HORIZON POWER

LESSONS LEARNT REPORT # 1 - INFRASTRUCTURE DEPLOYMENT AND CUSTOMER ONBOARDING

HORIZON POWER

Carnarvon Distributed Energy Resources (DER) Trials

ACKNOWLEDGEMENT TO COUNTRY

We acknowledge and pay our respect to Aboriginal and Torres Strait Islander peoples as the First Peoples of Australia.

We are privileged to share their lands, throughout 2.3 million square kilometres of regional and remote Western Australia and Perth, where our administration centre is based, and we honour and pay respect to the past, present and emerging Traditional Owners and Custodians of these lands.

We acknowledge Aboriginal and Torres Strait Islander peoples continued cultural and spiritual connection to the seas and the lands on which we operate on. We acknowledge their ancestors who have walked this land and travelled the seas and their unique place in our nation's historical, cultural and linguistic history.

Horizon Power uses the term Aboriginal and Torres Strait Islander (and Aboriginal on future references) instead of Indigenous. Therefore, within all Horizon Power documents the term Aboriginal, is inclusive of Torres Strait Islanders who live in Western Australia.

ARENA DISCLAIMER

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Lessons Learnt

Lessons Learnt Report #1: Carnarvon DER Trials

Project Name: *Carnarvon DER Trials*

Knowledge Category:	Infrastructure deployment and customer onboarding
Knowledge Type:	General and technical
Technology Type:	Distributed Energy Resources
State/Territory:	Western Australia

Introduction

Horizon Power is conducting a series of technology trials in the town of Carnarvon in the Gascoyne – Mid West region of Western Australia (WA), to explore economically efficient options for microgrid operation. The trials are exploring the management of high penetration levels of Distributed Energy Resources (DER), cloud-based aggregation of DER into Virtual Power Plants, advanced data analytics, and digital apps that provide customers with data with which they can make informed decisions.

Carnarvon, situated on the mouth of the Gascoyne River 900 km north of Perth, has a population of approx. 5,500. Horizon Power commissioned a new 13 MW gas-fired (with diesel peaking) Mungallah Power Station in 2014. Ownership of the power station offers the trials control system access, integration and optimisation options that would not be possible with an independent power producer operating under a power purchase agreement.

With an economic base of predominantly primary producers, Carnarvon experienced rapid uptake of solar photovoltaic (PV) systems in 2008 - 2011 with higher than average system sizes, typically 10-30 kW, used to offset cold storage and water pumping power purchases.

The distribution system has a high feeder and transformer loading of solar PV and requires sufficient spinning reserve to cover the variability in renewable energy generation caused by coastal weather patterns. Carnarvon was the first regional WA town to start pushing the boundaries of Horizon Power's solar PV hosting capacity in 2011. The town's population has always held great enthusiasm for solar PV with 121 customer connected systems as well as two commercial solar farms operated by Solex (45 kW), which was the first privately owned commercial solar farm in Australia, and EMC (300 kW).

The Carnarvon DER trials which commenced in late 2017, and include a team of researchers from the Engineering and Energy Discipline at Murdoch University, aim to resolve the technical, operational and transitional barriers to a high penetration DER business future. By conducting a series of technology trials and experiments over three years involving the monitoring and control of solar PV and energy storage, the technology trials aim to answer questions such as: Have we thoroughly explored the operational risks associated with a DER control system? Can we employ controls to manage DER in a microgrid to support Horizon Power's high penetration DER future assumptions? Can such a

DER management solution monitor and control energy storage to reduce peak demand or peak export? Moreover, can the use of such a control solution be used to increase DER hosting capacity and penetration of renewable energy into the network?

The project has engaged 82 residents and businesses with solar PV systems as participants in the data acquisition phase of the trials. Each participant was gifted a Solar Analytics solar smart monitor (rebadged Wattwatcher) to separately meter their solar PV system production and network load every five seconds. See Figure 1.

