Energy Transformation Taskforce

DER Roadmap

DER Project Stocktake

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Introduction

The rapid pace of innovation and adoption of Distributed Energy Resources (DER), particularly in Australia, has led to the proliferation of pilots, trials and projects to test concepts, technology, and alternative business models.

In Western Australia, where the challenges of DER are being felt acutely, Government and the private sector have initiated a range of DER projects to understand and mitigate these challenges, as well as seek to leverage related opportunities.

The focus of this DER Project Stocktake is to identify and summarise those projects conducted in Western Australia, with emphasis on possible barriers to the widespread adoption of beneficial project outcomes. Some national and international projects have been included where they are relevant. The findings are intended to inform the development of the DER Roadmap recommendations and actions.

How to read this document

The DER Project Stocktake contains background information of each project, key findings and considerations for the DER Roadmap.

This Project Stocktake includes the following information for each project:

- Background information
- Project objectives
- Approach
- Progress
- Barriers and critical lessons – categorised by their Customer, Regulatory, Technical and Market implications
- DER Roadmap considerations

This document is intended to be read alongside the DER Roadmap and has been drawn upon in the development of the DER Roadmap and its recommendations.

Roadmap considerations for each project can be referenced against corresponding elements in the DER Roadmap recommendations.

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1. Advanced Meter Infrastructure Rollout – Western Power

Start Date	May 2019	End Date	Ongoing (phase 1 ends June 2022)
Location	SWIS	Project Type	Enabling Technology

Background Information

- Standard meters deployed previously by Western Power have limited functionality in measuring two-way energy flows and communications.
- Advanced meters measure bidirectional flows in shorter time intervals and are capable of enhanced communications to facilitate data transfer and management.
    - Advanced meters also facilitate the detection of safety issues (such as neutral faults) and allow for the adoption of dynamic tariffs and peer-to-peer trading.
- The State Government announced in the 2019-20 Budget that $251 million would be provided to install a minimum of 238,000 advanced meters over three years.

(Image courtesy Western Power)

Project Objectives

- To facilitate the more efficient operation of the Western Power network, including the opportunity to implement alternative tariff arrangements and the provision of safety services such as neutral fault detection.
- To provide opportunity for consumer choice on energy usage.

Approach

- From May 2019, all meter installations for maintenance replacements, customer driven replacements and new connections will be for ‘advanced meters’.
- Advanced meters include a communications card that allows them to be remotely read and reprogramed, as well as allowing remote connect and disconnect capability.
- To enable these capabilities, Western Power will deploy a radio mesh network for remote communications (with the communications card inside each meter) across the SWIS. However, this will require a critical mass of meters to be installed to facilitate meshed coverage. This deployment as well as metering infill will be achieved in the metropolitan area and major town centres by mid-2020.

Progress

- The mesh radio communications infrastructure installation has commenced with communications ‘go-live’ targeted for mid-2020.
- The project is supported by the provision of customer education materials prior to and following meter installation.

Barriers and Critical Lessons

Regulatory

- Advanced metering is not explicitly contemplated within Metering Code and the rollout is limited to the funding provided by the State Government, as elements of the cost-benefit assessment (specifically, the communications infrastructure) were rejected by the ERA as part of Western Power’s AA4 determination.

Market

- AMI will typically only measure net supply at the customer connection point. Future DER transactions may rely on information from a DER device directly (such as a battery or solar photovoltaic (PV) inverter), however the current data outputs from advanced meters only provide net generation and consumption amounts. Alternative data arrangements may be required to facilitate such products as Virtual Power Plants (VPP), should they rely on DER data directly.

DER Roadmap Considerations

Element	Consideration
Tariff Pilots	The AMI deployment will deliver a minimum of 238,000 metering installations to June 2022, representing approximately 20% of the customer base. Tariff approaches that are dependent on interval data will require alignment with the AMI deployment profile, or consideration of any additional costs for tariff approaches that drive additional metering installations.
New Business Models	AMI only provides net customer import and export information. It does not assist with understanding of underlying gross demand, and DER generation or usage. While third party meters behind the Western Power meter can provide this information, there are currently limitations on how this is used for billing purposes.
Grid Response	The full recovery of advanced meters and communications infrastructure was not approved for the current Western Power Access Arrangement period (AA4) and was funded instead by the State Government.

Element	Consideration
	Future rollout of advanced metering beyond Western Power's current Access Arrangement will require review and possible amendment of the Electricity Networks Access Code.

2. Alkimos Community Battery – Synergy

Start Date	2016	End Date	2020
Location	Alkimos Beach	Project Type	Community Battery

Background Information

- Alkimos Beach, a sustainable residential community in Perth's northern coastal suburbs, has an extremely high concentration of residential solar PV – every property in the community has a solar PV system installed.
- Synergy, with funding from ARENA, and in collaboration with Lendlease and LandCorp, is leading a project to trial a community battery energy storage system (BESS) at Alkimos Beach to manage peak demand.
- The Alkimos community BESS was the first community battery in Australia.
- The four-year trial will provide a better understanding of how community scale infrastructure, combined with time-of-use incentives, may help manage and reduce household energy costs.

(image courtesy of Synergy)

Project Objectives

- To demonstrate the benefits of community scale BESS, in combination with a virtual storage retail offering.
- To understand customer usage and behaviour changes under a time-of-use tariff structure.

Approach

- A 1.1MWh lithium ion battery was installed and commissioned in April 2016.
- Participants are charged peak or off-peak (day and evening) time-of-use tariffs and can accumulate and spend solar 'credits' to reflect the charge and use of virtual storage.
- Under a Peak Demand Saver plan, participants are charged $11 per month for unlimited virtual storage of their solar PV energy exports.
    - Energy exported is used to offset any energy consumption between 4pm and midnight.
    - If, over a billing period, exported energy exceeds that consumed between 4pm and midnight, the participant receives a per unit rate equivalent to the current REBS rate.
    - To facilitate billing, manually extracted off market data is measured six times per year.

- Additionally, time-of-use pricing incentivises customers to use energy outside of a designated peak period (between 4pm and 8pm).

Progress

- Since the trial started on April 2016, participating households have saved $35,247 off their collective energy bills (an average of $311.92 per household per annum).

- The trial currently has 67 live customers and 113 total customers throughout the trial. The most common reason for leaving the trial is moving home, however Synergy has taken customers off the tariff who were not financially benefitting.

- A lack of access to interval data prior to product launch made it hard to assess customer consumption patterns and suitability for the trial.

- Lack of real time usage visibility and trial performance has made it difficult for customers to observe trial benefits, which may reduce customer engagement.

- Alkimos Beach development has smaller solar PV systems (the average system size is 2.51kW system with many just having 1.5kW) compared to South West Interconnected System (SWIS) average (4.6kW inverter with 6.0kW of PV panels). The development mandated installation of solar PV, and many people chose the minimum, which may have reduced benefits for some customers.

Barriers and Critical Lessons

Customer

- A centralised storage solution relies on adequate customer excess energy being available. Small solar PV systems are unlikely to have sufficient consistent excess generation beyond the net load of the occupancy. Future iterations should focus on larger systems – advanced metering data will facilitate identification of customers with sufficient net exports for effective participation.

- Community storage solutions currently require delivery via the customer's retailer in order to be implemented. For non-retailer community batteries, metering and settlement arrangements for the customer requires further review. Under the retailer-implemented model, customers' bi-directional flow of electricity can be settled within the retail portfolio ('off-market'). Future business models provided by parties outside the retailer would rely on alternative arrangements being developed such as multiple trading relationships or embedded network provisions to be implemented. Customer protections for such models would also require consideration.

Regulatory

- Community storage initiatives rely on multiple revenue streams to be cost-effective, including providing network services where a network need is identified. Regulatory requirements for publishing network opportunity maps and valuing the services the battery can provide the network would help underpin business cases for the future deployment of BESS.

Technical

- Access to interval data is critical. The settlement of inflows and outflows between the customer and the battery can only be achieved via interval data. Advanced Metering Infrastructure (AMI) will provide this dataset. The provision of interval reads daily can facilitate additional innovative products such as customer information services and retail tariff innovation.

Market

- The battery has its own supply point, accruing large network costs which make the battery non-commercial at the scale and on the arrangements provided.

DER Roadmap Considerations

Element	Consideration
Network Investment Process	Community storage initiatives rely on multiple revenue streams to be cost-effective, including providing network services where a network need is identified. Regulatory requirements for publishing network opportunity maps and valuing the services the battery can provide the network would help underpin business cases for the future deployment of BESS.
Distribution Battery Storage	The metering and settlement requirements as well as customer protections for third party models requires further consideration.
New Business Models	Ensuring customer protections are maintained under future business models that incorporate community batteries warrants further consideration.
Tariff Pilots	The development of innovative retail products including real-time and/or daily energy use feedback to consumers relies on interval data derived from AMI.
Tariff Pilots	The use of time-of-use tariffs (and theoretically, other tariff structures) can enhance the customer value proposition for additional innovative energy service offerings. This is particularly relevant where automation (e.g. in the operation of the community battery) and behaviour change can be used to flatten load profiles and increase network utilisation.

3. Alkimos Direct Load Control – Synergy

Start Date	2018	End Date	Ongoing
Location	Alkimos Beach (SWIS)	Project Type	DER Management

Background Information

- Evening peaks (between 5pm and 8pm) due to residential demand increases cause stress on Synergy generation infrastructure as it is required to ramp up supply rapidly.
- The ability to reduce residential consumption through control of high consuming appliances, such as air conditioners, can lessen the effect of this peak period on the grid, and reduce the strain on Synergy generation.

Project Objectives

- To test the technology around Direct Load Control (DLC) devices that can connect to compatible air conditioners on a small sample of customers.
- To trial, on projected peak demand days, 'control events' to reduce the energy consumption of air conditioners. This will not only provide information on the viability of the technology, but also provide data that can be extrapolated to show what the effect of this product on the grid would be with a high number of participants.

