

# CREATING A MARKET

VICTORIAN ELECTRIC  
VEHICLE TRIAL  
MID-TERM REPORT



# EXECUTIVE SUMMARY

With the arrival of electric vehicles onto Victorian roads, we are witnessing the creation of a new market.

Over 80 organisations have taken part in the Victorian Electric Vehicle Trial, providing the foundations of a market worth having.

Electric vehicles are fun to drive and cheap to run. They support local jobs, and create zero emissions when run on renewable energy. By 2040, the state may be over \$20 billion better off as a result of electric vehicle adoption – savings that will go largely in the pockets of Victorian drivers.

However, right now electric vehicles are expensive. Like all new technologies, prices will decrease over time. When mobile phones first arrived in 1987, they cost the equivalent of \$11,000 – around 100 times more than a basic phone costs today. Since 2010 Australian electric vehicle prices have dropped by over 30 per cent, and this is just the beginning.

For households, the technology will work now. During the trial most households used the electric vehicles as their main transport choice, without having to change anything about how or where they travelled. Most Melburnians can drive during the day and charge overnight, when it's cheapest and while they sleep.

Fleet operators successfully used the cars to showcase their environmental credentials. However, concerns about range, charging and vehicle management reduced the appeal of the trial vehicles for corporate fleet applications, even if cost was the main barrier to uptake overall. Workplace charging, where forward-thinking employers provide staff with the means to charge their car at work, may save Victorian commuters thousands of dollars each year.

Electric vehicle charging can be accommodated by Victoria's electricity network. Drivers will charge their vehicles during off-peak periods if they have a financial incentive to do so. Victoria's smart meter roll-out will allow charging to be managed, and may even address other problems by using electric vehicles for energy storage.

Connecting the vehicles to the electricity network is not without its challenges. Households can expect to pay between \$2,000 and \$3,000 for their charging solution. Renters and residents with shared parking will pay even more, and will need to work with their landlord or fellow residents. On average, fleet operators take around 10 weeks to get a charging solution and public charging outlets take even longer. With only a small number of customers for the foreseeable future, public charging is a difficult business proposition despite being a key enabler for electric vehicle adoption.

By 2020, the electric vehicle operating cost advantage is expected to outweigh the purchase price penalty for most Victorian drivers. Before then 'early adopters' will buy the vehicles as a reflection of their interests in technology and the environment, or to gain a marketing advantage for their organisation.



Measures which reduce electric car purchase prices, remove barriers to ownership, improve resale values or allow the vehicles to be driven further will all assist in bringing the 'take-off point' forwards. Raising awareness, understanding and acceptance of the technology will help realise the benefits for electric vehicle take-up sooner.

The results from the trial so far suggest that electric vehicles are likely to be an important part of Victoria's transport future.

The mid-term report explains the what, why, how and when of electric vehicle take-up for Victoria, and highlights the issues and opportunities for future market development:

**Section 1** provides a brief introduction and context to the report.

**Section 2** is an overview of electric vehicle technology.

**Section 3** outlines the trial design including the underlying principles and arrangements.

**Section 4** describes the vehicles and their deployment in households and fleets.

**Section 5** explains the charging infrastructure network experiences and insights.

**Section 6** is a triple bottom line assessment of the electric vehicle market impacts.

**Section 7** details the trial communications program and learnings.

**Section 8** summarises the issues and opportunities observed through the trial.

**Section 9** sets out the direction for the remainder of the project.



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# INTRODUCTION

This report documents the findings up to the half-way point of the Victorian Electric Vehicle Trial. It contains experiences, results and interpretations from the early stages of electric vehicle (EV) market development in Australia.

1



The trial is a \$5 million initiative of the Victorian Government that seeks to understand the process, timelines and barriers for transitioning to electric vehicle technologies. The trial was launched in October 2010 and will run until mid-2014.

On behalf of the Victorian Government, the Department of Transport, Planning and Local Infrastructure (formerly the Department of Transport) is running a trial to ensure that the roll-out of electric vehicles is safe and efficient, and that the needs of all Victorians are taken into account. It considers the effects electric vehicles will have on society and the State's resources. The trial considers people as well as technology. A successful trial will make sure that Victoria becomes an EV-friendly place, and that electric vehicles work for Victoria.

Through the trial the Victorian Government is providing the foundations for the Australian electric vehicle market. The findings will inform all levels of government on the issues and opportunities associated with electric vehicle uptake. This report allows many of the insights gained to be considered alongside the arrival of electric cars from a range of manufacturers from 2013 onwards.

The government's support for this initiative recognises the potential significance of a global trend towards electric vehicles for Victoria's automotive industry and transport system. Unlike many developed economies, Victoria has no previous history of EV technology. The vast majority of Victorians have only experienced electric vehicle technology through non road-going vehicles such as golf-carts or electric wheel-chairs. In considering EV market development, Victoria is effectively a blank canvas.

# BACKGROUND

Electric vehicles (EVs) have started to arrive on Victoria's roads. Most major vehicle manufacturers are now or soon will be delivering EVs into the market.

# 2





In 2012, Mitsubishi, Nissan, and Holden all delivered EVs into Victoria. In addition, Renault, Ford, Toyota, BMW and Porsche all have models in the pipeline.

Answers to some of the more common questions relating to electric vehicles are provided below.

## 2.1 WHAT IS AN ELECTRIC VEHICLE (EV)?

An electric vehicle is any vehicle that uses electricity as energy for propulsion. In simple terms, the main differences between a fully electric vehicle and a conventional Internal Combustion Engine (ICE) vehicle are:

- EVs have an electric motor instead of an ICE
- EVs store energy in a battery rather than a fuel tank
- EVs source energy via a plug and cable rather than a petrol bowser.

Figure 1 shows the functional and operational differences between vehicle types, while Section 2.3 provides further explanation on the different vehicle types available.

## 2.2 WHY ELECTRIC VEHICLES?

Electric vehicles can provide a range of benefits when compared to conventional ICE vehicles:

- Operating cost savings due to the lower costs of electricity relative to liquid fuels, and the higher efficiency and lower maintenance costs of electric drivetrains
- Greenhouse gas emission reduction, particularly when run on renewable energy
- Air quality improvements for populated areas due to the zero tailpipe emissions
- Traffic noise reductions, through the near-silent operation of the electric drivetrain
- Employment benefits through the use of domestically-produced electricity to replace imported oil, and within the automotive industry.

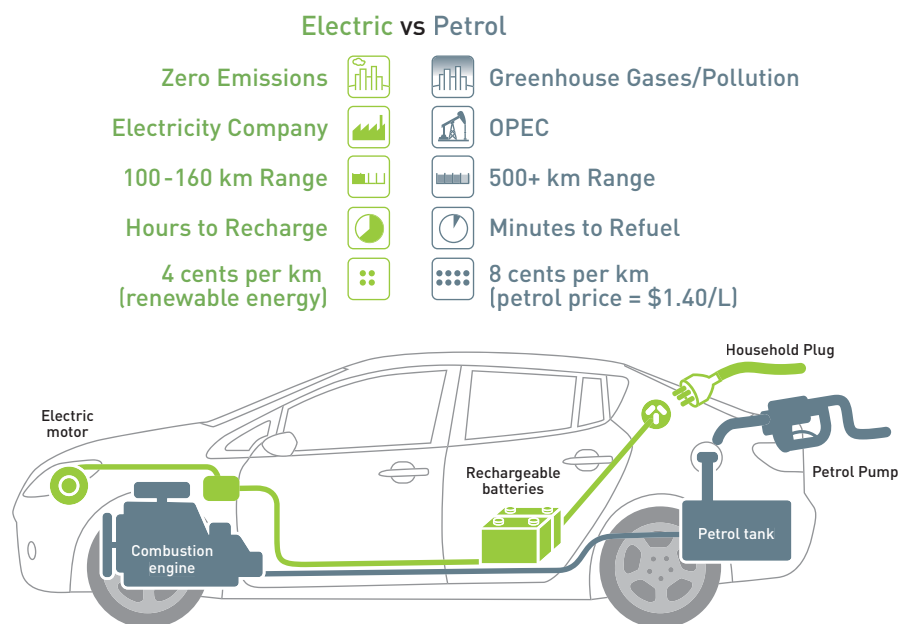


Figure 1. Schematic illustrating the functional and operational differences between electric and conventional petrol vehicles.

Electric vehicles have potential to help Victoria in a variety of ways. This is because:

- Private vehicles account for the significant majority of all travel made in Victoria, both in terms of the number of trips made and the total distance travelled (DOT 2009)
- Transport makes up 18 per cent of Victorian household expenditure (ABS 2011)
- Victoria increasingly relies on oil imports to fuel passenger vehicles (ACIL Tasman 2008)
- Transport makes up 16 per cent of Victoria’s greenhouse gas emissions, with the majority coming from cars (DCC 2007)
- Motor vehicles are the main source of urban air pollution (EPA 2012a)
- Road traffic noise has been identified as the most common noise source in Victoria (EPA 2007)
- Victoria has a competitive advantage in automotive design and manufacture (Invest Vic 2011).

## 2.3 WHAT TYPES OF ELECTRIC VEHICLES ARE AVAILABLE?

There are different types of electric vehicles. They vary according to the extent to which they rely upon electricity as their energy source. The various types can be roughly classified as follows – refer also to Figure 2:

- **Hybrid Electric Vehicles (HEVs)** have been on Victorian roads for over 10 years through cars such as the Toyota Prius, Honda Civic Hybrid and the locally-produced Toyota Camry Hybrid. They use liquid fuel (petrol) as their sole external energy source, but supplement this with electrical energy captured from the braking system and stored in batteries

- **Plug-in Hybrid Electric Vehicles (PHEVs)**, sometimes called Extended-Range Electric Vehicles (EREVs), use both electrical energy and liquid fuel from external sources. They vary in their choice of primary energy source, with the Toyota Prius PHEV biased towards petrol and the Holden Volt favouring electricity. They are easily differentiated from HEVs as they have a plug
- **Battery Electric Vehicles (BEVs)** or fully-electric vehicles, use electrical energy as their sole energy source. BEVs available in the Australian market include the Nissan LEAF and Mitsubishi i-MiEV.

As only PHEVs and BEVs use plugs to source electrical energy, they are collectively known as Plug-in Electric Vehicles (PEVs).

Through the remainder of this paper the term ‘EV’ will be used to denote vehicles which use solely electrical energy (that is, Battery Electric Vehicles described above).

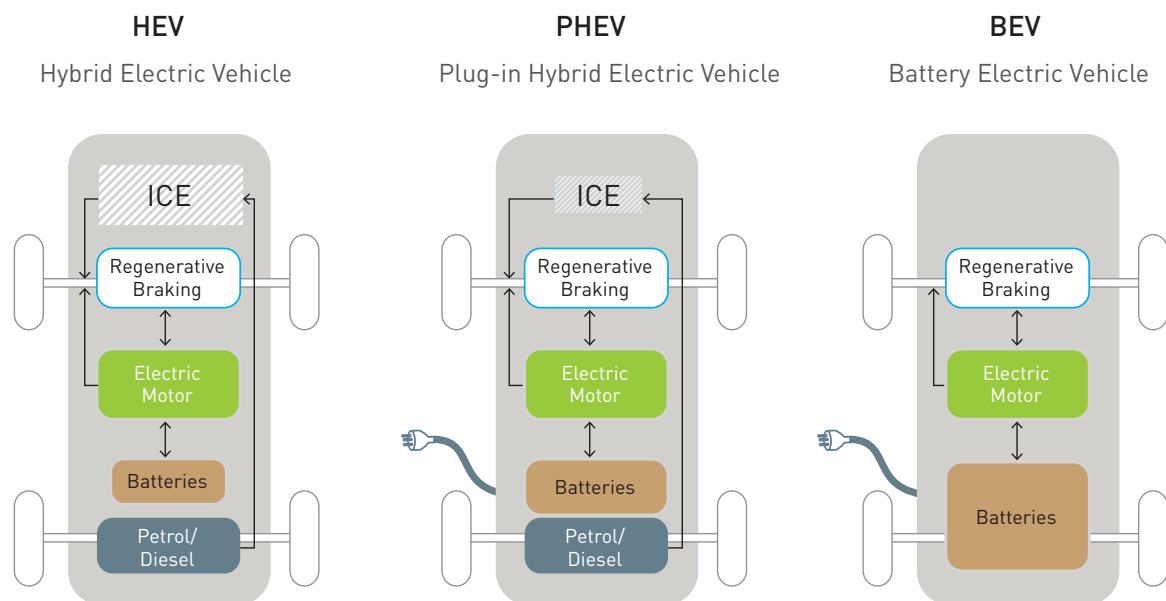


Figure 2. Schematic of the various electric vehicle types.

## 2.4 HOW DOES ELECTRIC VEHICLE CHARGING WORK?

Similar to mobile phones or other portable electronic devices, electric vehicles charge their batteries via a plug into an electrical outlet. Charging creates issues and opportunities in the context of how cars are used.

As they contain large batteries, electric vehicles can take hours to recharge. But as this process can take place unattended, EVs can charge while they're parked, allowing drivers to get on with living life.

Many EVs can be charged more quickly through high-voltage quick chargers, and some EVs will include the ability to swap their depleted batteries for fully charged replacements at dedicated swap stations. In future EVs may be able to use wireless induction-charging similar to electric toothbrushes, however the majority of EV charging in the near-term will use a plug/cable combination as for other electrical appliances.

Charging takes place where electric vehicles park – such as the home, workplace or shopping centre car-parks. As charging occurs unattended, EV drivers can simply arrive at their destination, plug in, and walk away. A simplified/idealised day-in-the-life of a corporate fleet EV based in Melbourne's CBD is shown in Figure 3 to help explain how charging/battery charge management works.

Most electric vehicles also contain the ability to charge significantly more rapidly using high-powered 'quick chargers'. This quick charging capability exists alongside the standard charging described above, and uses dedicated equipment – refer to Figure 4.

With reference to Figure 5, EV charging infrastructure consists of two basic elements:

- **Charging outlet**, which provides the charge management capability and is the hardware from which the connection is made to the vehicle
- **Charging circuit**, which connects the charging outlet to the point of electrical supply.

Charging outlets are proprietary technologies that contain a variety of features that vary across models and suppliers. A charging outlet could be a simple wall-socket, or it may be a fully networked device with enhanced safety, security, damage protection, user identification, data collection and management, energy management, billing capabilities, and information provision including advertising. Charging outlets may be owned by the site owner/occupant, or may be supplied under a service provision agreement by the EV charging service provider.



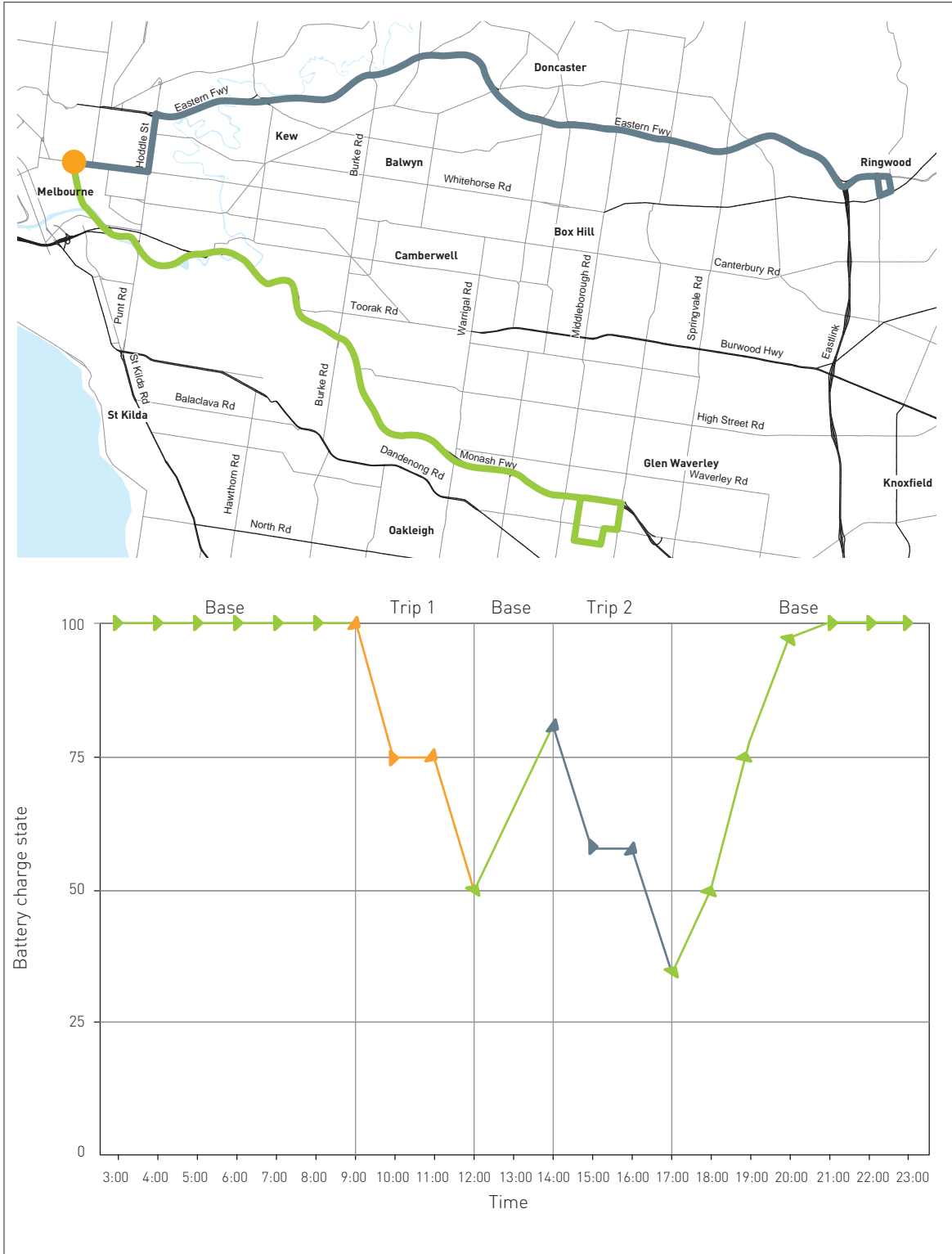


Figure 3. A day-in-the-life of a corporate fleet EV – the map (top) shows the route for two 50 km round-trips taken from Melbourne CBD, while the chart (underneath) shows the battery charge state as the EV completes these journeys along with an ‘opportunity’ charging event between 12 and 2pm and ‘overnight’ charging from 5pm. The figures assume that the EV has a range of around 100 km, and a zero-to-full charging time of 6 hours using standard (240 v / 15 A) charging.

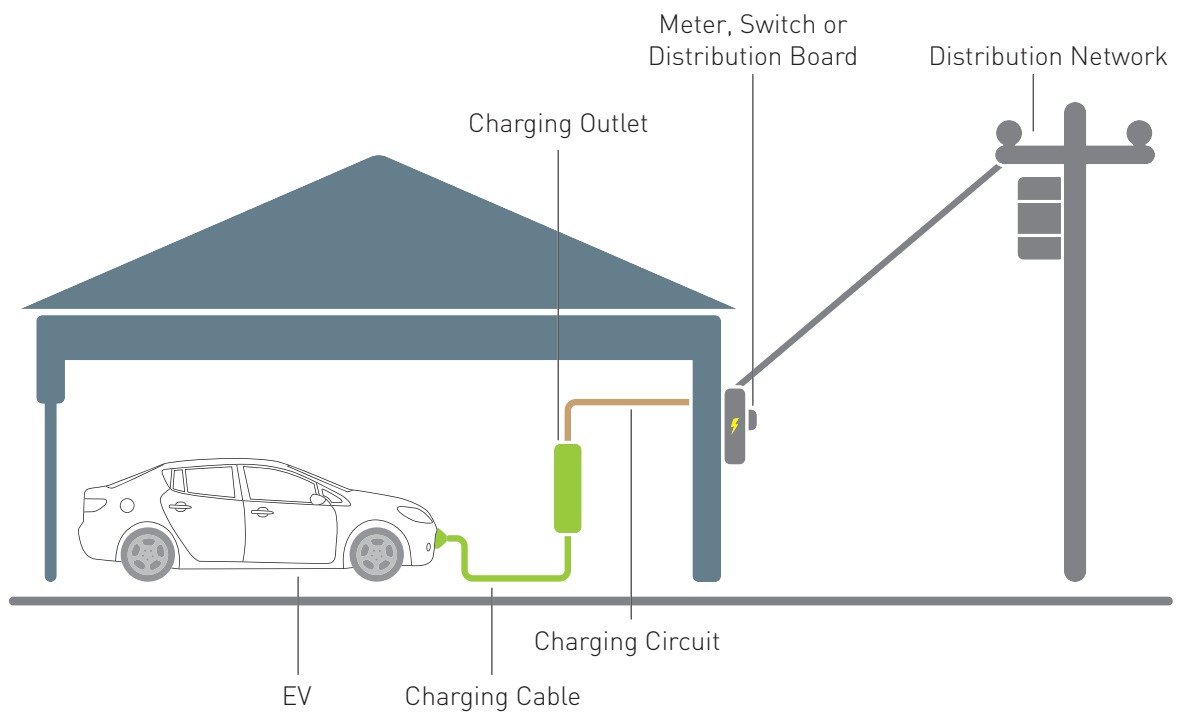


Figure 4 (Top). A Mitsubishi i-MiEV electric vehicle being plugged into a quick charger.

Figure 5 (Above). Electric vehicle charging infrastructure basic description for the purposes of the Victorian Electric Vehicle Trial roll-out.

# TRIAL DESIGN

The Department of Transport, Planning and Local Infrastructure's approach for the Victorian Electric Vehicle Trial initiative recognises the pathways and timelines for market development.

# 3



It has brought together all the pieces of the emerging electric vehicle market and provided participants with a low cost, low risk operating environment. The trial is a test-bed for deployment of new technologies and business models, the learnings from which will help streamline market development.

### 3.1 THE EV ECOSYSTEM

The trial has brought together around 70 corporate participants and 120 households to form the basis of the Victorian (and Australian) electric vehicle market.

As summed up by the following quote, efficient development of an EV market has been portrayed by many in the automotive industry as being dependent upon the presence of a functioning 'EV ecosystem':

*The Chevy Volt is truly coming to life, but preparing the market for electric vehicles also requires capable partners from outside the auto industry. Momentum is building as governments, technology companies, communities and universities are increasingly working together to prepare the market for electric vehicles.*

Ed Peper, then General Motors North America Vice-President for Chevrolet (Green Car Congress 2009)

The trial has adopted the ecosystem model at its foundation. An Expression of Interest (EOI) was launched in March 2010 seeking input from vehicle suppliers, charging infrastructure providers, electricity market participants, fleet operators and any other interested party on what they might offer in support of an electric vehicle technology trial project (DOT 2010a). Despite Australia's status as one of the most highly open and competitive automotive markets in the world (MMAL 2011), at the time of the EOI, no commitments had been made by original equipment automotive manufacturers to bring EVs to the Australian market. The EOI process sought to address this by leveraging the highly competitive market operating environment and in doing so chart a path forwards based upon the indicated market direction.

Following a multi-criteria analysis of the 76 submissions, around 60 were accepted at the outset to form the basis of a fully-functioning electric vehicle market model depicted as a schematic in Figure 6. Multiple participants were selected to take part at each level of the emerging EV market to avoid proprietary influence in terms of technology and/or business model, to provide a low cost/risk operating environment for the participants to deploy and refine their technologies and business models, and to promote coordination across the market and provide insights into barriers that may otherwise prevent it.

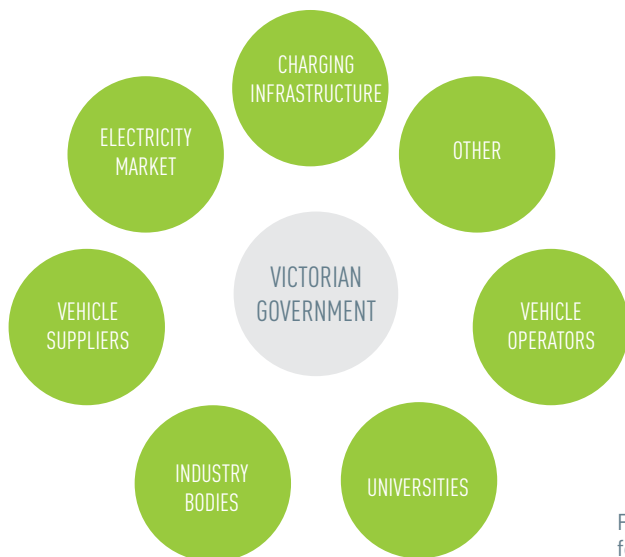


Figure 6. Schematic illustrating the EV ecosystem that forms the basis for the trial design.

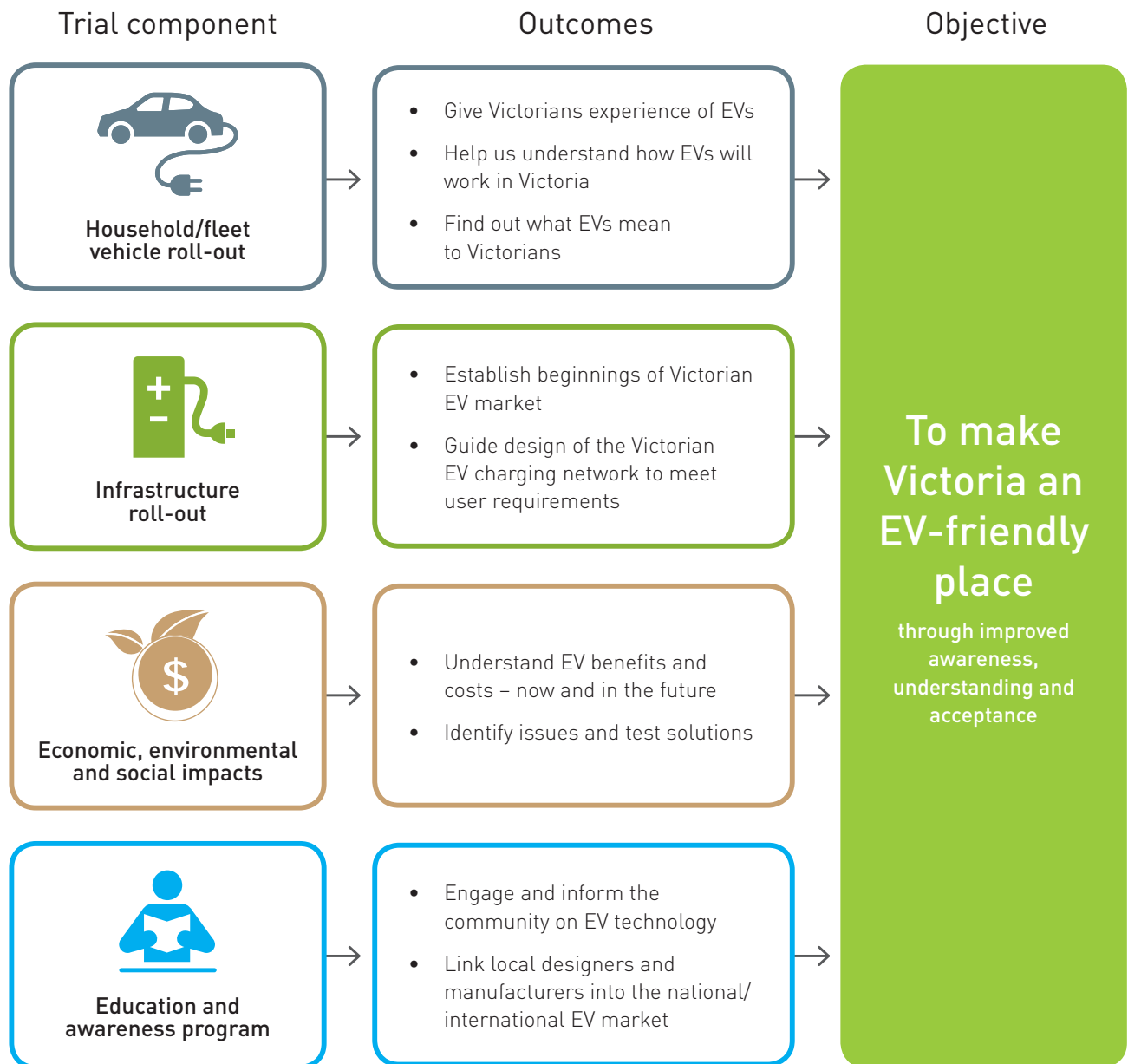


Figure 7. EV Trial conceptual model and delivery framework.



Commercial negotiations and a structured consultation process were then undertaken to inform the final trial design (DOT 2012b). The participants were announced in October 2010 to a backdrop of vehicles and charging technology previously unseen in the Victorian market (Autoblog 2010). Additional participants have joined the trial as the project has progressed – refer to *Appendix A – Victorian EV Trial* corporate participants for a full list of the 80 corporate trial participants including their role as of December 2012.

While the participants and their goods and services provide the basic building blocks for the trial, the four-part conceptual model shown in Figure 7 was designed to deliver the trial.

The diverse range of activities being done as part of the trial includes:

- Household vehicle roll-out: around 120 households living with an EV for three months each (refer to Section 4)
- Fleet vehicle roll-out: over 50 corporate fleets having the opportunity to trial a number of EVs for three months or more for each vehicle (Section 4)
- Charging infrastructure roll-out: around 200 charging outlets being installed for household, fleet and public use (Section 5)
- Economic, environmental and social impacts assessment: an evaluation into the triple bottom line impacts of EV technology introduction in Victoria (Section 6)
- Education and awareness program: a wide-ranging communications program to raise awareness, understanding and acceptance of EV technology in Victoria (Section 7).

The unifying objective 'to make Victoria an EV-friendly place' is to be achieved through improved awareness, understanding and acceptance of electric vehicle technology.

*The Victorian Electric Vehicle Trial is a trail-blazing study that provides consumers and businesses with a firsthand taste of what will be an exciting future transport option; electric vehicles.*

*The industry is looking to this trial as the cornerstone of future development in this area and a lot of work has already gone into overcoming barriers in testing these vehicles.*

Australian Gas Lighting (AGL), a premier partner for the Trial, 14 November 2012

## 3.2 A MARKET DEVELOPMENT MODEL

The trial design and outcomes are being viewed in the context of the market development model for new technologies.

New technology is adopted gradually, following an 'S-curve', similar to those depicted in Figure 8 for a range of technologies introduced over the last century.

This process has been characterised by Rogers (1962) and Moore (1991), and forms the basis for considering the status and path forwards for the Victorian electric vehicle market (Rorke and Inbakaran 2009).

With reference to Figure 9, theory suggests that around 16 per cent of the population form the early market for any new technology. These people, the 'innovators' and 'early adopters', are attracted to new technologies on account of the reflected symbolism, that is, what ownership of new technology says about them. This perceived benefit outweighs the costs and risks associated with any new technology for these early market participants.

In contrast 'mainstream' market participants, composed of the early and late majority, are primarily financially-motivated and will adopt the new technology because it makes sense. The transition from early to mainstream market adoption is commonly termed the 'take-off point'. Moore (1991) identifies the difficult transition between these two very different market segments as the key phase in the success or failure of any new technology – a challenge commonly described as 'crossing the chasm'.

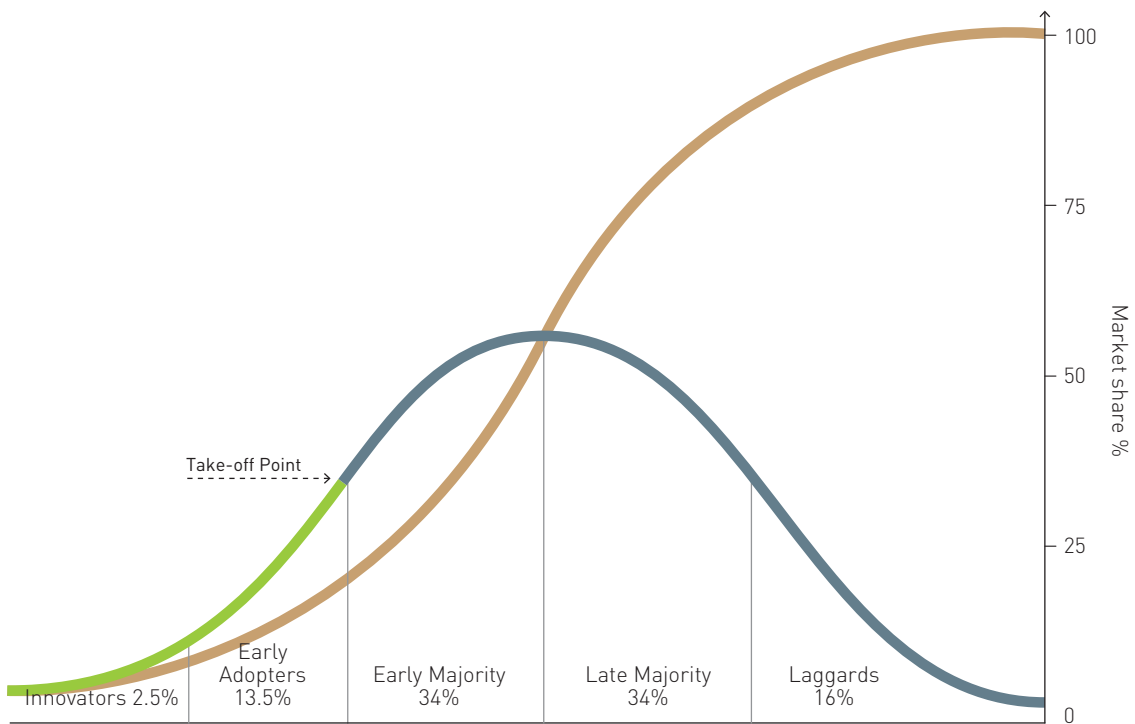
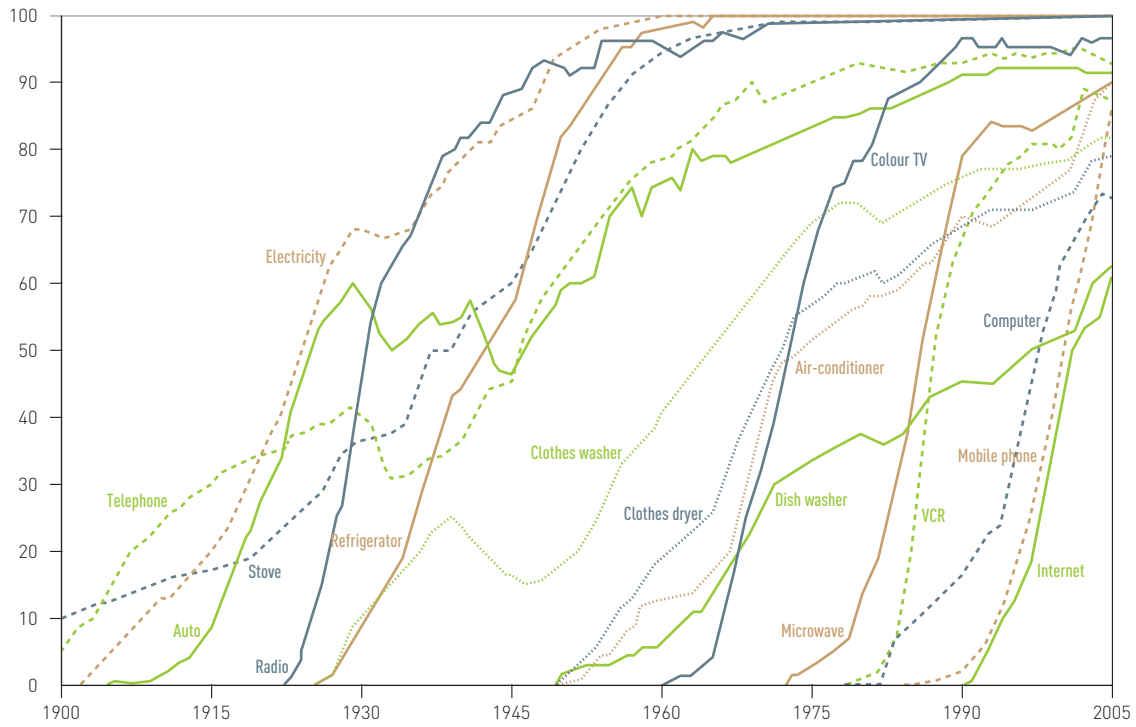


Figure 8 (Top). Technology adoption curves for a range of modern innovations (New York Times 2008).

Figure 9 (Above). Adoption lifecycle for new technologies, where the brown line represents the increase in market share with time, and the green/blue line represents the market share distribution among buyer types (Rogers 1962).

## TECHNOLOGY ADOPTION CASE STUDY

### MOBILE PHONES

Although it is difficult to now imagine life without it, mobile phone technology has traversed the innovation adoption curve within most people's lifetime.

The world's first commercial portable cellular phone became available to U.S. consumers in 1984 (Motorola 2012). The Motorola DynaTAC 8000x weighed over seven times as much as an iPhone, took 10 hours to charge and cost nearly \$USD 4000 (Time 2010) – equivalent to over \$USD 9000 in 2012.

In 1987 the first mobile phone and network was launched in Australia (Access Economics 2010). The Walkabout TM cost around \$5,200 (or around \$11,000 today), was around the size of ten iPhones, had around one hour of talk time between recharges and quickly became known as 'the ultimate yuppie accessory' (SMH 2007, Telstra 2012). The associated cellular network was launched by the Commonwealth Government telecommunications provider Telecom in Sydney in February 1987, Melbourne in May, and extended into other parts of Australia over time (ActewAGL 2009).

From these small beginnings, the mobile phone technology evolved rapidly:

- In 1993 second generation mobile phone technology (2G) commenced operation, including basic data functionality (Access Economics 2010)
- By March 1994 the one millionth subscriber had joined the network (ActewAGL 2009)
- With the arrival of 3G networks in 2003, the technology had improved to allow for video streaming (ABC 2011)
- By 2007 mobile phone subscriptions outnumbered people in Australia (ACMA 2008)
- By 2009 over three quarters of all 12-14 year olds were reported having their own mobile phone (ABS 2009) – a mere 25 years from when the DynaTAC 8000x went on sale in the U.S.

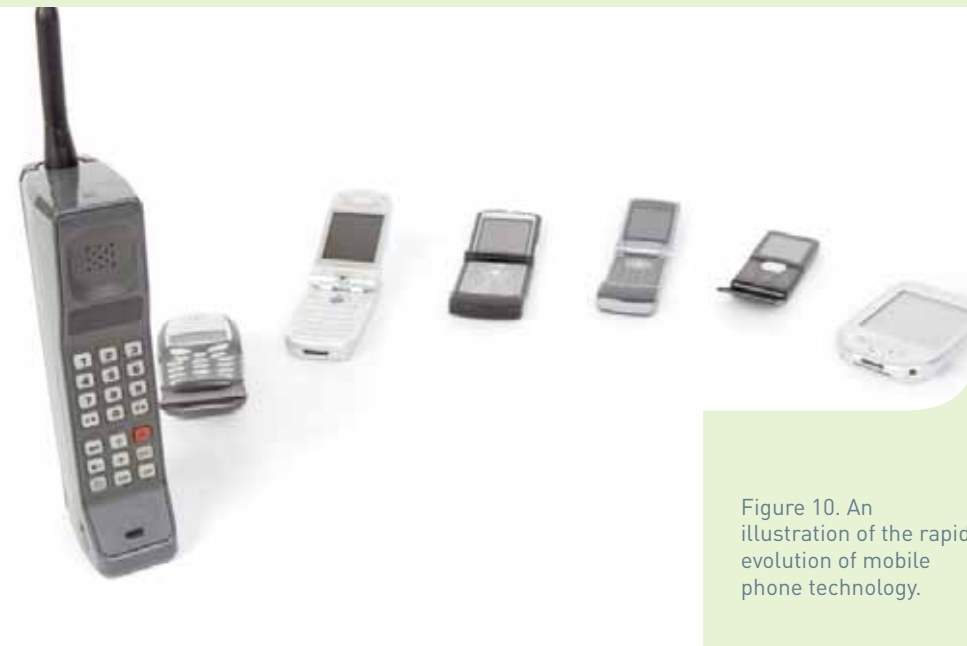


Figure 10. An illustration of the rapid evolution of mobile phone technology.

In seeking an understanding of the early versus mainstream market for electric vehicle technologies, the trial design has adopted these market development theories at its core. Procurement and deployment of vehicles and charging infrastructure has been overseen by the Department so as to gain insights into the issues and opportunities at different phases of the market development. Insights into the motivations, behaviours and opinions of the wide range of trial participants are being gathered and circulated as part of efforts to promote an efficient EV market roll-out.

### 3.3 COMMERCIAL ARRANGEMENTS

The trial design is underpinned by a large and diverse range of commercial agreements addressing the activities and risks associated with development of a new market.

An implication of the electric vehicle ecosystem project design was the need for a large number of commercial agreements to underpin the many and varied trial participant relationships. This complexity was compounded by the early market situation, which required new business models for service delivery, and the large amount of information exchange, which required an extensive privacy review and protections for sensitive information and intellectual property alike.

Trial-specific commercial agreements were designed for the following families of activities and relationships:

- Premier partner
- Vehicle procurement
- Vehicle operation by fleets including charging infrastructure hosting
- Charging infrastructure service provision
- Charging infrastructure hosting for a non-vehicle operator
- Private household trial participation
- Trial participation other than for households and fleets
- Data collection, transfer and management.

Building upon this, around 230 commercial agreements have been executed over the first half of the project. The effort and resource expended in the design and execution of these agreements delivered considerable benefits including:

- Insights into the issues and opportunities associated with the roll-out of EV technology, attained through the legal negotiations
- Consistency across commercial agreements, which has streamlined the trial delivery and ensured a low-risk operating environment for the trial participants.

The role of the Premier Partners has been key to the trial design and delivery:

- AGL supplied renewable energy to account for the trial vehicle operation
- CSIRO led the design, implementation and interrogation of the trial data collection and management framework
- Lumleys Insurance provided comprehensive insurance for the vehicles in support of the wide range of short- and long-term test-drive applications
- RACV partnered in delivery of the household application to participate process, and promotion of the trial generally.

Detailed observations regarding the negotiation and operation of the charging infrastructure agreements can be found in Section 5.1.1.



*RACV considers electric vehicles to be a major component of Victoria's sustainable transport mix. Work conducted through the Victorian Electric Vehicle Trial has contributed to strong engagement between the public, industry stakeholders and government on issues surrounding the successful uptake of electric vehicles in Victoria including price mechanisms, energy demands and land-use planning.*

Royal Automobile Club of Victoria (RACV), a premier partner for the Trial, 24 October 2012

### 3.4 DATA COLLECTION AND MANAGEMENT

The trial data has been collected using a range of techniques from a large number of sources. Management of the data has been centralised to ensure data integrity and protection of sensitive information. Distribution of the findings has taken place through regular meetings with the corporate participants as part of the trial stakeholder engagement strategy.

Collection and management of the trial data is a key element to the overall design of the trial. With reference to Figure 11, the range of data sources, attributes and outputs can be seen. The role played by CSIRO in both the design and operation of the trial data collection and management framework has been critical to ensuring private and commercially-sensitive information is protected, and in facilitating analysis of the results.

Data collection from the household participants is a major input for the trial. With reference to Figure 12, the households first supply data through their application to participate. Once shortlisted, the applicant is provided an offer of participation in the form of their Deed. As the agreement for their participation is finalised, they complete a short questionnaire to provide more information about their residence to inform the charging solution planning. At each point before, during and after their electric vehicle experience, they are requested to complete a one-week household travel diary and a 10 minute survey. The travel diary is analogous to the Victorian Integrated Survey of Travel and Activity<sup>1</sup>, except that it captures a week of household travel at each sample interval rather than a day. This qualitative data is supplemented by additional qualitative data gathered from the Victorian Electric Vehicle Trial Discussion Board (refer to Section 7.1.1).

Quantitative data is gathered from the vehicle instrumentation, the network of charging infrastructure and from either their electricity retailer or distributor. It represents the behavioural aspects of the household EV experience, as opposed to the attitudinal aspects represented by the qualitative data described above.



<sup>1</sup> <http://www.transport.vic.gov.au/research/statistics/victorian-integrated-survey-of-travel-and-activity>

The fleet participants supply quantitative data via the vehicle instrumentation and qualitative data via their application to participate and responses to various questionnaires delivered predominantly around events and through interviews. This approach addresses the limitations of the fleet data set in terms of the number of and variations between participants.

Additional input is sourced on an as-needs basis from the corporate participants in the trial. An example of this was a survey of the charging infrastructure providers to inform an understanding of a standardised charging infrastructure circuit.

Project meetings are held on a monthly basis for the trial's corporate participants. These meetings include:

- Trial Planning Working Group – open to all corporate participants; a variable roll-call of around 30 participants regularly attend from around 100 invitees
- Interoperability Working Group – open to all charging infrastructure providers and convened in recognition of the needs of this emerging industry sector; around eight representatives of different providers regularly attend from 10 invitees.

Additional meetings are convened around specific initiatives being advanced under the umbrella of the trial, for example a demonstration project for demand response and load control of electric vehicle charging (refer to Section 5.2.4).

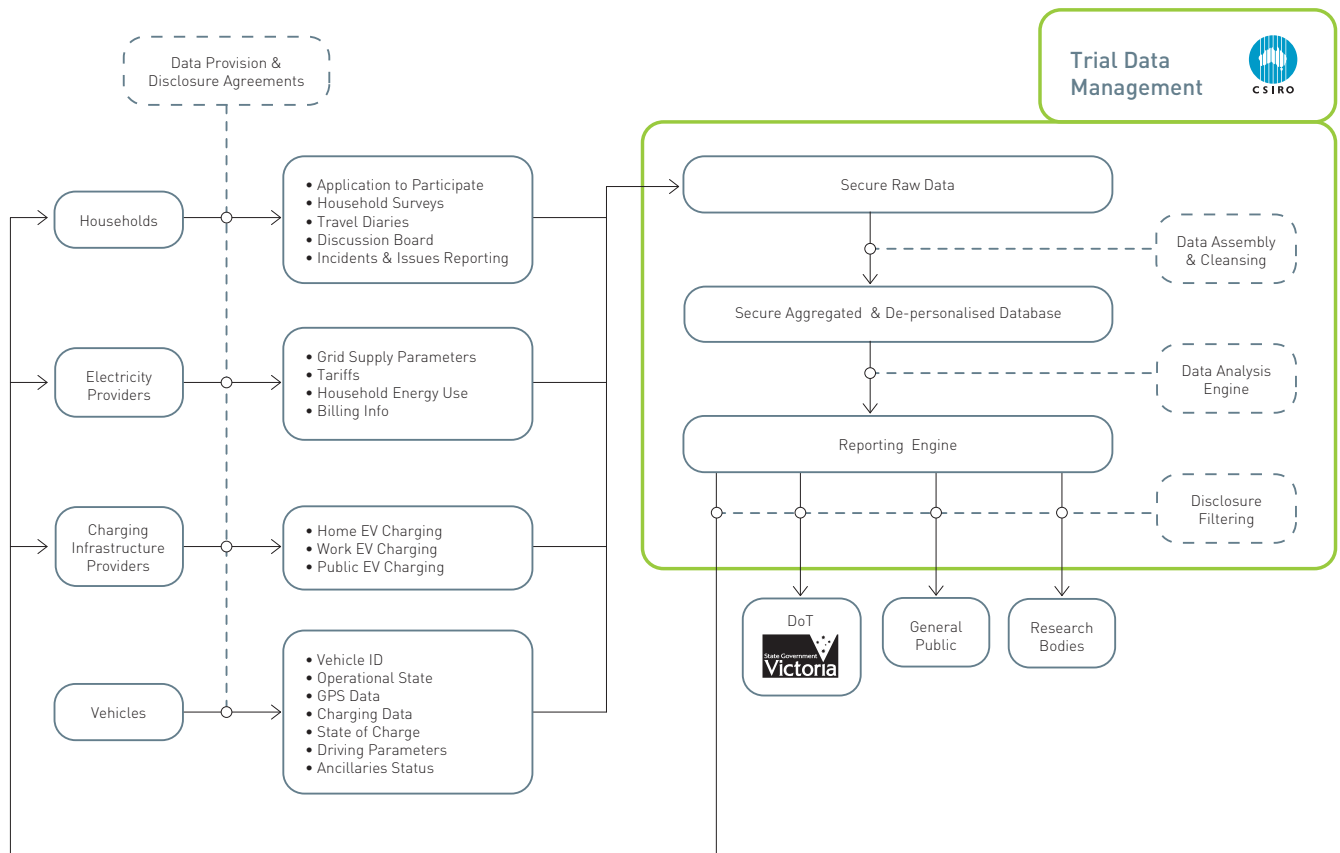
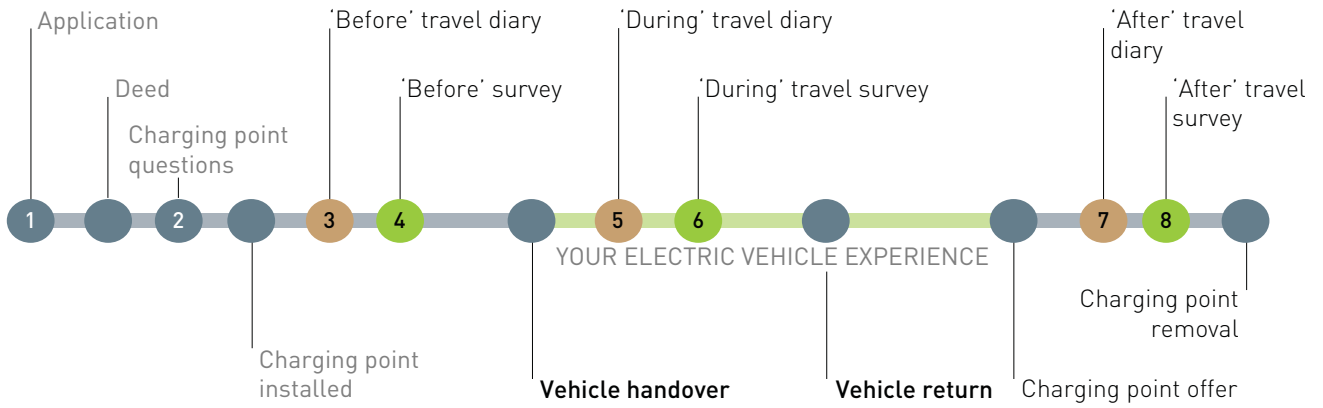


Figure 11. Trial data collection and management framework.

