Electric Vehicles and V2G technology in future grids

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To meet our shared targets to reduce GHG emissions and mitigate the effects of global warming, a major transition is needed in our energy and transport sectors. The increased uptake of Electric Vehicles (EVs) and the use of Vehicle to Grid (V2G) technologies (i.e. discharging the EV battery to provide grid services), present potential mechanisms to facilitate the transition to higher penetration of renewable energy sources and emission reductions in the transport sector. However, this transition comes with several engineering difficulties and challenges, like EV charging time conflicting with peak demand, anxiety range, network congestion, and lack of infrastructure.

Due to their low penetration, the impact of EVs on the Australian market is still not felt. However, current forecasts predict substantial growth of the EV market in the next decade, which if true, will require major adjustments in the electricity sector to facilitate the added EV load (Energeia/ARENA/CEFC, 2018).

Early studies analysing the feasibility of V2G, showed that the economic benefits were limited due to associated degradation resulting from additional battery cycling. The initial high capital cost of the batteries also presented challenges (Kempton and Tomić, 2005), while the opportunities to provide V2G are further reduced due to the limited infrastructure currently available and the small battery capacity of early EVs (Mills and MacGill, 2014).

With the recent advances in EV lithium-ion battery capacity, cost and charging speeds, new opportunities arise to improve the integration of EV in future power grids. This paper presents the findings of a modelling-based study using data from the Victorian Integrated Survey of Travel and Activity (VISTA), travel patterns of residential drivers are generated. The patterns are then used to formulate possible EV charging and battery State of Charge (SOC) profiles under different EV penetrations and charging regimes. The VISTA data set allows for detailed modelling of over 15,000 survey participants giving a large spread of driving patterns.

Early analysis of the VISTA data set was used to develop an example of travel patterns, which can then be used to study the potential conflicts between the transport market and the electricity market. Figure 1 below illustrates an overnight charging scenario, so to avoid these potential conflicts during peak demand times. The scenario is based on a simple 6.6 kW overnight (10pm-7am) charging regime of a 75 kWh battery (e.g. Tesla model 3). This scenario also assumes that charging occurs only when the battery SOC is below 60%. The average SOC of all vehicles in Figure 1 corresponds to the left axis, while the percent of vehicles traveling at a given time is shown on the right axis, together with the percentage of cars charging at a given time.

The results present a residential (metropolitan) travel pattern consisting of a morning and an evening peak, similar to the residential electricity load profile. The average SOC of the EV fleet progressively decreases throughout the day, until recharge starts at 10 pm. Nevertheless, a key observation of the results shows that at times of residential peak load (6pm), a significant portion of the battery charge remains available (~70% SOC). This shows that even with no charging during the day, there is significant battery capacity to provide V2G services at peak demand times, which could potentially improve grid security and stability. This conclusion is contrary to some of the early research mentioned above, which can be explained due to the significant increase in battery capacity of EVs.

Furthermore, the results indicate that an overnight charging regime might be sufficient in meeting average travel needs throughout the day while also preventing charging at times during peak demand.

However, it is important to note, that with higher penetrations of EVs, gradual charging will be required to smooth out the load spike seen at the start of the charging regime (22:00).

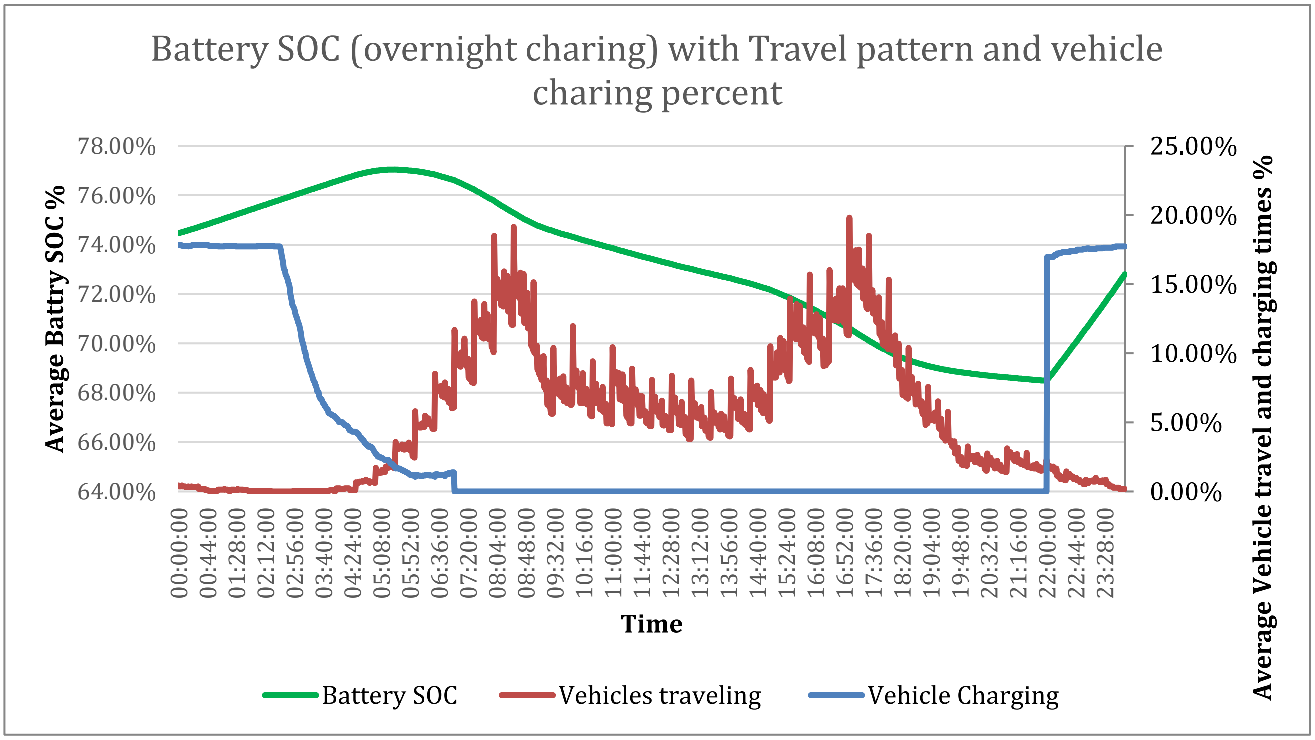

Figure 1 - Battery SOC (overnight charging) based on residential travel profile

This study will examine the above scnario and various other simulated traveling patterns for the Australian market, investigating the impact of different tariffs, habitual driving patterns, seasons and EV penetration. Additionally, these scenarios also show the availability of EVs to provide V2G services, which can allow for more flexible and sustainable operation of the grid.

Better understanding of potential EV load profiles under the different scenarios are important for efficient investment and operation of distribution networks. These in turn will help the integration of EVs while maintaining grid security and reducing overall emissions.

References

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