, the founder of PayPal. It produces cars in its factory on the outskirts of San Francisco. Tesla has produced an EV roadster based on the Lotus Elise (discontinued in 2012) and now builds around 20,000 of its four-door luxury hatch the Model S each year. Tesla has also licensed its drive-train and advanced lithium ion battery technology to Toyota and Daimler.

After initial financial challenges, Tesla listed on the US stock exchange in 2010. After two consecutive quarterly profit announcements, the Tesla share price increased this year by around 400 per cent (to around $170 per share), giving the company a market capitalisation of $20 billion (larger than Fiat/Chrysler). Most analysts and the company's CEO think this price is over-valued. One view is that Tesla is not being valued as a car company stock, but as a technology stock. Unsurprisingly, it has been likened to Apple and Google as similarly high-value tech stocks.

The Model S has won a number of automotive awards including *Automobile Magazine's* Car of the Year and *Motor Trend's* Car of the Year. There is a three month-waiting list of customers in the US, where it is on sale.[31] Unlike most other cars in the EV market, the Model S has been designed from the bottom up as an electric car. The top-of-the-range variant claims super-car acceleration, travelling from 0–100km/h in 4.4 seconds, enjoys superior handling because of its low centre of gravity, the second lowest drag coefficient for a production line car and was recently awarded a 5-star safety rating by the US National Highway Transportation Safety Administration (NHTSA).[32]

The four-fold increase in Tesla's share price in 2013 suggests broad public interest in the company as well as its cars. Consumer excitement around Tesla may be a contributing factor to the accelerated development of an EV market in California. As a dedicated electric vehicle car/technology company, Tesla's commercial interest is maximised by accelerating the market for EVs. By contrast while conventional car companies are developing new EV models, their business is still primarily making and selling conventional cars. It is rational for these companies to track and participate in development of EVs, to ensure they are well positioned to take a share of the growing EV market, and to demonstrate to their customers that they are up to date with leading edge technology and market trends. It's also helpful in meeting fleet emissions standards since EVs are treated as zero emissions for this purpose.

As a result, a key component of the accelerated development of EV markets may be the active presence of "iconic" EV companies like Tesla in that market.

> By May 2013 there were more than 1200 recharging stations available in California and nearly 6000 across the US.

[10] Victorian Department of Transport, Differences to conventional cars. Last accessed 31 July 2013.

[11] US Department of Energy (2013), from http://www1.eere.energy.gov/vehiclesandfuels/avta/light_duty/fsev/fsev_history.html. Retrieved 15 May 2013.

[12] ABMARC (2012) *Electric & Hybrid Vehicles Australia: An Automotive Perspective.*

[13] Alternative Fuels Data Centre, Light-duty AFVs, hybrid electric vehicles (HEVs), and diesel models offered by vehicle manufacturers. Last accessed 1 August 2013.

[14] International Energy Agency, Global EV outlook, April 2013.

[15] Argonne National Laboratory, Light Duty Electric Drive Vehicles Monthly Sales Updates. Last accessed 31 July 2013.

[16] US Department of Energy, EV Sales Skyrocketing. eGallon Holds Steady. Last accessed 1 August 2013.

[17] Ibid.

[18] Ibid.

[19] Ibid.

[20] Bureau of Resources and Energy Economics, 2013, Australian Petroleum Statistics No 202.

[21] Tesla, EV Incentives in Norway. Last accessed 1 August 2013.

[22] International Energy Agency, Global EV outlook, April 2013.

[23] Tesla (2013), from http://www.teslamotors.com/. Retrieved 14 May 2013.

[24] US Department of Energy, Visualizing Electric Vehicle Sales. Last accessed 9 August 2013.

[25] Edmunds.com, reported at http://green.autoblog.com/2012/11/09/california-leads-in-green-car-sales-but-there-are-surprises-on/. Retrieved 6 August 2013.

[26] California Plug-In EV Collaborative from www.evcollaborative.com. Retrieved 12 September 2013.

[27] Edmunds.com, reported at http://green.autoblog.com/2012/11/09/california-leads-in-green-car-sales-but-there-are-surprises-on/. Retrieved 6 August 2013.

[28] Green Car Report. Retrieved 13 September 2013.

[29] Edmunds.com August 27, 2013: 2013 Toyota RAV4 EV Discounts Are Latest Move in EV Price War.

[30] California Center for Sustainable Energy, *California Plug-in Electric Vehicle Owner Survey*, May 2013.

[31] Tesla (2013), from http://www.teslamotors.com/. Retrieved 14 May 2013.

[32] Safercar.gov. Retrieved 12 September 2013.

2 The Australian market for electric vehicles

The Australian electric vehicle market is almost non-existent. Fewer than 500 EVs have been sold in Australia since the release of the Mitsubishi i-MiEV in 2011. The three leading EVs currently available in Australia are the i-MiEV, the Nissan LEAF and the Holden Volt (hybrid).

Other manufacturers are preparing to launch PEV or PHEV models into Australia, such as Toyota's plug-in Prius and BMW's i3. Tesla has been taking orders for its Model S in Australia, with deliveries expected sometime in 2014.[33] Renault's Fluence ZE with battery swapping technology has been pulled from the Australian market following the bankruptcy of battery swap company Better Place.[34]

The majority of EV car sales were to corporate fleets, rather than private motorists. All three available EVs in Australia (Mitsubishi i-MiEV, Nissan LEAF, Holden Volt) have seen discounting off their original sticker prices while Mitsubishi stopped imports of its i-MiEV to Australia.[35] Vehicle manufacturers expect EV market uptake to remain low for some years.

At the same time manufacturers view EV technology as strategically important because of expectations for increasing EV market share, while investment in new technology enhances a reputation for innovation. Many consumers and manufacturers see EVs as the future of the global automotive industry.

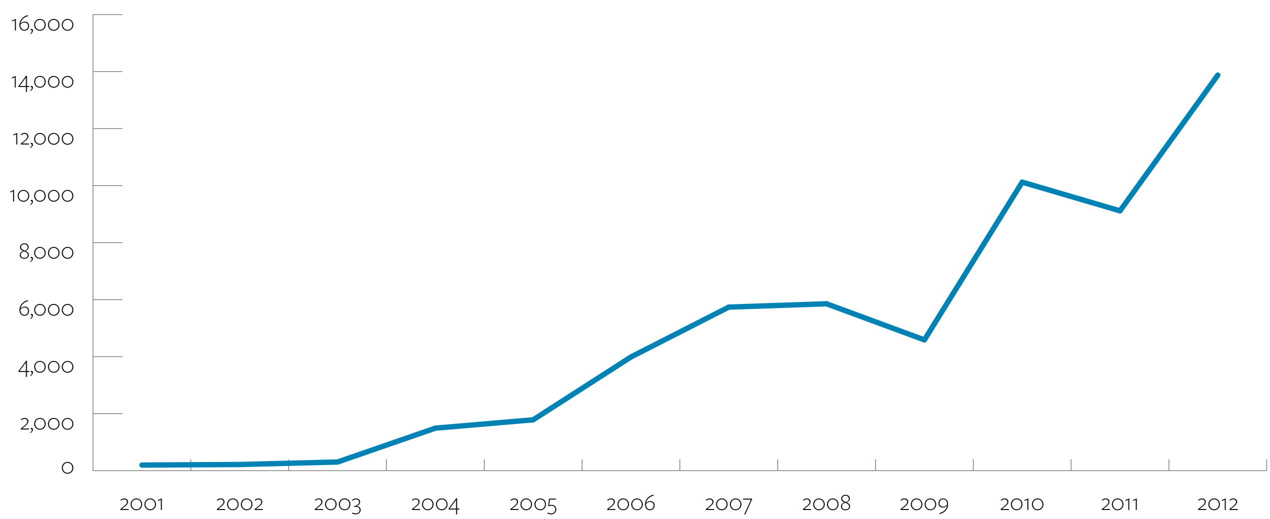
The Victorian Department of Transport (DoT) recently concluded a comprehensive trial in which it supplied around 60 electric vehicles to eligible households, in order to measure attitudes towards the technology.[36] The trial sought to assess the benefits of the technology, and debunk some of the myths surrounding EVs, given the Australian market for PEVs is currently in the 'pre-adoption' phase. This phase is volatile, with many short-term successes, challenges and barriers. However, once the market passes a 'tipping point', the technology becomes mainstream and is widely adopted. DoT indicated its expectation that EVs would follow this pattern, although it acknowledged the 'tipping point' for adoption may be two decades away.

2.1 The experience of hybrid petrol-electric cars in Australia

In 2012 more than one million new cars were sold with around 1.3 per cent of sales for hybrid vehicles (HV).[37] HVs have been available in Australia since 2001, with a gradual increase in the number of models available. Toyota has led the market with almost 42,000 hybrid vehicles sold in Australia since the Prius was first released here in 2001.[38] The locally-assembled Camry hybrid has been Toyota's most popular hybrid vehicle in Australia with more than 20,000 vehicles sold. Lexus hybrids have also sold well, with more than 8500 sold in Australia. Honda's hybrid vehicles have also been popular with 800 sold in 2012.[39] Porsche, BMW, Nissan and Mitsubishi all have hybrid offerings available in Australia.

HV sales have steadily increased to around 60,000 cars in Australia since first launched in 2001. Figure 2.1 shows the annual growth in sales. This suggests a potential growth rate that for other new technology cars over the first decade.

Figure 2.1 Annual petrol-electric hybrid sales in Australia 2001–12



Source: ABMARC, VFACTS

2.2 Electric vehicle forecasts in Australia

As with other emerging technologies, governments and other agencies were quick to forecast the potential growth of the EV market in Australia. A series of forecasts were prepared for different agencies. Based on current sales data, all could be accused of being "optimistic".

Many agencies have attempted to predict the potential growth of the EV market in Australia, including: AECOM, CSIRO, ABMARC, Federal Treasury and the Federal Chamber of Automotive Industries. In all calculations, Australian EV sales forecasts have been overstated. Contributing factors include flawed projections of oil, underestimating EV retail prices and availability in Australia.

2.2.1 AECOM

Consulting firm AECOM forecast EV uptake in New South Wales for the Department of Energy and Climate Change in 2009 ,[40] then adopted a similar approach to assess EV uptake for the Victorian Department of Transport in 2011.[41] Both sets of AECOM's forecasts are projected to 2040.

AECOM took a 'bottom-up' approach to its forecasts, defining scenarios, market segments, and relevant assumptions, before combining the results to inform a 'vehicle choice model' which was extrapolated across the forecast period.

In both Victorian and NSW studies, AECOM defined three distinct scenarios in addition to the base case, running its vehicle choice model on each. These scenarios were:[42]

- **Base case** – Only internal combustions and standard hybrid EVs are available. No plug-in hybrids or battery EVs exist in the market at all
- **Scenario 1** – Level 1 household charging available
- **Scenario 2** – Level 1 and 2 charging available. That is, consumers have the option to switch between slow and fast charging. Level 2 public charging is also available within the Victorian metropolitan region
- **Scenario 3** – As for Scenario 2, with the additional availability of EV service stations that offer Level 3 quick charging and battery swapping.

** Note: For definitions of charging see Appendix B.*

Overall, AECOM's results predict that a transition from internal combustion vehicles to hybrids will occur in the next five to ten years. This transition will then be made to plug-in hybrid EVs over 10–20 years, and EVs over the long term, that is, more than 15 years. Further, EV uptake will be sensitive to the year in which purchase prices reach parity with internal combustion vehicle prices. The availability of charging infrastructure, which is currently difficult to predict, is expected to have a significant impact on EV sales.

In 2012, AECOM produced a report for the Australian Energy Market Commission (AEMC) on the impact of EVs and Natural Gas Vehicles (NGV) on the Australian energy markets. [43] This report informed the AEMC's advice to the Standing Council on Energy and Resources on energy market arrangements for EVs and NGVs. AECOM used its vehicle forecasting model to deliver an Australia-wide forecast for EV uptake.

AECOM suggests that within 10 to 15 years, EVs could have a 'significant presence' in the Australian market, suggesting that supply constraints will ease by 2015, at which time EV sales are expected to increase dramatically. AECOM projected EVs to represent approximately 20 per cent of total new car sales by 2020, and 45 per cent by 2030.

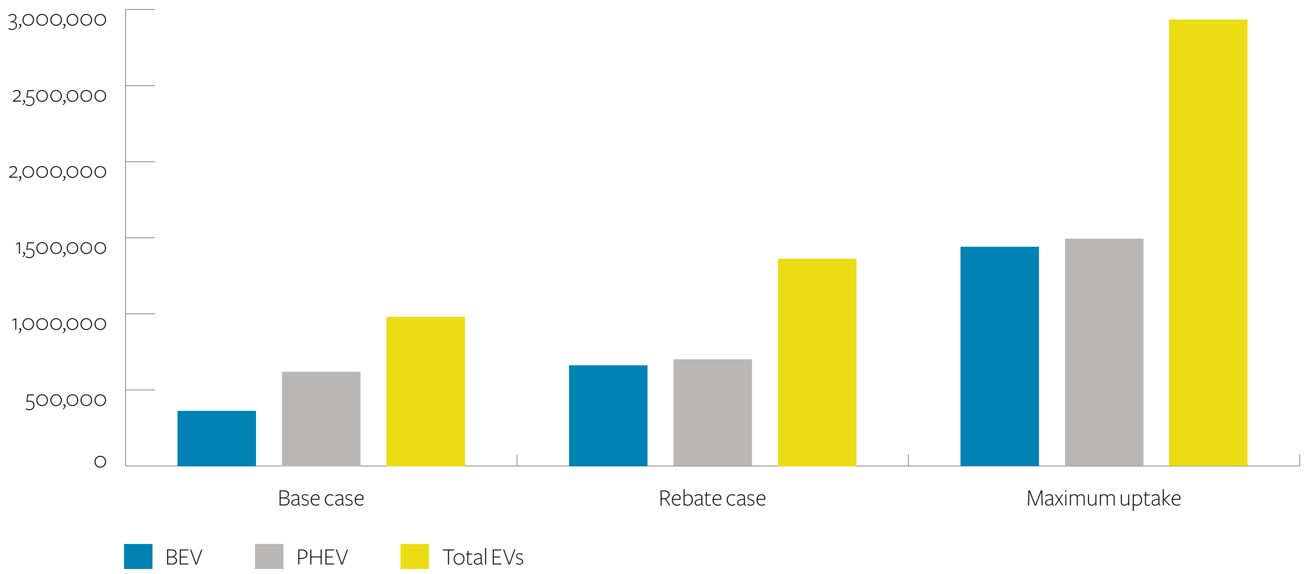
2.2.2 CSIRO

The CSIRO published EV forecasts for Victoria in 2012,[44] using an EV uptake diffusion model, which projects the market shares of battery EVs, plug-in hybrid EVs, hybrid EVs, and ICE vehicles under three scenarios to 2030. The CSIRO's objective in developing an EV forecast was to estimate the impact of incentives on EV uptake, rather than forecast uptake as per the status quo. As such, CSIRO's base case reflects the achievement of carbon dioxide (CO_2) targets, rather than 'likely' uptake. Modelled scenarios included:

- **Base case** – no rebates or incentives for EV purchases. Internal combustion and HEV market shares match an emissions target of a 60 per cent reduction in CO_2 below 2000 by 2050.
- **Rebate case** – $7500 rebate offered on the purchase price of certain EVs. The $7500 rebate applies to every battery electric and plug-in hybrid EV purchased between 2013 and 2033.
- **Maximum uptake case** – the case in which there are only battery and hybrid EVs in the market by 2033, and no other type of vehicle. It is not considered a plausible scenario for 2033, but serves as an upper bound for reference.

In the base case, the CSIRO forecasts total EVs to reach 981,518 in Victoria by 2033, while in the 'maximum uptake' scenario, this figure increases to 2,932,265.[45]

Figure 2.2: Total CSIRO projected EV penetration in Victoria, by scenario, 2033



Source: Adapted from CSIRO (2012)

Pure EVs are forecast to comprise between 12 per cent and 48 per cent of the total Victorian vehicle fleet by 2033, in the base and maximum uptake cases respectively. For plug-in hybrid EVs, market share to 2033 is 21 per cent in the base case, and 51 per cent of the total Victorian fleet in the maximum uptake case. This implies that in the absence of government support for the industry, uptake of battery EVs will be relatively slow, as the market for plug-in hybrid vehicles is assumed to be better able to support itself. As such, government support is particularly important in promoting battery EVs.

