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Creating a Market: The Victorian Electric Vehicle Trial

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Abstract

The Victorian Electric Vehicle Trial ('the Trial', www.transport.vic.gov.au/evtrials) in South-Eastern Australia is the largest EV trial in the southern hemisphere. It is aimed at making the state of Victoria an EV-friendly place through improved awareness, understanding and acceptance of EV technology. As part of the Trial, a functioning EV market model has been established with over 60 corporate partners. With multiple participants at each level of the EV market, the Trial avoids proprietary influence in terms of technology or business model. An extensive data collection and management framework has been established in support of a coordinated roll-out of nearly 50 vehicles to Victorian households and fleets. A range of other market development initiatives are being designed and deployed based upon research, Trial learnings and the indicated market direction. The supportive, low cost/risk operating environment is providing all market participants with the opportunity to test technologies, refine business models and develop policies in support of safe, efficient development of the Australian EV market.

Key words: Business model, demonstration, education, market, policy

1 Introduction

Governments and industry globally are aggressively promoting the roll-out of Electric Vehicle (EV) technology. Energy security, climate change, urban amenity and future job security are significant policy challenges all able to be addressed through a transition away from fossil-fuel based road transportation towards vehicle electrification.

However the shift towards EVs will come at considerable cost. Should government targets be met, it is estimated that around $USD 85 billion will need to be invested in manufacturing capacity in the period to 2020, in addition to which charging infrastructure will require an additional $USD 50 billion [1]. As governments seek to address the aforementioned policy challenges, large-scale financial risk and opportunity will abound.

The Australian state of Victoria is charting a course towards vehicle electrification within this prevailing climate of risk and opportunity. A selection of relevant indicators and influences on the Victorian economy include:

- Abundant, conveniently-located and easily-accessed brown coal reserves [2] that have underpinned cheap yet carbon-intensive stationary energy, a key factor in making Victoria home to Australian automotive manufacturing [3] and at the same time one of the world's highest greenhouse gas emitters per capita [4]
- National policy settings including a carbon tax and a renewable energy target

that will decarbonise the state's energy sector

- A competitive advantage in automotive design that has been built on the associated manufacturing industry [3], both now under pressure due to a market shift away from locally-built products [5] and global economic conditions that have resulted in a high Australian dollar that makes it difficult for Australian exports to compete internationally [6].
- Australia's fastest population growth [7] and one of the world's most urbanised populations, with the overwhelming majority of the state's 5 million people located in or around the capital city of Melbourne [8]
- A metropolitan passenger rail network that is reaching capacity while over 90 per cent of the total travel task is done by motor vehicles [9]
- An average daily travel distance for passenger vehicles of 40 km that reflects the high level of urbanisation and the system of time accounts [10]
- Increasing reliance on oil imports for passenger vehicles, which themselves generate over 14 per cent of the state's greenhouse gas emissions [11]

Through the Victorian Electric Vehicle Trial ('the Trial'), the Victorian Government is striving "to make Victoria an EV-friendly place". This goal sits within the context provided above, whereby Victoria's competitive advantage in automotive design and manufacture may be linked into its reliance on passenger vehicles, by transitioning away from imported, greenhouse-intensive fuels towards domestically-produced electricity from a steadily-decarbonising stationary energy sector.

However, unlike most developed economies Victoria has no previous history of EV technology. While many regions around the world have had previous EV exposure through earlier EV deployments [12], Neighbourhood EVs [13] and even electrified milk-floats [14], the vast majority of Victorians have only experienced EV technology via non road-going vehicles such as golf-carts or electric wheel-chairs. In considering EV market development, Victoria is clearly therefore a blank canvas. The remainder of this paper will describe the approach being taken by the Victorian Government to establish and promote growth of an EV market.

2 Market model

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, GM North America Vice-President, Chevrolet [15]

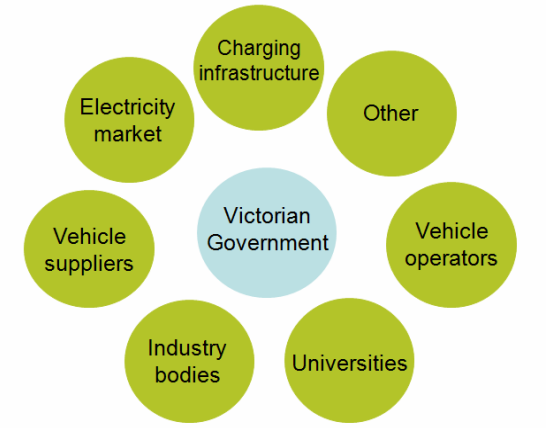

Figure 1. Victorian Electric Vehicle Trial market model

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 EV technology trial project [16]. Despite Australia's status as one of the most highly open and competitive automotive markets in the world [17], at the time