Approach

- Eligible customers in the Alkimos Beach development were recruited, being offered renumeration in the form of a $200 per year credit into their Synergy account to participate. Customers with a compatible air conditioning unit had a *SwitchDin* control device installed. There are currently eight customers on the trial with six more to be installed in summer 2019-20.
- The trial uses devices compliant with the Australian Standard for demand response (AS 4755). Previous trials undertaken by Western Power and Synergy (Perth Solar City) had controlled air conditioners at the circuit level (directly wiring into the air conditioning unit) which proved to be cost prohibitive.
- The device allows Synergy to reduce the power consumption to the compressor in the air conditioning unit in increments.
- Throughout the peak periods in summer and winter Synergy will reduce the consumption of trial participants' air conditioning to determine the functionality of the devices and to gather data around the effect of reducing load during peak consumption periods.
- Participates are sent surveys throughout the trial to understand the customer experience and perception.

Progress

- Only 35% of applicants had AS4755 compliant air conditioners.
- The devices function as expected and can reduce the power consumption of customers' air conditioners to 0%, 50% and 75% of what they would normally consume.
- Customer concerns relating to the impact of the device on their air conditioners were higher than anticipated, although occasionally these concerns were unrelated to the device.

Barriers and Critical Lessons

Customer

- Benefits need to flow through to the customer (via the retailer) to create incentives and ensure engagement.
- Customers can demonstrate a lack of understanding about how their air conditioning unit works and can blame unrelated air conditioning issues on the control – customer education may complement future rollout.

Regulatory

- There are no regulatory barriers – barriers to wider rollout relate to the economics.

Technical

- While Wi-Fi connection was suitable for this trial (which only test peak demand days), future load control requirements for live data quantity and consistency may warrant greater investment in alternative connection methods.
    - Devices connected via Wi-Fi were quicker and easier to install, requiring little to no modification of the property. However, they proved to be susceptible to disconnection. Future wireless communication types such as 5G may overcome this.
    - Devices connected directly by network cabling were found to be more reliable but needed a more invasive installation with higher costs. This may make this method unsuitable for installation in older homes.
- A low proportion of units were compatible.
- The largest cost component was cost of the electrician to wire the device

Market

- This trial was only focused on peak demand days however there could be opportunities to address localised network constraints. A network services market could address this issue.

DER Roadmap Considerations

Element	Consideration
DER Orchestration Pilot	The unit costs for appliance control is reducing with improvements in both the cost and ease of installation of control devices. Over time, these assets could provide aggregated services, including localised distribution network services. Aggregation of such devices should be considered in the development of DER aggregator registration and accreditation requirements and market participation opportunities (including market participation pilots and trials).
DER Orchestration Pilot	Potential opportunity to use Western Power's radio mesh network for cheaper and more reliable control communications and data transfer.
DSO/DMO Function Set	A transparent network services marketplace may offer an efficient way to unlock the value of DLC and ensure value flows to DER owners.

4. Amble Estate Solar PPA – Infinite Energy

Start Date	March 2018	End Date	Ongoing
Location	Girrawheen (SWIS)	Project Type	Solar PPA

Background Information

- The Department of Communities is developing 129 new lots at an in-fill project (The Amble Estate) located at a former school site in Girrawheen. Lots are available for sale, and buyers choose their own home builder.
- Infinite Energy is a large solar retailer and a preferred solar supplier for the Western Australian Local Government Association (WALGA).
- Infinite Energy is offering home buyers at The Amble Estate the opportunity to opt-in to a 10-year solar power purchase agreement (PPA), through which they'll receive discounted tariffs for all solar electricity used by the household.
    - Novel billing arrangements see customers billed only for consumption, with no net income for exported units.

Project Objectives

- To provide long-term savings to households on their power bills, including reducing their exposure to future power price fluctuations.
- To provide access to solar PV for owner occupiers and renters in affordable housing areas, while providing a sustainable margin to the private sector provider.

Approach

- Home buyers who build in The Amble Estate can enter a 10-year solar PPA with Infinite Energy.
- Installation of a solar PV system is offered to customers for free.
    - Infinite Energy retains full ownership, and maintenance responsibilities, of the solar PV system for the 10-year term of the PPA.
    - Installation includes the solar PV system, inverter, cabling and additional metering (to measure solar consumption and export).
- Infinite Energy bills the customer every two months for energy produced by the solar system.
    - Solar electricity used by the household is billed at 60% of the Synergy A1 tariff.
    - Solar electricity exported to the grid is billed to customers at the Renewable Energy Buyback Scheme (REBS) rate.
- Customers also receive a bill from Synergy, which includes a daily supply charge.
    - Electricity imported by the household is billed at the Synergy A1 tariff rate.
    - Solar electricity exported to the grid is credited to customers at the REBS rate.
- These billing arrangements deliver a consumption-only solar PPA, where customers are billed an amount commensurate to the REBS payments they receive for solar exports, with no net income for customers.

Progress

- The offering has been highly attractive to customers and 90% of homebuyers had signed up as at October 2019.

Barriers and Critical Lessons

Customer

- Solar PPAs can provide access to the benefits of DER for households who would otherwise not install it, particularly those who are unable to afford the installation costs.
- Under this PPA, Infinite Energy are incentivised to ensure the system operates correctly in order to recover the costs of installation, which may offer customers lower risk than installing a system themselves.
- Customer protections under such agreements may require further attention, particularly in relation to metering, billing and service quality.
- As customers retain a Synergy account, they receive two bills – engagement has been required to minimise confusion for customers.

Regulatory

- The home-owner is party to the PPA and retains these obligations even if deciding to lease the property.

Technical

- The installation also includes a meter installed by Infinite Energy to measure solar generation and units exported to the grid, facilitating billing.
    - The use of a second meter means alignment with Western Power (and therefore Synergy) solar export metering data is not guaranteed. Western Power meters are read manually while Infinite Energy meters are read digitally in 5-minute intervals. It is possible that this difference may lead to billing discrepancies for exported units displayed on Infinite Energy and Synergy bills.

DER Roadmap Considerations

Element	Consideration
New Business Models	New billing arrangements offer a path to DER-based bill reduction for customers in affordable housing areas but have implications for customer protections and requirements from licencing frameworks. For example, consideration of data measurement and validation under new business models requires consideration.
Tariff Pilots	New business models that utilise customer DER may extract value from tariff structures that are not cost reflective, thereby pushing costs onto remaining customers.

5. Bremer Bay Automation – Synergy, Western Power

Start Date	2017	End Date	Ongoing
Location	Bremer Bay (SWIS)	Project Type	Network Operations

Background Information

- Bremer Bay is supplied from an Albany substation via a long (180km) coastal distribution feeder which experiences poor reliability due to exposure to wind, salt and vegetation.
    - Including all spurs from the feeder, there are a total of 2,000km of overhead lines servicing the area, providing a challenge for finding and repairing faults.
- Bremer Bay customers have experienced 45 outages over the past five years, with an average duration of approximately two hours.
- Bremer Bay hosts a 600kW wind turbine and a diesel power station. The diesel generator is only utilised when supply from the network is lost. Start-up of the diesel power station operation has historically been initiated in response to phone discussions between Western Power and power station controllers.
- Automation of the Bremer Bay power station was proposed to expedite start-up times and reduce the length of outages experienced by local customers.

(Image courtesy of Synergy)

Project Objectives

- To provide an automated scheme through coordination between Western Power and Synergy that reduces customer outage durations to under one minute.
    - Outages shorter than one minute represent minimal disruptions for customers – longer outages are included in Western Power's outage duration and frequency performance metrics.

Approach

- Western Power and Synergy have collaborated on the development and implementation of an automation scheme for the Bremer Bay microgrid.

- The automated scheme is being developed that:
  - determines the location of a fault;
  - starts the power station automatically when supply from the network is lost (if determined to be safe to do so); and
  - stops the power station automatically when supply from the network is restored.

Progress

- The automation scheme was commissioned in December 2017.
- Since completion, the average annual outage hours experienced by customers in the town has been reduced from 18 to 12.
  - The 12 outage hours are attributable to the fact that the power station deliberately does not restart for faults inside the town.
  - Faults inside the town account for 12% of outages and is higher than anticipated due to a high volume of maintenance works in the town.
- Western Power estimates that the automation scheme had prevented an additional 50 hours of outages.

Barriers and Critical Lessons

Customer

- A complaint from a customer in the town was that they were expecting that the automated power station solution would be able to feed the town for all power outage events, including faults inside the island. Provision of a clearer message to customers that automation of the power station would not be able to cater for all faults could have avoided this confusion.

Technical

- Further improvement of visibility of the performance of both the microgrid and the long complex feeder in terms of communication and control would aid fault diagnostics, line repairs and customer supply restoration.

DER Roadmap Considerations

Element	Consideration
DSO/DMO Function Set	Management of islanded microgrids needs to be considered as part of Distribution System Operator (DSO)/Distribution Market Operator (DMO) functions and capabilities. Specific requirements and procedures may need to be developed for these scenarios.
Distribution Network and Visibility	Greater network visibility could facilitate the deployment of this solution in other locations, facilitating reliability improvements at minimal cost.
DER Orchestration Pilot	Further consideration is required for how more sophisticated VPP capability and automation solutions impact customers participating in VPPs, and in dispatch approaches under the DSO/DMO Function Set.

6. Broome Smart Sun – Horizon Power

Start Date	November 2017	End Date	June 2020
Location	Broome	Project Type	DER management, VPP

Background

- High levels of rooftop solar poses problems for electricity networks, particularly in smaller micro-grids such as Broome.
- As customer demand for rooftop solar increases, and with traditional centralised electricity generation still necessary to maintain reliability and security, there is a need to develop a way for increased rooftop solar and traditional generation to co-exist on the electricity network.
- Additionally, utilities have long faced the challenge of peak electricity demand, having to build and manage a disproportionate amount of infrastructure to service short but extreme spikes in electricity demand during periods such as the summer months when air conditioner use is high.
- In an attempt to simultaneously address these two challenges, Horizon Power and DevelopmentWA are piloting a way that rooftop solar, customer air-conditioning and battery energy storage DER can be actively managed via a single software platform in ways that achieves mutual benefit for customers, including land developers, and the electricity network.