**What we need from you: The participant**



**What is happening in the Trial**

**Note:** The Trial vehicles are monitored throughout.  
Household energy use will also be monitored by the relevant electricity retailer.

Figure 12. Household participant timeline for the trial, where the period from vehicle handover to vehicle return is of three months duration nominally.

# HOUSEHOLD AND FLEET VEHICLE ROLL-OUT

The Victorian Electric Vehicle Trial has sought a range of vehicles from different suppliers for deployment in households and corporate fleets. The car types have included Original Equipment Manufacturer (OEM) products and aftermarket conversions, with the former supporting all of the household and most of the fleet trials.

# 4





Information gained from the cars has allowed for a relative assessment of the vehicle use.

The household vehicle roll-out has provided around 120 households with the opportunity to live with an electric vehicle for three months. Information gained from the households has provided insights into the sort of people and motives for being interested in electric vehicles, what they thought of them and how they used them.

The fleet vehicle roll-out has provided around 40 fleets with the opportunity to trial a range of electric vehicles for periods of up to six months at a time. An understanding of the fleet types, motives and uses for the electric vehicles has been gained, along with the issues and opportunities for market development.

## 4.1 VEHICLES

### 4.1.1 What vehicles are taking part in the trial?

The mainstay of vehicles taking part in the trial are 100 per cent electrically-powered vehicles – primarily the Mitsubishi i-MiEV and Nissan LEAF. A small number of Toyota Prius PHEVs, both pre-production prototypes and conversions, have also taken part, along with a number of aftermarket EV conversions.

Table 1 provides a summary of the various vehicles operating as part of the trial. Vehicles for which the service application has been identified as 'fleets through affiliation' were owned and/or controlled by entities other than the former Department of Transport.

These vehicles took part in the trial to access a range of benefits including use of public charging infrastructure or the trial data collection and management framework, or simply in support of information exchange.

The supply arrangements for the OEM vehicles (Mitsubishi i-MiEV, Nissan LEAF and Toyota Prius PHEV pre-production) allowed them to be deployed to both households and fleets, whereas the remaining vehicles were operated solely by fleets. Furthermore, those vehicles taking part in the trial courtesy of 'fleets through affiliation' did not supply data into the trial collection and management framework – refer to Table 1 and Section 3.4.

Vehicle	Type	No. vehicles	Price	First vehicle commissioning date	Trial service application/s
Mitsubishi i-MiEV	OEM BEV	14	\$65,200 <sup>2</sup> (2010)	December 2010	Fleets, households
		3	\$48,800 (2011-12) \$36,888 <sup>3</sup> (2013)	December 2010	Fleets through affiliation
Toyota Prius PHEV <sup>4</sup>	OEM pre-production PHEV	3	N/A	December 2010	Fleets, households
	Aftermarket conversion PHEV	3	N/A	January 2011	Fleets through affiliation
Blade Electron <sup>5</sup>	Aftermarket conversion BEV	8	\$48,000 (2010-11)	March 2011	Fleets through affiliation
Nissan LEAF	OEM BEV	16	\$68,007 <sup>6</sup> (2010) \$51,500 (2012) \$46,990 <sup>7</sup> (2013)	June 2011	Fleets, households
EV Engineering Electric Commodore <sup>8</sup>	Aftermarket conversion BEV	7	N/A	June 2012	Fleets through affiliation
<b>Total</b>		<b>54</b>			

Table 1. Vehicles operating as part of the Victorian Electric Vehicle Trial as of December 2012, where 'Price' reflects the Recommended Retail Price (RRP) unless otherwise indicated.

2 Drive-away price includes \$20,000 guaranteed buyback price from Mitsubishi

3 Dealer drive-away price 16 January 2013

4 Vehicle ownership retained by Toyota (OEM pre-production) or operators (aftermarket conversion)

5 Blade Electric Vehicles ceased trading in April 2012

6 UK-specification vehicles supplied ahead of the Australian product launch; includes \$25,045 guaranteed buyback price from Nissan

7 Drive-away price, representing around \$8,000 saving on the 2012 RRP

8 Proof-of-concept prototype vehicles

Features of relevance regarding the vehicles included the following:

- In-vehicle GPS, a key enabling technology/driver-aid for EV range management, was present in only the Mitsubishi i-MiEVs, which utilised an aftermarket GPS solution. The Nissan LEAF trial vehicles were supplied ahead of the Australian-specification OEM GPS solution, which was not able to be cost-effectively retrofitted to the vehicles
  - The Nissan LEAF has a climate control pre-heat/cool feature that allows it to use mains electricity to warm/cool the cabin to a pre-set temperature/time, thereby preserving the battery charge for driving range. Although use of this feature was not able to be monitored, use of heating/cooling by both the i-MiEV and the LEAF during driving was monitored. This should have resulted in the i-MiEV being reported to use heating/cooling more, all else being equal
  - In-vehicle range estimation worked differently from one vehicle type to the next. By way of example, the i-MiEV evaluates/displays a remaining-range estimate based upon the current operating condition of the vehicle, resulting in instantaneous feedback to changes in operational state, whereas the LEAF evaluates this figure based upon a rolling five kilometres average, providing more gradual changes to the indicated range based upon changes to the vehicle operating state. The more immediate driver feedback supplied by the i-MiEV was perceived to influence driver choices differently from the LEAF, for example with regards use of heating/cooling
- Aftermarket instrumentation fitted for the trial vehicle monitoring drew charge from the 12 volt battery to the extent that this issue needed to be managed by the vehicle operators in the event of the vehicle not being driven regularly – one household participant rejected this solution and returned the vehicle after a short period, while some of the fleet participants reported this as being a deterrent for their staff to use the vehicle. Overall this may have reduced vehicle utilisation/acceptance for the i-MiEV in particular due to its relatively low capacity 12 volt battery
  - The complete vehicle instrumentation solution was applied to the Mitsubishi i-MiEVs and Nissan LEAFs only. Cost, complexity and operator preference were factors in the reduced solution specification applied to the other vehicles
  - The Blade Electrons were existing fleet vehicles retrofitted with an upgraded specification for use in the trial by their owner-operators.

As a consequence of the various issues presented above, the majority of the data captured related to the Nissan LEAF and Mitsubishi i-MiEVs.

#### 4.1.2 Were any differences seen in how the vehicles were used?

Significant differences were noted in how people used the trial vehicles, with the Mitsubishi i-MiEV being underutilised by comparison with the Nissan LEAF. The Toyota Prius PHEVs were generally driven further than the pure EVs, however this varied considerably between deployments. The Blade aftermarket EV conversions suffered from a range of issues which significantly impaired their utilisation.

With reference to Table 2, the Nissan LEAFs were driven substantially further per day than the Mitsubishi i-MiEVs. The Nissan LEAF average daily driving distance of 32.8 kilometres is close to the Melbourne average vehicle daily driving distance of 35 kilometres (DOT 2012a).

The Toyota Prius PHEVs logged substantially higher average daily distances travelled than either of the pure EVs – 42.6 kilometres versus 32.8 for the LEAFs and 24.5 for the i-MiEVs. Notably however, this was accompanied by a standard deviation of nearly 21 kilometres over the relatively small sample of 11 household and fleet vehicle assignments, indicating some statistical uncertainty in the results. Nevertheless, the results suggest that the PHEVs were generally driven further than the pure EVs.

Alongside differences in utilisation, the behavioural and attitudinal data obtained from the trial participants illustrates differences between the vehicles.

Despite household participants being selected partly on the basis of whether they had an existing small to medium size vehicle, i-MiEV drivers reported a marked difference in their response to the question, 'How well does the trial vehicle fit your needs, that is, in ways not related to it being an electric vehicle (for example size)?' (3.6 versus 4.5 for the LEAF on a rating scale from 1 = 'hardly at all' to 5 = 'to a great extent'; aggregate std dev 1.2).

In seeking to understand specifically issues drivers had with the i-MiEV, perceptions of it being a less safe vehicle were reported by some participants.

A typical quote drawn from the Victorian Electric Vehicle Trial Discussion Board sums up these sentiments:

*We have only once had the i-MiEV at speed (up to 100 km/h). It was OK... but not something I would want to do for prolonged periods of time. My VW Golf is definitely superior at speed and gives a much greater feeling of stability and safety.*

Victorian Electric Vehicle Trial household participant, 2012

Size limitations were also cited occasionally, however vehicle occupancy rates before, during and after the household EV experience suggest that this was not a major issue.

Table 2 below highlights the marked discrepancy between the use of heating and cooling on both vehicles. Several factors may have influenced this outcome including:

- Seasonal variations between the periods over which the vehicles have been allocated (further analysis of the raw data is being undertaken to verify this)
- Increased need to conserve energy as a result of around 10 per cent lower operating range of the i-MiEV relative to the LEAF.

Vehicle use attribute	Mitsubishi i-MiEV		Nissan LEAF		Toyota Prius PHEV		Statistically-significant difference?
	AV	SD	AV	SD	AV	SD	
Distance travelled per day (km)	24.5	12.7	32.8	15.3	42.6	20.9	Yes (i-MiEV / LEAF) No (Prius PHEV / others)
Distance between charge events (km)	34.3	10.6	35.9	8.0	N/A		No
State-of-Charge at plug-in (%)	57.5	10.2	52.0	9.4			Yes
Use of ECO driving mode (% of driving time)	26.1	25.6	23.1	23.0			No
Use of air-conditioning (% of driving time)	9.4	11.5	17.2	8.8			Yes
Use of heating (% of driving time)	50.0	31.2	65.7	25.0			Yes
Average energy economy (kWh/km) <sup>9</sup>	0.150		0.179				Yes

Table 2. Vehicle use data based upon 25, 33 and 11 three-month vehicle assignments for the i-MiEV, LEAF and Prius PHEV respectively, where AV = average value and SD = standard deviation for the data-set.

<sup>9</sup> Derived figures based upon vehicle odometer readings and charging activity data

Although the ability of the LEAF to be programmed to heat or cool the car using mains electricity whilst charging may have provided an explanation for increased use of these functions, the vehicle data monitoring did not capture this activity due to a quirk with the proprietary vehicle firmware.

An artefact of the way the trial was designed was the effect the aftermarket instrumentation had on the cars as a result of the increased load on the 12 volt battery. This effect was much more pronounced for i-MiEVs than for the LEAFs due to the relatively small 12 volt battery in the vehicle. A partial fix was implemented for the i-MiEV in the form of a device that isolated the 12 volt battery once the remaining charge dropped below a certain point, beyond which it was a short procedure to get the vehicle going again. Nevertheless, feedback from some of the trial participants highlighted the inconvenience of this situation, which for fleets in particular may have acted as a deterrent for vehicle use.

Although quantitative data was not supplied by the fleet owner/operators of the Blade Electron EV conversions, anecdotal and survey reporting suggests that vehicle utilisation did not meet expectations. Vehicle delivery and reliability issues significantly impaired the operation of these vehicles, in addition to which reference was made to range limitations versus operational requirements, along with driver disapproval of the charge management/range estimation. Feedback obtained from the vehicle supplier suggested that their product had been much more favourably received by private buyers, who were more accepting and accommodating of the vehicle idiosyncrasies.

#### 4.1.3 What are the issues and opportunities for the vehicles?

The purchase price barrier common to all new technologies is expected to reduce in the near-term through a range of avenues. The total cost of ownership argument in favour of electric vehicles will strengthen in parallel. Improved driver information will greatly assist in realising EV operational cost savings.

Relative to other markets, sales of vehicles analogous to plug-in EVs in Australia have traditionally been niche at best. Australian combined sales of the Toyota Prius and Honda Insight hybrid-electric vehicles have hovered between one and two per cent of the small vehicle market segment for a number of years, during which time these same vehicles have been the overall market sales leaders in Japan (GoAuto 2011).

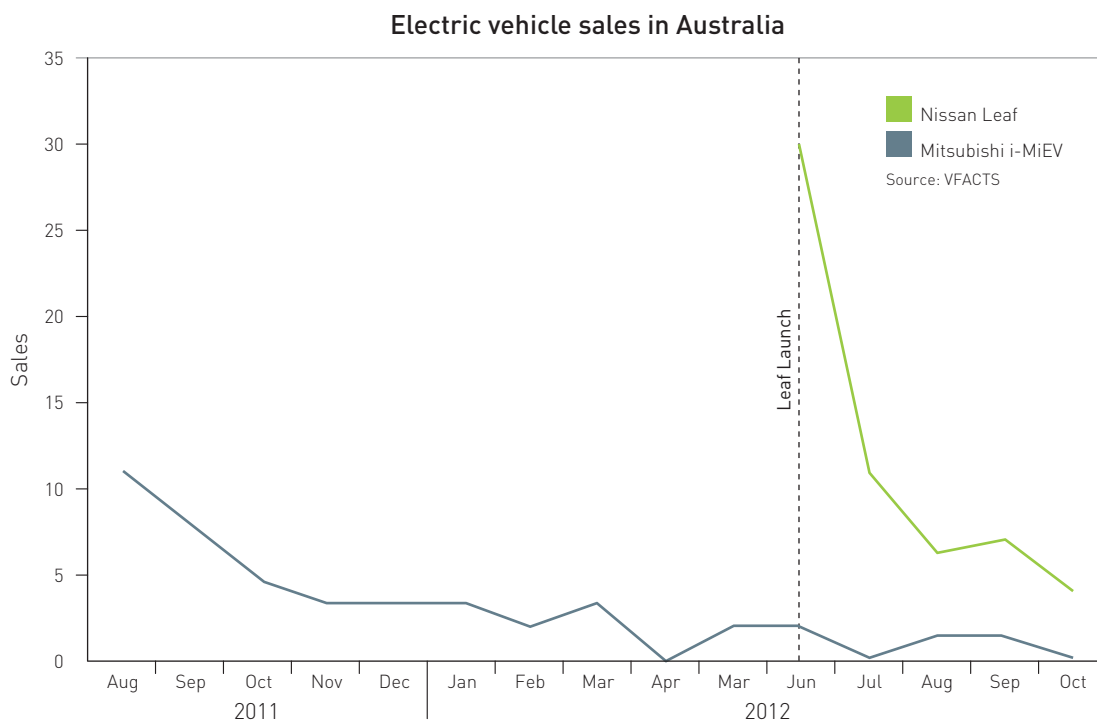


Figure 13. Early market Australian sales figures for the Mitsubishi i-MiEV and Nissan LEAF (GoAuto 2012a).

Evidence suggests that while purchase prices remain significantly higher than ICE vehicles of the same size and basic specification, EVs are likely to occupy a similar niche role in the Australian market. With reference to Figure 13, the early market sales figures for the Mitsubishi i-MiEV and Nissan LEAF illustrate relatively slow take-up.

However, various indicators suggest that this is an early-market scenario consistent with Rogers' theory of technology market development outlined in Section 3.2:

- Australian sales of green and specifically hybrid cars are increasing, due to lower prices, greater choice and increased buyer awareness, understanding and acceptance of these technologies (News 2012)
- OEM EV purchase prices are dropping in all markets – refer to Table 1 and Figure 14 for the Australian market story over the life of the trial
- Sales of plug-in vehicles globally are ahead of the sales of hybrid vehicles at a similar stage in their market development – in the U.S. alone sales of plug-in vehicles tripled in 2012 (US DOE 2013 and Figure 15)
- According to industry sources, there are a range of plug-in vehicles being considered for introduction to the Australian market, which will provide more choice for buyers and increased competition on prices – notably, 19 new plug-in vehicles from 15 manufacturers will arrive in the U.S. market in 2013-14 (Edmunds 2012).

While the inter-related issues of new vehicle purchase prices and sales figures are a major challenge currently, it is envisaged that local vehicle supply will be an issue as prices continue to fall and global demand increases. Industry consultation undertaken as part of the Department's economic modelling found that Australian vehicle supply represents around one per cent of global production (AECOM 2011). Global production is prioritised to supply the markets which hold the most appeal for the manufacturers – traditionally the U.S./Canada, Japan and Western Europe, although increasingly also the emerging economies of China, India, Brazil and Russia. As a result, the Australian market may be undersupplied for vehicles either by type or volume due to competition from other markets.

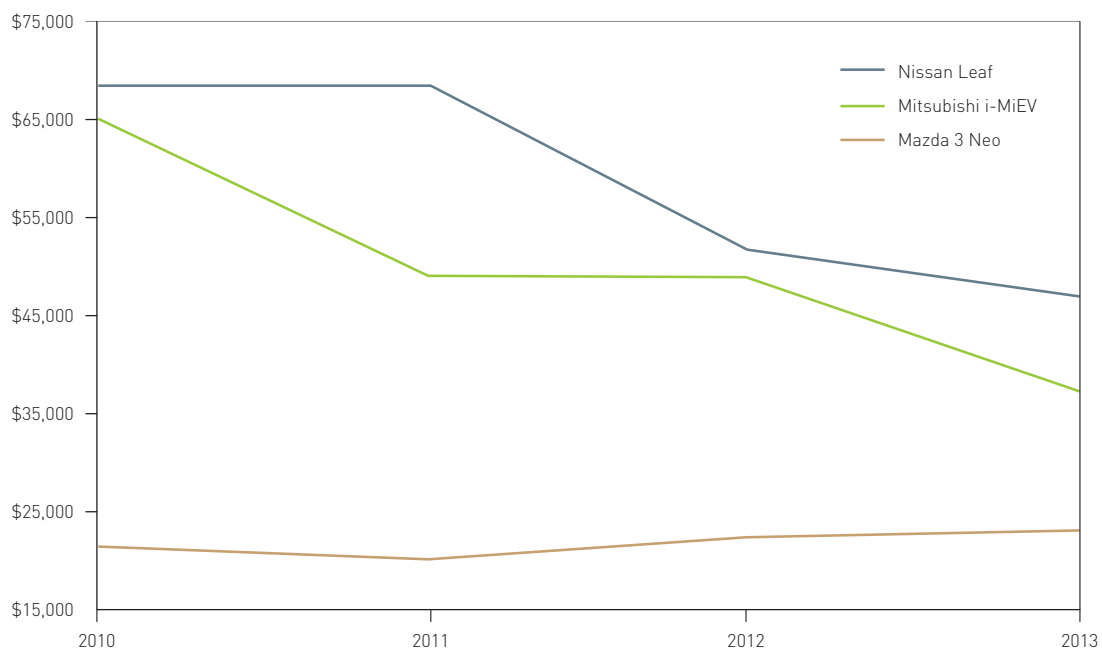


Figure 14. Recommended Retail Price history for the trial EVs and Australia's highest-selling small car.

Future product planning for the automotive OEMs occurs at least three years ahead of the product sale launch (CAR 2007). Discussions held with OEMs as part of the trial have found that vehicle model and sales volume forecasts are locked in at least two years ahead of vehicles arriving into the market. Noting the wide range of models forecast for delivery into the U.S. market (Edmunds 2012), this reality has implications for the timing of measures to encourage mainstream market adoption – refer to Sections 6.1.2 and 6.1.3 for further discussion on this issue.

Depreciation is another issue that history suggests will be a problem (Drive 2011). The absence of reliability and maintenance cost data for new technology creates uncertainty in the market that results in accelerated depreciation and lower resale values. This is a challenge for manufacturers as poor resale values can significantly hinder sales due to depreciation being the largest contribution to new vehicle total cost of ownership.

However, there are a range of influences that may help bolster resale prices and reduce vehicle depreciation costs:

- Australian electric vehicle sellers are known to be strongly interested in the second-hand market for their vehicles<sup>9</sup>, at least partly to satisfy a market for vehicles of lower cost
- The national EV standards project has within its scope an industry-standard for assessment of battery condition (Standards Australia 2010), which if implemented will improve market confidence within used vehicle transactions
- A range of 'second-life' applications exist for batteries at the end of their vehicle life, including trams and trains, marine applications, commercial and off-road vehicles, home energy storage, uninterruptable power supplies, and large scale grid energy storage (P3 2012).

As any/all these influences come to bear, the total cost of ownership EV value proposition for new vehicle buyers will improve beyond what will be delivered by transport energy costs alone.

In terms of range management, the effect of improved driver information is also a clear opportunity. A white paper prepared for the Michigan Department of Transportation (CAR 2011) outlined the synergy between electric vehicles and vehicle communication systems. It identified trip planning, including route finding, range estimation, smart parking, and identification of charging locations, as the earliest opportunity for improved vehicle and energy management.

Australian-specification models of Nissan's LEAF are equipped with in-vehicle route-finding systems that highlight charging options, along with smart phone connectivity that allows users to monitor and manage the charging of their vehicle remotely.

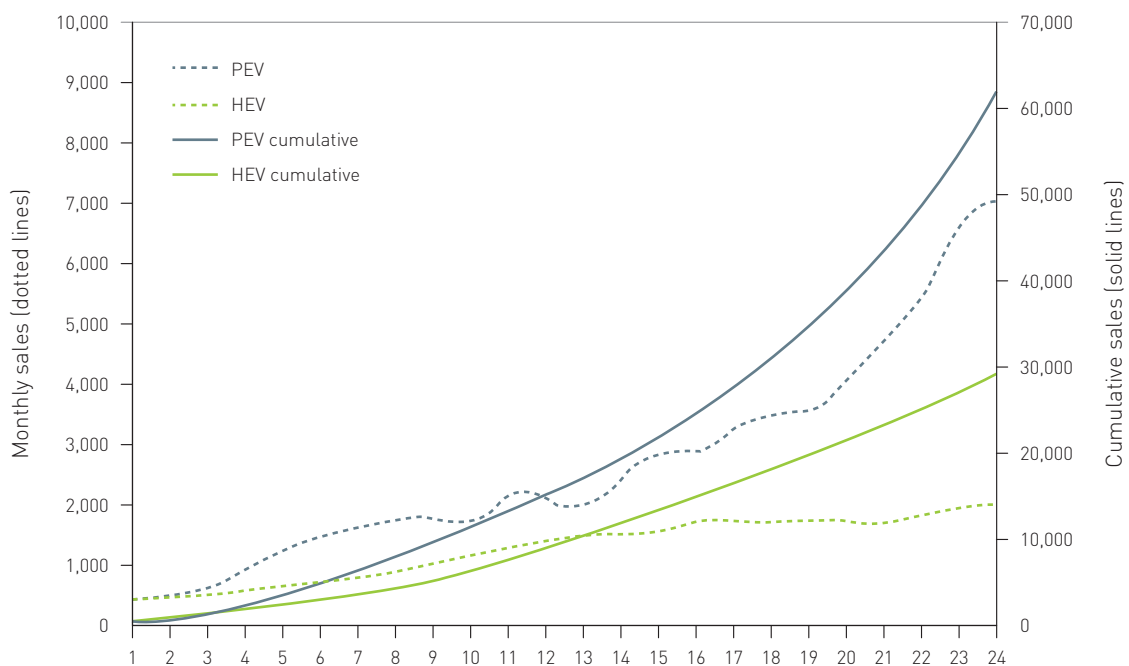


Figure 15. New Plug-in Electric Vehicle (PEV) sales compared to Hybrid Electric Vehicle (HEV) sales over their respective 24 month introductory periods in the U.S.; PEV sales 12/2010 to 11/2012, HEV sales 12/1999 to 11/2001 (US DOE 2013).

This sort of functionality is expected to be standard on most vehicles that enter the market in future, even if the solutions are region-specific (due to local telecommunications and transport network issues). Facilitating improved information on the charging network for the vehicle and/or intelligent transport systems technology suppliers may streamline market entry for all participants (refer also to Section 5.1.5).

Despite the limited data obtained for the Toyota Prius PHEVs, indications are that the absence of range limitations for this vehicle may have contributed to increased utilisation in terms of average daily driving distance. More data needs to be obtained before conclusions can be formed however.

The Blade Electrons clearly suffered from issues directly related to them being aftermarket electric vehicle conversions. Furthermore, there appears to be a significant mismatch between the private and fleet buyer expectations for these vehicles. While aftermarket EV conversions are well supported by enthusiasts, these findings suggest that more widespread acceptance may prove challenging.

#### 4.1.4 What about electric two-wheelers?

Electric two-wheelers are a transport option with great potential. International trends and Australian regulatory reform suggest that they may play a greater role in Victoria's future transport system as consumer awareness, understanding and acceptance of the technology improves.

Electric bicycles (e-bikes) can be defined as non-registered vehicles that are partly or fully propelled by an electric motor. Evidence suggests that electric bikes may provide an affordable, healthy mobility option for the aged and physically-impaired in particular. Sales of this relatively low-cost transport option are forecast to grow from around 30 to nearly 50 million vehicles annually between 2013 and 2018 (Green Car Congress 2012).

Research co-sponsored by the Victorian Electric Vehicle Trial (Johnson 2012) has found that the top reasons for purchase of e-bikes are (in descending order of importance):

- To replace some car trips
- To ride with less effort
- Health – increase fitness
- Live in a hilly area
- Health – medical condition.

Other findings from this research included:

- Nearly three quarters of e-bike charging takes place at home, with the remainder mainly at the destination and a minor amount elsewhere
- Nearly two-thirds of riders are male, and the largest age demographics 40-49 and 50-59
- The majority of e-bike trips were commuting and local journeys, predominantly in place of car travel resulting in average estimated savings of between \$21 and \$49 per week
- Nearly three quarters of respondents agreed that e-bike travel avoided the need for a shower at the end of the journey should it have been undertaken by bike, and also that the average speed was higher than for a bike
- The main advantages of e-bike travel included health/fitness and enjoyment/fun, while the disadvantages included the heavy bike and bad weather/rain.

A subset within the e-bike research group above is pedal-assist e-bikes or pedalecs, which are defined as 'a type of power-assisted bicycle equipped with one or more auxiliary propulsion motors, a maximum power of 250 watts, and a safeguard allowing for power assistance only when the bicycle is travelling less than 25 km/h and the rider is pedalling' (VicRoads 2012a). This definition was refined in 2012 through a national process which resulted in harmonisation across the states of Australia and with the European standard for these vehicles. As a result, the availability of these vehicles is set to increase greatly, promoting their adoption.

Electric motorcycles are road-registered vehicles that use electricity for part or (more commonly) all of their propulsion. Figures obtained from the VicRoads registration database showed that electric motorcycles are a rare sight on Victorian roads. There were just 45 registrations at the end of November 2012 which represents less than 0.03 per cent of total motorcycle registrations (VicRoads 2012b). However, the number of registrations has grown by almost 30 per cent in 18 months from the previous data point. While it is unclear as to whether this is a sign of an emerging trend, these figures are analogous to those for electric passenger vehicle registrations in Victoria, particularly once the trial vehicle registrations are discounted.

## ELECTRIC TWO-WHEELER CASE STUDY DOLOMITI E-BIKE TRIAL

Carlton-based Italian lifestyle store Dolomiti have taken a novel approach in bringing e-bikes to the Australian market. By offering commuters free e-bikes for a number of weeks, they hope to raise awareness, understanding and acceptance of e-bikes in the community.

Participants in the Dolomiti trial are required to travel at least 35 kilometres per week, including a commute into Melbourne's CBD. The e-bikes are equipped with GPS tracking, providing not only the means to assess performance against the weekly requirement, but also data for the Monash University research partners. Monash combine this information with entry and exit surveys of participants to gain a better understanding of how this new transport mode is used.

The outcomes from the Dolomiti trial will inform stakeholders, such as local government, on the motivations and applications for e-bikes. Through these insights, measures may be designed to encourage e-bike uptake. Early findings indicate that e-bikes deliver real benefits in terms of physical activity and traffic reduction.



Figure 16. Pedal-assisted electric bike or 'pedalec' being used for the Dolomiti e-bike trial.



#### 4.1.5 What about electric commercial vehicles?

Electric commercial vehicles are of strong interest to many fleet operators in Australia, particularly vans and other vehicles at the light-duty end of the market. Supply constraints currently inhibit further evaluation of the viability of these vehicles for Victorian roads.

Electric commercial vehicles, such as vans, buses and light and heavy trucks, are already operating on roads around the world with less of the fanfare that accompanies passenger vehicles. The reduced operating costs and improved environmental performance of electric vehicle technology are an attraction for operators of vehicles for which the potential savings may greatly exceed those from passenger vehicles. Additionally, the near-silent operation of electric vehicles holds potential for freight sector productivity increases through night-time deliveries in noise-sensitive areas (Freight Best Practice 2009).

Extensive investigations by a large Australian freight and logistics operator identified a number of potential EVs available globally for which discussions were pursued for local import. Although these investigations have been underway since the launch of the trial in 2010, no agreements have been reached on local supply of vehicles.

The main issues preventing vehicles from being trialled locally are:

- Relatively small numbers of vehicles being sought
- Australian market entry costs (vehicle homologation, service and repair etc.)
- Technology suitability for the intended service application/operating environment
- Price.

Separately, investigations into a local fleet purchasing coalition have discerned an appetite for electric light commercial vehicles. Consultation with local fleet operators, undertaken by the consultants Verdant Vision as part of a project led by The Climate Group and sponsored by the Victorian and South Australian Governments, found many fleets to be interested in trialling electric vans and other commercial vehicles. However, relatively few vehicles are being sought by the operators, which may not provide the critical mass required for the supply constraint to be addressed. The final report from this project is expected for release in early 2013.

Electric buses are already operating on Victorian roads as charter vehicles (Crown 2012). Assessment of electric bus technology was included as part of a wider investigation into alternative fuel and vehicle technologies for the bus industry (DOT 2012b). Indications from this and more recent analysis suggest that the long charging times for the vehicles and high purchase prices make them best suited to light duties with high promotional value.

## 4.2 HOUSEHOLD VEHICLE ROLL-OUT

### 4.2.1 Who's interested in electric vehicles and why?

In general, would-be Victorian EV drivers are strongly interested in new technology and environmentally aware. They are also highly educated relative to the general population. Although the spatial distribution of EV enthusiasts was fairly flat, there were notable 'hot-spots' around the middle suburbs in Melbourne's southeast and the outer suburbs in both the west and southeast.

A household application to participate and survey process was run in partnership with RACV in November/December of both 2010 and 2011 (DOT 2010d and 2012c). Applicants were requested to complete a 15 minute questionnaire that sought information not only to guide the participant selection process, but also to inform the understanding of the potential electric vehicle market in Victoria.

Some observations about the nearly 9000 households who applied to take part in the trial included:

- High levels of environmental awareness
- Positive attitudes towards government action in support of EVs
- Substantial take-up of solar PV systems and GreenPower (around 20 per cent of each)
- Large number of households consisting of two adults and no children
- A high proportion of households with postgraduate educational qualifications (nearly 20 per cent of applicants, as compared to around 3 per cent of the general population)

- Most significant motivations to participate in the trial were attributed to interests in new/EV technology (refer to Figure 17).

These findings are generally consistent with what has been observed elsewhere in relation to the electric vehicle early-adopter demographic (Rorke and Inbakaran 2009).

The spatial distribution of applicants was fairly flat (DOT 2012c). A significant cluster of applications was received from the south-east Melbourne suburbs around Waverley and Blackburn, along with outer suburban locations around Werribee and Cranbourne.

#### 4.2.2 What do drivers think of electric vehicles?

Drivers who experienced the trial EVs were highly accepting of the technology, with the caveat being purchase price. Purchase price was routinely cited as the reason for why they would not be buying one in the near-term. Performance, technology for the sake of technology, and quiet/environmentally-friendly/low-cost operation were common reasons for favouring the technology. The limited operating range of the vehicles was not a significant issue for the majority of participants, however one in five were concerned the majority of the time.

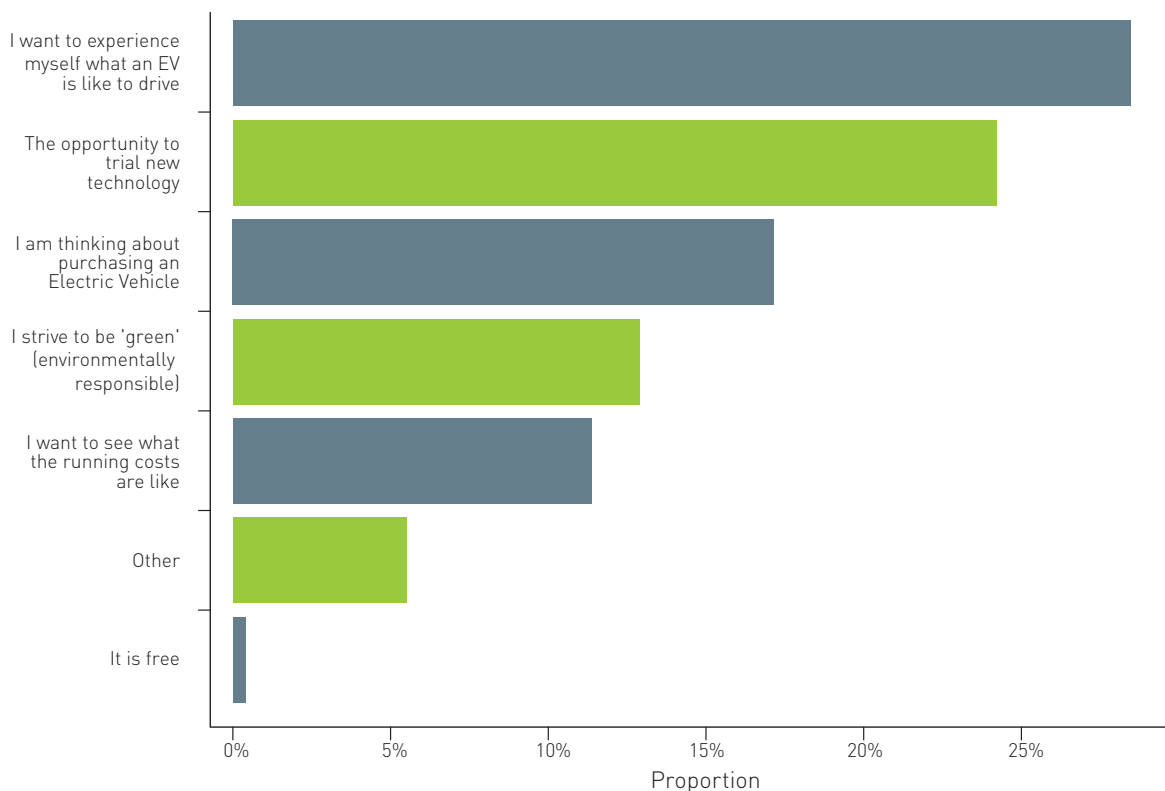


Figure 17. Results from the 2012 trial household application to participate process highlighting the primary reason for applying to participate in the trial (n = 2,200, single choice permitted, DOT 2012c).

A clearly positive influence on people's attitudes towards EVs is vehicle performance. This finding arises from the inherent characteristics of electric motors, which generate maximum torque from rest (in contrast to ICEs, which generate maximum torque near the middle of their operating range). Torque is 'twisting' force that is the basis of acceleration – a popular vehicle driving characteristic.

Evidence of this can be seen in the opinions of participants in the short-term test-drives, who were surveyed on their perceptions of electric vehicles before and after their test-drive experience. Of the 127 participants surveyed, 27.6 per cent changed their mind in favour of EVs as a result of their test-drive experience (that is, their answer to the question 'Would you use an EV as your regular vehicle?' changed from 'no' before their test-drive to 'yes' afterwards). With reference to Figure 18, the vehicle attributes that showed the greatest rating improvement according to these 'converted' participants were mostly performance related.

First impressions by the drivers as recorded in the trial discussion board most often cited the lack of noise and issues to do with comfort/space/storage, which were both cited by around half of the contributors each. Driving modes, range and technology/features were each cited by between 30 and 40 per cent of contributors.

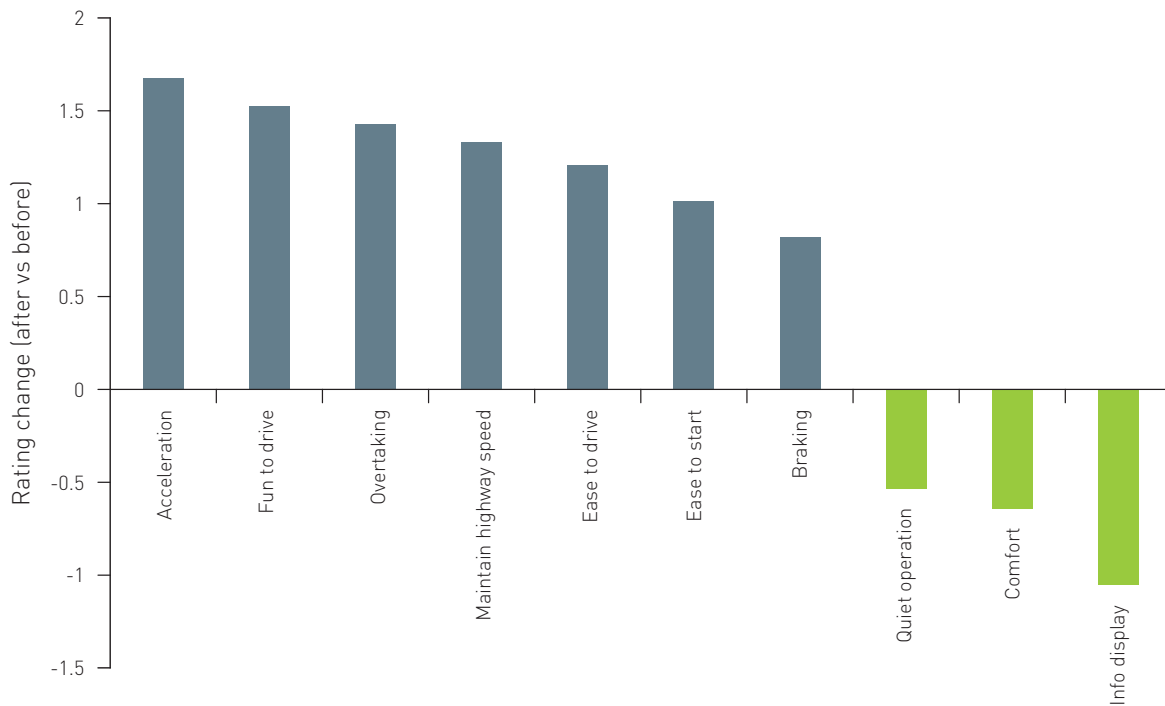


Figure 18. Changes to the vehicle attribute survey responses for the participants who changed their mind in favour of using an electric vehicle as their regular car as a result of their short-term test-drive experience (n = 127).

The limited operating range of the vehicles is a complicated issue. With reference to Figure 19, household participants surveyed around six weeks into their EV experience were biased towards only occasional concerns about range limitations, however around one in five participants were concerned the majority or all of the time. The following quote from the discussion board illustrates the majority view of participants:

*I drove Camberwell – Dandenong – Boronia – Ferntree Gully – Camberwell (91 km) ... in an i-MiEV. Was a little concerned that I might run out of power toward the end, but ... ended up with 7 km to spare according to the indicator. That was actually a pretty big drive for a suburban commute, and I don't think I'd ever go further in a day in Melbourne.*

Victorian Electric Vehicle Trial fleet participant driver feedback, 2011

The range difference between vehicle types does not appear to have overly influenced driver opinion. Responses to the question in Figure 19 from the i-MiEV drivers indicate only slightly more concern than the LEAF drivers (3.6 versus 3.4 on a rating scale from 1 = 'all the time' to 5 = 'hardly at all'; aggregate std dev 1.2). This suggests that range may not be the primary issue for the comparative underutilisation of the i-MiEV, and not an issue for most trial household participants.

With regards the 'significant minority' of participants who were not comfortable with the vehicle range, it is important to note that many were enthusiastic at the prospect of the technology. This finding may be significant in the context of public charging infrastructure – refer to Section 5.4.

Many household participants displayed ingenuity and resolve when it came to managing the range limitations of their vehicle. User-generated content from the trial discussion board highlights the concept of 'range anxiety', however the issue is more often expressed in the form of 'range management'. Users cite a range of considerations made as part of this:

- Trip planning and distance estimation
- Driving mode selection/benefits
- Public charging options/access arrangements
- Interpretation of the in-vehicle range indicator (of which they are highly critical)
- Efficient driving techniques
- Use of heating/cooling
- Other measures that assist with range optimisation.

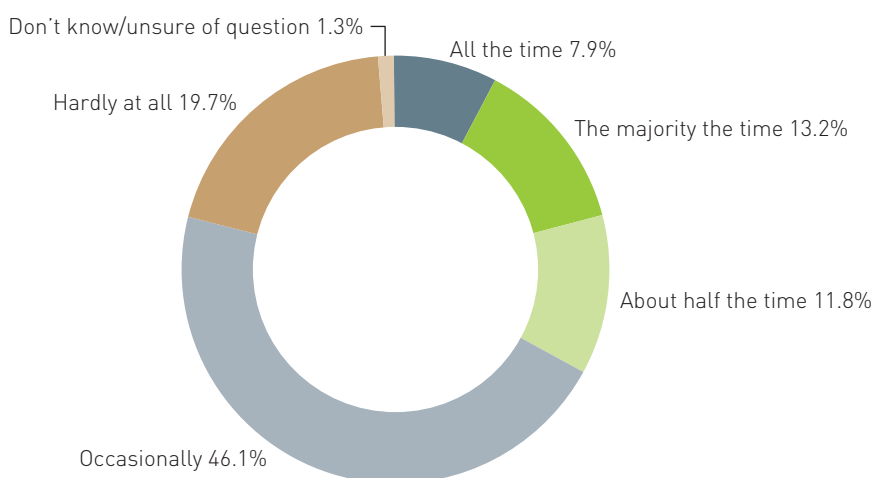


Figure 19. Household participant responses from around six weeks into their electric vehicle experience to the question, 'How often do you feel concerned about the available range of your vehicle?' (n = 76).

Having to make these considerations is occasionally cited as being an inconvenience that is not felt with petrol vehicles. A quote from the discussion board sums this up by saying:

*Driving in an EV isn't a mindless activity.*

Victorian Electric Vehicle Trial household participant, 2012

Of those participants who were accepting of EVs as a viable and even desirable transport option, the overwhelming majority highlighted purchase price as being the key obstacle to ownership. The quote supplied by one of the household participants subsequent to their three-month electric vehicle experience illustrates this issue:

*I was very close to buying my very own Nissan LEAF about 3 months ago. In fact, I went to the showroom and tried to find out the differences between the Australian model versus the model I had from the trial. I also considered various finance options and a special leasing option provided by Nissan itself for the LEAF. At the end, I could not financially justify the purchase of this EV. I went and bought a Toyota Prius instead.*

– Victorian Electric Vehicle Trial household participant, 2012

### 4.2.3 How do people use electric vehicles?

Results suggest that households seamlessly adopted the trial electric vehicles into their normal travel behaviours, and that they used the electric vehicles as their primary transport mode. Comparison with Victorian Government travel data suggests that these conclusions may be transferred to the majority of the Melbourne population. Vehicle range limitations are managed by the majority of drivers. Workplace commuting was the most common vehicle travel destination. Self-described 'early-adopters' were not found to use their vehicle differently to mainstream market participants.

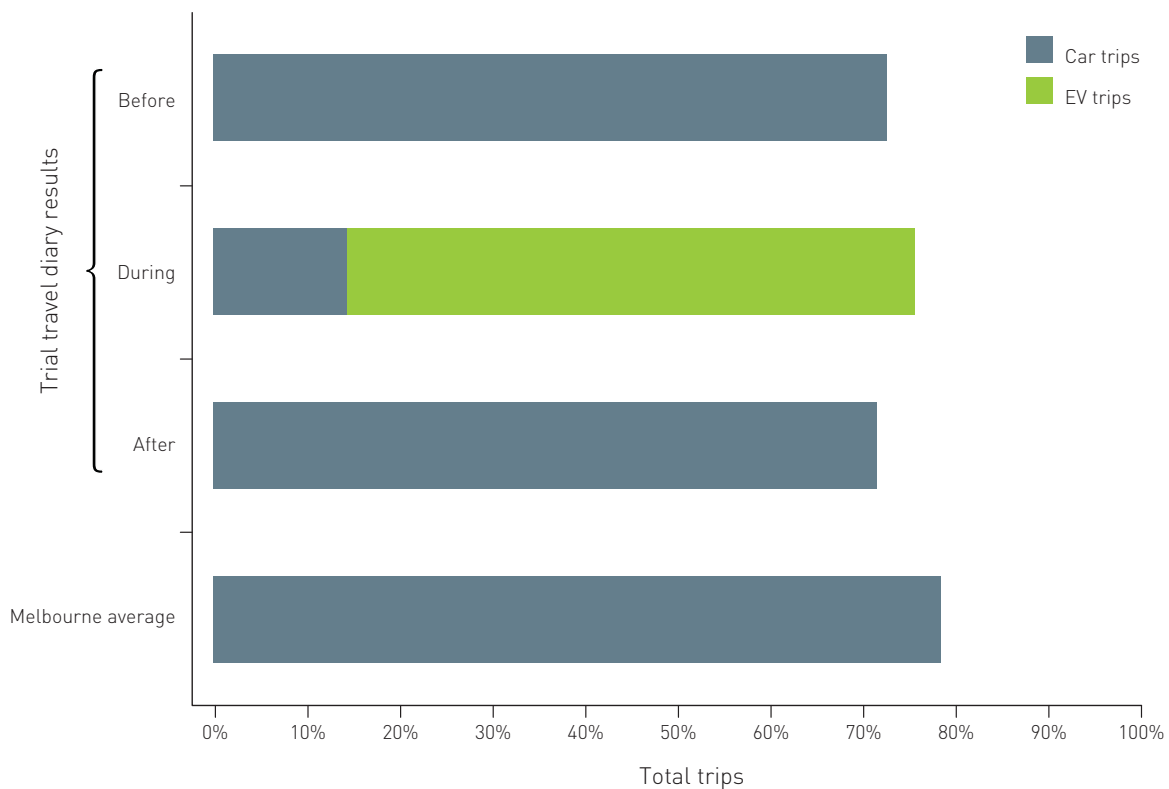


Figure 20. Results from the household travel diaries where the breakdown in car travel as a percentage of total trips is reported for all travel diaries submitted across the three phases of the household vehicle allocations.