The CSIRO's analysis highlights that support for EVs – and disincentives for ICE vehicles – has a strong impact on uptake of the technology. The CSIRO's report suggests that, in the case of battery EVs, rebates and a combination of CCM and vehicle to grid charging are, in isolation, the most effective policies in increasing uptake. By contrast, "feebates" discouraging the purchase of ICE vehicles, were the least effective policies, with a "feebate" of 4 per cent introduced from 2015 to 2030 having no impact on the forecast. These findings show that promotion of a new technology is likely to be more successful in growing the new market than discouraging existing substitutes.

2.2.3 ABMARC

ABMARC is an independent engineering and research consultancy, developing technical reports and analysis for industry sectors such as automotive, transport, fuels, energy and mining. In 2012, ABMARC released a study of the electric and hybrid vehicles market, both internationally and domestically.

ABMARC expects that, in the absence of a significant shift in government support for EV technology, it is unlikely that there will be a significant uptake of EVs by 2020. However, ABMARC expects growth in hybrid sales to be dramatic, driven by greater model range, positive customer experiences and a convergence in prices with equivalent internal combustion vehicles. Hybrids are expected to be the 'vehicle of choice' for Australian consumers in 2020. That is, conventional and plug-in hybrid growth is expected to be strong, with traditional hybrid EVs expected to command 5 per cent of the market in 2020 and plug-in hybrids an additional 1.4 per cent. In the absence of government intervention, battery EVs are assumed to reach just 4500 or 0.4 per cent of the market by 2020.

2.2.4 Treasury modelling for the Clean Energy Policy

The Australian Treasury conducted modelling of vehicle market share by type, and considered carbon emissions under local and international carbon reduction strategies. The market for EVs was considered in the context of emission levels from the road transport sector.[46]

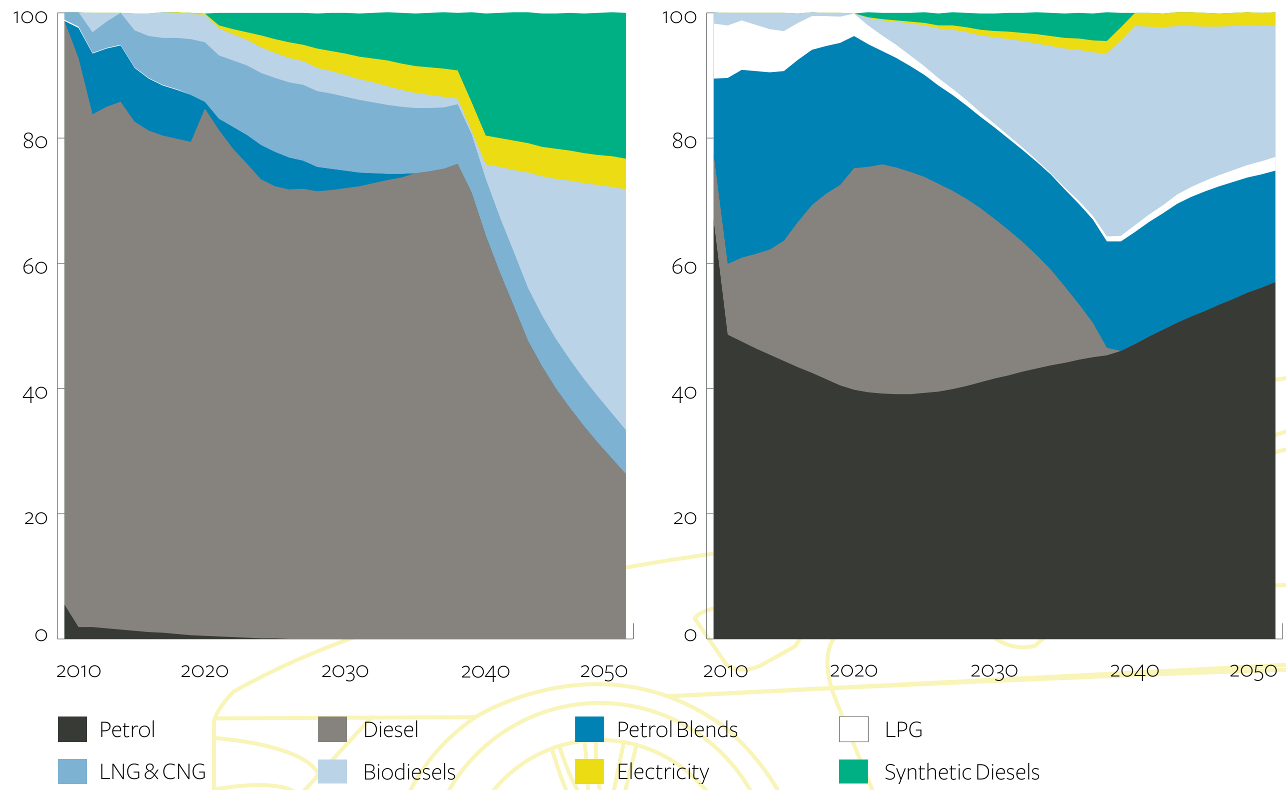
Treasury's 'core policy' scenario reflects the previous Labor Government's carbon tax policy. It assumes the global target equivalent to the policy, of a world with a 550ppm stabilisation target and an emissions target cut of 5 per cent on 2000 levels by 2020, and an 80 per cent cut by 2050. Under its core scenario, EVs are expected to enter the light and heavy vehicle road transport markets in 2021, growing at 16 per cent and 10 per cent respectively each year until 2050.

Treasury also considered scenarios with differing levels of global (outside Australia) action to mitigate climate change:

- **Strong Growth, Low Pollution core policy scenario** – EVs enter the light vehicle road transport sector in 2021, before the heavy vehicle transport sector, in 2025. To 2050, EV shares of road transport vehicles are expected to grow at 12 per cent and 10 per cent respectively.
- **Clean Energy Future scenario** – Electric road transport heavy vehicles are expected to comprise 0.1 per cent of the market in 2018, before growing to 4.9 per cent by 2050, at an annual growth rate of 13 per cent. Light EVs' share of road transport usage is expected to grow from 2021 to 2025, at an annual rate of 11 per cent.

In all scenarios, petrol engine vehicles remain the major type of light vehicle to 2050. See Figure 2.3 below.

Figure 2.3: Road transport fuel mix, heavy vehicles (left graph), and light vehicles (right graph), market share (%)



Source: The Commonwealth Department of the Treasury (2011)

2.2.5 Federal Chamber of Automotive Industries

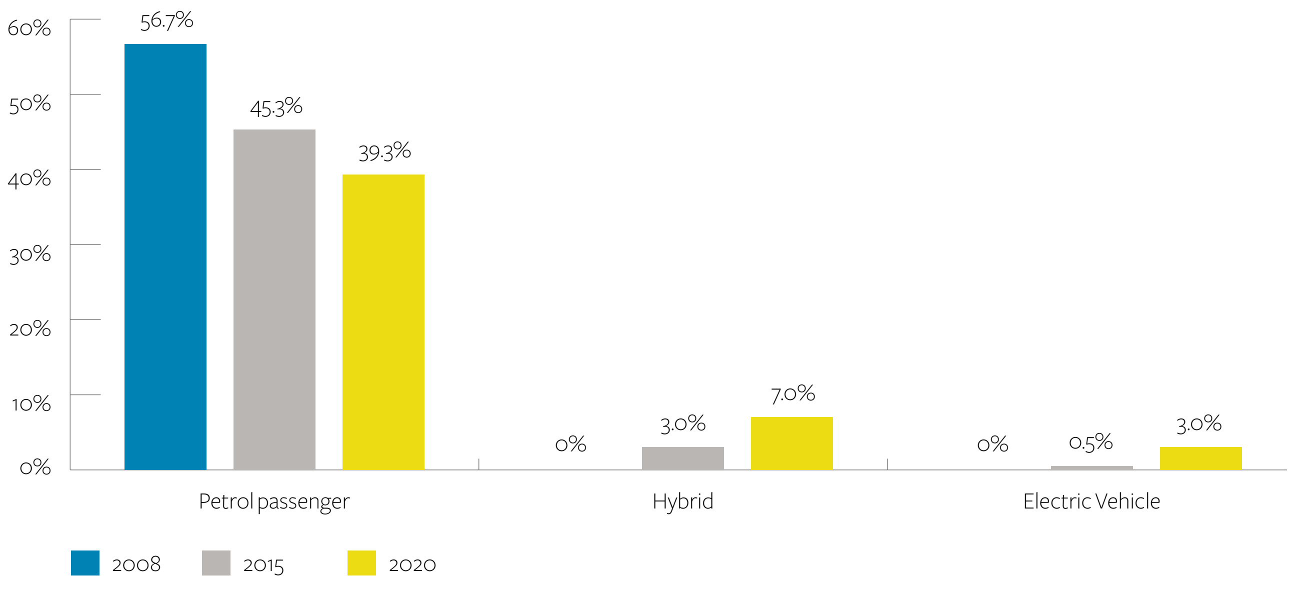
In 2010, the Federal Chamber of Automotive Industries (FCAI) engaged PricewaterhouseCoopers (PwC) to undertake analysis to assist in developing motor vehicle carbon emissions standards in Australia.[47] As part of this study, PwC made some projections about vehicle uptake, by category, of which hybrid and EVs were a component. PwC based its forecasts to 2020 on consultations with the FCAI and vehicle manufacturers and importers. It assumed market shares for each segment would remain unchanged beyond 2020. As shown in Figure 2.4, hybrid EVs are forecast to increase to 3 per cent of total fleet share by 2015, and 7 per cent by 2020. Electric vehicles are forecast to increase to 0.5 per cent and 3 per cent of total fleet share, over this time period, respectively.

2.2.6 Comparison of electric vehicle uptake forecasts

The variability in forecasts for key demand drivers such as fuel prices and battery costs suggests it is challenging to predict growth rates for electric vehicles in Australia. EVs have multiple risk factors: they are an emerging technology selling into an existing consumer market with incumbent players and they depend on supporting infrastructure support. It is evident that car companies have already begun to develop EV models. Most existing car companies will increase participation as the market evolves. Others, like Tesla and to some extent Nissan, have taken a more pro-active approach to encouraging the EV market.

The uptake rate for EV sales in Australia will depend on the availability of EVs in the Australian market, consumers being given a value proposition they find attractive at large scale and the support of other stakeholders to help drive and support critical mass for the EV market.

Figure 2.4: FCAI market segment projections (selected vehicles)



Source: PwC (2010)

2.3 Industry expectations for the Australian electric vehicle market

The esaa commissioned Deloitte to survey key stakeholders to gain an industry perspective on the future of the Australian electric markets. Stakeholders consulted included the Victorian Department of Transport (DoT), Better Place Australia, General Motors Holden, Mitsubishi, and Toyota. Their expectations for future growth and explanations for historical uptake are discussed below.

Stakeholders generally expressed the view that **growth in EV sales is inevitable, but the timing of penetration is difficult to predict and depends on a number of factors**. DoT noted that EV uptake is currently in the volatile pre-adoption phase typical of a new technology. It compared EVs to mobile phones, which were prohibitively expensive for many years in the absence of supporting technology which, once introduced, made them accessible to the mass market.

Developing industries typically follow an 'S' curve (see Figure 2.5), featuring a tipping point at which the technology begins to experience mainstream adoption. A critical sales mass is required to push the market past this point to the adoption phase, at which time the new technology is prevalent in the market, and considered a viable consumer choice. Sales growth tends to then increase quickly, before slowing once the market accepts the technology as a mainstream option. The market for EVs is yet to pass the tipping point, however it is expected that EVs will follow this path over the next three to four decades.

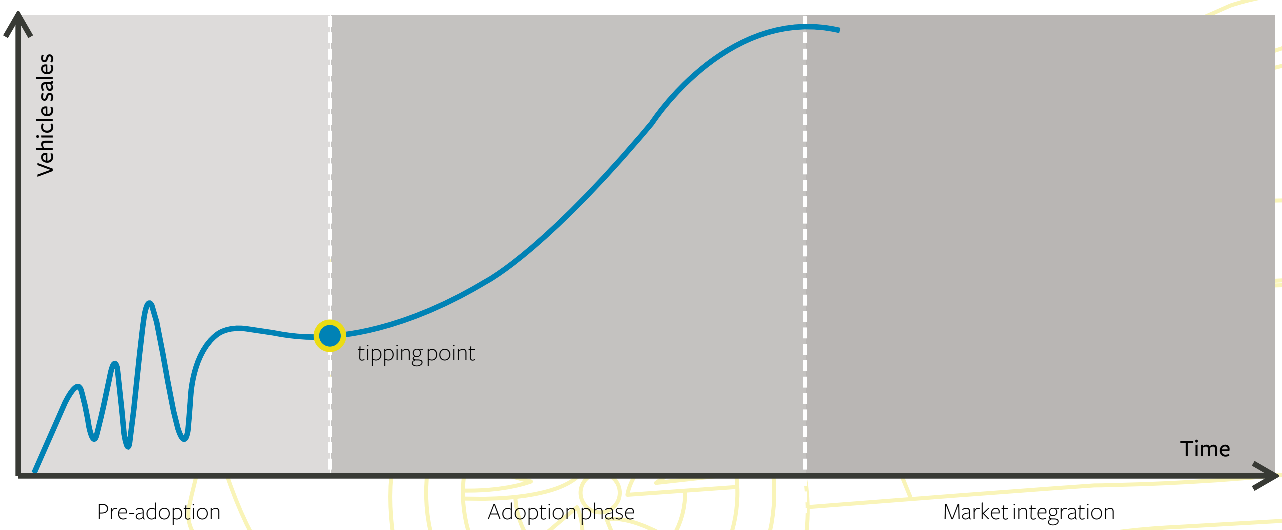
Vehicle manufacturers are less optimistic about growth in EVs. One large vehicle manufacturer suggested that it would be reasonable to expect PEV penetration could be less than 5 per cent of the total fleet in 2025. It is generally expected that electricity will eventually displace petrol and diesel. However, low government support means that petrol and diesel will remain the dominant fuels in the market.

Stakeholders also suggested that battery and other key components are not yet advanced enough to enable economies of scale to be realised, therefore manufacturers have unable to lower the price sufficiently for consumers to consider purchasing an EV. It was suggested by existing car manufacturers that the future of EVs lies predominately in hybrid technology, and that battery EVs will follow the success of hybrid vehicles.

Electric vehicle uptake has been hindered by a lack of support. Stakeholders consistently commented that EV penetration is primarily driven by government funding and incentives. Deloitte's consultations revealed there exists a classic policy conundrum in the market: manufacturers will not enter the market unless they know there is sufficient supporting infrastructure (e.g. charge points) to facilitate customer uptake. Conversely, infrastructure providers will not enter the market unless there is a real commitment from car manufacturers. At present, the economic value is insufficient to justify investment.

This first mover problem can be resolved with government support. Some vehicle manufacturers suggested it is their responsibility to make investment in Australia a viable economic decision.

Figure 2.5 New technology adoption phases: the 'S' curve



Source: Victorian Department of Transport

33 Tesla Motors, Reserve Your Tesla. Last accessed 2 August 2013.

34 CarsGuide (2013), *Better Place retreat stalls Renault Fluence EV*, from http://www.carsguide.com.au/news-and-reviews/car-news/better_place_retreat_stalls_renault_fluence_ev. Retrieved 15 May 2013.

35 Sourced from industry consultation.

36 For more information, visit http://www.transport.vic.gov.au/projects/ev-trial.

37 ABMARC (2012) *Electric & Hybrid Vehicles Australia: An Automotive Perspective.*

38 Toyota Australia, Toyota sells 50,000th Hybrid Car in Australia, Last accessed 1 August 2013.

39 *The Australian*, 28 February 2012, 'Honda lowers hybrid price', Philip King.

40 AECOM (2009), *Economic Viability of Electric Vehicles.*

41 AECOM (2011), *Forecast Uptake and Economic Evaluation of Electric Vehicle in Victoria.*

42 See Appendix B for details about specific charging levels.

43 AECOM (2012), *Impact of Electric Vehicles and Natural Gas Vehicles on the Energy Markets.*

44 See *Diffusion modelling of EV uptake: methodology and case study for Victoria* (2011), and *Spatial Modelling of Electric Vehicle Charging Demand and Impacts on Peak Electrical Loads in Victoria* (2012).

