MARCHMENT HILL
- consulting -

Electric Vehicles – the hidden costs of green ideals

Electric Vehicles (EVs) are on the rise internationally with an estimated 1 million vehicles sold worldwide to date, with approximately 300,000 of those purchased in the last 12 months([1]). Uptake in Australia has been more limited, with approximately 1,500 EVs sold to date.

A reason for the relatively low EV uptake in Australia is likely due to the absence of incentives or subsidies compared to, for example, California, but other factors such as fuel and electricity costs, access to charging infrastructure, and customer preferences and values could also be assumed to have an impact.

A number of studies have been undertaken to determine the customer profile of a typical EV owner([2]),([3]),([4]). Generally, they are younger, more affluent, more interested in new technologies and, importantly, more environmentally conscious than the average consumer.

This should in theory make the customer's investment decision heavily dependent on the level of emission reductions achieved by driving an EV. But how green are EVs and how costly is it to make them so? MHC has analysed the relative emissions impact of an EV compared with a conventional vehicle and assessed some of the options available to the customer for emissions reductions to reveal the hidden costs of green ideals.

Modelling EVs

MHC has modelled one example customer with a 30km daily commute, using the specifications of an EV (Nissan Leaf) and a comparable petrol car (Mazda 3), as shown in Table 1.

Table 1 – Modelled Cars Comparison

([1]) Includes Battery EVs (BEV) and Plug-in Hybrid EVs (PHEV)

([2]) Experian Automotive, *Electric and Hybrid Car Demographics Survey*, April 2014

([3]) McKinsey, *Profiling Japan's Early EV Adopters*, August 2012

([4]) Institute of Transport Economics, *Attitudes, ownership and use of Electric Vehicles - a review of literature*, April 2013

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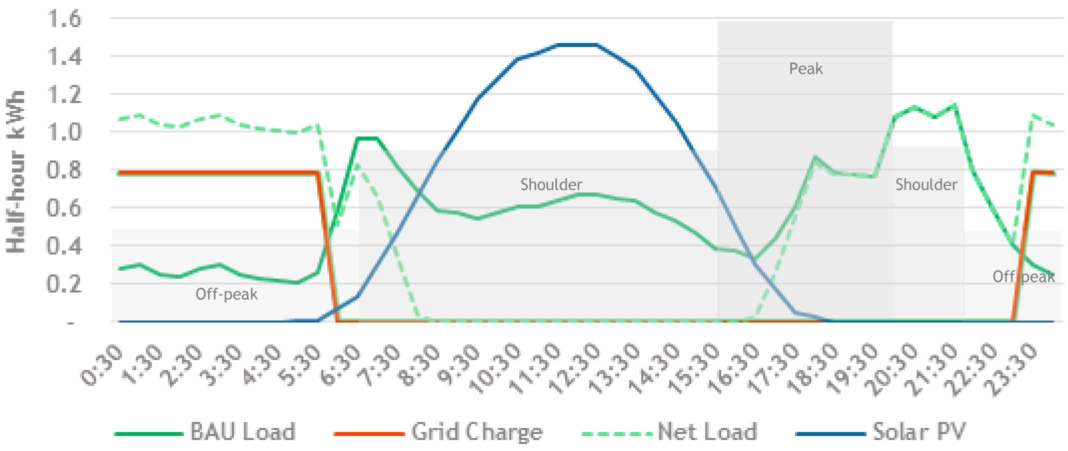
	Nissan Leaf	Mazda 3
		
Approximate Cost	$40,000	$25,000
Range	100km	NA
Battery Capacity	24kWh	NA
Charging Efficiency	70%	NA
Driving Emissions	0	178 gCO2e/km
Fuel Efficiency	0.35kWh/km	6L/100km

Source: Nissan, Mazda websites

It has been assumed for this case study that the EV owner would charge the EV from the grid overnight (charging time from 11pm to 6am). It has further been assumed that the customer has a 5kW solar PV system installed. The resulting average daily load profile is shown in Figure 1.

Figure 1 – Average Customer Load Profile – Grid Charging



As highlighted in Figure 1, the customer's load would increase during off-peak hours when charging, while typically remaining unchanged during the shoulder and peak periods.