With reference to Figure 20, households were asked to complete travel diaries for each phase of their involvement in the trial – before, during and after their EV allocation. Although the completion rate of the travel diaries fell away across the phases (from 5,586 trips reported in the 'before' phase, to 4,675 for the 'during' phase, to 2,733 for the 'after' phase), the percentage of total trips reported as using a car held steady at around 75 per cent – slightly less than the Melbourne average of 78 per cent. These findings provide some confidence in the comparability of the data across phases/households generally, and suggest that the households did not significantly alter their travel behaviours as a result of having an EV.

Reported household and vehicle occupancies support this conclusion. Households reported themselves as having an average of 2.87 occupants, translating to two adults with driving licences to operate the average of almost 2 vehicles owned per household, and one non-driving dependent. The average vehicle occupancy rates per trip were 1.94 occupants per vehicle in the 'before' phase and 1.85 'after', compared to 1.85 occupants per EV trip 'during' their trial vehicle allocation.

When considered in combination with the trip mode choice breakdown above, it may be concluded that households seamlessly adopted the trial electric vehicles into their normal travel patterns.

Furthermore, 62 per cent of all trips were reported as using the trial vehicle in the 'during' phase, equating to around two-thirds of all household vehicle trips. This suggests that households used the electric vehicle as their first-choice for vehicle travel. This result is a strong endorsement for the substitutability of EVs, as the participant selection process prioritised households who already owned small or medium vehicles so as to avoid a functional mismatch with the trial vehicles.

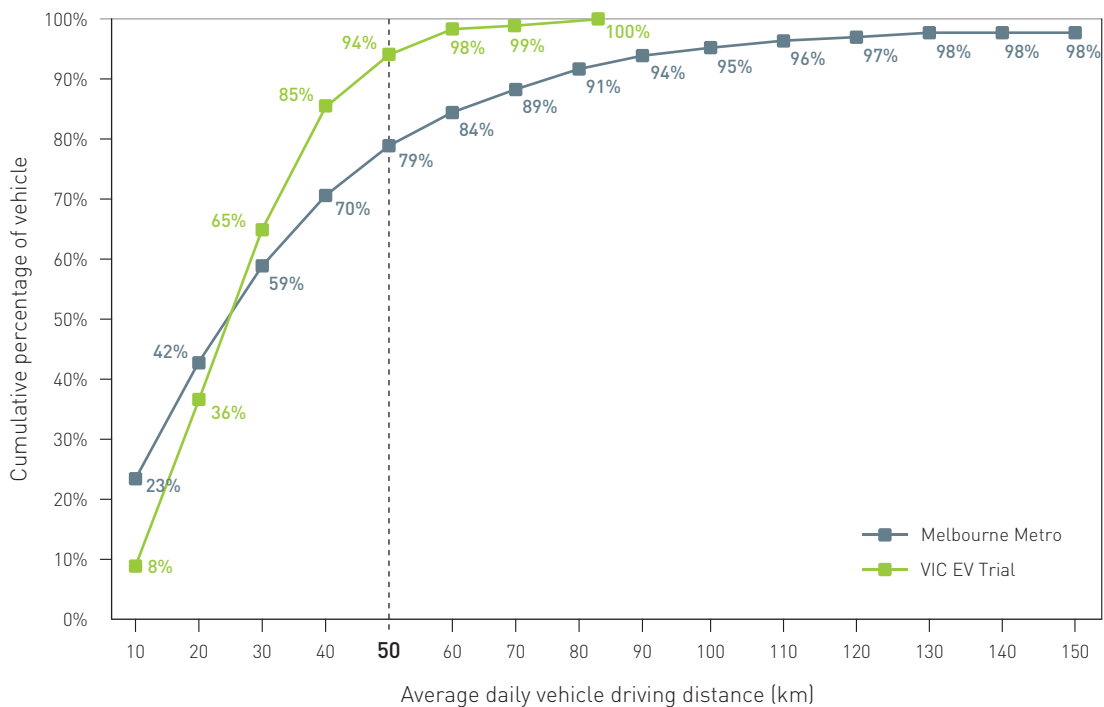


Figure 21. Average daily driving distances for the Melbourne metropolitan area (DOT 2012a) along with average daily driving distances for trial household participants.

Analysis of the vehicle monitoring data provides additional insights that support these conclusions and helps explain the spectrum of driver opinion regarding the vehicle range limitations (refer to Figure 19). Highly reliable data obtained from 44 household vehicle allocations of three months each found that the average distance travelled between charge events was 36.9 kilometre, with a standard deviation of 8.8 kilometres.

With reference to Figure 21, the average daily driving distance for the Melbourne metropolitan area is 35 kilometres (DOT 2012a), however the distribution of average daily driving distances reveals that there is a significant minority who travel further (much further in some cases). This correlates well with the findings above in suggesting that the electric vehicles supported by household charging are sufficient for the majority of Melbourne’s drivers, even if there is a significant minority for whom this would not work.

Further analysis of the vehicle use data illustrates driver management of range limitations. In practical terms, the operating range of the i-MiEV is around 90 kilometres on the highway and 100 kilometres around town, whereas the LEAF is 110 and 120 kilometres respectively. With reference to Table 3, i-MiEV drivers on average plug-in with less range remaining than LEAF drivers, despite having travelled a similar distance between charging (34.3 and 35.9 kilometres respectively). Given that the distance travelled between charging of both vehicles closely approximates the average daily driving distance for Melbourne (35 kilometres), this suggests that people used the i-MiEV as they would their normal vehicle despite the reduced range (relative to the LEAF) – in other words, they managed the range difference. These results also suggest that the tension between range anxiety and management has been resolved in favour of the latter for the majority of participants (refer also to Section 4.2.2).



Vehicle	Mitsubishi i-MiEV	Nissan LEAF
Practical operating range (km)	90 – 100	110 – 120
Average distance travelled between charging (km)	34.3	35.9
Average State-of-Charge at plug-in (%)	57.5	52
Average range remaining at plug-in (km)	51.8 – 57.5	57.2 – 62.4

Table 3. Derived average range remaining at plug-in values for the i-MiEV and LEAF, based upon the practical operating range and the average State-of-Charge at plug-in.

Analysis of the reported trip purpose provides more insights into how people use EVs. Participating households reported 11, 11 and 12 per cent of car-trips as being direct to work in the before, during and after phases respectively. Unsurprisingly given the two-thirds substitution for total vehicle trips above, 11 per cent of EV trips were reported as being direct to work in the 'during' phase. These results are slightly above the Melbourne average of 7 per cent, suggesting that the trial sample is biased towards 'car commuters'.

This conclusion may also apply to the broader group of would-be EV drivers. Figure 22 provides an insight into the driver travel behaviours for households applying to take part in the trial.

Noting that multiple responses were permitted, the workplace was three times more likely to be a travel destination than the next most popular alternative. This is a significant finding in the context of 'workplace charging' (refer to 5.3.5).

Potential differences between early-adopters and mainstream market participants were investigated in the context of the technology market development model adopted at the heart of the trial (refer to Section 3.2). The trial household participants were segmented according to their response to the question 'Thinking in general about when a new product comes on the market, which one of the following would best describe you?'.

Those who described themselves as 'I like to be in there early and get it straight away' were not found to exhibit any statistically-significant difference in behaviour from the rest of the population in terms of vehicle utilisation, charging behaviour or charge management (as described by average daily distance travelled, average distance travelled between charge-events, average state-of-charge at plug-in, use of heating/air-conditioning, use of eco driving mode). This suggests that 'early adopters' in this case may be characterised by their purchase rather than user behaviour, however further investigation may be warranted into this issue.

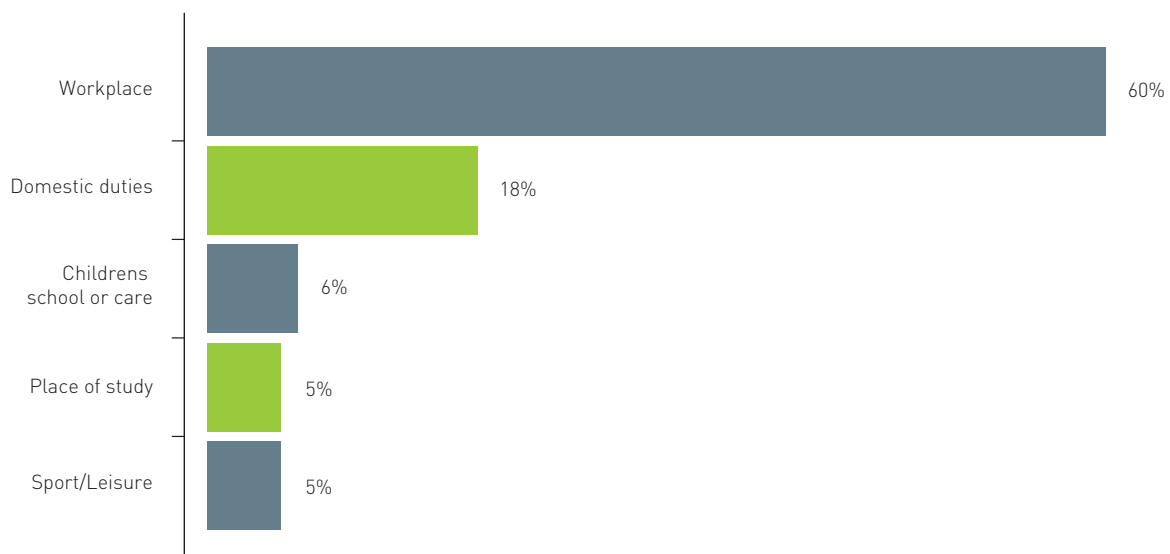


Figure 22. Results from the 2011 trial household application process showing the distribution of vehicle travel destinations for each driver in the household; multiple responses are permitted for each (n = 6,147, DOT 2010d).



#### 4.2.4 How much does it cost for an average household to run an EV?

Although there was significant variation across the vehicle assignments, the average cost for a trial household participant to run their electric vehicle on renewable energy was between \$7 and \$10 per week. This is about half of what it would cost to run an equivalent petrol vehicle, with none of the emissions.

Analysis of the data obtained from the trial household participants provides some insights into the average driving distances and energy economies – refer to Table 4. These values have been segmented by vehicle type due to the statistically-significant variation in energy economy recorded for the two vehicles.

Electricity costs have assumed a residential tariff of \$0.25 per kWh that includes a premium for GreenPower (renewable energy). Although households varied significantly in terms of their GreenPower and/or solar PV take-up, the former Department of Transport has accounted for all electricity used by the trial vehicles for reconciliation with an equivalent amount of renewable electricity supplied by AGL (DOT 2012d).

For the purposes of comparison a calculation was made for the Mazda 3 SP20 – Australia’s highest selling motor vehicle and a direct size competitor to the Nissan LEAF in particular. Although differences were observed between the vehicles, the EV transport energy cost saving is around 50 per cent even allowing for ‘zero emissions’ driving.

Limitations with these calculations include:

- Gaps in the trial data-set, limiting the number of vehicles from which an average electricity economy figure can be derived
- Wide variation in the daily driving distances, reducing the meaningfulness of the average distances used for the calculations
- Functional mismatch between the Mitsubishi i-MiEV and the Mazda 3 SP20, reducing the meaningfulness of the comparison
- Assumed fuel economy for the Mazda 3 SP20, which may not reflect reality (for example, city-based driving would increase the EV savings; DOT 2012f)
- Assumed energy costs for both electricity and petrol, which can be expected to change over time independently of each other (AECOM 2011).

A separate limitation relates to calculation of operating costs for the Prius PHEVs. As these vehicles utilised both electricity and petrol from external sources, significant challenges exist in obtaining reliable data and/or accounting for missing data. These issues have been set out more clearly in the GreenPower accounting report released by the trial (DOT 2012d), along with an operating cost analysis method for PHEV drivers.

Based upon the electricity use figures obtained, it is clear that significant variation exists in the extent to which individual PHEV users rely upon electricity. Possible explanations for this include mismatches between driving needs and charging opportunities, or a lack of awareness or understanding of how to access the cost savings provided by electric-operation.

Attribute	i-MiEV	LEAF
Average daily driving distance (km/day)	26.4	31.6
Average energy economy (kWh/km)	0.150	0.183
Daily electricity cost (\$/day)	0.99	1.45
Weekly electricity cost (\$/wk)	6.93	10.12
Saving relative to Mazda 3 SP20 (%)	56.1	46.4

Table 4. Renewable electricity operating costs for the trial household i-MiEV assignments (n = 45) and LEAF assignments (n = 31); GreenPower tariff assumed to be \$0.25/kWh, Mazda 3 SP20 fuel economy = 6.1 L/100km, petrol price \$1.40/L.

#### 4.2.5 What are the issues and opportunities for electric vehicles in households?

Electric vehicle technology, even as the technology currently stands, holds great promise for more widespread adoption by households. Based upon the results obtained, EVs are suitable for drivers averaging up to around 50 kilometres per day. For average daily driving distances of 50-80 kilometres, alternate solutions would include workplace charging and/or PHEVs. Beyond this, HEVs and ICEVs would likely be the best choice.

However, the significant minority of drivers who did not accept the trial electric vehicles as their everyday transport choice indicates that the technology is not for everyone. This sits alongside the much greater number of people who simply aren't aware of or don't know much about EVs.

These observations have been combined to form a conceptual model for electric vehicle take-up by households. Figure 23 shows the different groupings of households according to where they sit against the key attributes of EV awareness, understanding and acceptance, and average daily driving distance. Each household grouping has been scaled to provide some indication of the relative size of this grouping. The largest grouping, the mainstream market, are potential EV adopters who need to be made aware of, more knowledgeable about and ultimately more accepting of the technology.

Given that electric vehicles are a viable transport option for a majority of Victorian drivers, the clear obstacle to take-up is purchase price. Section 4.1.3 provides a discussion on the potential for improvement in this area, however significant change is required before EV technology becomes financially viable for the majority of households.

Marketing of EVs to early-adopters should focus on technology and driving pleasure/vehicle performance, backed up with messages relating to operating costs and the environment. Interestingly, no difference was observed in the vehicle use behaviours between early-adopter and mainstream market households. This suggests that these messages may remain effective through to mainstream market adoption, even if the emphasis should move towards cost savings.

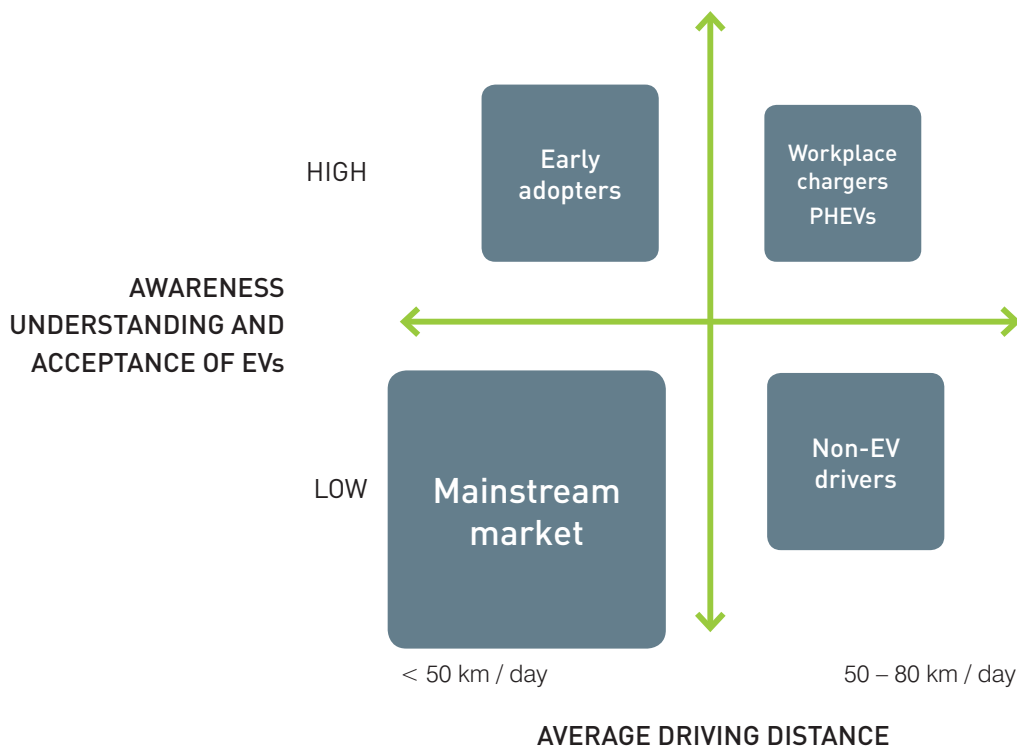


Figure 23. Conceptual model for electric vehicle take-up by households based upon trial results.

Experience from overseas suggests that non-financial measures can be highly effective in promoting consumer adoption of new vehicle technologies. In California single-occupant hybrid vehicles were permitted to travel in high-occupancy vehicle (car-pooling) lanes from 2005 to 2011 (LA Times 2011). Around 10,000 Clean Air Vehicle stickers were issued to cars that met stringent emissions and fuel efficiency standards from 2005 to 2007 as part of efforts to promote consumer uptake. In the year the program began, sales of hybrid vehicles increased from 85,000 vehicles nationally to 207,000, and continued growing to 353,000 in 2007 when the last sticker was handed out. Once the stickers stopped being handed out, hybrid vehicles with the sticker sold for more than \$USD 1,000 above comparable vehicles without the sticker. Although the program has sunset for hybrid vehicles, plug-in vehicles are now eligible and being marketed by manufacturers accordingly (Ford 2012).

## 4.3 FLEET VEHICLE ROLL-OUT

### 4.3.1 What fleets are interested in electric vehicles and why?

Government fleets, particularly local government, are a key market for electric vehicles. Motivations relate primarily to environmental objectives for their fleet operations or for their organisation more generally. Private sector interest has arisen predominantly through the electricity market, motivated by business planning and/or brand-building.

A breakdown of the fleet participants in the trial according to sector indicates that government fleets are a key market for electric vehicles, followed by the private sector – refer to Figure 24. Further analysis of these segments indicates that local government is the primary source of interest, representing nearly 30 per cent of trial fleet participants overall.

Within the private sector, participants are most commonly sourced from the electricity market, with three out of five being goods and service providers within this sector.

Fleet interest in electric vehicles is strongly motivated by environmental commitments relating to their fleet operations. Figure 26 illustrates this through the results of a survey of attendees at EV-related workshops targeted at fleet managers.

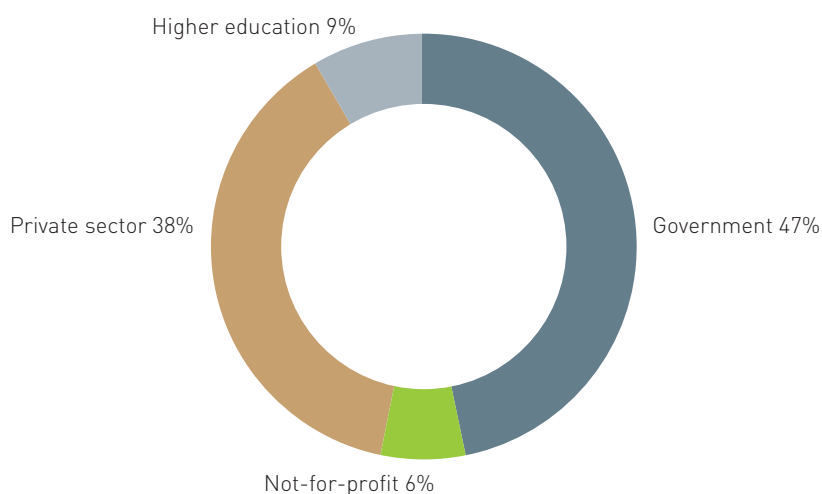


Figure 24. Sectoral breakdown of fleets participating in the Victorian Electric Vehicle Trial (n = 41).

## EARLY ADOPTER FLEETS CASE STUDY LOCAL GOVERNMENT FLEETS IN AUSTRALIA

The third tier of Australian government, local government, is responsible for community needs such as town planning, waste collection and recreational facilities (Aust Govt 2012). There are about 560 local government bodies in Australia, employing around 178,000 people (ALGA 2012). About one in four local government bodies are 'cities', the name historically given to urban or suburban local government areas (Wiki 2012).

In 2008 a survey was undertaken of local government fleet operations (ICLEI 2009). The survey gathered responses from 58 urban and 9 rural councils participating in the Cities for Climate Protection program, representing 8 per cent of all Australian local government bodies at the time. Councils reported on a total of 12,097 vehicles, of which around two thirds were passenger and light commercial vehicles. Of the councils who took part in the survey, almost three quarters reported having specific goals or objectives in place relating to the environmental performance of their fleet.

Local government procurement methods include autonomous procurement by individual councils, demand aggregation through state government contracts or third party aggregators, and regional procurement clusters (Ernst & Young 2008). Third party demand aggregation contracts exist for both vehicle and fuel procurement (Local Government Procurement 2012, Procurement Australia 2012). In Victoria, local government expenditure on vehicle purchasing in 2006/07 was estimated to be \$65–70 million (Ernst & Young 2008).

On a separate but related note, trial experience has found that the majority of local government fleets operate from sites which are owned by them. This is good news in the context of charging infrastructure roll-out. However, differences arise in the vehicle assignment (such as pool, tool-of-trade), and overnight garaging of vehicles (which may be at the depot or at employees' homes).

Most local government fleets operate one or more fuel-card systems that allow staff to refuel vehicles on an as-needs basis and according to the internal rules-of-use, and require staff to fill out log-sheets for reconciliation with Fringe Benefits Tax.

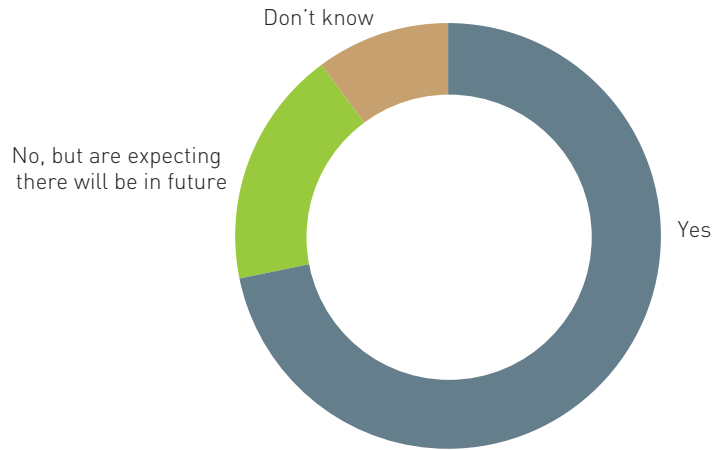


Figure 25. City of Kingston trial vehicle.

In terms of who drives the decision-making, attendees to the fleet EV workshops were asked about previous decision-making around deployment of the Toyota Prius hybrid vehicle into their fleet. According to responses from those attendees who had a Prius and knowledge of the factors behind the procurement decision, the Fleet Management team was identified as having the strongest influence, ahead of the CEO/Executive team and the Environment team – refer to Figure 27.

Building on this, attendees at the workshops were asked about measures that would most effectively promote EV adoption by their fleet within the next two years. With reference to Table 5, attendees were of the view that getting buy-in from their senior management held the most promise in terms of influencing their organisation's EV uptake.

**Does your organisation have any environmental commitments relating to your fleet purchasing/operations?**



**When making the decision to adopt a hybrid into your fleet, who do you believe had the most influence on this decision?**

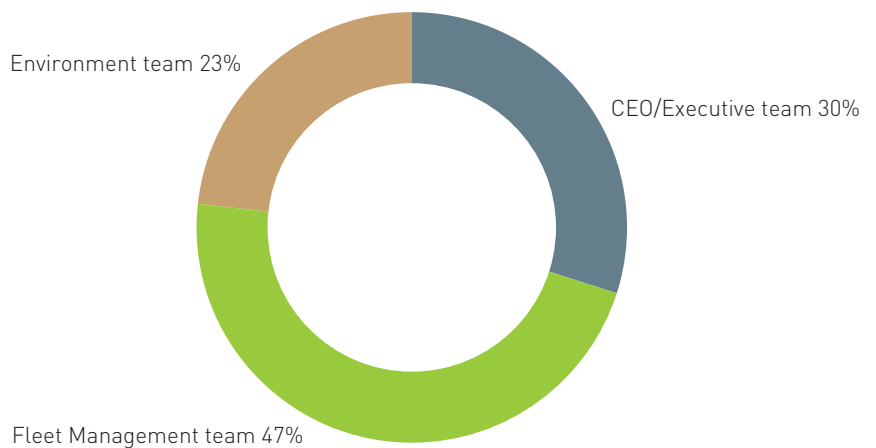


Figure 26 (Top). Survey responses from attendees at three EV workshop events staged in 2012, where the response 'No and not expecting any' was not selected by any attendees (n = 39).

Figure 27 (Above). Survey responses from attendees at three electric vehicle workshops held in 2012, where the response 'Marketing' was not selected by any attendees (n = 30).

### 4.3.2 How do fleets use electric vehicles?

At this early stage of the market, corporate fleets are predominantly using EVs to evidence their Corporate Social Responsibility (CSR) commitments and to gather information in support of forward business planning. These deployment decisions are contributing to relative under-utilisation of the vehicles in terms of distance travelled.

With reference to Table 6, the average daily distance travelled by the trial vehicles when operating as part of corporate fleets is significantly less than for other Victorian fleet applications.

Feedback from the trial fleet participants indicates that deployment decisions have been the strongest influence on this relative under-utilisation. Customer, staff and community engagement activities were prioritised by most trial participants, in between which the vehicles were often moved around to gain insights into their suitability for different service duties. This has translated to reduced distances travelled relative to purely-operational vehicles over the nominal three-month trial vehicle assignment periods.

While the trial fleet participants were on the whole very positive about their EV experience, other issues were noted that may have also contributed to this relative under-utilisation:

- The 'EV learning curve' in terms of trip planning, charging and range management was cited as a major barrier to use, particularly in situations where the vehicle was relatively unsupported in terms of a 'champion' to promote and assist
- The 12 volt battery issue for the i-MiEV in particular (refer Section 4.1.2) was cited as a deterrent for use by some fleet operators.

Option	Average score (out of 5)	Std dev
Gaining strong top-down commitment from senior management within your organisation	4.2	0.8
Access to an independent EV coalition to potentially reduce up-front costs and provide broad assistance with EV roll-out	4.1	0.7
Providing more options for improved visibility of EVs such as dedicated on-street charging sites	3.9	0.8
Improving the processes required for installing EV infrastructure on your premises to reduce costs and streamline installation	3.9	0.9
Assistance with efficient charge management strategies to maximise the utilisation of your EV	3.8	0.6
Providing information packages on effective EV roll-out for fleet managers	3.8	0.7
More concrete information on the environmental benefits of EV technology	3.8	0.9

Application	Average daily driving distance (km)
Victorian EV Trial fleet participants	22
Victorian EV Trial household participants	32
Vehicle with privately-paid running costs – Melbourne metro (DOT 2012a)	33
Vehicle with company-paid running costs – Melbourne metro (DOT 2012a)	54
Victorian Government pool fleet average (DTF 2012)	77

Table 5 (Top). Results from a survey of EVs & Fleets 2012 workshop attendees on their opinions of the options to promote adoption of EVs by their corporate fleet (n = 32; "In the NEXT TWO YEARS which of these do you think would PROMOTE the adoption of EVs by your fleet?"; marks out of 5 where 5 = strongly agree and 1 = strongly disagree)

Table 6 (Above). Average daily driving distances for fleet vehicles – a relative comparison

Despite this relative under-utilisation, fleet participants were generally very positive about their electric vehicle experience, indicating that the vehicles had been successful in promoting their organisation and informing future business planning. Corporate sustainability/branding, environmental benefits, operational cost and future total cost of ownership savings were all cited as important benefits of EV uptake by fleets following their trial involvement.

#### 4.3.3 How much does it cost for an average fleet to run an EV?

Fleet EV energy costs provide around 60 per cent saving on a comparable petrol vehicle, even allowing for renewable energy purchase in support of 'zero emissions driving'. Challenges exist in making reliable calculations of PHEV operating costs which may prevent their benefits from being realised by fleet operators.

Based upon the energy economy figures obtained for the different vehicle types, energy costs per kilometre can be calculated – refer to Table 7. These figures are based upon a commercial electricity tariff that includes an additional component for renewable energy.

Much of what is written in Section 4.2.4 about the household costs of running an electric vehicle applies to the fleet assessment also.

Due to the disconnect between the vehicle driver and the fleet manager, the challenges in accounting for energy use and by extension the operating costs of PHEVs are more significant for fleets than for households (DOT 2012d). A recent news item from the Netherlands tells of PHEVs which are being operated solely on petrol (Autoblog 2012a) in spite of a likely financial incentive to do otherwise. This may be partly explained by the difficulties in accessing information that highlights the cost advantage from optimised electric-only operation.

#### 4.3.4 What are the issues and opportunities for electric vehicles in fleets?

EVs currently provide fleets with the opportunity to showcase their organisation's 'brand' through a highly visible and engaging corporate asset. However, the cost of electric vehicle ownership for fleets is currently prohibitive in both financial and non-financial terms, and technical barriers exist in relation to range/charging. The significance of these items is expected to change as the EV market evolves, moving the emphasis towards the operational cost advantages of EV technology.

The brand-building benefits of EVs are most beneficial for organisations with environmental or CSR commitments, and/or business alignment with EV technology in some way. Based upon the trial experience, these organisations are predominantly (local) government, or electricity market or electrical goods and service providers. Surveys of the trial fleet participants found that the vehicles were very effective promotional tools for these organisations.

Further investigation indicates that many fleets are recognising the marketing value of the vehicles within the business case to support EV purchase. Specifically, the purchase price difference between an EV and a comparable ICE vehicle is being addressed through a contribution from the organisation's marketing budget. This approach also addresses the residual value risk of EVs, whereby the expected high rate of depreciation for the new technology can be dealt with as part of the business case by effectively 'writing off' the marketing budget contribution to the original purchase price.

Attribute	i-MiEV	LEAF
Average energy economy (kWh/km)	0.150	0.179
Renewable electricity cost (\$/km)	0.030	0.036
Saving relative to Mazda 3 SP20 (%)	64.9	58.1

Table 7. Renewable electricity operating costs for the trial fleet participants; GreenPower tariff assumed to be \$0.25/kWh, Mazda 3 SP20 fuel economy = 6.1 L/100km, petrol price \$1.40/L.

Recognising this near-term marketing objective, relevant insights gained from trial fleet electric vehicle roll-out included:

- The i-MiEV's distinctive appearance provided an immediate advantage relative to the more conventional-looking Nissan LEAF – this is consistent with historical observations regarding the Toyota Prius and its sales performance relative to less-distinctive HEV competitors
- Design and application of eye-catching and informative branding for the trial vehicles was perhaps the most crucial success factor for the trial fleet participants [refer to Figure 28] – the availability of exterior vehicle dimensions and/or design data, along with good relationships with vehicle livery designers/applifiers were important ingredients to delivery of the vehicle branding
- Ensuring the vehicle was fully-integrated with the organisation's wider internal/external marketing efforts was an important starting point for the successful trial fleet participants – online videos of the branded vehicle were a popular choice by the more successful participants, as was integration into messaging around renewable energy use strategies already being pursued
- Advanced marketing strategies included use of visible charging locations/opportunities, such as charging outlets located in front of the fleet's own corporate premises – this builds on the observation that 'plugged-in' vehicles are most effective at engaging passers-by
- The environmental bona fides of the vehicles were underwritten by the former Department of Transport's 'zero emissions' trial commitment (DOT 2012) – this allowed the fleet operators to confidently leverage the nominal environmental benefits of the technology.

Despite the clear promotional benefits from EV acquisition and successful trial experience, only three trial fleet participants are known to have acquired their own vehicles following participation. The primary obstacle cited by participants is price, although the range/charging issues were also cited as a significant obstacle to uptake.

The business case for electric vehicle acquisition is strongly dependent upon upfront purchase price and the residual value at the time of disposal. By way of example, in recent times the Victorian Government has turned vehicles over at service intervals of three years or 60,000 kilometres (whichever came first).



Figure 28. An example of the trial fleet vehicle branding



Within the traditional fleet asset management model, the operational cost savings within this period must exceed the initial purchase price penalty and residual value risk associated with electric vehicle uptake. This is summed up by the response of one fleet manager to an electric vehicle supply proposal:

*They've said they can do an EV for the same total package cost over three years as one of my current vehicles – but if I'm not going to save anything, why would I bother?*

Victorian fleet manager, 2012

A range of opportunities exist to address these issues, some of which are being addressed through the Victorian Electric Vehicle Trial:

- Fleet purchasing coalition – combining the EV procurement activities of a number of organisations is beneficial for suppliers and customers alike (refer Local Government fleets breakout in Section 4.3.1). To this end the trial has partnered with The Climate Group and South Australian Government to investigate a fleet purchasing coalition for Australia, the results from which will be released in early 2013
- Market competition – by creating consumer interest and removing barriers to market access, the trial is seeking to attract more vehicles into the market and in doing so create competition that will have a downwards influence on vehicle prices
- Marketing contribution – as described above, some fleets are seeking to address the initial purchase price/residual value risk issue through a contribution from their marketing budget, however this approach is not likely to extend much beyond the first vehicle purchase by any fleet
- Guaranteed buy-backs – the trial EV residual value risk for Victorian Government was addressed with guaranteed buy-back prices locked in at the time of purchase with both Nissan and Mitsubishi; these experiences can be expected to inform the business planning of both organisations as they approach EV fleet sales more broadly.

An additional cost issue identified as part of the fleet roll-out is the resource commitment associated with successful deployment of EVs. Compared to conventional vehicles, there are significantly higher overheads associated with the business case design, procurement process, charging strategy design and implementation, vehicle management, project communications and marketing, and staff training. In addition, organisations must acquire the knowledge and skills to complete these tasks in order to realise the benefits from their EV investment.

Benchmarking of the trial fleet participant experiences informed the design of two half-day training workshops delivered in early 2012 to address the information barriers to successful EV roll-out by corporate fleet operators. The topic breakdown from these workshops is provided in Table 8, with additional information in *Appendix A – Victorian EV Trial corporate participants*.

Time	Description
9:00 – 9:10	Introduction
9:10 – 9:30	EV technology 101
9:30 – 10:00	Procurement options panel discussion
10:00 – 10:30	Practical roll-out plan
10:30 – 10:50	Morning tea / networking / charging outlet demonstrations
10:50 – 11:30	Staff engagement and training panel discussion
11:30 – 12:00	Future business planning
12:00 – 12:30	Realising the value of your investment
12:30 – 1:15	Lunch / networking / EV test-drives

Table 8. EVs and Fleets 2012 training workshop agenda.

One of the objectives of the guidance above is to optimise the vehicle utilisation once in-service, and with this the operational cost savings. An implication of the observed under-utilisation of the trial vehicles is the reduced operational cost saving input into the total cost of ownership business case. This will work against EV uptake, which means addressing barriers to vehicle utilisation should be a priority to promote fleet adoption.

The inter-related issues of limited range, long charging times and a lack of widespread charging infrastructure availability were cited by trial fleet participants and attendees at the fleet workshops as a major barrier to more widespread fleet adoption of EVs. Options to address this include:

- Larger vehicle batteries – this would increase range, but at the expense of purchase price and charging time
- Faster charging – next-generation EVs are likely to be capable of drawing 32 amps, which will effectively halve the current 'standard' charging times; sufficient electrical supply must be available or installed to support the increased demand (refer to Section 5.1)

- Public charging network – including specifically quick charging and/or battery swap, would greatly increase the effective range of the vehicles, or possibly even support reduced battery size/vehicle cost for highly predictable vehicle applications that align with the charging network
- Corporate charging network – including charging locations at corporate sites, staff residences and common corporate fleet destinations (such as customer facilities); this approach may provide additional brand-building benefits (by increasing the visibility of the vehicles whilst plugged-in at strategic locations), as well as the battery size/vehicle cost optimisation described above.

The contrasting nature of these options highlights the importance of fleet service duty analysis and matching to the EV/charging solution. Service duties may include tool-of-trade, pool, executive, and a range of other specific purpose vehicle applications. Of these, vehicles which return to a central location are more easily supported with a simple charging solution; however vehicles which operate on predictable and relatively high mileage routes provide potentially the greatest opportunity for EVs. By way of example, salary-packaged vehicles for staff that commute relatively long distances may be supported with a home/workplace charging strategy that will deliver significant savings in transport energy costs that may be shared between both the employer and the employee.

Discussions with the trial fleet participants found that those who had most successfully integrated the electric vehicles into their operational fleet were:

- Designating an electric vehicle 'champion' who can manage and promote the vehicle/s, and train and support staff
- Mostly assigning the vehicles to small groups of (enthusiastic) staff, who could become familiar with the vehicle through regular use and report on their experiences to others
- Providing staff with one-on-one/tailored training in use of the EV (EV meet'n'greet sessions were popular, and one large fleet operator developed an online training/assessment tool)
- Actively promoting the EV to staff, and characterising it as new, exciting and interesting
- Providing feedback to staff on their own and their organisation's EV experience.

Conversely, the various issues that make up the electric vehicle learning curve were routinely cited by fleets in instances where operational use of the vehicles had either not been attempted or was less than successful. Noting the non-existent or less-than-ideal nature of the route-planning and charge-management technology employed in the trial (refer to Sections 4.1.1 and 5.1.1), these issues may be at least partly addressed by improved technology for management of the vehicle.

## CORPORATE CHARGING NETWORK CASE STUDY NHP ELECTRICAL ENGINEERING PRODUCTS

As a supplier of industrial electrical and automation products, NHP's core business is in good alignment with EV technology. NHP also have a commitment to environmental sustainability, including through a Sustainability Centre where many of their products are evaluated and demonstrated in renewable energy applications. This background has meant that NHP were ideally placed for participation in the Victorian Electric Vehicle Trial.

NHP have taken a holistic outlook towards translating this strategic alignment to their fleet operations through their corporate EV charging strategy:

- To maximise visibility, an EV charging solution has been installed out the front of NHP's corporate headquarters
- To maximise vehicle utility, an EV charging solution has been installed at the most common parking location for the vehicle at NHP's manufacturing and distribution centre, around 25 kilometres from their corporate headquarters
- To support their standard fleet practices, charging outlets have been installed at some of the more distant NHP staff residences to allow the EVs to be garaged at these locations overnight.

As a result of their corporate electric vehicle charging strategy, NHP have averaged nearly double the daily EV driving distance for the trial fleet participants, at 41 kilometres per day (km/day) for the i-MiEV and 46 km/day for the LEAF (at the halfway point for that vehicle assignment). Over this same time, NHP have trialled the vehicles in a number of different fleet service duties, and leveraged the trial vehicles for promotional opportunities. Should they go on to deploy EVs in their fleet operations, it is not unreasonable to expect that NHP will record much greater average daily driving distances even using the current generation of EV technology.



Figure 29. NHP Electrical Engineering Products branded trial vehicle parked in front of their Sustainability Centre, located at their manufacturing and distribution centre in Laverton North.

# CHARGING INFRASTRUCTURE ROLL-OUT

The Victorian Electric Vehicle Trial charging infrastructure roll-out has sought to establish the foundations of Victoria's EV charging network as an open and competitive market of different technologies and business models. The department has acted as an 'honest broker' in the formation of this new market, insulating providers, hosts and users from commercial and non-commercial risk.

# 5



Nearly 140 household, fleet and publicly-accessible charging outlets have been deployed up to the mid-point of the trial. Providers have rolled out the infrastructure through a non-prescriptive approach beyond basic 'rules of engagement' developed in consultation with key stakeholders.

Deployment and operation of the charging infrastructure has been benchmarked, providing insights into the issues and opportunities associated with this new market. An understanding of costs and benefits has been obtained, which will inform planning critical to the successful uptake of electric vehicles.

## 5.1 CHARGING INFRASTRUCTURE

### 5.1.1 What are the arrangements for the trial charging infrastructure?

The trial charging infrastructure is delivered under a model which addresses the early-market investment risks for the relevant parties. The delivery model has also sought to identify least-cost approaches to inform cost benchmarking activities, and facilitate creation of a legacy electric vehicle charging network for Victoria.

The former Department of Transport engaged charging infrastructure providers under service provision agreements that provide a framework for the infrastructure delivery, operation, removal and transition of responsibilities – refer to Figure 30:

- Once installed, the charging infrastructure operates for the period of trial participation
- Towards the end of this period, the charging infrastructure operator provides the site owner/occupant with an offer to retain the infrastructure
- The negotiation of this offer is undertaken by both parties drawing upon the knowledge acquired through trial participation, allowing them to more clearly understand the costs and benefits involved
- If no agreement is reached, the charging infrastructure is removed and the site remediated to the site owner/occupant's satisfaction.

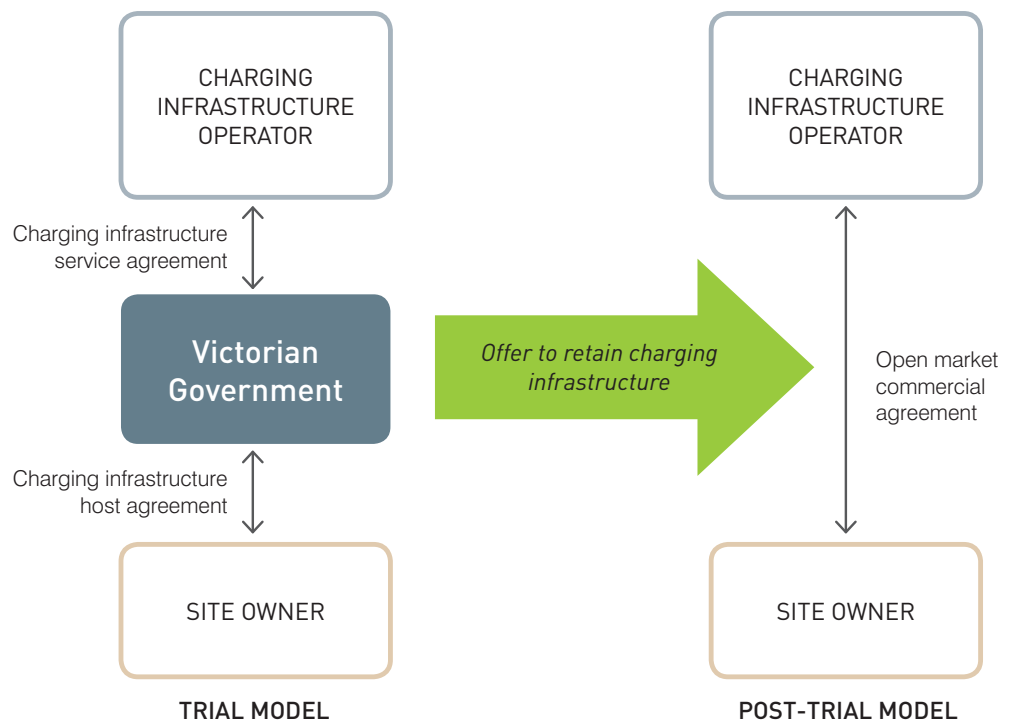


Figure 30. Schematic of the commercial model developed for the trial charging infrastructure.

With reference to Figure 5, the location of the charging outlet drives much of the costs associated with the charging circuit. As the decision on location generally rests with the site owner/occupier, under the trial arrangements, they bear the costs of the charging circuit. Households were an exception to this, however some contribution to the costs was sought in instances where either they insisted upon a solution other than the least-cost approach, or an electrical supply upgrade to their property was required (which is a general home improvement).

### 5.1.2 What charging infrastructure is being used in the trial?

In recognition of the very early state of the market development, a range of providers have been engaged for the trial household, fleet and public charging outlets.

As a result of the March 2010 EOI process, a range of EV charging infrastructure technology and service providers were engaged in support of the trial. These were supplemented by additional technology and service providers who joined the trial to access a range of benefits, including gaining experience in charging the range of trial vehicles or simply in support of information exchange. The list of charging infrastructure providers taking part in the trial, their role and the equipment supplied is detailed in Table 9.

### 5.1.3 What are the relevant features of the trial charging infrastructure?

The trial charging outlets are of 'Level 2' standard and have minimum requirements relating to vehicle compatibility, data provision and safety. Beyond this, the charging outlets are proprietary solutions tailored to the specific application. Through benchmarking and consultation, a list of relevant attributes has been defined to inform procurement processes for dedicated EV charging outlets.

As a minimum requirement, trial charging outlets need to be compatible with the vehicles and have enhanced safety and data collection/management capabilities relative to conventional wall sockets. Additional features are included according to the needs of the site, for example a public site requires enhanced security and damage protection.

According to the industry terminology, the charging infrastructure deployed in the trial was of 'Level 2' standard. This means that it is a 240 volt circuit (standard for Australia), and includes some interaction with the vehicle as set out by the SAE J1772 technical specification as part of the charging activity initiation. At the trial outset, 'Level 1' standard charging infrastructure was deployed in terms of vehicle interaction due to the trial Mitsubishi i-MiEV vehicle specification. In 2011 a modification was made to the vehicles to allow for standardisation of the charging infrastructure to Level 2 specification (refer to Section 5.1.4 for further explanation of this).

Although the trial vehicles only draw 15 amps current maximum, the trial charging circuits are standardised to 'future-protect' for the next-generation EVs that are expected to draw 32 amps. However, for locations with insufficient electrical supply this specification was de-rated to 16 amps to avoid costly upgrades.

The trial charging infrastructure varies widely in user feedback and network support. All charging outlets provide feedback at the point of use. However this varies from a simple beep/flashing light to indicate changes in operational status, to LCD screens able to provide guidance, promotional and/or charging activity information. While it may be argued that more information is better, the cost trade-off is generally not insignificant. An example of this is stand-by power consumption. For a charging outlet equipped with an 'always on' LCD screen, this may equate to an additional 20 per cent energy consumption for a typical household EV driver (DOT 2012c).

Although all charging outlets are nominally networked, only some provide network visibility from the user perspective. One network operator provides users with real-time/remotely-accessible information on the charging status of their outlets, charge management capability and a suite of data analytics. Other network operators provide reduced levels of support, due to the point they've reached in their Australian business development and/or overall corporate strategy/business model.

Three quick chargers were contracted for delivery at the start of the trial in 2010. As of December 2012, a site work order has been released for one quick charger and an agreement-in-principle reached for another.

Benchmarking of a procurement activity undertaken by the Southern California Association of Local Government informed a survey of the trial charging infrastructure providers on the relevant features for specification of charging infrastructure. These attributes should be considered by any entity procuring dedicated EV charging outlets. For more information, refer to *Appendix C – Charging outlet attribute list*.

Provider	Trial role	Equipment supplied / operated			
		Household	Fleet	Public	Other
Better Place	Contracted service provider	27	7	4	-
Bosch	Charging infrastructure operator	2	2	-	-
ChargePoint	Contracted service provider	31	11	2	Quick charger provider (x 2)
Club Assist	Charging infrastructure operator	-	-	1	SAE J1772 aftermarket vehicle solution (x 2); Mobile charging solution (roadside assistance)
DiUS Computing (ChargeIQ)	Contracted service provider	18	-	-	Grid-integrated charging solution ('ZigBee' communications protocol)
ECOtality (Blink)	Contracted service provider	21	6	6	-
General Electric (GE)	Charging infrastructure operator	-	-	1	-
Juicepoint	Trial partner (observer role)	-	-	-	-
Siemens	Trial partner (observer role)	-	-	-	-
<b>Total</b>		<b>99</b>	<b>26</b>	<b>14</b>	

Table 9. Breakdown of charging infrastructure providers and equipment taking part in the Victorian Electric Vehicle Trial as of December 2012.