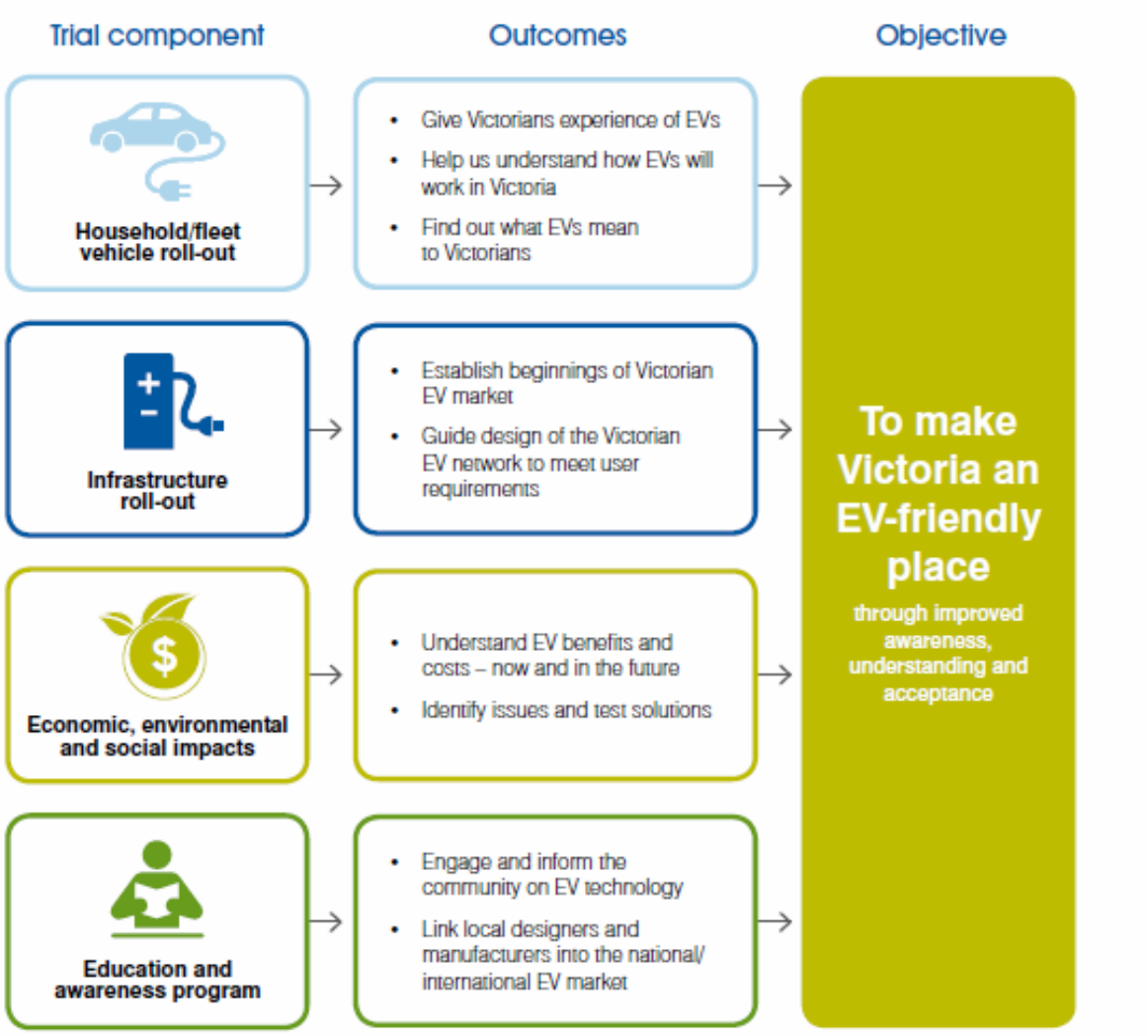

Figure 2. Victorian Electric Vehicle Trial conceptual and delivery framework

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 to form the basis of a fully-functioning EV market model depicted as a schematic in figure 1. 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.

