GREEN Grid

Future Proofing New Zealand's Electricity Supply

Electric Vehicles and Demand Response: An Economic Perspective

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Introduction

Electric vehicles (EVs) deployed in large numbers have the potential to substantially increase the demand for electricity from the grid. However they can also be seen as mobile batteries, which could be used to support the grid at times. This study looks at the economics of charging EVs and also using them to power the grid, and thereby provide demand response. It considers the following modes of charging and demand response:

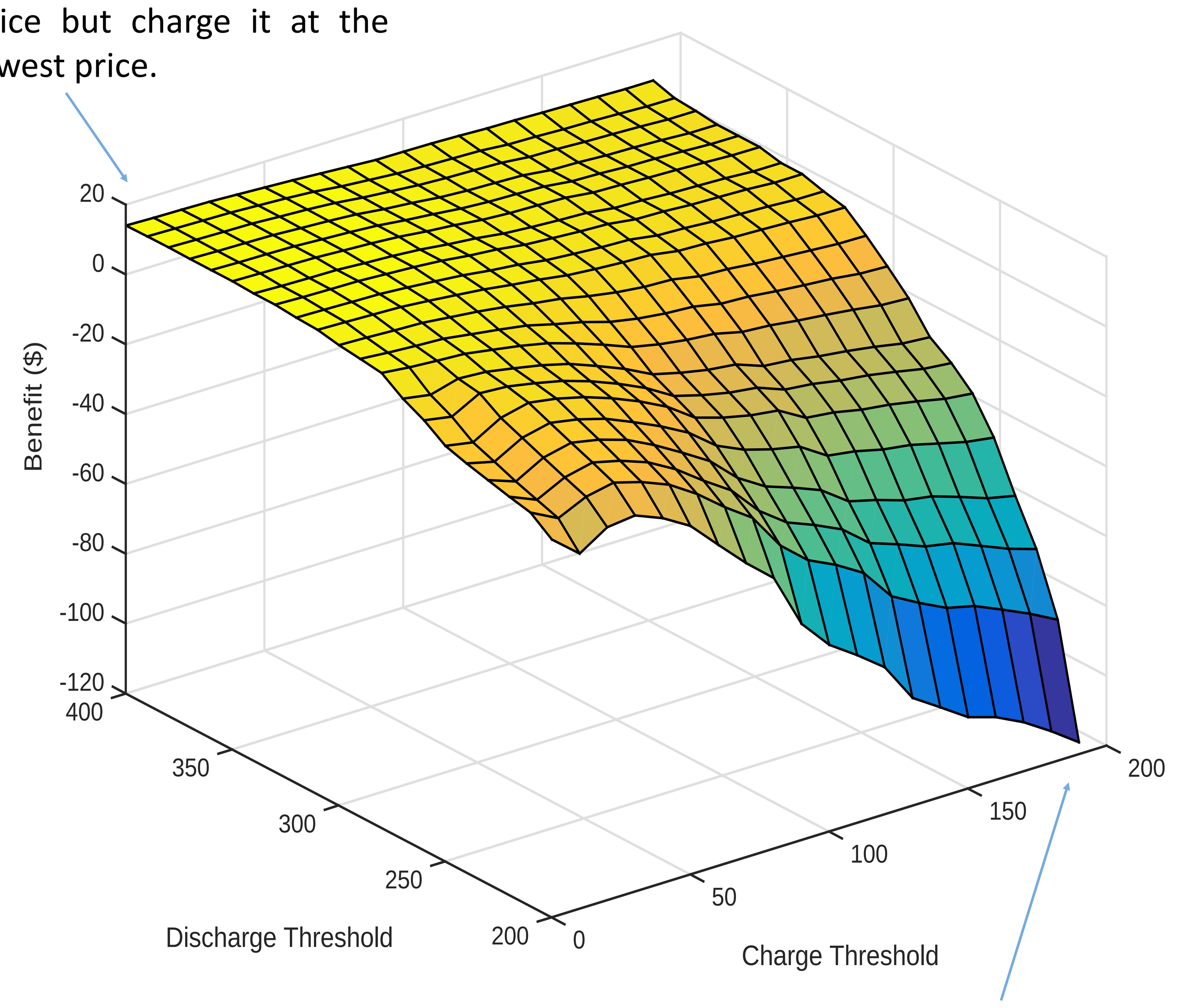
1. Vehicle to Grid (V2G) where the EVs can charge from the grid, but also supply the grid;
2. Smart charging (V1G) where the rate of charge of the EV is varied according to some criteria; and
3. Simply charging the EV at night to take advantage of the night-rate tariff – the simplest form of charging, called V0G.