#### 5.1.4 How do users 'roam' across the trial charging infrastructure network?

Participants have been able to use the various charging outlets provided under the trial through the provision of cables to match vehicles to charging outlets, RFID cards to activate the outlets, and information to guide planning and use. Payment for use has generally occurred through the underlying electricity billing arrangements for the site. Arrangements for the trial have been negotiated on a business-to-business basis by the Department, including with vehicle suppliers, charging infrastructure providers and hosts. Despite general agreement on the goal for streamlined network roaming capability, there is limited appetite for an industry standard at this stage of the market development due primarily to cost/time constraints.

Drawing upon the model provided by Nous (2010), roaming by users across different charging outlets and service providers is underpinned by basic elements of system 'interoperability':

1. Physical compatibility – the electrical connection plug configuration must match the outlet
2. Systems compatibility – the on-board vehicle system must be able to interact with the charging outlet controller
3. Financial reconciliation – arrangements must be in place to allow for the various costs associated with the charging activity to be reconciled
4. User information – users must know where to find charging outlets and how to use them.

Various layers of complexity may be added to these elements to support more advanced system models. By way of example, identification of users as part of the systems compatibility will allow for more advanced financial reconciliation through user accounts and across charging infrastructure providers.

At the start of the trial, some of the issues included physical and systems compatibility. Some fixes were needed to allow for basic user roaming:

- Each charging infrastructure provider technology has its own system activation strategy mostly utilising proprietary RFID cards – each trial participant is assigned a unique set of RFID cards for the relevant vendors, which also enables charging activity data to be reconciled to individual users
- One charging infrastructure provider adopted the IEC 62196 'Mennekes' connectors as opposed to the SAE J1772 as featured by the trial vehicles – in addition to their existing cables, each trial vehicle was kitted out with a 'floating' cable that utilised the SAE standard on the vehicle-end and the Mennekes standard on the infrastructure-end
- The Model Year (MY) 2010 Mitsubishi i-MiEVs were found to use a superseded specification for the on-vehicle charging outlet, resulting in varying degrees of physical incompatibility with the charging infrastructure – modifications of the charging cables were required to ensure physical compatibility with the vehicles
- The MY2010 i-MiEV and the UK production-specification MY2011 Nissan LEAFs utilised different charging protocols, preventing them from being charged from the same specification outlets and ensuring network system compatibility – a modification to the MY2010 i-MiEV charging outlet was undertaken to allow it to be charged using the SAE J1772 Level 2 charging protocol, supported by warranties from the charging infrastructure providers
- The Toyota Prius PHEV pre-production prototype vehicles were found to use an unfamiliar charging protocol for many of the charging infrastructure providers – this required some adaptation by the charging infrastructure providers to ensure system compatibility
- A commercial charging station using the SAE J1772 standard was installed at a site where aftermarket EV conversions were in operation, necessitating a vehicle-based solution to allow for both physical and system compatibility – the charging infrastructure provider Club Assist were able to provide a certified aftermarket solution that was accepted by the other charging infrastructure providers to allow for vehicle roaming across the network.



Through these efforts, trial participants can use the network of charging outlets operated by seven providers. They are assured of physical compatibility (the plugs match the sockets), systems compatibility (RFID cards and vehicle responses will activate the charging sequence), and are provided with sufficient information to allow them to navigate their way around the charging network and use the equipment.

Financial reconciliation of charging activities was an issue of much discussion at the outset of the trial. A discussion paper was authored for the most complicated of scenarios relating to on-street charging (DOT 2011), however the outcome has largely defaulted to the site owner and billing recipient for the electricity used by the charging outlet paying for the electricity costs associated with use. The main influence on this outcome has been the transaction costs associated with processing a relatively novel transaction as compared to business-as-usual.

The only instances where costs have been associated with the charging activity are when the financial transaction is not automated (note that a charging activity 'flat-rate' has been adopted in these instances to avoid the on-selling of electricity that is prohibited under electricity market rules).

User information has been standardised in terms of a common information source (the trial website) and typology (charging outlet description, access arrangements, signage). The preferred approach to utilise Google maps as the primary network information source was confounded by the need for a postcard containing the activation code for the listing to be sent to the listing business address.

As charging outlets are unmanned facilities, it proved impossible to have these postcards be received and the listing activated. At this point in time, the trial webpage 'Where do I charge my car?' remains the primary information source for trial participants seeking to navigate their way around the charging network. This represents a significant opportunity for improvement that is currently limited by the small market for this information.

Standardisation of signage for EV parking and charging has been progressed by the Victorian road regulator through the national signage standards working group – refer to Figure 31. Visual recognition testing and review by other road signage regulators has underpinned what is hoped to be the universal EV symbol to be adopted nationally.

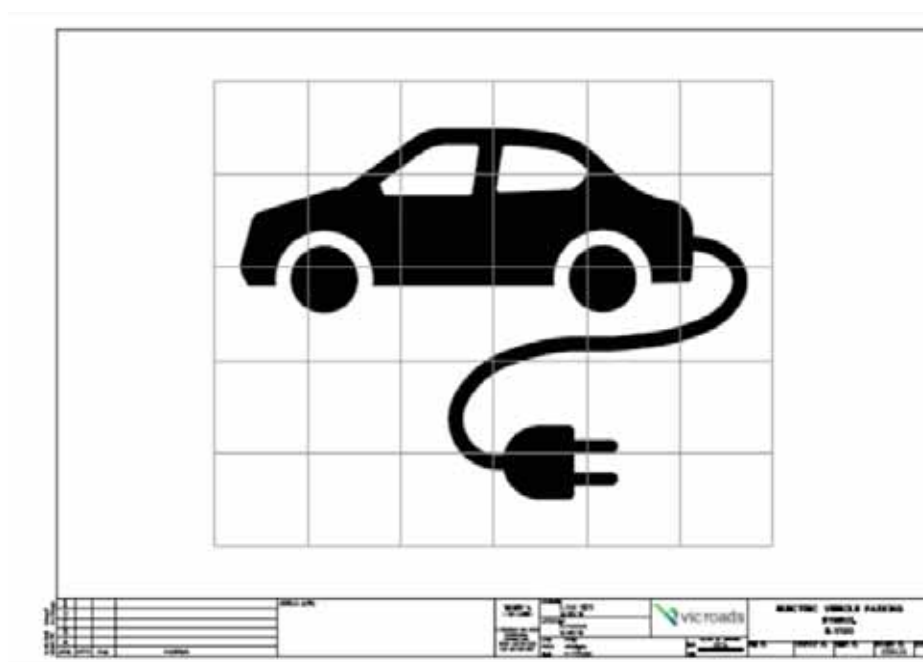


Figure 31. VicRoads-designed EV parking symbol, which has been endorsed for use in-principle nationally (VicRoads drawing no.V130<sup>11</sup>).

11 Contact [tem@roads.vic.gov.au](mailto:tem@roads.vic.gov.au)

Consultation with the trial charging infrastructure providers found that universal agreement existed on the goal for full interoperability across different EV charging networks. This goal was agreed to be outside the trial timeframe due to the large number of higher priority issues that need to be dealt with in the near-term by the fledgling companies involved. The companies also agreed that full interoperability requires a unique and universally-recognised user identification key.

The trial experience in negotiating a common data schema for use by all providers illustrated the issues and opportunities in this space. Each provider characterises charging events taking place on their network slightly differently, which necessitated some manipulation of data in most cases to make it suitable for export and incorporation into the main trial data-set. The trial defined unique user identification codes which were maintained on a 'look-up' table to be cross-referenced with the charging infrastructure provider's own user identification.

In most cases it was found that the RFID cards issued by the charging infrastructure providers formed the only unique user identification, as an individual user account may have multiple cards linked to it that are supplied and/or replaced as needs arise. The Department's look-up table and user identification codes to which the charging infrastructure RFID cards are mapped effectively provide a model for business-to-business or industry-wide interoperability models for the future.

### 5.1.5 What are the charging infrastructure network issues and opportunities?

A clear issue for the charging infrastructure network is provision of information to would-be users. Information is not supplied in a standardised way, nor is it available through easily-found or streamlined channels. This information is a key enabler for promotion of awareness, understanding and acceptance of EV technology. Additional opportunities exist to streamline user roaming across the electric vehicle charging network.

Signage is a prime example of the challenges and opportunities in this space. The visible presence of EV charging stations has a recognised impact upon electric vehicle take-up and ultimately the economic benefits to the state [refer to Sections 6.1.2 and 6.1.3]. Electric vehicle drivers need to locate the actual bays in which charging of their vehicle is possible – no small challenge in large multi-level car-parks. Educating non-EV drivers on recognition and avoidance of EV parking bays is critical to increasing EV driver confidence, recovering the value of the charging infrastructure investment, and minimising enforcement overheads.

The foresight of the Victorian road regulator has provided an excellent starting point in the form of the EV symbol depicted in Figure 31. However, this design is not currently available online, nor has it been formally recognised within the manual of standard drawings for road signs. Adoption of the symbol nationally will occur at the discretion of the road regulator in each jurisdiction.

A further challenge in promoting more widespread use of this symbol and standardised signs generally lay in the uncertainty around the distribution of responsibilities. Local government has responsibility for the majority of informational signage of this nature in the public domain, however there are 79 councils in Victoria who must be educated as to the existence and appropriate use of these standardised designs. For private property the situation is even more complicated due to the large number of potential players who may be involved.

Drawing upon lessons from both the fleet and public charging infrastructure roll-out (refer to Sections 5.3.2 and 5.4.2), the best solution for the signage appears to be:

- The road regulator in each jurisdiction to formally adopt the EV signage symbol depicted in Figure 31 as part of their standard drawings for road signs
- Charging infrastructure providers to arrange for the signage design/manufacture as part of their 'turn-key' EV charging product/service offering
- A leading council to design standard work practices and training of staff for signage, enforcement etc. in relation to EV parking arrangements, and for them to make this information available through the relevant local government networks.

To support trip planning and range management (refer to Section 4.2.2), electric vehicle drivers will also greatly benefit from remotely-accessible, real-time information about the charging network. Drivers need to be able to find charging locations, understand how to access them and reliably plan on gaining access. Feedback from the trial participants suggests that an inability to access this information results in underutilisation of both the vehicles and the charging network, and reduces the likelihood of EV take-up.

The trial charging network directory in the 'Where do I charge my car?' webpage is a temporary and imperfect solution. Although the information for all charging network locations has been standardised and is linked to an online mapping resource, there is no integration into vehicle navigation systems, no real-time information, and no easy pathway to engage with the relevant service provider for each charging service/location (for example, to reserve a charging station in advance of needing it, or to verify the parking bay/charging station as being operational and available for use).

These are potential areas of competitive advantage for individual providers and so may be best left to the market; however a centralised directory would provide a virtual marketplace for these services. Government and third-party solutions have emerged internationally<sup>12</sup>, some of which have spawned innovations such as listings by private EV owners offering their home-charging station for EV drivers in-need. There are also a range of pilot and demonstration projects in the EU that are focused specifically on connected vehicle solutions as a key input to the EV value proposition<sup>13</sup>.

However, discussions with international providers found a limited appetite to extend their solution to Victoria. This is partly attributable to the small size of the Victorian market for the foreseeable future, which also undermines the likelihood that a local charging network directory solution will emerge. According to a 2009 survey of U.S. experts in vehicle communications systems (CAR 2011), a comprehensive plan and funding for road network infrastructure are the two main obstacles to widespread connected vehicle deployment.



12 In the United States, [www.afdc.energy.gov/locator/stations](http://www.afdc.energy.gov/locator/stations) and [www.plugshare.com](http://www.plugshare.com)

13 For instance, [www.ict4eveu.eu](http://www.ict4eveu.eu), [www.mobieurope.eu](http://www.mobieurope.eu), [www.molecules-project.eu](http://www.molecules-project.eu) and [www.smartcem-project.eu](http://www.smartcem-project.eu)

The 'holy grail' is a fully-interoperable charging network that supports seamless user roaming across providers, as is the case for banking services or mobile phone use. While there is a consensus amongst industry participants on the desirability of this scenario, it is unlikely in the near-term due to the fledgling status of the charging service provider industry (refer to Section 5.1.4). Lessons from the toll-roads industry and the banking sector (Nous 2010) suggest that charging service providers will need to work with each other to progress towards a better customer experience overall, even if there may be a role for an 'honest broker' to facilitate this outcome.

Business-to-business relationships are emerging internationally as a stepping stone towards this outcome (Green Car Congress 2013). One clear observation made by all parties lay in the need for a unique data key for individual users – a potentially low-cost opportunity now in terms of its potential benefits for the future, and a critical component of the trial framework.

An obstacle for the entire electric vehicle space relates to harmonisation of charging requirements and specifications for different vehicle types. Electric bikes and motorcycles generally use conventional 10 amp GPO plug/cable as for most other electrical appliances. At the other end of the spectrum, electric commercial vehicles often employ industrial high-voltage charging systems due to their large batteries and need for short charging times to keep the vehicles on the road. Passenger vehicles sit somewhere between the two, such that even quick charger technology is generally different to what is being used in commercial vehicles globally.

These differences in charging strategies arise out of trade-offs between battery size, cost and charging speed, the balance for which changes according to the vehicle type. Furthermore, the vehicles generally park in different locations. As a result of these issues, few opportunities exist currently to deploy charging solutions that can satisfy a number of different vehicle types. This creates further challenges for the public charging business model as outlined in Section 5.4.5.

Many of the standardisation issues may be addressed through a national standards development process for electric vehicles being delivered by Standards Australia with the support of the Victorian Electric Vehicle Trial (Standards Australia 2010). The most significant workstream within this project is focused upon EV charging infrastructure. Resumption of the work program following a hiatus as funding issues are resolved is expected in 2013.

A further issue relating to EV charging generally is the potential revenue impact for government. Fuel excise is a major contributor to government budgets around the world, helping to fund those services that are not able to be funded within themselves (for instance, public education and health). In Australia, fuel excise raises the largest amount of revenue of all taxes on specific goods (Aust Govt 2011).

Increased use of electric vehicles will reduce government revenues, as electricity is not subject to excise. Internationally, some jurisdictions are responding to this by introducing annual fees for electric vehicles (CNET 2012).

A corollary to the reduction in fuel excise is the relative impact of carbon pricing. The Australian Government's Clean Energy Plan (2012) applies to electricity but not transport fuels such as petrol. Although the Department's analysis suggests that the relative impact of carbon pricing on the competitiveness of electric vehicles is minor by comparison with oil prices (AECOM 2011), the contrasting treatment of electricity compared to other transport fuels represents a regulatory barrier of the type discussed in Section 8.



## 5.2 HOME CHARGING

### 5.2.1 How much does household charging infrastructure cost?

Household charging infrastructure costs around \$1,750 for the charging circuit and up to \$2,500 for a fully-featured dedicated EV charging outlet. While the costs for the latter reflect user preference and technology, the charging circuit is a cost that reflects the specifics of the residence.

Based upon the trial experience, home charging outlets can vary in price from:

- Less than \$100 for a standard wall-socket
- Up to around \$500 for an entry-level dedicated EV charging outlet
- Up to around \$2,500 for a more advanced unit with a range of features.

It should also be noted that as of December 2012, one service provider provides the charging outlet at no cost to the household under the terms of their ongoing service provision agreement.



The charging circuit varies significantly in price according to the needs and wishes of the household. With reference to Table 10, the average cost for the charging infrastructure circuit cost for the trial households was \$1,750. Key influences on this price were distance from the point of electrical supply, the condition and capacity of the electrical supply board, and the need for a free-standing charging outlet as opposed to being mounted off an existing structure.

No. INSTALLATIONS	94
AVERAGE COST	\$ 1,750
MEDIAN COST	\$ 1,429
STD DEV	\$ 1,124
MAX	\$ 6,650
MIN	\$ 392

Table 10. Cost benchmarking of the trial household charging circuits.

Information sourced from the households prior to the initial site visit assisted with the installation planning process, which sometimes included phone conversations with the householder to source additional information and/or negotiate least-cost alternatives.

With reference to *Appendix D – Household charging infrastructure questions proforma*:

- The age of the dwelling or date of most recent major renovation provided an early indication of potentially insufficient electrical supply to support the addition of an EV charging load
- Photos of the meter/switchboard were a good indicator of the potential need for an electrical supply upgrade or refurbishment of the board itself (in support of a certificate of electrical safety)
- Photos of the property and parking location assisted with a subjective review for potential aesthetic concerns with regards the EV charging outlet location – heritage or new/recently-renovated housing, along with locations where the charging outlet would be visible from the front of the property increased the need to address aesthetic issues as part of the charging solution
- Diagrams/house-plan mark-ups explaining the property layout in terms of the parking location/s relative to the point of meter/switchboard greatly assisted with initial discussions to find the least-cost approach – note that this information was able to be sourced from less than 50 per cent of participants
- Observations from the photos/diagrams along with discussions with the resident were also critical to ensuring that charging cable tripping hazards were avoided – for instance, by considering the likely parking location and orientation in relation to the vehicle charging outlet location.

Despite these efforts, around one in five dwellings required multiple visits from the installers. Discussions with the charging infrastructure providers suggest that around half of these multi-visit sites were due to issues that may have been possible to discern from the initial information and with more experience on behalf of the installers. The residual 10 per cent of households for which multiple site visits were thought to be unavoidable could be mostly attributed to the limited ability to discern the need for an electrical supply upgrade without a site visit. Figure 32 suggests that this estimate is correct based upon the conclusion that residences built earlier than 1970 that have not undergone significant renovation in the interim are more likely to be in need of an electricity supply upgrade.

### 5.2.2 How is charging infrastructure installed in households?

Charging infrastructure is installed by electrical contractors drawing upon information supplied by the household. From the time of the contractor being notified of the need for an installation, the process to handover usually takes about five weeks.

The average time to install a trial household charging solution was 35 days, even if there was some variability across installations (standard deviation of 17 days across 94 installations).

Key influences on the installation leadtime include:

- The accuracy and extent of information provided beforehand describing the household charging installation context
- Involvement of a third party such as a landlord or body corporate
- The availability and responsiveness of the householder
- Stipulation of target dates for the installation at the time of the request, and progress tracking thereafter (in other words, working to a deadline)
- Pre-approvals for installations where the site works are less than a reasonable threshold value (\$2,000 was selected for the trial following the initial round of 14 installations)
- The experience of the installer.

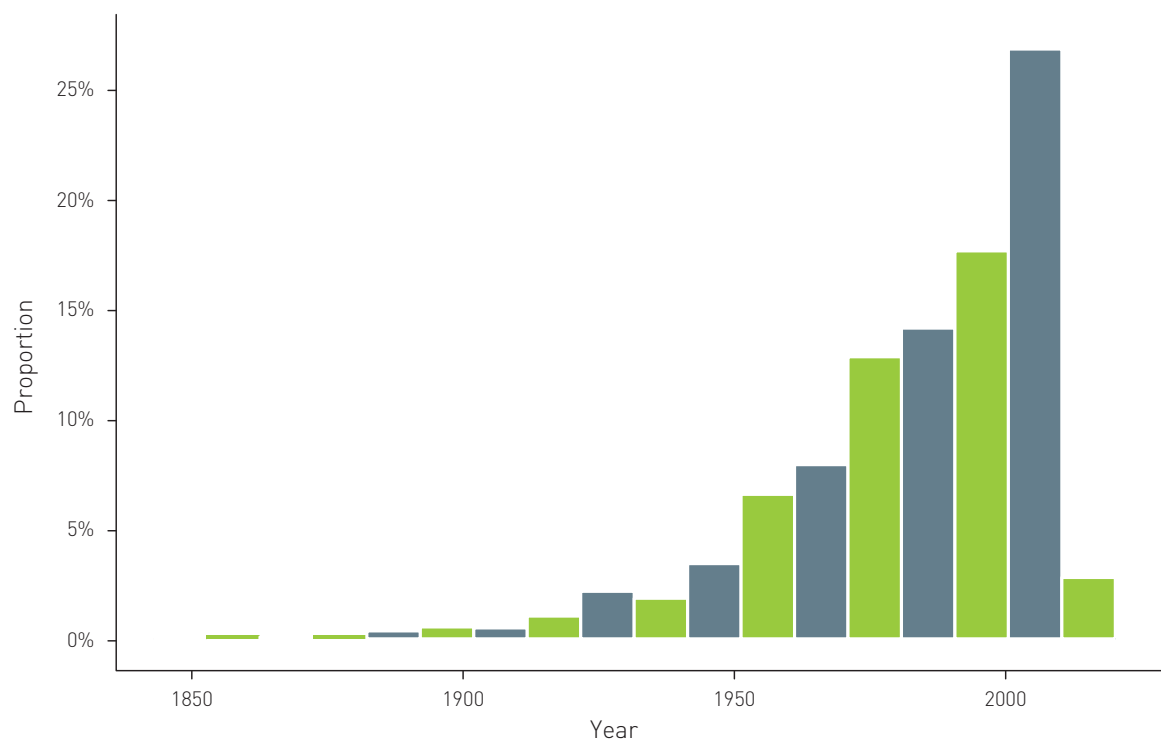


Figure 32. Results from the 2012 trial household application process illustrating the age of the housing stock for potential electric vehicle drivers in Victoria – this attribute was felt to be a key indicator of the need for an electrical supply upgrade (n = 2,200, “Can you estimate about when your residence was built, or the most recent date it underwent a major renovation?”, DOT 2012b).

The general process for the household charging infrastructure installation can be seen in Figure 33.

Further explanation of what these steps encompass can be found below:

1. **Contract negotiation** – the formal agreement for the household to participate in the trial is explained and executed
2. **Site works planning** – information is sought from the householder to inform the charging infrastructure solution (refer to *Appendix D – Household charging infrastructure questions proforma* and Section 5.2.1); answers are supplied to charging infrastructure provider along with contact details – this is the start date for assessment of the installation leadtime; charging infrastructure provider contacts household to both provide preliminary information and prepare them to hear from the installation subcontractor; charging infrastructure provider equips installer with relevant hardware, including pre-coded RFID 'membership' card
3. **Site works** – installer arranges site visit, during which the charging solution is installed/ commissioned if possible; issues preventing immediate installation are referred back to the charging infrastructure provider for further action – this may involve deliberation on the preferred solution and negotiation with the householder
4. **Handover** – charging station operation is demonstrated to householder; Department notified once complete so that vehicle handover can be scheduled – this is the finish date for assessment of the installation leadtime
5. **Operation** – Department receives invoice/actions payment; charging activity commences; data gathered through telemetry link to network operating centre; at completion of trial the household is provided with an offer to retain the charging outlet if so desired, otherwise it is removed and the site remediated to householder's satisfaction.

The longest leadtime components of this process generally relate to coordination between the household and the installation subcontractor, and in resolving any complications with the installation (step 3).

The trial changed its process after receiving feedback from the household participants. Introductory information from each charging infrastructure provider is now prepared to help streamline and gain their support for the installation process. Key information included an explanation and images of EV charging infrastructure (including how it would look once installed), what impact the installation would have on their property, along with an explanation of options/costs. Although many households were nominally interested in free-standing units, the overwhelming majority accepted a wall-mounted solution where possible to avoid bearing the cost difference of the alternative.

**AVERAGE / MEDIAN LEADTIME = 35 / 37 DAYS**

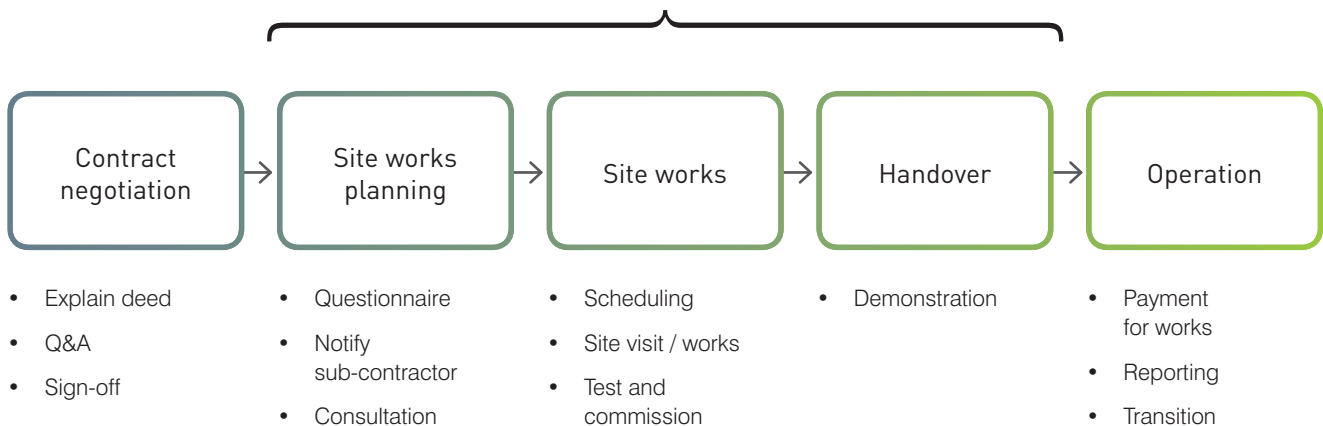


Figure 33. Schematic of household charging infrastructure installation process based upon 94 installations.

### 5.2.3 What is the charging solution for rentals or shared parking?

Based upon trial findings and data from other sources, an increasing number of potential electric vehicle drivers in Victoria will require charging solutions for rental accommodation, with fewer for shared parking. Although charging solutions were able to be delivered for all situations investigated as part of the trial, the installation costs and resistance of key stakeholders are likely to prove an obstacle to more widespread roll-out.

With reference to Figure 34, analysis of the household applications to participate in the trial indicates that around one in five potential electric vehicle drivers lives in rental accommodation, which is slightly less than the proportion of renters for the Victorian population more broadly (DOT 2010d, ABS 2012).

The trial investigated the implications of this through a selection of household participants residing in rental accommodation. A proforma letter was designed for the participant to pass onto their landlord succinctly describing what was being proposed in terms of the charging infrastructure installation and operation, and reassuring them that all costs and liabilities would be covered including full remediation of the site to their satisfaction upon the trial conclusion (as per arrangements for the trial more generally). In some instances clarifications were sought which extended the leadtime for the installation, however in all instances the approval was gained for trial participation.

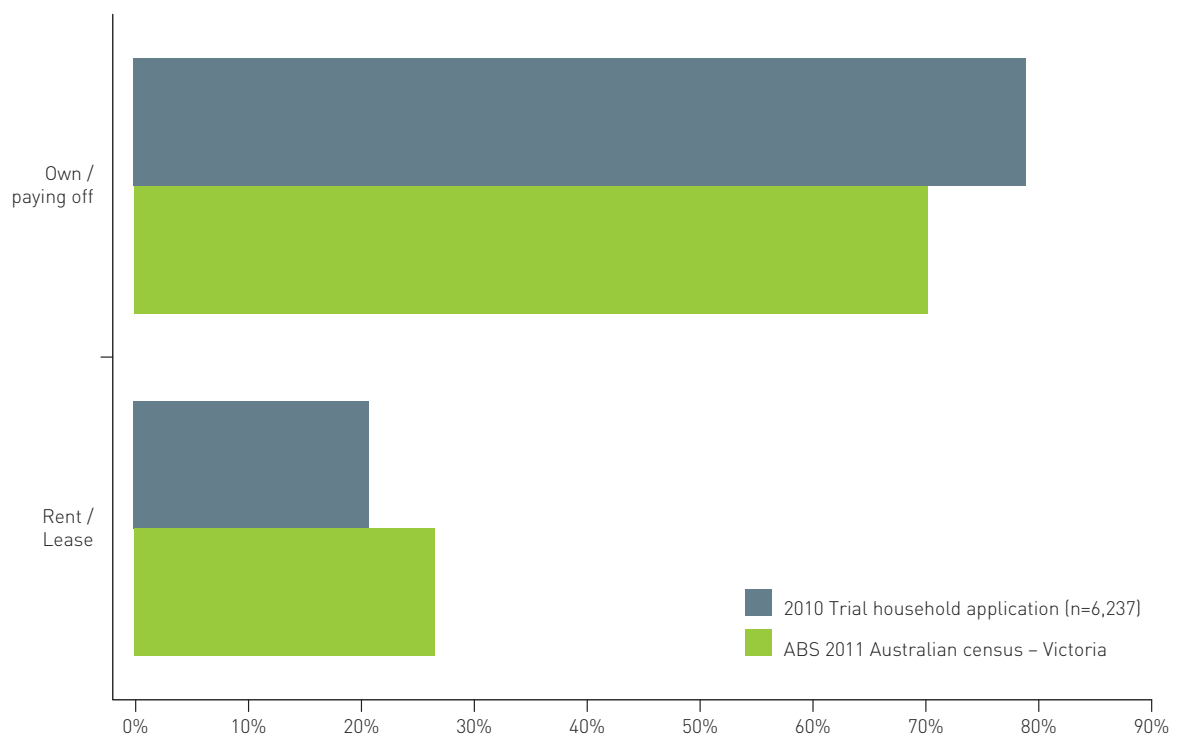


Figure 34. Results from the 2011 trial household application to participate process as compared to the Victorian results from 2011 Australian census, highlighting the significant minority of rental accommodation with an interest in EVs (n = 6,327, DOT 2010d, ABS 2012).



Although this outcome was a success in the context of the trial delivery, it does not provide any insight into the more likely scenario where costs must be borne by one of the landlord or the tenant. Installation of electric vehicle charging infrastructure in tenanted premises is characterised by the 'principle-agent problem' that has been found to inhibit investment in energy efficiency (de T'Serclaes and Jollands 2007). Landlords were clearly concerned about any aspect of the installation or operation of the charging infrastructure that may impact them in terms of cost or effort. Given that the charging circuit represents a cost of just under \$2,000 that cannot be recovered by the tenant should they move, it seems likely that this will represent a significant barrier to EV adoption by the one in five Victorians who rent.

Dwellings with shared parking arrangements were found to be a special case. Although differences were observed in the approach taken by different charging infrastructure providers, a common solution was to run a circuit from the agreed parking/charging location to the point of metered electrical supply for the dwelling. In some instances this required a cherry-picker to route the circuit to apartments above ground level, driving significantly higher costs into the installation – around double that of detached housing with off-street parking.

With reference to the results from the trial application process as described in Figure 35, this issue does not appear to be as significant as for renters.

However, urban development trends are likely to increase the significance of this issue as accommodation with shared parking increases in prevalence.

Expert advice provided for Melbourne's Metropolitan Planning Strategy (MAC 2012) illustrates this issue:

*About half of all new housing in Melbourne is being constructed in established areas. Work by the Grattan Institute shows there are 'shortages' of semi-detached dwellings and apartments in Melbourne's middle and outer suburbs.*

This suggests that the costs of retrofit for apartments are likely to be a deterrent for EV take-up by a growing number of Victorians.

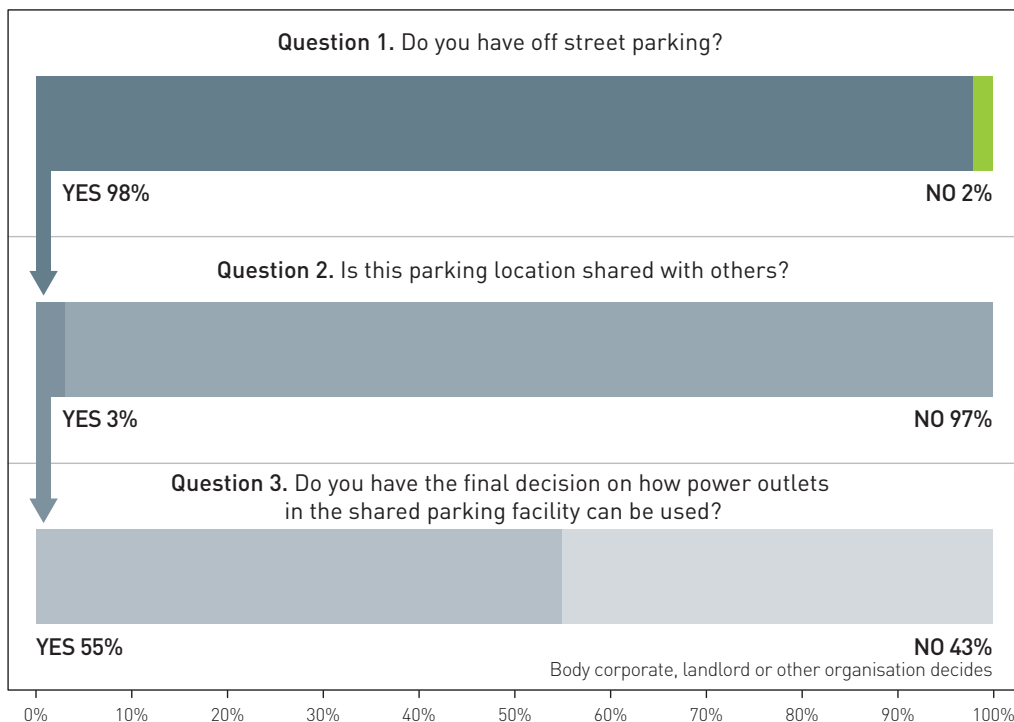


Figure 35. Results from the 2011 trial household application to participate process, highlighting the relatively low number of people without off-street parking and/or oversight of the decision-making that relates to their regular place of parking (n = 6,327, DOT 2011).

### 5.2.4 When do households charge electric vehicles?

In the absence of outside influence, charging by households takes place immediately upon their arrival home. However, results from solar-PV equipped trial participants suggest that households will defer their charging to off-peak periods should they receive a financial benefit to do so. Households may also agree to have their charging managed in line with network demand, if the implications of this are demonstrated to be minor and provided they have some control over the situation.

Data recorded from the household EV charging infrastructure showed that charging demand basically aligns with general household electricity demand (CSIRO 2012). This is because for the majority of households, the most convenient and desirable option is to begin charging by plugging in immediately upon arriving home before heading inside to turn other electrical appliances on. Although the charge management options available to households varied according to their specific vehicle and charging solution (refer to Sections 4.1.1 and 5.1.2), these all require some effort and possibly inconvenience.

With reference to Figure 36, some variation in the charging demand profile was observed for participants who reported having a solar PV installation at their home. This is significant as a majority of solar PV owners are on a time-of-use electricity tariff that provides a financial incentive to defer electricity use to off-peak periods.

Peak EV charging demand for trial households with solar PV occurs at midnight, coinciding with the likely beginning of the off-peak tariff period. This indicates that in the absence of outside guidance and with limited charge management capability, solar PV households are managing their EV charging in response to the financial incentive to do so – refer to the following unprompted quote from one of the household participants:

*As I have solar panels with feed-in tariff I did virtually all charging at night*  
 Victorian Electric Vehicle Trial household participant, 2012

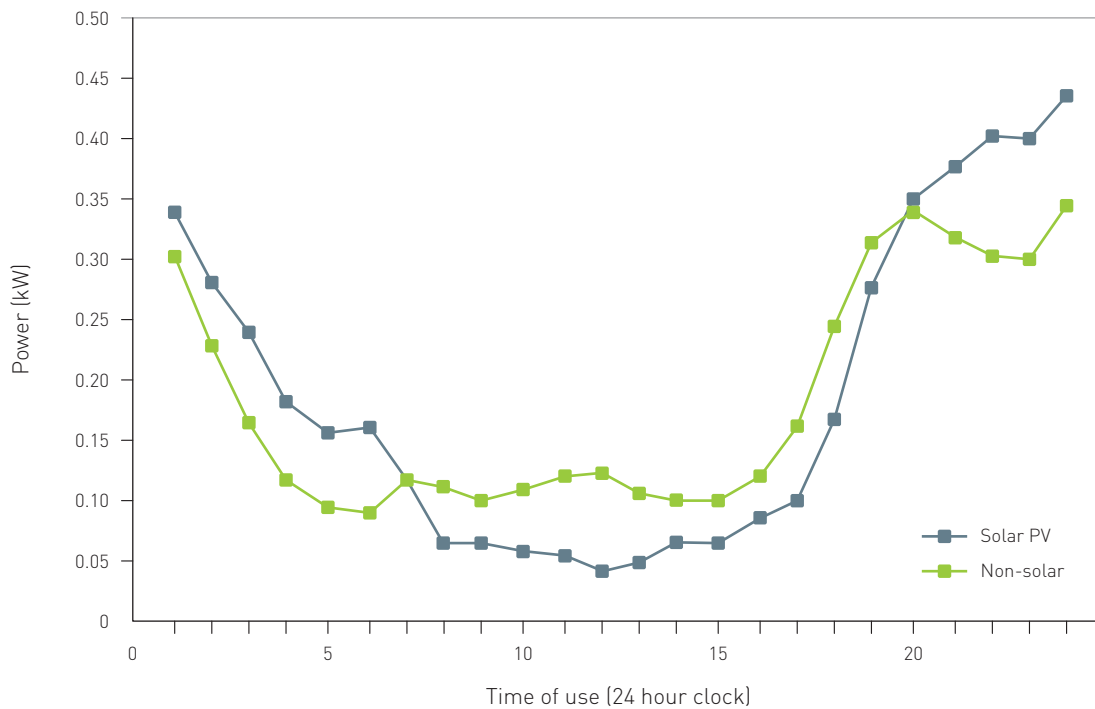


Figure 36. EV charging demand profiles for solar and non-solar trial household participants (n = 12 and 71 respectively).

The appeal of a financial incentive to defer charging was investigated with the entire sample of household participants. With reference to Figure 37, the bias in the results was towards maximising the vehicle utility. This result is consistent with findings from the Ergon Energy EV trial in Queensland, where drivers pushed back on mandatory deferred charging of their vehicle under the 'Tariff 33' arrangement that is more generally applied to pool-pumps [Ergon 2012].

In late 2012, a small group of trial household participants were selected to take part in an electricity demand response and load control demonstration project – refer to the breakout box below. These households were equipped with DiUS Computing's ChargeIQ EV charging outlet, which was bound to their residential smart meter upon installation. The objective of the project was to demonstrate use of Victoria's Advanced Metering Infrastructure for the purposes of managing EV charging demand.

A total of 64 charge-management events were deployed by the distribution network operator for the region, split between 'peak charging' events for which 24 hours' notice was provided to participants, and 'emergency charge management' events for which just one hour notice was provided. Results from a survey of participants indicated widespread acceptance of the charge management method and technology, to the extent that the majority of participants would agree to have their charging managed this way in future even if there was no financial benefit to them.

This outcome suggests that smart grid, or other charge management technologies, will be effective in the management of EV charging so as to avoid costly network investments.

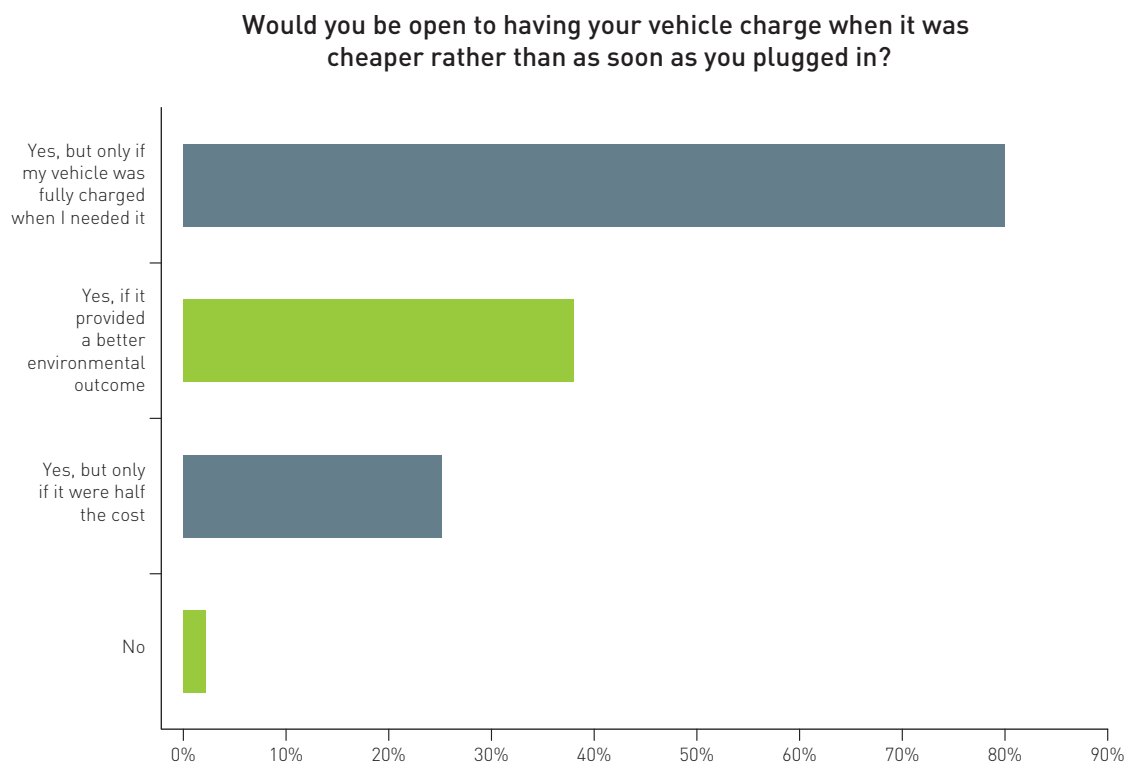


Figure 37. Results from a survey of trial household participants on their outlook towards deferred charging in response to a financial incentive; survey interval was around six weeks into their EV experience (n = 77; multiple choices permitted).

## HOME CHARGING CASE STUDY DIUS COMPUTING / CHARGEIQ

In late 2012 Melbourne-based DiUS Computing, in what appears to be a world-first, used Victoria's 'smart grid' to manage electric vehicle charging as part of the Victorian Electric Vehicle Trial (Smart Grid News 2012).

The DiUS ChargeIQ unit, already the world's first smart grid (Zigbee) certified EV charger (Electronics News 2012), was deployed to 'smart meter' equipped households within United Energy's distribution region. Charge management events were then issued to the ChargeIQ units through the United Energy network. The charge management events formed part of an EV charging demand management project known to participants as 'grid-friendly' charging.

The ChargeIQ units are equipped with charge management capability that allows users to take advantage of cheaper 'off-peak' electricity tariffs – this is a form of demand response generally known as 'smart charging'. The ChargeIQ units also allow EV charging loads to be controlled by the electricity distributor – these events were termed 'peak charging' and 'emergency charge management' in the project according to the extent participants were pre-warned.

Participants were informed of the charge management events through the ChargeIQ network, including via email, SMS, the internet and on the ChargeIQ device. Control of the vehicle charging was possible through phone applications, the web portal and on the ChargeIQ unit. In simulated conditions to real network scenarios, participants received warnings either 24 hours or immediately before charge management events, along with options that would allow them to control charging of their vehicle while minimising impacts on cost and/or use.

Charge management capabilities ensure that households are able to minimise their charging costs without impacting upon their vehicle use. Additionally, charging is able to be managed by the electricity distributor so as to preserve the reliability of the network and prevent increases in electricity costs as a result of avoidable network investments.

Technology solutions, such as ChargeIQ, will help ensure that electric vehicle charging can be easily accommodated by our electricity networks at minimal cost and inconvenience for everyone.



Figure 38. DiUS Computing ChargeIQ home charging device, the world's first smart grid EV charger.

### 5.2.5 What do households think of electric vehicle charging?

The majority of households felt that home charging alone met their needs. Despite the relative immaturity of the technology, most found it easy to use, and felt confident and reassured in their understanding of what was going on. However, an appetite existed for more information about costs and energy use.

Around six weeks into their EV experience household participants were asked, 'Does home charging of the trial vehicle meet your needs?' Consistent with the findings in Sections 4.2.2 and 4.2.3, 79 per cent of respondents replied in the affirmative (n = 76). Notably however, the majority of respondents felt they would also charge outside of their home under certain circumstances – this is explored further in Section 5.4.3.

Additional information was sought from the household participants on what they thought of their home charging solution. With reference to Table 11, participants were generally very positive about their charging outlet design and operation. The cable/plug combination and basic feedback provided by the outlets were best received, the former potentially having implications for the wireless charging solutions currently being developed (Pike Research 2012). The least well received and most highly varied responses related to supporting information on costs and energy. This is likely due to the significant variation in user feedback and network support across the providers (refer to Section 5.1.2).

Household participants were also asked about the sort of information they thought would be useful in relation to EV charging. Although the survey question was not constrained to home charging, for most participants this formed the basis of their EV charging experience. With reference to Figure 39, cost information was clearly the highest priority according to participants.

Although the survey question above limited respondents to cost information about each charging session only, other survey responses indicate that households generally consider their vehicle fuel costs in weekly or monthly terms (65 and 32 per cent of 107 respondents respectively; 'daily', 'quarterly', 'yearly' and 'don't know' being the other options).

Additional suggestions for charging information were provided by about one third of respondents. The most common requests were for information relating to charge management of the vehicle, including how long until charging would be complete and/or notifications on when charging had been completed.

Charging infrastructure attribute	Average score (out of 5)	Std dev
Ease of use – cable/plug	4.6	0.7
Confidence in understanding what was happening	4.6	0.7
Convenience	4.3	1.0
Perceived safety	4.3	1.0
Reliability	4.2	1.2
Something to look forward to if all cars go this way	4.0	1.0
Costs and energy use info	3.6	1.3

Table 11. Results from a survey of trial household participants on their perceptions of their home charging solution; survey interval was around six weeks into their EV experience (n = 76).

### 5.2.6 What are the issues and opportunities for home charging?

The home charging infrastructure cost is a potentially significant obstacle to wider electric vehicle take-up, particularly for renters and the increasing numbers of apartment dwellers. This issue not only compounds the purchase price obstacle of the vehicle itself, it represents an additional cost for would-be EV buyers that is not factored into their initial vehicle purchase consideration.

The best case/least cost home charging solution for around \$500 will provide no charge management capability or insight into energy use – a significant limitation based upon the current generation of electric vehicles.

For an average household seeking basic charge management capability, a home charging solution will cost \$2,000-3,000. Electricity supply upgrades, charging circuit complications, and shared parking arrangements are likely to double this cost. Most of this investment gets written-off for EV owners who move house. When it is considered that most would-be electric vehicle buyers will not even be aware of these issues, home charging costs represent a potentially significant barrier to EV adoption.

Charging outlets are an evolving and largely proprietary technology, the specification for which will vary according to the specific needs of the user and their vehicle. However, a clear opportunity exists for charging circuits to be included as part of the design and construction of new property developments or as part of refurbishments.

For a greenfield development, the cost of charging circuit materials and labour are estimated to be \$200-300. This represents nearly an order of magnitude less than the average retrofit, underpinning a clear net present value argument in favour of charging circuit inclusion during the initial build. For apartments and other developments with shared parking the solution may be to include a revenue-grade meter to allow for electricity use to be reconciled to any user, which may add \$50-100 to the parts and labour cost above.

The Department has recognised this opportunity with its *Guidance on Land-use Planning for Electric Vehicle Parking and Charging* (DOT 2012e). This document explains the public and property value benefits of including charging circuits during initial design and construction of new developments.

