Australasian Transport Research Forum 2019 Proceedings
30 September – 2 October, Canberra, Australia
Publication website: http://www.atrf.info

The path to EV uptake – The Fourth Wave

Alan Dunn[1*], Martina Calais[1], Gareth Lee[1]
[1]School of Engineering & Information Technology, Murdoch University, Perth, Australia

*Email for correspondence: 30379386@student.murdoch.edu.au

Abstract

The replacement of conventionally fueled passenger cars by electric vehicles (EVs) has long been expected across the world as developed nations move away from fossil fuels and towards energy use that is cleaner, cheaper and renewable. However, where some nations have shown a clear path towards rising EV uptake during the past decade, Australia has steadfastly refused to follow: EV uptake has been extremely limited, while established patterns of liquid fuel consumption have continued unabated. The potential virtues of EV adoption have been extolled from all the usual perspectives: environmental benefits have been measured, low economic running costs have been highlighted, and even improved levels of energy security have been indicated. But these arguments to encourage EV uptake have failed to gain any traction sufficient to replace the status quo of a national road transport system that has grown to rely on a diet of imported conventional liquid fuels.

A recent survey of industry, research and government operatives by Murdoch University researchers probed public awareness of the complex issues surrounding transport fuel economics and the reasons for consumer reluctance to change to EVs. The main aim of this paper is to use information from the survey as evidence to support the theory that the path to improving EV uptake in Australia will continue to fail unless EVs become available under a certain set of conditions, or possibly until it happens by default when The Fourth Wave arrives.

1 Introduction

Commercial sales of plug-in electric vehicles (EVs) in Australia began in 2008 with the Blade Electron, which was a domestic electrical conversion of the popular Hyundai Getz hatchback (Porter, 2011). A year later, the Mitsubishi i-MiEV was introduced, followed by the initial rollout of the Better Place charging network (Stevens, 2010), then several EV trials around the country, such as the WA EV Trial (Speidel et al. 2012). But despite this activity and all the optimistic forecasts of their expected uptake, a decade has passed and in 2019 EVs are yet to be embraced by Australian consumers. They still form less than 0.1% of the national light passenger vehicle fleet (ClimateWorks Australia and Electric Vehicle Council, 2018), with less than 10,000 plug-in hybrid or pure rechargeable EVs registered on Australian roads (Martin, 2019) out of the 14.3 million strong passenger vehicle fleet (ABS, 2018).

This response is quite different to that of many European nations, such as Norway where EVs now account for almost 60% of new car sales, rapidly increasing from the 31% market share of new sales they achieved in 2018 (Chappell, 2019). Even parts of the car-friendly USA have experienced relatively strong EV uptake in recent years, particularly in California. And just like Norway, this has occurred on the back of strong government subsidies and other policies to encourage uptake of low emission vehicle types such as EVs (HEV TCP, 2019).

But federal government support for EVs has not been forthcoming in Australia. Nor has there been a strong follow-up from industry, with few models being supplied to the Australian market due to its small size (ClimateWorks Australia and Electric Vehicle Council, 2018). Also, the value proposition for EVs, in particular the economics of ownership compared to internal combustion engine (ICE) equivalents, has been poorly presented to consumers from the outset (Parliament of Australia, 2019). Until recently, most of the encouragement for EV uptake has focused on three main perspectives:

(i) Environmental benefits: increased uptake of EVs as a replacement for conventional ICE vehicles should lead to lower atmospheric pollution due to the corresponding lower levels of greenhouse gas, particulate and other emissions produced from battery recharging compared to conventional vehicle fuel combustion, especially if recharged from renewable energy sources (Gaton, 2018).

(ii) Energy Security benefits: uptake of EVs will mean decreased domestic demand for foreign oil and petroleum fuels (e.g. petrol and diesel), therefore reducing imports overall, and in particular from geopolitically unstable locations. This means Australian motorists will be less vulnerable to erratic global oil prices (Energeia, 2015).

(iii) Economic benefits (macro and micro): at a macro level, uptake of more EVs will mean less oil and petroleum fuel products are imported at high cost, and therefore the national trade balance will be less affected by debt (PwC, 2018). At a micro level, uptake of EVs by individuals will mean that in addition to reduced maintenance costs, vehicle owners can pay a lower price to recharge their car batteries compared to refueling an ICE vehicle. This means that EV owners will be able to travel the same distances at a lower cost (Energeia, 2018).

It is apparent from the minimal EV uptake that these arguments have not been strong enough in Australia to persuade potential EV consumers to look beyond the high initial costs of purchase, or other perceived EV deficiencies, such as low driving range or recharging convenience (Dunn et al., 2018b). Or perhaps Australian consumers are more skeptical of the environmental benefits that EV owners claim, in a land where most electricity is still sourced from coal-fired generators (Gaton, 2018). But is this likely to change anytime soon? Are the comparative economics or environmental credentials of EV ownership likely to swing in their favour, or is it possible that another more powerful influence on EV purchase can be found which makes the value proposition for EVs more acceptable?

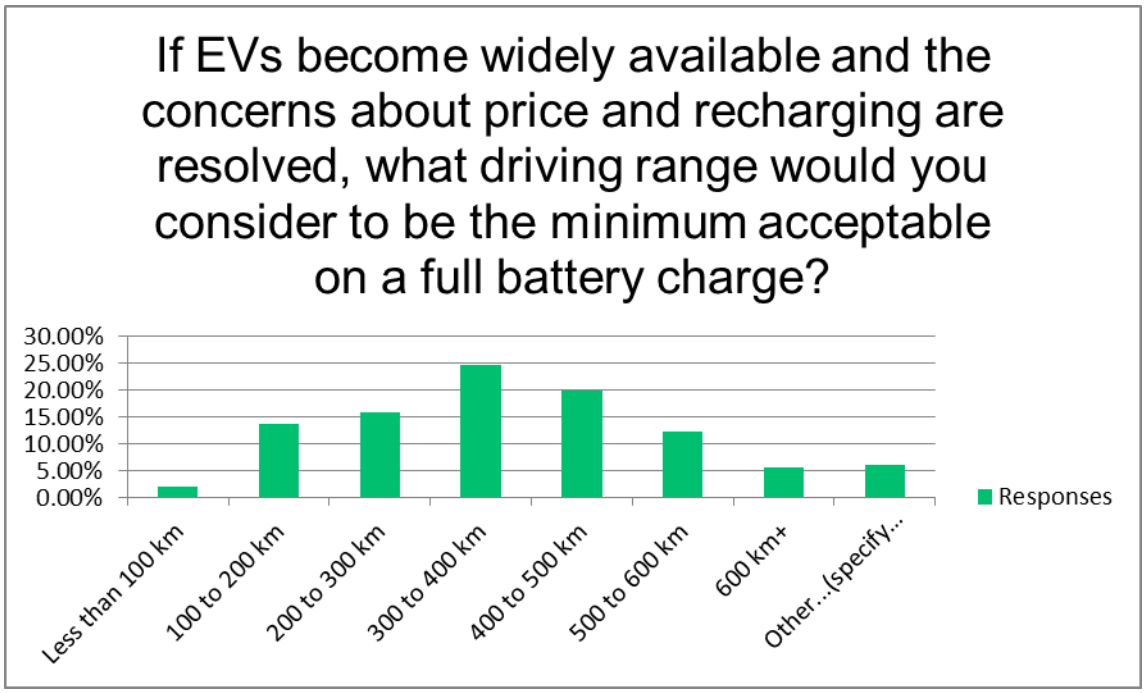
As a result of the findings from a recent survey conducted as part of a doctoral research program at Murdoch University in Western Australia, it is now thought the answer to these questions may be affirmative. The reasons for this are described in detail as follows, starting with a brief overview of the surveys which investigated the main issues surrounding EV uptake and their potential impacts.