Project Objectives

The Pilot aims to demonstrate that numerous distributed devices may be coordinated as a fleet to:

- Enable generation from rooftop solar while managing reverse power flows and preventing related power quality issues. The major potential benefits of this include enabling the connection of a higher number of solar PV systems by customers and Horizon Power.
- Reduce peak electricity demand on the local electricity infrastructure. The major potential benefits of this include connection of additional customers to existing infrastructure, potentially reducing residential lot development costs via the need for less infrastructure, deferring network augmentation and/or reducing peaking generation costs.

Approach

- The first phase of the Pilot included a cohort of ten participating homes in DevelopmentWA's Waranyjarri Estate in Broome North which are all connected to the same electricity Distribution Transformer (DT). At the time of the Pilot, the Broome micro-grid had reached the perceived network hosting limit for connected solar PV systems, and installation of new solar PV systems was not permitted.
- The Pilot provided participating households a highly incentivised DER package consisting of a rooftop solar PV system, BESS, installation of air conditioner coordination device and an energy efficient heat pump Hot Water System.
- Whilst the installation of this equipment typically leads to a significant reduction in household energy consumption from the grid, it does not avoid the power quality issues which arise from unmanaged daytime export of solar PV and does not maximise the reduction of peak demand. Therefore, SwitchDin were engaged to provide and enhance their DER coordination technology (StormCloud) as the primary means of coordinating customer DER to balance customer comfort and savings with network requirements.

Progress

- A total of 70.8kW of rooftop solar panels were installed across ten homes, and remotely operated via SwitchDin's StormCloud to manage solar generation output by progressively limiting output to 75% and 50% of solar PV capacity.

- Ten BESS, with a combined storage of 100kWh and inverter rating of 40kW, were installed in the Pilot participant households. In self-consumption mode the BESS are charged by the excess solar PV generation not being used in the house. When the solar PV generation is below household demand the BESS will discharge to supply the household load. In coordination mode the BESS can be discharged at the inverter rated output which may result in export to the grid at some sites while reducing peak demand.

- Results from the Phase 1 trials showed whilst there were a total of thirty households on the DT, the solar PV export from the ten trial households was sufficient to cause reverse power flow on the DT on many days during the trial (resulting in very low power factor at the DT).

- Remotely coordinating the participants solar power output during the day avoided excess unused power from going back onto the grid and affecting power quality.

- Remotely managing the export of participants' excess battery storage was effective in reducing the evening peak demand on the network.

- These findings support the hypothesis that higher levels of solar PV penetration may be accommodated within electricity networks when combined with adequate coordination and battery storage.

- An additional five customers have been recruited for Phase 2, bringing the total to 95.5kW of PV, and 150kWh of BESS.

Barriers and Critical Lessons

Customer

- While overall customer electricity bills were reduced by up to 70% by rooftop solar in combination with BESS, the hypothesis that participants would use more power if it was cheaper proved to be correct. The participants recorded an overall higher average household energy consumption compared to non-pilot households on the same distribution transformer. This is possible evidence of the Jevon's paradox that a reduction in the price of a resource results in an increase in the consumption of that resource.
- Customers did not report any negative changes in comfort levels through the control of household air conditioners.
- Customers are willing and accepting of DER coordination if appropriately informed and incentivised.

Technical

- Default solar PV inverter settings often caused the inverters to curtail output or prevent connection and reconnection to the grid. In order to rectify these problems Horizon Power has revised these settings in its recently published Embedded Generation Connection Technical Requirements.

- Technical issues related to the connection and coordination of inverters, smaller capacity air conditioners and heat pump hot water systems were encountered on the project. Overall, it demonstrates that manufacturer interpretation and application of standards is not uniform and cannot always be relied upon until actively tested in the field.

DER Roadmap Considerations

Element	Consideration
DSO/DMO Function Set	Customer contracting arrangements need to be considered in light of the longer-term DSO interactions and likelihood of dispatch and curtailment of customer DER. Dynamic connection agreements require development, and interaction with existing customer contracts (supply contract, REBS contract) should be considered, and where appropriate, duplication removed.
DSO/DMO Function Set	The outcomes of the Pilot will inform how the DSO may interact with individual customer DER, and identify other prerequisites for the establishment of DSO, such as enabling technology.
Education	Customers who are made aware of the hosting capacity limitations of the network display some willingness to have their DER orchestrated in order to receive benefits from DER.
VPP Pilot	The development of DER Management Use Cases was critical to informing the required technical outputs of installed DERs (for example, validating frequency support capability of installed DER). The development of DER Management Use Cases for the SWIS should be explicitly included in future VPP pilots and trials.

7. Carnarvon DER Trials – Horizon Power

Start Date	October 2017	End Date	October 2021
Location	Carnarvon	Project Type	DER Management

Background Information

- High uptake of solar PV by Horizon Power customers in Carnarvon threatened to impact the reliability of power supply and so Horizon Power set in place a hosting capacity target limit in the town. The unmanaged portion of the hosting capacity target, i.e. conventional solar PV with no battery solar smoothing, was reached in 2011.
    - Consequently, connection of new DER without solar smoothing was unavailable to customers in Carnarvon.
- Small electricity systems like that in Carnarvon are particularly vulnerable to high levels of solar PV penetration.
- DER trials are being undertaken by Horizon Power over three years to assess DER through a variety of behind-the-meter system tests.

Project Objectives

- To understand the impact of cloud events on customer DER generation and network operation.
- To test the use of small-scale batteries to manage customer demand and bills.
- To test the monitor and control of DER systems to achieve orchestration for network optimisation.

Approach

- Ten trial participants were selected through a competition to receive a DER system comprised of solar panels (with an inverter), battery storage (with an inverter), DER control technology including Repost Box and VPP cloud aggregation, and a Wattwatchers monitoring device.
- Six trial participants with legacy PV systems received a battery upgrade and the DER control technology to test how these customers could use energy storage to minimise their electricity bill after the withdrawal of the premium feed-in tariffs.
- As a condition of receiving the system, participants agreed to give Horizon Power access to the system for three years in order to collect data and test DER visibility and control.
- A network battery storage system enables islanding of that part of the network which includes the trial participants.
- There are currently more than 120 Horizon Power customers in Carnarvon with a rooftop solar PV system.

Progress

- Solar PV and battery systems have been installed in participants' properties.
- Testing of the DER systems, and data analysis by the project's academic partner Murdoch University is underway.

Barriers and Critical Lessons

Customer

- Customers appear willing to have their DER managed for network optimisation, however, this is in response to the provision of free DER systems and constraints on the ability for new DER to be connected.

- Future constraints on the connection of new DER in the Horizon Power service area will hinge on their ability to be managed, while legacy PV systems which require replacement inverters will need to be bought in line with the new standards.

DER Roadmap Considerations

Element	Consideration
DSO/DMO Function Set	Customer contracting arrangements need to be considered in light of the longer-term DSO interactions and likelihood of dispatch and curtailment of customer DER. Dynamic connection agreements require development, and interaction with existing customer contracts (supply contract, REBS contract) should be considered, and where appropriate, duplication removed.
Education	Customers who are made aware of the hosting capacity limitations of the network display some willingness to have their DER orchestrated in order to receive benefits from DER. Broad-based education of the impacts of solar PV on electricity supply have set expectations in Carnarvon and Onslow.
DSO/DMO Function Set	The outcomes of the Carnarvon trial will inform how the DSO may interact with individual customer DER, and identify other prerequisites for the establishment of DSO, such as enabling technology.
Data Collection	Consideration of data collection prerequisites and permissions from customers as a result of DER orchestration.

8. DER Management Capability – Western Power

Start Date	2019	End Date	2019
Location	SWIS	Project Type	Network Operations

Background Information

- Excess power generated by DER has the potential to impact the resiliency of the grid, but also provides an opportunity to provide network support services and offset network infrastructure investment.
- New roles in the energy market are emerging, such as that of a DSO, however the functions and boundaries of these roles are yet to be determined in Western Australia.
- The management of DER and its impact on the distribution network requires significant capability development within network operators and technology service providers.
- Western Power has issued and evaluated a DER Management Capability Expression of Interest (EOI) to inform its business and key stakeholders of the relevant capabilities required to continue to operate and manage its network.

Project Objectives

- To understand the relevant capabilities required to continue to operate and manage the Western Power network, as technology and customer behaviour changes over time.
    - This includes discovering solutions that reveal future opportunities associated with DER and adjacent systems, services and technology.
- To understand availability of services to respond to changes in the energy industry, including grid planning; grid operations and Distribution System Operation enablement.

Approach

- Western Power issued a DER Management Capability EOI, requesting input from vendors on their view of the changes in the energy system, and how their goods or services could help Western Power to understand market capability surrounding DER management capability.
- Vendors were invited to demonstrate how their offering would overcome thermal, overvoltage and microgrid reliability at three example sites.

Progress

- No vendor demonstrated capability to manage the entire DSO value chain. A hybrid approach to trials and vendors will be required to test the spectrum of the DSO value chain.
- Vendors demonstrated the capability to use DER to maintain network within parameters including voltage and thermal constraints. This could be scaled to defer or alter network augmentation investment decisions.
- Established vendors of network management systems have higher integration requirements, while DER Management System (DERMS)-focused vendors have developed products that plug into common existing platforms (allowing for modularity).
- Prior to defining the trial scope/s, an evaluation of what other utilities have tested, or are testing, is being completed so that existing learnings can be leveraged, rather than duplicated.

Barriers and Critical Lessons

Customer

- Customer participation is critical to the operation of a DSO; however, a minority of vendors have established capabilities managing behind-the-meter services.
    - These services are focused on the optimisation of DER for customers (to reduce electricity costs) rather than network management.
- A scaled DERMS has potential to provide insightful customer data, however data ownership and confidentiality obligations will need to be considered.

Regulatory

- Expenditure on technology such as DERMS to facilitate DER integration is likely to require clarification of Electricity Networks Access Code revenue coverage.

Technical

- The majority of DERMS are not intended to replace or interfere with existing distribution management systems but provide a supplementary view visualising (and in some cases managing) DER performance.
- All DERMS products rely on some form of two-way communications infrastructure to receive data and send signals.
- Product maturity is highly variable, from laboratory trials to active DER management at scale.

Market

- No vendors providing aggregator services made a submission, suggesting multiple vendors will typically be required to facilitate end-to-end DER orchestration.
- Market integration and price optimisation capability appears to be several years away.