### What information would be useful in relation to electric vehicle charging?

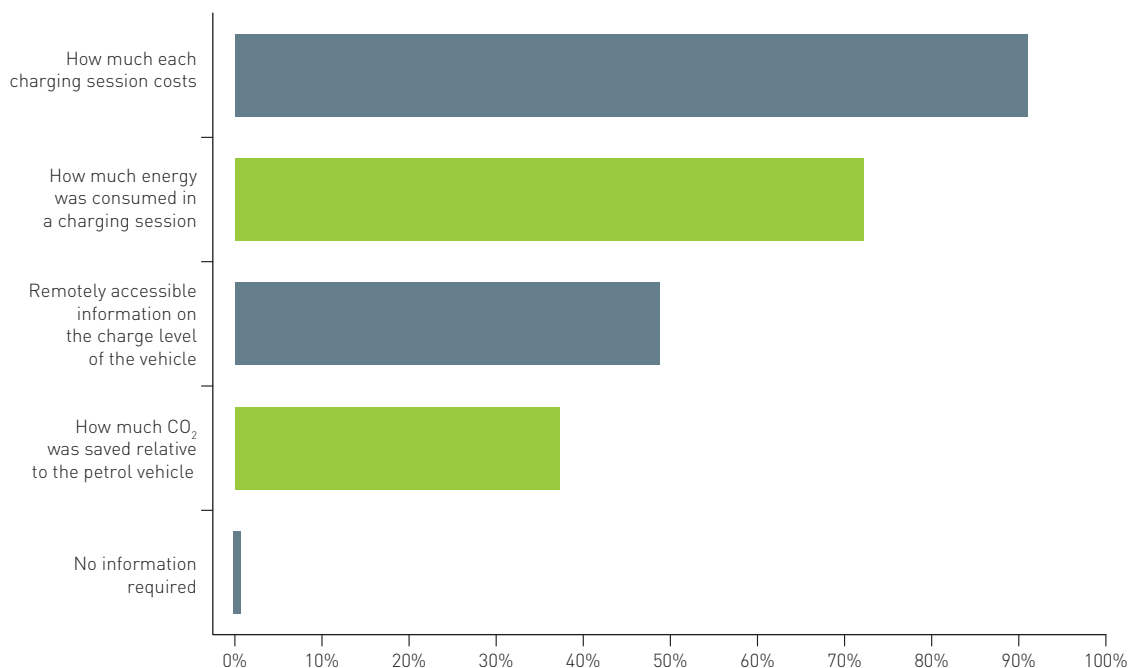


Figure 39. Results from a survey of trial household participants on the sort of EV charging information they thought would be useful; survey interval was around six weeks into their EV experience (n = 77; multiple choices permitted).

It provides guidance on the allocation, placement and design of electric vehicle charging infrastructure. The advice addresses the information barriers for land-use planners, traffic managers and property developers looking to future-proof for EV take-up.

Savings for building retrofits may be possible through improved information gained from homeowners and learning benefits from the installers. This will have the added benefit of reducing the leadtime on the installation, allowing consumers to more quickly take delivery of and start using their electric vehicles. Market forces are likely to drive this innovation amongst the various charging infrastructure providers.

Promoting an improved awareness and understanding of electric vehicles should include consideration of landlords and other entities with a key role in the approvals for installation of charging infrastructure. By providing a credible source of information on the emerging technology and its implications for landowners, barriers to uptake of the technology will be reduced. For example, descriptions of preferred models for EV charging infrastructure installation and operation specific to rental properties and/or body corporate administered parking locations may help streamline the negotiations between parties. Internationally, some jurisdictions have legislated to resolve challenges associated with electric vehicle charging by renters and in multi-unit dwellings<sup>14</sup>.

Integration of electric vehicle charging into Victoria's electricity network is both manageable and desirable. Results from the trial clearly show consumers to be responsive to the price signals, including specifically the time-of-use electricity tariff that accompanies most solar PV installations. As Victoria's electricity market evolves towards wider use of time-of-use tariffs, consumers can be expected to select and employ technologies that allow them to take advantage of off-peak tariffs. Communicating the benefits of off-peak charging practices that avoid undesirable impacts upon vehicle utility should and is likely to be prioritised by EV technology and service providers.

An emerging opportunity may be using electric vehicles as energy storage devices. Japanese EV suppliers are bringing products into the market that allow for energy to be drawn back from the vehicle (Mitsubishi 2012, Nissan 2012). Although these devices are not configured for Australian electricity network standards, the potential appeal to the large number of households with solar PV is a potentially synergistic opportunity to more closely align the two technologies.

Beyond home energy storage, other activities suggest that the opportunity to use EVs for grid-energy storage may not be too far away:

- The standards development process for *Demand Response Capabilities and Supporting Technologies for Electrical Products* is progressing towards completion of an Australian Standard for EVs as energy storage (working title AS 4755.3.4) – this will provide government, industry and consumers with a consensus-backed technical and performance specification for EV charge management systems capable of supplying energy into the grid
- The Victorian Competition and Efficiency Commission recognised distributed storage in their review of feed-in tariffs (VCEC 2012), providing a starting point for consideration of the use of EVs as distributed energy storage devices in Victoria
- Victoria's Advanced Metering Infrastructure roll-out is progressing towards completion in 2013 (DPI 2012), which will provide network operators with the means to manage energy transactions with EVs (as has been demonstrated with the DiUS Computing EV charging demand-response load-control project described in Section 5.2.4).

Finally, local grid impacts have been investigated by United Energy Distribution as part of the trial. Although the findings are preliminary, indications are that the main issue created by EV charging is potential voltage drop below the regulated minimum standard of 230 volts. This is an issue that may need addressing particularly where EV take-up has 'clustered' into a number of households along a single feeder.

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14 For example, Hawaii (Act 186 HRS 196-7.5) and California (Senate Bill 880)

*The Energy Networks Association (ENA) appreciates the opportunity to have participated in the Victorian Electric Vehicle Trial and has been pleased with the results to date. In particular, our objectives to gain, through participation, a clearer understanding of the implications of and opportunities from the introduction of electric vehicles for energy networks have been largely satisfied.*

*We applaud the Victorian Government's initiative in committing funding and resources to the trial and believe that electric vehicles have a definite and important role in Victoria's transport and energy future.*

Energy Networks Association,  
8 November 2012

## 5.3 FLEET AND WORKPLACE CHARGING

### 5.3.1 How much does charging infrastructure for corporate applications cost?

At around \$5,000, charging outlet costs are generally higher than for home charging due to the preference for increased functionality and durability. Average charging circuit costs of around \$2,200 are also slightly higher due to the increased separation between parking locations and points of electrical supply. However, many fleets have implemented lower cost solutions drawing upon existing infrastructure and their own electrical tradespeople.

Similar to home charging solutions, the entry-level 15A GPO electrical outlet is likely to cost around \$100. However for most fleets there is a preference towards devices with enhanced safety, security and data capture. Based upon the trial experience this translates to around \$4,000-\$6,000 for a fairly sophisticated charging outlet, although prices are likely to have fallen due to market competition, economies of scale and design/manufacturing process improvements.

The charging circuit was generally installed at the cost of the fleet operator, ensuring strong interest in identifying least cost solutions. For this reason many fleets elected to install the charging circuit themselves using existing infrastructure and/or their own electrical tradespeople. A consequence of this is a reduction in the cost data obtained for analysis relative to the sites installed.

With reference to Table 12, the average cost of the charging circuit was found to be slightly higher than for home charging at around \$2,200. While the difference between the average figures sits well within the standard deviation for both sets of data, there is a \$500 difference in the median values which reflects the generally shorter distance that home charging circuits have to travel between the point of electrical supply and the parking/charging location. It should be noted that due to there being more control of the design solution with owner-occupied sites, the missing data from the sites where the charging circuit was installed by the fleet operator is likely to be biased towards lower cost solutions.

No. INSTALLATIONS	14
AVERAGE COST	\$ 2,152
MEDIAN COST	\$ 1,910
STD DEV	\$ 1,279
MAX	\$ 4,382
MIN	\$ 550

Table 12. Cost benchmarking of the trial fleet charging circuits.

As for the home charging solutions, sites which necessitated more complex solutions such as free-standing units had the potential to greatly increase costs. In most cases lower cost solutions were able to be identified, however this often greatly extended the leadtime for the installation or even resulted in a different site altogether serving as the charging location for the vehicle.



An example of this was the Department's own experience with its property at 121 Exhibition St, Melbourne. The Department leases levels 5 to 16 of the 36 level building, along with a portion of the underground car-parking. As part of the trial, the Department requested permission to install an electric vehicle charging solution. The building manager proposed a charging circuit be run from the lowest point of metered electrical supply billed to the Department on building level 5 to the nearest underground car-park on basement level 3. This was determined to be cost-prohibitive, and despite extensive negotiations to obtain a cost-effective alternative the proposal had to be aborted.

A charging outlet was instead installed in a nearby property also tenanted by the Department, using an unused electricity billing meter that was one level away from the nearest Department parking location. This installation cost \$4,500, which was still significantly higher than the average for a commercial property but much lower than what was expected under the alternate arrangement.

### 5.3.2 How is charging infrastructure installed for corporate applications?

Charging infrastructure for corporate applications is installed by electrical contractors. Charging circuits can be installed by in-house contractors, even if this is often done by the charging service provider during installation of the dedicated electric vehicle charging outlets. From the time when commitment to establish EV charging capability is made, the average leadtime to commissioning/handover is around 10 weeks.

Installation of electric vehicle charging infrastructure for corporate applications is greatly complicated by internal approval requirements, along with the likely involvement of a third and sometimes fourth party in the property management and ownership. As a result, the average leadtime for installation of a corporate charging solution is around 70 days, which is twice as long as for a home charging solution.

The general process for the installation of charging infrastructure for corporate applications can be seen in Figure 40.

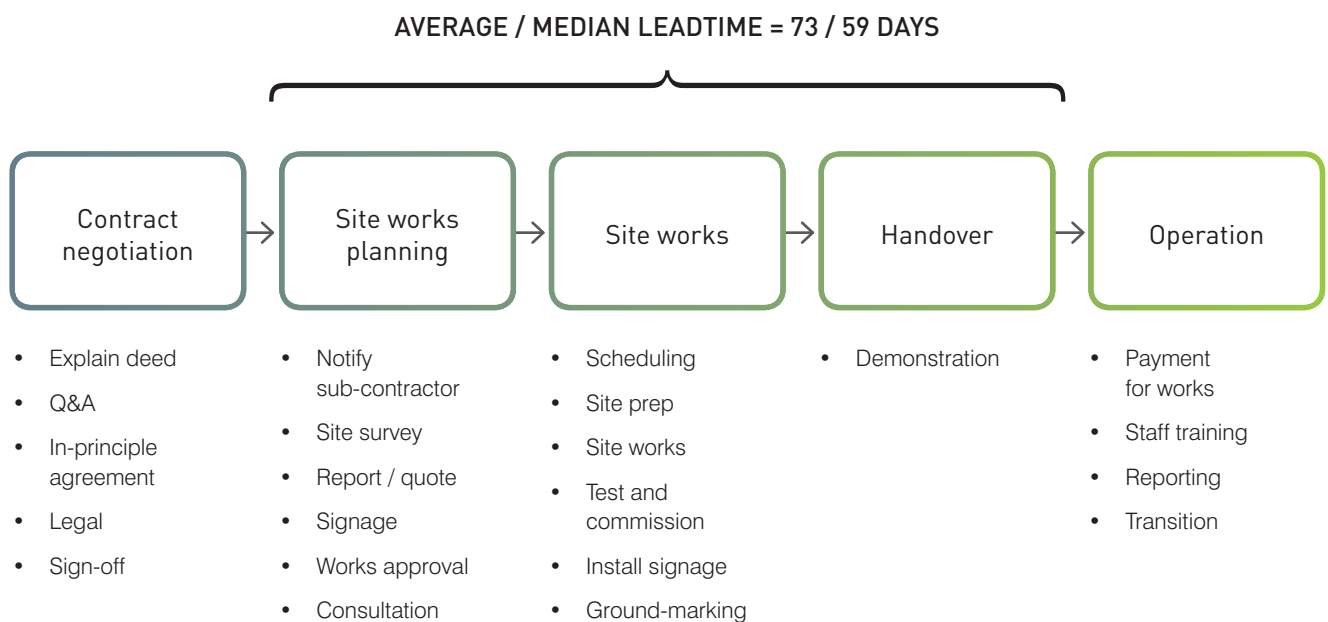


Figure 40. Schematic of the charging infrastructure installation process for commercial property.

Further explanation of what these steps encompass can be found below:

1. **Contract negotiation** – the formal agreement for the corporate entity to participate in the trial is negotiated through to sign-off; the agreement includes provisions for lease of the trial vehicles, which was the focus of the corporate participant involvement; gaining internal approval for the costs associated with the charging circuit and vehicle lease was the cause of significant variation in the leadtime for completion of this step (which due to the vehicle lease issue has been excluded from the installation leadtime scope definition)
2. **Site works planning** – the charging infrastructure provider is introduced to the corporate participant and a site visit arranged – this is the start date for assessment of the installation leadtime; the site visit kicks the project off and includes a preliminary survey of options informed by all parties; the corporate participant identifies their preferred location taking initial advice into account and agrees on the installation strategy – to use the charging infrastructure provider subcontractor or install the charging circuit to the charging infrastructure provider specification; example content is supplied to the corporate participant for deliberation on the signage/ground-marking for the site, and the plan for manufacture and installation agreed; the works plan is formalised between parties and signed-off through a works approval/work order process

3. **Site works** – installer arranges site visit, to either complete the entire installation or install the charging outlet at the terminal to the charging circuit supplied by the corporate participant; charging station commissioned into service; signage and ground-marking is delivered/installed as per the works plan agreement
4. **Handover** – charging station operation is demonstrated to corporate participant; Department notified once complete so that vehicle handover can be scheduled – this is the finish date for assessment of the installation leadtime
5. **Operation** – Department/corporate participant receives invoice/actions payment; corporate participant staff are trained as part of electric vehicle induction; charging activity commences; data is gathered through a telemetry link to the network operating centre; at completion of trial the corporate participant is provided with an offer to retain the charging outlet if so desired, otherwise it is removed and the site remediated to their satisfaction

The site works planning (step 2) has the strongest bearing on the installation leadtime. Various pitfalls that may be encountered include:

- Budget approval for the works (as a spillover from step 1)
- Unforeseen cost blow-outs, due to:
  - the need for trenching in support of a free-standing charging outlet
  - long cable-runs to link up with a point of electrical supply that is billed back to the corporate participant
  - Parking and/or traffic management issues for the site, particularly in seeking least-cost locations relative to a point of electrical supply.
- Third-party approvals from the property management/owner, which may stumble on:
  - difficulties engaging with the property management/owner, or fostering an understanding in what is being proposed
  - acceptance of risks and liabilities, particularly for issues arising out of site works conducted in the vicinity of the charging outlet
  - institutionalised approvals processes, such as those that relate to airports or other sites with security concerns.

Based upon the trial experience, the incidence of these issues greatly increases in shared tenancies. These premises were often characterised by unsupportive property management, challenging energy metering and inflexible parking arrangements. For these reasons, corporate entities that lease space in multi-storey buildings in which their parking allocation is located remotely from their office space often face insurmountable obstacles to installation of electric vehicle charging capability. The Department's own experience described in Section 5.3.1 took nearly four months to resolve by ultimately resorting to a different location from where the vehicle would have been located by choice.

Signage and ground-marking issues are also worthy of special mention, both on account of their importance in realising the fleet operator EV value proposition (by maximising visibility of their vehicle), and on account of the inefficient process and problems commonly experienced.

The trial charging infrastructure providers generally did not include this as part of their service offering. The corporate participant generally did not have expertise or capacity to address the issue. Where required, the Department usually facilitated the design of the signage/ground-marking based upon the basic designs developed as part of the trial (refer to Figure 31 and Figure 49). Signage was generally delivered to the site for installation by the corporate participant or their property management, a process which was prone to lengthy delays (for example, to source fasteners for attachment of the signage, or simply due to a lack of prioritisation by the relevant parties). Ground-marking was generally completed by specialist providers referred on by the Department to the corporate participant, a process which was also prone to lengthy delays. Efficient signage/ground-marking design and implementation was generally dependent upon it being included as part of the overall works planning/delivery process.

### 5.3.3 When do fleets charge electric vehicles?

In contrast with the households, the fleets participating in the trial have mostly charged their vehicles during business hours.

As shown in Figure 41, the fleet charging demand profile can be explained in terms of the following vehicle travel behaviours:

- Returning from having spent the night travelling to/from employee residences that are mostly not equipped with charging outlets (6am to 12pm)
- Returning from work-related travel duties during the day (10am to 4pm)
- Departing from the fleet garaging location to employee residences (4pm onwards).

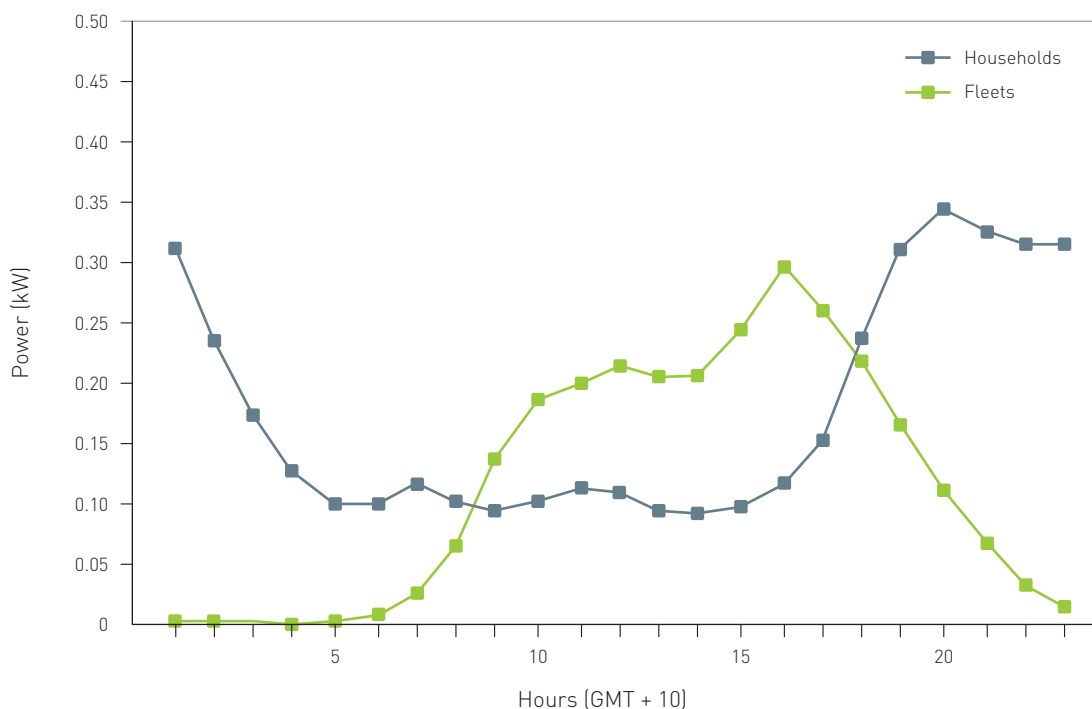


Figure 41. Electric vehicle charging demand profiles for fleet and household trial participants (n = 41 and 83 respectively).

Very few fleet participants deployed 'network' charging strategies that provided overnight charging options outside of the central charging location for the vehicle. Despite this, the majority of the fleet participant charging has taken place at the business premises during business hours, effectively reducing the vehicle availability for operational duties.

This may be explained by the deployment strategy for the trial vehicles, which were strongly promoted for staff to 'experience' through overnight evaluations. While this may have contributed to the staff enthusiasm for the vehicles reported by many fleets, it may have been a significant contributor to the relative under-utilisation of the vehicles as was evidenced by average distance travelled (refer Section 4.3.2).

### 5.3.4 What do fleets think of charging?

Fleets were generally of the view that fast charging, longer range and/or public charging options were needed for electric vehicles to succeed. These responses reflect the asset management challenge for a corporate EV – a vehicle that is plugged in and charging is also incurring depreciation and other standing costs without providing any benefit to the organisation.

Trial fleet participants were also resistant to the staff time required for charging management. Ensuring a vehicle was plugged in, balancing vehicle bookings with charging requirements, easily and reliably knowing what the actual charge level was of a vehicle at any one time – these were issues that persisted for many fleet operators over the duration of their involvement in the trial and reduced their acceptance of the vehicle.

These experiences varied between fleet participants on account of the variation between charging service providers, and also due to the deployment strategy for the vehicle. At least one fleet operator developed an automated booking system that took charging needs into account, reducing the vehicle management overhead for staff.

It should also be noted that none of the trial vehicles and only a small amount of the charging infrastructure/services provided real-time, remotely-accessible information about the charging status or level of the vehicle. These features are available to varying degrees on vehicles and charging infrastructure that are now in the Australian market.

### 5.3.5 What has been the experience of workplace charging?

Workplace charging for the household participants was a key enabler for increased utilisation and acceptance of the trial vehicles. Although the trial findings suggest that workplace charging could significantly enhance the EV value proposition for would-be buyers, the case for employers has yet to be substantiated.

The average daily electric vehicle driving distance for the 11 households with a workplace charging option was 38 kilometres compared to 27 kilometres for the 65 non-workplace charging households. Furthermore, of the eight households who had an average EV driving distance of 50 kilometres or more, four were equipped with workplace charging. This indicates that workplace charging has been a key enabler for increased utilisation of the trial vehicles.

In addition, discussions with the household participants who had access to workplace charging discerned increased acceptance of their EV as a result of the workplace charging option. Many drivers described workplace charging as having removed the range limitation of the vehicle, even for relatively long distance commutes – refer to the break-out for a more detailed account for one of these participants.

## WORKPLACE CHARGING CASE STUDY VICTORIAN EV TRIAL HOUSEHOLD PARTICIPANT

One household participant supplied with a Nissan LEAF had a workplace commute of around 40 kilometres each way. Their normal vehicle was a current model Volkswagen Golf GTI, for which the Nissan LEAF is a reasonable comparison for assessment of EV acceptance. Prior to commissioning of their workplace charging option they described the vehicle as being a pleasure to drive, but significantly limited by the available range with a home charging option alone –

*'It prevented me from doing anything more than simply driving to and from home, which has meant that most of the time I left the vehicle for my wife to drive'.*

Following commissioning of the workplace charging option, the participant said their perception of the EV had been transformed –

*'I don't have to worry at all about range now... it's just like a normal car'.*

Further assessment of the costs and benefits revealed some interesting findings. Based upon the reported fuel economy figure for the Golf GTI, this household participant would spend around \$45 per week on fuel costs for their commute alone (using petrol priced at \$1.40/L). When asked as to what they would be prepared to pay for the workplace charging option, the participant was of the opinion that the service should either be free or no more than the cost of the electricity supplied under a commercial tariff (which is likely to be cheaper than their residential tariff). Under a commercial tariff the cost of the electricity consumed by workplace charging of their LEAF can be approximated as \$5.50 per week, which would be in addition to the \$9 per week they would pay for their home charging contribution to the commute (assuming \$0.25/kWh for GreenPower).

This suggests that even if required to meet the electricity costs of their workplace charging use, the trial participant would save around \$30 per week on transport energy costs from their commute as compared to their Golf GTI, or nearly \$1,400 across the working year (46 weeks).



### 5.3.6 What are the issues and opportunities for electric vehicle charging by corporate entities?

The clear challenge for corporate charging locations relates to the involvement of third parties in the approval process for the many commercial properties which are leased. Delays and even denials on requests for cost-effective charging solutions have proven to be a major obstacle for many corporate trial participants.

This situation appears to mirror the experiences elsewhere. A survey of 70 Californian employers found that the majority that were supplying workplace charging options for employees owned both their own building and the accompanying parking area (CALSTART 2012).

Future-proofing for electric vehicle charging during the design and construction of new developments should be promoted – this is the objective of the *Guidance on Land-use Planning for Electric Vehicle Parking and Charging* (DOT 2012e) described earlier.

This document should support efforts to raise awareness, understanding and acceptance of EV technology within the commercial property management sector. Engagement should include consultation to better understand what the preferred solutions are for property owners and managers, with a view to streamlining approvals processes for all involved. Industry associations such as the Real Estate Institute of Victoria and the Property Council of Australia provide a starting point for dissemination of information and discussion of 'best practice' solutions for all parties. There are also a number of key players within the sector who can be engaged directly and efficiently.

Another means by which support for electric vehicle charging outlets in commercial property may be increased is through recognition within building rating schemes, as is the case with the U.S. Leadership in Energy and Environmental Design program<sup>15</sup>. Recognition of this type would provide benefits to property owners and managers in terms of increased marketability and returns. To this end the trial has been in discussions with the Green Building Council of Australia around development of their *Green Star – Interiors* building fit-out rating tool. The pilot rating tool has included recognition of EV charging (GBCA 2012), and support has been offered for pilot tool users to assist in take-up of this option as part of their Green Building fit-out plan.

A corporate network charging strategy provides a range of benefits that may greatly increase the appeal of EVs to fleet operators. Locations that may be considered based upon the service duties for fleet vehicles include the portfolio of corporate sites, key customer sites (installed under partnership), and staff residences – refer to Table 13.

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15 <http://new.usgbc.org/leed>

Workplace charging appears to be a key enabler for the EV business case – charging at both ends of the journey allows high mileage drivers to take advantage of the EV operational cost savings, and removes any concerns about range limitations.

The significance of workplace charging for the emerging EV market is highlighted by the results from the trial application to participate process. Figure 42 provides a breakdown in day and night-time parking locations for the would-be EV drivers who applied to participate in the trial. For all cars in these households, nearly four in five were reported to be parked at the workplace during daytime hours. Additional evidence in support of workplace charging can be seen in Figure 22.

Employer benefits are suggested to include improved staff attraction/retention, reduced transport energy costs for salary-packaged employees, and addition of a leading-edge capability to their sustainability credentials. However while the evidence-base for these items is only now being compiled, the costs to employers may be a significant deterrent. Direct costs may be incurred from parking, infrastructure and/or energy use, while indirect costs include staff education and training, planning and management overheads.

Once an organisation elects to pursue workplace charging, this may occur through a number of different avenues:

- Making fleet EV charging outlets available for staff use
- Partnering with nearby commercial car-parking for the provision of EV charging locations
- Installing EV charging outlets in company car-parking
- Aligning vehicle and charging salary packaging options.

Location	Opportunities	Issues
Portfolio of corporate sites	<ul style="list-style-type: none"> <li>Increase vehicle utilisation</li> <li>Promote learning across the organisation</li> <li>Increase visibility to key stakeholders</li> </ul>	<ul style="list-style-type: none"> <li>Coordination across facilities managers</li> <li>Vehicle energy use accounting across charging locations</li> </ul>
Key customer sites	<ul style="list-style-type: none"> <li>Increase visibility to key stakeholders</li> <li>Share learnings</li> <li>Promote EV uptake through the supply-chain</li> <li>Potential cost sharing between organisations</li> <li>Increase vehicle utilisation for all parties</li> </ul>	<ul style="list-style-type: none"> <li>Negotiations to finalise arrangements</li> <li>Vehicle energy use accounting and/or cost reconciliation across charging locations</li> <li>Potential/perceived risk and liability issues</li> <li>Sunk investment if partnership dissolves</li> </ul>
On-street sponsored sites	<ul style="list-style-type: none"> <li>Increase visibility of branded vehicle</li> <li>Cost sharing may be a key enabler for charging station establishment</li> <li>Increased/guaranteed utilisation for charging station</li> <li>Promote EV uptake in wider community</li> </ul>	<ul style="list-style-type: none"> <li>High upfront cost of on-street locations</li> <li>Vehicle energy use accounting across charging locations</li> <li>Increased damage risk for vehicle/charging station</li> </ul>
Staff residences	<ul style="list-style-type: none"> <li>Improved oversight of transport energy costs</li> <li>Reduction in transport energy costs for salary-packaged vehicles</li> <li>Employee attraction/retention</li> </ul>	<ul style="list-style-type: none"> <li>Arrangements for installation of charging outlet</li> <li>Vehicle energy use accounting and/or cost reconciliation across charging locations</li> <li>Fringe benefits tax treatment of charging</li> </ul>

Table 13. Corporate charging network locations – opportunities and issues.

CALSTART (2012), a Californian membership-based organisation that promotes clean transport solutions, is seeking to address these issues through their EV Employer Initiative. They are currently developing a range of materials to assist in the promotion of workplace charging:

- Case studies of electric vehicle strategies and internal policies
- Electric vehicle infrastructure options
- Guidance on electric vehicle infrastructure installation
- The electric vehicle value proposition (costs/benefits) for businesses.

An example early-mover company is Google. At March 2012, Google had installed 227 workplace charging stations at their Californian headquarters (Schreiber 2012). The installations are part of their goal to provide EV charging capability at five per cent of regular parking places. Take-up has been impressive, with around 200 EV driving employees taking advantage of the workplace charging option provided. Google's motivations for this included staff recruitment and retention, consistency with their Corporate Social Responsibility commitments, alignment with their EV fleet practices, and support for their green building certification.

A corporate network charging strategy has many potential benefits:

- Increases effective vehicle range/utilisation
- Increases productivity through avoided refuelling of normal vehicles and better transport energy data access/reliability
- Increases visibility and by extension the marketing potential of the vehicles
- Provides partnership opportunities with key stakeholders/common destinations.

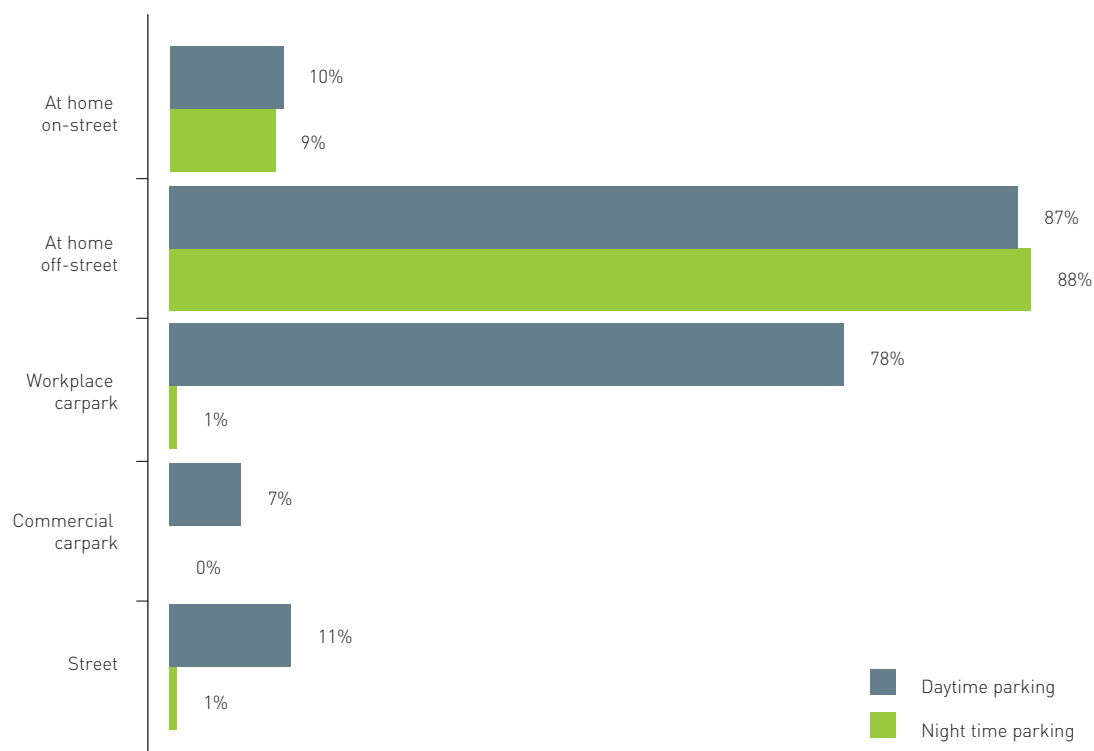


Figure 42. Results from the 2010 trial household application to participate process, highlighting the significance of the workplace as a daytime charging location for would-be EV drivers; responses to the question 'For each car in your household, please provide the daytime/night-time parking location' (n = 6,237).



One scenario of particular interest is the 'milk run' as is applied in the freight and logistics sector. Figure 43 shows a simple milk run of component parts being supplied to a manufacturing plant. For a vehicle servicing this route, each stop-off presents as a potential charging opportunity. Furthermore, if the energy consumption between stop-offs and the charging opportunity are both fairly reliable, the vehicle battery might be downsized so as to be 'fit-for-purpose'. This would make the vehicle cheaper to buy and may even increase the carrying capacity of the vehicle.

Preliminary investigations into this scenario failed to progress due to supply constraints on electric light and medium commercial vehicles.

An additional opportunity exists for fleet vehicles that are charged in a central location to be used as the basis for a distributed electricity storage facility. Advanced management systems would be required to optimise against electricity and vehicle demands, however this scenario is the best stepping stone for network-wide vehicle-to-grid (V2G) interactions as outlined in Section 5.2.6.

A pilot project utilising a captive fleet of electric vehicles that are managed to provide useful energy storage, particularly in alignment with on-site renewable energy generation, would provide a better understanding of the technical solution and commercial viability for larger grid-scale deployment.

## 5.4 PUBLIC CHARGING

### 5.4.1 How much does publicly-accessible charging infrastructure cost?

Standard charging outlets for public locations generally cost about the same as for corporate fleet applications – around \$5,000 per unit. Standard charging circuit costs are higher however, with the average of nearly \$3,500 reflecting the greater emphasis on parking location over cost minimisation. Since the Victorian Electric Vehicle Trial launch in 2010, high voltage 'quick charger' equipment costs have halved to be now around \$40,000. Quick charger installation costs are highly variable, but can be minimised if provisions are made during general site construction or refurbishment.

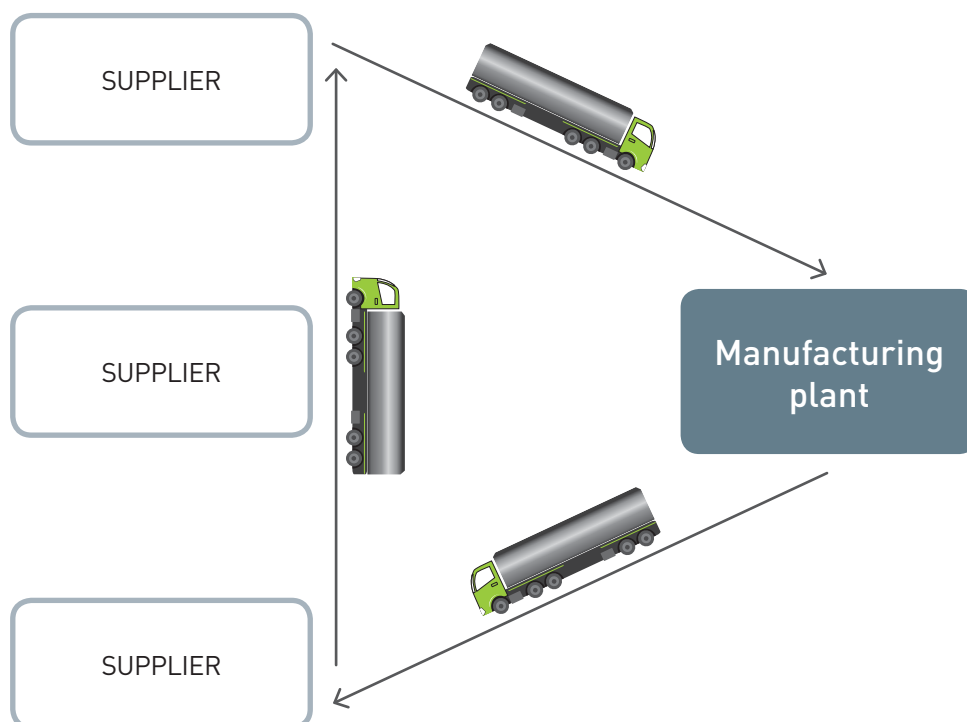


Figure 43. Conceptual model of 'milk run' logistics for freight delivery from a range of regular suppliers to a manufacturing plant – a scenario potentially well suited to a corporate charging strategy.

With reference to Table 14, the limited number of public charging locations for which cost data is available resulted in average cost for the charging circuit of around \$3,500. These costs reflect public charging outlets located in commercial premises rather than on-street locations.

No. INSTALLATIONS	11
AVERAGE COST	\$ 3,393
MEDIAN COST	\$ 3,224
STD DEV	\$ 995
MAX	\$ 5,500
MIN	\$ 2,056

Table 14. Cost benchmarking of the trial public charging circuits.

Several on-street charging outlets located on public lands were investigated, and found to be largely cost prohibitive without additional funding assistance (beyond that provided by the Department). Three on-street locations investigated in Melbourne's CBD had installation costs quoted from \$15,000-\$25,000, in response to which only one site was approved to go forwards with the assistance of supplementary funding. The funding provider was a corporate fleet operator seeking a high profile location in the vicinity of their place of business in which to charge their branded vehicle.

Influences on these costs were primarily related to the trenching requirements for cabling between the nearest point of electrical supply (sourced from an underground pit) and the on-street location for the charging outlet.

Quick chargers were contracted at the outset of the trial in 2010 at a cost of around \$90,000 per unit based upon estimated prices for equipment that was undergoing commercialisation at that time. Design evolution and manufacturing improvements have resulted in rapid cost reductions such that in late 2012 the equipment costs were around \$40,000. In 2012 Nissan began rolling out quick chargers in the U.S. and Europe at a price of \$US 10,000 (Autoblog 2012b), suggesting that further cost reductions are highly likely.

For reasons explained in Section 5.4.4, the trial quick charger roll-out has yet to be completed. Two quick chargers are being installed in locations which are undergoing significant redevelopment for separate reasons, limiting the ability to extract cost data in relation to the quick charger installation specifically.

Item	Cost	Comments
Site preparation	\$ 2,000 – 4,000	Includes review of site, works planning, applications and submissions for permits / approvals
Trenching	\$ 10,000 – 50,000	Varies according to site specific issues including extent of cable-run, allowances for existing ground assets/utilities encountered, special excavation requirements, possible soil contamination/asbestos/geotechnical issues, consultation required with affected land owners etc.
Pipe, pits, conduit	\$ 3,000 – 6,000	Varies according to extent of cable-run, size of conduit; typically 3 pits for 50 metre cable-run
Cabling	\$ 1,000 – 1,500	Varies according to extent of cable-run; 16 mm diameter typical cable size cost is around \$20 – 30 per metre
Cabling pull-through	\$ 250 – 500	Varies according to extent of cable-run; typical cost is around \$5 – 10 per metre
Distribution board	\$ 1,500	Varies according to distances, capacity and supply
Slab, mounting, installation	\$ 5,000 – 7,000	For a typical slab length/width/depth of 1.2 x 0.8 x 0.2 metres
Termination and commissioning	\$ 1,000	Includes connection of cables, RCD installation, equipment testing and commissioning, customer handover and training; note that this excludes network testing and commissioning
<b>Total</b>	<b>\$ 23,750 – 80,500</b>	<b>Establishment costs only – excludes quick charger hardware cost</b>

Table 15. Quick charger establishment cost estimates for a 'brownfield' site, where distance between the 25 kW quick charger and the point of electrical supply is around 50 metres and electrical supply upgrades are not required.

Cost data obtained from various site negotiations has been benchmarked to provide indicative costs for quick charger establishment – refer to Table 15. For a ‘brownfield’ site it is clear that the establishment costs can greatly exceed that of the quick charger unit, highlighting the reasons for leveraging site works being undertaken for separate reasons (for example, to reduce/avoid trenching costs).

### 5.4.2 How are publicly-accessible charging outlets installed?

Charging infrastructure is installed by electrical contractors drawing upon information supplied by the household. From the time of the contractor being notified of the need for an installation, the process to handover usually takes about five weeks.

The general process for the installation of publicly-accessible charging infrastructure on commercial property can be seen in Figure 44.

Further explanation of what these steps encompass can be found below:

1. **Site identification** – consideration of electric vehicle ownership and usage informs initial consideration of the region and specific locations that public charging options may best support; potential host sites in these locations are contacted either at the premise or through the parent organisation; discussions are pursued to engage potential hosts and identify preferred sites based upon a willingness to proceed

2. **Contract negotiation** – the formal agreement for the corporate entity to participate in the trial as a charging infrastructure host is negotiated through to sign-off; finalisation of the agreement occurs in parallel with determination of the transaction model for the site operation (user payment for parking, charging activities, both or neither); consideration of the communications plan for the site is also initiated; this step was generally found to be the most lengthy, for reasons that are explained further below

AVERAGE / MEDIAN LEADTIME = 201 / 140 DAYS

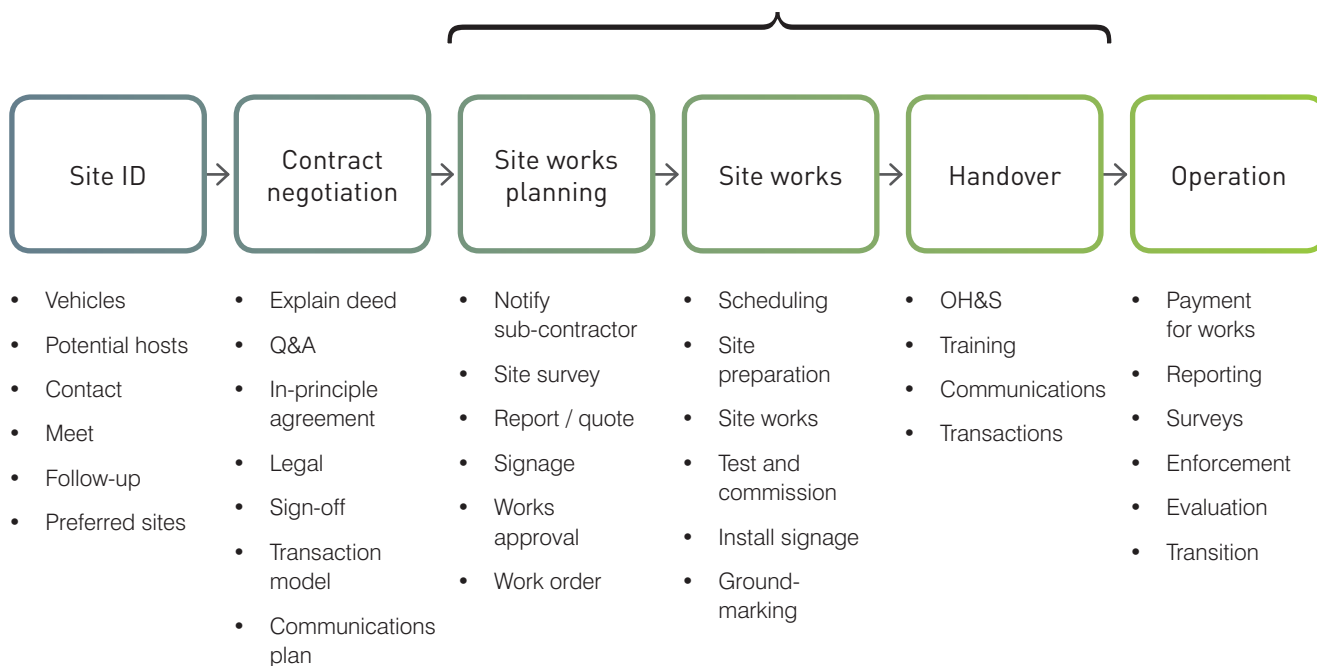


Figure 44. Schematic of the publicly-accessible charging infrastructure installation process for commercial property.

3. **Site works planning** – the charging infrastructure provider is introduced to the potential host and a site visit arranged – this is the start date for assessment of the installation leadtime; the site visit kicks the project off and includes a preliminary survey of options informed by all parties; the corporate participant identifies their preferred location taking initial advice into account; example content is supplied to the corporate participant for deliberation on the signage/ground-marking for the site, and the plan for manufacture and installation agreed; the works plan is formalised between parties and signed-off through a works approval/work order process; this step was found to be lengthy due to the need to negotiate agreement with multiple stakeholders for reasons that are explained further below
4. **Site works** – installer arranges a site visit to undertake the installation as per the agreed works plan; the host prepares the site by ensuring that it is cordoned off for the duration of the works; charging station commissioned into service; signage and ground-marking is delivered/installed as per the works plan agreement
5. **Handover** – an OH&S review may be undertaken of the site; instruction on the arrangements for the site/equipment operation is provided to staff on the ground if required; a launch event and/or other communications are kicked off as part of the service promotion and benefits realisation; Department notified once the site can be advertised to trial participants as being available for use – this is the finish date for assessment of the installation leadtime

6. **Operation** – Department/corporate participant receives invoice/actions payment; charging activity commences; data gathered through telemetry link to network operating centre; various surveys of users/stakeholders initiated to assess awareness/understanding/acceptance of the charging facility; management of site undertaken as part of broader enforcement program; collective evaluation of site performance against pre-determined targets undertaken at agreed milestones; arrangements at completion of trial implemented based upon host agreement.

The contract negotiation (step 2) has been by far the most challenging and longest leadtime aspect of the public charging infrastructure roll-out. On the part of the hosts there is a desire to not cede ownership of any commercial benefits to the charging service provider. From a legal perspective, the uncertainty and perceived risks in dealing with a new concept such as electric vehicle charging translate to an unwillingness by the host legal team to accept liabilities regardless of however reasonable. Despite the former Department of Transport acting as an 'honest broker' in these negotiations and underwriting the cost and risk issues, the majority of negotiations with portfolio-level property owners broke down at this stage. In the case of one large property asset investment group who have majority interests in some of Melbourne's most prominent shopping centres, negotiations have been stuck in this stage for nearly 14 months as of January 2013 despite there being an expressed desire from senior management to participate in the trial and host electric vehicle charging services.

The site works planning (step 3) was by far the greatest contributor to the lengthy leadtime that has been quantified above. The main issue was the handover between the corporate-level project supporters and those on the ground who own the detailed decision-making. By way of example, a large property investment firm entered into an agreement to participate as a charging infrastructure host at a corporate level, following which a new round of negotiations commenced with the individual site managers. The site manager resistance is generally related to the opportunity cost associated with assignment of the parking asset exclusively for EV parking/charging. Institutional failures in transferring decisions between the strategic and operational arms of the organisation are also very common, insofar as there being no support to ensure that the corporate-level agreement progresses to implementation.

The signage/ground-marking issues described in Section 5.3.2 for corporate properties are also evident, however organisations playing the role of 'host' are generally of the view that this forms part of the charging service provider's responsibilities.

## PUBLIC CHARGING CASE STUDY

### ON-STREET CHARGING STATIONS IN MELBOURNE CBD

In 2010 City of Melbourne agreed to provide up to 12 on-street parking bays in Melbourne's CBD for exclusive use as electric vehicle parking/charging locations for the duration of the trial. This commitment has underpinned an investigation into the process, timelines, obstacles and opportunities for on-street charging stations.

Initial attempts to identify suitable sites were confounded by the limited information available about the underground cables, pipes etc. that may enable/inhibit establishment of electrical infrastructure. A key input into site selection is the location of convenient points of electrical supply, as this has a large bearing on the excavation/structural works and with this the project costs. This information was possible to obtain through:

- (i) Formal applications to the electricity network operator in response to detailed works plans (a large and costly commitment at the site identification stage), or
- (ii) Informal dialog with the electricity network operator via their representative taking part in the trial project meetings (who agreed to investigate a number of regions of around 300 metres diameter as an in-kind contribution to the trial), or
- (iii) On-the-ground site surveys to identify potential sources of electrical supply (signified most often by the presence of electrical man-hole covers/pits, or above-ground ventilation stacks for underground substations).

As a starting point for the trial site identification, an informal request was supplied to the electricity network operator for information about relevant underground electrical infrastructure within a 300 metre radius of six locations of interest. These locations were selected to coincide with fleet EV operator parking preferences, which would help ensure site utilisation. In response to this request a mark-up map was supplied of potentially relevant electrical infrastructure in each area. On-the-ground site surveys eliminated all but one site, primarily due to the network infrastructure not aligning with the parking and/or traffic arrangements. Criminal damage risks, for example due to the proximity of a late-night entertainment venue, were also an influence on the site review.

One preferred location was taken forwards initially via an application by the charging service provider for an exemption from Energy Safe Victoria under the Electrical Safety Act 2000. The exemption was granted partly due to the agreement with City of Melbourne for the provision of on-street parking/charging locations as an in-kind contribution to the trial. Having gained the exemption, the charging service provider developed a detailed works plan in consultation with the electricity network operator. Despite the preliminary site surveys undertaken above, the detailed works plan was costed at around \$30,000 for a single standard charging outlet, in addition to which complications were identified in relation to some heritage-listed trees in the vicinity of the site. At this point a decision was made to not proceed with this site.

Separate and subsequent to the experience above, a new site was identified in partnership with a corporate sponsor who was seeking a highly visible location outside of their offices to showcase their branded electric vehicles. Having secured the supplementary funding commitment along with a minimum-level site utilisation, a decision to proceed with the preliminary works plan and approvals processes was made in May 2012.

A similar process to that outlined above was undertaken by a trial charging service provider. An exemption approval was obtained from Energy Safe Victoria, following which a detailed works plan was developed. The detailed works plan drew on input supplied by the electricity network operator, confirming the adequacy of electrical supply and outlining the proposed method of connection to the network. At this point the project proposal costs were estimated at around \$20,000.