Commercial negotiations and a structured consultation process were then undertaken to inform the final Trial design [18]. The participants were announced in October 2010 to a backdrop of vehicles and charging technology previously unseen in the Victorian market [19].

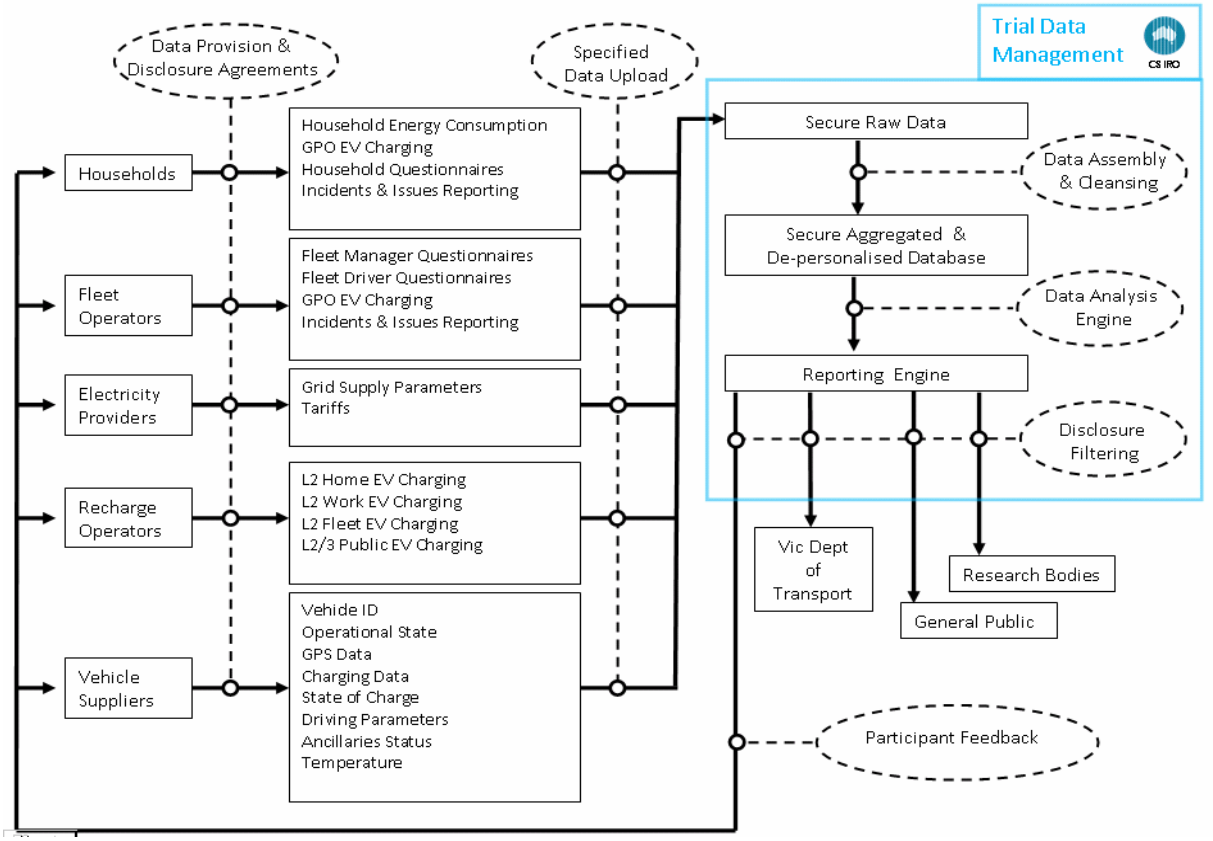

Figure 3. Victorian Electric Vehicle Trial data collection and management framework

While the participants and their goods and services provide the basic building blocks for the Trial, the four-part conceptual model shown in figure 2 was designed for the Trial delivery. The household/fleet vehicle roll-out; charging infrastructure roll-out; economic, environmental and social impacts assessment; and education and awareness program provide the framework for the diverse range of activities being undertaken in the Trial. The unifying objective "to make Victoria an EV-friendly place" is to be achieved through improved awareness, understanding and acceptance of EV technology – a theme that will be revisited throughout the remainder of this paper.