2 The Murdoch University surveys

A recent survey, conducted in August 2018, was the second in a series (after Survey-1 in 2015) which investigated issues about Australian liquid fuel security and the potential benefits that alternative fuel adoption could have on the current situation, particularly with respect to increased uptake of electric vehicles and battery recharging technology. The initial 2015 survey explored the main reasons for the lack of consumer interest in alternative fuels and EVs (Dunn et al., 2018b), while the second survey in 2018 investigated whether the same issues and obstacles to EV uptake still existed three years later.

Both surveys were targeted at experienced workers in the Transport and Energy sectors from Industry, Government and Academic circles because it was thought that these specialists might provide unique insights into the main issues confronting alternative fuel adoption, having gained specialized knowledge from technical, research or managerial roles in these industries combined with consumer input from the general public (Dunn et al.,2018b). The survey targets were selected from online searches of publically available information for vehicle manufacturers, transport regulator offices, transport and energy research conference material, transport and energy industry reports, trade and safety association links. The selected targets were canvassed on numerous themes, including: concerns about current transport fuel use and their energy security or environmental impacts; assessment of domestically available alternative fuels; potential funding for alternative fuels; vehicle and recharging features needed to make electric vehicles more competitive with ICE vehicles; government policy incentives required to encourage electric vehicle uptake; plus, potential impacts of EV uptake on future vehicle numbers and fuel prices. An example of the topics discussed is provided below with the results of Survey Question 12 from the 2018 survey (Figure 1).

Figure 1: A graph of the results for Question 12 from the 2018 Murdoch survey.



The 20-question multiple-choice 2018 survey was released online to 1000 participants selected from Industry, Government and Academia, and received 157 responses within 30 days. This was larger than the 16-question 2015 survey which was released via email to 550 participants and received 47 responses in 60 days (Dunn et al, 2018b). In both cases, non-respondent bias at specific questions was negligible, and overall group bias was minimized by restricting recipient numbers to 50% from industry targets and 50% from combined government and academic groups. However, there was a sizeable gender and age imbalance as women form far less than 50% of the senior industry leadership group (and < 20% of respondents in both surveys), and workers with over 20 years' experience in their roles represented almost 50% of the survey respondents in both 2015 and 2018.

The overall results provided valuable insights about conventional fuel usage and how the transport and energy sectors may develop in the near future as a result of EV uptake. Many of these insights also provided further detail regarding the expected benefits and costs of increased EV uptake, as presented below.

3 The expected benefits of EV uptake – 3 main arguments

3.1 Environmental benefits

As of September 2018, 18.9% of Australian greenhouse gas (GHG) emissions were being produced by the transport sector (Australian Government, 2018) and domestic road transport accounted for 72% of the 2017 transport sector fuel consumption (DoEE, 2018). With diesel fuel consumption having risen by almost 24% during the past six years (Australian Government, 2018), there has also been a consequent increase in urban air pollution via diesel particulates and toxic gas from exhaust emissions, which include Nitrous Oxides (NOx), Carbon Monoxide (CO), unburnt Hydrocarbons (CxHy), and Sulphur Oxides (SOx) (Dean and Green, 2017). Some studies suggest that air pollution is responsible for over 3000 premature deaths in Australia each year (Dean and Green, 2017), and in 2010 the OECD estimated the cost of this morbidity from vehicle emissions to the Australian economy was over USD $5.8 billion (OECD, 2014).

Both Murdoch surveys since 2015 investigated the potential impacts of EV uptake on the light passenger vehicle sector GHG emissions. They found that respondents were overwhelmingly aware (78% in 2015 Survey, 95% in 2018 Survey) that the continued use of conventional transport fuels contributed to environmental degradation, mostly via atmospheric pollution (Dunn et al., 2019). Both surveys also found that a large majority of respondents (78% in 2015 Survey, 82% in 2018 Survey) were sufficiently alarmed or concerned by this continuing environmental impact that they agreed with the proposal that a government strategy should be developed to reduce these effects which involves the replacement of conventional fuels with domestically available sustainable alternatives (Dunn et al., 2019).

Foremost among the possible alternatives, as selected by 65% of respondents to Survey-2 in 2018, was the wide-scale adoption of rechargeable electric vehicles (Dunn et al., 2019). It is expected that the increased uptake of EVs would be particularly effective in reducing GHG emissions, given that many current EV owners recharge batteries from residential solar power or other renewable sources (Jabeen et al., 2013).

3.2 Energy Security benefits

Government data indicates that Australian domestic annual production of crude oil, LPG and condensate had dropped by 37% since 2010/11 to about 18.2 GL in 2017/18, but annual consumption had risen by 17% to over 60.4 GL of petroleum products, or 165 ML (1.04 million barrels) on a daily basis (DoEE, 2019a). At first glance, this data suggests that about 70% of the petroleum products to meet domestic consumption must be imported (DoEE, 2019a). However, imported crude feedstocks, though reduced 30% since 2011 along with domestic refining capacity, still reached 22.4 GL annually in 2017/18 and the importation of refined petroleum products more than doubled in the same period to about 36.3 GL annually (DoEE, 2019a). Therefore, on this basis it could be argued that a volume of liquid fuel equivalent to 97% of Australia's consumption is now imported, but this is offset by the 2017/18 export of 18.8 GL of crude oil and petroleum products. Regardless, 71% of this consumption occurs in the transport sector (Geoscience Australia, 2018), and a large proportion of this is the result of the daily driving activity of the ~14.3 million light passenger vehicle owners across the nation.