DER Roadmap Considerations

Element	Consideration
DSO/DMO Function Set	Participation of customers and aggregators or VPPs is critical to the development of a DSO. Consistency in the approach to interoperability standards for DER vendors to integrate with DERMS providers will be required at a national level.
DSO/DMO Function Set	There are no evident single providers currently able to supply the suite of functions required for a DSO – the development of a DSO is likely to require time for the vendor market to mature, and leverage hybrid solutions of multiple specialised services.
DSO/DMO Function Set	Market integration, participation, and optimisation capability will take several years to mature. Pilots and trials will be required to test end-to-end operations from market dispatch to DER response.
DER Orchestration Pilot	DER management capability is dependent on the demonstrated capability of DER to respond in a timely and accurate way. The development of DER Management Use Cases for the SWIS should be explicitly included in future DER Orchestration Pilots and trials.
New Business Models	Consideration needs to be given to whether customers with DER be required to have a default aggregator or VPP, through which the DSO issues dispatch instructions.

Element	Consideration
Data	Customer data ownership and availability requires further consideration, particularly as third-party products and services emerge.

9. EV Tariff – Synergy

Start Date	November 2017	End Date	Ongoing
Location	SWIS	Project Type	Electric Vehicle (incentive)

Background Information

- Launched in late November 2017, the EV Home Plan is a simple tariff that seeks to encourage the adoption of Electric Vehicles (EVs) and position Synergy as an innovative energy partner whilst shifting consumption away from peak periods.
- The tariff is designed with an EV off peak period between the hours of 11pm and 4am that rewards customers for charging during network off peak periods.

(Image courtesy Synergy)

Project Objectives

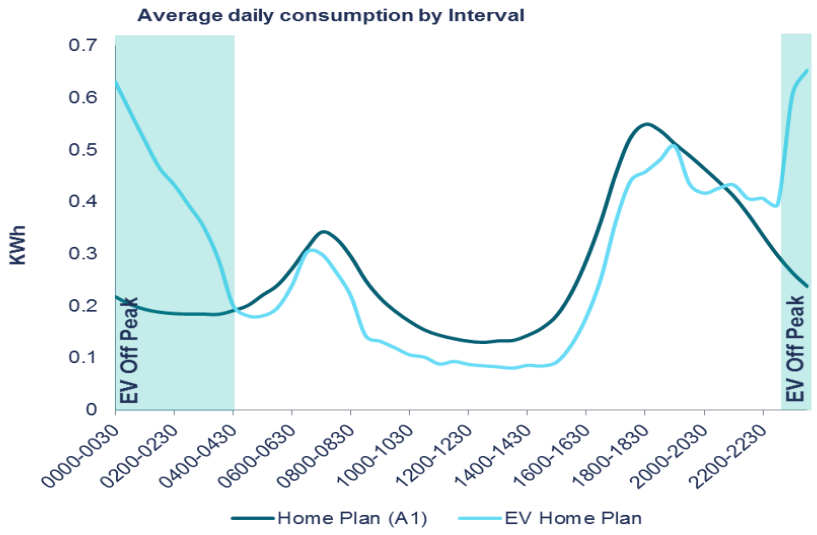
- Understand how tariffs can influence charging behaviour of EV owners.
- Encourage the uptake of EVs.

Approach

- Introduced a simplified time-of-use tariff, adopting an off-peak discounted rate between 11pm and 4am, standard unit prices outside of these hours, and a standard supply charge.
- Other incentives were provided to encourage uptake by customers:
  - Free monthly kilometres: 60 free kilometres' worth of energy per month (10 units)
  - EV Home Plan Incentive: $200 credit (over 12 instalments) to offset EV procurement costs in the first year of the plan.

Progress

- 73 customers on the EV Home Plan (average six renewals per month) with 30% growth per quarter.
- When compared to A1 residential tariff customers eligible for the REBS and the Feed-in Tariff (FIT), the EV home plan appears to reduce the peak time consumption load.
  - EV Home Plan REBS/FIT customers use 37% of their total consumption in the off-peak period.
  - By comparison A1 REBS/FIT customers use 17% of their total consumption in the same period (11pm to 4am).



Barriers and Critical Lessons

Customer

- Implementing time-of-use as a regulated tariff to replace the existing A1 and drive widespread behavioural change is a significant variation from the way most customers are currently billed, however cost reflective network time-of-use tariffs would ensure that retailer price signals are aligned with network needs.
- The current underlying network tariff signals a night-time off-peak period.
- Findings from the trial are limited by the very small number of participants, all of whom have self-selected to participate. The wider community may not respond in the same way as trial participants.

DER Roadmap Considerations

Element	Consideration
Tariff Pilots	Customers have shown an ability and willingness to change their consumption profile in response to the price signal from time-of-use tariffs.
Tariff Pilots	The tariff targets night-time periods for EV charging. It would be beneficial to trial an alternate tariff structure providing incentives to charge during low daytime demand hours, as a mechanism to mitigate system security risks that emerge from high solar generation conditions and low daytime loads.
Electric Vehicles	Advanced capabilities emerging on new chargers and work undertaken as part of AS4755 will assist with allowing dynamic management and load management. Vehicle-to-grid (V2G) capability, while still in its infancy, is emerging and needs to be considered as part of planning.

10. EV Chargers – Synergy

Start Date	2017	End Date	Ongoing
Location	Perth Metropolitan Area	Project Type	Electric Vehicle (infrastructure)

Background Information

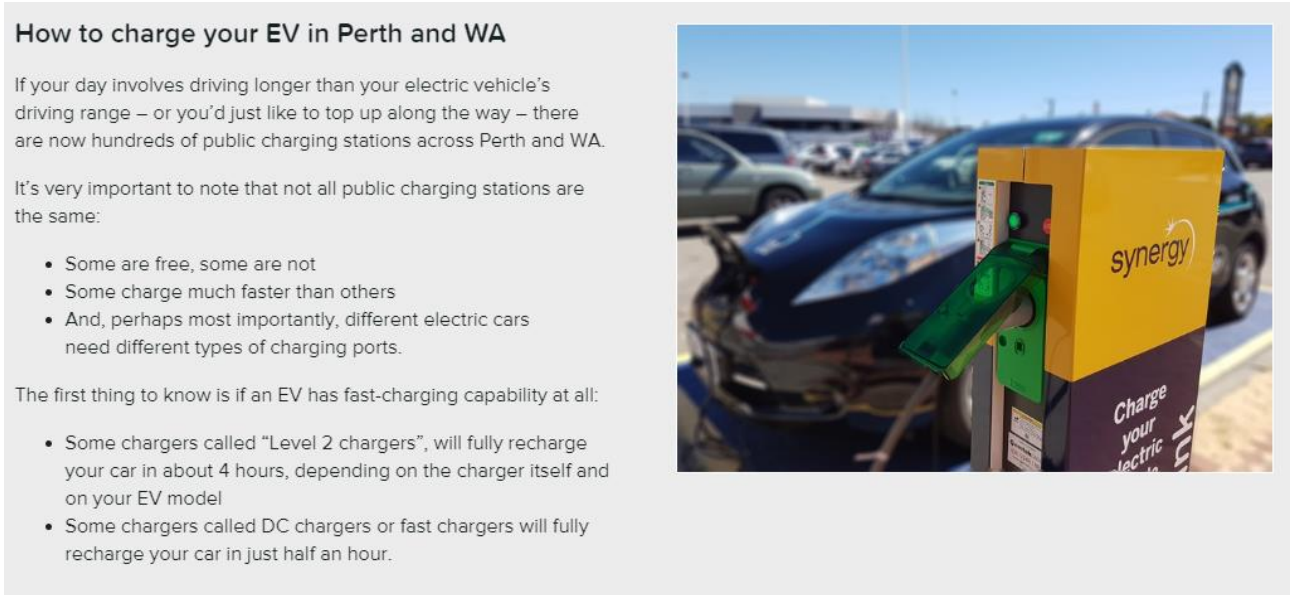
- In 2017, Synergy installed EV chargers in public places to better understand the viability of the technology and commercial opportunities.
- An accelerated uptake of EVs is one of the few drivers of increased grid demand and represents a revenue opportunity for Synergy.
- Increased demand from EVs, if managed appropriately could contribute to reducing the peakiness of the daily load curve. The associated increase in utilisation of the distribution network may also place downward pressure on energy costs.

Project Objectives

- To understand the EV charger technology.
- To understand EV charging behaviours in public places.

Approach

- The stations are located at: Lakeside Joondalup Hoyts Carpark, Lakeside Joondalup Myer Carpark, CBRE parking, Synergy Corporate parking, and Homebase at Subiaco. The charging stations have two ports for plugging in with the Type 2 plug and can be used for single-phase and 3-phase charging.
- The Synergy charging stations are level 2 and are equipped with the Type 2 charging plug socket. The Type 2 is capable of 3-phase charging, allowing vehicles to charge faster than single-phase charging



(Image courtesy Synergy)

Progress

- Data is being collected for all sites, including on length of stay, battery charge times and time of use.
- Single-phase charging is the most common across all sites, with 80% of charging being by single-phase. This is an indication of the type of charger in use – the Type 2 plug often must be purchased as an additional cost to the vehicle and EV owners are likely opting for the cheaper single-phase capability plugs.

Barriers and Critical Lessons

Customer

- Customers used single phase charging more often, despite the slower charge rate. This could indicate that few have purchased a Type 2 plug capable of 3-phase charging.
- Customer behaviour may change when the energy being provided is not free.

Technical

- There is no current standard in Australia for EV charging points. The Australian Electric Vehicle Association is working with Standards Australia to develop an Australian Standard.

DER Roadmap Considerations

Element	Consideration
Electric Vehicles	Acceleration of EV uptake is beneficial for customers, energy businesses and the State. Incentivising charging at times of high solar generation may maximise this benefit.
Electric Vehicles	There are multiple charging plug configurations in use by EVs internationally and no Australian standard in place.
Electric Vehicles	Understanding how customers use EV charging stations will inform wider deployment of the facilities and planning by Western Power for likely locations of new installations.
Electric Vehicles	Public charging facilities do not currently cater for V2G. This may change in the future.

