Potential Early Adopters of Electric Vehicles in Victoria

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1. Introduction

Under the *Victorian Transport Plan*, the Victorian Department of Transport has committed to conducting trials of electric vehicles in Victoria for a period of 5 years from 2009-10. The purpose of these trials is to provide real-world information on the use of electric vehicles in Victorian conditions, including any impact on driver behaviour, refuelling patterns and vehicle performance and efficiency. For the purpose of this paper, 'electric vehicles' are passenger vehicles that are able to be charged from the electricity grid, i.e. fully electric and plug-in hybrid passenger vehicles.

This paper seeks to develop a picture of likely early adopters of electric vehicles within metropolitan Melbourne and where they are located. It will examine theories of market development for new technologies and overseas evidence of the characteristics of early adopters of new electric vehicle technologies. This information will be used to inform the development of the electric vehicle trials, including identifying consumers or areas for placement of electric vehicles and/or recharging infrastructure.

Commercial and government fleet purchases are particularly important markets for new car sales, and are likely to be important markets for early electric vehicles. The drivers of the purchasing decision for commercial and government fleet vehicles are however likely to be very different than for private purchasers. This paper seeks to explore the drivers of the purchasing decision for electric vehicles by private consumers only.

With so few electric vehicles available worldwide, it is not possible to assess consumer willingness to purchase electric vehicles on the basis of revealed purchasing behaviour. However, it may be possible to approximate who would be likely early market electric vehicles adopters on the basis of who is currently purchasing hybrid vehicles. Hybrid vehicles share a number of key features with electric vehicles, including significantly improved fuel efficiency, a price premium relative to a comparable internal combustion vehicle and perceptions of the innovativeness of the technology.

Electric vehicle technology has been around for well over one hundred years, dating back to the 1830s. The electric drive was the dominant vehicle technology in the early 20th century (Department of Energy 2009). However, this changed with increasing availability of oil reducing the price of petroleum, better road infrastructure between cities enabling longer-distance driving, the invention of the electric starter in 1912 and mass production of internal combustion vehicles by Henry Ford (Department of Energy 2009). These factors made internal combustion vehicles more attractive than electric vehicles and led to internal combustion engines becoming the dominant technology by the 1920s, a situation that continues to this day.

There is a small range of vehicles with electric motors available worldwide today that allow storage batteries to be recharged from the grid. The US Energy Information Administration (2007) estimated there were 55,730 electric vehicles (passenger and other) on the road in the United States in 2007. Blade Electric Vehicles supplies a small number of retrofitted (internal combustion engine replaced with an electric engine and battery storage) passenger vehicles in Victoria. While there are few electric passenger vehicles available in 2009, a number of new vehicles are expected at market in the near future.

While electric vehicles have a number of characteristics in common with current internal combustion engine vehicles, there are also some key differences. Refuelling requirements of electric vehicles are very different to internal combustion vehicles. Electric vehicles present a challenge in that single-charge range will likely be far below that of a comparable internal combustion vehicle, with no simple and quick way to recharge (assuming fast recharge infrastructure is not available).

2. Literature Review

2.1 Market development theory

In many ways, excluding issues with range and recharging requirements, the evolution to electric vehicles is similar to the evolution from internal combustion vehicles to petrol-electric hybrids. Hybrids represent the first real evolutionary shift in vehicle technology since the internal combustion became the dominant vehicle technology in the early 20th century. Because of the newness of electric vehicle technologies, potential adopters of these vehicles would likely have different characteristics and needs to the average purchaser of internal combustion vehicles.

Rogers (1962) ‘technology adoption life cycle’ (Figure 1) identifies different groups of consumers according to their potential for adopting a new technology. He argues that around 16 per cent of the market is quick to adopt new technologies, such as hybrid or electric vehicles, once they come to market, so long as the new technology is seen as better than the one it is replacing. Early adopters of a new technology, including both Rogers’ ‘innovators’ and ‘early adopters’, are followed by the majority, who are likely to adopt the new technology once it is mature and is more likely to address their needs.