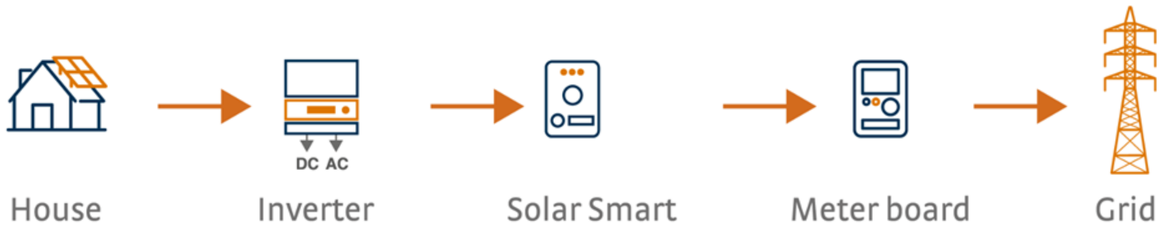

Figure 1 Solar Analytics solar smart monitors (rebadged Wattwatchers)

The second phase of the trials, completed in March 2019, saw the installation of new combined solar PV and battery systems at the houses of an additional ten participants. Six of the existing data participants also received a battery and inverter to augment their legacy PV systems, and the Solex commercial solar farm received an inverter upgrade to a portion of its array.

These seventeen participants received a ‘Reposit Box’ DER controller allowing Horizon Power to monitor and control their DER systems through aggregation into a VPP established in the Reposit cloud platform.

We have concentrated the majority of the new DER and system upgrades onto a single feeder with an existing moderately high penetration of solar PV. The solar PV production on the Gibson Street low voltage feeder regularly exceeds the combined average load on the feeder at midday, exporting its excess energy into the wider Carnarvon medium voltage network. By installing additional DER, we have created a high penetration DER environment, to test DER control techniques on a live network with real customers and variable weather.

Throughout the trials, we are conducting a series of experiments using customer's DER systems to investigate the network impact of solar PV generation and behind the meter (BtM) systems, confirming the viability of high penetration DER in Horizon Power’s microgrid networks.

This report covers initial technology choices, customer onboarding into the trials and infrastructure deployment. A lessons learnt report at the end of the project in 2020 will cover technology performance and R&D objectives in greater detail.

Key Learnings

Customer onboarding

- The Solar Analytics/Wattwatchers devices were provided to customers free of charge, including the cost of installation. After applying for the device an electrician assessed of the applicant's property, checking, among other things, the suitability of their solar PV system for trials data acquisition, the PV systems proximity to the meter box, solar access, and asbestos in the meter box. The assessment exercise paid dividends by avoiding several systems that were unsuitable for the trails.
- Anecdotal evidence collected in customer information sessions indicated that smartphone familiarity was high and that most customers had used the Solar Analytics app to both observe their PV systems performance, and used the information to make behavioural changes to their energy consumption. Only a handful of customers had not installed the app, preferring instead to use a browser and webpage approach. One customer had contacted Solar Analytics and was pulling his data directly from the Solar Analytics - Application Program Interface (API).
- Customers with existing Solar PV embraced the opportunity to receive the Solar Analytics/Wattwatchers device. Many had no previous visibility of their system performance, most of which were more than six years old. Having visibility of their energy production enabled them to see the impact of shading and dirt build up on panels, one customer discovered one of his inverters had failed. Matching load profile to renewable energy production in the solar analytics app gives customers the information they needed to make informed decisions about their energy production and consumption.
- The project used a competition to gift ten PV/Battery systems to customers without an existing PV system. A condition of receiving a gifted system was allowing the project to gather system performance data and conduct experiments on the system for three years. It turned out to be surprisingly complicated to run a competition in Western Australia without attracting the need for a gaming license. The complexity necessitated the services of a probity auditor to ensure adherence to process. It is also surprisingly complicated for a government entity to gift DER systems to customers. While the outcome complemented the objectives of the trials, on reflection, we would not use this method again. It is also worth noting that while these trials were primarily technical, objective social science is complicated when the participant is gifted assets that will, by their very nature, alter their attitudes or behaviour around energy consumption. Care should be exercised if social science is a project objective to ensure that the pool of participants can contribute unbiased observations through well-designed questionnaires. Analysis of behavioural change requires a 'before and after' data set that spans at least one year to capture the influence of DER on energy use behaviour during seasonal variation. Also, Feed-in tariff or pricing signals should be applied to complement the research objectives
- The project also gifted a battery and inverter to six customers with existing solar PV systems, again, a condition of receiving a gifted system was allowing the project to

gather system performance data and conduct experiments on the system for three years.