Australian transport fuel is sourced from numerous global locations to limit the chance of supply disruption (DoEE, 2019a). However, in the unlikely event that fuel imports are significantly impeded, government data indicates that industry storage facilities in 2017-18 only held primary fuel supplies (e.g. petrol, diesel and aviation fuel) for a combined 50 days of net import coverage (DoEE, 2019a). This puts Australia in breach of its IEP Treaty (Agreement on an International Energy Program) with the International Energy Agency (IEA) which requires that it stores within its borders crude oil and petroleum reserves equal to a minimum 90 days of the net import demand of the previous year (Twomey, 2012). Notably, Australia has been in breach of this agreement since 2012 and, while there are no penalties for treaty non-compliance (Joint Standing Committee on Treaties, 2018), recent governments have been investigating various alternatives to regaining compliance, other than the estimated AUD $6.8 to 10.5 billion cost of building additional onshore storage capacity (Hale and Twomey, 2013).

In terms of daily consumption, in February 2019 the onshore fuel storage volumes were equivalent to just 21 days of petrol, 20 days of aviation fuel and 18 days of diesel (DoEE, 2019a). So, if imported supplies were cut for as little as 3 weeks, it is likely that normal Australian businesses and community facilities would be drastically affected because short and long distance transport would run out of fuel due to the current Australian dependence on imported product. In fact, problems could potentially occur much more quickly because most petrol stations hold less than a week of fuel onsite, and when this is used up supermarket, pharmaceutical and hospital supplies would be affected within 7 days, plus defence force and police activity would be similarly restricted (Blackburn, 2013).

For many people, this risk to energy security is estimated to be a very low probability event but has an incredibly high and detrimental potential impact – one that is wholly avoidable if Australia's reliance on imported fuel could be addressed. In both of the Murdoch surveys, a large majority of respondents (72% in both the 2015 and 2018 Surveys) were sufficiently alarmed or concerned by this growing risk that they agreed this concern could be mitigated by the implementation of a government strategy to replace conventional fuels with domestically available sustainable alternatives (Dunn et al., 2019). Once again, replacement by EVs was seen as the

alternative with lowest energy security or production risk by most respondents (65%) in the 2018 Survey-2 (Dunn et al., 2019).

3.3 Economic benefits

From a macroeconomic perspective, the replacement of conventional transport fuels by EVs would be a significant benefit on at least two fronts. Firstly, there would be considerable savings on liquid fuel imports, given that combined oil and petroleum product imports were required throughout 2018 at about 1.04 million barrels per day to meet demand and that crude oil prices on the international market have been increasing in 2019: at the end of April 2019 they were USD $63.90 (~AUD $90) per barrel for the commonly traded West Texas Intermediate (WTI), and about USD $75.70 (AUD $107) for Tapis crude (AIP, 2019), which is generally considered more applicable to Australia because Malaysia is its largest supplier (~31%) of imported crude oil (DoEE, 2019a). This equates to AUD $115 per barrel of the refined MOP S95 petrol and AUD $118 for diesel from Singapore refineries (AIP, 2019a) which, combined with South Korea, supply over half of Australia's refined fuel products (DoEE, 2019a), and indicates an estimated AUD $115 million for the national daily cost of fuel imports. Annually, this amounts to almost AUD $42 billion, and would value the combined crude and refined petroleum import fraction at almost 10% of Australia's total import costs for goods and services in 2019 (DFAT, 2019). As one of the highest value products imported into Australia, conventional transport fuels have a significant impact on the national trade balance, and this could be considerably reduced if conventional fuel imports were largely replaced by domestic electricity generation for rechargeable EVs.

Secondly, if Australia continues to be dependent on conventional fuel imports and wishes to participate in global energy forums with the IEA, then it must continue with the current plan to become compliant with the IEP Treaty by 2026 (DoEE, 2019b). As noted previously, the cost of upgrading the existing onshore storage infrastructure to the required level was estimated in 2013 to be between AUD $6.8 and $10.5 billion (Hale and Twomey, 2013). But presumably, if the national fleet of light passenger vehicles was largely converted to rechargeable EVs, then the demand for imported petroleum products would drop, and the requirement for building additional fuel storage infrastructure would be eliminated. The money set aside for this task could then be used for other means. In the 2018 Survey-2, an overwhelming majority (81%) of respondents agreed with this proposition, and while 31% suggested that the money would be better used to catalyze the development of a wide range of viable and domestically abundant alternative fuel technologies, 27% indicated that it should be used specifically to develop the infrastructure for rechargeable electric vehicles (Dunn et al., 2019).

From a microeconomic perspective, if conventionally-fueled vehicles were replaced with EVs by the average driver, then considerable transport energy savings could also be achieved by individual drivers. For example, from government data, the average Australian light passenger vehicle driver now travels 34.5 km per day with average fuel efficiency of 10.8 litres per 100km, thereby consuming 3.73 L/day of fuel (ABS, 2019). At April 2019 petrol prices of $1.47 per litre (AIP, 2019b), owners now spend over $2,000 per year on fuel, and $20,000 in a 10-year period – the average lifespan for light passenger vehicles in Australia (ABS, 2019). The cost of conventional vehicle maintenance could also be considered, and although this varies between about AUD $300 and $1,200 annually (Canstar Blue, 2017), average

service costs could be estimated as about $600 per year, or $6,000 over 10 years, giving basic ICE vehicle 10-year running costs of AUD $26,000.

For EV drivers, if vehicles were always recharged by home solar power then it could be argued that fuel (electricity) costs would be minimal, and possibly equivalent to just the annualized partial cost of the residential solar power installation, plus the displaced feed-in tariff rate of AUD $0.07 to $0.20 per kWh depending on the geographic state of residence (Solarmarket, 2019). The cost of a residential battery system would make this far less favourable, but these are highly variable and bought for many reasons beyond the daily top-up of an EV battery, complicating estimates of annualized partial cost: few EV owners would buy one dedicated to recharging a vehicle at night from stored solar power when off-peak grid power is cheaper (Brakels, 2019). For EV owners that can't utilize direct solar power, grid electricity rates would be paid for recharging EVs, such as the national average AUD $0.30 per kWh (AEMC, 2018). This would then make EV recharging costs for the average 34.5 km daily journey in a medium sized EV like the Nissan Leaf, with an energy consumption rate of 0.173 kWh/km, to be estimated at AUD $1.79, $654 per year, or AUD $6,540 over a 10-year period (Australian Government, 2019). Additional to this, for most EV owners, particularly those who want fast-rechargers at home, the set-up costs for a dedicated residential EV charging outlet as supplied by many EV or charging companies is commonly available for $1,000 to $2,000 plus an installation cost of $750 or more (EVSE, 2018), with the average total cost of AUD $1750 relatively unchanged for the past few years (State Government of Victoria, 2013).