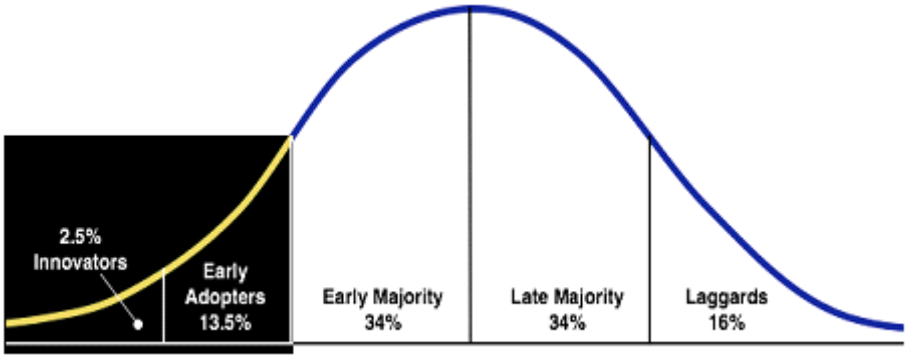

Figure 1: Adoption Life Cycle for new technologies

Source: Rogers (1962)

Moore (1999) further refines Rogers' model, suggesting that there is a disassociation between adopter groups, representing the next group's reluctance to adopt the new product in the form that appealed to the previous adopters. Moore suggests that the largest such break is between the early adopters and the majority. Technologies that appeal to early adopters and gain a strong following amongst these consumers may struggle to find mass acceptance or take some time to transition from niche to mass-market appeal. From Moore's work, it can be assumed that potential early adopters of electric vehicles will have different characteristics to the majority, hence this paper's focus on the early market.

2.2 Overseas evidence

Economic rationalists view the vehicle purchase decision – why consumers choose a particular vehicle – purely in terms of costs and benefits. That is, vehicle purchase and running costs are seen as the main drivers of which vehicle a consumer will purchase. Thus, under the rationalist view, a higher purchase price would only be justified with lower vehicle running costs, most notably fuel efficiency, and vice versa.

However, vehicle purchase decisions are seldom made on the basis of fuel economy or environmental performance alone. Evidence suggests that, while consumers list fuel consumption and running costs as important factors when choosing a car, most do not fully value future fuel savings (OECD 2008). Fuel consumption and environmental performance do not tend to feature highly in the factors that people consider when choosing which car to buy, with performance, power, engine size and the brand image rated as more important (King 2008). In some cases, these features may act against realising better overall fuel economy performance. Australian fleet average fuel consumption over the past 20 years has barely changed, despite engine technology improvements reducing the amount of fuel required to move a new vehicle of a given size by around 1.3 per cent per year, because of a shift towards increased vehicle power and weight, growth in demand for large vehicles such as four-wheel drives and increased availability of in-car accessories such as air-conditioning and other auxiliary devices (DOTARS 2002).

Electric vehicles, along with petrol-electric hybrids, offer better fuel economy than a comparable internal combustion vehicle, but at a cost premium. The Toyota Prius, the best selling hybrid vehicle to date with world sales of over 1 million since release, retails from US$22,000 in North America and from $37,400 in Australia (Toyota 2009). Heffner et al (2007) find that the private benefits of hybrid vehicles (from reduced cost of fuel consumption) are less than the price premium relative to a comparable non-hybrid alternative.

While hybrid vehicles have been available for a number of years, they still appear to be firmly in the early adopter segment. Eight years after introduction into North America, hybrid vehicles accounted for less than 2 per cent of light-duty vehicle sales by 2005 (Heffner et al 2007).

3. Methodology

3.1 Electric Vehicle Early Adopters

Early adopters of hybrid and electric vehicles are likely to share certain key characteristics. Turrentine et al (2007) found that hybrid vehicle purchasers made their purchase decision for ideological reasons and not primarily to save money, and paid little attention to fuel costs. To these buyers, the higher fuel economy of the hybrid compared to other vehicles made them feel good about their vehicle choice. Turrentine and Kurani (2006) found hybrid vehicle purchasers talked about “making a commitment”: setting an example, being a pioneer, talking to other people about their car. These people were attracted by the new technology, the low emissions and by the sense of consuming fewer resources and saw their hybrid as worth the price, given the ‘whole package’.