2.1 Household /fleet vehicle rollout

The most visible component of the Trial is the allocation of EVs to Victorian households and fleets. As of February 2012, 48 vehicles have been deployed under the Trial banner, consisting of 18 Mitsubishi i-MiEVs, 16 Nissan LEAFs, 9 Blade Electrons (Hyundai Getz EV conversions), and 5 Toyota Prius Plug-in Hybrid EVs (PHEVs). Although the specific allocation at any one time of these vehicles varies, a selection of 20 out of the 48 vehicles sourced from the i-MiEVs, LEAFs and Prius PHEVs are allocated to households. Vehicle allocations run nominally for 3-months per operator, with fleets able to trial different vehicle types over successive allocations. Over the monitoring phase of the Trial to 2013, 180 households and around 40 fleets will host one or more vehicles.

Quantitative and qualitative data is gathered from these allocations through aftermarket vehicle instrumentation, structured surveys and an unstructured survey in the form of a web forum (refer to Education & Awareness program below). The data collection and management framework for the Trial is illustrated schematically in figure 3,

while the household participant event timeline is depicted in figure 4.

As of 1 February 2012, the data-set contains nearly 19 million vehicle raw data records for a combination of 30 i-MiEV and LEAF vehicles. Based upon these records, an estimated 15,000 trips and 2600 charging events have been recorded since 25 June 2011. The trips spanned a distance of over 111,000 km over a duration of 3800 hours (i.e. 158 days). The total energy consumed is around 18 MWh translating to an energy economy of 0.16 kWh/km. The vehicles are averaging 27 km/h over a trip length of 8 km and consuming 1.24 kWh of energy.

Once the data has been collated and processed to address privacy issues, it is made available to the Trial participants. Up to January 2012, this reporting has mostly taken the form of selected extracts and anecdotes as development of the reporting portal is completed and challenges in the data reliability are addressed. Nevertheless, the value in having undertaken a task of such complexity is being realised not only through the rich data-set, but also in having directly and deeply involved the Victorian community and so many participants in the emerging EV market.

2.2 Charging infrastructure rollout

Around 250 dedicated EV charging outlets are being implemented under the banner of the Trial, predominantly in direct support of the vehicle allocations above but also including a significant presence in the public domain. As of January 2012 around 100 charging outlets have been installed, including 12 public. All charging outlets conform to the SAE J1772 standard.

Although EVs are a novel variation of vehicle technology within the Victorian vehicle fleet, dedicated EV charging infrastructure (also known as EV Supply Equipment, or EVSE) is a brand new technology and service sector. Prior to the Trial, the four main Trial EVSE providers (Better Place, ChargePoint, ECOtality and DiUS Computing) had little to no Australian experience with the implementation of their technology or services. Business models for the EVSE market operation were unknown and untested, and the role for government unclear.

As a consequence, business models and commercial agreements were designed specifically for the Trial delivery, but also with an eye towards a legacy network to persist beyond the life of the Trial. With reference to figure 5, service delivery arrangements have been established whereby the EVSE provider maintains ownership and operation of the EVSE under agreement with the Victorian Government, in parallel with which the Victorian Government holds EVSE host agreements with individual site owners. These arrangements are time-limited to the duration of the Trial or the site owner's involvement, following which transition to a direct commercial relationship between the site owner and the EVSE provider occurs or the EVSE gets removed and the site remediated.

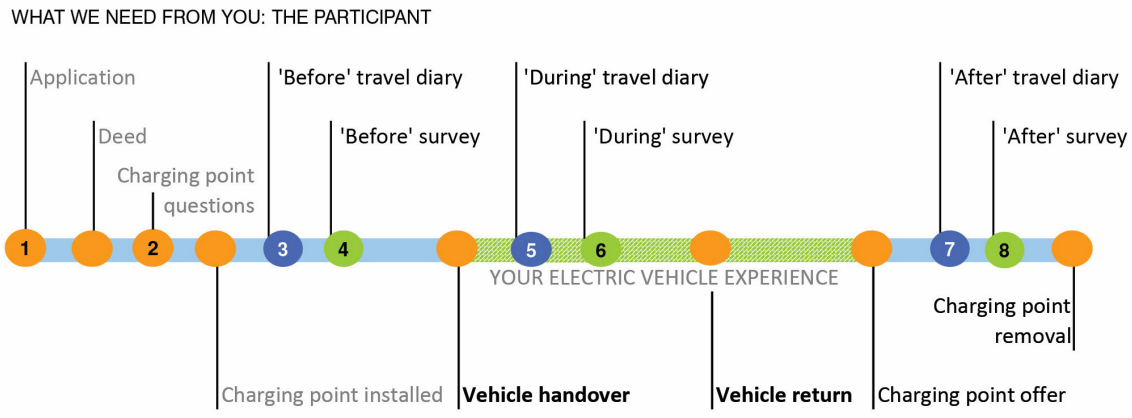

Figure 4. Victorian Electric Vehicle Trial household participant event timeline

These arrangements ensure that the Victorian Government maintains oversight of the Trial design and delivery without having to become an EVSE owner or operator. They also address the business risk issues associated with a lack of market experience in the operation or hosting of EVSE, which may otherwise have prevented timely delivery of the EVSE network in support of the Trial.

