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Road mapping an equitable transition to EVs in Perth

Sinead Thompson[1]
[1] Arup

Australia needs to accelerate the uptake of electric vehicles (EVs) to meet its commitment to net zero emissions. A lack of federal policy has seen the states progress to differing levels of adoption, with Western Australia one of the worst performers. Despite Perth's reputation as a car dominated city it is still suffering from a slow uptake. This is underpinned by a lack of local government cohesion and a state framework that focuses on large scale infrastructure development while neglecting the barriers that inhibit uptake at the individual scale. Leading jurisdictions have been able achieve high EV uptake rates through implementation of policies that target three key barriers to adoption: affordability, public charging infrastructure, and the ability to charge their vehicles at home. However, in their effort to reach accelerated uptake, many of these support mechanisms disproportionally benefit high income earners, widening existing equity gaps in transport access, opportunity, and affordability. Perth is in a unique position to learn from established EV networks and do better.

The aim of this presentation is to highlight the findings of a recent research piece completed in March 2023, that was a joint collaboration between Arup and the University of Western Australia (UWA). The project introduces an innovative data-driven approach to zero emission vehicle planning by applying a method commonly used in offshore wind site selection within a new context. A spatial multi-criteria assessment (MCA) using Geographic Information System (GIS) software is undertaken, which combines Australian census data with engineering factors that influence Perth's demand for and vulnerability towards the transition to EVs, to generate heat maps of Perth. The results of the MCA allow the suburbs across Perth to categorised into four 'service layers' for policy provision, based on their average vulnerability to transition and demand score. The analysis finds that Perth is at risk of several equity issues including a disproportionate provision of charging infrastructure based on socio-economic class and poor wheelchair accessibility to EV charge points.

Targeted support mechanisms based on insights gained from a literature review into best practice EV policy from leading jurisdictions are linked to the unique challenges of each service layer to develop a road map that showcases how a unified effort from government bodies and industry advisors can be used to achieve an equitable transition to EVs in Perth. Secondly, by analysing Perth's social context and infrastructure landscape using a spatial MCA, the study demonstrates how a data-driven approach can be used to improve equitable outcomes for strategic planning.

Observed destination charging behaviour at Monash University

Roger Dargaville[1]
Bunny Kheang[1] and Liam Morgan[1]
[1] Monash University

Since 2017, Monash University has had a range of electric vehicle (EV) charging infrastructure installed with the goal of both providing a service to staff, students and the broader community as well as enabling observations early adopter behaviour with public charging infrastructure. EV charging offers the potential to help alleviate problems with managing high penetrations of renewable energy in the grid by using the onboard batteries as sponges to absorb energy at times of otherwise low demand and high production. The most likely scenario for this is during the middle of the day when solar PV output is at a maximum, however current wisdom suggests that most EVs will be charged at night. Finding ways to incentive EV charging during the day will be critical to making EV charing a benefit to the grid rather than a burden.

Charging EVs during the day requires infrastructure to be installed where the vehicles will be parked - this will be at parking garages, work places, schools and universities, train stations and shopping centres - know as 'destination charging'. EV chargers come in a range of capacities, from level 1 (2 or 7kW AC), level 2 (22kW AC) and level t3 (50kW DC and above). Understanding how EV drivers interact with the different charging capacities is key to optimising the role out of EV charging infrastructure at charging destinations. This shows how EV drivers interact with level 2 (22kW) and level 3 (50kW) chargers at Monash Clayton and Caulfied campuses.

Results show that the 50kW chargers are typically engaged for less than an hour, enough time to fully charge (or close) most EV batteries. For this type of charger, the option of conducting 'smart charging' where the load is varied in response to availability of renewables, network congestion or other constraints is limited. However, with the 22kW chargers, EVs are parked for several hours, typically 4 or more, which allows the EVs to be fully charged with a significant degree of flexibility in when the energy is delivered. Data shows that EVs drivers typically begin charging sessions at the start of the working day, but that peak load occurs around midday, closely in sync with the availability of solar energy.

The results suggest that a greater availability of 7 and 22kW chargers at charging destinations would greatly enhance the ability of EV charging infrastructure to play a positive role in managing a high penetration renewable energy grid. Other results show the trends in onboard inverters, indicating a majoring of 11kW inverters, superseding the lower capacities (3 and 7kW) seen in the early years of installation. Surveys of potential EV users also suggest a distinct lack of knowledge of how EV charging works, suggesting that new EV drivers could be incentivised to adopt optimal charging behaviour if the right information and tariffs are available.

The future of hot water flexible demand in the age of rooftop solar

Baran Yildiz[1]
David Salazar[1], Hossein Saberi[1], Anna Bruce[2] and Alistair Sproul[1]
[1] School of Photovoltaic and Renewable Energy Engineering (SPREE)/UNSW
[2] UNSW Sydney

More than half of Australian households own an electric water heating system which makes up around 25GWh of daily flexible demand in our electricity network. The majority of these electric water heating systems have been on a controlled load circuit where the electrical circuit of the water heaters is energised and de-energised by the distribution network service providers (DNSPs) based on their demand-side management strategies. DNSPs have traditionally used controlled load to shift the electricity demand of water heating systems into late night periods to minimise their impact on network peak demand that usually occurs in the afternoon and evening periods (this type of control is also known as Controlled Load 1, Off-peak or Secondary tariff).