This view of vehicle purchasers as non-rational agents argues that it is more appropriate to view the vehicle purchase decision as a means of expressing personal symbolism than as a means to minimise costs. Heffner et al (2007) find symbolism is particularly strong in vehicles that use new types of technology and was particularly relevant to early buyers of battery electric vehicles and hybrids.

Evidence from overseas suggests that early hybrid adopters broadly share a number of characteristics, including:

- Higher incomes than the average population. Studies in the US found early hybrid purchasers had average incomes of more than twice the national average (Klein 2007, Scarborough 2007), and early Prius adopters in Switzerland also had significantly higher average incomes than purchasers of other vehicles (de Haan et al 2006);
- Higher levels of education (de Haan et al 2006), with adults in hybrid-owning households over twice as likely to have a university degree and above-average technological skills (Scarborough 2007); and
- In general older than the average car buyer (Scarborough 2007, de Haan et al 2006).

4. Victorian assessment

4.1 Hybrid vehicle sales

As can be seen in Figure 2, Toyota Prius[1] registrations in Victoria have increased continually over the period 2002 to 2009. Areas with highest total Prius registrations are the Local Government Areas (LGAs) Melbourne (963) and Boroondara (242). It should be noted however that total Prius registrations remain very low, with the total of 3,267 Prius registered in Victoria in 2009 representing 0.1 per cent of the total registered Victorian passenger vehicle fleet (VicRoads 2009). While low, this figure represents a 49 per cent increase over Prius registrations in Victoria in 2008 (ABS 2008b).

While total Prius numbers remain small compared to the total number of passenger vehicles in Victoria, the exponential growth in numbers is typical of the early adopter market as described by Rogers and Moore (see Figure 1).

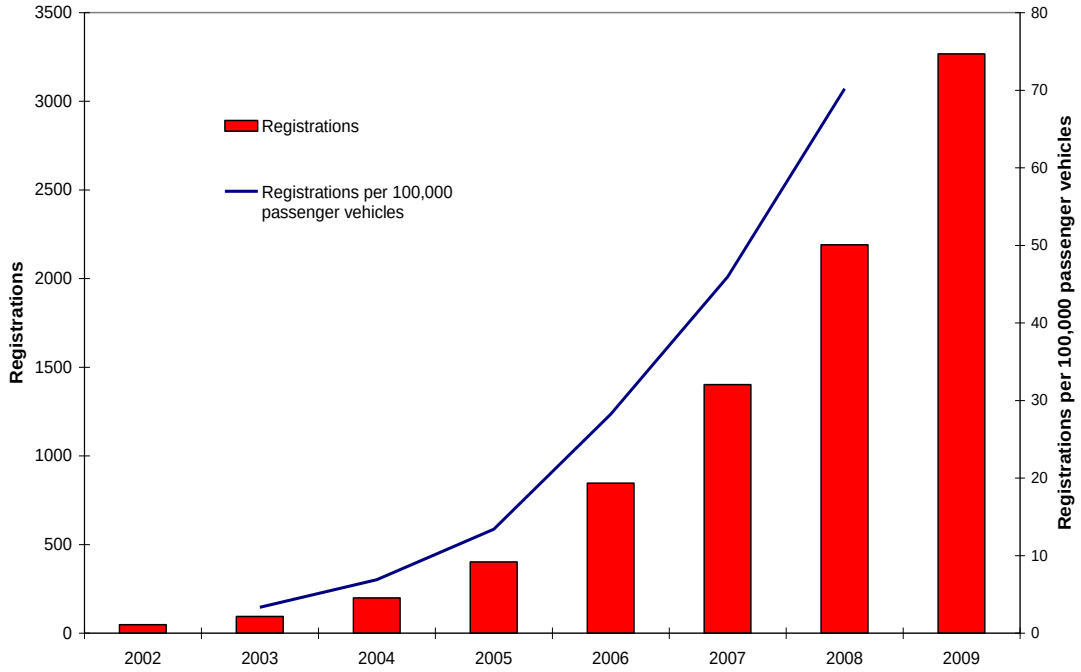

Figure 2: Toyota Prius registrations, Victoria, 2002 – 2009

Source: ABS (2002-2008) and VicRoads (2009)

4.2 Early Adopter market

Assuming that early adopters of electric vehicles would have similar characteristics to early adopters of hybrid vehicles, we were able to examine households within metropolitan Melbourne to see where potential early adopters may be located. Population census data (ABS 2006) provides a range of socio-demographic information on Victorian households, including income, education and age profiles. Based on evidence from overseas, the following criteria were used to assess whether households were potential early market adopters of electric vehicles:

[1] While the Prius is not the only hybrid vehicle sold in Victoria, it was selected for this analysis due to ready availability of sales data.