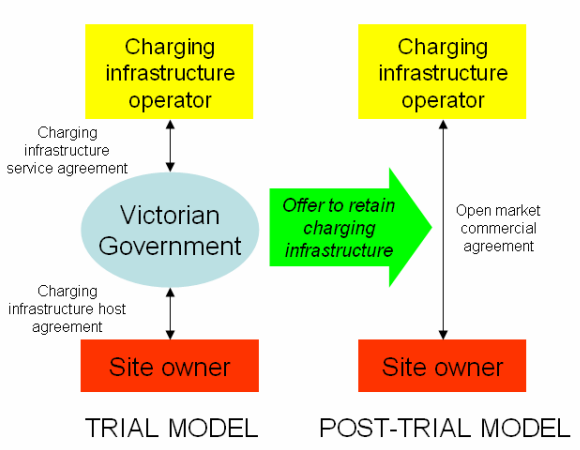

Figure 5. Victorian Electric Vehicle Trial charging infrastructure model

2.3 Economic, environmental and social impacts assessment

Assessment of the triple-bottom line impacts of a Victorian EV market is critical to policy development and ensuring future market sustainability. Accordingly, an economic model of the Victorian EV market has been developed that provides insights into the medium to long-term impacts from the market development under a range of scenarios [20]. The partial-equilibrium model captures primarily the capital and operating costs and benefits associated with the deployment of EVs in Victoria and compares them to a baseline which assumes no EV uptake. The initial model outputs have shown that under all scenarios, EVs provide a long-term economic benefit for Victoria primarily due to the transport energy cost savings in switching from oil-based fuels to electricity. These benefits flow mostly to Victorian households, then onwards into the Victorian economy as a reflection of increased household spending-power. The timing and scale of these benefits is influenced most by oil prices relative to electricity, EV purchase prices relative to 'conventional' vehicles, and the accessibility of EV charging infrastructure. The policy levers available to the Victorian Government include reduced EV purchase prices and increased access to EV charging infrastructure through investment in research and development, streamlined market access and promotion of market competition.

The social impacts of EV uptake in Victoria are mostly considered in the form of employment. The economic model described above fails to capture the benefits associated with local industry development, which given Victoria's automotive industry may be significant. Additional benefits through job creation in the electricity market may be even more significant, noting that most of Victoria's electricity is locally produced, the labour requirements for construction and operation of a widespread EV charging network, and the pre-eminence of the utility sector as an employment multiplier over the next best industry sector – automotive manufacture [21]. A 2010 survey of a small number of Trial participants reinforces these views, as over the life of the Trial it was predicted that 500 new jobs would be created and around $AUD 43 million would be invested in Victoria [22].

In addition to the emissions modelling captured as part of the economic model above, a scoping study has been carried out into the environmental impacts of EVs in Victoria [23]. The findings of the desktop review indicate that the operational benefits from EV operation will likely exceed the manufacture/disposal impacts associated primarily with the batteries. A specific issue for Victoria is however the greenhouse gas emissions arising from Victoria's predominantly brown-coal sourced electricity. National electricity generation emissions factors indicate that a vehicle operating from electricity sourced from the Victorian grid will currently produce more greenhouse gas emissions that its petrol equivalent. The Trial is addressing this through the purchase of renewable electricity credits for an equivalent amount of energy as that consumed by the Trial vehicles, and

by clearly linking renewable energy to EV operation (e.g.) as part of "total cost of ownership" calculations.

2.4 Education and awareness program

The education and awareness program includes activities aimed at the corporate and government market stakeholders, and community engagement more broadly.