Therefore, over a 10-year period these home recharging costs might conservatively amount to AUD $6540 + $1750 = $8290. Similarly, annual maintenance costs for an EV could be estimated as relatively low due to a lack of moving engine parts compared to equivalent ICE vehicles, and are found to range between AUD $230 per year for the Renault Zoe and $2,100 per 3-year plan for the Tesla Model S (DeGasperi, 2018). An annual generic EV service cost of about $470 per year could be assumed, leading to a basic EV running cost of AUD $12,990 over 10 years.

Compared to conventional fuel and service costs, this brief analysis suggests the basic EV running costs are less than half that of ICE vehicles, with a considerable $13,000+ saving over the life of a vehicle. However, beyond this refueling versus recharging comparison, other issues could be considered, such as EV battery replacement needs, registration and insurance costs, plus many other performance and economic aspects that have clouded the uptake of EVs in Australia.

4 A major barrier to EV uptake – the comparative economics of EV purchase

With respect to the value proposition for EV purchase, Survey-1 results gained in 2015 (Dunn et al., 2018b) indicated that the three least competitive features of plug-in battery rechargeable electric vehicles compared to conventionally fuelled ICE vehicles were their high initial cost, low driving range, and extra time required at or unavailability of recharging facilities. The recent Survey-2 in 2018 investigated these aspects in more detail and found, unsurprisingly, that many respondents would consider EV purchase only if they were the same initial price as equivalent petrol or diesel vehicles. However, several respondents also suggested they would be prepared to pay 10 to 20% (or $10,000) more for a new EV, rather than the conventional equivalent, due to the lower operating and maintenance costs expected

throughout the life of the vehicle. Additionally, a majority of respondents (54%) indicated that they would be prepared to pay $20,000 to $50,000 for a plug-in battery rechargeable EV, depending on the size and type of vehicle required, and assuming concerns about driving range and recharging times had been resolved (Dunn et al., 2019).

However, after a decade of EVs in Australia, very few pure EV models have been made available within this price range. In 2011 the Mitsubishi i-MiEV micro-hatch became available to the public at AUD $48,880 plus on-road costs, after starting at $65,000 (Dowling, 2013). In early 2019, even the smallest plug-in EVs still cost near AUD $50,000, most are over $60,000 and many are over $100,000 (Alex, 2018). The price difference between the small range of EVs available in Australia during 2019 can be seen in the table below (see Table 1), as compared to base model prices for some conventional vehicles of the same vehicle class.

Table 1: 2019 Purchase Price comparison between EVs and ICE vehicles in Australia

2019 EV Model	2019 Base Price* (AUD$)	Conventional (ICE) vehicle equivalent	2019 Base Price**(AUD$)	EV-ICE Price Difference(AUD$)
Small sedans / Hatchbacks				
Hyundai Ionic	44,490	Hyundai Accent	15,990	28,500
Renault Zoe	47,490	Mazda 2 Neo	17,290	30,200
Nissan Leaf	49,990	Mitsubishi Lancer	20,990	29,000
Renault ZE Kangoo	52,500	Renault Kangoo	26,990	25,510
Tesla Model 3	66,000	Hyundai Elantra	20,990	45,010
BMW i3	68,700	Mazda 3 G20 Pure	28,879	39,821
Large sedans / SUVs				
Kia e-Niro	55,000 (est)	Kia Sportage	31,990	23,010
Hyundai Kona	59,990	Hyundai Tucson	27,990	32,000
Tesla Model S	117,900	Mazda 6 Sport	38,650	79,250
Jaguar I-pace	119,000	Mitsubishi Outlander	28,990	90,010
Audi E-tron	120,000 (est)	Hyundai Santa Fe	47,323	72,677
Tesla Model X	126,300	Mitsubishi Pajero	49,990	76,310
Mercedes Benz EQC	150,000 (est)	Toyota Fortuner GXL	50,990	99,010

*Sources include Ottley, 2018; Alex, 2018; Collie, 2019; Kelly, 2019
** Sources include Mitsubishi Motors, 2019; Hyundai Australia, 2019; Mazda Australia, 2019; Renault Australia, 2019; Toyota, 2019.

Many overseas reports have commonly suggested a purchase price difference of $10,000 to $15,000 between equivalent new ICE and EV models (Breetz and Salon, 2017; Logtenberg et al., 2018), but as indicated above, in Australia that difference is generally AUD $20,000 to $30,000, and often much more due to exchange rate

fluctuations, import duties or luxury car taxes, and the low number of EV models available in the domestic market (Gratton, 2019; O'Kane, 2018).

5 The potential for changing the economic obstacles to EV uptake

As previously indicated, results from the Murdoch 2018 Survey suggest that, if concerns about EV driving range and recharging facilities were mitigated, a majority (54%) of respondents would be interested in buying an EV in the AUD $20,000 to $50,000 price range, even if they were $10,000 more than the equivalent ICE model. This means that EVs do not necessarily need to reach price parity with ICE models in Australia, but getting within $10,000 for most people will be good enough if more EVs were in the $20,000 to $50,000 bracket.

A purchase price reduction is expected to occur over the next 5 to 10 years as more EV models become available locally, as more recharging infrastructure is established, and as EV uptake increases (Qld Govt, 2017; NSW Govt, 2019). When Murdoch 2018 Survey participants were asked to select one or more potential policy options for encouraging EV uptake, their preferences were ranked as follows: (i) 46% want new policy to include a reduction in the vehicle stamp duty payable and/or vehicle registration fees for EV owners; (ii) 44% prefer the introduction of rebates for owners of zero or low-emission vehicles; and (iii) 39% want the introduction of a government subsidy to assist initial purchase of EVs (Dunn et al., 2019).

With respect to mitigating the EV range and recharge concerns, it was indicated in the 2018 Survey that the preferred driving range of EVs for most people would be in the 300 to 400 km range, and many of the current models sold overseas and due for release in Australia in 2019, can claim a range of that distance (Alex, 2018). Additionally, when asked about acceptable recharge times for EVs, the results were bimodal, with popular responses for both 15 minute and 30 minute recharge times. This suggests that as the rollout of recharging infrastructure progresses, people will support facilities that enable them to recharge within 15 minutes or quicker in dedicated recharge stations around urban areas, and within 30 minutes if they are parked at café or shopping facilities in urban areas or recharging on intercity highway locations.

Another result from Survey-2 that could impact the economic viability of EVs compared to ICE vehicles concerned the cost of conventional fuel and whether there was a particular price point for petrol or diesel that might trigger vehicle owners to move away from conventional vehicles towards an alternative like EVs, assuming electricity costs remain stable.