- The original intention was to offer the customers with existing solar PV systems an inverter upgrade; however, the age of the existing systems meant that they all had inverters with transformers. The switch to a transformerless inverter was complicated by the requirement to upgrade PV module wiring to the latest standard, which in turn equated to a system upgrade substantial enough to render the customers ineligible for continued participation in the premium feed-in tariff scheme. Naturally, this was highly undesirable to the participants. The project was also reluctant to invest in costly PV system upgrades at a time when PV hosting capacity in the town was limited, and customers who were waiting for the opportunity to connect PV might view the legacy system upgrades as giving to the 'haves' while ignoring the 'have nots'.
- We did note that despite offering to gift them a battery augmentation to their existing PV system, some customers were reluctant to embrace any technology that would reduce their renewable energy export during the middle of the day. Reliant on the premium feed-in tariff over the last ten years to supplement their income they were unwilling to embrace anything that would impact it, i.e. using a battery to store their renewable energy for use during the peak period. Even after we explained that battery technology would save them money when the premium Feed-in tariffs period came to an end around 2020/21, they declined to commit. We envisage that the gradual withdrawal of the premium feed-in tariff over the coming years will change the economics of PV such that customers will start to see the value of maximising self-consumption of their renewable energy. In cases where customers have a legacy PV system that produces much more power than they can consume during the hours of sunlight, a battery system will begin to look attractive.
- While experimenting with differing battery dispatch profiles and maximising self-consumption of self-generated solar PV energy, some customers bought to our attention they were no longer exporting as much renewable energy as they had done previously. The project decided to reimburse those customers for reduced bill credit over the remaining term of the experiments.
- Data collection from customers required a bespoke contract which each participant was required to sign as they were on-boarded into the trials. The traditional boundary point for the utility is the electricity meter. This project was not only reaching behind the meter for data that would not otherwise be collected but also sought to control the customer's assets through Feed-in Management control of the solar inverter and dispatch of the battery. Through the bespoke contract, the customer gave the project permission to collect DER performance data, granted Horizon Power sole ownership of all IP generated from the data and permission to share the data with contracted third parties who adhere to the privacy act. Also, the project was able to control DER assets to facilitate research for the duration of the trials. The project observed that where it was transparent about precisely what data was collected, the period of collection, and how it would be used, there was no complaint from customers. Also, where the aim was to create a win-win situation, customers appreciated having visibility of their system performance through the smart device apps that they

received, i.e. the Solar Analytics or Reposit Power apps. The evolution of privacy and data legislation in Western Australia will influence future data collection contracts; however, until then, this proved to be a useful exercise in how to communicate data collection and privacy to customers.

Installer training

- Horizon Power committed to regional upskilling and using local services for the trials wherever possible, and worked with the Clean Energy Council and the three local DER contractors to ensure their accreditation for grid-connected battery systems was current. The project flew staff from the three contractors down to Perth for training sessions conducted by Reposit Power and Energy Matters, which included installation and commissioning of all of the technologies used in the trials. The training proved very beneficial when troubleshooting installation issues. It also ensures a base of qualified resources to support the technology for the term of the trials and beyond.