A model of an EV battery was developed to determine the life-time reduction of the battery when used for supplying the grid as well as motoring. Typical usage of EVs was also considered, with the average trip distance by city determined from New Zealand Transport Authority figures and the Centre for Advanced Engineering study into the impact of EVs. This study was modelled on the Nissan Leaf EV, with the benefits determined according to:

1. V2G: the benefit from supplying the grid based on arbitraging energy – buying energy below a certain spot price and selling it above a certain spot price, with battery degradation from increased cycling of the battery accounted for. The resulting net benefit from this is shown in Figure 1.
2. V1G: only charging the vehicle below a certain spot price, with the requirement that the vehicle be charged by 8am.
3. V0G: charging on night rate, which varies by region in New Zealand, compared to charging on the day rate.

Results of the study are summarised in Figure 2.

Maximum benefit when discharge price is high & charge price is low i.e. sell battery energy at a high price but charge it at the lowest price.



Benefit is lowest when discharge price is low & charge price is high. Negative due to battery life degradation.

Figure 1: Economic benefit of V2G from energy arbitrage, with the constraint that there must be sufficient energy in the vehicle at 8am for the average commute.

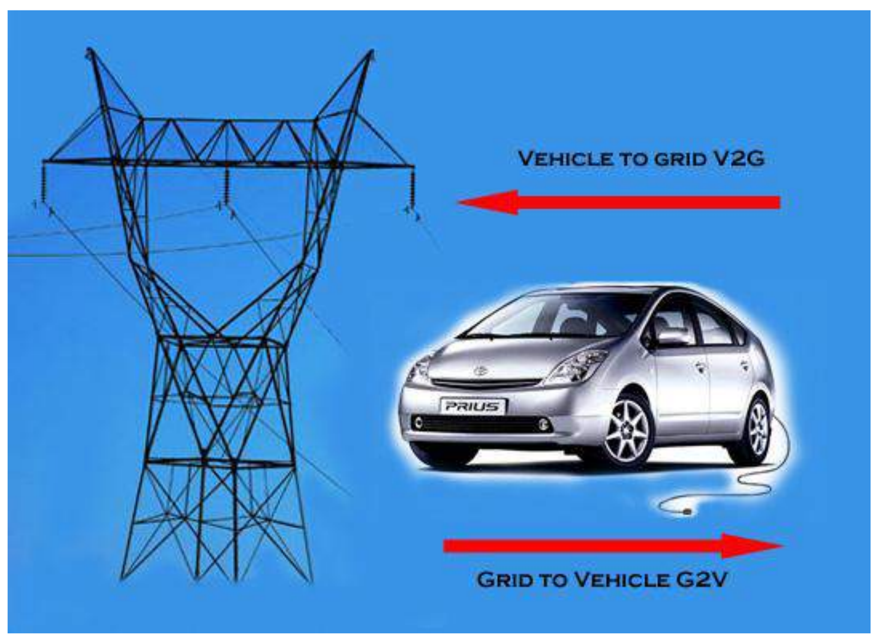
	Vehicle to Grid (V2G)	Smart Charging (V1G)	Charging (V0G), using night rate
			
North Island:	$4-$14	$29-$31	$90-$170
South Island:	$2-$5	$17-$21	$130-$337

Figure 2: Annual benefit from charging an EV using one of the three methods considered, compared to simply charging at the flat day rate.

Discussion and Conclusion

The benefit of charging using night rate is far higher than other means, and varies considerably depending on distribution companies' day-night pricing. However as more EVs are connected to the grid, it is likely that smart charging (V1G) will be required, to coordinate the instantaneous demand from many EVs, rather than have them all turn on at night rate.

There are other sources of benefit for both V2G and V1G, such as instantaneous reserve and frequency keeping. As more EV chargers move to V1G it may be possible to also benefit by providing these services.

The low benefit of V2G was initially surprising, and warranted further investigation. Since an EV is constrained to trading energy on the spot market within a night, and the EV must be sufficiently charged by 8am, it has only a limited time to trade energy. Moreover, an analysis of spot price variations shows that there are few periods of very high spot price, and hence limited opportunity to benefit.

More information is available in the papers at this link:

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