11. Grid Transformation Engine – Western Power

Start Date	2017	End Date	Ongoing
Location	SWIS	Project Type	Network Operations

Background Information

- Network infrastructure typically has a long-life span (beyond 50 years in some instances) and requires forward-looking investment planning.
- The rapidly changing nature of energy consumption and the use of electricity networks requires an update to traditional network planning approaches.
- The Grid Transformation Energy (GTEng) is a software modelling system under development by Western Power to forecast economic, demographic and technology changes over a 30-year period, to inform network planning and investment.
- Enhanced planning systems like GTEng are considered an essential part of the suite of capabilities that will enable the full benefits of DER to be realised.

Project Objectives

- To develop a modelling system that considers customer demand, technology changes and network management approaches to inform grid transformation planning and investment.

Approach

- Western Power is developing the GTEng as a series of discrete modules that can be installed incrementally.
- The GTEng is to serve as a proof of concept for eventual replacement by an ‘enterprise grade’ solution in the near term.

Progress

- Several GTEng capabilities have already been developed, relating to customer profiles, energy forecasts and distribution network augmentation.
- Planned development activity includes transmission topology, scenario evaluation and user interfaces.
- Preliminary grid transformation scenario outputs have been produced, and early insights indicate that avoided network investment in the order of $2 billion can be achieved over 30 years.

Barriers and Critical Lessons

Regulatory

- Regulatory acceptance of enhanced network planning approaches will be integral to the further development of the GTEng and long-term scenario planning. Regulatory reform is required to address this issue.

Technical

- While long-term energy demand scenarios are simulated with GTEng using sophisticated energy forecasting models, a method of simulating the capacity, location and cost of DER has not been addressed. This would be needed to enable optimisation of network investment and DER responses to network issues.

- Western Power has identified system level network voltage modelling as a new capability that can be incorporated to enhance network planning.

Roadmap Considerations / Use Cases

- Enhanced visibility and planning will influence decision making around distribution BESS investment and non-network solution procurement.

DER Roadmap Considerations

Element	Consideration
Network Operation	The economic regulation of Western Power's network planning approaches such as use of the GTEng to support decision making is uncertain and may require further assessment and reform of the economic regulation process.
Distribution Network and Visibility	The development of the GTEng will have implications for future visibility requirements and may supersede other visibility improvements. Development of Distribution Visibility Requirements and Strategy documentation outlining requirements and existing capabilities across the entire distribution network is necessary to ensure efficient investment.
Grid Response	Development of the GTEng is likely to impact investment decisions in network infrastructure or pursuit of non-network solutions. Facilitation of net market benefits capability within the GTEng requires further scoping.

12. Inverter Settings – Western Power

Start Date	2017	End Date	2019
Location	SWIS	Project Type	Network Operations

Background Information

- The widespread installation of solar PV systems, inverters and changing customer load characteristics has seen Western Power move from managing one-way to two-way flows of electricity

- Western Power has identified excess reactive power flows on the network which have resulted in an increase in the number of complaints from customers experiencing power quality issues due to overvoltage.

    - Customers identify power quality issues when the 'self-protecting' functionality within PV inverter systems decreases power output. The decreased output from the PV system reduces the financial benefit of PV installation for customers.

- The Australian Standard *AS/NZS 4777.2:2015* outlines the requirements for inverters connected to the grid, including technical characteristics, settings and functionalities such as volt-watt and volt-var response.

    - Volt-watt and volt-var functionality sees an inverter incrementally adjust its power and reactive power exports in response to network voltage fluctuations, preventing larger network voltage increases that cause many inverters to cease all output.

- Updating inverter functionality can see DER used to mitigate power quality and system disturbance issues rather than exacerbate them, enabling additional customers to install solar PV systems whilst optimising network stability.

(Image courtesy Western Power)

Project Objectives

- To introduce mandatory settings for inverters connected to the Western Power network requiring that volt-watt and volt-var response functionality be enabled.

Approach

- Western Power engaged in consultation at the national level, including with Energy Networks Australia (The ENA has included volt-var functionality as a mandatory requirement in their National Connection Guidelines as of March 2019).

- Western Power has also worked with industry stakeholder to ensure adoption of changes in line with the Australian Standard AS/NZS 4777.2:

    - Western Power has contacted all 19 inverter manufacturers who have had inverters connected to the Western Power network within the last six months.
    - All inverters connected to the Western Power grid in the last six months have volt-var functionality.

- Western Power is now working with manufacturers to develop/update a Western Power-specific inverter setting that will have preferred volt-watt and volt-var settings included. This could take 6-12 months to be fully implemented, so Western Power will work to ensure installers are aware of manual entry instructions.

Progress

- As of August 2019, Western Power has:

    - released an updated Network Integration Guideline;
    - released an industry update sheet for installers to be made aware of the changes;
    - sent an update to the Clean Energy Council for their weekly installer news email;
    - contacted electrical contractors with news of the change; and
    - released information through social media, including targeted posts to solar industry members.

- The aspect that has not yet been considered is application of such functionality to existing inverters with the available (but dormant) functionality

    - Western Power are currently undertaking power system modelling to demonstrate effectiveness of retrospective application of volt-var functionality, that will highlight the benefits at a zone substation level

Barriers and Critical Lessons

Customer

- Substantial customer and industry engagement is critical to successful implementation of technical requirements.

Technical

- As these changes only apply for new (or upgraded) inverter connected generators, it will be some time before the positive impacts of this update are noticed from a technical perspective

DER Roadmap Considerations

Element	Consideration
Inverter Standards	Autonomous functions can be updated through the Western Power Network Integration Guideline but require extensive customer and industry engagement. This should be factored into any planned upgrades into the future.
Inverter Standards	Many existing inverters installed in recent years will have now mandatory capabilities sitting dormant within their firmware. It is possible for many existing inverters with this dormant functionality to be retrospectively upgraded, however the costs (including any likely incentives for customers) and effectiveness of this upgrade requires further consideration and scoping.
System Operations	As the SWIS market operator, the Australian Energy Market Operator (AEMO) will need to have up to date information on DER capabilities to ensure the best possible system modelling. Any program that upgrades installed DER capability will need to incorporate communication with AEMO.

13. Kalbarri Microgrid – Western Power

Start Date	2020 (commissioning)	End Date	Ongoing
Location	Kalbarri (SWIS)	Project Type	Network Battery

Background Information

- Kalbarri is a small regional town connected to radial network by a 140km 33kV feeder line from Geraldton.
    - Exposure to salt and dust pollution, feeder length and remoteness can lead to extended outages.
- The Kalbarri feeder has historically been one of the highest contributors to Western Power's supply interruption metrics.
    - Some reliability approaches in the past (silicon application and vegetation clearance) have provided marginal improvements.
    - Undergrounding or duplication of the line is economically unfeasible, due to the costs and conditions.
- Peak demand (of approximately 3.7MW) is highly seasonal and very brief.
- The existing Synergy 1.6MW windfarm operated near the town meets approximately half of the town's demand, 30% of the time. However, during outages, the windfarm is unable to supply power due to absence of a reference voltage.
- A microgrid, supported by a BESS, was installed to improve the reliability of supply to customers and facilitate the use of renewable resources in Kalbarri.

Project Objectives

- To improve reliability of power supply to customers in Kalbarri.
- To improve Western Power's understanding of the interaction between microgrids and its network.
- To develop a replicable and adaptable regional power supply model that maximises the value of existing investment in power networks.
- To understand customer response to a BESS, and the most appropriate model for customer engagement.

Approach

- Installation is planned for a 4.5MWh battery (supplying 5MW peak capacity with of 2WMh battery storage).
- The microgrid has been designed to integrate existing renewable generation sources in Kalbarri, whilst including provisions for the connection of anticipated generation sources.
- Construction was to be completed through joint venture between Western Power, LendLease and Carnegie.
- Energy storage and management systems can provide the frequency and voltage references that will allow renewable generators to supply electricity in cases of outages.

(Image courtesy Western Power)

Progress

- Installation is currently underway, with commissioning expected in 2020.

Barriers and Critical Lessons

Regulatory

- A Western Power Kalbarri microgrid feasibility study found that the regulatory framework 'does not preclude' DNSPs from incorporating battery storage systems into their regulated asset base, however, further assessment is required, including an assessment of existing legislation.

Technical

- Partnerships with private entities exposed the project to additional risk. A key partner was placed into administration, requiring a new technical engineering approach and impacting the project critical path.