For example, if Australian retail fuel costs increased by 50% from their April 2019 price, and became similar to those paid in Europe, i.e. if they rose by AUD $0.73 to $2.20 per litre, then annual fuel bills for ICE vehicle owners would rise on average by $1000 per year, or $10,000 over 10 years. By coincidence, a $2/L price point is the marker that many people selected in the 2018 Survey as the price point for considering EV purchase (Dunn et al., 2019). The other popular choice was $3/L, with a majority of respondents indicating they would consider buying an EV if conventional fuel prices reached some point between these two markers.

This means that, according to these 2018 Survey results, EV uptake based purely on an economic comparison with ICE vehicles could change quite quickly if

conventional fuel prices rose above $2/L and were sustained at that price long enough for people to consider their alternatives. Notably, conventional fuel prices at that level have never been experienced in Australian capital cities before, but they are common in a dozen or more European countries where fuel taxes are more than double the excise rate in Australia (DoEE, 2019a). In the UK, for example, average premium unleaded petrol prices during the December quarter of 2018 translate to almost $2.30/L in Australian dollars, with diesel costing just over $2.40 (DoEE, 2019a). Despite the fact that the majority of this price difference is due to markedly different levels of fuel taxation, it is also apparent that Australian petrol prices are greatly affected by volatile shifts in international oil prices plus fluctuations in the value of the Australian currency (ACCC, 2012).

In late 2018, average Australian city pump prices rose by AUD $0.18 in just three months to $1.60/L because the WTI oil price increased $11/bbl to USD $76 while the Australian dollar dropped $0.04 against the USD (ACCC, 2019). If similar economic conditions are extended in future then it is possible to envisage a rise at the pump of a further $0.40 to $2.00/L. Given that pump prices for petrol had strengthened by April 2019 to about $1.47/L, with the Australian currency valued near USD $0.71 and the WTI crude oil price near USD $63/bbl, an extrapolation of the above changes suggests that the conditions for metro petrol prices at $2/L could be met by any of the following macroeconomic combinations: AUD valued at USD $0.71 and WTI oil price of USD $96/bbl; AUD at USD $0.67 and WTI price of USD $85/bbl; or AUD at USD $0.63 and WTI price USD $74/bbl.

6 Another possibility for EVs – The Fourth Wave

Future macroeconomic scenarios aside, the comparison of EV and ICE vehicle costs suggest that few Australians would have bought an EV during the last decade for economic reasons. Apart from a handful of ‘early adopters’, the majority of the Australian population has been slower than any other advanced economy to adopt EVs. This has led some reports to suggest that high EV uptake may never occur in this country (Zhou, 2018), unless another driving force is found that makes people change to EVs en masse.

Results from the 2018 Murdoch Survey suggest that such a force may indeed exist, and is expected to arrive within the next decade as what may now be called ‘The Fourth Wave’ (after environmental, energy security, and macroeconomic drivers for EV uptake have tried and failed). When asked for an opinion regarding future EV uptake and potential growth of the national light passenger vehicle fleet, several respondents to the 2018 Survey indicated that these would be severely impacted by the introduction of Autonomous (driverless) Vehicles (AVs) during the next decade, their adoption by ride-sharing services, and an expected boom in ‘transport as a service’ (TAAS) businesses (Dunn et al., 2019). Together, these are predicted, by government and industry alike, to disrupt traditional levels of vehicle ownership, along with the transport industry in general (Arbib and Seba, 2017; Australian Government, 2017).

For example, car-sharing enterprises, such as GoGet, and ride-sharing companies, such as Uber, are two modes of TAAS business that have already achieved considerable success, and consequent expansion, in the major cities of Australia and around the world, particularly in the more congested areas (NRMA, 2017). Both of these modes have grown to meet increasing social and economic demands for the

reduced use of private cars, and will continue to do so in future. By some estimates (Webb, 2019), the human driver in taxis or Uber-style TAAS businesses accounts for 40 to 50% of the cost of the service. This suggests that when fully automated AVs are finally available to these services at an economic price, then many professional drivers are likely to be replaced by AV uptake (Arbib and Seba, 2017). Additionally, combined with the fact that a single electric AV could perform multiple journeys, virtually maintenance free compared to ICE vehicles, and tirelessly around the clock compared to humans, it is predicted that private vehicle ownership will drop substantially, possibly by as much as 90%, in a matter of decades according to some estimates (Arbib and Seba, 2017).

The potential benefits of AVs are manifold. By removal of potentially error prone human drivers, combined with the ability of AI navigation systems to continually communicate with other vehicles and traffic systems, it is expected that traffic safety and efficiency will increase dramatically (Sun et al., 2016). By enabling vehicle passengers to travel privately and without the responsibility for vehicle control or navigation, then they will become free to pursue other activities, including business or work activities, entertainment or relaxation (Gruel and Stanford, 2016). Additionally, as driverless taxis or delivery vehicles, AVs will also be available to safely operate for longer periods, and on more journeys, than human operated vehicles (Cross, 2018). For these reasons, AVs are likely to change the whole culture around driving, transport and potentially vehicle ownership (Webb, 2019).

Importantly, several major vehicle manufacturers, including GM, Honda, Ford and VW, plus of course Tesla, and Waymo (formerly Google), that have begun developing AVs have chosen to incorporate electrical drivetrains and battery rechargeable systems because these are much easier to control and integrate with IT systems (LeBeau, 2019; Gastelu, 2019). This means that when AVs are ultimately introduced on a large scale and have rapid uptake, as expected, then the era of EVs will finally be ushered in by default.

7 Conclusion

An examination of the recent Murdoch University survey results has indicated that there are still many obstacles on the path to increased EV uptake in Australia. However, despite the fact that the potential environmental, energy security and long-term economic benefits of EV ownership have not encouraged EV uptake by many Australians in the past decade, there is some possibility that suitable conditions could occur in the near future to improve their comparative value and increase uptake. These conditions include: a reduction in EV purchase price to within $10,000 of equivalent ICE vehicles, minimum EV driving range of 300-400 km, maximum battery recharging time of 15-30 minutes, and an increase in conventional fuel prices beyond $2 per litre while electricity costs remain stable.

Additionally, it is possible that another driving force for EV uptake in the form of Autonomous Vehicles (AVs), whenever they are introduced in affordable numbers, will completely disrupt traditional models of vehicle ownership in Australia and around the globe. Due to the relative ease in controlling electric drivetrain components and battery recharging processes with IT systems, AVs will be effectively driverless EVs. So, when they are adopted in rapid succession as expected, the uptake of EVs will finally take place and an era of rapid change in the transport industry may begin.