However, due to the relatively high component of fossil fuel generation in Australia, using the grid for charging may actually increase a customer's carbon footprint. A similar story has recently been highlighted in the Netherlands([5]), where EV uptake to date has been relatively strong with approximately 60,000 BEVs and PHEVs sold to date, but it has been reported that much of the subsequent increase in electricity demand is being met by three recently commissioned coal-fired power plants.

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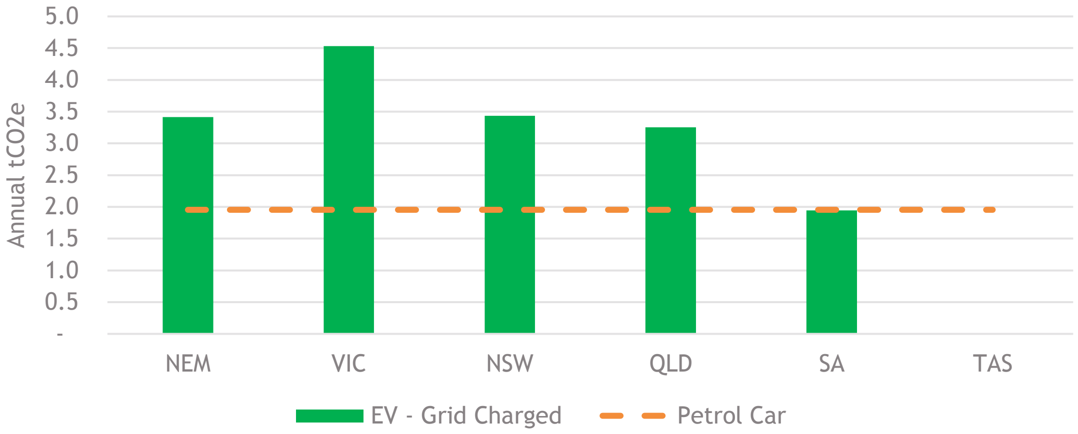
([5]) Australian Financial Review, *Electric car boom fuels demand for coal*, 25 Nov 2015

Figure 2 below compares estimates of the annual emissions generated from the additional customer load from EV grid charging using the average annual grid emissions profiles of each state and the national energy market (NEM) average.

Figure 2 - Annual Emissions by State - Grid Charging



Source: AEMO, MHC

Figure 2 shows a variety of emissions impacts depending upon the location of the vehicle - ranging from steep emissions reductions in Tasmania up to roughly a doubling of emissions in Victoria in comparison to driving an equivalent petrol-fueled car.

These estimates demonstrate that the charging location and associated access to renewable energy generation options are currently significant factors impacting the average emissions profile of an EV in Australia.

How can EV charging emissions be reduced?

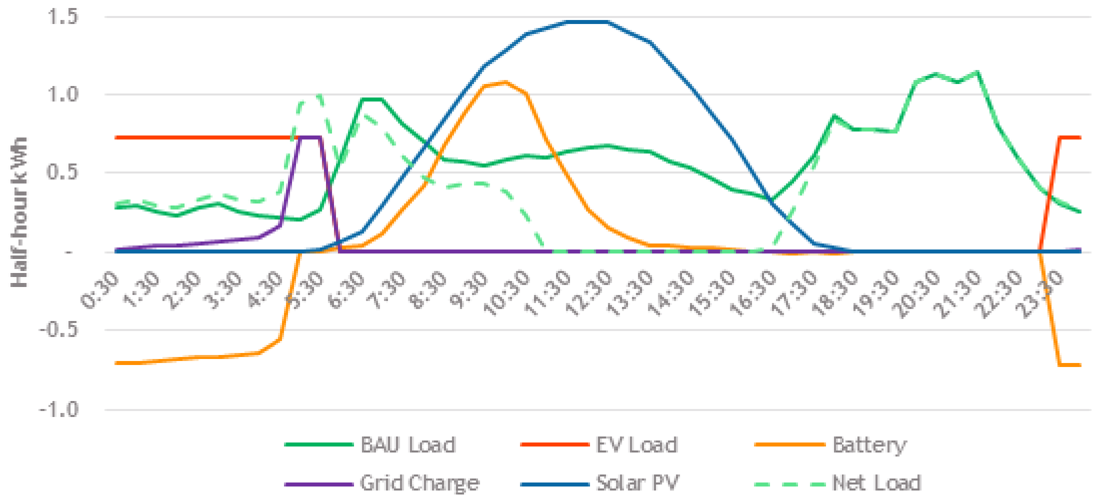
The above analysis has shown that in most cases, charging your EV from the grid actually increases your annual emissions. MHC has therefore explored two options to reduce the emissions related to EV charging: the use of distributed energy resources; and, the use of grid supplied green power.