The project consults and communicates directly with the market participants through a monthly "Trial Planning Working Group" meeting, during which emerging market learnings are conveyed, Trial design directions tested and findings delivered. Around 40 representatives of corporate, advocacy and government organisations regularly attend this meeting from the 100 who are invited and provided with the meeting inputs/outcomes. This meeting is supplemented by a monthly "Interoperability Working Group" meeting aimed specifically at EVSE issues in recognition of the needs of this new sector.

The state of Victoria is one of 7 states in the Australian federation, sitting between the Australian government and local government, which itself consists of 79 councils in Victoria alone. The need to coordinate across the portfolio and jurisdictional responsibilities of government is being addressed through a local government working group, and through a National EV Network that is being superseded by a National EV Roadmap development process delivered under the auspices of the ministerial councils for transport and energy. In addition, the project managers for the various EV trials underway around Australia are engaged through a monthly working group, aimed at sharing information and coordinating activities where appropriate. Engagement with national policy and regulatory development processes includes sponsorship of a National EV Standards development project [24] and close involvement with the review of energy market barriers to EV uptake [25].

The Trial community engagement program uses four channels: a website for "permanent" content, an e-newsletter for "time-specific" content, a web forum/discussion board for "user-sourced" content, and project partner communications for more widespread distribution of content to varied and specific audiences. The design of content draws on basic messaging that forms part of a project communications plan, following which delivery is coordinated across the aforementioned channels.

The 2012 household application to participate process provides a case study of this approach. The key high-level messages relevant to this activity include "Victoria is an EV-friendly place", and "Victoria will benefit from the uptake of EVs". The application process was then delivered in partnership with Victoria's peak motoring organisation, and promoted through the website, e-newsletter, social media and independent communications by around 20 of the Trial project partners. By way of example, the following message was provided to project partners for delivery through their corporate Twitter accounts:

Drive an #EV for 3 months. Take part in the Victorian Electric Vehicle Trial. Applications open til 16 DEC #electriccar http://ow.ly/7uX6W

Supplementing the household and fleet vehicle allocations is a range of structured and unstructured test-drive opportunities being delivered specifically for the purposes of community engagement. These experiences are aimed at moving EV technology from being an abstract and future concept in the minds of Victorians [26] to the here and now.

3 Market establishment

The technology market development theories of Rogers [27] and Moore [28] are widely known and have been adopted in considering the status and path forwards for the Victorian EV market [29]. This is reflected in the design of the Trial vehicle roll-out, whereby participants for the first year of the Trial have been selected on the basis of their alignment with the "first mover" demographic. Due to the higher prevalence of "mainstream" consumers amongst the Trial participation applicants, the 2012 and 2013 participants are able to be selected on the basis of other criteria in support of separate lines of inquiry.

Figure 6. Victorian Electric Vehicle Trial public charging infrastructure roll-out process

Profiling of the participant consumer demographic is being undertaken to provide insights into the issues and opportunities for each of the consumer groups, which it is hoped will increase the probability of the Victorian EV market "crossing the chasm" [28].

The household application to participate process itself provides a rich data-set upon which the market can build. General media coverage at the launch of application process in October 2010 ensured that a wide cross-section of the Victorian community was alerted to the Trial participation opportunity, and with this the insights into the demographic profile of potential market participants identified. By way of example, postgraduate-qualified individuals were the largest educational demographic among applicants [30].

The fleet roll-out has similarly focused upon first mover issues and opportunities. Fleet motivators and barriers have been analysed through the lens of early market development, and the learnings collated for distribution to the wider market. Information compiled from the 2011 fleet roll-out has been collated and interpreted to inform the design of a training workshop for fleet managers [31], the first of which was delivered in January 2012. A communications program targeting CEOs is being designed in recognition of the identified point at which first mover market decisions are located.

Short-term vehicle allocations have been more focused upon the community engagement objectives of the Trial. As of January 2012, around 1000 people have been able to sample EV technology through the structured test-drive programs. In addition, Trial EVs are being deployed into car-share programs as a means of promoting more widespread experience of EV technology, while providing insights into the suitability of the technology for that application.

Under the Trial, the Victorian EV charging network is being established using a holistic approach originating from stakeholder and issues analyses. Each aspect of the roll-out is being benchmarked to identify issues, design and test solutions, and refine the approach to promote efficiencies for the Victorian market operation. The public site roll-out process illustrated in figure 6 provides a vivid illustration of the many opportunities available for greater efficiency. The time and resource found to be involved in the commercial negotiation stage has led to a portfolio approach being taken with future roll-outs, whereby single/parent legal agreements with large commercial property owners are being pursued to deliver multiple EVSE sites at various locations within their portfolio of assets.