References

ABS. 2018. 9309.0 - Motor Vehicle Census, Australia 2018. *Australian Bureau of Statistics*, Australian Government, Canberra, 27 July 2018. (Viewed 14 March 2019) https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/9309.031%20Jan%202018?OpenDocument#Data

ABS. 2019. 9308.0 – Survey of Motor Vehicle Use, Australia, 12 months ended 30 June 2018. *Australian Bureau of Statistics*, Australian Government, Canberra, 22 March 2019. (Viewed 2 May 2019) http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/9208.012%20months%20ended%2030%20June%202018?OpenDocument

ACCC. 2012. Fuel facts: International prices drive Australia's fuel prices. *Australian Competition and Consumer Commission*, Department of the Treasury, Australian Government, Canberra, 10 May 2012. (Viewed 25 May 2019) https://www.accc.gov.au/publications/fuel-facts/fuel-facts-international-prices-drive-australias-fuel-prices

ACCC. 2019. Report on the Australian petroleum market December quarter 2018. *Australian Competition and Consumer Commission*, Department of the Treasury, Australian Government, Canberra, February 2019. (Viewed 25 May 2019) https://www.accc.gov.au/system/files/1528_Report%20on%20the%20Australian%20petroleum%20market%E2%80%94December%20quarter%202018_D05.pdf

AEMC. 2018. Final Report 2018 Residential Electricity Price Trends Review. *Australian Energy Market Commission*, Australian Government, Canberra, 21 December 2018. (Viewed 2 May 2019) https://www.aemc.gov.au/sites/default/files/2018-12/2018%20Price%20Trends%20-%20Final%20Report%20-%20CLEAN.PDF

AIP. 2019a. International Market Watch. *Australian Institute of Petroleum* webpage. (Viewed 1 May 2019) https://aip.com.au/pricing/international-prices/international-market-watch

AIP. 2019b. Pump Prices – Average Weekly Prices for National Average, Weeks to Sunday 28 Apr 2019. *Australian Institute of Petroleum* webpage. (Viewed 4 May 2019) https://www.aip.com.au/pricing?f%5B0%5D=facet_data_type%3A46&f%5B1%5D=facet_fuel_location%3A13

Alex. 2018. An Overview of all EVs coming to Australia 2018/2019. *DriveZero* website, 30 December 2018. (Viewed 30 April 2019) https://www.drivezero.com.au/cars/overview-of-all-evs-coming-to-australia-2018-2019/

Arbib, J. and Seba, T. 2017. RethinkX Disruption, Implications and Choices. Rethinking Transportation 2020-2030. *A RethinkX Sector Disruption Report*, May 2017. (Viewed 27 May 2019) https://www.rncan.gc.ca/sites/www.nrcan.gc.ca/files/energy/energy-resources/Rethinking_Transportation_2020-2030.pdf

Australian Government. 2017. Social Impacts of Automation in Transport. Submission to the House of Representatives Standing Committee on Industry, Innovation, Science and Resources. *Department of Infrastructure and Regional*

Development, Canberra, February 2017. (Viewed 25 May 2019) aph.gov.au/DocumentStore.ashx?id=ebbdd83c-b61e-40ea-8bf5-47ab70cad11d&subId=463736

Australian Government. 2018. Quarterly Update of Australia's National Greenhouse Gas Inventory: September 2018. (Viewed 12 April 2019) https://www.environment.gov.au/system/files/resources/4391288e-fc2b-477d-9f0b-99a01363e534/files/nggi-quarterly-update-sept-2018.pdf

Australian Government. 2019. Green Vehicle Guide. *An Australian Government Initiative* website. (Viewed 2 May 2019) http://www.greenvehicleguide.gov.au/Vehicle/Search

Blackburn, J. 2013. Australia's Liquid Fuel Security. *A report for NRMA Motoring and Services*, Canberra, Australia, February 2013. (Viewed 10 January 2017) https://www.mynrma.com.au/media/Fuel_Security_Report.pdf

Brakels, R. 2019. Charging your EV from the grid is cheaper and greener than charging from a home battery. *Solarquotes* website, 17 July 2019. (Viewed 3 August 2019) https://www.solarquotes.com.au/blog/charging-ev-battery-grid/

Breetz, H. and Salon, D. 2017. Do electric vehicles need subsidies? A comparison of ownership costs for conventional, hybrid, and electric vehicles. *Draft prepared for the TE3 Conference*, September 25, 2017. (Viewed 25 May 2019) https://energy.umich.edu/te3/wp-content/uploads/sites/2/2018/09/Final-Breetz-Salon-EV-Ownership-Costs-v3-TE3-2.pdf

Canstar Blue. 2017. Running costs for Australia's most popular cars. *Canstar Blue, Vehicles* website, 25 August 2017. (Viewed 2 June 2019) https://www.canstarblue.com.au/vehicles/running-costs-popular-cars/

Chappell, B. 2019. Electric Cars hit record in Norway, making up nearly 60 percent of sales in March. *National Public Radio Inc*. (US), 2 April 2019. (Viewed 6 April 2019) https://www.npr.org/2019/04/02/709131281/electric-cars-hit-record-in-norway-making-up-nearly-60-of-sales-in-march

ClimateWorks Australia and Electric Vehicle Council. 2018. The state of electric vehicles in Australia, Second Report: Driving Momentum in Electric Mobility, June 2018. (Viewed 2 October 2018) https://www.climateworksaustralia.org/sites/default/files/documents/publications/climateworks_australia_state_of_electric_vehicles2_june_2018.pdf

Collie, S. 2019. New models 2019 Nissan Leaf priced from $49,990. *Caradvice* website, 8 March 2019. (Viewed 4 May 2019) https://www.caradvice.com.au/733017/2019-nissan-leaf-pricing/

Cross, B. 2018. Have we reached Peak Car? *The Conversation*, 3 December, 2018. (Viewed 23 March 2019) http://theconversation.com/have-we-reached-peak-car-107847

Dean, A. and Green, D. 2017. Climate change, air pollution and health in Australia. *UNSW Sydney*, Grand Challenges, Sydney, Australia, November 2017. Submission 94 to the Senate Select Committee on Electric Vehicles, Parliament of Australia, Canberra, January 2019. (Viewed 12 April 2019) https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Electric_Vehicles/ElectricVehicles/Submissions

DeGasperi, D. 2018. How much do electric cars really cost to own? *Drive*, 10 October 2018. (Viewed 25 May 2019) https://www.drive.com.au/motor-news/how-much-do-electric-cars-really-cost-to-own--119474

DFAT. 2019. Composition of Trade Australia 2017-18. *Department of Foreign Affairs and Trade (DFAT),* Australian Government, Canberra, January 2019. (Viewed 28 April 2019) https://dfat.gov.au/about-us/publications/Documents/cot-2017-18.pdf