45 CSIRO (2012), *Spatial Modelling of Electric Vehicle Charging Demand and Impacts on Peak Household Electrical Load in Victoria, Australia.*

46 Treasury, (2011), *Strong Growth, Low Pollution: Modelling a Carbon Price*, pp.75–76.

47 PwC, (2010), *Managing Vehicle Carbon Emissions: Options for development of a standard.*

3 The pros and cons of electric vehicles

Whether a car is powered by petrol, diesel, steam or electricity, it is still a car. The direction of the car market is still determined by consumer preference. The potential for a new technology to make inroads into an existing market will depend on its ability to provide an effective value proposition. Widespread public interest in innovative new technologies does not automatically translate in their willingness to buy them.

This chapter examines some of the key factors that are likely to influence consumer choices in whether or not to consider an EV for their next vehicle, and consider how policy makers and industry stakeholders might introduce measures to make electric cars a more attractive alternative.

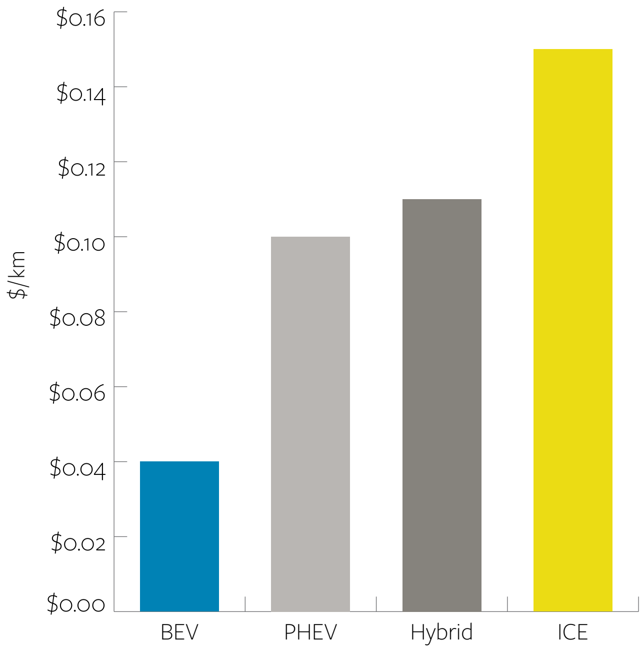
3.1 Benefits of an electric vehicle

3.1.1 Lower fuel costs

Fuel costs are typically the greatest ongoing cost associated with vehicle ownership. Battery EVs currently produce the lowest fuel costs per kilometre of all engine types, analysis conducted by AECOM for the Department of Transport shows.[48] Battery EVs are estimated to incur an equivalent fuel cost of approximately $0.03 per kilometre, compared to an ICE which incurs more than $0.10 per kilometre, according to AECOM's analysis. This is due to the relative cost of electricity ($0.25–30c/kWh) compared to petrol ($1.40–1.50/L).

> Battery EVs currently produce the lowest fuel costs per kilometre of all engine types.

Figure 3.1 Fuel costs per kilometre, by vehicle type



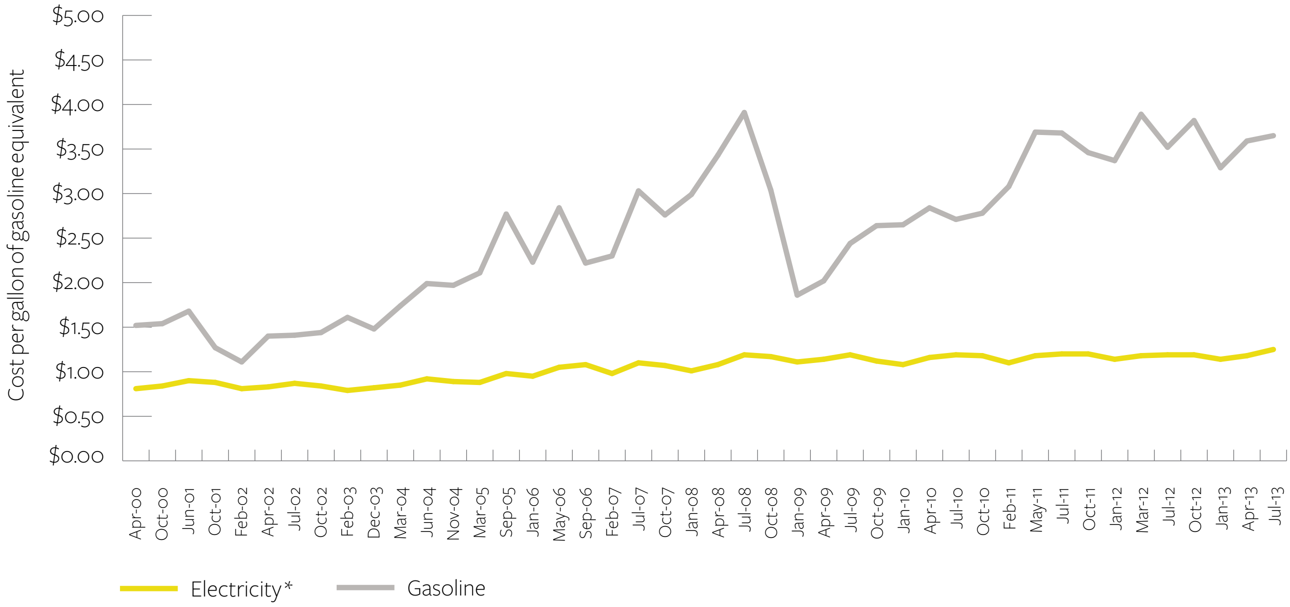
Source: AECOM, (2011) Forecast uptake and economic evaluation of EVs in Victoria

ABMARC conducted a similar study to AECOM, comparing total running costs of battery electric and hybrid vehicles to ICE vehicles. The running cost of EVs will vary depending on the price paid for electricity. ABMARC developed a comparative range, finding that the cost of charging a battery EV is 22 per cent of the cost of operating an ICE at off peak times, and approximately 50 per cent of the running cost of an ICE at peak times.[49]

The US Department of Energy calculates the equivalent fuel cost for EVs through its e-Gallon tool. It gives consumers an indication of the fuel savings available with EVs. Figure 3.2 shows how refuelling an EV has not only been cheaper than petrol since 2001, but that electricity prices have been far more stable than petrol prices over the same period.

Australian petrol prices are around 50 per cent higher than in the US.[50] While electricity prices are also higher in Australia, the equivalent 'e-Petrol' price in Australia would still be commensurately less than current petrol prices.

Figure 3.2: Comparison between petrol and electricity refuelling costs, US, 2001–13



*Electricity prices are reduced by a factor of 3.4 because electric motors are approximately 3.4 times as efficient as internal combustion engines

Alternative Fuels Data Centre, US Department of Energy, Clean Cities Alternative Fuel Price Report

3.1.2 Efficiency

More than 90 per cent of car trips are in urban driving conditions, which are typified by constant stop-start motion. One of the principle benefits of electric vehicles in these conditions is that the engine stops operating when stationary. This improves range, reduces noise and pollution in traffic. This feature has been utilised in the development of petrol-electric hybrid vehicles to date.

Electric motors are highly efficient at delivering energy and converting it into movement. They achieve this energy conversion efficiency over the full range of speeds and power output and can be precisely controlled. As a result they do not require gearboxes, further reducing weight and running costs.

They can also be combined with regenerative braking systems that have the ability to convert movement energy back into stored electricity. This can be used to reduce the wear on brake systems (and consequent brake pad dust) and reduce the total energy requirement of a trip. Regenerative braking is especially effective for start-and-stop city use.

ABMARC also conducted analysis on 'well to wheel' efficiency, which is the efficiency of the refining (or recharging) process, multiplied by the efficiency of the vehicle. It found that an ICE converts just 18 per cent of the petrol it uses into power, as more than 70 per cent of the energy generated is lost as heat (e.g. due to friction or exhaust), with the remainder lost through the drivetrain. ABMARC concluded that the total efficiency of an average ICE is just 15 per cent.

By comparison, a battery EV is highly efficient, ABMARC found. Approximately 76 per cent of power from the battery is converted to power. However, it is recognised that the total efficiency of an EV is diminished through inefficiencies in the electricity transmission and distribution phases. As such, ABMARC concluded that a battery EV has a total efficiency of 23 per cent.

ABMARC estimated that a battery EV is 58 per cent more efficient than an ICE vehicle from an energy conversion perspective alone, and an additional 8 per cent more efficient than an ICE from a total 'well to wheel' perspective.

Technical energy efficiency conversion levels are not especially relevant in themselves, but they provide an underlying physical rationale for why PEVs should be able to sustain significantly lower fuelling costs than ICEs.

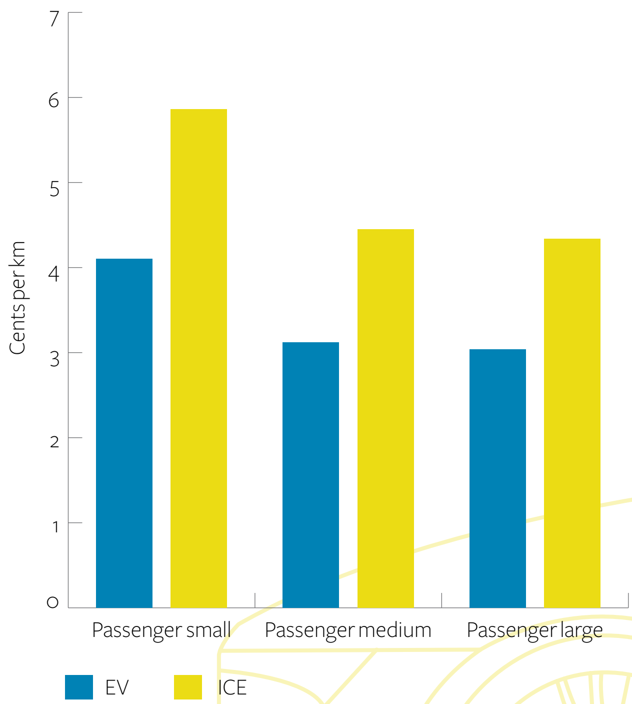
3.1.3 Maintenance costs

Electrical motors are very simple in design and simple to operate and maintain. Electrical components such as the motor and controllers require less maintenance, with additional savings attributable to EVs over ICEs through reductions in the frequency of brake pad replacements.

AECOM, in its 2011 report for the Department of Transport, considered total maintenance costs for battery EVs as a proportion of total maintenance costs for ICEs. This included battery replacement costs, which AECOM assumed to be negligible, as battery life was presumed to equal or exceed vehicle life. It noted that over time, battery replacement costs would diminish as economies of scale and industry efficiency gains prevail.

Overall, AECOM found that an EV incurs approximately 70 per cent of the maintenance costs per kilometre of an ICE.[51] A breakdown of maintenance costs by vehicle type and size is given in Figure 3.3 below.

Figure 3.3 Maintenance costs per kilometre, by vehicle type and size



Source: AECOM (2011), Forecast uptake and economic evaluation of EVs in Victoria

The RACQ's Private Vehicle Running Costs Guide 2013 showed that servicing costs showed that for EVs were lower than equivalent ICE vehicles.[52]

3.1.4 Performance

The performance of passenger vehicles reflects the handling, braking and acceleration of the car. It is clearly an important consideration for a significant share of the consumer market. While the development of EVs is in its infancy, it is clear from a number of high-end models that EVs have the potential to enjoy considerable torque, resulting from the highly efficient and immediate transfer of energy to the wheels.

To illustrate, the top of the range Tesla Model S can accelerate from 0–100km/h in 4.4 seconds, the company says. This type of acceleration is not evident on smaller EVs where the engine and battery has been reduced to reduce weight and cost.

EVs can also exploit a lower centre of gravity in the car and advanced aerodynamics, both due to the absence of the engine high up in a conventional car (which contributes to drag), and the distribution of battery weight lower in the vehicle. The Tesla Model S has a claimed drag coefficient of 0.24, among the lowest ever recorded for production line vehicles.[53]

3.1.5 Safety

High safety standards have become synonymous with most new cars. But a recent independent safety test of an all-electric car suggests EVs may have a clear safety advantage to combustion engine cars, primarily because of the absence of the engine block.

In August, the Tesla Model S was given a 5-star safety score by the US National Highway Traffic Safety Administration (NHTSA). Tesla claimed the four-door sedan topped the NHTSA safety rankings with a score of 5.4 out of 5 (safety levels better than 5 stars are captured in the overall Vehicle Safety Score (VSS) provided to manufacturers). But the NHTSA has pointed out that 5 stars is the highest possible rating.[54]

The absence of a large combustion engine located inside the car enabled designers to increase crumple room and to use the reduced weight to increase structural safety throughout the car. This, in addition to its low centre of gravity and superior handling, may signal that EVs enjoy a potential safety advantage over conventional cars.

3.1.6 Noise

EVs make no noise when stationary and low levels of noise when operating. The collective impact is difficult to measure, although the CityHush Project funded by the European Commission proposed EV-only precincts in cities, estimating this would result in a15dB(A) reduction in ambient noise levels.[55]

Conversely there have also been concerns raised about the impact on pedestrians, in particular if they are visually impaired.[56] Work is underway to find methods to ensure that there is some noise from EVs to act as a warning for pedestrians and cyclists. The European Electric Vehicle Alert for Detection and Emergency Response (eVADER) project is finding ways to warn people of an oncoming EV.[57] In the US, the National Highway Traffic Safety Administration has developed standards for a minimum noise level from EVs.[58]

3.1.7 Image and brand

After upfront and ongoing costs, image and brand are among the top factors that impact a vehicle purchase decision. In fact, brand image is, on average, a more influential factor in determining consumer decisions than both fuel consumption and environmental performance.[59]

In 2007, Topline Strategy Group conducted a survey investigating the main reasons consumers purchased a Toyota Prius. It found that while over 70 per cent of purchasers had strong financial motives as the primary reason for their purchase, the image of the vehicle was another prominent reason for these respondents' purchases. Five per cent of respondents nominated the image of the Prius as the *primary* reason for their purchase.[60]

A similar logic can be applied to battery EVs. As an emerging technology, there will be a subset of 'first-movers' who purchase a vehicle simply to be among the first to do so, or to experience first-hand the latest advancements in vehicle technology.[61]

In its 2011 study of global consumer preferences, Deloitte found that first movers are likely to be well-educated, live in urban areas, and represent the upper or middle classes. They view themselves as environmentally conscious and trendsetting, emphasising the environmental benefits of EVs, as well as their stylish characteristics.[62]

Along with emphasising the technical benefits of the vehicle, manufacturers understand the importance of designing EVs in stylish, innovative fashions, to appeal to consumers and reflect the cutting edge technology that the vehicles represent. Small, mainstream EVs are compact and futuristic, whereas premium vehicles are more associated with a sports vehicle style and performance.[63]

3.1.8 Environmental and efficiency values

The environmental benefits of EVs, in terms of lower tailpipe emissions and the potential for recharging with renewable energy to lower overall emissions (discussed in section 4.1), are key selling points for some customers. Research has suggested that early adopters of hybrids and EVs have been impacted by ideological reasoning, such as seeing themselves as: "making a commitment: setting an example, being a pioneer, talking to other people about their car." [64]

While the environmental benefit of owning an EV in Australia is highly dependent on the recharging fuel mix, the potential for lower overall emissions is clearly an important selling feature. Adding to this, the fact that controlled charging of EVs could improve the efficiency of the overall electricity supply system could be a powerful incentive for customers who are affected by environmental efficiency arguments.

3.2 Barriers facing electric vehicles

While electric vehicles have the ability to exploit some clear design and performance advantages, some barriers remain when compared to conventional vehicles. These include purchase price premiums over conventional cars, driving range of vehicles, the availability of charging (refuelling) infrastructure and uncertain resale values.

In 2011, Deloitte conducted a survey of global vehicle customers, identifying average perceptions of EV technology, some characteristics of potential 'first movers' in the market to purchase EVs and some of the issues which would make them less likely to purchase an EV.[65] The results of this global study suggest that:

- China and India lead the world with customers considering themselves a 'first mover' in the purchase of EVs, with 50 per cent and 59 per cent of survey respondents respectively.
- Only 13 per cent of Australian respondents consider themselves first movers, whereas 41 per cent of Australians said they were 'not likely to consider' purchasing an EV.
- 37 per cent of Australian respondents said they would prefer a mid-size sedan EV, with 16 per cent preferring a small sedan, and 14 per cent preferring a large sedan.

3.2.1 Price

Although EV operating costs are low compared to an internal combustion vehicle, the cost of the vehicle is considerably higher relative to commensurate petrol engine vehicles. For example the Nissan LEAF ($39,990) is similar to the Nissan Tiida ($17,990), but more than double the sticker price. Price differentials on this scale are a major barrier to consumers, particularly in the compact car market.