DER Roadmap Considerations

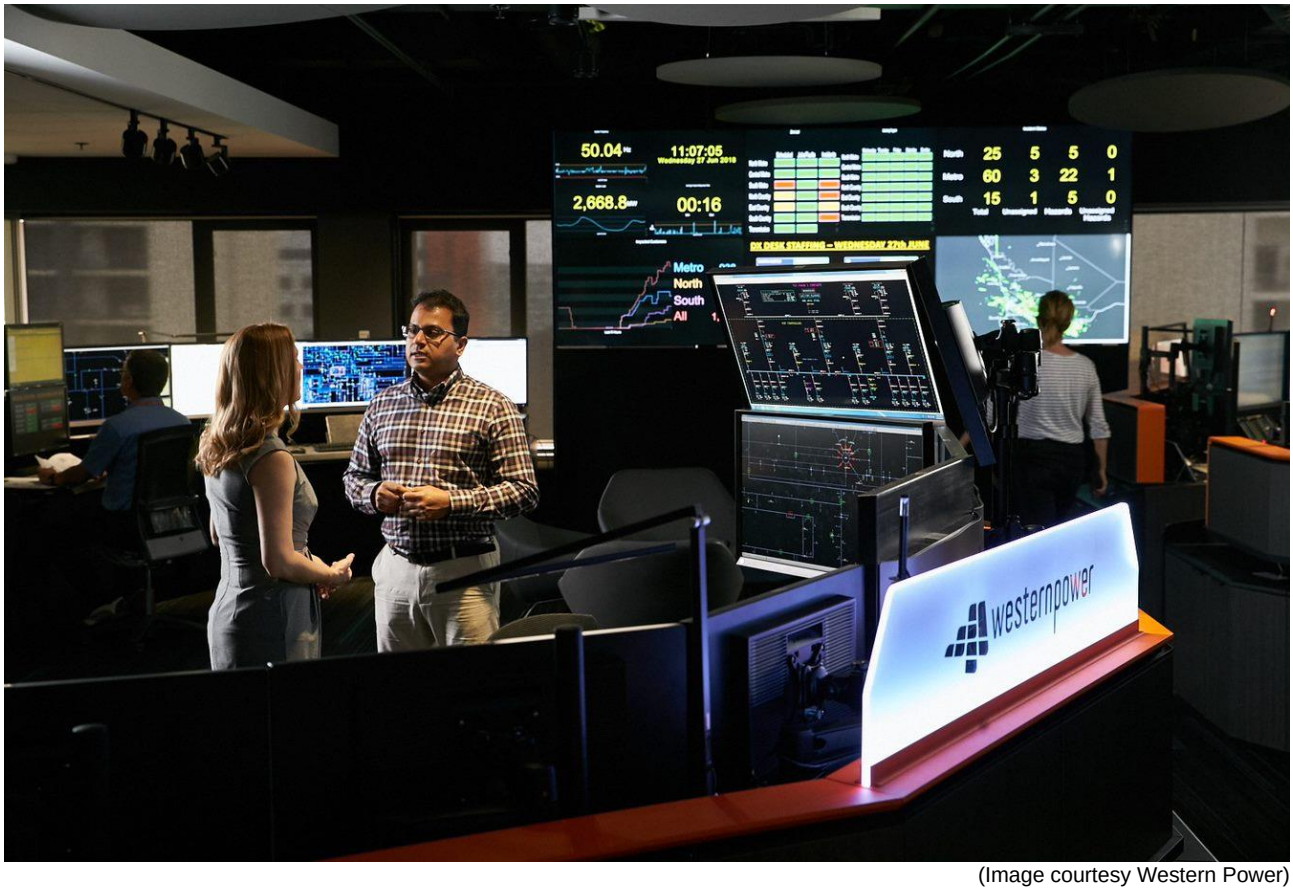
Element	Consideration
DSO/DMO Function Set	Management of islanded microgrids needs to be considered as part of DSO/DMO functions and capabilities. Specific requirements and procedures may need to be developed for these scenarios.
DER Orchestration Pilot	Further consideration is required for how automation solutions impact customers participating in VPPs, and in dispatch approaches under the DSO/DMO Function Set.
System Operations	Consideration will need to be given to how large microgrids and embedded networks with high levels of DER participate in system restart arrangements and how they are modelled.
Distribution Battery Storage	Broader adoption of network storage requires further assessment of the regulatory framework, specifically the Electricity Networks Access Code, to consider asset ownership and provide revenue certainty (where appropriate).

14. Mandurah Demand Management Services – Western Power

Start Date	01 July 2020	End Date	30 June 2021
Location	Mandurah and Meadow Springs	Project Type	Demand Management

Background Information

- Western Power forecast considerable demand growth over 10 years at the Mandurah and Meadow Springs zone substations, while recognising a degree of variability in the forecast.
- Under the strong forecast growth scenario, demand would exceed the installed capacity of existing infrastructure and would require the addition of transformers (a traditional infrastructure solution) at the Mandurah substation.
- Alternatively, a non-network solution was examined with the aim of deferring the addition of transformers at Mandurah substation. The deferral of capital expenditure allows an additional year to further validate the forecasts, strengthening the justification for transformer addition and reducing the risk of installing assets that may be stranded in future.



(Image courtesy Western Power)

Project Objectives

- To implement a non-network solution that defers the need for capital expenditure by Western Power.

- To develop Western Power's capability to utilise non-network options to defer other network augmentation.

Approach

- An EOI was prepared to test the market for a non-network response to manage the risks associated with the projected exceedance of installed capacity.
- Western Power received responses to the EOI from 19 vendors, with some vendors submitting multiple options. The vendor submissions demonstrated how they would deliver outcomes aligned to Western Power's requirements.
- Following evaluation of the EOI responses, one vendor was assessed as the strongest in terms of both its qualitative response and price competitiveness.

Progress

- A contract had been agreed by Western Power and the successful vendor for dispatch availability in 2020-21.
- An availability fee, paid to the vendor, is budgeted at Western Power from non-recurring operational expenditure.
    - A one-year extension option is available if agreed by both parties and is dependent on whether the service is required in response to a capacity shortfall, works as expected and the vendor can continue to provide such a service.

Barriers and Critical Lessons

Regulatory

- The first non-network demand management projects will be higher in cost, as systems and organisational capability will need to be developed as a foundation for subsequent projects.
- There are regulatory considerations for how costs are recovered by Western Power, which is subject to economic regulation, when using operational expenditure over to capital expenditure to solve a given issue.

Technical

- The potential load at risk is continually monitored, but it has not materialised as the original forecast projected, and the demand response may not be called upon in summer 2021.
    - Risks to changing load forecasts, and the resultant recommended network option, need to be understood and managed accordingly.
- Significant communication with the vendors was necessary to clarify technical requirements and expectation of performance and availability.
- More responses to the EOI were received than expected, which took considerable time to assess.

Market

- Without adequate network monitoring, it is difficult to gauge if the desired demand response has been achieved, particularly at lower levels of the distribution system.

DER Roadmap Considerations

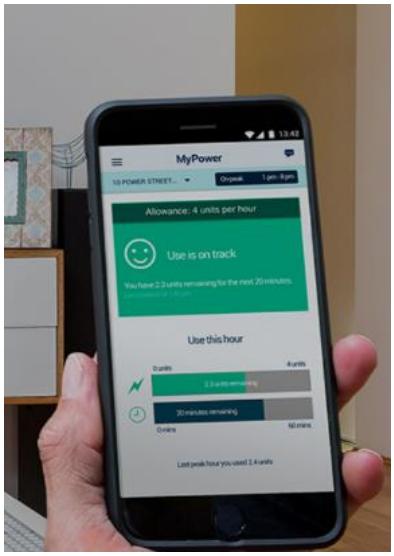
Element	Consideration
Network Investment Process	The economic regulation of Western Power's network investment may lead to uncertainty in the recovery of non-network solutions costs, where network needs do not emerge as forecast. This may require further assessment and reform of the economic regulation process.
Network Investment Process	The assessment of the value and costs of non-network solutions requires further consideration, particularly for early projects being undertaken prior to the development of organisational capability and systems.

15. MyPower – Horizon Power

Start Date	January 2018	End Date	Ongoing
Location	Broome, Port Hedland	Project Type	Tariff Pilot

Background

- Electricity tariffs for customers on the Horizon Power network are not reflective of the costs of service provision – variable charges are used to recover costs that are, predominantly, fixed.
- Electricity demand by Horizon Power's customers is characterised by very high peak loads, generally caused by summer air-conditioning driving extreme seasonal peaks.
    - Ensuring electricity supply at times of peak demand presents an issue in many regional towns and managing peak demand through infrastructure investment contributes to high fixed costs.
- Smaller, regional microgrids, like those owned and maintained by Horizon Power, have greater exposure to consequences of DER as there is limited physical network capability available to absorb its impact.
- Ongoing customer uptake of DER was exposing Horizon Power to financial pressures through revenue reduction, and as variable usage declined, fixed costs needed to be recovered from a smaller base.



(Image courtesy of Horizon Power)

    - Over time, due to tariff equality policies, the State Government and SWIS customers would therefore be required to provide greater regional subsidies.
- Moving to a tariff structure based on capacity charges presented an opportunity to ensure financial sustainability, while providing a price signal for types of DER that are effective in reducing cost to serve (e.g. solar PV with battery storage added).

Project Objectives

- To introduce a demand-based tariff structure aligned with the cost of electricity service provision that would be understood by customers.
- To incentivise customers to manage their peak and overall usage.

Approach

- The pilot was introduced through a staged implementation:

1. 'Power Ahead' Research Pilot	• 400 residential/small business customers participated in a virtual trial in Port Hedland to refine the proposal. Actual customer bills were not changed.
2. MyPower roll-out	• Pilot commenced to include voluntary participants, including in Broome. Customer's billing reflected the MyPower structure.
3. Extended opt-in	• MyPower available to all of Broome and Port Hedland on an opt-in basis.

- Customers are matched with a plan with an hourly electricity usage limit applicable between 1pm - 8pm.
    - Customers who exceed their peak allowance four times within a year are transferred to a higher plan.
    - Customers who demonstrate that they can meet lower plan requirements are able to move down.
- Plans are characterised by higher fixed daily charges, and lower per unit electricity costs.
    - Customers are made aware that reducing energy use during peak periods may reduce their annual charges, and Horizon Power offers assistance to estimate possible savings.
    - Higher fixed charges have the effect of smoothing bills for customers, reducing instances of 'bill shock'.
    - A free app allows customers to monitor and receive notifications about their consumption.

Progress

- A target take-up of 800 customers was achieved in 2017-18, and MyPower plans continue to be available to customers in Port Hedland and Broome. Currently over 1600 customers have signed up.
- The pilot demonstrated customer understanding of the product and benefits, and customer willingness and ability to adapt consumption.
- Ongoing opt-in is anticipated to have variable financial outcomes for customers – only customers who can reduce their peak demand are likely to benefit.
- Project results demonstrate that tariffs can be aligned with underlying costs.
- Project results demonstrated that participating customers:
    - understood the product;
    - were motivated to make changes that returned benefits;
    - chose to remain on the product; and
    - liked more frequent billing/electronic billing (24%).
- The initial implementation of MyPower targeted those who were expected to have lower bills (based on advanced metering data analysis).
- However, Horizon Power received some registrations for households that were expected to experience higher bills.
    - Their participation is thought to be due to preference for supplementary features such as bill smoothing, frequent billing, and real-time meter information.
- When a customer is moving into a new residence no assessment of financial impact is possible.

Barriers and Critical Lessons

Customer

- Customers who were not likely to benefit financially were responsive to non-financial features of the trial, including billing and real-time monitoring of their usage.
- Customers receiving concessions and experiencing financial hardship were found to be more likely to benefit under the trial.

- Some customers find it difficult to adjust their usage (such as seasonal customers, or those with high intermittent peaks but low overall usage, like sports facilities).