The detailed works plan was then lodged with City of Melbourne for a planning approval. The initial review returned an approval in-principle for the parking reassignment, along with a request for further information. The main risk issues discerned by council as needing to be addressed were:

- Tripping hazard from the charging cable
- Cyclist hazard from the charging plug protruding from the vehicle
- Shock hazard potential.

As of January 2013 discussions were still underway regarding the risk assessment submission – eight months from when the detailed works planning process was initiated.

Indications from City of Melbourne are that works are generally scheduled to occur around eight weeks from when the planning approval is finalised.

### 5.4.3 What do people think about public charging?

Widespread opinion both here and overseas indicates that on account of its role in addressing electric vehicle range limitations, the availability of public charging infrastructure is a key issue for EV uptake. Even once people have lived with the vehicles, opinion persists on the value of public charging infrastructure despite widespread acceptance that home charging addresses most driver needs. The role of public charging infrastructure as a range 'insurance policy' was further highlighted by the identification of measures to ensure the accessibility of charging outlets as being of high priority.

Surveys of stakeholders on the barriers to widespread/successful introduction of electric vehicles have routinely identified the availability of public charging infrastructure as being a key issue for EV market development:

- The 2,200 applicants for participation in the household vehicle roll-out rated the lack of recharge infrastructure 4.2 out of 5 (std dev 0.8) in terms of significance as a barrier to successful EV introduction for Victoria (DOT 2012)
- Fleet participants and attendees at the fleet workshops all rated charging infrastructure availability as a key issue for EV uptake (refer to Section 4.3.4)
- A survey of 53 attendees at the December 2012 EV Conference in Melbourne rated the lack of recharge infrastructure 4.1 out of 5 (std dev 1.0) in terms of significance as a barrier to successful EV introduction for Victoria.

These results correlate well with findings from overseas, where non-EV owners in particular consider the lack of public charging infrastructure to be a key barrier for EV adoption (Gopal and Thawrani 2012).

Public charging outlets have been commissioned into service gradually over the life of the trial such that 20 locations were available in the greater Melbourne area by January 2013. For the majority of trial participants, this has meant that charging locations have only occasionally been available at their intended destination. Nevertheless, the trial household participant survey results are representative of people with a minimum of six weeks experience of life with an electric vehicle.

Issue for consideration	Average score (out of 5)	Std dev
Fines for non-EV users who park in EV-specific locations	4.5	1.0
Promote EV usage with high-profile locations and/or free charging	4.4	0.9
Availability of charging points similar to that of petrol stations / bowzers	4.2	1.1
Provision of a booking facility that allows drivers to reserve their charging point before arrival	4.0	1.1
Ensure the safety of other road users (for example pedestrians, cyclists)	3.8	1.3
User-pays approach where charging costs reflect energy use, parking and equipment costs	3.4	1.0
Preferential treatment for EV drivers on account of their contribution to the 'public good'	3.3	1.3
Appease the concerns of local stakeholders in nearby businesses	3.1	1.1
Discourage car use in highly-populated areas	2.9	1.3

Table 16. Results from a survey of trial household participants on their opinions of the issues that should be taken into account in the provision of publicly-accessible EV charging points; survey interval was around six weeks into their EV experience (n = 76, marks out of 5 where 5 = very important and 1 = very unimportant).

Household participants were asked about various issues they felt should be taken into consideration in relation to public charging. With reference to Table 16, the highest priority issues according to trial household participants were:

- Accessibility – ensuring charging outlets would be accessible when required, with enforcement of EV-only parking the highest ranked response and provision of a reservation facility also highly ranked
- Availability – consistent with the views of other stakeholders, provision of public charging infrastructure was highly ranked – at high profile locations in order to promote EV usage, and at a density similar to petrol stations/bowsters.

The importance of accessibility may be interpreted as an insight into the role of public charging infrastructure as an ‘insurance policy’ for electric vehicle range limitations. With reference to Section 5.2.5, nearly 80 per cent of participants felt that home charging met their needs. This suggests that most EV drivers will only use public charging outlets infrequently, but they want to be able to reliably access it when they do need it. This interpretation is consistent with the perception of the role of public charging infrastructure as a key enabler for promoting adoption of EVs.

Household participants were also asked about the influence of cost and convenience on the likely appeal of public charging infrastructure.

Results suggest that convenience outweighs cost in terms of its effect on driver appeal, with the number of participants who would not use public charging outlets regardless of price increasing from 5 to around 50 per cent if they had to go out of their way to find them – refer to Figure 45. This finding is potentially inconsistent with the view of public charging infrastructure as an ‘insurance policy’.

While nearly 87 per cent of drivers say they’d be willing to pay for the service if the charging outlet was located at their intended parking destination, it should be recalled that a high proportion of drivers also said that home charging met their needs (refer to above/Section 5.2.5). These results highlight the potentially high-risk market opportunity for public charging infrastructure hosts and operators.

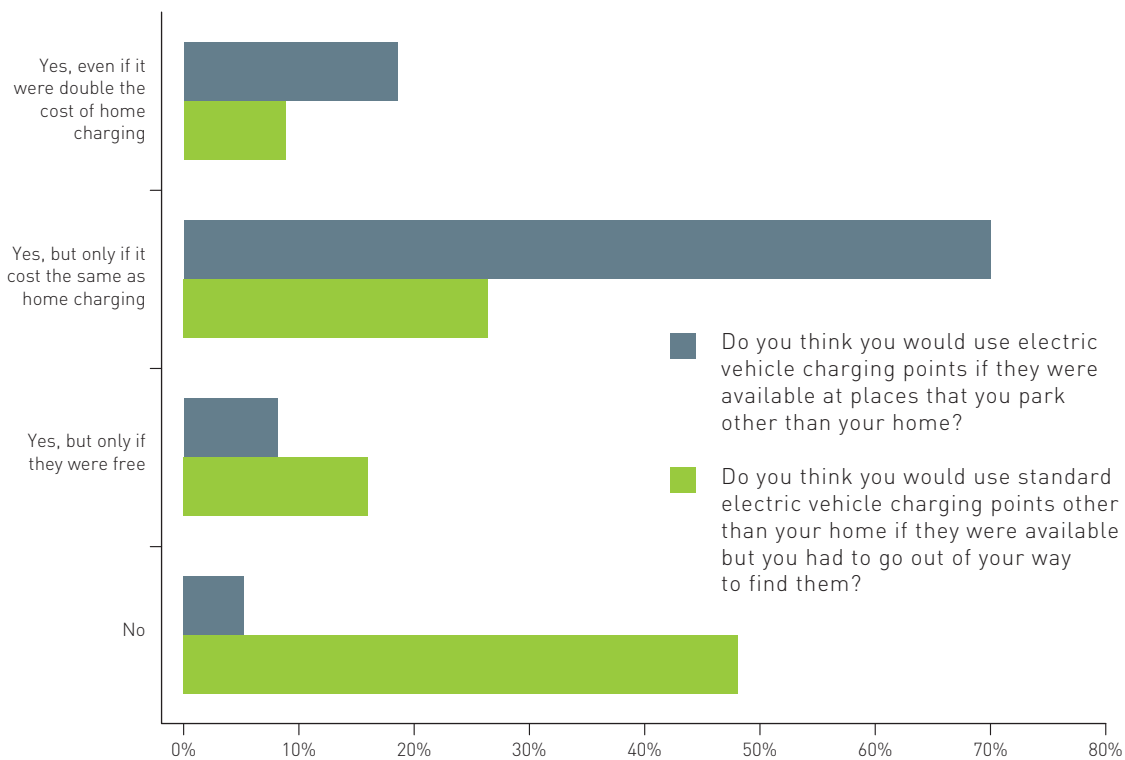


Figure 45. Results from a survey of trial household participants in response to two questions relating to the likely appeal of public charging outlets; the identical response options for both questions examined cost influences, while the difference between the two questions assessed convenience; survey interval was around six weeks into their EV experience (n = 76; multiple choice/single choice only).

As further evidence of the uncertainties within the public charging station business model, the quote below sourced from the Victorian Electric Vehicle Trial Discussion Board provides an interesting insight into one driver's reckoning on use of public charging outlets:

*So where's the line between the convenience, economy and luxury of driving to work in an EV and the commute by public transport?... for us the economy is the governing factor, followed closely by convenience. The basic maths says if we can commute in and out on one charge from our home or if required an additional charge from a free charge point in the CBD, then it's an economical solution, while at least two people are traveling.*

*The approx \$3 for the full charge at home @ 16kWh x approx \$0.20/kWh for the i-MiEV or approx \$0.80 for the full charge of the Prius and the \$15 parking costs is comparable but cheaper than the \$22 odd for two all day zone 1&2 myki transactions (wear and tear on the EV plays a part, but in the interest of simplicity I've ignored those additional costs).*

*The convenience of the 40 to 50 minute commute by EV beats the 1 to 1.25 hour commute on public transport until you add a 20 min walk to work and back to the car if the charge point is not conveniently located near work, then the two options come frighteningly close.*

Victorian Electric Vehicle Trial household participant, 2012

Results from more mature markets in terms of vehicle and charging infrastructure roll-out provide similarly mixed messages about the viability of publicly-accessible charging outlets. Up to September 2012 the largest infrastructure roll-out taking place in the United States as part of 'The EV Project' had delivered 1,818 publicly-accessible charging stations (ECOtality 2012). In the assessment of the charging activities of the 6,071 vehicles taking part in the project, a preliminary assessment is that around 80 per cent of private electric vehicle charging events typically take place at the home. The remaining 20 per cent of charging events take place at publicly-available and workplace charging locations. Although the performance of individual charging stations has not been reported, it was noted that the presence of an electric car-share operator in San Diego resulted in significant increase in utilisation of the public charging stations.

#### 5.4.4 Where should public charging be available?

Parking areas within or nearby to shopping centres and strips should be a priority for public charging facilities. Specific locations should be selected on the basis of their alignment with the EV driver demographic. Local factors relating to existing parking demand or management, along with electricity network configuration and potential sponsorship opportunities should also be taken into account in order to streamline the roll-out. Quick chargers should be strategically placed along traffic corridors.

The most convenient locations for 'opportunity' charging are those where vehicles are most commonly parked other than home and work (the two most common locations – refer to Figure 42). Based upon the responses from the household application to participate, this means shopping centres or strips – refer to Figure 46. This observation is consistent with public infrastructure guidance provided elsewhere (US DOE 2012a).

Other locations where vehicles may park regularly and for periods of several hours may also be well suited to 'opportunity' charging of electric vehicles. Hospitality and entertainment locations such as restaurants and cinemas, recreation facilities, airports, railway stations and other 'park-and-ride' locations could all play a role in a comprehensive public EV charging network.



The following quote supplied to the trial discussion board at an early stage of the public charging network roll-out sums up the driver perspective:

*I got a list of public charging locations from both ChargePoint and Better Place but didn't actually use any during the trial as they didn't prove to be convenient to the places I went.*

*Given the time required to be useful (probably min 1-2 hours), none ended up being close to the shops, cinemas or work where I spent any extended time – I would've had to change where I went. Obviously this will change as more get rolled out – I think it would be great to be able to plug in at shopping centre or cinema for example.*

In terms of specific locations, there are a range of indicators that may be useful in ascertaining whether a site is a good candidate for public charging (Luskin 2012):

- Electric vehicles are already using the site or a nearby site
- Customer/driver surveys reveal an interest in electric vehicles or intention to purchase an electric vehicle
- There is a higher-than-average concentration of hybrid vehicles using the site or a nearby site

- The site user demographics match those of people likely to be interested in electric vehicles, such as higher levels of educational achievement, higher than average household incomes, interest in new technology, environmentally-aware (refer also Section 4.2.1).

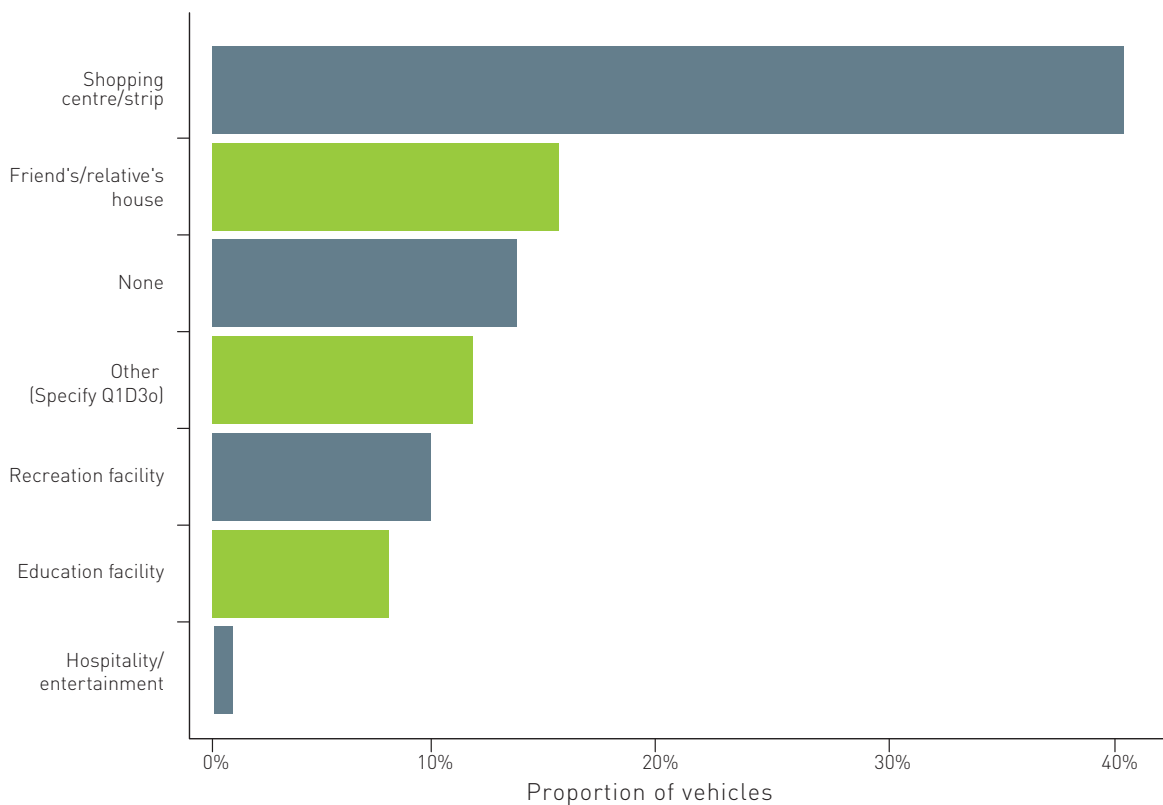


Figure 46. Results from the 2012 trial household application to participate process in response to the question 'What is the most common parking location for each vehicle in your household other than home or work?' (n = 2,200; DOT 2012c).

Drawing upon the trial experience, additional factors which may promote or reduce the likely success in a site hosting EV charging infrastructure include:

- Existing parking demand: where demand exceeds supply, allocation of parking for exclusively electric vehicles may be resisted by the operator and resented by other users
- Existing parking arrangements: where the concerns of key stakeholders for any site limit the appetite to reconfigure existing parking allocations to better align with EV charging establishment or operation
- Parking user model: where vehicles are normally parked for the entire day, this will limit the ability to recover costs on charging infrastructure
- Electricity network infrastructure: where electrical supply is insufficient, difficult to access, or requiring separate metering, establishment costs for charging infrastructure may be prohibitive
- Sponsorship opportunities: where nearby retailers or hospitality providers are seeking to attract the EV driver demographic, or where a fleet EV operator is seeking to promote the visibility of their (branded) vehicle in a specific location (refer to Section 5.4.3 for an example relating to electric car-share).

From the perspective of influencing EV market growth, high profile sites are more likely to influence driver perceptions regarding management of EV range limitations. While this drove much of the planning behind the trial public charging infrastructure roll-out, the factors above were found to be the ultimate determinants of a site owner electing to host EV charging infrastructure.

Quick charger locations align more closely with the 'emergency' charging model where a quick top-up is required en route. This suggests that locations should be sited as close as possible to high traffic thoroughfares such as arterial roads. Service stations are often sited at these locations for similar reasons, making them well-suited to the role of hosting quick chargers.

Despite this, the trial experience has found that the issues identified for standard chargers above dominated negotiations on quick charger sites. Even in instances where solutions for these issues existed, the difficulty in providing compelling answers to the key questions of 'why here?' and 'why now?' severely delayed or ultimately prevented sites from being progressed.

### 5.4.5 What are the issues and opportunities for public charging?

Due to their influence on driver perceptions regarding management of EV range limitations (refer to Section 5.4.3), public charging options appear to have a significant influence on electric vehicle uptake. Consequently, the challenges in promoting a viable public charging network are some of the most pertinent for the promotion of the electric vehicle market generally.

The opinions of the trial household participants indicate that there may be a market for public charging by EV drivers, however this market is likely to be financially-challenging for charging service providers.

Experience from the United States supports this view. Between July and September 2012 the most advanced market for public charging infrastructure availability taking part in the EV Project was the Phoenix metropolitan area<sup>16</sup> (ECotality 2012). During this time, 259 publicly-accessible EV Project charging outlets were servicing a market of 250 participating EVs and an undisclosed number of EVs beyond this. These outlets were reported as having a car plugged in around two per cent of the available time and delivering energy (charging) around half that.



<sup>16</sup> Oregon had more publicly-accessible charging infrastructure than Phoenix during this period, however it has been excluded from this discussion due to the distortion in the utilisation figures reported by the involvement of an electric car-share service

Despite these challenging figures and based upon the large body of information arising out of The EV Project overall, ECOtality (2012) believe that around 20 per cent of charging activities may be carried out at publicly-accessible locations. This conclusion may be influenced by a contrast between the behaviours adopted by drivers of different electric vehicle technologies. The average number of charge events per day for Nissan LEAF participants is 1.1 and the daily driving distance is within the battery capacity – results consistent with those from the Victorian Electric Vehicle Trial. However for the Chevrolet Volt PHEV the average charge events per day is 1.4 – this indicates that Volt drivers, who drive a greater distance each day than LEAF drivers, are striving to operate their cars as much as possible on electricity (due to the financial advantage in doing this).

It may also mean that Volt drivers seek out public charging infrastructure more often than LEAF drivers to realise this benefit – a theory that may be substantiated by future data from The EV Project.

On-street charging locations are rarely economic to install and operate due to uncertainties in the planning process, high installation costs, parking policy challenges, and low revenue potential. Information about electricity network configuration is not openly available and decision-making on electrical infrastructure proposals is fraught with uncertainty in relation to time, requirements and outcomes. Most on-street sites require carefully planned and executed excavation works as part of the installation, making costs far higher than for off-street locations.

Parking revenue is a valuable budget input for many councils, which combined with efforts to disincentivize car traffic, limits council appetite to offer free or even reduced parking costs for EV parking/charging. Users will only pay a small premium (at most) for the charging service beyond the cost of the energy and parking combined. Transaction arrangements may be challenging, either for the user who must pay separately for parking and charging, or for the host/operator who must integrate payment systems.

Some of these issues may be addressed through better support from the electricity network operators and councils, particularly in municipalities where on-street EV charging services are most desired, however off-street charging locations are clearly the preferred public charging option. An exception to this may be locations where visibility is a priority for promotional purposes – in these instances funding support from third-parties such as corporate fleet EV operators seeking exposure may be a key enabler.

While easier, off-street public charging locations are significantly impeded by the opportunity cost for parking facility operators. Parking is a lucrative business. Based upon daily and monthly revenue estimates, a single parking bay in Melbourne's CBD generates between \$6,000 and \$15,000 of income per year (Colliers 2012). Furthermore, many parking locations are already over-subscribed (trial examples include Westfield Doncaster Shopping Centre, Doncaster Park & Ride and many railway station car-parks). For a parking bay to be exclusively assigned to EV parking/charging, the relatively low number of likely users in the near-term creates a significant opportunity cost that most facility operators will not accept. This issue has been the most significant barrier to roll-out of public charging facilities as part of the trial.



Quick charging may be a potential solution to this issue – refer to Figure 4 and Figure 47 for examples. For the same footprint, quick chargers are able to service many more customers than standard chargers. Quick charging also provides an enhanced value proposition relative to standard charging that users will pay a premium for (that is, more than simply the cost of the energy used). They have the potential to significantly extend the operating range of EVs, both from actual use and as a by-product of the reassurance they provide EV drivers (who consider quick charging to be a range ‘safety net’). In Japan, the country with the highest concentration of quick chargers, Nissan (2012b) have reported positive impacts on both electric vehicle uptake and use from the presence of quick chargers. Following an increase from 2 to 7 quick chargers on the 350 kilometres highway between Tokyo and Nagoya, electric vehicle registrations increased from around 1500 to 1900 vehicles and the number of EV highway drivers increased from 19 to 41 per cent in the surrounding region.

While quick chargers hold great potential in their ability to influence electric vehicle uptake, they are not without their challenges. Table 17 provides a description of these issues along with a snap-shot of current progress towards resolution.

An additional opportunity that applies to both standard and quick chargers relates to better information for the market on likely EV parking/charging locations. Although general information has been supplied in Section 5.4.4 above, specific information in terms of a map of priority locations would help address property owner/manager uncertainty on the risks of allocating real-estate for EV parking/charging.

While the Department’s *Guidance on Land-use Planning for Electric Vehicle Parking and Charging* (DOT 2012e) provides advice for new developments, it is not targeted at existing land-uses/facilities. Southern California Association of Governments have been developing a regional plug-in electric vehicle readiness plan that seeks to address this information barrier for the market with more specific guidance (Luskin 2012). The opportunity exists to develop and publish more detailed information for Victoria that will assist with site identification and negotiations, thereby streamlining public charging infrastructure roll-out.

The existence of the trial public charging locations does however prove the existence of a value proposition for some parking facility operators. According to the operators, this mostly related to the marketing benefits for their facility through having been an early-adopter of EV charging technology – a view endorsed by findings in the U.S. (RMI 2009).



Figure 47. ChargePoint quick charger installed in North Strathfield, New South Wales.

According to theory (Lieberman and Montgomery 1988), early-adopter advantages that may be obtained by a parking facility operator in this situation include:

- Influence customer choice under uncertainty – early-adopter parking facilities may establish a reputation for quality from having the latest technology, which may then translate to a preference from customers (particularly given that parking is a relatively low-cost ‘convenience good’ where the benefits from finding a superior alternative may be insufficient to outweigh the search effort involved)

- Create switching costs for customers – building on the advantage above, once a customer has adapted to the characteristics of a parking facility, competitor parking facilities must invest additional resources in order to tempt them away from their initial choice.

These benefits are difficult to discern at a practical level and mostly related to the marketing value of hosting EV charging facilities, which has a ‘use-by-date’ in terms of novelty. As a result, most parking facility participants drew comfort at the outset from the finite term of their trial involvement, and indicated their intention to remove the EV charging capability unless the corresponding parking bays met expected occupancy levels. Some operators also opened up the EV parking/charging bay to general use, but would rope the bay off temporarily in response to an EV driver ‘reservation’.

Issue	Description	Mitigation strategy
Equipment costs	Early-market designs cost \$55,000–\$90,000	Latest generation equipment costs have reduced to \$10,000–\$40,000
Establishment costs	Exceed equipment costs – potentially \$80,000 depending upon site specifics (refer to Table 14)	Latest generation 25 kW quick chargers have much lower installation costs with only minor impact on charging times
		Streamlining through the development of ‘best practice’ installation processes
		Provisioning during initial site development or leveraging site redevelopment will potentially avoid trenching costs (the largest contribution to establishment costs)
Connector standards	A range of designs have emerged globally, increasing complexity and market-access barriers	A combination standard is in the final stages of development that will be globally recognised, backwards compatible and allow for a single connector that may be potentially adopted even by PHEVs
	PHEVs do not generally include quick charger capability	
	Separate connectors for standard and quick charging increases costs	
Grid impacts	Quick charging increases the peak- to-average electricity demand load, reducing network reliability or necessitating investment	New standards will support grid communication and demand management strategies
		On-site energy storage may reduce grid impacts by smoothing the demand profile
Vehicle battery impacts	Quick charging degrades battery life more quickly than standard charging	Battery technologies are evolving to reduce charging times and increase battery life
	Uncertainty relating to quick charging impacts on battery life, including vehicle re-sale	Increased understanding and transparency for all EV market participants on quick charging impacts upon battery life
User ergonomics	Early-market designs are not especially user-friendly	Latest generation/emerging standard designs are more user-friendly
	Drivers are unfamiliar with quick charger operation	Drivers acquire experience in the use of quick chargers

Table 17. Quick charging issues and mitigation strategies.

## PUBLIC CHARGING CASE STUDY

### RETAIL STORE CHARGING STATIONS IN CALIFORNIA

California, as one of the major EV markets globally, provides some useful insights into the public charging models.

In January 2012 six dual-outlet charging stations were installed in the parking-lot for a retail premises in Fremont South, California. The charging stations are available for public use free of charge during the business hours of the associated retail store.

Customer feedback for the store is tracked via an online user-review site for local businesses. Of the 42 customer reviews of this store, 26 per cent mention the EV charging stations highlighting their influence on customer perceptions:

*I've never been a Target shopper and as a matter of fact I don't really like big box stores BUT I just bought a Chevy Volt.*

*This store has a row of EV chargers – that's enough for me and they will now be my store of choice for pretty much all my shopping and my Starbucks of choice will now be the one in this store.*

*The fact that they are forward thinking enough to recognize the benefit of dedicating a row of parking places and spending money to install EV chargers is enough for me.*

Use of the public charging stations has increased steadily from the time they were commissioned such that in November 2012 around 1.3 MWh of electricity was consumed by EV charging activities (equivalent to the battery capacity of 54 Nissan LEAFs). Most significantly, the average charging session for users was two hours – substantially longer than the 30 minute average customer visit duration companywide – at a cost of under \$USD 0.50 per customer for the electricity.

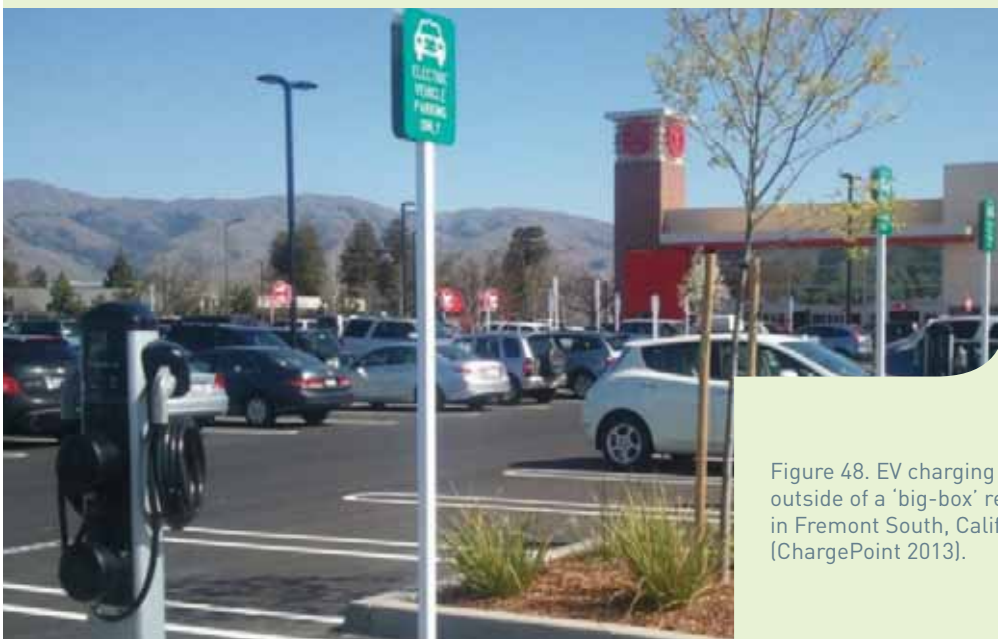


Figure 48. EV charging outlets outside of a 'big-box' retailer in Fremont South, California (ChargePoint 2013).

The pushback by parking operators against reserving parking assets solely for the use of EV drivers highlights another challenge within the public charging business model – protecting and promoting utilisation of the EV charging infrastructure asset. Public charging outlets may be underutilised for a range of reasons:

- Inappropriate occupancy – where non-EV drivers, or EV drivers who do not use the charging facility, occupy the parking/charging bay either mistakenly or in spite of the ‘EV charging only’ restrictions, thereby preventing EV drivers from accessing the charging facility; a U.S. survey of EV owners found that the Toyota Prius hybrid-electric (not the plug-in) was the most likely vehicle to be inappropriately occupying an EV-only parking/charging bay (PSRC 2010)
- Customer confidence – where would-be users err towards non-use due to a lack of confidence that the parking/charging facility will be available when they need it; many trial household participants provided feedback on this issue, particularly for the Melbourne Airport EV parking/charging facilities
- Commuter charging – where users occupy the parking/charging bay for most of the day in spite of needing the charging facility for only a fraction of this time. Anecdotal reports from California suggest that EV drivers are conscious of how much the electricity used in a charging session costs, reducing their appetite to pay a premium for extended occupancy.

A range of measures were identified to promote public charging asset utilisation:

- Signage/ground-marking – standardisation of the EV parking symbol depicted in Figure 31, and inclusion of this design in directional and restriction signage (Figure 49) and ground-marking was felt to be the most cost effective deterrent for inappropriate occupancy, in addition to which it increased the visibility and marketing benefit for the site owner
- Real-time/remote charging status reporting and reservation capability – provided to varying degrees by the trial charging service providers; provides users with better information and confidence but does not eliminate inappropriate occupancy
- Parking technology – which if used in combination with the real-time/remote charging status reporting can address uncertainty about inappropriate occupancy; preliminary investigations found that there was limited appetite to integrate the technology into the charging service provider networks at this time
- Enforcement – training of parking officers for on-street EV parking/charging restriction enforcement has been agreed in-principle with the City of Melbourne, but deferred until an on-street parking/charging location is commissioned; conversely, parking enforcement for many commercial car-parks was found to be haphazard or non-existent; enforcement also fails to address inappropriate occupancy beyond serving an infringement notice on the offending vehicles
- Low-value parking asset utilisation – discussions with charging service providers in the U.S. found that some were pursuing the least-utilised parking assets in their negotiations with parking facility operators, primarily to gain access to the site but with the added benefit of reducing the likelihood of inappropriate occupancy
- Charging etiquette – where a protocol is developed that allows EV drivers to unplug other vehicles to allow them to charge their own in a neighbouring location; this is best suited to workplace/commuter charging, where simple signage has been developed by users in the US informing other drivers of their charging outlet availability for this purpose (refer to *Appendix E – EV charging courtesy signage*)
- Interoperability/network roaming – increasing the number of potential users by promoting the ability of users to roam across the network is an agreed medium to longer-term objective for charging service providers which was felt to be a lower priority at this end of the industry development (refer to Section 5.1.4).

At this stage of the market development, the signage/ground-marking and real-time/remote charging status reporting and reservation capability have emerged as the two solutions for the near-term, with enforcement likely to have application in on-street locations and charging etiquette for workplace/commuter charging. Section 5.1.5 contains insights into the issues and opportunities for network-level issues.

Another major challenge encountered in the trial was the legal negotiation that accompanied the commercial agreement to host public charging infrastructure. The most common issue raised by would-be hosts related to the distribution of liabilities for claims made in relation to the public charging infrastructure.

A lack of understanding about electric vehicle charging infrastructure and EVs generally was a common theme from the would-be host legal advisor/s, in response to which they would insist that all risks be borne by the Department and/or charging service provider. While this is generally appropriate, there are limits to the liabilities that will be accepted by these parties – for example, for issues arising from unrelated site works that come into contact with some aspect of the charging infrastructure.

By comparison with the issues outlined above, equipment and installation costs were of lesser concern. While it is unclear if any/all of the sites commissioned would have occurred without government funding support, the majority of hosts accepted the charging circuit costs with little complaint. However, some sites were clearly resistant to any expenditure, pointing out that their contribution was the not-insignificant opportunity cost associated with the likely lost parking revenue.

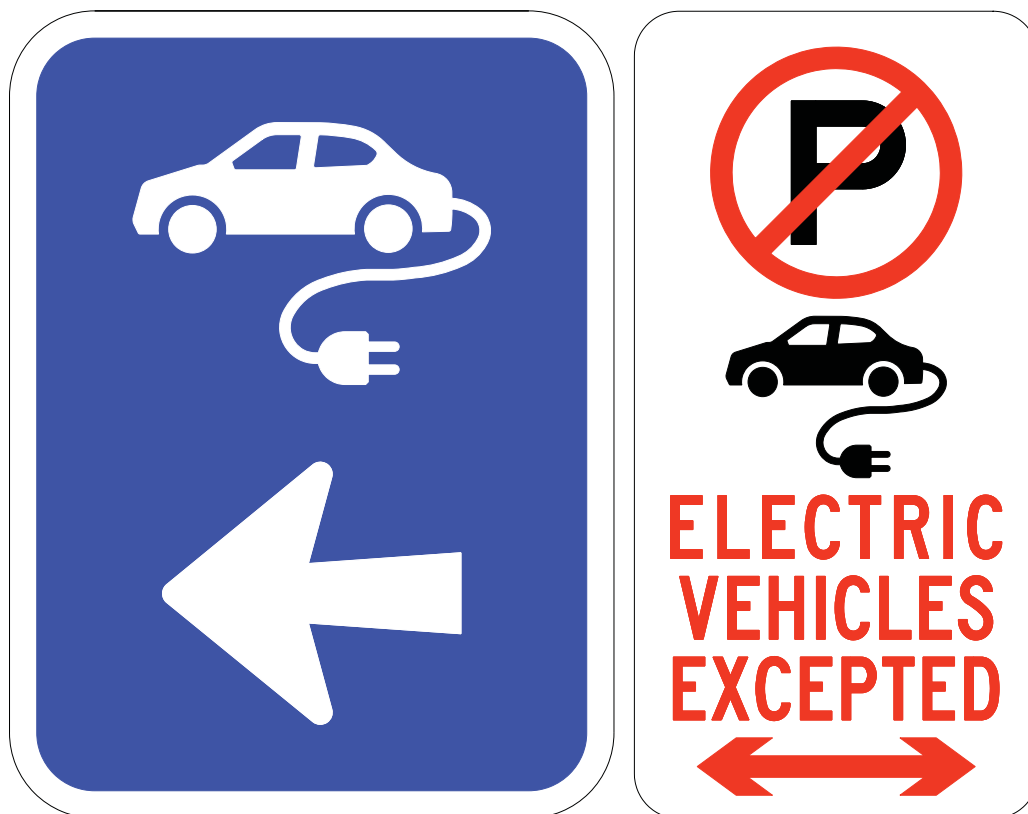


Figure 49. VicRoads-designed EV directional and parking signage, drawing upon the standardised symbol design depicted in Figure 31.



*There's a lot to like about increased use of electric cars in Victoria. They're much quieter and cleaner than petrol vehicles. EVs can reduce our dependence on oil imports and can play a big part in making our electricity system more efficient. However, EVs could also potentially exacerbate peak demand, putting more pressure on our energy networks and increasing costs for all consumers.*

*Finding out how people use and recharge their EVs is essential to help us plan for the future of our energy system and the long-term development of the EV industry. The Victorian Electric Vehicle Trial will give the market real-life direction about opportunities and challenges of more cars becoming part of the energy grid.*

Energy Suppliers Association  
of Australia (ESAA),  
19 November 2012



# ECONOMIC, ENVIRONMENTAL AND SOCIAL IMPACTS

As part of the Victorian Electric Vehicle Trial, an analysis of the economic, environmental and social impacts of electric vehicle adoption in the state of Victoria has been undertaken.

# 6



The economic analysis has examined the likely costs and benefits to the State under a range of scenarios up to 2040. It has identified key influences on the outcomes, along with timing for various milestones in the market development.

The environmental impacts assessment has included a comprehensive investigation of the lifecycle impacts of electric vehicle production, operation and disposal in Victoria. It has sought an understanding of the main issues influencing environmental impacts, and determined pathways to secure the best environmental outcomes. The trial has been used as a test-case for management of the environmental impacts, and guidance has been developed for Victorian EV operators.

An understanding of the social impacts from EV uptake has been sought in terms of employment benefits along with education and training needs. Opportunities for the Victorian economy in terms of research, design and development have been collated. Measures to protect and enhance community safety have been identified and are being progressed through a collaborative process.

## 6.1 ECONOMIC IMPACTS

### 6.1.1 How have the economic impacts been assessed?

The case for or against electric vehicles in Victoria will depend to a large extent upon the economic implications for the State. In recognition of this, the former Department of Transport commissioned consultants AECOM in mid-2010 to undertake economic modelling of future EV uptake in Victoria (AECOM 2011).

The economic model directly calculates likely take-up rates of electric vehicles using known data and industry input about the relative importance of different criteria in shaping consumer purchasing decisions. The benefits of this approach are two-fold:

- (i) It avoids use of assumptions about take-up of vehicles based upon past behaviour – this is a new market for which little information of this type is available; and
- (ii) By directly estimating take-up, it is possible to consider the impact of various potential sensitivities around prices (such as, electricity prices, fuel prices, vehicle prices) and how these affect take-up.

The analysis considers three scenarios against the base case, reflecting availability of electric vehicles and charging infrastructure. The base case assumes that only conventional vehicles are available, including ICEVs and HEVs. The three comparison scenarios investigate the levels of PHEV and BEV take-up under market conditions that vary as follows:

- Scenario 1 – assumes that there is household charging available only
- Scenario 2 – assumes there is enhanced household charging relative to Scenario 1, and public charging available in the Victorian metropolitan region
- Scenario 3 – same as for Scenario 2 with the addition of electric vehicle service stations that offer battery-swap or fast-charge capability.

The analysis:

- Looks at small, medium and large passenger vehicles, taxis and light-commercial vehicles being used in the Victorian metropolitan region (that is, Melbourne plus regional centres). Passenger vehicle use was further segmented according to how many kilometres vehicles travel each year. This approach recognises the differences in capital costs, operating costs and payback rates for each technology choice relative to a conventional vehicle
- Includes consideration of vehicle prices, fuel and electricity prices (including carbon price impacts) along with other vehicle operating costs, vehicle supply constraints, discount rates, emissions impacts, and consumer acceptance criteria
- Provides an estimate of the net economic impacts over a 30-year period from 2010 to 2040.

Notably, the economic analysis does not include assessment of potential impacts on Victoria's automotive industry (costs or benefits), which are discussed further in Section 6.1.4.

It should also be noted that the summary of issues presented in Section 8 is also a key consideration for interpretation of the economic model. Many of the issues identified must be resolved in order for the electric vehicle market to progress in line with the modelling forecasts.

### 6.1.2 What is the timeline for electric vehicle adoption in Victoria?

Results from the modelling predict that sales of PHEVs/EVs will make up a small share of new vehicle sales until around 2020, however current oil and vehicle technology prices suggest that this 'take-off point' may occur slightly earlier depending upon local vehicle supply.

The 'take-off point' reflects the point at which purchase of an electric vehicle becomes a financially prudent choice for new vehicle buyers relative to a conventional ICEV, and there are sufficient EVs available for purchase. It is an important date in the context of the economic analysis, as EV uptake before this time occurs at a cost to the economy (due to expenditure on vehicle purchase that is not paid back by operating cost savings). Following the take-off point, EV adoption provides a benefit to the economy through savings in transport energy costs that outweigh the vehicle purchase price penalty.

Up until the take-off point, vehicles are bought mostly by 'early adopters' who purchase the vehicle at least partly for non-financial reasons – refer to Section 3.2. Following the take-off point, EV purchase is a financially prudent decision.

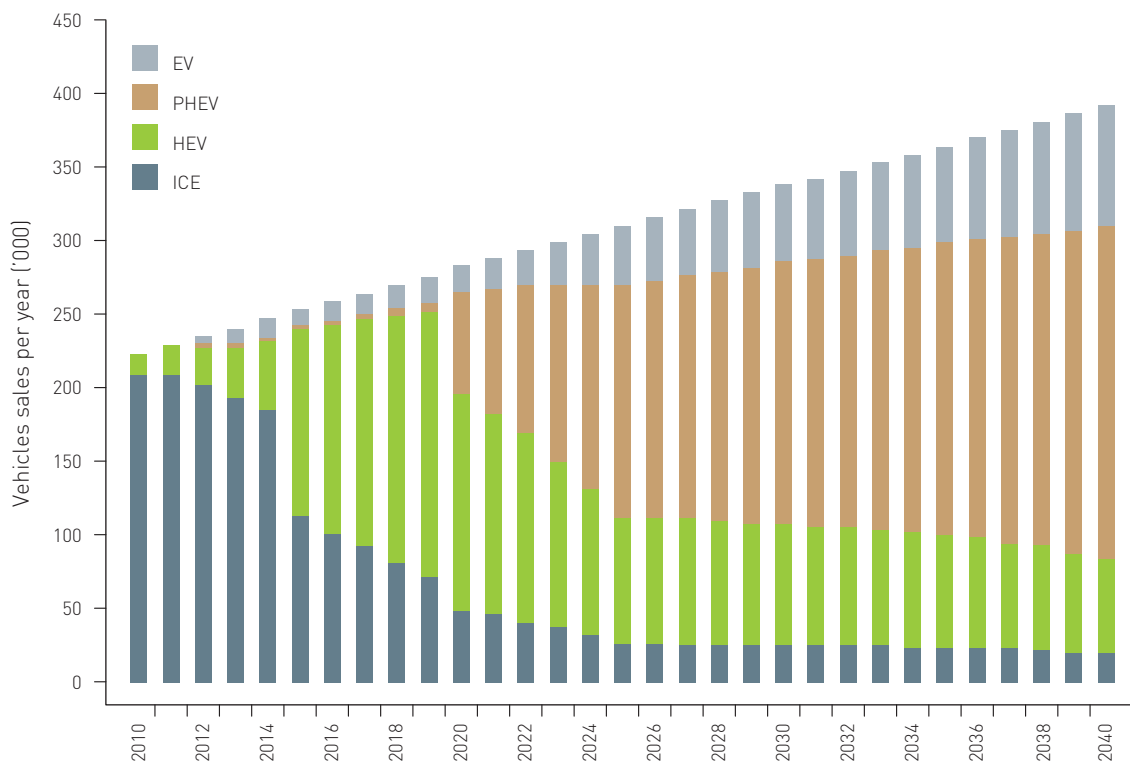


Figure 50 The breakdown in projected new vehicle sales for Victoria according to technology type. The scenario depicted represents a 'mid-range' forecast in terms of oil prices, vehicle purchase prices and public charging infrastructure availability (AECOM 2011).

Under a 'mid-range' scenario as envisaged in 2010 for oil and vehicle purchase prices, the take-off point for Victorian electric vehicle market is 2020 (AECOM 2011). Based upon this modelling, electric vehicles will make up around 25 per cent of new vehicle sales from 2020 if they are available and supported with a basic public charging network – refer to Figure 50. Under this scenario, uptake will increase to become around two thirds of new car sales by 2030.

To better understand both this and alternate scenarios, the influence of key variables on the market development should be noted. Extensive modelling commissioned by the United States Department of Energy (US DOE), who are responsible for President Obama's 'one million EVs by 2015' target, highlights the uncertainty in forecasts for electric vehicle market development – refer to Figure 51.

This uncertainty is due to the highly uncertain nature of key variables that influence the purchase price versus operating cost balance that economic models use to determine electric vehicle market development:

- **Technology costs** – EV purchase prices relative to conventional vehicles are influenced by EV technology costs, particularly batteries, and by the decisions on 'price-point' by the sellers, which reflect their positioning in each market and the business case that underpins each vehicle development program
- **Oil prices** – potential savings in vehicle operating costs are a key influence on EV uptake, however the extent of these savings is highly dependent upon oil prices which themselves are highly uncertain; oil prices reflect the balance of global supply and demand, the former in particular being strongly influenced by non-market forces such as political instability or interference (Sperling and Gordan 2009), or the emergence of new sources of supply such as shale oil (Reuters 2012)

PEV annual U.S. market penetration projections

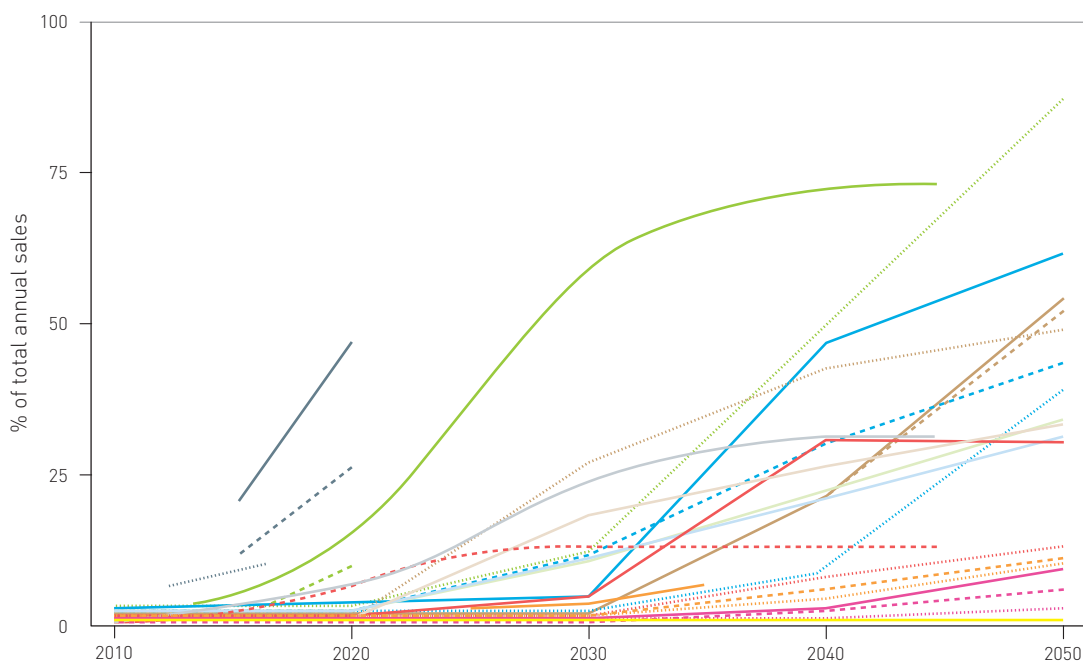


Figure 51. Predictions for PEV market uptake in the United States according to modelling commissioned by the US Department of Energy (DOE) drawing on predictions from the Argonne National Laboratory, AT Kearney, Bloomberg, Deutsche Bank, EIA, Electric Coalition, EPRI, MIT, National Academies, Deloitte, JD Power, JP Morgan, Lux Research, Pacific Northwest Laboratory, Roland Berger, Shell and the US DOE amongst others (US DOE 2012b).

- **Consumer preferences** – operating costs are only one consideration made by consumers in the vehicle purchase decision alongside other factors such as safety, quality, purchase price and reliability; the relative importance of each factor varies over time (for example, fuel economy becomes more important when fuel prices suddenly increase), and may not be 'economically rational' (such as the decision to purchase a vehicle with high fuel consumption when fuel prices show a short-term dip despite the long-term trend upwards); the availability of public charging infrastructure has been identified as a key influence on consumer preference towards electric vehicles.

The variations seen in the economic modelling can be mostly explained by the differences in how these key variables are forecast to unfold and interact with each other.

According to the Department's model, if both technology and oil prices follow forecasts, the take-off point for EV technology mainstream market adoption is 2020. With reference to Section 4.1.1, vehicle prices are decreasing slightly ahead of forecasts, whereas oil prices are slightly above projections (EIA 2012). This suggests that the breakeven year for EVs may be slightly earlier than 2020.

Consumer preferences manifest themselves differently before and after this take-off point. Before the take-off point, the early market is driven primarily by 'early adopters' as outlined in Section 3.2 who purchase the vehicles for mostly non-financial reasons. This behaviour may be thought of as 'economically irrational', and by extension not well suited to economic modelling. As a result, EV sales predictions differ wildly up to their predicted take-off point.