DoEE. 2018. Australian Energy Update 2018. *Department of the Environment and Energy*, Australian Government, August 2018, Canberra. (Viewed 12 April 2019) https://www.energy.gov.au/sites/default/files/australian_energy_update_2018.pdf

DoEE. 2019a. Australian Petroleum Statistics, Issue 271, February 2019. *Department of the Environment and Energy*, Australian Government, Canberra. (Viewed 12 April 2019) https://www.energy.gov.au/sites/default/files/australian_petroleum_statistics_-_issue_271_feb_2019.pdf

DoEE. 2019b. Liquid fuel Security Review Interim Report. *Department of the Environment and Energy*, Australian Government, Canberra, April 2019. (Viewed 2 May 2019) https://www.environment.gov.au/system/files/consultations/7cf6f8e2-fef0-479e-b2dd-3c1d87efb637/files/liquid-fuel-security-review-interim-report.pdf

Dowling, J. 2013. Mitsubishi pulls plug on electric iMiev. *Carsguide* website, 24 January 2013. (Viewed 4 May 2019) https://www.carsguide.com.au/car-news/mitsubishi-pulls-plug-on-electric-imiev-21331

Dunn, A., Calais, M., Lee, G. and Pryor, T. 2018a. Why EVs? A Comparison of Alternative Fuels to Help Australia Regain Energy Security. Transition Towards 100% Renewable Energy - *Selected Papers from the World Renewable Energy Congress WREC 2017*, pp 103-114. Editor Ali Sayigh, Springer International Publishing, Switzerland, February 2018.

Dunn, A., Calais, M., Lee, G. and Pryor, T. 2018b. The Impact of Energy Security and Environment Concerns on the Fuel Mix for Light Passenger Vehicles in Australia During the Near Future: Findings from a 2015 Murdoch University Survey. Transition Towards 100% Renewable Energy - *Selected Papers from the World Renewable Energy Congress WREC 2017*, pp 115-123. Editor Ali Sayigh, Springer International Publishing, Switzerland, February 2018.

Dunn, A., Calais, M. and Lee, G. 2019. A comparison of results from 2 Electric Vehicle Surveys in 2015 and 2018: The Impact of Energy Security and Environment Concerns on the Fuel Mix for Light Passenger Vehicles in Australia During the Near Future. *Murdoch University*, Perth, 2019, unpublished.

Energeia. 2015. Review of Alternative Fuel Vehicle Policy Targets and Settings for Australia. *Prepared by Energeia for the Energy Supply Association of Australia*, July 2015. (Viewed 27 April 2019) https://energeia.com.au/energeia/wp-content/uploads/2016/03/Energeia-Report-for-ESAA_-Optimal-AFV-Policy-Targets-and-Settings-for-Australia.compressed.pdf

Energeia. 2018. Australian Electric Vehicle Matket Study. *Prepared by Energeia for ARENA and CEFC*, May 2018. (Viewed 27 April 2019) https://arena.gov.au/assets/2018/06/australian-ev-market-study-report.pdf

EVSE. 2018. Residential EV Charger Installation. *EVSE* website. (Viewed 4 May 2019) https://www.evse.com.au/ev-charger-installation-australia.html

Forrest, A. 2018. The charge is on. The latest and greatest electric vehicles coming to Australia in 2019. *RAC WA*, 20 November 2018. (Viewed 14 February 2019) https://rac.com.au/car-motoring/info/future_new-electric-vehicles-coming-to-australia-in-2019

Gastelu, G. 2019. GM Cruise autonomous car company gets $1.15 billion investment ahead of 2019 launch. *Fox News* website, 7 May 2019. (Viewed 29 May 2019) https://www.foxnews.com/auto/gm-cruise-autonomous-car-company-gets-1-15-billion-investment-ahead-of-2019-launch

Gaton, B. 2018. Understanding EV emissions: Are electric vehicles really so great? *Renew Magazine*, 4 April 2018. (Viewed 24 April 2019) https://renew.org.au/renew-magazine/transport-travel/understanding-ev-emissions/

Geoscience Australia. 2018. Australian Energy Resources Assessment. *Australian Government*, Canberra, 2018. (Viewed 27 April 2019) https://aera.ga.gov.au/

Gratton, K. 2019. Why should you not buy an EV? *Carsales.com Limited* (AU), April 12 2019. (Viewed on 25 May 2019) https://www.carsales.com.au/editorial/details/advice-why-should-you-not-buy-an-electric-car-117954/

Gruel, W. and Stanford, J. M. 2016. Assessing the Long-Term Effects of Autonomous Vehicles: a speculative approach. *Transportation Research Procedia*, 13 (2016), pp 18-29. (Viewed 29 May 2019) https://www.sciencedirect.com/science/article/pii/S2352146516300035

Hale, R. and Twomey, I. 2013. Australia's Emergency Liquid Fuel Stockholding Update 2013: Australia's International Energy Agency Oil Obligation. Main Report. *Department of Industry*, Canberra, Australia, October 2013. (Viewed 10 January, 2017) https://www.energy.gov.au/sites/default/files/aust-emergency-liquid-fuel-stockhold-update-2013.pdf

HEV TCP. 2019. United States – Policies and Legislation. International Energy Agency Hybrid & Electric Vehicle Technology Collaboration Programme. (Viewed 7 April 2019) http://www.ieahev.org/by-country/united-states-policy-and-legislation/
Hyundai Australia. 2019. Car price calculator. *Hyundai Australia* website. (Viewed 4 May 2019) https://www.hyundai.com.au/shop/calculator?model=Tucson&variant=252

Jabeen, F., Olaru, D., Smith, B., Braunl, T. and Speidel, S. 2013. Electric vehicle battery charging behavior: findings from a driver survey. *Australasian Transport Research Forum 2013 Proceedings*, 2-4 October 2013, Brisbane Australia. (Viewed 27 April 2019) https://www.atrf.info/papers/2013/2013_jabeen_olaru_smith_braunl_speidel.pdf

Joint Standing Committee on Treaties. 2018. Report 182 Oil Stocks Contracts: Netherlands. *Parliament of the Commonwealth of Australia*, September 2018, Canberra. (Viewed 28 April 2019) https://parlinfo.aph.gov.au/parlInfo/download/committees/reportjnt/024210/toc_pdf/Report182.pdf;fileType=application%2Fpdf

Kelly, I. 2019. Tesla Model 3 price: what we know so far. *Carsguide* website, 16 April 2019. (Viewed 4 May 2019) https://www.carsguide.com.au/car-advice/tesla-model-3-price-what-we-know-so-far-74172

LeBeau, P. 2019. Ford to build new factory in Michigan for autonomous vehicles. *CNBC* website, 20 March 2019. (Viewed 29 May 2019) https://www.cnbc.com/2019/03/20/ford-to-build-new-factory-in-michigan-for-autonomous-vehicles.html