- Additional features for the tariff structure were considered in the initial design but were not included for later iterations due to excessive complexity for customers.

    - This included a rebate mechanism for maintaining a demand lower than the allocated threshold.

- Customers who have recently, or plan to, install solar PV-only systems face a significantly longer payback period than what would be experienced under the existing residential tariff structure.

    - This is because the variable rate for energy supplied by the grid has decreased to around 10c/kWh (from around 29c/kWh), however the contract maximum demand period extends until after solar hours (4pm – 8pm).

Regulatory

- Meter data transfers are simplified within a vertically integrated Horizon Power – transfers between Western Power and retailers will require facilitation in the SWIS.

- The applicability of this trial to the SWIS may be limited due to possible limitations on Western Power's ability to recover meter costs under existing regulation.

Technical

- Existing AMI, with enabled communications, was integral to the roll-out of the pilot.

    - Real-time metering data also facilitated to features such as phone app customer monitoring.

- Widespread deployment of the product will likely require additional IT and communications infrastructure to manage greater volumes of usage information flowing between Horizon Power and customers.

DER Roadmap Considerations

Element	Consideration
Tariff Pilots	MyPower provides a demonstrated case where tariffs can be brought into line with underlying costs. As a result of this, the tariff signals customer behaviour and DER investment that benefits both the customer and the system, as well as provides for greater revenue certainty for Horizon Power.
Tariff Pilots	Changes in underlying tariff structure, including increases in fixed daily supply charge, can have material impacts on the vulnerable customer cohort. Complimentary schemes to review and assist vulnerable customers where any change occurs are critical alongside tariff structure changes.
Tariff Pilots	Implementation was not only dependent on AMI but may require additional investment beyond the standard AMI capability (due to higher data flows). This is likely to be a major limiting factor in the SWIS in the near term.
Tariff Pilots	MyPower remains a complex tariff arrangement for consumers and is dependent on real-time feedback to customers triggering a response to reduce peak demand. Tariff Pilots should consider complexity of deployment at a larger scale relative to other design options.
Tariff Pilots	The MyPower tariff structure incentivises solar PV plus battery storage uptake over solar PV-only installations. Customers who have recently installed solar, or those seeking to install solar only systems, will experience significantly lengthier payback periods under the MyPower tariff structure than under existing tariffs.

Element	Consideration
Tariff Pilots	MyPower specifically targeted the summer peak, incentivising both load reduction and load shifting during summer months. Consideration of how the price signal would be designed to incentivise load shifting during critical system low months (typically during spring and autumn) as well as areas with both winter and summer peaking profiles will be required.
Customer Engagement	Customer offerings, such as real-time or near real-time visibility of usage and prices, and monthly billing, as well as broad-based education are extremely important complimentary measures to support tariff changes. This is particularly relevant when customer bills increase.

16. On-Load Tap Changes – Western Power

Start Date	2019	End Date	2020
Location	SWIS	Project Type	Voltage Management

Background Information

- Western Power is required to maintain voltages on its low voltage (LV) networks within a limit of ±6% on a nominal voltage of 240V.
- The ongoing installation of customer solar PV is contributing to substantial voltage variations over the course of a day on some LV networks.
    - Voltage drops under peak load and low PV generation conditions, whereas there are a potential voltage rises during light load and high PV conditions.
- Distribution transformers fitted with an On-Load Tap Changer (OLTC) can help to actively manage these voltage variations within prescribed limits.
- Western Power is planning to undertake a trial of 11 separate sites, with the expectation that a successful trial of this technology will allow Western Power to address multiple drivers via deployment of distribution transformers that are fundamentally the same units as currently used, with additional OLTC functionality.

(Image courtesy Western Power)

Project Objectives

- To ensure network infrastructure continues to cope with voltage variations due to high DER penetration.
- To automatically regulate the voltage on the 415-240V network such that all customers on the LV network are within Western Power's acceptable voltage limits, including but not limited to periods:
    - at high PV generation / low load periods (e.g. middle of a sunny, mild day); and

- no PV generation / high load periods (e.g. early evening on a hot day).

Approach

- The trial will replace 11 existing pole top transformers on Western Power's 22kV/415-240V network.
- If the trial is successful, it is envisaged that more of these transformers with OLTCs will be sourced and integrated into the network.
- It is envisaged the trial period will run for approximately 12 months.

Progress

- Factory Acceptance Testing occurred in July and August 2019, with units to be installed by December 2019.

Barriers and Critical Lessons

Regulatory

- The benefits of OLTC technology require further assessment including methodologies for valuing the maximisation of solar hosting capacity.

DER Roadmap Considerations

Element	Consideration
Grid Response	Changes to nominal voltage and ranges under the *Electricity Act 1945* (see Project 7 - Voltage Limits) may reduce the urgency and value of OLTC program expansion.
Grid Response	The supplementary benefits of OLTC functionality, such as maximising solar hosting capacity, for Western Power's power quality program will require modelling and validation to support wider rollout under the existing regulatory regime.
Distribution Network and Visibility	Visibility facilitates better targeted investment to manage voltage issues, allowing for continued DER uptake. OLTC provides visibility of electrical quantities (such as active and reactive power flows, and current) through the transformer, which facilitates better network management.

17. Onslow DER – Horizon Power

Start Date	May 2018	End Date	2020
Location	Onslow	Project Type	DER Management

Background Information

- Small towns like Onslow are susceptible to power supply issues caused by high penetration of DER.
- The project has included the construction of a nominal 8MW gas-fired power station, 1MWh battery and 1MW solar farm.
- Horizon Power has offered subsidies to Onslow residences and businesses to encourage installation of up to 2MW of solar PV and 1MW of battery storage in the town, fast-tracking the take-up of DER.
- Horizon Power's Onslow microgrid pilot will be testing direct control of DER via a DERMS, communicating directly with customer DER.

(Image courtesy of Horizon Power)

Project Objectives

- Building on smaller scale deployments such as Carnarvon DER Trial and Smart Sun in Broome to demonstrate the technical capability of DERs to be orchestrated to provide energy whilst significantly exceeding the calculated hosting capacity limit for the local microgrid.
- The system will include:
  - A combination of centralised energy assets (owned by Horizon Power) and distributed energy resources (owned by customers and Horizon Power);
  - Include an intelligent control system with robust control architecture to ensure the stable and efficient inter-operation of centralised power system assets with very high levels of DER;
  - Have protection schemes to help manage the risk associated with reduced fault levels; and
  - Be capable of supporting greater than 50% of the town's annual energy volume (MWh) being supplied by centralised and decentralised renewable energy sources.

Approach

- Horizon Power has contracted with PXiSE for a DERMS software solution that allows Horizon Power to monitor and manage grid connected assets, ranging from power stations to solar panels, using machine learning to balance and orchestrate the energy generation and storage mix in a coordinated system.
- The DERMS communicates with customer DER via a Secure Gateway Device, to be provided by Australian company SwitchDin.
- The DERMS will be integrated with customer DER, utility-scale storage, utility-scale solar and gas generation located within the Onslow Microgrid.
- As well as support for high levels of customer DER the project includes centralised solar power generation with battery storage as well as separate battery storage at the gas power station to optimise spinning reserve, with overall orchestration delivered centrally via the DERMS.
- The delivery of the technical trial was underpinned by the development of DER Management Use Cases to validate the capability of DER to provide required technical outcome, as well as validate the performance of end-to-end DERMS to DER response timeframes.

Progress

- The construction of a gas-fired power station and associated network infrastructure was completed in July 2018 and the solar farm and network battery was commissioned in June 2019.
- Customer DER installations commenced in May 2019.
- DERMS and Secure Gateway Device development has commenced, with commissioning likely in early 2020.

Barriers and Critical Lessons

Customer

- Customer contracting arrangements require review to become business as usual (i.e. the REBS contract does not currently include any provision around DER management).

Technical

- The Horizon Power trial is using the IEEE 2030.5 communication protocol to interact with inverters. This is likely to be adopted nationally as the preferred communication protocol, however alternatives do exist.
- The Onslow project uses dedicated communications devices to transport DER commands. Given the nature of the microgrid, reliable and timely response times are required to ensure microgrid reliability and avoid generator tripping. This scale of communications and response time may not be required in larger networks, where cloud-to-cloud communications may be enough.

DER Roadmap Considerations

Element	Consideration
VPP Pilot	Due to the reliable and timely response required in isolated microgrids, communications infrastructure used by Horizon Power may be over-specified relative to the needs of a larger system such as the SWIS. Definition and testing of DER response and latency requirements within the SWIS should be explicitly included in future VPP pilots and trials.
VPP Pilot	The development of DER Management Use Cases was critical to informing the required technical outputs of installed DERs (for example, validating frequency support capability of installed DER). The development of DER Management Use Cases for the SWIS should be explicitly included in future VPP pilots and trials.
DSO/DMO Function Set	Customer contracting arrangements need to be considered in light of the longer-term DSO interactions and likelihood of dispatch and curtailment of customer DER. Dynamic connection agreements require development, and interaction with existing customer contracts (supply contract, REBS contract) should be considered, and where appropriate, duplication removed.
Engagement	Customers who are made aware of the hosting capacity limitations of the network display some willingness to have their DER orchestrated in order to receive benefits from DER. Broad-based education of the impacts of solar PV on electricity supply have set expectations in Carnarvon (see below) and Onslow.