- Household weekly normalised income[2] of $1,052 or higher (top quartile);
- At least one adult member of the household with a bachelor degree or higher;
- Households with broadband internet access (as a proxy for technological skills); and
- households with two or more vehicles

The additional criterion of two or more vehicles in a household was included to account for the potential single-charge range limitations of electric vehicles that do not exist with hybrid vehicles. While the single-charge range of electric vehicles should be sufficient for average per vehicle weekday travel across Greater Melbourne of around 36km (Department of Transport 2009), consumers who make occasional longer trips, or value the potential ability to make longer trips, may be unwilling to adopt a vehicle where there is concern over range. It should be noted however that some households with only one vehicle may become early adopters of electric vehicles.

In our analysis, a household has to meet all of these criteria to be considered a potential early market adopter of electric vehicles. Nearly 80,000 households (6.2 per cent) across metropolitan Melbourne meet all of the specified criteria out of a total of just over 1,283,000 households (ABS 2006).

While overseas evidence suggests age is a significant factor in the decision to purchase a hybrid vehicle, it has not been included in our analysis. It is worth noting that the pattern of tertiary education by age differs significantly locally from overseas. A total of 15.4 per cent of Melbournians aged 45 and over have completed tertiary education (ABS 2006), compared to 27.1 per cent of people in the United States (US Census Bureau 2008)[3].

While there would likely be a number of potential early market adopters of electric vehicles in regional Victoria, in particular within large regional centres such as Geelong, Bendigo and Ballarat, for simplicity this analysis focuses on metropolitan Melbourne only. Future work may include an analysis of the potential for electric vehicles in regional Victoria.

4.3 Location of potential early adopters

As shown in Figure 3, which maps the proportion of households that meet all of our criteria by Census collection district[4], the majority of potential early electric vehicle adopters are located in a band east of Melbourne's CBD from Bayside in the south through to Nillumbik in the north (see highlighted area on map). While there are a number of other Census collection districts not in this

[2] Income estimates adjusted by equivalence factors to standardise them for variations in household size and composition, while taking into account the economies of scale that arise from the sharing of dwellings

[3] This difference is likely to be even greater for metropolitan areas, with the US figure including rural populations. USDA (2003) and ACER (2002) note that in both the US and Australia, participation in tertiary education is much higher for urban than non-urban populations.

[4] In urban areas a collection district comprises on average about 200 dwellings, while in rural areas this number is usually fewer.

band with a relatively high proportion of households meeting all criteria, including Sanctuary Lakes in Wyndham LGA in Melbourne's west and a number of areas on the Mornington Peninsula, none of these collection districts have in excess of 25 per cent of households that meet all criteria.

The electric vehicle trials are intended to include representatives from different market segments, including potential early and late adopters with different vehicle usage patterns. The identified area in Melbourne's inner east may be the most appropriate location to conduct trials, particularly with regard to siting electric vehicle recharging infrastructure, to capture the majority of the early market for electric vehicles.