Technology infrastructure role out

- The original intention of the project was to leverage the Advanced Meter Infrastructure (AMI) in the town to gather DER performance data. The AMI was unable to deliver the required timestamping or synchronisation of data acquisition at the required resolution. The project timeline pushed the exploration of other options and the eventual decision to use Solar Analytics/Wattwatchers and the local 3/4G network instead. The AMI was originally designed and built for billing and connection/disconnection purposes. The original business case did not include advanced data acquisition features. Horizon Power has recently invested in software and technology to improve data acquisition through the AMI, but this was too late for the project.
- Installing over one hundred and sixty 3/4G connected devices in a regional/rural town over a matter of weeks caused unforeseen network connectivity issues. Analysis of gaps in the data collected, 3/4G signal strength and network connection logs, together with anecdotal evidence gathered over the last two years suggests that the local telecoms network has struggled to manage the sudden increase in data activity. Connection drop in favour of voice calls causes data devices to switch to distant towers with lower signal strength, subsequently losing internet connectivity and thus data. The installation of range extender antennae on some Solar Analytics/Wattwatchers and a firmware update to all of them now enables them to switch to other towers without loss of data. Future planning for DER projects that include comms to an IoT device will include an analysis of bandwidth availability. In addition, Horizon Power has conducted experiments investigating the use of the AMI mesh network as a secure communications channel for IoT devices, which have proven very promising.
- Using the customer's internet connection for the Reposit Boxes has proved surprisingly successful. It is worthy of note that in the event of a loss of internet connection, the Reposit boxes ramp the DER to zero export, so customers are

incentivised to ensure an internet connection is available. Device availability across the seventeen Reposit boxes is >97%.

- The project encountered unexpected delays in local council approvals for the DER installations. The local authority, unusually, required building inspections by a structural engineer as part of their approval procedure but did not have a structural engineer on staff, preferring instead to employ an engineer from an authority 500 km away. The engineer limited his travel to Carnarvon pending a certain quantity of inspections, which, coupled with his availability, created a bottleneck in the approval process. Understanding the processes and constraints of regional authorities and how they differ between regions, earlier in the project could have avoided this.
- The design process for the individual DER systems was complicated by the choice of the distribution feeder selected for the project, which consisted of semi-rural properties. One of the project's aims was the investigation of Nett Feed-in Management of DER. This requires a reference point upstream of any distributed loads or the point of network connection. Semi-rural properties very often have their dwelling distant from the meter box, in some cases over 50m. It is also quite common for these propertied to have loads between the meter box and the dwelling, i.e. sheds or bore pumps. Trenching was required to accommodate an ethernet cable running from the location of the Reposit Box in the distribution centre at the dwelling, to the meter box on the boundary of the property, to accommodate the current transformer used in nett flow management. The trenching was an unforeseen complexity which further delayed the installation of several DER systems.

Project team

- Ensure that everyone on the project is enthusiastic about the project's objectives and willing to bring their intellect and talent to the table. Work hard to maintain a unifying vision that recognises a creative and talented workforce.
- Adopting an Agile[1] working environment, the use of Kanban[2] boards, Design Thinking[3] and Lean[4] canvases to develop the DER Monitor and Control software stack worked very well. The project engineers and developers worked well together and provided a flexible solution that is very well suited to collecting the vast amount of project data, making that data available to our research partners Murdoch University, and controlling the DER systems.
- The project used JIRA and Confluence (Atlassian products) as a basis for sprints and employed a competent scrum master with domain knowledge and a good understanding of physics. The practice of assigning multiple squads or scrum management to a novice in JIRA should be avoided, similarly avoid using a developer to manage the sprints on the side of his dev role.
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[1] https://www.atlassian.com/agile
[2] https://www.atlassian.com/agile/kanban
[3] https://hbr.org/2018/09/why-design-thinking-works
[4] https://leanstack.com/leancanvas

External research partners

- Active engagement with research or academic partners is time well spent. Both parties benefit from the open and honest discourse, intentionally moving away from a consultant style relationship to a partnership brings collaboration, insight and mutual benefit.
- Research institutions need assistance engaging with a utility organisation and vice versa.
- Academic institutions need assistance with project timeline management and maintaining milestones which can sometimes conflict with teaching commitments and the academic calendar.
- Employ regular reviews of academic output to ensure ongoing alignment with contracted objectives and business requirements.
- Regularly review recommendations from research or academic partners to ensure they are both practically implementable and relevant to a utility perspective.