High vehicle production development costs are driving the high purchase prices of EVs. One manufacturer indicated that it is unlikely to ever recover the total research and development costs of its EV through sales. Another manufacturer noted that due to the overall cost of a car in proportion to incomes, people are unwilling or less likely to take a risk on new technologies without a significant demonstration of additional value. However, it was noted by a number of stakeholders that EV sales during the pre-adoption phase were never expected to be strong.

Deloitte's global EV survey found that most survey respondents would not be prepared to pay any premium for an EV. In Australia, 69 per cent of respondents indicated that they would not be prepared to pay any premium at all. Further, 75 per cent of Australian respondents suggested they would want to purchase an EV for $30,000 or less.[66] Unfortunately this shows that work still needs to be done to inform consumers over the long-term costs of running ICE vehicles and EVs to show that although EV cost more initially, running costs are lower.

All stakeholders listed high purchase price compared to ICE substitutes as a major barrier to uptake. This is driven by the battery cost, which can comprise up to 50 per cent of the total cost of an EV. The ability of key components like batteries to fall in cost and improve in efficiency will be critical to improving the cost and value of EVs for consumers.

Box 3.1: Battery costs

Batteries are one of the main costs in an EV. As such, forecasting EV prices and sales are very much contingent upon the price of batteries over the period.

The lithium-ion (L-ion) battery is being heavily researched and developed for EVs. Commonly found in laptop computers, the L-ion battery yields impressive power, energy and charge density: three factors which are critical to the range and performance of an EV. However, much conjecture exists about the price of batteries into the future. Some industry experts predict battery prices, through increased competition, research and demand for batteries from vehicle manufacturers, will fall rapidly in coming years, whereas others feel the outlook for batteries is somewhat less promising.

Battery price reduction estimates are mixed, ranging from a 33 per cent to 67 per cent reduction by 2020 on 2010 levels.

The combination of higher up-front costs but lower fuel and maintenance costs means that at EVs could at some point cost less overall than a comparable ICE vehicle. EPRI found that at a $10,000 premium, EVs become a lower cost option than an ICE after around 8 years.[67]

There are qualifications to EPRI's analysis. EVs will likely need a battery replacement after around 8–10 years at a cost of around $5000. But at around the same time, running costs for ICE vehicles tend to rise as the maintenance schedule increases. Based on this, at a $10,000 premium, an EV will be more or less cost competitive with a comparable EV over the life of a vehicle (10–15 years). The exact point at which an EV breaks even with an ICE will depend on electricity and petrol prices, driving distances and battery replacement costs.

3.2.2 Range

The typical range for PEVs is from 120–300 km, depending on vehicle type (range tends to be further in larger vehicles). Range is extended to “conventional” combustion engine distances if a hybrid engine is added (at additional cost and weight).[68] Interestingly even the shortest range EVs appear to be sufficient for the majority of average daily commutes in Australian cities.

In surveying typical commuter distances in Australia, AECOM found that between 95–99 per cent of return commuter trips in Adelaide were 100km or less, and between 85–90 per cent were 100km or less in Sydney.[69] Deloitte’s global EV survey found that in Australia, 78 per cent of respondents drove less than 80kms each day[70] and in metropolitan Melbourne 91 per cent of drivers travel 80km or less each day.[71] Yet, according to Deloitte only 50 per cent were satisfied with a vehicle that drove 200kms or less on a single charge, and only 73 per cent were satisfied with 300kms or less.

Concern over the range of EVs has been termed “range anxiety”. EVs pose range challenges for the occasional longer trips. These concerns are exacerbated by the lack of recharging infrastructure. Behaviourally, car drivers have become accustomed to refuelling irregularly and carrying a few hundred kilometres of fuel around in their car. They are unaccustomed to treating a car more like a mobile phone, and recharging it daily.

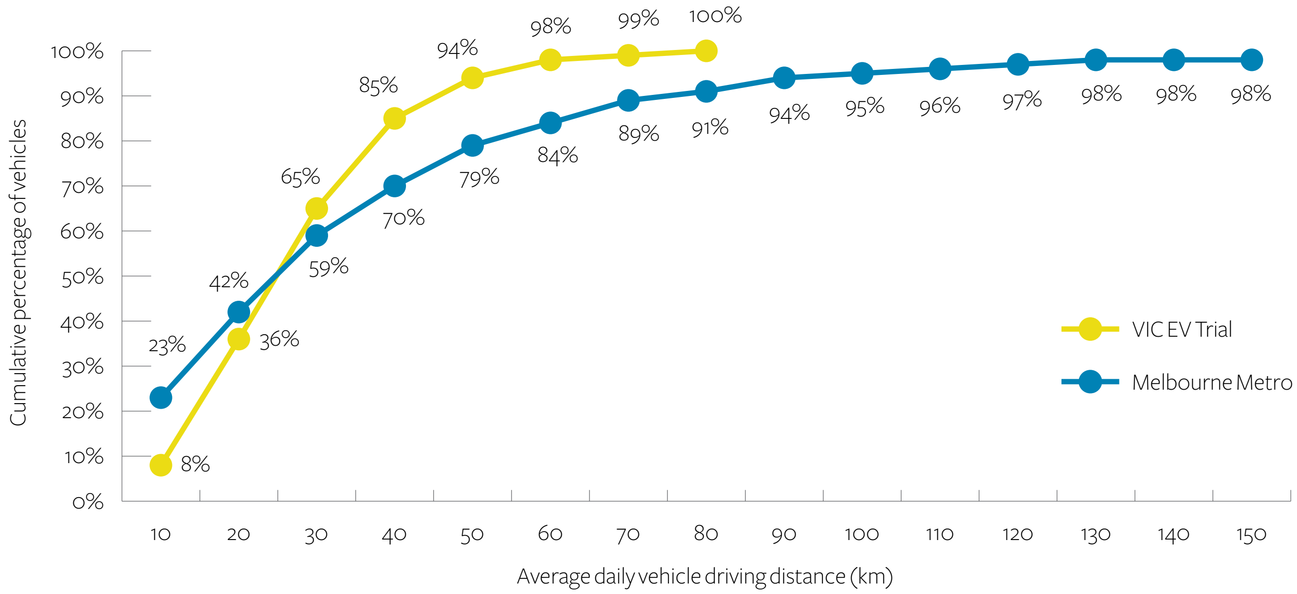
EVs could already manage the usual needs of most drivers, most of the time. Evidence from California indicates that 94 per cent EV drivers also own a conventional vehicle.[72] This shows that some EV owners are addressing their range anxiety by having a second vehicle available.

It seems that unrealistic tests are put on cars – like the ability to drive uninterrupted between two major cities – when most Australians fly these routes or drive inter-city a few times in their lifetimes. In the Australian context, almost 80 per cent of travel between Melbourne and Sydney is now done by air.[73] In 2012 more than 8 million passengers flew between Melbourne and Sydney.[74]

Improvements in range and fuel efficiency are expected to occur over time. The main limiting factor for range is energy density, or how much energy the battery can store per unit of mass. Although it is expected that energy density will improve by 2020, most vehicles to be introduced to 2014 are likely to offer similar ranges to those already available.[75]

A Victorian Integrated Survey of Travel and Activity found that 79 per cent of drivers travelled 50km or less per day. The Victorian Government’s EV Trial showed that EV drivers had different driving patterns: 94 per cent of vehicles travelled 50km or less per day. Figure 3.4 shows the average daily driving distance for metropolitan Melbourne drivers and for EV trial participants.[76] Preliminary research from EPRI found that EV drivers frequently adapt to the limited range of an EV.[77]

Figure 3.4: Driving patterns of average Melbourne drivers vs EV Trial drivers, 2012



Source: Victorian Department of Transport

But EV manufacturers are working on ways to address 'range anxiety' through a variety of measures. Tesla is building a network of 'Supercharger' fast chargers where Tesla owners can recharge for free. Tesla has installed 16 stations which provide half a charge in about 20 minutes and an 80 per cent charge in 40 minutes. Tesla's plan is to have the network cover 80 per cent of the US population in 2014, and 98 per cent in 2015.[78] Similarly, Nissan plans to add 500 quick charging stations in the US by mid-2014.[79] Meanwhile, BMW and Audi are providing EV owners with petrol-fuelled loan vehicles to allow drivers to complete longer trips.[80]

The American Automobile Association has also developed an EV mobile charging unit to assist drivers who have run out of charge.[81] It provides them with 8 kilometres of driving range in less than 10 minutes of charging time.[82] Finally, the development of phone apps and navigation systems can provide EV drivers with information about remaining range and the closest charging stations. This can help drivers to plan their journey and adapt to changing conditions.

3.2.3 Charge times and availability

At present, there are very few public charge points in Australian metropolitan areas, meaning it is difficult for consumers to charge their EV outside of home. The use of Level 1 charging (from a standard wall outlet) typically takes around eight hours to recharge most electric vehicle batteries.

Figure 3.5: Electric vehicle charging station at Melbourne Museum, 2013

Source: esaa

Public recharging company chargepoint.com.au currently offers 51 public charge points across Australia.[83] By comparison, there are 6444 in total across the US.[84]

One of the key barriers to EV uptake identified from the trials conducted by the Victorian Department of Transport was lack of infrastructure. This limits the EV market to households with a garage or equivalent off street parking where they can recharge the vehicle.

Consumer expectations of speed of charging are far greater than current technology permits. There are three current levels of EV recharging:

- Level 1 (plug-in conventional power point): 5 to 10 kilometres of range per hour of charging
- Level 2 (dedicated inverter): 15 to 25 kilometres of range per hour of charging
- Level 3 (DC fast charging): up to 100 kilometres of range in 20 minutes of charging

Level 2 rechargers are falling rapidly in price and are now sold for under $1000. Level 3 rapid chargers currently cost between USD 17,500–50,000, with energy requirements that can place stress on the grid. Australian company Tritium has developed a Level 3 charging technology that can give 50 kilometres range in just 10 minutes.[85]

Most respondents to Deloitte's global survey[86] expected the vehicle to recharge in two hours or less. In Japan, 73 per cent of respondents said they would not purchase an EV whose battery took over one hour to charge. In Australia, 23 per cent cited 30 minutes as the longest acceptable charge time. Current battery capacities simply do not allow for this.

3.2.4 Other factors

Battery switching – Vehicle manufacturers suggested that one way to reduce upfront costs, reduce recharge times and therefore improve range would be to swap rather than recharge batteries. But due to intellectual property issues, manufacturers appear to be unwilling to take part in a battery swapping schemes. With Renault Fluence indefinitely halting its entry into the Australian market and Better Place going bankrupt, there appear to be significant barriers to battery swap models at this time.

Box 3.2: Better Place and battery swapping

Better Place was an EV recharging network, offering battery swapping facilities and recharge infrastructure to customers on a membership basis. Better Place's business model was to manufacture batteries and battery technology, as well as battery switching infrastructure. It launched its first facility in 2008 in Israel. It went into bankruptcy in 2013.

The Better Place business model required customers to pay a monthly fee that included the battery costs and energy used in travel. In this way, consumers would be able to spread one of the major up-front costs of owning and EV – the battery cost – over time through a leasing arrangement.

Better Place built its business on a specific technology solution in an emerging product market. Its demise reflects the scale of risks in investing in emerging markets: regulatory risk, commercial risks (prices of EVs, price of oil) and technology risk as well as the uncertainty that surrounds consumer behaviour and preferences.

Car heating – In colder weather some of the surplus heat energy from an ICE is used to heat the vehicle interior and to defrost the windows. This heat already exists in ICEs as waste combustion heat diverted from the engine cooling circuit. This option is not available for EVs, although some EVs, such as the Nissan LEAF can be pre-heated, or cooled. Tesla vehicles can be pre-cooled or pre-heated using a mobile application.

Some EV engineers are developing a reversible air-conditioning system, which uses a heat exchanger attached to the car's batteries. This technology has already been trialled in some EVs, prolonging the life-span of the battery as well as improving the performance and overall energy-efficiency of the vehicle.

Soft oil price – The price of oil is likely to influence the value to potential consumers of switching to EVs. Global demand for oil is expected to grow substantially to 2020, led by increasing demand from emerging markets, and the oil price path will depend on whether or not increases in global supply will be sufficient to meet this demand. Some industry analysts expect supply will be more than sufficient, which would be likely to dampen the oil price overall, whereas others expect demand will outstrip supply, forcing prices upwards.[87]

Consumer attitudes toward carbon emissions – Vehicle manufacturers commented that consumer willingness to adopt environmentally friendly technology appears to have declined in the last five years, making the market more difficult to penetrate for EVs.

This change in consumer attitudes is consistent with broader attitude changes since the Global Financial Crisis. One vehicle manufacturer specifically noted that had it been able to release its EV in 2007 when environmental interest was higher, sales would have been far higher than was the case following its eventual release in 2011–12. Given the speed with which consumer attitudes can change, it is possible that concern about greenhouse gas emissions could resurface as a factor.

Resale values – Resale value is a key factor for many consumers when purchasing a car. Confidence (or lack thereof) in resale prices is the result of reputation, performance, and an active market for used cars. Recent evidence suggests that resale value for EVs is quite poor, with Brisbane City Council recently selling one of two EVs in its fleet for less than one-third of the purchase price, two years after purchase. However, this is a common trend in emerging technologies, where there is greater uncertainty about the durability and performance of new products.[88]

Research from the US has shown that EV resale values are typically lower than for ICE vehicles or hybrids.[89] Table 3.1 shows the actual and predicted rates of used vehicle price depreciation. Some convergence of depreciation rates can be observed.

Table 3.1: Resale values for cars by drivetrain, US 2012

Powertrain Type	Actual	Forecast	
	2012	2013	2014
ICE	-12.4%	-13.3%	-16.8%
Hybrid	-14.0%	-16.9%	-18.5%
EV	-31.5%	-29.7%	-27.4%

Source: National Automobile Dealers Association

48 AECOM (2011), *Forecast uptake and economic evaluation of electric vehicles in Victoria.*

49 ABMARC (2012) *Electric & Hybrid Vehicles Australia: An Automotive Perspective.*

50 Australian Institute of Petroleum, International Price Comparisons, retrieved from http://www.aip.com.au/pricing/internationalprices.htm.

51 AECOM (2011), *Forecast uptake and economic evaluation of electric vehicles in Victoria.*

52 RACQ, Private Vehicle Running Costs 2013.

53 *Car and Driver*, 'Tesla Model S Review', January 2013.

54 NHTSA, from www.nhtsa.gov. Retrieved 11 September 2013.

55 www.cityhush.org.

56 *Physics Today*, 'Noisy Electric Vehicles but Not Too Noisy', 13 June 2013.

57 eVADER, Electric Vehicle Alert for Detection and Emergency Response (eVADER), from http://evader-project.eu/. Retrieved 6 August 2013.

58 National Highway Traffic Safety Administration, US Department of Transportation Proposes New Minimum Sound Requirements for Hybrid and Electric Vehicles, 7 January 2013.

59 Victorian Department of Transport, *Potential early Adopters of Electric Vehicles in Victoria,* 2012, p. 4.

60 Topline Strategy Group (2007), *Why People Really Buy Hybrids*, p.5.

61 Ibid.

62 Deloitte (2011), *Unplugged: Electric vehicle realities versus consumer expectations*, p.2.

63 motortrend.com (2013), themotorreport.com.au (2013), extremetech.com (2013).

64 Victorian Department of Transport, *Potential early Adopters of Electric Vehicles in Victoria*, 2012, p. 4.

65 Deloitte, (2011), *Unplugged: Electric vehicle realities versus consumer expectations.*

66 Ibid.

67 Electric Power Research Institute, *Total Cost of Ownership for Current Plug-in Electric Vehicles*, EPRI, Palo Alto, CA, 2013.

68 AECOM (2012), *Impact of Electric Vehicles and Natural Gas Vehicles on the Energy Markets.*

69 Ibid.

70 Deloitte (2011), *Unplugged: Electric vehicle realities versus consumer expectation.*

71 Victorian Government, 2013, *Creating a Market: Victorian Electric Vehicle Trial Mid-term Report*.

72 California Center for Sustainable Energy, *California Plug-in Electric Vehicle Owner Survey*, May 2013.

73 Department of Infrastructure, *Transport, Regional Development and Local Government, Sydney-Melbourne Corridor Strategy*, 2007.

74 Bureau of Infrastructure, *Transport and Regional Economics, Domestic Aviation Activity Annual 2012.*

75 Deloitte Touche Tohmatsu Limited, (2012), *Global Manufacturing Industry group analysis.*

76 Victorian Government, 2013, *Creating a Market: Victorian Electric Vehicle Trial Mid-term Report.*

77 Electric Power Research Institute, *Total Cost of Ownership for Current Plug-in Electric Vehicles*, EPRI, Palo Alto, CA, 2013.