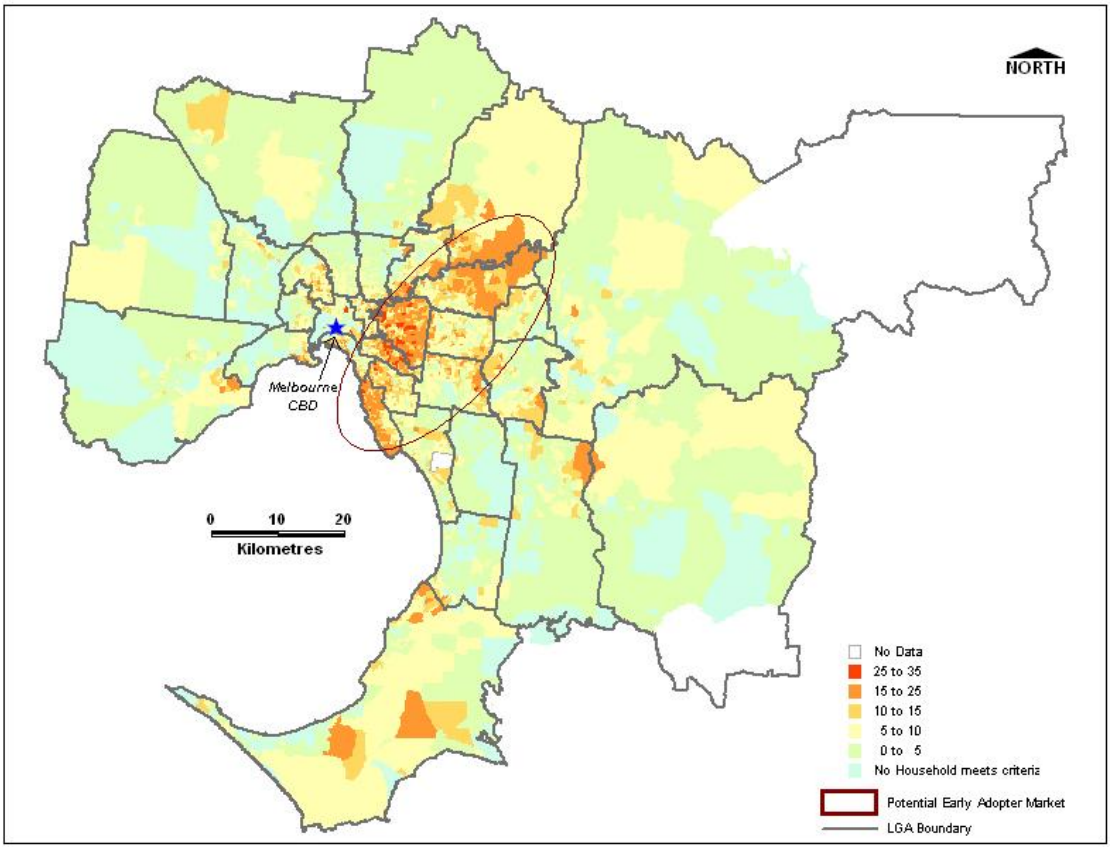

Figure 3: Households meeting electric vehicle early adopter criteria

Source: ABS Census of Population and Housing (2006)