With increasing levels of rooftop solar installations and soaring levels of solar exports in the middle of the day, DNSPs have started introducing new controlled load schemes such as time of use-controlled load (for example in South Australia where controlled load is active 24/7). Some have extended the traditional night-time controlled load periods to cover some part of the solar generation period (for example in New South Wales and Queensland).

As the controlled load circuits get energised in the middle of the day, hot water tanks can soak-up the excess solar generation in the network and, as a result, they don't require as much heating at other times of the day when fossil fuel generators dominate the electricity mix. Therefore, shifting the controlled load into the middle of the day can reduce associated emissions with water heating. There can be other benefits of heating water in the middle of the day. When water tanks soak up excess solar in the network, they can lower network voltages and, as a result, reduce curtailment of rooftop solar systems due to high voltages. This can also potentially lower electricity bills and increase the lifecycle of appliances, which can also be impacted by high network voltages.

Our CRC RACE for 2030 funded research project, SolarShift investigates the solar-soaking potential of orchestrating electric water heating systems via smart meter control. We study different optimization methods based on thermal modelling, weather conditions and whole-sale market prices and compare the associated financial and GHG emissions saving opportunities for different water heating technologies such as resistive electric, heat-pump and gas across different regions of Australia. The project has received real-world dataset from Endeavour Energy's Off-peak+ Trial to analyse the operational conditions and validate the modelling results. Our research aims to find an optimal allocation of the potential benefits that can be achieved via orchestration of electric water heating systems across the stakeholders: networks, aggregators/retailers and households. We propose new value proposition for the consumers to ensure controlled load remains an attractive option compared to other hot water control options such as diverters, timers and smart home energy management systems.

Machine learning approach to detecting electric vehicle charging at both meter-level and feeder-level

Fucai Ke[1]
Hao Wang[1]
[1] Monash University

The surging adoption of electric vehicles (EVs) has exerted substantial pressure on residential EV charging, creating challenges for the distribution grid operations. To obtain insights into EV charging behaviours, Distributed Network Service Providers (DNSPs) can turn to advanced metering infrastructure data to explore non-intrusive load monitoring (NILM) methods for EV charging detection. These NILM techniques play a vital role in EV charging management and the broader goal of decarbonizing the energy and transportation sectors.

While previous research has predominantly focused on deep learning detectors at the single household level, there is a pressing need for a lightweight, reliable, and interpretable NILM pipeline. Furthermore, the more complex task of feeder-level disaggregation, which involves detecting EV charging by analysing aggregated load data from multiple households, has received limited attention in existing studies.

Our work addresses these challenges by introducing an interpretable detection method that combines innovative adaptive sliding window-based feature extraction and machine learning models. The proposed approach offers a shallow learning solution that employs machine learning models like XGBoost, enabling rapid training, which significantly influences detection effectiveness and interpretability.

Our work also presents real-world case studies, including both offline and online EV charging detection across various EV user groups and time frames. Our proposed framework offers a comprehensive solution to the EV charging detection problem and provides insights into the development of lightweight and effective detection methods at both meter-level and feeder-level, contributing to an enhanced understanding of EV charging on distribution networks.

Lessons from the rEVolution: The (almost) first residential vehicle-to-grid instance in Australia

Stuart White[1]
[1] Institute for Sustainable Futures, UTS

This presentation is about the experience of establishing the (almost) first residential-only vehicle-to-grid instance in Australia. The preparation, approval, purchase, installation, configuration, testing, and operation will be described. The lessons that were learned from this case study will be outlined, including the broader implications for the Australian energy transition. The specific instance is a Nissan Leaf 62 kWh battery connected behind the meter via a 7.4 kW Wallbox Quasar 1 to an electric-only townhouse in a 120-unit complex in inner Sydney, retrofitted with efficient equipment, appliances, and insulation including gas cooktop conversion to induction, and 3.5 kW of rooftop photovoltaics (PV). The system is controlled using Flexmeasures and V2GLiberty based on dynamic wholesale prices through Amber Energy and monitored using WattWatchers power metering.

Moreover, this presentation will sketch the potential for the widespread deployment of similar technology and system configurations, specifically emphasising their role in supporting renewable energy integration and advancing the broader energy transition agenda. Australia's substantial experience in power electronics and its widespread use of rooftop PV systems suggest a significant opportunity for the country to become a global leader in this domain. However, the realisation of this potential hinges on expeditious actions to navigate the development, regulatory frameworks, and deployment of such systems. Failure to take these steps within the next 12 months could result in the forfeiture of this promising opportunity.