78 Tesla, Supercharger, from http://www.teslamotors.com/supercharger. Retrieved 7 August 2013.

79 Nissan News, from http://nissannews.com/en-US/nissan/usa/releases/nissan-to-triple-electric-vehicle-fast-chargers-partners-with-nrg-energy-to-build-first-fast-charge-network-in-washington-d-c-area. Retrieved 12 September 2013.

80 Rocky Mountain Institute, *Is the End of EV Range Anxiety in Sight? Nine Strategies To Put EV Owners At Ease,* from http://blog.rmi.org/blog_2013_06_20_is_the_end_of_ev_range_anxiety_in_sight. Retrieved 7 August 2013.

81 AAA, AAA Presents Electric Vehicle Mobile Charging Unit to Electric Drive Transportation Association, from http://newsroom.aaa.com/2011/06/ev-mobile-charging-unit/. Retrieved 7 August 2013.

82 Rocky Mountain Institute, op cit.

83 www.chargepoint.com.au.

84 www.afdc.energy.gov.

85 http://reneweconomy.com.au/2013/australian-tech-breakthrough-slashes-electric-vehicle-charge-time-26696.

86 Deloitte (2011), *Unplugged: Electric vehicle realities versus consumer expectation.*

87 Reuters (2012), *Analysis: Does US shale mean cheap global oil by 2020?* From http://www.reuters.com/article/2012/10/31/us-oil-poll-idUSBRE89U0LQ20121031. Retrieved 8 April 2013.

88 Carsguide.com.au (2012), *Electric car resale values low*, from http://www.carsguide.com.au/news-and-reviews/car-news/electric_car_resale_values_low. Retrieved 15 May 2013.

89 National Automobile Dealers Association, *Plug-in Electric Vehicles: Market Analysis and Used Price Forecast, Q2 2013.*

4 A role for government? The strategic benefits of electric vehicles

New technologies constantly evolve into consumer markets. The role of government is mostly prudential – to ensure that the safety of consumers is not compromised with the evolution of new technologies. In some cases there are broader, strategic benefits that governments may seek to capture by advancing or facilitating new technologies. The first mobile phone network was developed in Australia by a government owned business – Telecom Australia. Both major parties support government co-ordinating the provision of a national broadband network, they just disagree on the specific method.

This section discusses what strategic benefits would be delivered by an accelerated roll out of electric vehicles in Australia.

4.1 Pollution and greenhouse emissions

Pure EVs are viewed as 'green' alternatives to ICEs. An electric motor has no waste gases or exhaust fumes. Conventional combustion engines have continued to reduce the levels of pollutants they release into the air. But these pollutants still accumulate in urban airsheds creating smog, which in turn can contribute to upper respiratory problems and lung damage.

In its EV trials, the Victorian Department of Transport tested cumulative greenhouse gas emissions calculated over an average vehicle lifetime for an ICE, and a comparable battery EV, operating on both the Victorian electricity grid and renewable energy.[90] The study found that a vehicle charged via Victoria's grid electricity is likely to produce more greenhouse emissions than an ICE, with no likely break-even point.

This result occurs because measurements of total EV emissions must incorporate emissions embedded in the electricity generation process. In Victoria in particular, brown coal is the primary fuel for electricity generation. Brown coal is among the most greenhouse emissions intensive fuel source. As a result, EVs charged primarily from this source will have a greater carbon footprint than emissions from an ICE.

However, the Victorian study found that when an EV was charged via renewable energy sources, a battery EV will produce net lifecycle greenhouse gas emissions reductions within three years of operation.[91] That is, a battery EV charging on renewable electricity is projected to generate lower cumulative greenhouse gas emissions than an ICE within three years.

If fuel combustion alone is considered, even when the electricity used to charge EVs comes from a CO_2-emitting source, such as a coal- or gas-fired powered plant, the net CO_2 production from an electric car can be lower than from a comparable combustion vehicle. New passenger vehicles emit 198gCO_2-e/km.[92] An EV uses about 0.18kWh of energy to travel 1 km. Based on the average emissions intensity of Australia's grid of 0.86tCO_2-e/MWh, an EV will emit 154gCO_2-e/km, around 22 per cent less than new passenger vehicles.

The advantage of EVs compared to conventional vehicles is their ability to reduce emissions based on the source of energy used, whereas combustion engines lock in a pre-determined rate of greenhouse emissions (unless the driver switches to biofuels). GreenPower or Renewable Energy Certificate purchases present opportunities for promoting EV charging with renewable energy. There is also scope for interaction between EV recharge periods and wind farm generation, as the times at which EVs are likely to be generally charged (overnight) coincides with the times at which wind farm energy generation is higher.[93]

4.2 More efficient use of energy networks

One of the benefits of using electricity to power transport vehicles is that the distribution network and infrastructure already exists, and is widespread. The main initial additional cost is the provision of fast charging infrastructure, and in the longer term the potential to integrate EVs and their storage as part of a smart grid. In the short to medium term, the modest uptake of EVs is unlikely to pose significant impact on the network, or on its operation. Given EV battery sizes and driving patterns in Australia, each EV may require from 2kWh to 20kWh of electrical energy per day.[94] But CSIRO modelling projected to 2033 identifies the need for strategic planning during the development of an EV to ensure that pricing incentives and charging technologies are used to optimise the network.

Controlled charging, combined with Vehicle to Grid capabilities, where the EV batteries are used to support the network at times of peak demand, has the potential to lower peak demand on the system, improving the utilisation or load factor of networks. Significant uncontrolled charging of EVs could have adverse consequences for the electricity system, in terms of peak demand, as well as creating system instability.

Deloitte's analysis on Vehicle to Grid technologies (based on analysis of AECOM's EV forecasts for Victoria and NSW, 2009 and 2011 respectively) concluded there were substantial potential peak demand reduction benefits available to both the NEM and SWIS, of between $60 and $537 million.[95] This value calculation was based on ranges of assumptions on the number of EVs available (plugged in and controllable) at peak time, capacity per vehicle and discharge time.

Subsequent research and consultation has confirmed that Vehicle to Grid technology faces some considerable barriers due to the early phase of development of EV acceptance and technologies. Several vehicle manufacturers indicated that while they see the benefit of Vehicle to Grid for electricity suppliers, given the low rate of consumer adoption of EVs generally in Australia, it is unlikely to be a development priority. However, the substantial value that Vehicle to Grid represents for the electricity supply system presents an opportunity for electricity utilities and vehicle manufacturers to work together to realise the benefits of Vehicle to Grid.

There are significant costs associated with controlled EV charging, including smart metering and other devices, and there are many other barriers which currently prevent controlled charging. However, arrangements to support cost reflective pricing signals (such as TOU pricing) are being considered by the AEMC and other energy market stakeholders as part of the broader Power of Choice Review.[96] In Victoria, the mandatory rollout of smart metering for small customers provides an opportunity for controlled charging technologies to develop.

4.3 Energy security and terms of trade

The value of Australia's imports of crude oil, automotive and diesel fuel totalled more than $32 billion in 2011–12, even though Australia is one of the biggest energy exporters in the world.[97] A shift to vehicles fuelled by domestic fuel sources such as electricity or natural gas would reduce this reliance on imported fuels and the risks of price vulnerability due to oil supply constraints.

90 Victorian Department of Transport (2012), *The Victorian Electric Vehicle Trial: Environmental Impacts of Electric Vehicles in Victoria*, pp.2–5.

91 Ibid.

92 NTC, *Annual report 2011–12: Delivering on priority reforms*, National Transport Commission, Canberra, 2012, accessed 30 July 2013.

93 esaa internal wind generation analysis.

94 CSIRO Energy Transformed Flagship: *Spatial Modelling of Electric Vehicle Charging Demand and Impacts on Peak Household Electrical Load in Victoria*, June 2012.

95 Figures in 2012 dollars, quoting net present values over a projection period of 2012/13–2022/23. Source: Deloitte, (2012), *Analysis of Initiatives to Lower Peak Demand – Final Report*, p. 45.

96 AEMC, (2012), *Final Advice – Energy Market Arrangements for Electric and Natural Gas Vehicles.*

97 Bureau of Resources and Energy Economics, 2013, Australian Petroleum Statistics No 202.

5 Unlocking the potential for electric vehicles

Electric vehicles can play an important role in improving the environmental performance and efficiency of Australia's energy networks and transport sector, while delivering consumers a safe, reliable, efficient and enjoyable transport option. Significant barriers still need to be overcome to deliver these benefits and trigger this transformation.

5.1 Changing the perceptions of electric vehicles

For many daily driving journeys undertaken by Australians, an EV could deliver the same or better performance as a traditional ICE providing there is an adequate network of charging facilities. Consumers are still understandably discouraged by the high prices for EVs, concerns about range, performance and uncertainty about resale values. The speed at which this perception changes is fundamental to the rate at which the EV car market expands in Australia.

5.2 Partnerships on the road to electric vehicles

Development of an EV market in Australia is likely to reflect the unique features of electric vehicles. New partnerships and opportunities may arise from this.

- Airlines (fly rather than drive longer distances)
- Hire car companies (hire cars for specialised journeys)
- Car share companies (using EVs in car share fleets)
- Retailers and shopping centres (provide recharge facilities while customers shop)
- Electricity companies (increased volume and improved grid stability)

5.2.1 Energy retailers and networks

Electric vehicles create new opportunities for electricity retailers. The uptake of EVs is likely to encourage and depend upon tariff reform, smart grid development and invite more dynamic billing and charging arrangements to ensure EVs help improve and optimise use of the energy network. Network companies will have a clear stake in this as providers of the network to co-ordinate and manage new customers and recharge facilities, as well as exploring how to best utilise more advanced Vehicle to Grid technology as it becomes available. It is feasible that the value of Vehicle to Grid for electricity networks and retailers could eventually offset the up-front cost of EVs.

5.2.2 Car share companies

Commercial and residential car share companies have seen rapid expansion in the past decade, in particular in high-density urban centres. These locations have reduced opportunities for off-street parking and recharging of EVs. There is potential synergy (short range, frequent urban driving) between car sharing schemes and EV usage. Dedicated parking locations provide ideal recharge locations, although scheduling will need to accommodate time for recharging.

5.2.3 Car hire companies

Car hire companies can provide both initial EV driving experience for those (mainly business) customers who are renting cars to conveniently manage travel inside short distances. With EVs suited to more than 90 per cent of car travel needs, there may be a growing window for car hire companies to provide vehicles specifically suited to those infrequent longer range or specialised journeys.

5.2.4 Airlines and trains

Increased use of EVs may encourage consumers to build more travel around mass transport systems like trains and air travel, and then make local car hire or other arrangements upon arrival. The average distances between major Australian cities, safety considerations and availability of discounted airfares already mitigates against long distance driving trips.

5.2.5 Retailers

The development of an EV market in California has seen a number of park-and-go retailers offer free or discounted recharging facilities to encourage customers to visit and stay in their store. These include Target, Ikea, McDonald's and US based retailers Walgreens, Kohl's and Kroger.

For many daily driving journeys an EV could deliver the same or better performance as a traditional petrol-driven car.

5.3 Who are the key target customers?

Market research in the US and by CSIRO suggests some demographic and geographic factors are correlated with EV ownership. Demographic factors include higher household income and education levels.[98] Geographic factors that mitigate increased uptake of EVs include proximity to large urban centres, availability of off street parking and more than one car per household. The CSIRO has estimated that urban areas have three times the proportional uptake of EVs when compared to regional areas.[99]

The CSIRO's analysis of EV uptake in Victoria, found that early adopters of EVs are likely to be similar to the early adopters of hybrid vehicles.[100] Studies have found that early hybrid purchasers had higher average incomes, higher levels of education, high technology skills and are generally older than the average car buyer.[101, 102, 103] A survey of California EV drivers found similar results.[104]

The Victorian EV Trial based its assessment of potential early adopters of EVs on similar criteria. These were:

- Household weekly normalised income of $1052 or higher (top quartile);
- At least one adult member of the household with a bachelor degree or higher;
- Households with broadband internet access (as a proxy for technological skills); and
- Households with two or more vehicles.

The esaa has conducted its own analysis of which suburbs in Australia's capital cities may be suitable for early EV adopters using data from the 2011 Census. The criteria assessed were:

- Distance from CBD
- Proportion of separate houses (Separate houses are used as a proxy for access to a garage or off street parking)
- Proportion of households with 2 or more vehicles.

Suburbs were scored out of 2 for each criterion to give a total score from 0 to 6. The scoring was assessed as follows:

- Distance
    - o 0–30km from CBD, 2 points
    - o 30–50km from CBD, 1 point
    - o More than 50km, 0 points
- Proportion of separate houses
    - o Greater than 70 per cent, 2 points
    - o Between 40 and 70 per cent, 1 point
    - o Less than 40 per cent, 0 points
- Proportion of households with 2 or more vehicles
    - o Greater than 60 per cent, 2 points
    - o Between 40 and 60 per cent, 1 point
    - o Less than 40 per cent, 0 points

Based on this, 5 of the most suitable potential EV suburbs in each capital city are:

City	Suburbs
Sydney	Baulkham Hills, Frenchs Forest, Kellyville, Menai, Terrey Hills
Melbourne	Balwyn North, Derrimut, Greensborough, Ivanhoe East, Point Cook
Brisbane	Bridgeman Downs, The Gap, North Lakes, Carindale, Upper Brookfield
Perth	Canning Vale, City Beach, Duncraig, Karrinyup, Nedlands
Adelaide	Aberfoyle Park, Athelstone, Beaumont, Crafers, Happy Valley
Hobart	Acton Park, Collinsvale, Howden, Tolmans Hill, Roches Beach
Canberra	Greenleigh, O'Malley, Fadden, Macarthur, Giralang

Source: esaa

Contrary to what many people would expect, 'hip' inner urban suburbs like Fitzroy, New Farm or Newtown are less suited to uptake of EVs because of the relatively small proportion of off-street recharging capacity and houses with two or more vehicles. These two criteria appear to be important guides to identifying early adopters of EVs. On the other hand, such suburbs could be promising markets for electric car share schemes, which would enable users to get the EV "experience" without having to purchase one. This could then facilitate take-up of EVs at a different stage of life, when the hipsters move further out to buy a house.

Maps showing the distribution of suburbs based on their scores are available at Appendix C.

In Sydney, the most likely area for an EV market to develop appears to be on the north shore where most houses are free-standing and large proportions have two or more vehicles. In contrast, suburbs with these characteristics in Melbourne are largely on the fringe of a 20km radius from the CBD.

Due to their higher upfront costs and potentially lower ongoing fuel costs, EVs could also be an attractive option for retirees who place a premium on low operating costs.

[98] CSIRO Electric Driveway Project, *Social Study on Attitudes, Drivers and Barriers to the Uptake of Electric Vehicles*, 2011, p. 9.

[99] CSIRO, (2012) *Spatial Modelling of Electric Vehicle Charging Demand and Impacts on Peak Electrical Loads in Victoria.*

[100] Stephan Gallon, *Who Will Buy Tomorrow's Electric Vehicles?* R.L. Polk & Co. September 2009.

[101] Klein J., 2007, *Why people really buy hybrids*, Topline Strategy Group http://www.toplinestrategy.com/Topline_Strategy_Report_Why_People_Really_Buy_Hybrids.pdf.

[102] Scarborough Research, 2007, Hybrid Vehicle Owners are Wealthy, Active, Educated and Overwhelmingly Democratic, According to Scarborough Research, http://www.scarborough.com/press_releases/Hybrid%20FINAL%2012.4.07.pdf.

[103] De Haan P., Peters A. and Mueller M., 2006, Comparison of buyers of hybrid and conventional internal combustion engine automobiles: Characteristics, preferences and previously owned vehicles, Transportation Research Record: Journal of the Transportation Research Board, No. 1983, Transportation Research Board of the National Academies,Washington, D.C.

[104] California Center for Sustainable Energy, *California Plug-in Electric Vehicle Owner Survey*, May 2013.

6 Policy enablers for electric vehicles

In the US, California has more incentives for EVs than any other state[105] and the strongest uptake of EVs.

Australian governments have largely lagged behind our international counterparts in providing policies to support the development of an EV market. Industry stakeholders identified this as one of the main reasons EVs have not reached the 'tipping point' into mainstream adoption in Australia.

Past and present government initiatives to support EVs are detailed in Table 6.1.