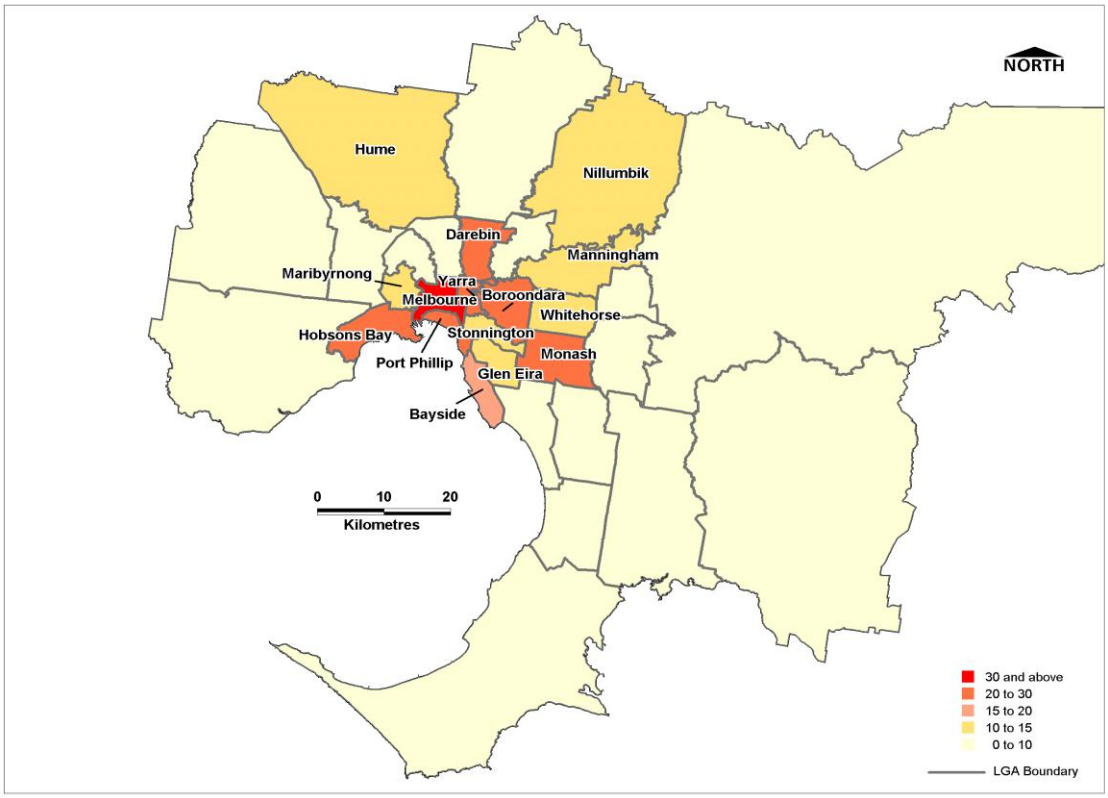

Figure 4: Prius Registrations per 10,000 households 2009, by LGA

Source: VicRoads (2009)

Figure 4 shows Toyota Prius registrations per 10,000 households at June 2009 within each of the metropolitan Melbourne LGAs. The areas with highest concentrations of Prius registrations are Melbourne and Boroondara[5]. Prius registrations are largely within the inner city and in the inner-east band.

Comparing Figures 2 and 3 allows us to determine if hybrid vehicle registrations is an appropriate basis for determining potential early market adopters of electric vehicles. Figure 5 charts potential early adopter households against Prius registration intensity for each LGA within metropolitan Melbourne. There appears to be some correlation between the two although it is not strongly statistically significant, with a number of LGAs with higher than expected Prius intensity. These LGAs (circled) are explored further in Table 1, with the corresponding average figures for the Melbourne Statistical Division included for reference. Melbourne LGA, with 5.4 per cent early adopter households but 56.7 Prius registrations per 10,000 households, has been excluded from Figure 5 but is included in Table 1.

[5] Melbourne LGA has in excess of 700 Prius registered with Victorian Government fleets (73 per cent of the total number), and Boroondara 84 Prius registered with VicRoads (35 per cent). These figures have been excluded from the analysis.