At a micro level, the performance of individual sites is being measured against a common assessment framework, and the outcomes interpreted into guidance to inform the various stakeholders who will take the market forwards. By way of example, training materials are being prepared for parking enforcement officers to be delivered alongside the standardised signage, ground-marking and number-plate stickers that have already been developed. Through

coordinated development and implementation, these items will help ensure that optimum value will be realised from investment in public charging infrastructure.

The early market supply-side activities above are accompanied by demand-side activities mostly relating to addressing information barriers for consumers. As of January 2012, the project e-newsletter had around 4000 subscribers who are treated to monthly updates on the achievements and learnings from the Trial and EV-related announcements from the 60 corporate Trial partners. The public-facing discussion board contains over 200 posts originating from individuals who have experienced the Trial vehicles. The Trial project team has presented to over 30 conferences or seminars. The Trial household participants have independently initiated their own blogs, have voluntarily taken part in a range of media reports with widespread distribution to the Victorian community, and have provided a human face for this new technology. These activities are helping to raise awareness, understanding and acceptance of EV technology in a market which as of January 2012 is estimated to consist of around 100 vehicles, half of which operate under the auspices of the Trial.

4 Market growth

Understanding the 'sweet-spots' for EV take-up in Victoria is an objective for analysis of the household participant data-set. By drilling down into the household demographics, travel behaviours and attitudes, a better understanding of the key indicators and influences on future market growth will be established. The Victorian Government is a funding partner in the Commonwealth Science and Industrial Research Organisation (CSIRO) Electric Driveway project, an output of which is a spatial model of the Victorian EV market uptake [32]. Improvements to the model predictions will be made possible through insights obtained from the household vehicle allocations. Improved reliability of the modelling predictions will support more targeted investment and thereby promote more effective, efficient market uptake.

A key issue to be managed alongside EV market growth is impacts upon the electricity network. The CSIRO Electric Driveway project is building upon the spatial model of market uptake described above to provide insights into impacts on the Victorian electricity network that may arise from different market uptake scenarios [33]. The measured demand profiles arising from the charging behaviours of the Trial household participants informs the modelling, which in turn informs the design of the Trial. Deployment of vehicles for the second and third years of the Trial is focusing on geographically specific areas of the network that are well characterised and able to be monitored – refer to figure 7 for a map of the 2012 allocations. Grid impacts on several network feeders arising from 10 per cent EV penetration and equivalent or more solar PV generation capacity are being measured. Behavioural response of these households to tailored information and electricity tariff price offers will be investigated. As these studies are being undertaken in partnership with various electricity market participants, the outcomes will inform business model development, investment and policy design in support of sustainable EV market growth.

The other objective for the 2012/13 household vehicle allocations is to further investigate public EVSE's impact upon behaviours and attitudes. Households taking part in the Trial provided information about their travel destinations as part of the application process, which was subsequently used as part of the selection process to create likely user-groups for "destinations of interest" – figure 7 shows the locations for two of these sites relative to the household participants.

The owners of these sites have since been engaged to partner with the Trial in hosting publicly-accessible EVSE, with the roll-out being phased to align with the vehicle allocations for each site user-group. By optimising the information and management strategies for these sites and measuring the user-group behaviours and opinions, insights will be gained to guide future investment in public EVSE.