Table 6.1: Government support for EVs in Australia

Initiative/State	**Discussion**
Federal Government	
Green Car Innovation Fund	This Fund was expected to provide a subsidy of $1 in every $3 of investment in projects to enhance the commercialisation of emissions-reducing vehicles. The Fund was cancelled in 2011 due to budgetary constraints.
Green Vehicle Guide	A consumer choice tool, assisting consumers to purchase 'green' vehicles.
Clean Energy Future	As well as the carbon tax, a number of schemes associated with the Clean Energy Policy could assist in promoting EVs through support for research and development.
Mandatory vehicle CO_2 targets	Due to commence in mid-2013, mandatory emissions targets will be of strong benefit to electric and hybrid vehicles.
Energy White Paper	Sets out the previous Government's strategy for alternative transport fuels in Australia. Electric vehicles are emphasised as one of the emerging technologies to be supported, as they generate emissions savings from electricity. While the type of support is not made expressly clear, the development of EVs coincides with the one of the objectives of the Paper, which is to reduce greenhouse gas emissions and use energy sustainably. The new Coalition government is likely to develop their own Energy White Paper.
State Governments	
NSW	• Running small scale EV trials (including buses) • Legislated requirement to increase the number of hybrid vehicles in the Government fleet
ACT	• Recently cancelled an initiative with Better Place to install recharge points in Canberra
VIC	• Department of Transport completed an EV trial to inform consumers and policymakers of the benefits of EVs • Hybrid bus trial, completed in 2011, the trial tested two hybrid electric buses in the Victorian fleet • Purchases of hybrid vehicles for Government fleets • $100 annual registration discount that applies to electric and hybrid vehicles
QLD	• Small scale EV trial • 15% discount on taxi licences if a low emissions vehicle is used
TAS	• Committed to support the installation of EV charge stations in the Hobart metropolitan area • Electric vehicles are mentioned as development opportunities in Tasmania's 2011 Renewable Energy Strategy[106]
WA	• In 2011, the WA Department of Transport committed to participating in WA's first large-scale EV trial, using converted internal combustion vehicles

Source: ABMARC (2012)

** Note: No Federal Government support currently exists for the installation of refuelling infrastructure. Very limited information is currently available for EV schemes in the Northern Territory.*

This report does not aim to specify which policies should be introduced. Rather, the esaa seeks to start a discussion around whether support for EVs is justified and if so, which kinds of policies could be considered.

6.1 Price and cost enablers

Our research has identified the following enablers that could be used to overcome the high price premium and act as incentives to stimulate EV uptake in Australia. We are not suggesting that these be adopted immediately, but rather, they be used to begin a discussion around how EVs could be supported. These policy measures have been successful in stimulating demand for EVs in a number of international markets:

- Purchase price subsidies for consumers, as was applied for diesel technology when it was a developing industry
- 'Feebates' which involve increasing the purchase price of conventional fuels, such as petrol excise tax increases
- Discounts and rebates on registration and other taxes

A Luxury Car Tax (LCT) applies to Australian vehicles priced above $59,133, or $75,375 for fuel efficient vehicles (fuel consumption of seven litres or less per 100 kilometres). As such, this tax is unlikely to apply to small EVs whose recommended retail prices fall below this threshold. However, the LCT applies to a premium EV. Accordingly, exempting EVs from LCT could potentially improve the rate of adoption of EVs in Australia.

In addition to the LCT, imported vehicles are subject to a 5 per cent customs duty, levied against the Australian Customs' valuation of the vehicle. Removing or lowering this duty for EVs could take some pressure off the purchase price and stimulate uptake.

Granting on-road privileges to EV users could also help stimulate uptake. Such privileges might include transit lane access for EVs, or designated EV parking spaces in metropolitan areas.

A summary of international support to lower the price of EVs is provided in Table 6.2.

Table 6.2: Examples of international price support for EVs

Country	Financial incentive
USA	A federal tax rebate of between US$2500–US$7500 is available for plug-in hybrid vehicle purchases, to be phased out after 200,000 vehicles are sold.[107] State credits available to purchasers include:[108] 1. $2500 for light-duty zero emission plug-in vehicles in California 2. State sales tax exemptions for vehicles, vehicle power sources and associated parts in Colorado 3. Income tax credit of $667, plus $111 if the vehicle has at least 5 kWh of battery capacity, and an additional $111 for each additional kWh, to a maximum value of $2000, in South Carolina
Canada	Incentives are available from federal and provincial governments. For example :[109] • Quebec – Rebates of between CAN$4500–$8000 for EVs, as well as $500 for hybrid EVs • Ontario – From 1 July 2010, purchase rebates offered of $5000–$8500, for battery capacities of 4 kWh–17 kWh, respectively • British Columbia – $14.3 million Clean Energy Vehicle Program, including purchase rebates of $5000 per vehicle, and $500 rebates for the installation of in-home charging infrastructure
Japan	Purchase subsidies of up to 100,000 yen (approximately AU$1040) for the purchase of a standard low-emissions vehicle, as well as automobile and sales tax reductions[110]
France	Maintains a 'bonus-malus' system which rewards purchasers of EVs with a purchase bonus, and penalises purchasers relatively high-emissions vehicles. The bonus in 2013 is €7000 (approximately AU$9000) for vehicles with between 0–20 g of CO_2/km. Conversely, a vehicle that emits more than 201 g/km is penalised €6000[111]
Spain	€6000 (approximately AU$7600) maximum purchase rebate available under the SITVE scheme, to November 2012[112]
Norway	Annual registration fee of just 45 KR (approximately AU$60), preferential access to bus lanes and toll road concessions, exemptions from car tax and VAT[113]
Denmark	Free parking in cities, exemption from environment and 180% car tax applied to internal combustion vehicles[114]
Sweden	Low or zero carbon emission vehicles receive a 10,000 SEK (approximately AU$1500) subsidy, after owning the vehicle for 6 months, as well as tax exemptions for electric and hybrid vehicles. Subsidies are also available to assist refuelling stations supplying renewable fuel[115]
Netherlands	Deductions on vehicle registration tax, exemptions from purchase and congestion taxes[116]
Greece	Electric vehicles are exempt from road and car registration taxes[117]

6.2 Charge time and availability enablers

Due to the limited number of EVs on the road in Australia, there is at present no guaranteed income for charging infrastructure providers. Accordingly, to support investment in charging infrastructure, government support for upfront capital or fixed revenue agreements are needed to ensure infrastructure providers have the incentive to enter the Australian market.

In the US, there is support for charging infrastructure providers. The Texas Government, for example, has partnered with local energy providers to offer rebates to purchasers of plug-in EVs on the cost of installing home charging infrastructure.[118]

AECOM suggested that increased infrastructure availability would be likely to ‘significantly increase’ EV uptake in Australia, however, vehicle manufacturers acknowledge the car industry must drive the uptake of EVs, and to do this, they require government assistance. Electric vehicles can still function with limited charge infrastructure, whereas infrastructure providers cannot manage without a sufficiently high number of EVs on the roads.

Government support for research and development into battery technology could expedite improvements in vehicle range. In addition, battery leasing business models such as Better Place have the potential to shield consumers from range anxiety and other battery capacity issues, though their commercial viability is in question.

6.3 Other enablers

6.3.1 Demand side

It is essential that EV users are able to take advantage of TOU tariffs to help stimulate demand. Customers would benefit from lower electricity rates for charging their EVs at non-peak times. Given that there are clear economic benefits in greater take-up of flexible pricing increasing interest and shift towards customer choice as a driver for smart metering and TOU tariffs in the National Electricity Market and in Western Australia, there are clear synergies for the EV industry.

In California, High Occupancy Vehicle Lanes (HOV lanes) exemptions that provide access for low emissions vehicles have been introduced. This has proved an excellent incentive for EV uptake. Other low cost, demand side incentives include free parking for EVs, additional council parking permits, waiving congestion charges and parking permit fees. All of these incentives could be tiered to a CO_2 level to encourage low emissions vehicle uptake.

Information campaigns aimed at overcoming generic concerns about EVs including range, safety and performance are a relatively low cost strategy that could be employed by governments and industry.[119] They could also be used to educate consumers about the ‘whole of life’ cost of owning and operating an EV.

The interoperability of charging infrastructure and different vehicle makes is important. Stakeholders suggested that standards for new vehicle technology are best taken up by countries with greater potential demand in the early adoption phases. Nevertheless some progress has been made on Australian EV standards.

Opportunities for consumers to experience driving an EV before committing to purchase would be helpful. ‘Try before you buy’ schemes have effective in other countries. These schemes allow public fleets to enter into short term leases which can be extended or converted into sales upon expiration. Similarly, car share schemes or rental fleets could provide similar opportunities for consumers. This gives customers the opportunity to experience an EV, and overcome any potential misconceptions about vehicle performance.

In the longer term, Vehicle to Grid technology could also be an extremely beneficial EV market driver, which is discussed further in sections 4.2 and 5.2.1. Vehicle to Grid technology allows an EV to deliver surplus electricity back into the grid at times of peak demand. Along with generating improvements in energy system efficiency, Vehicle to Grid technology could potentially also be used in emergencies to enable EVs to act as portable generators to power a house, which presents another marketing angle. EV batteries could even be marketed as a camping vehicle feature.

6.3.2 Supply side

Manufacturing and research and development grants could stimulate the Australian automotive industry to begin developing EVs locally. Other research and development grants might allow vehicle manufacturers to research Vehicle to Grid technology more extensively, generating energy and cost savings for the grid and the user.

[105] AFDC, *Laws and Incentive Data*, Alternative Fuels Data Center. Last accessed 31 July 2013.

[106] Tasmanian Renewable Energy Industry Development Board, (2011), *Advice to the Tasmanian Government on a Tasmanian Renewable Energy Strategy*, from http://www.development.tas.gov.au/__data/assets/pdf_file/0015/47121/DEDTA_TasRenewEnergyStrat.pdf. Retrieved 8 May 2013.

[107] US Department of Energy, (2013), from http://www.afdc.energy.gov/laws/law/US/409. Retrieved 15 May 2013.

[108] US Department of Energy, (2013), from http://www.afdc.energy.gov/laws/. Retrieved 15 May 2013.

[109] Tesla Motors (2013), from http://www.teslamotors.com/en_CA/incentives/CA. Retrieved 15 May 2013.

[110] Japan Automobile Manufacturers Association (n.d.)., *Japanese Government Incentives for the Purchase of Environmentally Friendly Vehicles*, from http://jama.org/pdf/FactSheet10-2009-09-24.pdf. Retrieved 16 April 2013.

[111] Ministère de l'écologie, du développement durable et de l'énergie (2013), *Bonus-Malus*., retrieved from http://www.developpement-durable.gouv.fr/Bonus-Malus-2013.

[112] Tesla Motors (2013), from http://www.teslamotors.com/incentives/ES/. Retrieved 16 April 2013.

[113] Tesla Motors (2013), from http://www.teslamotors.com/incentives/NO/. Retrieved 16 April 2013.

[114] Tesla Motors (2013), from http://www.teslamotors.com/incentives/DK/. Retrieved 16 April 2013.

[115] Clean Vehicle Europe, (2013), from http://www.cleanvehicle.eu/info-per-country-and-eu-policy/member-states/sweden/national-level/. Retrieved 16 April 2013.

[116] Clean Vehicle Europe, (2013), from http://www.cleanvehicle.eu/info-per-country-and-eu-policy/member-states/netherlands/national-level/. Retrieved 16 April 2013.

[117] Clean Vehicle Europe, (2013), from http://www.cleanvehicle.eu/info-per-country-and-eu-policy/member-states/greece/national-level/. Retrieved 16 April 2013.

[118] More information can be found at http://www.afdc.energy.gov/laws/law/TX/8625.

[119] For more information about consumer perceptions of EVs, see Deloitte, (2011), *Unplugged: Electric vehicle realities versus consumer expectations.*

Appendix A: International electric vehicle uptake

Developments in international EV uptake, by country

Country (City)	Comment
United Kingdom	• In 2012, uptake increased by 58% from 2011. • A £5000 grant was introduced for EV owners in January 2011. • There is an increasing variety of models available, with more to come. • Battery leasing programs have lowered costs to consumers in the UK. • The Plugged in Places program matches the funding of private investors to install EV charging points. £30 million has been set aside for the scheme. • Electric vehicles still comprise less than 1% of the total country's fleet, and 85% of current EV sales in the North East region were to businesses, suggesting penetration is still low in small consumer markets.
USA	• The US has a Federal government tax credit of up to $7500 for plug-in EV purchases. 0.1% of Los Angeles' total fleet is electric, although this is expected to increase from 2000 to 80,000 by 2015, with a California-wide target of 1.4 million EVs. • California also offers High-Occupancy Vehicle (HOV) lane (lanes restricted for use by specific vehicles) preferences for single occupant Zero-Emission Vehicles, and will mandate a 10% reduction in fuel carbon intensity on all fuels by 2020. • The US Federal Government appears to no longer support its original goal of one million electric cars in the US by 2015. It now feels these goals are too ambitious and that consumer support doesn't exist across the country as a whole.[120] The revised objective is to promote alternative technology vehicles (including EVs), and reduce their purchase price over the next nine years.[121]
China	• In 2009, EVs were identified as one of nine new industrialisation priority projects in Shanghai. The city offers rebates for plug-in hybrid and battery EVs, in addition to national rebates of approximately $7700 and $9000, respectively. • National goal of 500,000 plug-in and battery EVs by 2015.
Japan	• Pure EVs represent 0.16% of new car sales from 2009 to 2012, that is, 28,000 were sold over this period. Considering plug-in hybrid EVs as well, this figure increases to 41,000. • National target of 20% of all vehicle sales to be EV/plug-in hybrid EV, 2 million normal charge points, and 5000 fast charge points, by 2020. • Purchase price discounts , tax benefits for purchasers. • Japanese manufacturer Toyota announced in 2012 that it would scale back its sales strategy for its eQ minicar, saying it has 'misread' market demand and battery technology predictions.[122]

Country (City)	**Comment**
Netherlands (Amsterdam)	• Market for EVs is still developing. In Amsterdam, EVs represent just 0.3% of the total fleet Countrywide EV targets: o 2015: 20,000 o 2020: 200,000 o 2025: 1 million • Electric vehicles are exempt from registration taxes. • 350 public charging stations (highest rate per inhabitant in the world), aiming for 1000 by the end of 2013.
Spain	• Pure EVs represented just 0.05% of Spain's total fleet in 2012. • National EV/plug-in hybrid EV target for 2014: 250,000 EV/plug-in hybrid EV. • Government aims to install 4400 slow charging stations, and 20 fast charging stations by 2014. • Electric vehicle users pay lower electricity tax, and receive priority parking and purchase subsidies. • 50% of the powered two wheeler fleet is expected to be electric by 2014.
Germany (Berlin)	• Germany had 4541 EV/plug-in hybrid EVs in 2012, with a 2020 target of 1 million. • To October 2012, EV sales for the year were 2956, or just 0.096% of the total car industry. However, sales to October 2012 increased 37% from total sales for 2011. • Currently, there are approximately 350 EVs in Berlin (0.03% of total fleet), although this number is targeted to increase to 15,000 by 2015. • Germany's goal is a 640% increase in the number of public charging points in Berlin by 2015 from 2012 levels. • 10 year car tax exemptions, transferable licence plates.
Norway	• The largest electric fleet of any European country, with 8581 on the road in September 2012, projected to be over 10,500 by early 2013. The national goal is to reach 50,000 zero emissions vehicles by 2018.[23] • Substantial demand side incentives, including sales taxes discounts, VAT reductions (which is usually 25% on purchase), and bus lane usage allowances. Norway also applies substantial duties on petroleum. Norwegian electric power provider Ishavskraft is also reportedly working with EV charge manufacturer Delta Electronics to introduce a number of fast chargers in the country.

Source: Electric Vehicle City Casebook, (2012), A look at the global EV movement; Plugged-in Places (2013).

[120] The Economist: Economist Intelligence Unit, (2013), *World fuels: Hybrid harvest*, retrieved from http://viewswire.eiu.com/index.asp?layout=ib3Article&article_id=90142993&pubtypeid=1112462496&country_id=1510000351.

[121] Reuters, (2013), *US backs off goal of one million electric cars by 2015*, retrieved from http://www.reuters.com/article/2013/01/31/us-autos-greencars-chu-idUSBRE90U1B020130131.

[122] Reuters, (2012), *Toyota drops plan for widespread sales of electric car*, retrieved from http://www.reuters.com/article/2012/09/24/us-toyota-electric-idUSBRE88N0CT20120924.