Once the take-off point has been reached, the market is effectively 'mainstream' and more likely to behave in 'economically rational' ways. Once this occurs the economic forecasting becomes more reliable, even if consumers may still pursue purchase preferences which are not economically rational.

A consideration made in the economic modelling commissioned by the Department relates to Australian market vehicle supply constraints (AECOM 2011). As was outlined in Sections 4.1.3 and 4.1.5, supply of vehicles into the Australian market does not match that for markets elsewhere. For electric vehicle technologies this is envisaged to be an issue until around 2020, which has significant implications for the sales volume forecasts prior to this time.

A range of factors may influence local supply constraints. Poor sales and/or a perceived lack of support may reduce OEM interest in the Australian market, thereby extending the supply constraints. Conversely, burgeoning consumer interest and/or support for local manufacture may reduce supply constraints. These influences are relevant to considerations relating to optimisation of the economic benefits to the state made in Section 6.1.3.

A relatively constant influence on consumer preference is the availability of public charging infrastructure. Charging infrastructure availability will not affect the timing of the take-off point for mainstream EV adoption, however it will strongly affect the vehicle sales either side of this date. This is discussed further in Section 6.1.3 below.



### 6.1.3 What are the costs and benefits of electric vehicle adoption for Victoria?

Under all scenarios, electric vehicles will provide a net economic benefit for Victoria. The benefit varies from \$1.8 billion to \$23.4 billion over the period to 2040, without considering the economic contribution of the electricity and automotive industry sectors. Oil prices and EV purchase costs are the key factors driving the timing and extent of the economic benefit. Local vehicle supply constraints are an important influence on the economic analysis, both in the early years while the vehicles are expensive and following the point at which they become economically viable. The availability of public charging infrastructure has a strong influence on the size of the economic benefit once EV uptake begins at scale.

EVs cost more to purchase initially, but they are cheaper to run than conventional vehicles. Over time, the purchase price for EVs is expected to fall, and running costs of conventional vehicles are likely to increase as oil gets more expensive. Under all scenarios modelled, the EV market is both economically and financially strong with a net present value that becomes positive in the period between 2026 and 2031. Over the 30-year evaluation period, economic benefits to the State range from \$1.8 billion to \$23.4 billion, mostly as savings to households and businesses in transport costs.

Notably, the modelling does not take into account the potentially significant economic contributions from electric vehicle market goods or service provision, electricity generation for EV operation, or from local design and/or production of EV technology. These contributions may be additional to existing economic activity, as is the case with electricity generation, or simply an evolution, such as design of electric rather than internal combustion engine vehicles. Section 6.1.4 provides some insights into potential employment benefits for the state.

The key influences on the modelling predictions are the same as those described in Section 6.1.2:

- **Technology costs** – in the short to medium-term take-up of EVs is strongly influenced by their price relative to conventional vehicles. Measures to reduce EV costs earlier bring forward the economic benefits
- **Oil prices** – take-up of EVs is highly sensitive to oil prices but less sensitive to electricity prices and/or a carbon tax. Should oil prices increase ahead of forecasts, measures to promote EV uptake will increase economic benefits
- **Consumer preferences** – increasing the availability of charging infrastructure and removing barriers to EV ownership will encourage take-up of EVs when prices become more affordable, and bring forward the economic benefits.

The economic model finds that in order to optimise the economic benefit of EVs, rapid uptake of EVs should be promoted once the take-off point is reached where the higher purchase price of an EV (technology costs) is matched by the operating cost savings EVs provide versus conventional vehicles (oil prices).

An important consideration in promoting uptake of EVs is vehicle supply constraints. As outlined in Section 4.1.3, the Australian market is envisaged to be constrained to around one per cent of global production until 2020 (AECOM 2011). This forecast is beneficial in the context of the economic analysis, as prior to this time EV uptake occurs at a cost to the economy due to the unfavourable purchase price/operating cost relationship. Following the removal of supply constraints, uptake is determined by the factors above (technology costs, oil prices and consumer preferences).

It is important to note however that due to the leadtime on product planning decisions (refer to Section 4.1.3), automotive OEMs should be made aware of EV market support measures at least two years ahead of when improved supply is being sought to optimise the overall economic benefit to the state – in other words, around 2018 based upon the forecasts contained in the Department's economic modelling.



A range of levers exist to influence EV prices relative to conventional vehicles. Investment in research and development has documented benefits in terms of bringing forward technology price reductions. Manufacturing investments provide economies of scale for vehicle production. Bulk procurement programs provide economies of scale for vehicle sales. Measures to promote market competition and reduce the costs of doing business will also put downward pressure on vehicle prices. By reducing EV technology costs to consumers, the take-off point for mainstream EV adoption is brought forward and the economic benefits from EV take-up increased.

In contrast, oil prices are determined by global commodity markets that are largely outside the control of individual markets or entities. For this reason, the economic benefit to the state can be maximised by identifying measures to effectively promote EV take-up by mainstream consumers and introducing them as oil prices show signs of increasing.

As described in Section 6.1.2, the availability of public charging infrastructure is one of the main influences on consumer preferences towards electric vehicle take-up and the corresponding economic benefits for Victoria. To optimise the economic benefits, widespread public charging infrastructure should become available just prior to the take-off point for mainstream EV adoption described above. Based upon current forecasts, this would suggest a widespread charging network should come on line around 2018–19 having been committed to at least two years earlier to inform OEM product planning.

#### 6.1.4 How will electric vehicle market development affect Victorian jobs?

Electric vehicles may be a 'sweet-spot' for Victorian jobs. Opportunities exist to protect and enhance employment in Victoria's automotive industry, one of the State's key industries. Greater use of domestically-produced electricity for transport in favour of imported hydrocarbon-based fuels will create local jobs.

Victoria's automotive industry employs around 28,000 people (Invest Vic 2011). In 2010, the industry identified vehicle electrification as the highest priority opportunity area for the long-term success of the Australian automotive industry (AutoCRC 2010).

A survey conducted of the trial participants in 2010 suggested that over 500 new jobs would be created over the life of the trial, accompanied by \$43 million of investment in Victoria (DOT 2010c).

The Automotive Australia 2020 roadmap (AutoCRC 2010) provides some insights into the EV technology applications around which these jobs may be created:

- Supercapacitors for EVs
- Design and assembly of Power Electronics Modules (PEMs)
- High energy-density batteries
- Low cost, robust, efficient electric machines
- Modular, standardised battery packs
- Expertise in solutions for EV architectures and technologies
- Seamless integrated charging infrastructure
- Software and hardware for EV specific driver-interface
- Hybrid and EV production for fleets and taxis.

Additional jobs can be expected in other sectors that form part of the EV ecosystem described in Section 3.1. The consultants McKinsey (Klintsov et al 2010) identify utilities and automotive assembly as the top two employment multiplier sectors, with 5.1 and 4.6 additional jobs in the wider economy for every full-time employee within either sector. Electric vehicle uptake, which will drive employment in electricity utilities and potentially automotive design and manufacture, represents a unique sweet-spot to protect and enhance Victorian jobs.



## 6.2 ENVIRONMENTAL IMPACTS

### 6.2.1 How will electric vehicles impact the environment?

If run on renewable energy, electric vehicles can provide significant reductions in total lifetime greenhouse gas emissions for Victorian drivers. These benefits increase as conditions tend towards more 'stop-start' driving. Impacts from vehicle operation far outweigh those from vehicle production, and vehicle disposal impacts are expected to be relatively minor.

In late 2012, the department released a paper which provided a comparative assessment of the environmental impacts of EVs relative to their 'conventional' petrol vehicle counterparts in the Victorian context out to the year 2030 [DOT 2012f].

The paper found that the impacts arising from vehicle operation far outweigh those in relation to vehicle production, even allowing for an EV battery replacement over the vehicle life. Vehicle disposal impacts, including those of the EV battery, were found to be negligible due to the high expected rate of material recycling.

The dominant influence of vehicle operation on EV lifecycle impacts highlights the importance of the way in which electricity is made, energy conversion efficiency, and the way in which a vehicle is used on the overall environmental performance.

The source electricity used to power electric vehicles is a key issue in Victoria. Despite various influences driving decarbonisation of the stationary energy sector, projections indicate that for a vehicle operating on Victoria's grid electricity the breakeven point in terms of carbon emissions from vehicle operation is some years away. Conversely, an electric vehicle operating on renewable energy may provide a net benefit in terms of lifecycle carbon emissions within three years of operation, and a saving of over 50 per cent across the 20-year average Victorian vehicle lifetime.

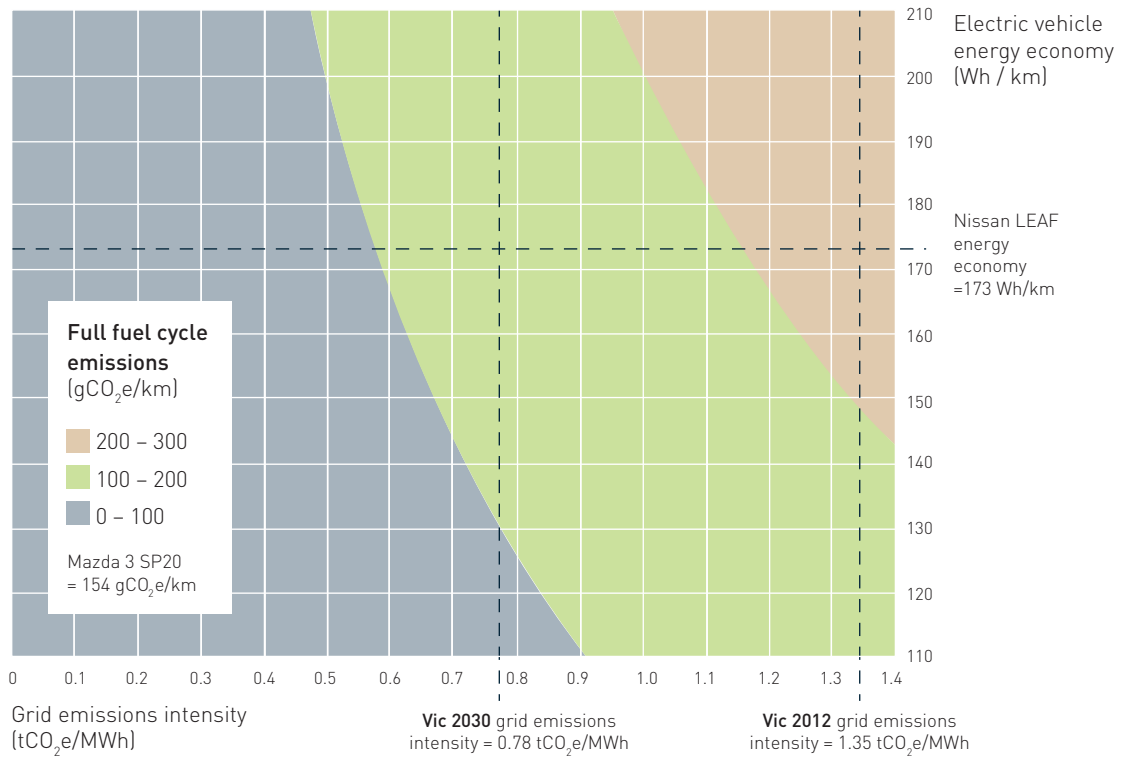


Figure 52. Chart depicting the interrelationship between EV energy economy and the electricity grid emissions intensity in determining full fuel cycle greenhouse gas emissions, including some pertinent figures for comparison [DIT 2012, DCCEE 2012b, personal communications].

Based upon current information, the advantage of electric vehicles over petrol engine vehicles grows as the conditions tend towards more 'stop-start' driving. Given the strong influence of vehicle energy economy on overall environmental impacts, better information and guidance on the selection of vehicle technologies, particularly electric vehicles, so as to be 'fit-for-purpose' could provide significant benefits.

Other observations of note as relate to greenhouse gas emissions from EV operation include:

- As a result of the Victorian electricity generation mix characteristics, 'demand' charging during peak periods of electricity use is likely to be of lower greenhouse gas emissions intensity than 'smart' charging during off-peak periods

- The most reliable, if complicated, way to charge an EV using grid-connected on-site renewable energy generation such as a home solar system, is to voluntarily surrender the associated renewable energy certificates
- By comparison, the GreenPower purchasing program was found to be the simplest, most effective way of using renewable energy for electric vehicle charging, even for those with on-site renewable energy generation such as home solar
- Complications associated with electricity metering and billing arrangements for publicly-accessible electric vehicle charging facilities highlight the need for transparency and diligence in support of renewable energy charging strategies.

Consideration of the impacts that may be transferred elsewhere through electric vehicle uptake in Victoria highlighted both existing and emerging risks to the environment. The EV battery and electric motor may cause harmful impacts to land, water and air quality if using raw materials and/or production processes in locations that have either weak or poorly-enforced environmental regulation. However, these risks are already evident for oil and rare earth metal extraction and/or processing for 'conventional' vehicles operating on Victorian roads.

Nevertheless, greater transparency with regards to the environmental impacts from EV battery production would go some way towards ensuring all of the nominal environmental benefits from EV uptake translate to reality. A further sensitivity relates to battery replacement timeframes, which have the effect of multiplying the uncertain impacts associated with battery production.

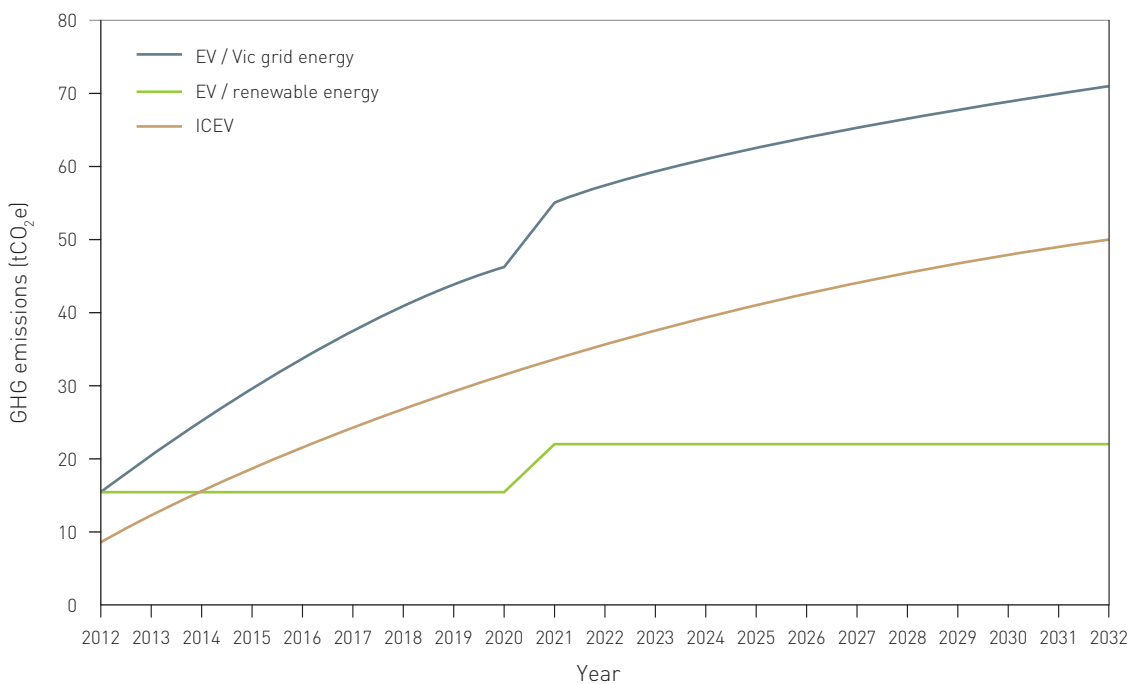


Figure 53. Cumulative greenhouse gas emissions calculated over an average Victorian vehicle lifetime for an ICEV and a comparable electric vehicle operating on both the Victorian electricity grid mix and renewable energy. The step change in both EV calculations reflects impacts arising from the single battery replacement forecast.

Based upon the limited information available, up to six battery replacements would be possible over a vehicle life before the greenhouse gas emissions advantage of a petrol vehicle over an EV operated on renewable energy would be lost.

Impacts arising from increases in electricity production are considered to be minimal as a result of Victoria's effective program of environmental management for industrial facilities. Rather, impacts on the environment are likely to be reduced through avoidance of the transferred impacts attributable to oil extraction processes, and from preferential use of renewable energy for electric vehicle charging.

Due to Victoria's carbon-intensive electricity production, potential localisation of any aspects of electric vehicle production may increase the embodied greenhouse gas emissions of the vehicles. This conclusion draws upon evidence that highlights Victoria's existing vehicle production as being more carbon-intensive than for comparable facilities elsewhere.

Benefits to urban air quality and human health are likely to be minimal as the period of EV market growth corresponds with the implementation of ever-tighter emissions standards for conventional vehicles. A more detailed assessment of this may become available in the near-term as an outcome from EPA's *Future Air Quality in Victoria* project.

Environmental impacts arising from electric vehicle electromagnetic fields are likely to be negligible, EV near-silent operation at low speeds is likely to be manageable, and EV reduced traffic noise impacts are likely to be beneficial.

## 6.2.2 How have environmental impacts arising from the trial been managed?

The greenhouse gas emissions associated with the trial vehicle operation have been accounted for and reconciled with renewable energy purchases by the Australian energy retailer AGL, a premier partner for the trial (DOT 2012d). In having done this, the trial is effectively 'carbon neutral' in terms of operational impacts.

The total electricity used by vehicle deployments and charging infrastructure operation up to and including 30 June 2012 was 66,393.9 kWh. This is the equivalent to around 79 tCO<sub>2</sub>e in greenhouse gas emissions from electricity production.

Results from the energy-use inventory have been presented to the trial participants to help inform decisions around EV technology roll-out. For example, the potentially disproportionate impacts arising from charging outlet stand-by power consumption have been highlighted.

## 6.2.3 How can an electric vehicle be 'zero emissions' in Victoria?

Zero emissions driving of Electric Vehicles (EVs) requires renewable energy for charging via one of the following options:

- On-site renewable energy generation
- GreenPower or Renewable Energy Certificate (REC) purchase
- Charging service agreements.

Each option must deal with issues such as EV charging time and location relating to renewable energy production, cost and convenience. This means charging should be undertaken using outlets which are known to use renewable energy. In instances where this isn't possible or certain, charging should be monitored and accounted for as part of the overall renewable energy strategy.

In 2012 the department published a guidance document for drivers describing the options above in more detail (DOT 2012g) – refer to Table 18 for a summary of this information.

*The Climate Group believes that effectively implemented, innovative electric vehicle deployment will help accelerate a Clean Revolution: the massive upscale of smart technologies, design and new policy and business practices that will ensure that the nine billion people on the planet by 2050 will not only subsist – but thrive. The Victorian Electric Vehicle Trial has played an important and critical role in articulating the case for electric vehicle deployment in an independent, rigorous and comprehensive manner.*

The Climate Group,  
27 November 2012

Renewable electricity supply option	Advantages	Disadvantages	More information
On-site renewable energy generation	<p>Takes advantage of existing renewable energy supply</p> <p>More obvious link to renewable energy supply</p>	<p>Confusing in prospect</p> <p>Upfront cost if no system already in place</p> <p>Measurement and accounting required to reconcile EV charging with renewable energy production</p> <p>Need to cater for off-site charging</p> <p>May prove more costly than GreenPower or REC purchase</p>	<p>Clean Energy Council solar PV accreditation <a href="http://www.solaraccreditation.com.au/">www.solaraccreditation.com.au/</a></p> <p>Alternative Technology Association <a href="http://www.ata.org.au">www.ata.org.au</a></p> <p>Clean Energy Regulator <a href="http://ret.cleanenergyregulator.gov.au/">http://ret.cleanenergyregulator.gov.au/</a></p>
GreenPower or Renewable Energy Certificate (REC) purchase	<p>No upfront costs</p> <p>Simple</p> <p>Most reliable way of linking EV charging to renewable energy use</p> <p>REC purchase accommodates off-site charging</p>	<p>Ongoing costs</p> <p>GreenPower may struggle with off-site charging</p> <p>REC purchase a burden and may be complicated</p> <p>Measurement and accounting required if only a percentage of the bill is GreenPower or to reconcile with RECs</p>	<p>Your electricity retailer</p> <p>GreenPower program <a href="http://www.greenpower.gov.au">www.greenpower.gov.au</a></p> <p>REC trading companies</p>
Charging service agreement	<p>Likely to support off-site charging</p> <p>Simple</p> <p>Good information and charge management capabilities</p>	<p>Need to account for charging using outlets not operated by your contracted provider</p> <p>Ongoing costs</p> <p>Upfront cost for a dedicated charging unit (if so desired)</p>	<p>Electric vehicle charging service providers</p>

Table 18. 'Zero emissions driving' options for electric vehicle operation in Victoria [DOT 2012g].

## 6.3 SOCIAL IMPACTS

### 6.3.1 How is community safety being protected as part of the electric vehicle roll-out?

The safety of the Victorian community is being ensured through the creation and application of a technical standards framework and accredited training courses for technicians. These initiatives streamline the existing, individual approaches being taken by electric vehicle market participants.

Electric vehicle technology must be designed and deployed to cope with the enormous range of scenarios which could result in a safety risk. Figure 54 illustrates just one such scenario, where an electric vehicle has been left to charge prior to a thick blanket of snow falling. Equipment suppliers and operators must pre-empt these scenarios in their design, manufacture and deployment of equipment so as to ensure community safety is maintained.

Regulators must verify that equipment suppliers and operators have taken the necessary measures as part of their due diligence when reviewing/approving deployment proposals.

Technical standards are peer-reviewed, consensus-backed rules relating to the design and operation of products and work practices. They draw upon expertise from all relevant stakeholders to ensure consistency with existing practices and management of emerging issues. While community safety is likely to be maintained through the individual efforts of various companies and regulators, standards support harmonisation of these efforts and avoid individual entities from having to 'reinvent the wheel' at great cost in both time and resources.

In 2009, the Victorian Government commissioned a scoping study for a national electric vehicle standards framework (Standards Australia 2010). An agreed work-plan was developed, following which the first phase of the technical standards development was initiated under the umbrella of the trial. The project will ultimately deliver a comprehensive technical standards framework that will help electric vehicle market participants harmonise their approach to ensuring community safety.

Separately accredited training course providers are addressing the knowledge gaps within workforce training for electric vehicle technologies. Through the systematic deployment of training alongside the arrival of EV technology in the market, workplace safety will be maintained and the community can be confident in the work practices that keep their vehicles on the roads.



Figure 54. Electric vehicle charging in the New York winter (photo by A.Rogers – used with permission).

One issue that may need to be addressed as part of standards and regulatory development processes relates to the potential hazard to other road users as a result of the near-silent operation of electric vehicles at low speed. Around six weeks into the electric vehicle experience, the trial household participants were asked how frequently the quiet operation of their EV had caught other road users unawares. Nearly one in three participants reported this experience occurring either 'frequently' or 'very frequently'.

International regulators have acted to address this risk by requiring electric vehicles to emit a minimum sound level during low speed operation (NHTSA 2011). The Australian Government (Aust Govt 2012b) is committed to harmonisation with international vehicle safety standards, as is evidenced by the following excerpt from the responsible Department:

*The Australian Government's policy is to harmonise the national vehicle safety standards with international regulations where possible and consideration is given to the adoption of the international regulations of the United Nations Economic Commission for Europe (UNECE). Australia is a signatory to the UNECE 1958 Agreement and the 1998 Agreement. The policy to harmonise is also important to fulfil World Trade Organisation and Asia Pacific Economic Cooperation commitments.*

Australian Government Department of Infrastructure and Transport website, February 2013

As these standards are agreed internationally and applied to the design and manufacture of electric vehicles destined for the Australian market, community safety will be ensured.

### 6.3.2 How is Victoria's future electric vehicle workforce being prepared?

As the focus of Australia's automotive industry, Victoria is home to a range of education and training providers who specialise in automotive engineering and repair. Recognising the future needs of the EV market, many of these providers have been actively developing their programs in support of EVs.

The emerging trend towards electric vehicle technology is being recognised in Victoria's higher education sector:

- Swinburne University of Technology has established an electric vehicle research group that in 2012 was working on drivetrain and electric motor technologies, battery technology and management, vehicle architecture and design, lightweighting, Clean21 Manufacturing, vehicle-to-vehicle and vehicle-to-infrastructure communications, the smart electricity grid, consumer behaviour and public policy, new business models and entrepreneurship, and EV promotion, training and education (Swinburne 2012a)
- University of Melbourne has a research program underway on the impact of mass adoption of electric cars on the Australian electricity grid (Uni of Melb 2010).

A novel means by which the future EV workforce is being prepared is through the Formula SAE-A event. Formula SAE is an international education program where university students design, build and compete in small open-wheeler vehicles (SAE-Aust 2012). Since 2009 it has been possible to enter an electric vehicle in the competition, with local entrants including Swinburne University of Technology (Swinburne 2012b) and Royal Melbourne Institute of Technology (DOT 2012h).

Technical standards such as those described in Section 6.3.1 can form the basis of training course and workshop practices for EV technicians. Training providers such as the Victorian Automotive Chamber of Commerce and Kangan Institute have already begun to address these skills shortages with the creation of nationally accredited training courses (VACCSDC 2012). As electric vehicles spread through dealership and repair networks, manufacturers and workshop operators will be increasingly able to draw upon widely recognised competencies rather than be required to address this skills gap in isolation.

A key challenge for many electric vehicle market participants is gaining a return on the investment in training and equipment required to support what will be a relatively small market in the near-term. Additionally, the implications of this can influence other market participants. By way of example, a major automotive service and repair organisation has deferred the decision to train staff and fit workshops out with equipment to service hybrid-electric vehicles (HEVs) due to the relatively low number of vehicles on Victorian roads<sup>17</sup>. As a result, HEV manufacturers must rely upon a limited number of trained technicians in the field to support their product, and operators of HEVs have a reduced number of service and repair options.

The trial experience of this issue has been limitations in the dealer and roadside assistance network. In instances where roadside assistance has been sought, the attending technician has often little electric vehicle knowledge and/or experience. Parts inventory and/or supply have also been key influences in the response to vehicle damage and repair. This has resulted in delays and/or inconvenience in remedying problems and getting the vehicles back on the road.



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<sup>17</sup> personal communication

# EDUCATION AND AWARENESS PROGRAM

The Victorian  
Electric Vehicle Trial  
has undertaken a  
comprehensive  
education and awareness  
program encompassing  
a range of online and  
outreach initiatives.

# 7





The effectiveness of these initiatives has been measured and interpreted to inform future efforts aimed at promoting awareness, understanding and acceptance of electric vehicles.

## 7.1 OUTPUTS AND OUTCOMES

### 7.1.1 How has the trial been communicated?

The project has been communicated broadly through three online outlets, all of which have been found to be effective when assessed against comparable benchmarks:

1. Website – providing a range of information about the trial
2. E-news – monthly news updates which also directs users back to the website
3. Discussion board – for users to discuss their experiences of the EV trial.

From the start of 2011 to the end of June 2012, the Victorian Electric Vehicle Trial website received nearly 30,000 visits. The most popular pages were the 'what's happening' page with 4,103 visits, followed by the homepage with 3,886. The various publications made available through the website had been downloaded 1,108 times, with the trial information booklet that accompanied the trial launch having been downloaded most at 83 times. Over 80 per cent of the 76 household trial participants surveyed reported the Victorian Electric Vehicle Trial website as being 'somewhat' or 'very helpful'.

The trial's e-news was launched in July 2011 and has been published monthly since that time except for January 2012 which was deferred to February due to likely impact of the holiday season on readership. With reference to Figure 55, the number of subscribers grew markedly as a result of the inclusion of an 'opt-in' question as part of the 2012 household participation survey and questionnaire, and has held fairly constant ever since.

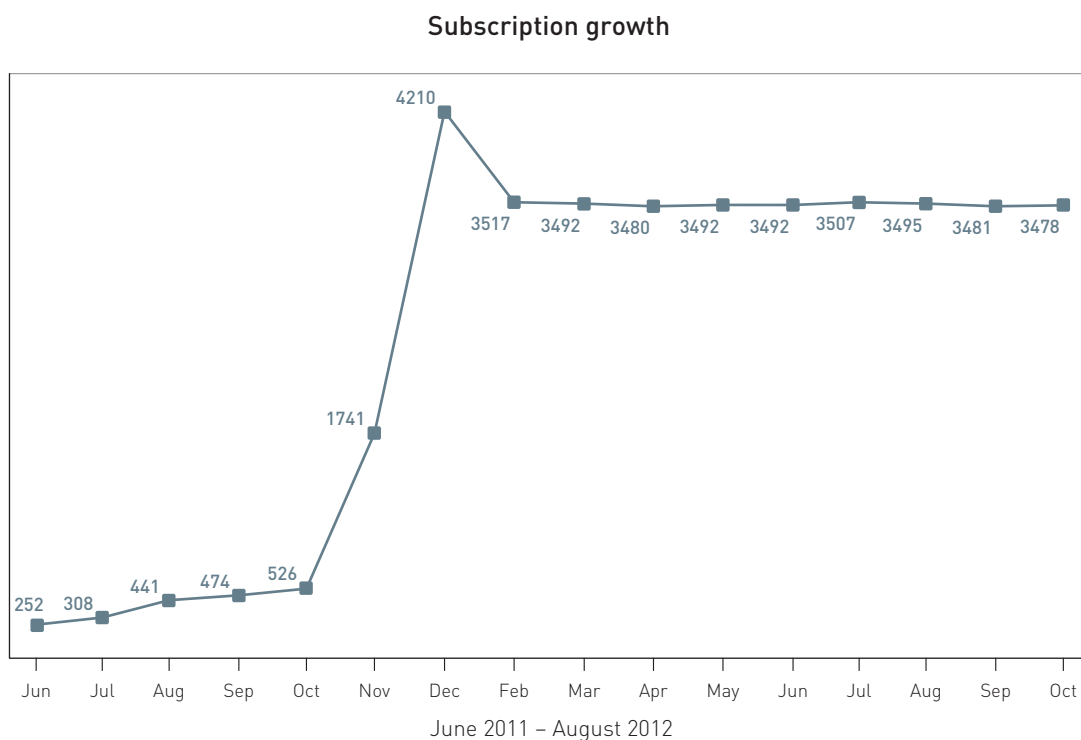


Figure 55. Victorian Electric Vehicle Trial e-news subscription rates.

Figure 56 shows the open rate for the e-news email has averaged around 46 per cent. This measure is considered a good indicator for audience engagement, with the open rate for the trial being more than double the industry average figure of 20 per cent (Silverpop 2012).

Click-through rates, another indicator of e-news effectiveness, were observed to be relatively low as a percentage of email opens, however feedback from recipients suggests that the e-news software design and copy-writing style make much of the content visible in the email. Recipients suggested that this is the preferred approach, as it is sufficient for readers to glean the story content quickly and efficiently.

The most popular stories (according to click-through rate as a percentage of the email opens) have been those relating to the trial household participants. This can be explained in the context of the majority of subscribers joining through the 2012 household application to participate. Information about where and/or how to charge cars was also popular, with the most surprising result being the fifth-most popular story titled 'Would you unplug someone else's car?'<sup>18</sup>, relating to the etiquette surrounding shared use of charging facilities.

The objectives of the Victorian Electric Vehicle Trial Discussion Board were:

- To provide a facility for trial participants to interact in a virtual space and in doing so create an online Victorian electric vehicle community
- To gain unprompted feedback from participants on their attitudes towards electric vehicles with which to supplement the structured survey responses.

From the launch of the discussion board on 1 December 2010 to 6 September 2012, 3,656 users had registered generating 378 posts and 276 replies to 101 topics in 6 forums. This user-generated content had been viewed 15,796 times, with the winner in terms of content and views being 'first impressions' with 6920 views of 29 topics/120 replies, followed by 'day-to-day experiences' with 4,694 views of 41 topics/81 replies.

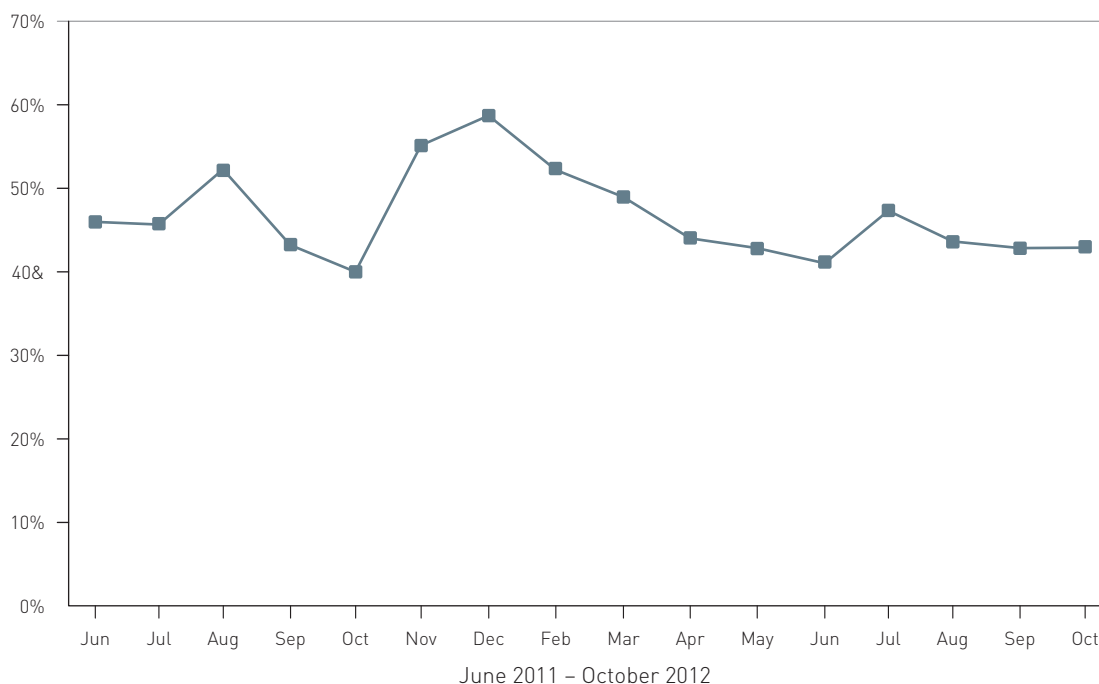


Figure 56. Victorian Electric Vehicle Trial e-news open rate, which has averaged 46 per cent over 16 editions up to October 2012.

18 <http://enews-evtrials.transport.vic.gov.au/link/id/zzzz4ffccf7b47eb8706/page.html#zzzz4ffccbcf305e132>

The supplementary data and interaction with participants enabled by the discussion board has proven invaluable. Many EV industry participants, particularly the car-makers, drew insights from the content provided. Issues raised by the trial participants were able to be addressed through the discussion board environment. A variety of observations were drawn from the discussion board that weren't arrived at via other means.

An example of this relates to the Melbourne Airport charging facility, which was identified as being of strong interest to users, with the caveat being their lack of confidence that it would be vacant and available upon arrival. Measures were investigated to optimise the site in terms of availability, access and information provision, with the case for action supported by the unprompted, user-generated content provided through the discussion board.

Efficient communication and consultation with the trial's corporate participants has been achieved primarily through the monthly Trial Planning Working Group meetings described in Section 3.4. Learnings from the trial have been delivered continuously through this pathway, streamlining participant interactions and reducing the overheads associated with more formal communications. The mailing list for this group is around 100 individuals representing 80 organisations – the emerging Australian EV market participants. Attendance at this meeting has been reliably around 30 to 40 individuals who themselves vary from one meeting to the next. The persistence of attendance has been interpreted as an endorsement for the meeting effectiveness and the trial more generally.

The appeal of EVs as a topic to a wide variety of audiences has been leveraged to communicate the trial through speaking engagements. Up to November 2012 the project has been presented to around 75 formally-convened audiences. This method of communication has been found to be very effective in promoting awareness, understanding and ultimately acceptance of EVs.

### 7.1.2 How has awareness of electric vehicles been promoted?

Awareness of electric vehicles has been promoted through the use of easily-recognisable branding on collateral and signage, along with formal test-drive events and car-share facilities. While these methods have been efficient in terms of project resources, their effectiveness in terms of Victorian community engagement is limited in terms of reach.

Cars are an iconic and powerfully-engaging consumer product. As a result, EVs have a significant advantage over many other 'clean' technologies in terms of community engagement.

This advantage has been leveraged to raise awareness of EVs by simply making the trial vehicles available for events, exhibitions and displays. Collateral has been created to accompany the vehicles, along with an interactive storyboard that explains the background to EVs and the trial project more generally. Over 5,500 DL brochures of the design shown in Figure 57 were distributed in the 12 months to October 2012.

The vehicles used for the trial have been made available for over 1,000 people to experience EV technology first-hand through a short test-drive. The largest test-drive opportunities have been the 2010 and 2011 RACV Greenzone events, the 2011 Australian International Motor Show and the 2012 LEV Automotive Partnership Fleet Forum and Drive-day. The attraction of new technology has been clearly evident throughout, with the electric vehicles being the most popular choice in terms of test-drives taken at each event. In addition to the results from participant surveys presented in Section 4.2.2, key success factors relating to the event delivery included:

- Involvement of an event organiser with experience in delivering vehicle test-drive events
- Partnerships with the car manufacturers, who provide funding support and staff resources
- An online test-drive booking facility to maximise vehicle utilisation and streamline the participant experience
- Comprehensive vehicle insurance to cover the test-drive activity coupled with participant licence checking and consent forms
- Dedicated event staff including for bookings and to provide one-on-one instruction/supervision for the test-drives
- Printed collateral to provide participants with more information/sign-posting to online resources
- Participant surveys to gauge perceptions before/after the test-drive experience (including advance consideration and on-the-ground verification of the survey delivery arrangements).

Test-drives have also been possible through a car-share facility. As a test-drive option, car-share has significant advantages over the formal events described above in terms of cost (funding and staff) and access for participants. This option was investigated in partnership with Places Victoria, ChargePoint and GoGet, through placement of a trial EV in a car-share facility located at The Nicholson residential development. While complications arising from the operating environment have limited and ultimately curtailed the car-share facility at this location, insights gained from the initial roll-out are informing the design of other electric car-share roll-outs elsewhere.



Figure 57. Victorian Electric Vehicle Trial DL-size brochure design.

## EV PROMOTION CASE STUDY ELECTRIC CAR-SHARE

Car-share is a fast-growing alternative to vehicle ownership where members have access to a fleet of vehicles in a network of locations and typically pay per use (Shaheen et al 2010). In Australia and around the world, car-sharing is gaining popularity as a means to reduce transport costs, traffic congestion and impacts on the environment (SGS 2012).

Electric vehicles are a potentially great fit with car-share. The vehicles can be charged where they park, rather than needing to be refuelled at a service station. The majority of car-share journeys are well within the range of an electric vehicle – GoGet (2011) reported 97 per cent of trips made by their members as being less than 50 kilometres.

Car-sharing also provides a means for the wider community to experience electric vehicle technology first-hand. Users can choose when and where they take a test-drive, potentially to a location which has priority parking for electric vehicles.

GoGet joined the Victorian Electric Vehicle Trial in 2011, and have since deployed three electric car-share services in contrasting locations. Insights gained to date suggest that similar issues and opportunities exist for electric car-share deployment as for fleet EV take-up more broadly (refer to Section 4.3.4).



Figure 58. GoGet electric car-share vehicle at The Nicholson residential development.

### 7.1.3 What electric vehicle educational activities have been delivered and what do they tell us?

Electric vehicle education programs are an effective way of promoting acceptance of the technology, and are popular with those who experience them. Attracting interest at the outset is however a major challenge that requires further work.

Lyons and Breakwell (1994) found that attitudes towards the environment begin to form early in childhood development. Additional research suggests that higher levels of commitment to environmental education programs in schools not only result in greater understanding and behaviour change in the children partaking in the program, but can even have flow on effects in raising parental awareness of these concepts (Davison et al 2003, Kopina 2011).

These insights, along with engagement by school teachers and children in the trial household participation process, led to a dedicated EV education program for schools being developed. The EV School program ([www.transport.vic.gov.au/evschool](http://www.transport.vic.gov.au/evschool)) was launched in early 2012.



The EV School program draws upon the Victorian teaching curriculum learning objectives in the areas of science, humanities, civics, and design, creativity and technology. It aligns with the Victorian Essential Learning Standards (VELS) for primary (Grade three to six) and secondary (Years seven to ten) school levels. With reference to the step-guide shown in Figure 59, the program provides educators with all they need to achieve their required teaching objectives through the topic that is electric vehicles.

Although the program was successfully piloted with a Melbourne high school, promoting its wider adoption has proven challenging. Brochures have been prepared for distribution at the many teaching conferences that take place at the end and start of each calendar year, following which it is hoped that widespread awareness of the program in time for formulation of the 2013 teaching plans will help uptake.

## EV School for teachers

### 1 Enlighten

Read the **teacher's notes** to discover electric vehicles and find out more about the EV School program.



### 2 Educate

- Go to the **EV School lesson plan curriculum matrix** and select the matrix for your teaching domain
- From the Matrix, choose a **lesson plan** which best suits your teaching needs
- **Classroom resources** are also available to support your lesson.

### 3 Explore

- The **student project ideas** provide expanded and printable versions of the project ideas for primary and secondary students found in the 'Learning Method Matrix'
- If you're looking for an entertaining classroom activity, check out **end of unit fun** for some ideas!

Figure 60 (Top). Kingswood College 2012 World Environment Day electric vehicle showroom event.

Figure 59 (Above). Step-by-step guide for the EV School program introduced by 'Evie', the EV School mascot.

In addition to the EV School program, an education partnership has been formed with the Centre for Education and Research into Environmental Strategies (CERES). CERES is a not-for-profit sustainability centre and Australia's largest deliverer of environmental education. In recognition of CERES's role in hosting regular visits by schools, conducting incursion programs into schools, and being a community hub for sustainable living, trial vehicles have been provided for the CERES fleet and a solar-charging station has been built at their facility to form part of the Victorian EV charging network – refer to Figure 62 and the break-out box.

The trial has also partnered with a local school for an EV-themed World Environment Day event. An electric car showroom was created for the Year 11 students to 'sell' the vehicles to their Year 7 'buyers'. The strong engagement from the students involved provides further evidence of the effectiveness of EVs as an example of 'clean technology'.

The department also delivered two EVs and Fleets 2012 workshops as outlined in Section 4.3.4 and *Appendix B – EVs and Fleets 2012 Practical roll-out plan*. These workshops were intended to address the knowledge gap on successful EV deployment by educating those responsible for the vehicle roll-out. Surveys of attendees returned a 98 per cent approval rating on the workshop ("Would you recommend the EVs & Fleets 2012 workshop attendance to colleagues looking to roll-out EV technology?", n = 53).

While this result is encouraging with regards the workshop design and delivery, promoting and securing attendance was and remains the greater challenge. This finding highlights the need to address other stakeholders within organisations to secure support for electric vehicles. With reference to Table 5 (page 46), a major educational opportunity to promote fleet EV uptake would be to target senior management/executives. To this end the Department has conceived a small project to be delivered in 2013 aimed at investigating this further.

**Select which features you like the most about electric cars**  
(more than one option may be selected)

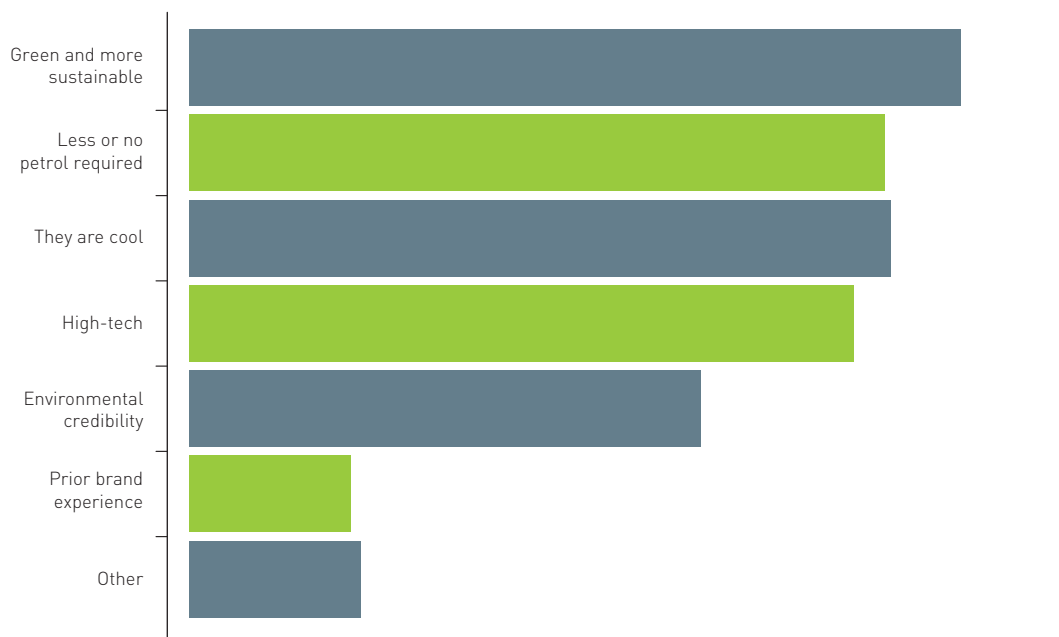


Figure 61. Results of the Year 11 'sellers' survey of their Year 7 'buyers' from the Kingswood College 2012 World Environment Day EV showroom event (n = 57).

## EV EDUCATION CASE STUDY CENTRE FOR EDUCATION AND RESEARCH INTO ENVIRONMENTAL STRATEGIES (CERES)

The Centre for Education and Research into Environmental Strategies, or CERES, is a 4.5 hectare community environment park based in East Brunswick. The award-winning not-for-profit has been internationally recognised for its work in community and environmental practice (CERES 2012).

Around 60,000 students and their teachers visit the CERES facility per year, along with three adult tours per week and a thriving community market. With their focus on sustainable living, CERES has emerged as the ideal location for the solar EV charging canopy launched in 2012 (refer to Figure 61). Although grid-connected, co-location of the solar canopy with the EV charging facility has proven to be an excellent means of engaging the community on electric vehicle technology (ABC 2012). Awareness of the CERES public charging facility is among the highest in the trial charging network.

CERES has previously been active in the delivery and training of EV aftermarket conversions, and has successfully integrated electric vehicles into its sustainable energy education programs. In 2013 they are building upon these experiences to more fully integrate electric vehicles into their school incursion/excursion programs, including use of the trial EVs as part of the program delivery.

CERES is amongst the most successful of the trial partners in promoting electric vehicle awareness, understanding and acceptance.



Figure 62. CERES solar EV charge station – a hub for community EV education.



#### 7.1.4 How has the local electric vehicle industry and market been promoted?

The role of the trial in providing a meeting place for over 80 corporate participants in the emerging EV market has been significant. No other forum exists in Australia for the various market players to interact and in doing so engage with the wider market.