Software development cycle

- Commitment to the development of internal capability is especially important in technology trials of this scale. Continuity of resources in software development, coders and scrum masters, should be, where possible, prioritised.
- The project recruited scrum masters and developers with demonstrated capability in .Net, C and Python, a strong understanding of physics, management of very large data sets and data visualisation.
- The current trend in short term contracts or utilising external resources is inconsistent with the retention of knowledge or IP in the business. Project contracting practices require careful management to protect project velocity and retention of capability.
- Ensure adequate documentation is included as a distinct deliverable within the JIRA tickets, in addition to quality commenting within the code and not separated notebook documentation. Documentation should be peer-reviewed and signed off by the scrum master.
- Ensure the software development cycle is managed carefully, particularly testing, which requires interface with equipment in the field and where responsibility for those in-field assets sits within other divisions within the business.
- Exercise caution when using third party API's, they will rarely work the first time. Third-party APIs will require testing regularly.
- Process alarms and a nominated recipient of those alarms are required to ensure stable and ongoing functionality of new applications which may be sitting outside a production environment during development, especially where project critical data acquisition is taking place.
- Set clear expectations around data quality to all stakeholders in the early stages of the project. The appetite for large complex and gapless datasets needs careful management.
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R&D tax credits

- It is always worth checking a project's eligibility for R&D tax credits where a research component exists in the project scope. Your CFO or accountant will advise how this can be done.

Implications for future projects

Knowledge transfer between the Carnarvon DER trials and other Horizon Power projects, particularly the DER deployment in the Onslow microgrid projects is ongoing. Many of the staff associated with this project work on other key initiatives within Horizon power providing an organic spread of learnings throughout the decision making processes. Lessons learnt in the Carnarvon DER trials have influenced the 2019 release of DER Connection Technical Requirements and supported the decision the recent release of 10 MW of hosting capacity across the Horizon Power service area.

Horizon Power is currently modernising our business to further improve our efficiency and ability to deliver our customers more affordable electricity – we aspire to create a 'Digital Utility of the Future' that is a reference case in the Energy Sector. This may include digital twins, artificial intelligence, automation, enhancing cloud-based services and supporting the deployment of Distributed Energy Resource Management Systems (DERMS).

The work done to date in the Carnarvon DER trails has provided valuable insight into DER performance in Microgrids and how that can be improved through visibility, control and orchestration through virtual power plant applications.

Similarly, we've had the opportunity to examine the costs associated with DER orchestration and where they can be cost-effectively managed e.g. finding a balance between acceptable DER network performance and reduced communications cost.

Knowledge gap

This report covers initial technology choices, customer onboarding into the trials and infrastructure deployment. A second lessons learnt report at the end of the project in 2020, together with technical reports, and R&D deliverables will cover technology performance and R&D objectives in greater detail.

Perhaps the most impactful knowledge gaps identified so far are:

- Customer understanding of energy storage options. While they have heard about battery technology in the media, few customers interviewed in these trials understand the technology and how it could work with solar PV systems. This is further complicated by the current Feed-in Tariff, which encourages customers to maximise the export of their solar PV energy into the network by shifting as much of their load as possible to the peak period. We expect this to change with the withdrawal of the premium Feed-in Tariff in Western Australia. At this time, we expect there will be increased interest in battery technology from customers who seek to maximise self-consumption.

- The industry needs to invest effort into installer education with respect to inverter settings. Changing network conditions due to increased penetration of inverter technology will see more frequent activation of primary response curves in inverters. This will change the nature of conversations between system retailers or installers and the prospective end customers. Installers will need to understand and be able to communicate that a customer must start to treat the ability to export their excess energy into the network as an opportunity rather than a right. There will be times when network conditions do not grant that opportunity and their inverter will behave accordingly. This may be manifested in reduced output during certain times of the day.
- Similarly, as inverter primary response curves start to play an increasingly important role as front line managers of DER, ensuring the correct settings are programmed into the inverter upon installation becomes critically important. Clear communication of the setting required by the network operator and easy access to that information by retailers and installers will play an important part in ensuring the future fleet of next-generation inverters can play their part in preserving network stability.