[123] GronnBil,(2013), *Rechargeable vehicles Norway*, retrieved from http://www.gronnbil.no.

Appendix B: Electric vehicle charging specifications

Charge specifications, by level

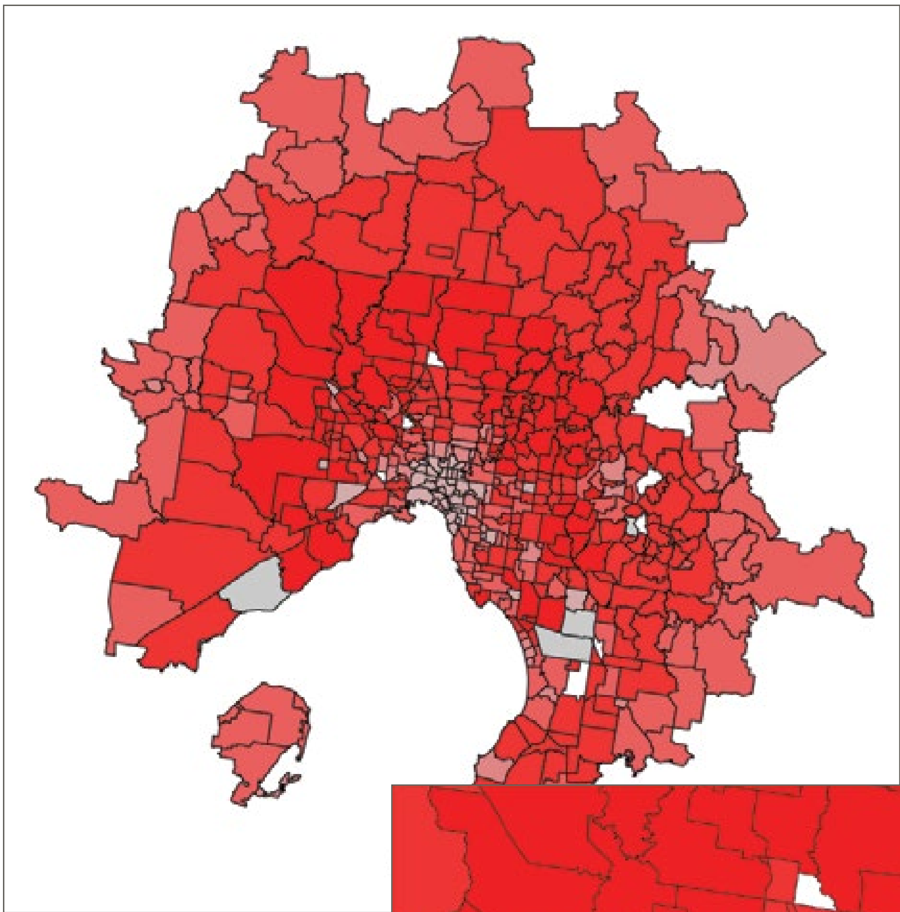
Level	Requirements	Circuit Rating	Power consumption (kW)	Charge rate (km/min)	Charge time for 40km (minutes)
Level 1	Requires a standard power outlet, found in homes.	240AC (single phase)	2.4–3.6	0.2–0.3	133–200
Level 2	Requires EV Supply Equipment to be hard wired into a building's electricity supply.	240V AC (single phase) 32A2	7.7	1.6	63
Level 3	Requires off-board charging to charge the battery directly. High energy requirements mean it is unlikely that recharging would be performed in homes.	415V AC (3-phase) 125–330A (Output 400–700V DC, 125 to 550A)	50–250	4.2–21	2–10

Source: AECOM (2011)

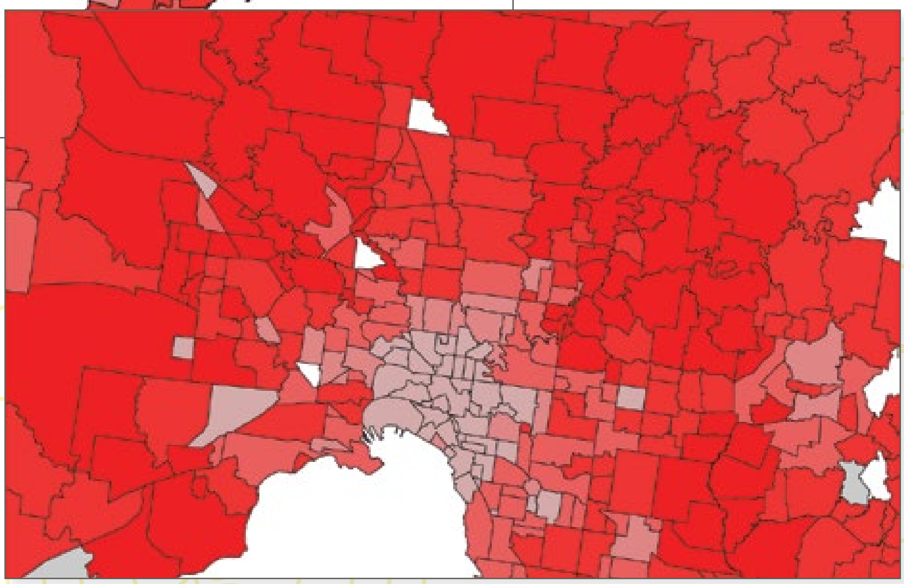
Appendix C: Mapping EV suburbs

The following maps display the suitability of suburbs in each state and territory capital city for EV adoption. Suburbs have been scored from 0 (least suitable) to 6 (most suitable) based on distance to the CBD, the proportion of households with 2 or more vehicles and the proportion of separate houses in the suburb. Bright red indicates that these suburbs could be well suited to EV uptake, while grey suburbs are the last suitable.