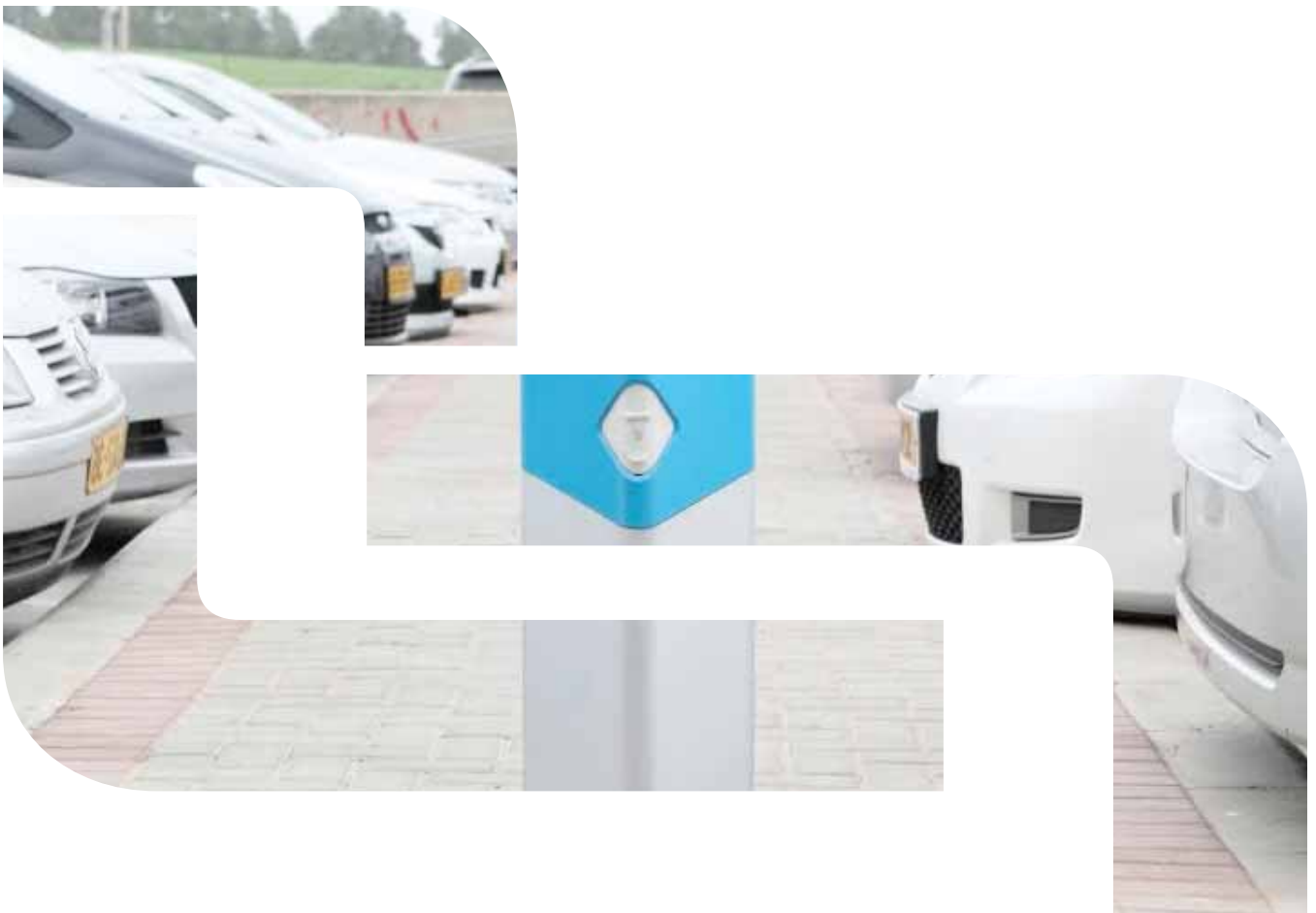
A key objective for the trial has been to promote Victoria as a place to do business. This has several obvious benefits:

- Promote investment and employment in Victoria
- Create competition in the Victorian market and downwards pressure on costs for consumers.

To this end, the trial has been successful in positioning Victoria as the most electric vehicle-friendly state in Australia. As of November 2012, around 60 per cent of Australia's EV charging facilities are located in Victoria. Victoria is the only state to have a registration discount for EVs, and has recognised EVs within the road safety framework including number-plate labelling and standardised signage.

Promotion of Victoria has been achieved through numerous national and international forums. In May 2012, Victoria took part in the World EV Cities and Ecosystems conference in Los Angeles. Victoria has also taken part in the International Energy Agency's Implementing Agreement on Hybrid and Electric Vehicles.

The value of the trial in bringing the market together at its outset is evidenced by the regular and reliable attendance of the monthly project meetings (refer to Section 3.4), and by the steady base of subscribers to the project e-news (Section 7.1.1).



## LOCAL EV INDUSTRY CASE STUDY BOSCH AUSTRALIA

Robert Bosch Australia Pty Ltd are part of the global Bosch group of companies. Founded in 1922 and headquartered in Clayton, in 2012 Bosch Australia had over 1,100 employees and \$680 million in sales split between automotive, consumer goods, building and industrial technologies.

Bosch Australia have participated in the Victorian Electric Vehicle Trial as a fleet operator, charging infrastructure provider and host, and vehicle supplier courtesy of their support for the EV Engineering project. As one of the first fleets to receive a Mitsubishi i-MiEV in December 2010, Bosch Australia have leveraged their trial involvement to good effect.

By receiving one of the trial EVs so early in the global market roll-out, Bosch Australia were able to engage at the forefront of Bosch's global electro-mobility development activities. As a result, valuable EV charging station and network software product and operational experience has been gained by the Bosch Australia organisation, years earlier than what may have occurred otherwise.

A particular area of interest for Bosch both locally and globally has been network roaming interoperability as is discussed in Section 5.1.4. Bosch's eMobility platform is a network solution for charging infrastructure operators to provide customers with a seamless 'roaming' experience.

With reference to Sections 3.1 and 5.1.2, the size and complexity of the trial has permitted Bosch Australia to investigate the network roaming model and business arrangements as an input into their global product development. An outcome has been the introduction of new products and innovation into the local market, all of which will ultimately benefit the Victorian consumer.



Figure 63. A trial vehicle charging from a Bosch charging outlet at their Australian headquarters in early 2013.

## 7.2 INSIGHTS

### 7.2.1 How do we best tell the story about electric vehicles?

A range of insights can be drawn from the trial results that may inform communication plans relating to electric vehicle technologies. Key issues that should be considered in communicating the 'EV story' include environmental bona fides, new technology as a defining characteristic, driving enjoyment due to the inherent characteristics of electric motors, and operating cost benefits expressed in familiar ways. Challenges include the complexity of the individual and inter-related environmental and electricity supply stories.

Based upon insights gained from the trial, a range of opportunities exist to more effectively communicate the 'EV story':

- Technology is clearly a significant reason as to why individuals may become initially interested in EVs – 'interest in new technology' was the primary motivation for household applicants to the trial (Section 4.2.1)
- The demographic skew towards higher education for those interested in EVs (Section 4.2.1) may provide some opportunities in terms of communications pathways – for example, most universities publish and distribute magazines to alumni and maintain active social networks, and often have road systems on campus that may lend themselves to test-drive events
- Vehicle performance in terms of acceleration and other characteristics that make electric vehicles fun to drive should be a focus for bringing people across to the technology, as has been evidenced by the results from the test-drive events undertaken as part of the trial (Section 4.2.2)
- Environmental benefits as the basis for brand-building is the primary reason for fleets to become initially interested in EVs (Section 4.3.1), and a significant motivator for households also (Section 4.2.1). The majority of fleets who applied to participate in the Victorian Electric Vehicle Trial have significant corporate social responsibility commitments they believe EVs may visibly demonstrate
- 'Getting the story straight' on the environmental benefits of EVs is a key to avoiding perceptions of 'greenwash' and gaining a 'social licence' for EV technology to operate within the community. Almost without fail at any exhibit of the technology, questions have been asked about the legitimacy of the environmental benefits of EVs. This is even more so in Victoria given the state's widely-acknowledged carbon-intensive electricity generation, which is a key issue that needs to be addressed as part of EV charging strategies (Section 6.2)
- Operating costs should be expressed in terms of dollars per week or month. Of the 107 household participants surveyed, nearly 65 per cent recorded the existing vehicle fuel costs as a weekly expense, while nearly 32 per cent recorded these costs in monthly terms (Section 5.2.5)
- Solar PV owners have a good understanding of electricity costs and use, including the financial benefits of deferring energy use to off-peak periods, providing a potential avenue for discussion of the low operating costs of EVs charged in off-peak periods (Section 5.2.4). Solar PV owners are also an excellent demographic fit for 'technology/environment' as highlighted above, and so represent a likely early market opportunity for EVs
- The first EV drivers are effectively 'ambassadors' for the technology who should be provided with relevant information so as to be well-informed. This was evidenced by the frequency of conversations reported by the trial household participants with family, friends, work colleagues and even strangers on the topic (refer to Section 7.2.2).

Communicating the environmental benefits of electric vehicles is both an obstacle and an opportunity. With reference to Section 6.2, the reliance on and arrangements for renewable energy to deliver the environmental benefits of electric vehicles is a complicated story. Experience from the trial suggests that a general lack of understanding or even cynicism regarding operation of the electricity market creates additional challenges in explaining the environmental benefits of renewable energy powered electric vehicles.

Given that environmental benefits are a strong motivator for EV take-up by early adopters (Section 3.2) in both households (Section 4.2.1) and fleets (Section 4.3.1), providing an easily-understood, defensible means to evidence 'zero emissions driving' may be a key enabler for EV take-up. Options to address this may include:

- Linking EV support and identification measures to GreenPower purchase contracts
- Documenting, publicising and recognizing 'zero emissions' stories for households and fleets that link distributed renewable energy generation with EV operation
- Working with key stakeholders to develop or leverage an existing accreditation program/brand that can underpin recognition of EVs that can be defensibly linked to renewable energy
- Leveraging the good understanding of solar PV owners and the 'EV ambassador' role of the first EV drivers identified above as part of a recognition program.

### 7.2.2 Do electric vehicles educate or inform people about other issues?

Results from the household participants suggest that electric vehicle experience engages, educates and motivates people in relation to energy use issues more broadly. These and other insights are likely to be shared with family, friends, colleagues and even strangers on account of the 'conversation-starter' effect of EV ownership.

Although around 80 per cent of household participants reported themselves as 'having a good understanding of their household energy use', nearly 60 per cent of participants suggested that they would 'like to know more about their household energy use/costs' as a result of having an electric vehicle (n = 62). As an outcome from their electric vehicle experience, nearly one in three household participants reported themselves as having an improved understanding of household electricity use/costs, and one in four on measures to save on electricity use/costs.

To a lesser extent this also applied to vehicle fuel use. Around 40 per cent of participants suggest that they 'would like to know more about how to drive in a way that saves fuel in conventional cars', to the extent that nearly one in five actually sought this information out as a result of their EV experience. And as a result of their EV experience, nearly 41 per cent of participants reported themselves as having an improved understanding of how to drive in a way that saves fuel in conventional cars.

This improved awareness and understanding often translates into action. Some 29 per cent of participants reported themselves as having made changes to their home and/or behaviour that will reduce electricity use/costs, which is the same number of participants who reported themselves as having changed their driving style so as to be more economical in conventional cars.

Household participants also reported themselves as having regularly talked with others about their electric vehicle experience. Over 96 per cent of participants reported having 'frequent' or 'very frequent' conversations with family, friends or work colleagues on account of their Victorian Electric Vehicle Trial experience, and over 45 per cent reported similar experiences with strangers. This suggests that EV drivers may act as 'experts' in the community in relation to energy use issues more broadly.

# ISSUES AND OPPORTUNITIES

A significant outcome from the Victorian Electric Vehicle Trial has been the range of issues and opportunities observed in relation to electric vehicle market development in Victoria. The issues/opportunities apply to both the early and mainstream market, and are relevant for all electric vehicle market stakeholders.

# 8



With reference to Section 3.2, the trial focus is on technology market development, or in other words the adoption of new technology. Drawing upon Dunstan et al (2011) and Jaffe et al (2005), barriers to technology adoption may be broken down according to the categories listed in Table 19.

Barrier		Definition
Technical	Current technology	The performance of the new technology (as compared to the incumbent/competitors)
	Current costs	The cost of the new technology (as above)
Institutional	Regulatory barriers	Regulation biased against the new technology
	Externalities and price structures	Failure to reflect costs accurately in prices, including: <ul style="list-style-type: none"> <li>• Environmental impact costs from a technology that are not borne by users</li> <li>• Knowledge acquisition costs about a new technology for one individual/firm which create benefits for others</li> <li>• Adoption costs of a new technology for one user being dependent upon the number of other users that have adopted the technology (sometimes called 'dynamic increasing returns').</li> </ul>
	Payback gap	The gap in acceptable payback periods between stakeholders
	Split incentives	The challenges of capturing benefits spread across numerous stakeholders
	Incomplete information	Absence or difficulty in accessing relevant, reliable information
	Cultural values	Insufficient attention given by individuals and organisations to new technologies and opportunities
	Confusion	The additional barriers created by the interaction of the barriers above

Table 19. The classification of barriers to adoption of new technology/innovations.

With reference to Section 3.2, an additional consideration relates to the significance of a barrier in the context of the timeline for adoption of a new technology/innovation. Some barriers may be particularly significant at the outset of the market development, but may reduce over time. Other barriers may be of greater significance as the market goes 'mainstream'.

Dunstan et al (2011) have provided a systematic and comprehensive analysis of the wide range of barriers to electric vehicle adoption against the classifications in Table 19. Building upon this and the phases of market development as outlined in Sections 3.2 and 6.1.2, Table 20 provides a summary of the issues and opportunities for EV market growth identified throughout this report. It should be noted that the observations made are relevant for all electric vehicle market stakeholders, not just government.

Issue	Classification	Sections	Opportunities	Early market	Mainstream market
Early-adopter value proposition	Confusion	6.2	<ul style="list-style-type: none"> <li>Evidencing environmental bona fides</li> <li>Linking EV uptake to renewable energy.</li> </ul>	x	
	Current costs	7.2.1	<ul style="list-style-type: none"> <li>High Occupancy Vehicle lane access</li> </ul>	x	
	Current costs / Payback gap	4.2.5 4.3.1 5.2.6 5.3.6 5.4.5	<ul style="list-style-type: none"> <li>Local government and/or electricity market fleet focus</li> <li>Building rating program recognition</li> <li>Workplace charging program promotion</li> <li>Sponsorship of on-street public charging locations</li> <li>Signage for public charging locations</li> <li>Reservation facility for commercial charging / parking locations.</li> </ul>	x	
	Externalities (knowledge acquisition, dynamic increasing returns)	4.2.3 4.3.2 4.3.4 5.1.5 5.2.3 5.2.6 5.3.2 5.4.2 5.4.5	<ul style="list-style-type: none"> <li>EV drivers forum</li> <li>Fleet knowledge sharing</li> <li>Corporate charging networks</li> <li>Centralised charging network information</li> <li>Information for developers, landlords, property managers etc.</li> </ul>	x	
Electric vehicle purchase prices	Current costs	4.1.3 4.3.4	<ul style="list-style-type: none"> <li>Reduced barriers to market entry</li> <li>Increased market competition</li> <li>Purchasing coalitions.</li> </ul>	x	
Depreciation / resale values	Current costs	4.1	<ul style="list-style-type: none"> <li>OEM intervention</li> <li>Battery standards</li> <li>Second-life battery market.</li> </ul>	x	
Electric vehicle range / charging time	Current technology	4.2.3 4.3.4 5.3.6 5.4.5	<ul style="list-style-type: none"> <li>Workplace charging</li> <li>Public charging network, including quick chargers.</li> </ul>	x	x
	Incomplete information	4.1.3 4.2.2 4.3.4 5.1.5 5.3.6 5.4.5	<ul style="list-style-type: none"> <li>Improved charging network information</li> <li>Optimised vehicle connectivity</li> <li>Promote awareness of driving patterns/distances</li> <li>Knowledge-sharing through EV drivers forum.</li> </ul>	x	x

Issue	Classification	Sections	Opportunities	Early market	Mainstream market
Fleet EV uptake	Current costs	4.1.2 4.1.5 4.3.1 4.3.3 4.3.4	<ul style="list-style-type: none"> <li>Purchasing coalitions (particularly E-LCVs)</li> <li>Promotion to decision-makers</li> <li>Improved charging activity data</li> <li>Improved operational cost data for PHEVs</li> <li>Knowledge sharing</li> <li>Marketing-focused vehicle deployments (local government and electricity market fleets; corporate charging strategies).</li> </ul>	x	
	Current technology	4.3.4 5.3.6	<ul style="list-style-type: none"> <li>32 amp charging vehicle capability</li> <li>PHEVs</li> <li>Quick charger network</li> <li>Corporate charging strategies</li> <li>Improved charging management capability.</li> </ul>	x	x
	Cultural values	4.3.4 5.3.6	<ul style="list-style-type: none"> <li>Designated EV champions</li> <li>Strategic vehicle deployments</li> <li>Corporate charging strategies.</li> </ul>	x	
Charging infrastructure roll-out	Current technology	4.1.3 4.2.2 4.3.4 5.1.5 5.3.6 5.4.5	<ul style="list-style-type: none"> <li>Improved charging network information</li> <li>Optimised vehicle connectivity</li> <li>Technical standards development / adoption.</li> </ul>	x	
	Externalities (knowledge acquisition, dynamic increasing returns)	5.1.5 5.2.1 5.2.3 5.2.6 5.3.2 5.4.2 5.4.5	<ul style="list-style-type: none"> <li>Agreed signage</li> <li>Guidance for parking management / enforcement</li> <li>Analysis of Victorian housing stock</li> <li>Measures to address rentals, leased commercial premises, on-street locations holders</li> <li>Identification of priority locations for public charging outlets.</li> </ul>	x	
	Payback gap	5.1.4 5.1.5 5.3.6 5.4.3 5.4.5	<ul style="list-style-type: none"> <li>Facilitation of network roaming arrangements / agreements</li> <li>Workplace charging program promotion</li> <li>Sponsorship of on-street public charging locations</li> <li>Promotion for public charging locations</li> <li>Reservation facility for commercial charging / parking locations.</li> </ul>	x	



Issue	Classification	Sections	Opportunities	Early market	Mainstream market
Charging infrastructure roll-out	Incomplete information	5.2.3 5.3.2 5.3.6 5.4.2 5.4.5	<ul style="list-style-type: none"> <li>Information for developers, builders, landlords, property managers, councils, electricity distributors etc</li> <li>Identification of priority public charging locations.</li> </ul>	x	
	Split incentives	5.2.3 5.2.6 5.3.2 5.4.2 5.4.4 5.4.5	<ul style="list-style-type: none"> <li>Building rating program recognition</li> <li>Measures to address new developments, rentals, leased commercial premises</li> <li>Support for priority public charging locations</li> <li>Quick chargers.</li> </ul>	x	x
Environmental impacts	Externalities (environmental impacts)	6.2	<ul style="list-style-type: none"> <li>Linking EV uptake with renewable energy.</li> </ul>	x	x
Grid impacts	Incomplete information	5.2.4 5.2.6 5.3.3	<ul style="list-style-type: none"> <li>Information for EV operators (households, fleets) on 'smart' charging strategies</li> <li>Information for electricity distributors on grid impacts from EV charging and management options.</li> </ul>		x
	Externalities (dynamic increasing returns)	5.2.6 5.3.6	<ul style="list-style-type: none"> <li>Measures to promote EVs for energy storage (V2G).</li> </ul>		x
Electric vehicle awareness, understanding and acceptance	Cultural values	4.1.4 4.2.2 4.2.5 5.4.3 5.4.5 5.3.6 7.2.1	<ul style="list-style-type: none"> <li>Information about E2Ws</li> <li>Promotion of the performance characteristics of EVs</li> <li>Targeting information at universities and their alumni</li> <li>Specify EV operating cost advantages as weekly / monthly</li> <li>Establish environmental bona fides</li> <li>High Occupancy Vehicle lane access</li> <li>Partnerships for on-street charging locations</li> <li>Promotion of the public charging network.</li> </ul>	x	x

Table 20. Issues and opportunities for EV market development as observed within the trial.

The timeline and economic benefits of EV market development as outlined in Section 6.1 are heavily dependent upon resolution of these issues and opportunities. In simple terms, many of these issues must be addressed if the electric vehicle market is to ever move beyond its current state of infancy.

# WHERE TO FROM HERE?

The Victorian Electric Vehicle Trial project will be completed in mid-2014. The final phase of the trial will seek to position Victoria for the period following the trial conclusion up until 2020, the forecast 'take-off point' for mainstream market adoption.

# 9



Drawing upon the learnings acquired in the project to date, the three broad subject areas that will be the primary focus for the remainder of the trial are:

1. Enhancing the early-adopter EV value proposition ('early adopters')
2. Reducing the costs of EV uptake – now and in future ('reducing costs')
3. Raising awareness, understanding and acceptance of EVs in the Victorian community ('education and awareness').

A range of detailed tasks will be completed in the intervening period, a summary of which can be seen in Table 21 including alignment with the subject areas above. The final project report will update the findings presented in this mid-term report, along with additional insights made in the interim.

Task	Description	Subject area			Timeframe
		Early-adopters	Reducing costs	Education and awareness	
EV charging DR/LC project report	Publication of final report for the electric vehicle charging demand response / load control demonstration project	X	X		March 2013
EV purchasing coalition report	Publication of final report for the fleet electric vehicle purchasing coalition feasibility study		X		March 2013
Completion of household vehicle roll-outs	Finalisation of household participant data sets, including vehicle and charging activity monitoring, surveys and travel diaries	X	X	X	April 2013
National leadership EV test-drive program	In partnership with RACV, test-drive program aimed at executive-level management of large fleet operators	X		X	July 2013
Land-use planning guidance project	Further engagement with land development sector and final assessment	X	X	X	October 2013
EV School education program report	Continued delivery and final assessment of school-based education program			X	November 2013
Completion of fleet vehicle roll-outs	Finalisation of fleet vehicle data sets, including charging activity monitoring and surveys	X	X	X	December 2013
Completion of charging infrastructure roll-outs	Installation and commissioning of all household and fleet charging infrastructure, quick chargers, and decommissioning/transition of legacy infrastructure at trial conclusion	X	X	X	April 2014
Final report	Compilation and validation of complete trial data set; analysis and completion of final project report	X	X	X	June 2014
EV stakeholder engagement	Continuation of and transition arrangements for EV market stakeholder engagement	X	X	X	June 2014

Task	Description	Subject area			Timeframe
		Early-adopters	Reducing costs	Education and awareness	
National EV standards development process	Continuation of and transition arrangements for the national EV standards development process	X	X	X	June 2014
Project website and associated publications	Transition and/or exit arrangements for the website, discussion board, guidance materials etc.		X		June 2014

Table 21. Victorian Electric Vehicle Trial high-level task list for project completion.

With reference to Sections 4.1.1 and 5.1.1, the vehicles and charging infrastructure will be transitioned out of the trial through arrangements set out in the initial project agreements:

- The trial vehicles are to be returned to the relevant vehicle suppliers via the Victorian Government fleet management organisation
- The trial charging infrastructure will be either transitioned over to a direct commercial relationship between the site owner/operator and the charging infrastructure provider as a result of an offer made by the latter to the former, or it will be removed and the site remediated back to near-original condition.

These arrangements reflect the finite duration of the trial project along with the objective to provide a foundation for the Victorian electric vehicle market.

# ACRONYMS, GLOSSARY AND UNITS OF MEASURE

10



**A** – ampere or amps, a measure of electrical current

**BEV** – Battery Electric Vehicle, or a vehicle that runs exclusively on electrical energy

**Advanced Metering Infrastructure** – or smart meters, a type of high technology electrical meter that identifies consumption in more detail than a conventional meter and communicates that information by way of a network back to the local utility for monitoring and billing purposes

**Balance of Payments** – a system of recording all of a country's economic transactions with the rest of the world over a period of one year

**Baseload** – or baseload demand, is the minimum amount of power that a utility or distribution company must make available to its customers, or the amount of power required to meet minimum demands based on reasonable expectations of customer requirements

**Charge state** – the amount of electrical energy stored in a battery as a reflection of its total storage capacity

**Charging circuit** – the electrical circuit which connects the charging outlet to the point of electrical supply

**Charging event** – the activity of supplying electrical energy to an electric vehicle from an external source, for example via a plug/cable

**Charging outlet** – the device that sits between the vehicle and the electricity network, sometimes known as EVSE

**Charging infrastructure** – the dedicated equipment used for delivering electrical energy to EVs via charging events

**Coal-generated electricity** – electricity generated from burning coal

**Corporate Social Responsibility (CSR)** – a form of corporate self-regulation that underpins efforts by business to protect and promote community values

**Cradle-to-grave** – a total product lifecycle assessment (LCA)

**CSIRO** – Commonwealth Science and Industrial Research Organisation

**Demand charging** – or Convenience charging, are Charging events that commence as soon as a vehicle is plugged in (as opposed to a later time based upon other considerations)

**Duty cycle** – the way in which vehicles are driven, taking into account driver inputs, traffic conditions, vehicle payload in terms of passengers and cargo etc.

**EIA** – Environmental Impact Assessment

**Electric Light Commercial Vehicles or E-LCVs** – commercial vehicles such as vans and small trucks that are either partly or completely electrically-powered

**Electric Two-Wheelers or E2Ws** – two-wheeled vehicles such as bicycles and motorcycles that are either partly or completely electrically-powered

**EOI** – Expression of Interest

**EV** – Electric Vehicle, used in this document to mean any vehicle with a plug (i.e. a PEV)

**EVSE** – Electric Vehicle Supply Equipment, which is the emerging industry-standard name for electric vehicle charging outlets

**Economies of scale** – savings in the per unit costs of production that are gained through production of larger quantities, for example via amortization of the production facility overheads across larger volumes

**EV charging network** – the network of charging infrastructure

**gCO<sub>2</sub>e** – grams of carbon dioxide equivalent, a measure of greenhouse gases

**GHG** – Greenhouse Gas

**Grid** – a network of cables designed to connect power stations with their customers in offices, homes, schools, factories, etc.

**HEV** – Hybrid Electric Vehicle, or a vehicle that uses solely a hydrocarbon-based fuel but supplements this with electrical energy recovered through regenerative braking

**ICE** – Internal Combustion Engine

**ICEV** – Internal Combustion Engine Vehicle

**Km** – kilometre, a measure of distance

**LCA** – Life Cycle Assessment, an EIA method

**Lead-acid battery** – an electricity storage device based upon a lead (Pb) and sulphuric acid electrochemical cell

**Lithium-ion battery** – an electricity storage device based upon the family of lithium (Li) electrochemical cells

**MWh** – Megawatt hours, a measure for electrical energy

**N<sub>2</sub>O** – Nitrogen dioxide, an air pollutant

**NO<sub>x</sub>** – Oxides of Nitrogen, an air pollutant

**OEM** – Original Equipment Manufacturer, a term that describes the company that is the original supplier of a vehicle

**On-street charging** – Charging events which take place using charging infrastructure located on public lands ('on-street')

**OPEC** – Organisation of the Petroleum Exporting Countries

**Peak / off-peak** – periods of greater or lesser demand for something; in the context of this paper, the term relates to electricity demand

**PEV** – Plug-in Electric Vehicle, one of either a PHEV or a BEV, both of which use plugs to source electrical energy

**PHEV** – Plug-in Hybrid Electric Vehicle, a vehicle that uses both electrical and hydrocarbon-based energy sourced externally

**PV** – Photovoltaic, a technology for turning solar radiation into electrical energy

**PM2.5** – Particulate Matter of 2.5 microns or less in diameter, sometimes known as ‘fine particles’ (an air pollutant)

**Primary use / secondary use battery market** – terms to distinguish the two markets for electrical storage batteries (new and used)

**Quick chargers** – a high current/voltage charging infrastructure device that reduces the amount of time needed to charge an EV

**Range** – the distance a vehicle can travel based upon the amount of energy stored and the energy conversion efficiency of the vehicle technology

**Rare Earth metals** – or Rare Earth elements, are a collection of seventeen chemical elements in the periodic table, namely scandium, yttrium, and the fifteen lanthanides, that are key materials for automotive catalytic converters and a range of electrical equipment

**Regenerative braking** – a method of braking whereby the kinetic energy that is normally lost as heat during stopping is instead gathered and stored for re-use

**Renewable energy** – energy generated from renewable sources such as the sun and wind

**RFID** – Radio Frequency Identification, which is communications technology commonly used for ‘swipe cards’ such as Victoria’s myki public transport ticketing system

**Smart charging** – sometimes known as off-peak charging, are charging events that are scheduled to take place during periods of low electricity demand

**SOx** – Sulfur oxides, an air pollutant

**SO2** – Sulfur dioxide, an air pollutant

**Standard charging** – Charging events that are based upon the standard domestic electrical supply (240 v in Australia)

**Supply chain** – a system of organisations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer

**Swap stations** – a proprietary charging infrastructure technology where depleted EV batteries are swapped out of the vehicle for fully-charged equivalents in automated facilities

**Tailpipe emissions** – a term to describe the measured quantities of air pollutants emitted from a motor vehicle exhaust

**Tank-to-wheel** – a vehicle lifecycle assessment term that relates to the upstream impacts

**tCO2e** – tonnes of carbon dioxide equivalent, a measure of greenhouse gases

**Torque** – the measure of rotational force that is the basis for vehicle acceleration

**Traction battery** – the propulsion energy electrical storage device in an EV (as opposed to the 12 v battery that is used to operate the ancillary systems such as lighting, security etc.)

**Upstream/downstream impacts** – the outcomes from different aspects of a vehicle lifecycle that relate to the fuel energy cycle (upstream) and the vehicle energy conversion cycle (downstream)

**Vehicle-to-grid/ vehicle-to-building/ vehicle-to-home** – scenarios where an EV is used as an electrical storage device

**Voltage** – electrical potential, measured in volts (v)

**VOCs** – Volatile Organic Compounds, an air pollutant

**Wh/km** – Watt hours per kilometre, a measure of EV energy economy

**Well-to-tank** – a vehicle lifecycle assessment term that relates to the downstream impacts

**Well-to-wheel** – the total vehicle lifecycle assessment, also known as Cradle-to-grave

**Wireless induction charging** – a type of charging infrastructure technology that utilises electromagnetic induction to transfer energy as opposed to conduction through a plug/cable arrangement

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# APPENDIX A

## VICTORIAN ELECTRIC VEHICLE TRIAL CORPORATE PARTICIPANTS

Participation in the trial is underpinned by a formal contract for each participant. Various other organisations not listed below have engaged to varying degrees over the life of the project however these interactions have not involved a formal agreement.

An explanation of what each participant role constitutes can be found at the foot of the table.

Entity	Charging Infrastructure Host	Charging Infrastructure Provider	Fleet Operator	Premier Partner	Service Provider	Trial Participant	Vehicle Supplier
AECOM					x		
AGL Energy			x	x	x		
Austin Health			x				
Bayside City Council			x				
Better Place Australia		x	x				
Cardinia Shire Council			x				
Centre for Education and Research in Environmental Strategies (CERES)	x		x		x		
Cloud Utility		x					
ChargePoint Australia		x	x				
CitiPower			x			x	
CSIRO			x	x	x		
City of Casey			x				
City of Frankston			x				
City of Greater Dandenong	x		x				
City of Kingston			x				
City of Maribyrnong			x				
City of Melbourne	x		x				
City of Melton			x				
City of Port Phillip			x				
City of Monash			x				
Club Assist	x				x	x	
Colonial First State Global Asset Management	x						
DiUS Computing		x			x		
Dolomiti Italian Lifestyle						x	
ECOtality		x					
E-Day Life						x	
Enhance					x		

Entity	Charging Infrastructure Host	Charging Infrastructure Provider	Fleet Operator	Premier Partner	Service Provider	Trial Participant	Vehicle Supplier
EPA Victoria			x				
Exigency						x	
EV Engineering						x	
Federation Square	x						
FreeFuel			x				
General Electric (GE)	x	x				x	
GM Holden						x	
Go Get Car Share			x				
Green Energy Trading			x				
JuicePoint						x	
Kangan Institute of TAFE			x				
Linking Melbourne Authority			x				
LINK Community Transport			x				
Lumley Insurance				x	x		
Manningham City Council			x				
Melbourne Airport	x		x				
Melbourne Museum	x		x				
Mitsubishi Corp			x				
Mitsubishi Motors Australia							x
Momentum Energy			x				
Monash University	x		x				
Moreland City Council			x				
Mornington Peninsula Shire Council			x				
Mount Alexander Shire Council			x				
MT Data					x		
Municipal Association of Victoria (MAV)						x	
Nissan Motor Company (Aust)	x						x
NHP Electrical Engineering Products			x				
Origin			x			x	
Powercor Australia			x			x	

Entity	Charging Infrastructure Host	Charging Infrastructure Provider	Fleet Operator	Premier Partner	Service Provider	Trial Participant	Vehicle Supplier
RMIT University			x				
Robert Bosch (Australia)	x		x				
SG Fleet			x				
Sofitel on Collins	x						
South East Councils Climate Change Alliance [SECCCA]			x				
SP AusNet			x			x	
Swinburne University	x		x				
Sustainability Victoria			x				
Synergetics (The Green Spaces)			x				
The Climate Group					x		
Royal Automobile Club of Victoria (RACV)	x		x	x			
The Victorian Arts Centre Trust	x						
Toyota Motor Corp Aust							x
TRUenergy						x	
United Energy Distribution						x	
University of Melbourne			x			x	
VACC			x			x	
VicRoads			x				
VicUrban	x						
VisionStream		x	x				
Wellington Shire Council			x				
Yarra City Council			x				
Yarra Trams			x				

## DEFINITIONS

The role of each participant as set out in the column headings above is defined below:

- Charging Infrastructure Host** – owner/manager of property which hosts publicly-accessible charging outlets (refer to Section 5.1.1)
- Charging Infrastructure Provider** – provider of charging infrastructure services for household, fleet and/or public use (refer to Section 5.1.1)
- Fleet Operator** – commercial fleet operator for vehicles participating in the trial (refer to Section 4.1.1)
- Premier Partner** – foundation partner for the trial, including in-kind contribution of goods/services
- Trial Participant** – formal participant in the trial including data/information exchange and/or promotional activities
- Vehicle Supplier** – provider of vehicles for use as part of the trial.



# APPENDIX B

## EVS AND FLEETS 2012 PRACTICAL ROLL-OUT PLAN

The guidance material below draws upon the experiences of fleets who have participated in the Victorian Electric Vehicle Trial. The material was presented to attendees at the EVs and Fleets 2012 workshops.

No.	Task	Inputs	Outputs	Start timing	Key Questions
1	Design vehicle deployment plan	Strategic / corporate objectives Fleet / operational data	EV type EV deployment location / task EV champion	- 14 wks	What do we want to know? Who is our audience? Where should the EV be based? Who is best suited to managing the EV? Which technology matches our fleet task?
2	Procure vehicle	EV type Budget / timing	EV spec EV delivery date	-12 wks	Which technology and functional spec? Buy or lease? What are our charging needs/options? When will the vehicle be delivered?
3	Design charging plan	EV spec EV deployment location / task Budget / timing	Charging plan Charging spec / provider	-10 wks	Where could/should we charge to maximise vehicle utilisation and exposure? What charging solution/s are available in these location/s? What info do we require from charging activities? Do we need a charging service provider? Do we need a renewable energy strategy?
4	Implement base charging solution	Charging spec / provider Charging plan	Base charging solution	-10 wks	Where is our base charging solution located and how does it work? How do we ensure the availability of our base charging solution? Do we want/need signage/ground-marking? How do we get energy use info?
5	Design marketing plan	Strategic / corporate objectives Corporate communications plan Charging plan	EV marketing strategy EV livery design	-6 wks	What are we trying to tell our audience with the EV? What comm's pathways work best for this story? How can we maximise the vehicle visibility to our audience?
6	Design vehicle management plan	EV deployment location / task Charging plan EV marketing strategy	EV management plan Staff training & engagement plan	-6 wks	What's our operational plan for the vehicle? How do we find out what we want to know? How do we minimise risk/maximise utilisation?

No.	Task	Inputs	Outputs	Start timing	Key Questions
7	Receive vehicle & validate plans	EV delivery date EV livery design Charging plan	Branded EV Validated management/ charging plans	0	Who can make/apply our vehicle livery and when? Does our EV operate as expected? Does our EV champion understand all aspects of the vehicle operation/ management plan? Does our EV work with all aspects of our charging plan?
8	Commission vehicle into fleet	Branded EV Validated management/ charging plans Staff training & engagement plan EV marketing plan	EV deployment	+2 wks	Are our staff aware of the vehicle? Who of our Exec team could drive the vehicle? Do the drivers understand how to operate the vehicle in line with the management/ charging plans? Have drivers accepted the vehicle? When do we implement our communications activities?
9	Evaluate performance & realise value	EV deployment EV management plan EV marketing plan	Optimal vehicle utilisation Fulfilment of strategic / corporate objectives	+3 wks onwards	Are we meeting our vehicle utilisation targets and if not, why and what changes can be made? What are our target audience awareness levels of the vehicle? Have we obtained investment-grade information to inform future business planning?

Notes:

- Advice applies to early-market / initial vehicle adoption in 2012-3
- Assumes the business case to proceed has already been approved
- Start timing doesn't take internal approval processes or product supply leadtimes into account
- Variations in supplier business models may influence the solution design and timing.

# APPENDIX C

## CHARGING OUTLET ATTRIBUTE LIST

The charging outlet attribute list below should be considered by people or organisations seeking to buy dedicated electric vehicle charging equipment. It is a comprehensive list of features that are available in the market and potentially relevant to the buyer. Buyers should consider the list of attributes an input into their final equipment specification, due to the inevitable cost trade-off in seeking such a comprehensive list of features.

The list is an outcome from benchmarking of international procurement activities and consultation with eight charging infrastructure providers taking part in the Victorian Electric Vehicle Trial.

The benchmarking activity focused primarily on the 2011 Southern California Association of Local Government joint procurement activity RFB-IS-12200325 for 300 to 400 'Level 2' chargers to be installed over 2012-13<sup>19</sup>. The outcomes from this joint procurement activity are available online in the form of an evaluation matrix<sup>20</sup>.

Area	Attribute	Definition
General	Mounting style	Wall / pedestal (free-standing)
	Weather-proofing	Indoor / outdoor
	No. charging outlets	Single / multi (no.)
	Dimensions	Unit; mounting (anchor bolts, concrete pad etc)
	Compliance	AS/NZS 3000 KEMA C-Tick NEMA
	Charging standard	SAE J1772 / IEC 62196 AC / DC Various levels and modes
	Rated power delivery	Kilowatts (kW)
	Amperage	Amps (A)
	Stand-by power consumption	Watts (W)
	Re-start / cold load pick-up	Intermediate / randomized / none
	Cable type	Floating (detached) / fixed Straight / formed-coil / retractable
	Cable length	Metres (m)
	Electrical protection	Residual Current Device (RCD) / Residual Circuit Breaker with Overload (RCBO)
	General power outlet	Standard 240 v outlet included / not included
	User interface	Included / not included Solution description
	Billing / cost recovery	Included / not included
Payment system integration	Included / not included Payment systems supported	

<sup>19</sup> [http://www.google.com.au/url?sa=t&rct=j&q=rfb-is-12200325&source=web&cd=5&cad=rja&ved=0CEQQFjAE&url=https%3A%2F%2F3.amazonaws.com%2FResearchDocuments%2FProd%2F11-2-2011%2FRFB\\_IS\\_12200325\\_SPECIFICATIONS.docx&ei=xjAYUc32A7GyiQeE94G4Ag&usq=AFQjCNFyz3VsfAoZKIM-uDiWXdzj3T-CSw&bvm=bv.42080656,d.dGY](http://www.google.com.au/url?sa=t&rct=j&q=rfb-is-12200325&source=web&cd=5&cad=rja&ved=0CEQQFjAE&url=https%3A%2F%2F3.amazonaws.com%2FResearchDocuments%2FProd%2F11-2-2011%2FRFB_IS_12200325_SPECIFICATIONS.docx&ei=xjAYUc32A7GyiQeE94G4Ag&usq=AFQjCNFyz3VsfAoZKIM-uDiWXdzj3T-CSw&bvm=bv.42080656,d.dGY), viewed 11 February 2013

<sup>20</sup> [http://www.aqmd.gov/tao/Demonstration/ElectricHybrid/SoCalEV\\_RFP\\_Evaluation.pdf](http://www.aqmd.gov/tao/Demonstration/ElectricHybrid/SoCalEV_RFP_Evaluation.pdf)

Area	Attribute	Definition
General	Parking access and revenue control system (PARCS) integration	Included / not included PARCs supported
	Web-based / mobile phone system integration	Included / not included Systems supported Solution description
	Energy demand response system integration	Included / not included Description
Data capture	Percentage of time the vehicle is drawing power	Captured / not captured
	Each unique charging event	Captured / not captured
	Date / time of use (start / end)	Captured / not captured
	Length of time vehicle was connected per charging event	Captured / not captured
	Total electricity consumed (kWh) and peak power drawn (kW) per charging event	Captured / not captured
	Each unique vehicle charged from outlet	Captured / not captured
	State-of-charge of each vehicle as it was connected / disconnected to outlet	Captured / not captured
	Ability to indicate time and energy consumption for cost recovery	Captured / not captured
	Data collected and stored	Including / in addition to attributes above
	Length of time data is stored	Duration
	How long / how many transactions are stored if there's a communications failure	Included / not included Description
	What happens when communications failure occurs	Description
	Method of accessing data locally	Description
	Where does / will data collected reside	Provider network / host network
	Fleet vehicle data provision	Description
	Reporting description	Description
	Network capabilities for data transmission	Fibre / cellular / wireless / Ethernet
	On-Board & remote diagnostics	Included / not included Description
Alerts	Included / not included Description	

Area	Attribute	Definition
Billing / cost recovery	Capable of accepting / processing user payments and managing settlements with host	Included / not included Description
	Point-of-sale payment capability	Included / not included Description
	Payment Card Industry Data Security Standard (PCI DSS) compliant	Included / not included
	Authentication system for user ID	Included / not included Description
	Billing options (time, energy etc)	Description
	Service fees	Applicable / not applicable
		Costs Terms and conditions
Support	Service / inspection / maintenance schedule	Description
	Warranty for parts	Terms and conditions
	Warranty for labour	Terms and conditions
	Upgrade capability / method / costs	Description

Additional considerations relating to service performance should also be made as part of a procurement agreement for electric vehicle charging services. Evidence relating to the reliability of service provision, time taken for fault diagnosis and remedy and other metrics relating to service delivery should be considered as part of the initial procurement activity and subsequent service agreement.

# APPENDIX D

## HOUSEHOLD CHARGING INFRASTRUCTURE QUESTIONS PROFORMA

The following questionnaire was supplied to the trial household participants following completion of their formal agreement to participate. The participant's response informed planning on the choice of charging infrastructure provider and the design of their charging solution, thereby streamlining the charging infrastructure installation process.

*A charging unit will need to be installed at your home to enable recharging of your EV. The following questions relate to where you will be parking the EV when it's not being driven. To avoid us making numerous visits to your home, please answer the following questions as best you can:*

1. *Is the parking location undercover or outside?*
2. *Is a wall-mounted charging unit possible, or will the charging unit need to be on a free-standing pole?*
3. *Is there any risk of asbestos in the location where the charging unit will be installed?*
4. *What is the age and type of your house (free-standing, semi-detached, town-house, apartment etc)?*
5. *When was your house last renovated (if at all)?*
6. *Is the EV parking bay attached to the home or building where the power supply is available? Or will there need to be wiring installed between the house and garage?*
7. *Is the path between EV parking bay and household power supply blocked by trees, household storage, rubbish, walls etc?*
8. *What is the estimated length from your electricity meter and/or switchboard to parking bay?*

*If it is not too much trouble, could you please supply photos of the house, the garage, the proposed parking space and location, the meter and switch boards, and anything else you think might be useful*

*The answers to these questions will give us a good indication of what to expect when we come out to your residence to install the unit. If you're not sure what the question is asking, please don't hesitate to give us a call.*



*Example electricity meters*

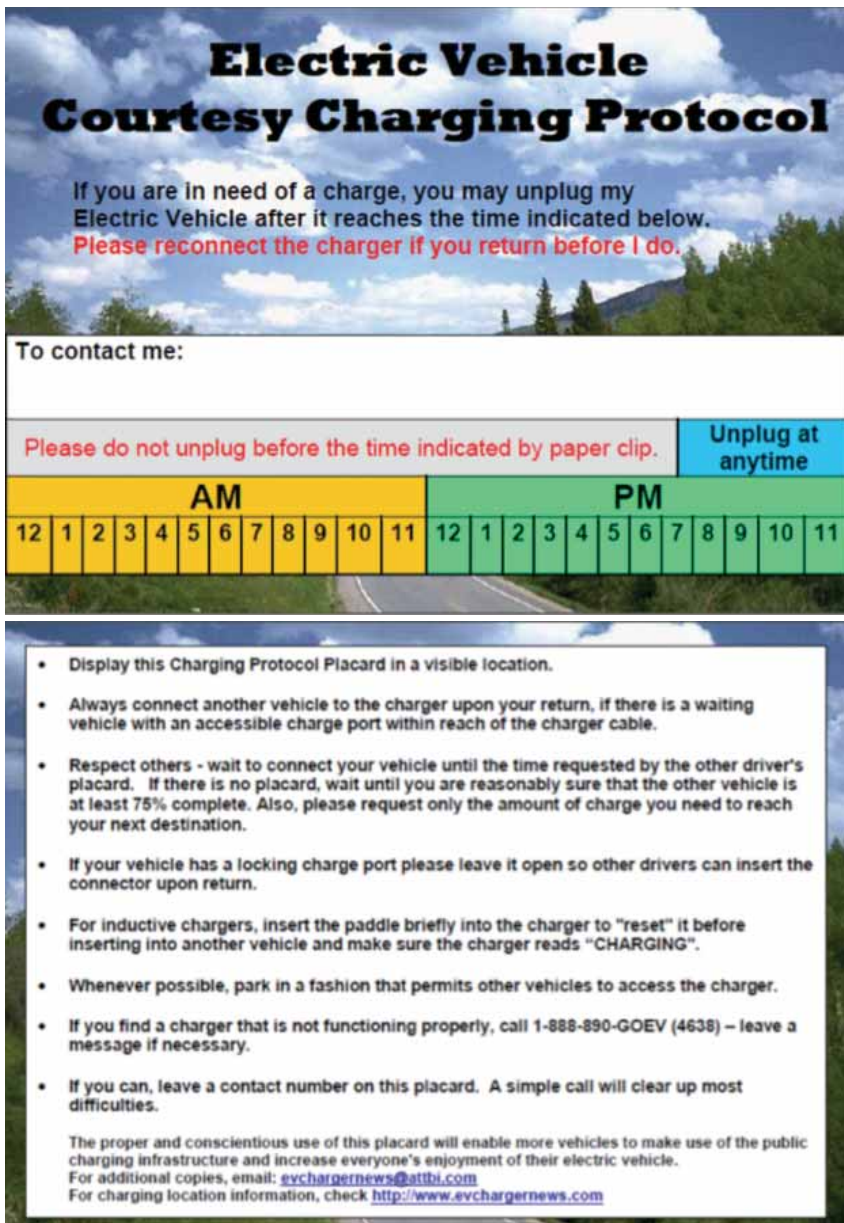


*Example switchboards*

# APPENDIX E

## EV CHARGING COURTESY SIGNAGE

The proforma design from the U.S. below<sup>21</sup> is an example of simple but effective communication between EV drivers that allows them to share EV charging infrastructure.



**Electric Vehicle Courtesy Charging Protocol**

If you are in need of a charge, you may unplug my Electric Vehicle after it reaches the time indicated below.  
**Please reconnect the charger if you return before I do.**

To contact me:

Please do not unplug before the time indicated by paper clip. **Unplug at anytime**

AM											PM												
12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11

- Display this Charging Protocol Placard in a visible location.
- Always connect another vehicle to the charger upon your return, if there is a waiting vehicle with an accessible charge port within reach of the charger cable.
- Respect others - wait to connect your vehicle until the time requested by the other driver's placard. If there is no placard, wait until you are reasonably sure that the other vehicle is at least 75% complete. Also, please request only the amount of charge you need to reach your next destination.
- If your vehicle has a locking charge port please leave it open so other drivers can insert the connector upon return.
- For inductive chargers, insert the paddle briefly into the charger to "reset" it before inserting into another vehicle and make sure the charger reads "CHARGING".
- Whenever possible, park in a fashion that permits other vehicles to access the charger.
- If you find a charger that is not functioning properly, call 1-888-890-GOEV (4636) – leave a message if necessary.
- If you can, leave a contact number on this placard. A simple call will clear up most difficulties.

The proper and conscientious use of this placard will enable more vehicles to make use of the public charging infrastructure and increase everyone's enjoyment of their electric vehicle.  
 For additional copies, email: [evchargernews@atbi.com](mailto:evchargernews@atbi.com)  
 For charging location information, check <http://www.evchargernews.com>

<sup>21</sup> <http://www.evchargernews.com/chargeprotocolcard.pdf>, viewed 23 December 2012

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