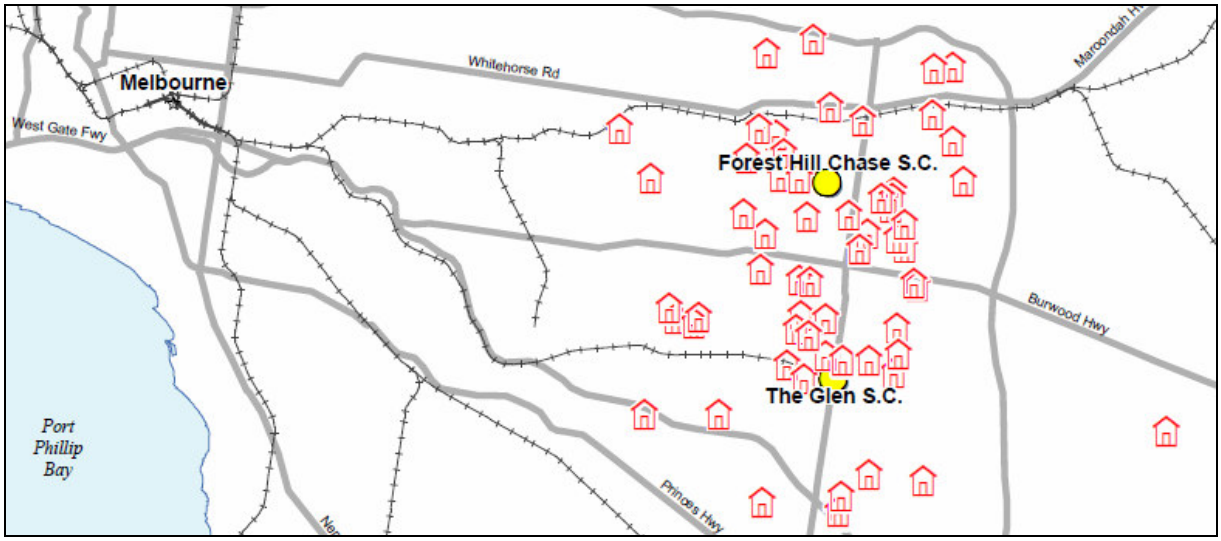

Figure 7. Victorian Electric Vehicle Trial 2012 household allocations, including location relative to two Shopping Centres (SCs) that were identified by participants during the application process as likely travel destinations

The fleet activities are being progressed towards market growth through a project aimed at quantifying the Australian fleet market for EVs. The project, being delivered in partnership with The Climate Group, draws on international precedents in being targeted at delivery of a fleet EV purchasing coalition. As part of the investigation, effective measures to promote EV uptake by fleets are being investigated for implementation to promote market growth even if a purchasing coalition is not pursued.

A key enabler for long-term market growth is alignment of planning provisions for land development with EV charging requirements. To this end the Trial is striving to influence land-use planners, traffic managers and developers through the provision of guidance applicable to the existing planning frameworks [34].

In recognition of the proprietary solutions that are continually emerging for dedicated EV charging technology and the avoided cost argument that is mostly associated with pre-installation of the underground/in-wall cabling, the recommended solution is to install capped wiring and distribution board capacity to support future implementation of dedicated EVSE by the building owner/vehicle operator at the time of it being required. This approach optimises the net present value of the pre-installation while minimising the cost impost upon the developer, in recognition of the equity distribution of costs and benefits.

A survey of the EV technology and/or service providers taking part in the Trial found that most believed roll-out of a fully interoperable market that allowed EV drivers to roam across charging networks to be a worthy but longer-term objective. Analysis commissioned by the Trial based upon lessons borne of telematics (toll-roads in particular) found that interoperability could be broken down into three key issues: physical, systems and back-office [35]. Due to the involvement of so many technology and/or service providers the Trial has been effective at progressing considerations of interoperability both as a threshold issue for Trial delivery (vehicle/EVSE compatibility), and in support of a fully-interoperable model in the medium to longer-term. By way of example, provision of data into the Trial by the various corporate participants has necessitated agreement on a common data schema for each data segment – vehicles, EVSE, electricity transactions. In the case of EVSE, agreement on a common data schema is the starting point for market interoperability, as charging activities are able to be communicated between providers using a common set of attributes.

An interesting outcome from incidental discussions with the households participating in the Trial has been the number who first entered to participate at the behest of one of their school-age

children. As an outcome from this a decision was taken to invest in the development of a teaching program for schools focused upon EVs. A steering group of education professionals was established and a literature review undertaken of teaching technology concepts to children. From this, a holistic teaching program was developed in alignment with the learning objectives of the Victorian school curriculum, thereby providing teachers with an answer to their existing needs rather than to a problem they didn't actually have. The program includes a range of teacher and student resources have been validated through a pilot program and now made available free and online [36] – refer to figure 8 for an image of "Evie", the program mascot. Through delivery of this educational program improved awareness, understanding and acceptance of EV technology can be brought into homes right now and in support of the next generation of drivers/car-buyers.

Figure 8. The EV School mascot - Evie

5 Summary and conclusions

In this paper a description has been provided of the Victorian Government's Electric Vehicle Trial market development initiative. The Trial represents an innovative approach to public policy development, that offsets the risks associated with public sector deliver of such a project with the key insights that are provided from maintaining close involvement in the market establishment. Through this approach, benefits to Victoria will be optimised through an efficient, safe roll-out of the EV market.

Acknowledgments

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