Greater Melbourne



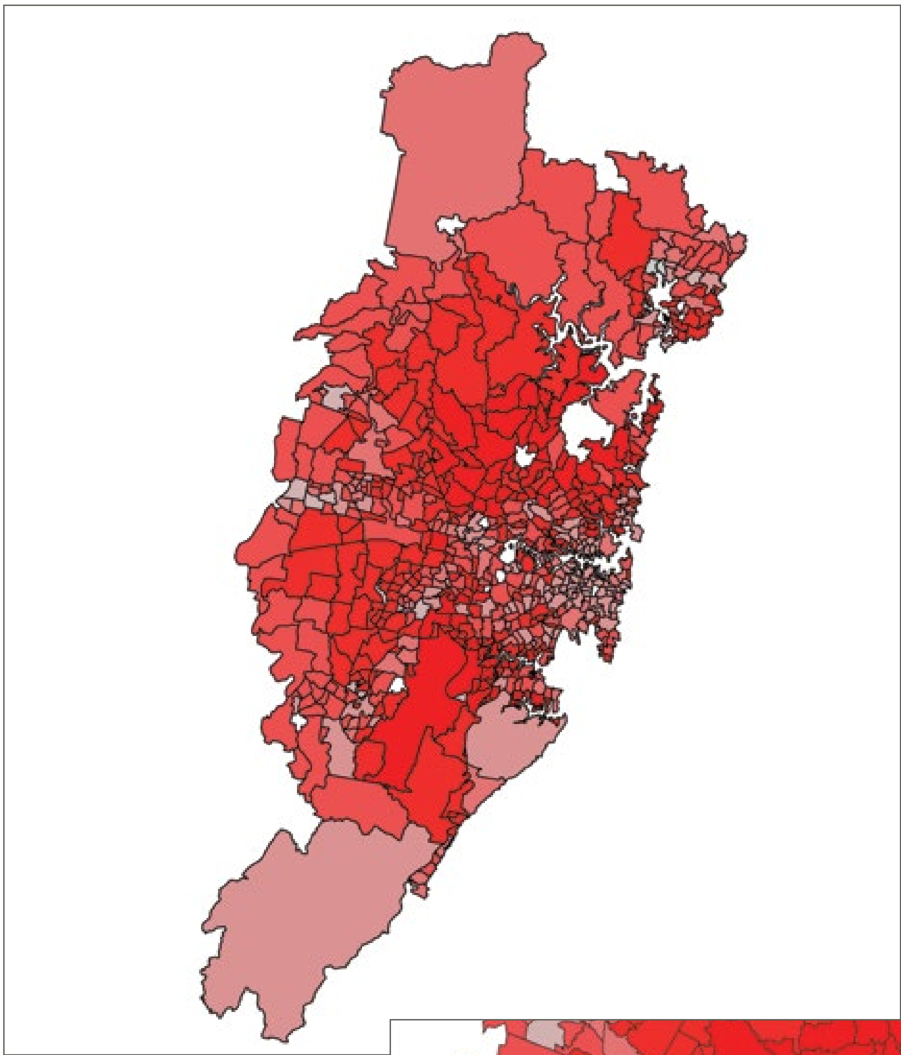
Inner Melbourne



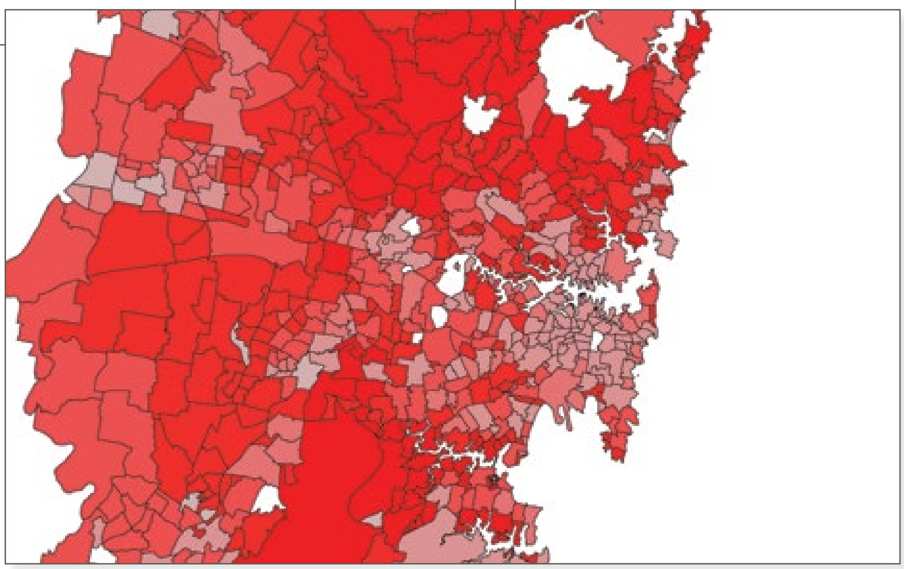
Least Suitable to Most Suitable

1 → 6

Greater Sydney



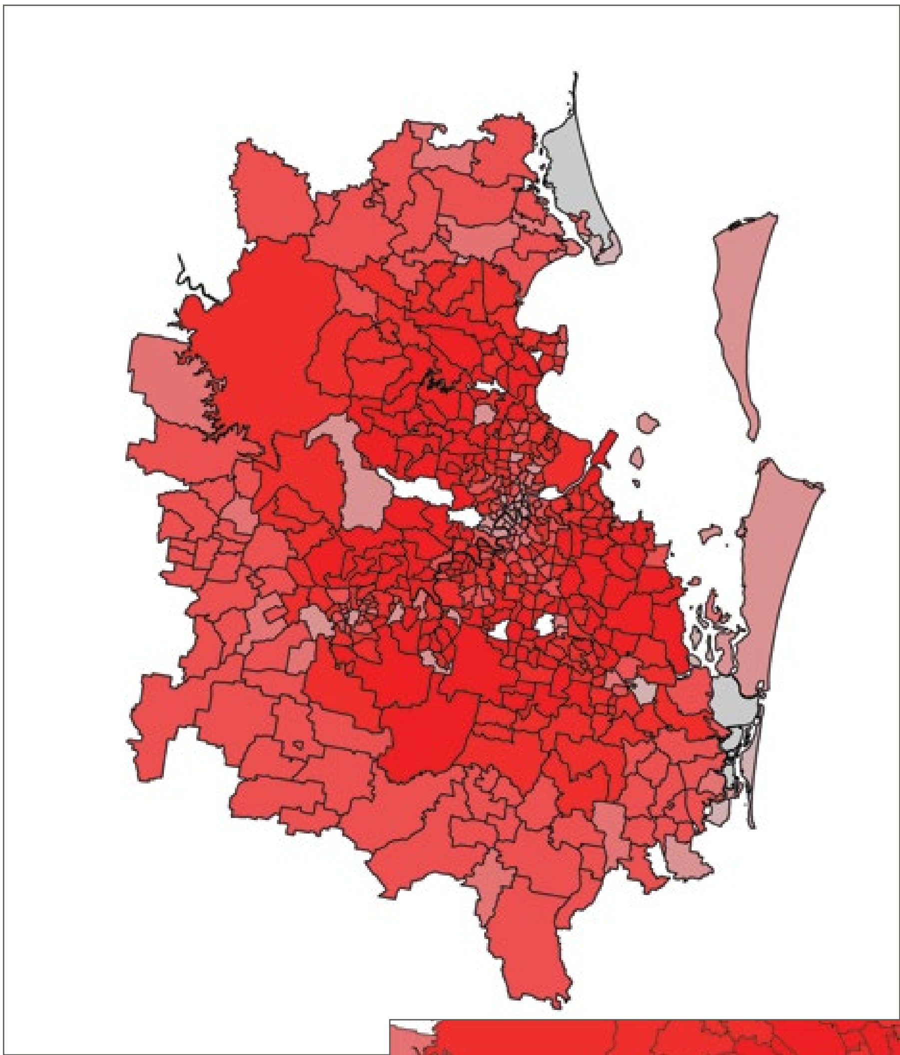
Inner Sydney



Least Suitable to Most Suitable

0 → 6

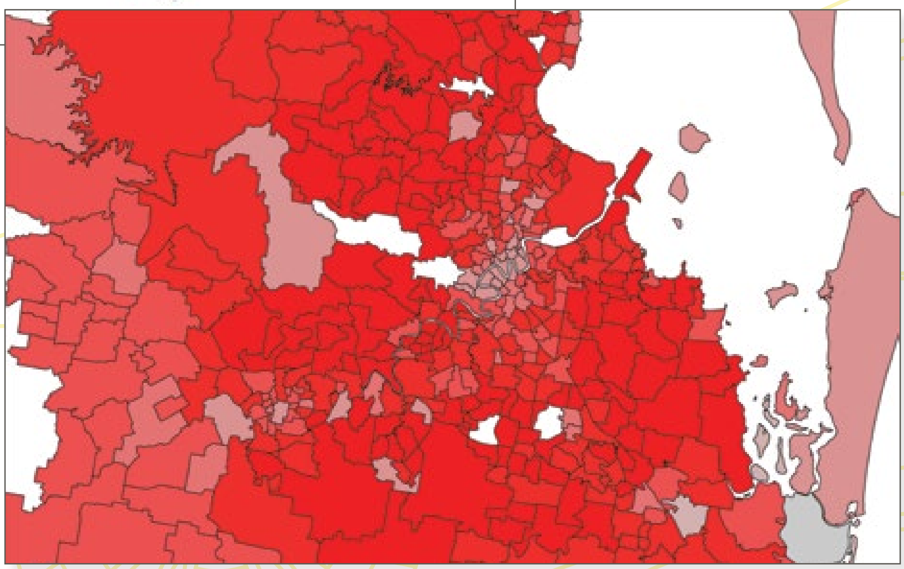
Greater Brisbane



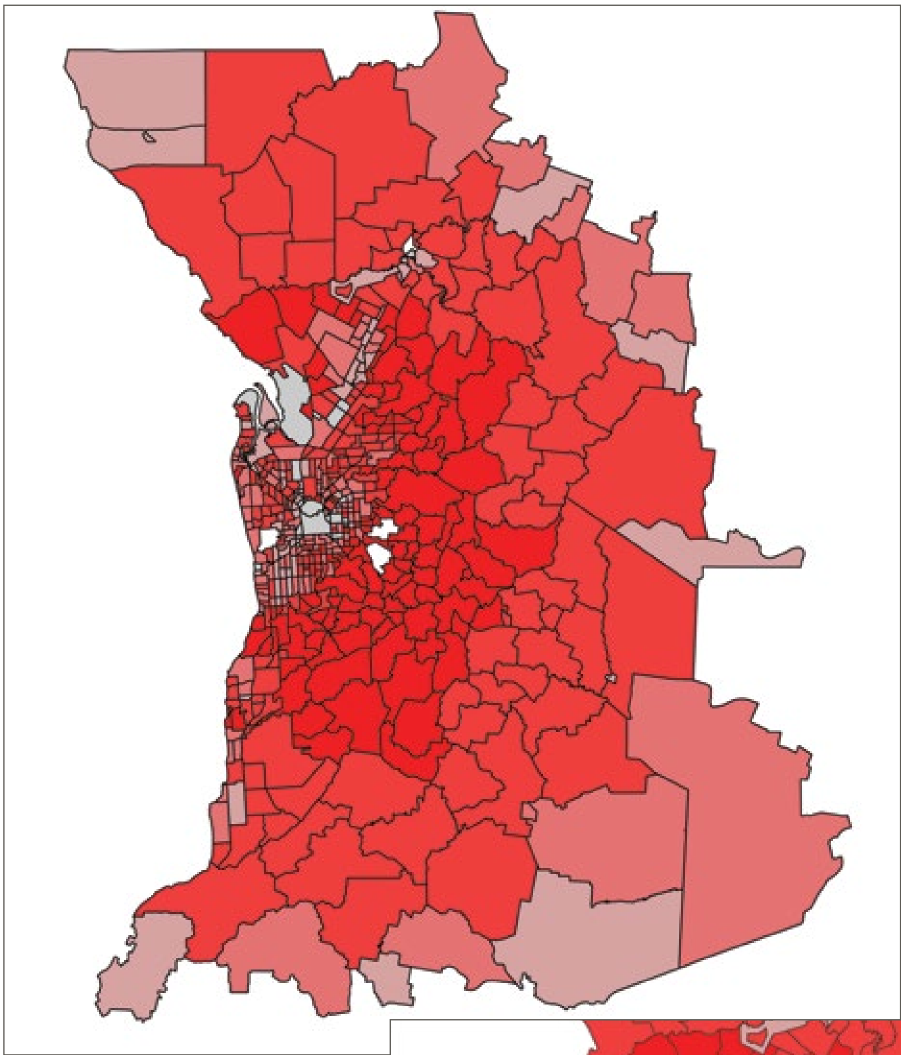
Least Suitable to Most Suitable

0 → 6

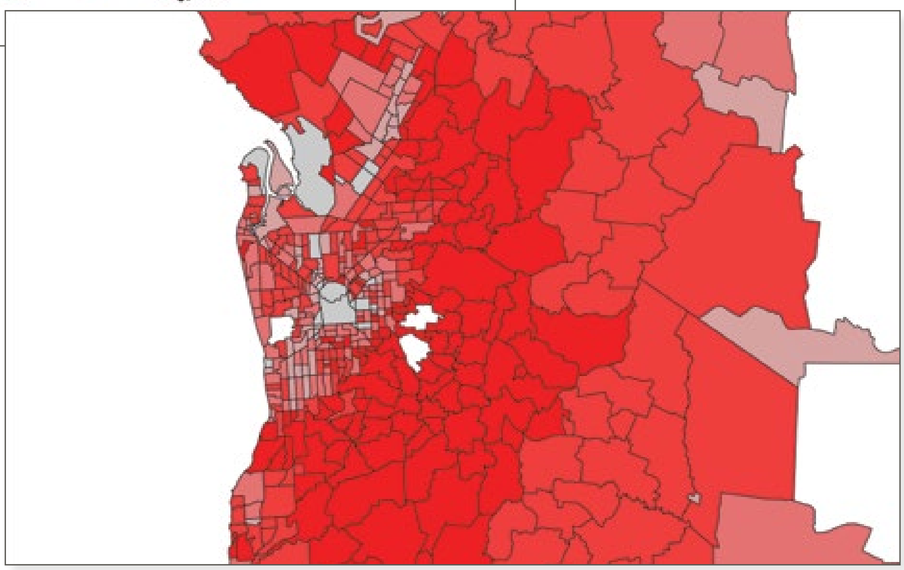
Inner Brisbane



Greater Adelaide



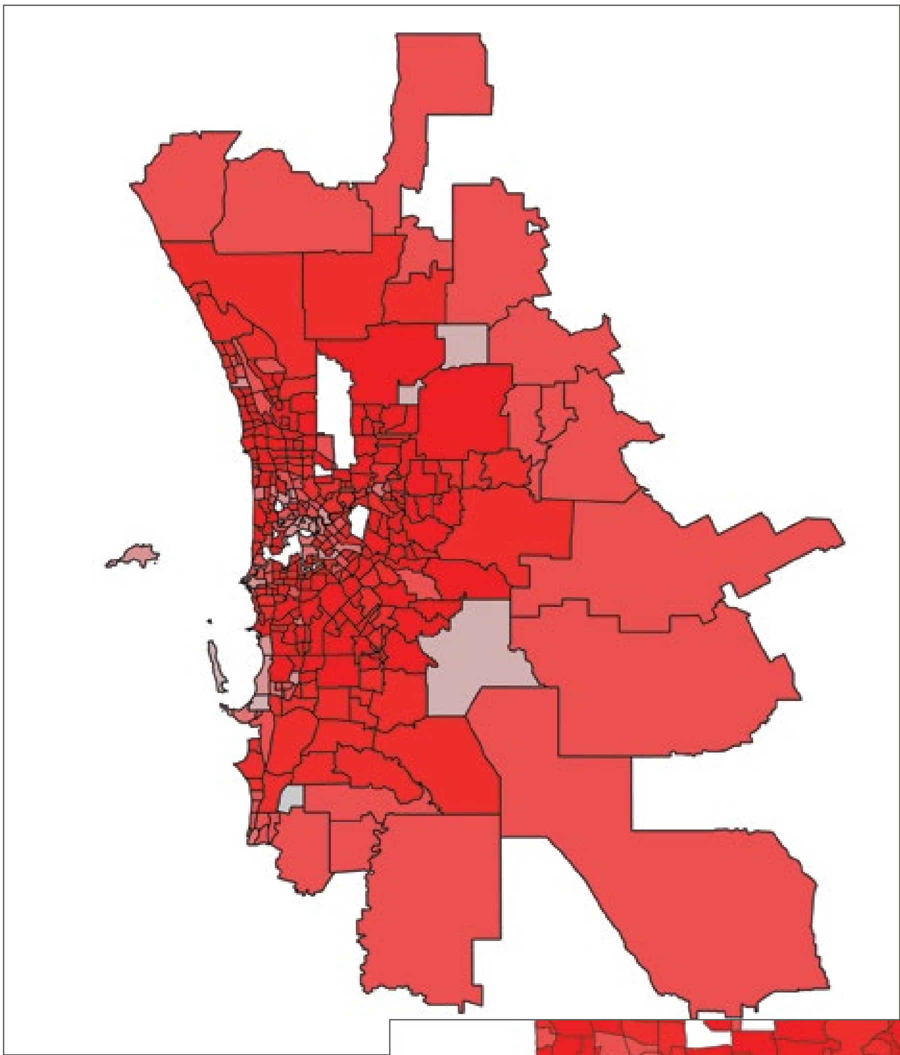
Inner Adelaide



Least Suitable to Most Suitable

2 → 6

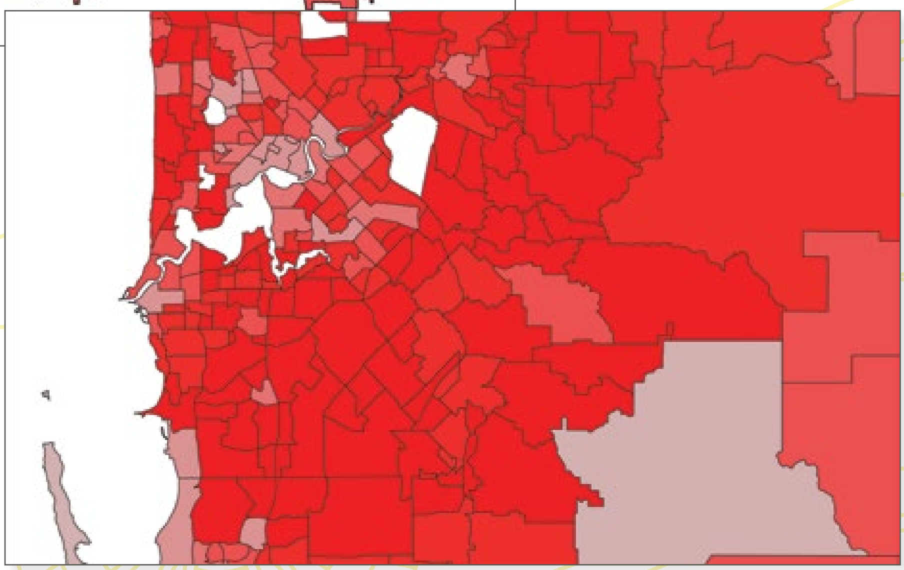
Greater Perth



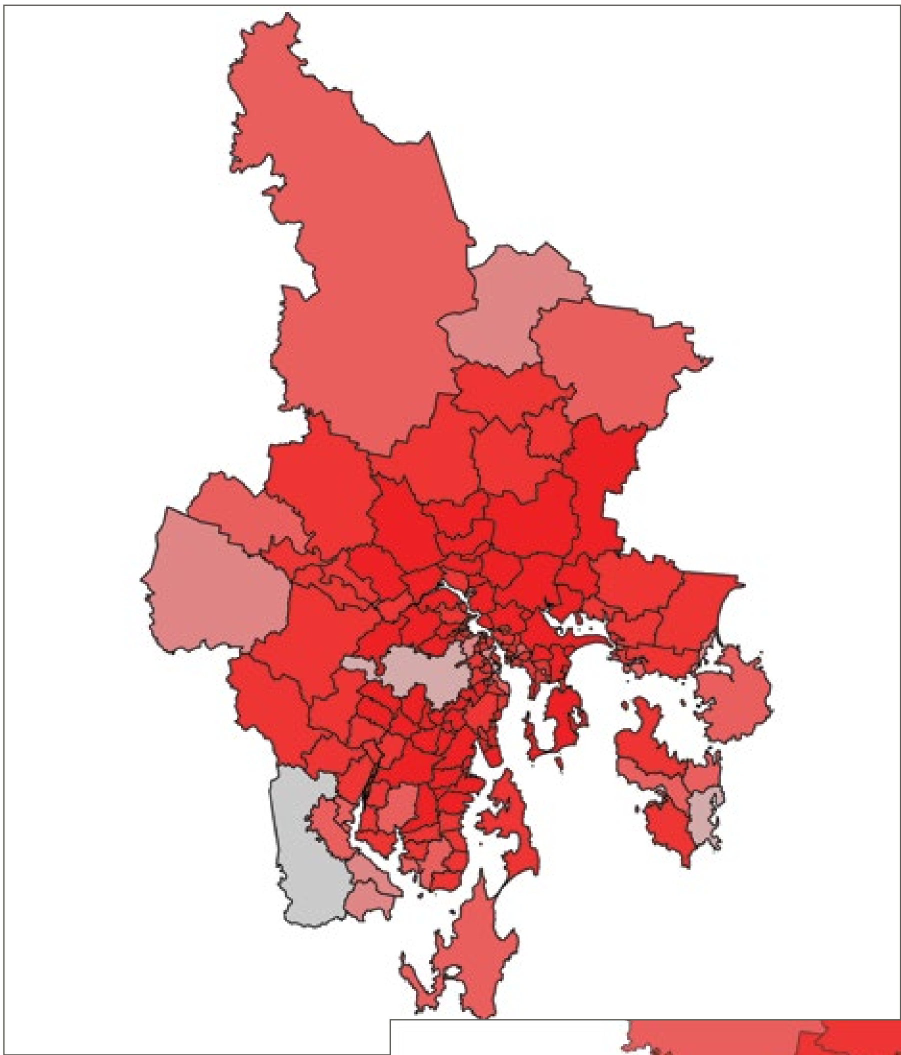
Least Suitable to Most Suitable

0 → 6

Inner Perth



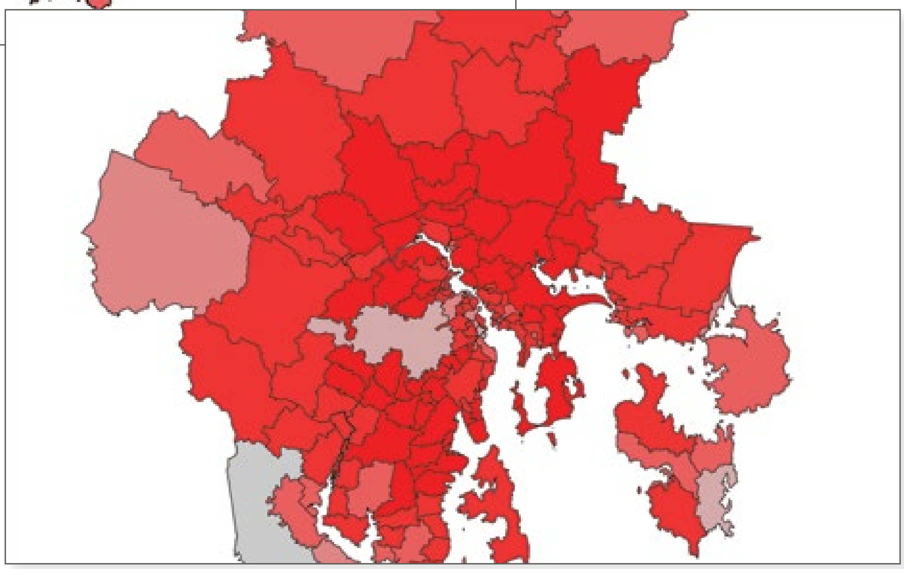
Greater Hobart



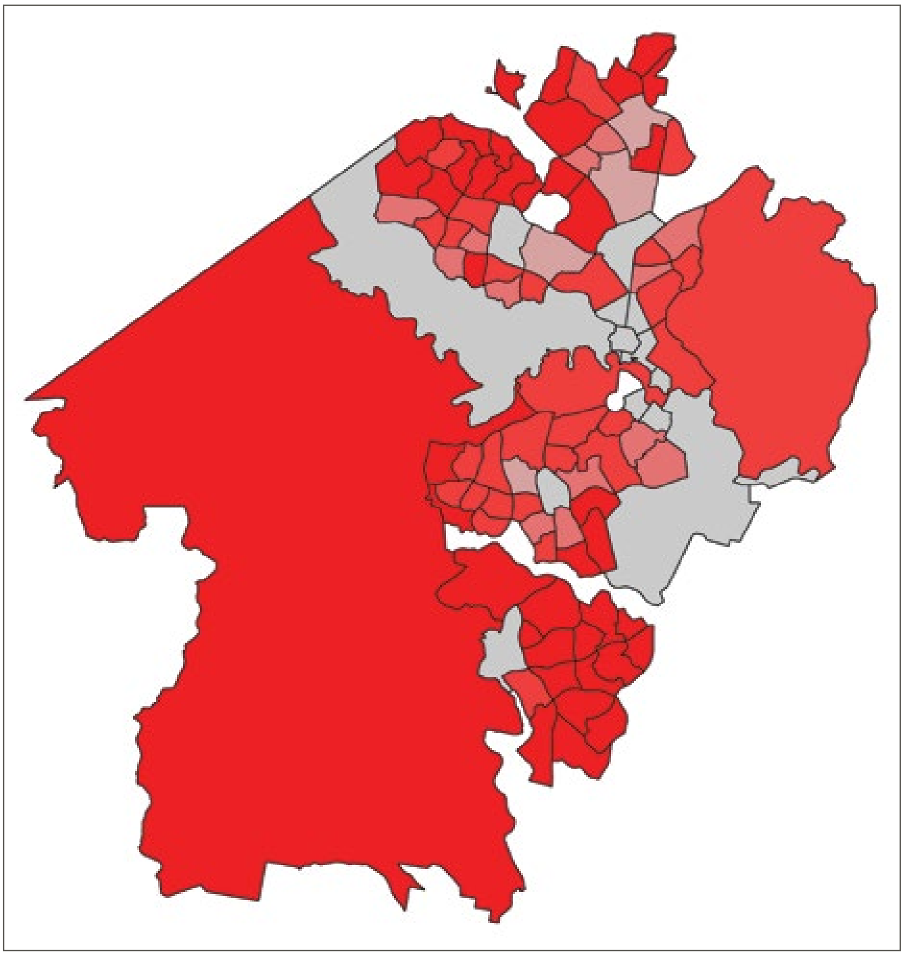
Least Suitable to Most Suitable

1 → 6

Inner Hobart



Canberra



Least Suitable to Most Suitable

2 → 6

Disclaimer

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esaa

GPO Box 1823
Melbourne VIC 3001

T +61 3 9205 3100
www.esaa.com.au