Logtenberg, R., Pawley, J. and Saxifrage, B. 2018. Comparing Fuel and Maintenance Costs of Electric and Gas Powered Vehicles in Canada. *2 Degrees Institute*, September 2018. (Viewed 25 May 2019) https://www.2degreesinstitute.org/reports/comparing_fuel_and_maintenance_costs_of_electric_and_gas_powered_vehicles_in_canada.pdf

Martin, T. 2019. Australia's electric avenue. *GoAuto News Premium*, 5 February 2019. (Viewed 6 April 2019) https://premium.goauto.com.au/australias-electric-avenue/

Mazda Australia. 2019. Mazda 3 Specs and Prices. (Viewed 3 June 2019) https://www.mazda.com.au/cars/mazda3/#specs-and-prices

Mitsubishi Motors. 2019. Mitsubishi EOFY Sale. *Mitsubishi* website. (Viewed 4 May 2019) https://www.mitsubishi-motors.com.au/shopping-tools/special-offers#

NRMA. 2017. The future of car ownership August 2017. (Viewed 29 May 2019) https://www.mynrma.com.au/-/media/documents/reports-and-subs/the-future-of-car-ownership.pdf?la=en

NSW Govt. 2019. Future Transport 2056. NSW Electric and Hybrid Vehicle Plan. *Transport for NSW*, NSW Government, January 2019. (Viewed 24 March 2019) https://future.transport.nsw.gov.au/sites/default/files/media/documents/2019/Future%20Transport%20NSW%20Electric%20%26%20Hybrid%20vehicle%20plan.pdf

OECD. 2014. The cost of air pollution: Health impacts of road transport. *OECD Publishing*. (Viewed 27 April 2019) http://www.sviva.gov.il/english/env_topics/airquality/pollutionfromtransportation/documents/the-cost-of-air-pollution-oecd-report-2014.pdf

O'Kane, T. 2018. Is it time to go electric? *WhichCar*, Car Advice, 27 September 2018. (Viewed 25 May 2019) https://www.whichcar.com.au/car-advice/evs-by-the-numbers-do-they-make-financial-sense

Ottley, S. 2018. Hyundai Ioniq 2018 new car review [Online]. Drive website, 7 December 2018. https://www.drive.com.au/new-car-reviews/hyundai-ioniq-2018-120273 (Accessed 4 May 2019)

Parliament of Australia. 2015. The Senate RRATRC. 2015. Australia's transport energy resilience and sustainability report, June 2015. *The Senate Rural and Regional Affairs and Transport References Committee*, Parliament of Australia, Canberra. (Viewed 10 January 2017) https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Rural_and_Regional_Affairs_and_Transport/Transport_energy_resilience/Report

Porter, I. 2011. Blade does a runner. ESC laws force local electric vehicle producer to switch from cars to commercials. *GoAuto News*, 11 November 2011. (Viewed 14 February 2019) https://www.goauto.com.au/news/blade.html

PwC. 2018. Recharging the economy: the economic impact or accelerating electric vehicle adoption. *PwC assessment for the Electric Vehicle Council, NRMA and the St Baker Energy Innovation Fund*, 2018. (Viewed 27 April 2019) http://electricvehiclecouncil.com.au/wp-content/uploads/2015/05/Recharging-the-economy.pdf

Qld Govt. 2017. The Future is Electric. Queensland's Electric Vehicle Strategy. *Queensland Government*, 3 October 2017. (Viewed 25 May 2019) https://publications.qld.gov.au/dataset/the-future-is-electric-queensland-s-electric-vehicle-strategy/resource/7e352dc9-9afa-47ed-acce-2052cecfec8a

Renault Australia. 2019. End of Financial Year Sale Now On. (Viewed 3 June 2019) https://www.renault.com.au/latest-offers/commercial

Solarmarket. 2019. Solar Feed-in Tariffs in Australia. *Solarmarket* website, The Quote Company. (Viewed 2 May 2019) https://www.solarmarket.com.au/residential-solar/current-feed-in-tariffs/

Speidel, S., Jabeen, F., Olaru, D., Harries, D. and Braunl, T. 2012. Analysis of Western Australian Electric Vehicle and Charging Station Trials. *2012 ATRF Proceedings.* (Viewed 8 June 2017) https://atrf.info/papers/2012/2012_Speidel_Jabeen_Olaru_Harries_Braunl.pdf

State Government of Victoria. 2013. Creating a Market. Victorian Electric Vehicle Trial Mid-term Report. *Department of Transport*, State Government of Victoria, Melbourne, Australia. (Viewed 10 January 2017) http://pandora.nla.gov.au/pan/141186/20130618-1013/www.transport.vic.gov.au/__data/assets/pdf_file/0011/92666/Electric-Vehicle-trial-mid-term-report.pdf

Stevens, M. 2010. Better Place Australia announces first EV charging point in Canberra. *The Motor Report*, 29 October 2010. (Viewed 6 March 2019) https://www.themotorreport.com.au/car-article/better-place-australia-announces-first-ev-charging-point-in-canberra-72758.html

Sun, Y., Olaru, D., Smith, B., Greaves, S. and Collins, A. 2016. Road to autonomous vehicles in Australia: A comparative literature review. *Australasian Transport Research Forum 2016 Proceedings,* 16-18 November 2016, Melbourne, Australia. (Viewed 26 May 2019) https://api.research-repository.uwa.edu.au/portalfiles/portal/15944690/Roads_to_AVs_in_OZ_ATRF2016_Final_ReSubmission.pdf

Toyota. 2019. Current offers and Toyota value. (Viewed 3 June 2019) https://www.toyota.com.au/current-offers

Twomey, I. 2012. National Energy Security Assessment (NESA) Identified Issues: Australia's International Energy Oil Obligation. *Department of Resources, Energy and Tourism*, Canberra, Australia, July 2012. (Viewed 10 January 2017) http://www.environment.gov.au/system/files/energy/files/ht2012australiasintenergyoilobligation.pdf

Webb, J. 2019. The future of transport: Literature review and overview. *Economic Analysis and Policy*, 61 (2019), pp 1-6. (Viewed 29 May 2019) https://reader.elsevier.com/reader/sd/pii/S0313592618300638?token=E13966C4E8609E09ABEFABA1A921F4E1A8E61598D08A6CC4D34B362C911332789C0EE1FB0B33131DBFBD8FAACB172C36

Zhou, N. 2018. Stuck in first gear: how Australia's electric car revolution stalled. *The Guardian*, 25 January 2018. (Viewed 24 March 2019) https://www.theguardian.com/environment/2018/jan/25/stuck-in-first-gear-how-australias-electric-car-revolution-stalled