Background

Objectives

This project aims to resolve the technical, operational and transitional barriers to a high penetration DER business future. It also aims to leverage Horizon Power's experience with network-connected energy storage to build capabilities in the management and optimisation of high penetration renewable energy generation in remote microgrids.

In order to achieve the project objectives, Horizon Power is researching the management of renewable energy generation and energy storage through a series of trials on its network in Carnarvon.

A three-year project, the Distributed Energy Resources (DER) trials will test distributed energy systems through a variety of behind-the-meter product tests, with the aim of better understanding how to manage the variability of renewable energy and its impact on the network.

The trials comprise two different components, including data acquisition and two control trials.

Data Acquisition – there are currently 116 Horizon Power customers in Carnarvon with a rooftop solar PV system. Currently, 82 of these customers are participating in this component of the trial and have a Solar Smart Monitor device installed on their property. As mentioned above the Solar Analytics/Wattwatchers devices were provided to customers free of charge, including the cost of installation and a three-year subscription to the solar analytics service. The device is helping Horizon Power to monitor their energy consumption to determine:

- the amount of solar PV energy generated
- the amount of solar energy consumed by the participant
- the amount of conventional energy imported from the network, for any particular time of the day; effectively unmasking the real load which has been obscured by PV for the last decade.

The data acquisition forms an integral part of building a database of information used for power system analysis throughout the trials.

A sky camera and meteorological data station have been installed at the Carnarvon depot to record cloud movements and weather data including temperature, humidity, wind speed and direction, solar isolation and barometric pressure.

PV and Energy Storage Monitor and Control trials – Horizon Power is conducting two DER monitor and control trials behind the customer meter. The first is Monitor and Control of PV, and the second is the monitor and Control of Energy Storage.

These trials involve a combination of PV only and PV/battery combo systems recruited to participate in the trials,

- Horizon Power has gifted ten solar PV and battery systems to customers who previously did not have solar PV, specifically for the trials. Three residential and two business customers in the greater Carnarvon Area and five residential customers on the Gibson Street feeder. These customers were selected based on their responses to the competition held in the town, along with meeting several locational criteria set out in the competition's terms and conditions.
- Horizon Power has recruited an additional seven customers with existing PV systems on the Gibson Street feeder to participate in the DER trials. These seven customers received a free DER system upgrade; six received a battery and battery inverter while the Solex solar farm received an inverter upgrade (no batteries). Horizon Power will monitor their DER system performance and control battery charge/discharge, and the amount of renewable energy they export onto the network using a feed-in management device.
- The participant DER systems are equipped with monitor and control devices (Reposit Boxes) that allow the project to gather PV and battery performance and network operational data as well as experiment with different types of controls signals from an intelligent DER Monitor and Control System.

Process undertaken

DER trials

- Meet project deliverables as set out in the ARENA funding contract.
- Build and develop relationships with trial partner Murdoch University and energy technology suppliers: Solar Analytics, Wattwatchers, Fulcrum 3D, Reposit Energy, Energy Matters.
- Explore the most economically efficient way to design and manage a microgrid with

high levels of DER and reduce dependence on centralised fossil-fuelled generation.

- Potentially increase distributed energy targets throughout Horizon Power's service area.

Data acquisition component

- >80 customers to install a Solar Smart monitor on their premise.
- Gather sufficient weather, DER and power system data to enable Horizon Power to understand how cloud movements impact energy generated from solar panels and how this impacts the network.

PV and Energy Storage Monitor and Control trials 1 & 2

- Install ten new PV/battery combo systems with a range of smart inverter and energy technologies in Carnarvon. Five of these to be on the Gibson Street Feeder and five in the wider Carnarvon region.
- Upgrade seven DER systems at properties with existing PV on the Gibson Street Feeder.
- Gather participants' data to measure how much renewable energy their system produces and how much renewable energy they use in their home so that Horizon Power can better understand the effects of large numbers of PV and battery systems connected to our network.

Further project information

https://horizonpower.com.au/our-community/projects/carnarvon-distributed-energy-resourcder-trials/