Using Distributed Energy Resources (DER)

One solution is for the customer to use a local generation and storage system to charge the EV, reducing the amount of charging from the grid. A combined rooftop solar PV and storage system would provide the customer with a low-emissions EV charging solution.

MHC's DER modelling involves a combined 5kW solar PV system and a 10kWh storage solution. The charging algorithm in this instance assumes that the battery is only charged with excess energy from the solar PV system. The resulting average customer load profile is shown in Figure 3.

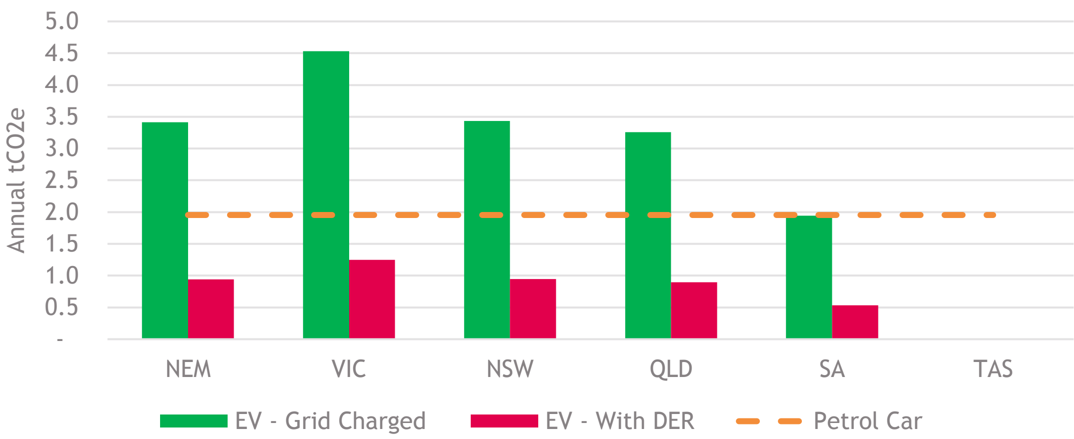
Figure 3 - Average Customer Load Profile - with DER



As highlighted in Figure 3, the 10kWh storage system has sufficient capacity to provide the majority of the EV's charging requirements, with only a relatively limited top-up required from the grid.

This solution would allow the customer to significantly reduce the additional emissions associated with EV-charging, as shown in Figure 4.

Figure 4 - Annual EV-charging Emissions by State - with DER



As Figure 4 demonstrates, using a combination of solar PV and battery storage to charge the EV reduces the annual charging-related emissions by approximately 80% in comparison to the NEM emissions average, making the annual emissions profile of an EV about half that of a petrol-fuel comparison.

Costs and benefits of using DER for EV charging

Having established that using DER to charge your EV can significantly reduce emissions, the next step is to determine the costs and benefits of the approach to understand its viability.