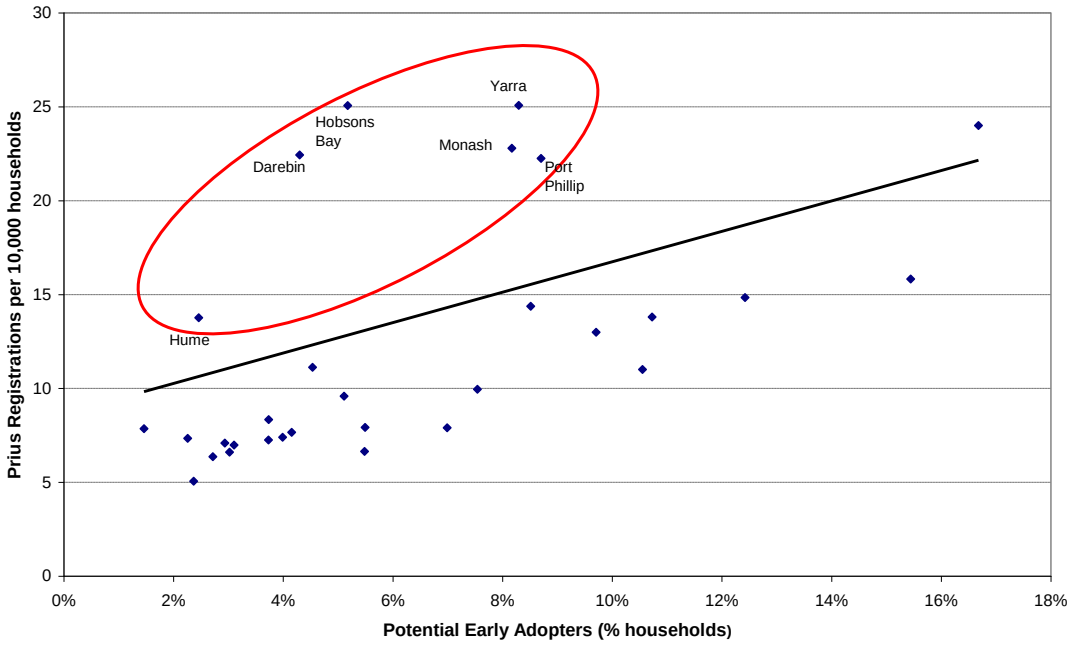

Figure 5: Potential early adopters and Prius registrations

Source: ABS Census of Population and Housing (2006)

Table 1 shows those LGAs identified in Figure 5 where total Prius registrations are higher than the number of identified early adopter households would suggest. It can be seen that Melbourne, Port Phillip and Yarra LGAs in particular have a very low percentage of households with 2 or more vehicles (Darebin similarly has 13.4 per cent fewer households with two or more vehicles than the metropolitan Melbourne average). Darebin, Hobsons Bay and Hume all have a below-average number of households meeting the income and broadband connection criteria. Hobsons Bay and Hume also have fewer persons with university education than the Melbourne average.

Table 1: Early adopter criteria, selected metropolitan Melbourne LGAs

LGA	Weekly income $1,052+	2+ vehicles	Broadband internet access	Bachelor degree or higher
Melbourne Statistical Division	*48.6%*	*51.6%*	*44.7%*	*36.2%*
Darebin	**41.0%**	**38.2%**	**36.5%**	40.6%
Hobsons Bay	**45.6%**	**47.9%**	**39.5%**	**31.8%**
Hume	**45.5%**	59.4%	**40.3%**	**19.4%**
Melbourne	49.1%	**18.3%**	61.3%	53.1%
Monash	50.0%	55.2%	51.0%	43.7%
Port Phillip	54.8%	**29.2%**	48.2%	49.7%
Yarra	53.0%	**28.7%**	45.8%	57.0%

Source: ABS Census of Population and Housing (2006)

5. Implications for Electric Vehicle trials

Based on our assumptions about who are likely to be early adopters of electric vehicles, early adopters are likely to be concentrated in the band running from the southern part of Nillumbik LGA down to Bayside east of Melbourne's CBD (Figure 3). Comparing our prediction about early adopter households with evidence of early adoption of hybrid vehicles in metropolitan Melbourne (Figure 4) suggests that our identified electric vehicle adopters will largely be drawn from the same areas as current hybrid purchasers. This paper finds that early adopters of electric vehicles are however less likely to be drawn from those inner-city areas where hybrid sales have been strong, largely due to the assumption that early market adopters of electric vehicles will come from 2+ car households due to potential range limitations of these vehicles and the potential for consumer reluctance to purchase a vehicle with limited range.

Figure 3 provides a picture of where electric vehicle early adopter households are most likely to be located, and thus may be used to support the development and implementation of electric vehicle trials. While the intention of these trials is to generate electric vehicle usage information for all market adoption segments, early adopters in particular will be critical in proving the new technology in the market place. Those areas identified as having a high proportion of potential early adopters may also be appropriate locations for installation of electric vehicle refuelling infrastructure as part of the trials.

This paper represents a beginning in understanding the potential for electric vehicles in Victoria. However, the analysis could be extended in a number of areas that were beyond the scope of this paper, including looking beyond the early adopter market to later market segments, including their characteristics and any potential barriers to adoption of electric vehicles by these groups. We could further seek to improve our understanding of diffusion models for green technologies and undertake further analysis of a range of scenarios of electric vehicle take-up based on choice and economic modelling.

Further work also needs to be done to understand potential electric vehicle refuelling patterns and behaviour for different market adopter segments across different geographic areas. This would include any implications for time-of-use electricity demand and pricing and how electric vehicle single-charge range constraints may impact on the uptake and usage patterns of these vehicles by different users. Further analysis could also be undertaken to assess the potential for electric vehicles across other areas of Victoria, including the potential for electric vehicles in major regional centres including Geelong, Bendigo and Ballarat. Further analysis could also be undertaken to assess the potential for adoption of electric vehicles by commercial and government fleets.

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