Benefits

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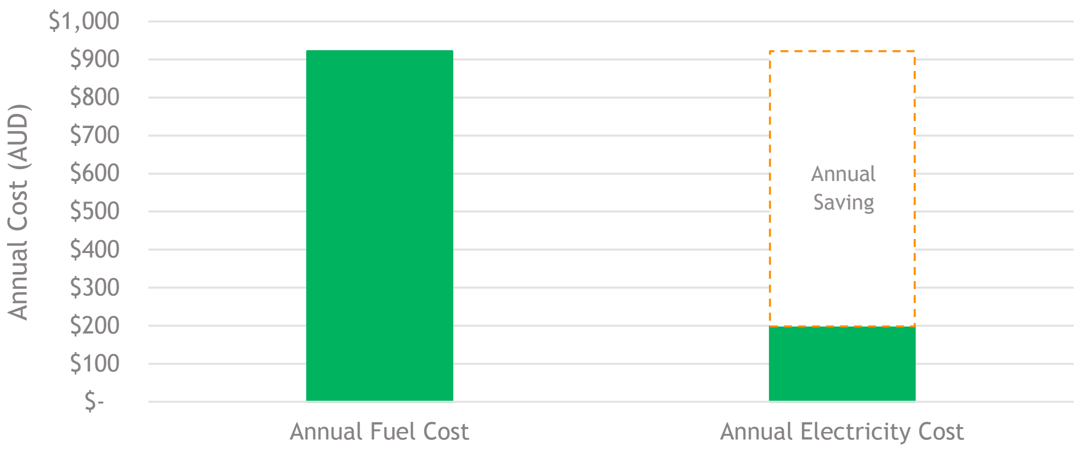
Figure 5 shows the annual vehicle-related savings available for an EV owner with DER in Queensland (top-up charging under ToU off-peak) compared with annual fuel costs for a conventional petrol car.

Figure 5 – Annual Savings - Queensland case study



As shown in Figure 5, an EV delivers approximately $700 of annual savings due to lower charging costs in comparison to annual fuel costs. As all of the available storage capacity is used to charge the EV, the additional potential benefits from storage such as bill reductions have not been considered in this analysis.

Costs

However, the upfront costs of the EV compared with a conventional car, as well as the additional costs of the storage solution must also be considered.

Assuming a 10kWh system at a cost of approximately $13,000 (fully installed), in addition to the $15,000 EV premium, the annualised cost of the combined solution is approximately $3,300 (assuming a 10-year lifetime), delivering a net annual cost of $2,500. As the solar PV system has been assumed to already be installed, it has been treated as a sunk cost.

In relation to emission reductions, the EV and DER combination achieves annual CO2 savings of approximately 1.1 tCO2e compared to driving a conventional petrol car. This means that the annual abatement cost is approximately $2,400/tCO2e. To put that into perspective, $2,400 would buy you about 190 tCO2e of abatement at current EU Emissions Trading Scheme (EU ETS) prices, enough to offset about 15 years of grid electricity consumption and commuting.

Hence, adding onsite storage for the purpose of charging your EV makes little sense both from a cost and emissions perspective.

Purchasing GreenPower

Another option for the customer to address the increase in emissions is by signing up to a ‘green’ electricity retail offer – such as that provided by the government accredited GreenPower program - in order to address any additional emissions caused from charging the EV.

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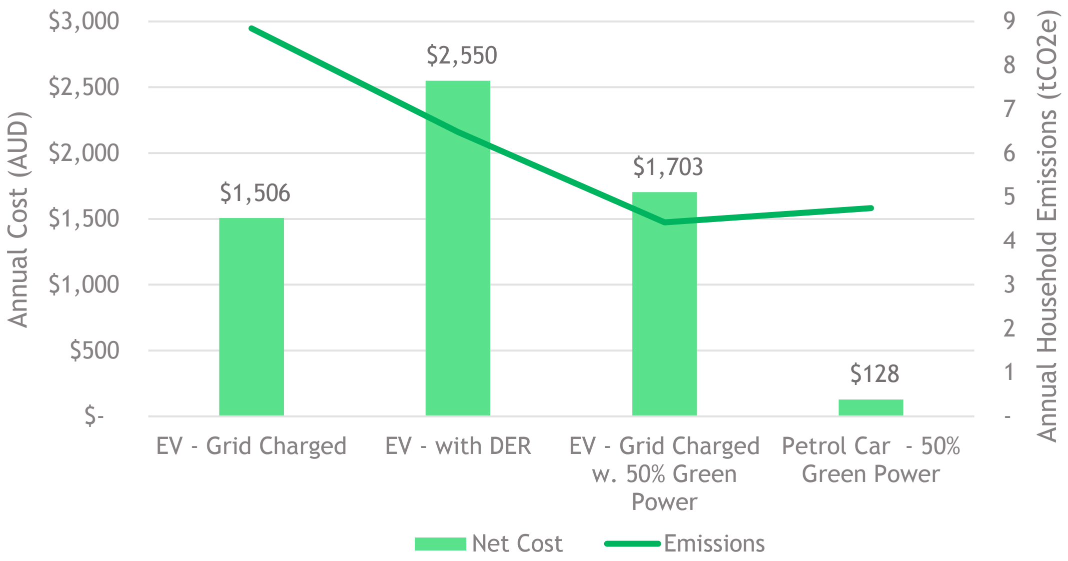
In this instance, EV charging for the modelled customer makes up approximately 40% of their total electricity consumption. As GreenPower is commonly offered in 25% increments, it has been assumed that the customer would need to purchase a quota of 50% renewable energy to offset their emissions.

50% GreenPower for this particular customer would result in annual overall emissions reductions of about 4.5 tCO2e. At an annual cost of approximately $200, this returns an annual abatement cost of $45/tCO2e. This is significantly less that the abatement cost available with DER ($2,400/tCO2e), but still relatively high in comparison with prevailing CO2 credit costs. This raises the question – is there a better option available?

Figure 6 shows the household annual emissions (electricity consumption + commute) and net cost associated with the commute (includes EV premium and benefits, charging costs and Green Power premium) for:

- EV charged solely through the grid
- EV charged through onsite battery storage
- EV charged solely through the grid with 50% GreenPower
- Petrol car with 50% GreenPower

Figure 6 – Emissions and Annual Cost



As Figure 6 demonstrates, out of the modelled options, charging the EV from the grid results in the highest annual emissions. Adding DER reduces the annual emissions by approximately 2 tCO2e, but comes at a significant premium. Adding 50% GreenPower to the home retail bill cuts annual household emissions in half, and comes at a relatively modest added cost of approximately $200 per year.

However, a similar emissions reduction is also achieved by simply driving a conventional petrol car in combination with purchasing 50% GreenPower. This option has the added benefit of being a more cost-effective option due to the avoidance of higher upfront costs of purchasing the EV.

In highlighting this point, it should be noted that although purchases of GreenPower are additional to the mandatory retailer requirements under the renewable energy target (RET), at their current small-market scale, it is very doubtful if these purchases currently are having any impact on the amount of renewable generation development in Australia. The renewable capacity installed in Australia is still very much driven by the RET and large-scale investments in renewable energy investment would not be based on meeting the uncertain and volatile consumer market for GreenPower.

Unless GreenPower offers attract enough customers to actually drive additional investments in renewable energy capacity (i.e. in addition to the RET target), the broader impact on renewable energy investments can be assumed to be marginal.

The solution?

MHC's analysis has found that charging location and associated access to renewable energy options have a significant impact on the emissions profile of an EV in Australia under current generation profiles. For the majority of Australian consumers, as long as EVs remain at a significant premium to their contemporary competitors, they remain unattractive both from a cost and emissions perspective.

However, customer preference also has a significant impact on the cost equation. For example, it has been assumed that reducing emissions is a key driver for potential EV owners. However, EVs also have other, more intangible appeals, such as driving experience (acceleration, noise levels etc.), and the appeal of embracing new technologies and owning 'the latest and greatest' product on the market (particularly true for the Tesla Model S). These factors on their own can clearly be sufficient for some customers to justify their purchase of an EV.

Additionally, comparing the EV to a more premium car in a similar price bracket would again change the equation, making the EV more cost-effective in comparison due to lower running costs (although the current projections on steep depreciation of EVs compared with conventional cars would still be an issue). Therefore, what constitutes a comparable car is very much in the eyes of the beholder.

Also, assuming that the cost of lithium-ion batteries follow the forecasted cost-curve, EVs are likely to reach parity with conventional cars within the next 5-10 years, while also making small-scale battery storage more cost-effective. This would address the current pricing gap, making EVs more attractive from an investment perspective.

Another determining factor will be how green the Australian electricity network grid may become. As highlighted in Figure 2, currently only EV drivers in Tasmania and South Australia have been found to achieve lower emissions without the need for additional investments in products such as DER or GreenPower.

However, this may only be a small speed bump in the trajectory of EV growth in Australia. With higher grid uptake of large-scale renewable energy, driven by an expansion of the RET and/or the (re-)introduction of a carbon price, coupled with falling EV and DER technology cost-curves, more Australian's could soon be driving up and plugging in, with a greener outcome.