18. Peel Business Park Microgrid – LandCorp

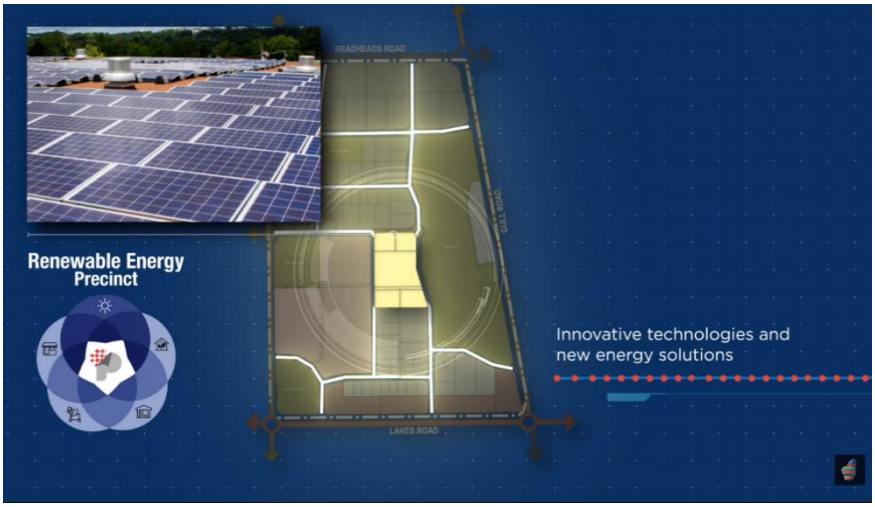
Start Date	2020 (commissioning)	End Date	-
Location	Peel (SWIS)	Project Type	Microgrid

Background Information

- Peel Business Park (PBP) is a greenfield industrial land development being established by LandCorp.
- The existing electrical infrastructure has insufficient capacity to supply the new PBP load requirement and a new feeder is to be extended from Pinjarra (15km away), funded by the State Government's Royalty for Regions program.
- However, the new feeder's capacity (of 20MVA) is likely to be insufficient for Phase 1, and the entire PBP will require significant additional capacity of 100MVA.
    - Preliminary information from Western Power has indicated that under standard servicing arrangements, this level of capacity would require a new local zone substation as well as transmission line upgrades, at a cost of tens of millions of dollars.
- Under a standard approach to power supply, the cost of augmenting the Western Power network to underwrite power requirements for the PBP was likely to render the project uneconomic.
- Additionally, LandCorp have sought to achieve a sustainability accreditation for the PBP through the implementation of renewable energy on an industrial scale.
- An alternative proposal will see Lot 600 (currently under development) treated as a microgrid with a single connection point to the Western Power network, thereby avoiding significant augmentation costs.
    - Demand for power would be met from generation located on site (behind the network connection point) and supplemented by power from the Western Power network.

Project Objectives

- To reduce the capital expenditure required to deliver the PBP development project.
- To meet LandCorp's goal for increased penetration of renewable energy in the PBP.
- To deliver low cost, clean energy to businesses in the park.



Approach

- The detailed design of the microgrid has not yet been completed but is likely to include a combination of solar PV, batteries, and possibly gas turbines.
- Following a tender process, LandCorp selected the Enwave Consortium to operate the microgrid for the PBP.

Progress

- LandCorp is working with consortium partners towards final contracts.
- Commissioning is estimated to occur in 2020.

Barriers and Critical Lessons

Customer

- Customer engagement has not yet started in this project; however, the project is seen as an attractive selling point for prospective business tenants.

Regulatory

- Several regulatory challenges have been identified through the project, that require further investigation. These challenges relate to arrangements for:
  - embedded networks spanning green titles;
  - licensing under the *Electricity Industry Act 2004*, including the obligation to hold an exemption from a licence;
  - consumer protections; and
  - third party retailing.

Technical

- There is a need to consider a 'network of last resort' and ensuring embedded networks meet the network operator's standards if they are forced to take control of the embedded network in the future.

DER Roadmap Considerations

Element	Consideration
New Business Models	Customer protections and licencing arrangements require further consideration for embedded network projects.
DER Orchestration Pilot	VPP market participation work will have to consider how embedded networks might integrate and participate in energy and Essential System Services (ESS) markets, acknowledging the 'single connection point' nature of the embedded network with multiple DERs behind it.
DSO/DMO Function Set	Further consideration needs to be given to the potential proliferation of embedded networks, including consequences for DSO, DMO and the role of the network service provider.
System Operations	Consideration will need to be given to how large microgrids and embedded networks with high levels of DER participate in system restart arrangements and how they are modelled.

19. Perenjori BESS – Western Power

Start Date	July/August 2018 (commissioned)	End Date	Ongoing
Location	Perenjori (SWIS)	Project Type	Network Battery

Background Information

- Perenjori is located at the end of a long, radial 33kV network connection, susceptible to high winds, falling vegetation and fire risks.
- In the two years prior to 2018, the town experienced 20 outages of varying lengths.
- Installation of a network battery at Perenjori enables it to be used as backup supply in case of loss of network supply.
    - Western Power estimated, based on outage history, that the battery would eliminate up to 80% of extended outages.

Project Objectives

- To improve reliability for Perenjori customers.
- To understand how energy storage systems can be used to improve reliability.

Approach

- A 2.4MW/1MWh (0.7MW continuous power) lithium-ion BESS was installed and programmed to export power instantaneously in event of loss of supply from the network.
    - The BESS has off-grid, grid forming functionality, and 'seamless' transition with to the grid.
    - An inverter, transformer and 33kV switchgear were installed at the same site.
- Customers in Perenjori given choice to opt-in for notifications when the battery is triggered; the battery is running low and power outages are imminent; and the fault is fixed.

(Image courtesy of Western Power)

Progress

- The BESS was commissioned in August 2018 - technical issues with equipment, software and protection maloperations caused a protracted commissioning phase.
- Since commissioning, BESS islanding support has been provided in response to over 100 network faults and system underfrequency events.
  - Customer outages were prevented for a cumulative 16 hours to August 2019.
  - Customers experienced depressed voltage for much shorter times.
  - Two outages have occurred where the BESS has not operated correctly.

Barriers and Critical Lessons

Customer

- Western Power's notification system, which included a request to minimise power use during BESS supply (without direct incentives), did not result in material changes in customer behaviour.

Regulatory

- Only a portion of the total cost was approved for inclusion in Western Power's regulated asset base. A consistent methodology for valuing the services DER can provide is required.

Technical

- Western Power notes insights gained from this trial are helping it determine how it can deploy network batteries effectively to other communities.
- Issues during commission have led to learnings about performance analysis for BESS interaction with the network during and following commissioning.
- Perenjori typically experiences frequent, shorter outages – if most outages were long, this would result in limited improvement to the number of customer supply interruptions. Consequently, the benefits provided by the Perenjori BESS may not be replicable to the same extent in other locations.

DER Roadmap Considerations

Element	Consideration
Distribution Network and Visibility	The nature of outages at Perenjori made it suitable for the use of a BESS – improved visibility of the distribution network will facilitate better understanding of the benefits of BESS in other locations on the distribution network, and will facilitate more efficient, targeted infrastructure investment.
Customer Engagement	Despite receiving notifications requesting that customers reduce consumption, customers were not observed to change their behaviour – the use of incentives or expanded customer education programs may deliver improved outcomes.
Distribution Battery Storage	The value of the services provided by a network battery to Western Power as well as any system wide benefits are not well understood. A DER valuation methodology would provide much greater investment certainty for Western Power and other parties seeking to provide similar services.
DSO/DMO Function Set	Understanding how distribution connected storage participates under DSO/DMO needs further work.

20. PowerBank – Synergy, Western Power

Start Date	October 2018	End Date	Ongoing
Location	Meadow Springs	Project Type	Community Battery

Background Information

- Meadow Springs, 70km south of Perth, is home to just over 68,000 people with more than 11,170 rooftop solar PV systems installed, making it third in the nation's top 10 solar hotspots (by postcode).
- The region has grown considerably in recent years, and a large amount of installed DER is putting strain on the existing electricity network infrastructure, potentially requiring significant network augmentation investment.
- In such a high DER environment, the existing tariff structure (in combination with REBS) does not allow Synergy to adequately recover its costs from customers, nor signal energy consumption behaviours that reduce local network issues such as peak demand.
- The PowerBank trial provides a community BESS at a network feeder level, paired with a retail offering to allow customers to 'virtually' store excess electricity generated by their solar PV, while providing network management services and deferring infrastructure investment.
- The use of a community BESS takes advantage of cost efficiencies for larger battery systems, as well as avoided installation costs for individual battery storage system.

(Image courtesy Western Power)

Project Objectives

- To provide valuable insights such as customer behaviour and appetite for a front-of-the-meter battery solution along with the profitability of this offer.
- To test the current battery technology at hand and provide performance insights.
- To explore the benefits and challenges of charging and discharging the physical battery and understand impact to the wholesale market.
- To explore possible future retail tariff models.
- To understand the total costs of setting up and running this type of infrastructure.

Approach

- A 105kW / 420kWh Tesla BESS was installed and integrated into the already-established major metropolitan network, creating a shared storage service.
- The BESS is owned by Western Power and connected to the grid, allowing participating households to maximise their existing grid connection.
- Synergy manages the operational dispatch of the battery within network constraints to maximise its value.
- 49 households were recruited to the 24-month trial and were transferred (from the A1 residential tariff) to a time-of-use tariff plan, with peak, off peak, and shoulder pricing.
- Each household receives 8kWh of virtual storage for their solar energy fixed daily charge ($1), which can then be accessed at any time after 3pm.

Progress

- Since the trial started on 8 November 2018, participating households have saved an estimated $5,486 on their collective energy bills, an average of $112 per household.
- Trial participants' average daily virtual battery storage is 7.7kWh and the average daily virtual battery consumption is 5 kWh. For many customers PV systems generate on average far more energy is used over the course of a day, which results in power being left in the battery at midnight when the virtual product resets with remaining banked energy paid out at the REBS rate.
- This means that consumption between midnight and dawn, which for some customers will represent part of their morning peak before school and work, is not drawn from the virtual battery. By comparison, customers with a behind-the-meter battery would still have access to this energy.
- Customers receiving the greatest savings were those that consumed a high amount of energy over the evening peak period – average consumption of 6kWh indicates that larger households benefit most.
- The load on the local transformer has decreased since the commencement of the trial. Reduced transformer loads can improve efficiency and extend asset life.

Barriers and Critical Lessons

Customer

- As demonstrated by the average participant having energy left over when the virtual product resets each day, there may be value in offering a variety of virtual storage capacity to suit customer needs (4kWh, 6kWh, 8kWh etc). This could allow better utilisation of the storage across all customers.

Regulatory

- The *Electricity Industry Act 2004* and Electricity Networks Access Code potentially limit the ability of Western Power to recover its portion of battery costs under regulated revenue.
    - The current cost of batteries relative to the calculated value of network services provided by the battery means only part of this solution meets the New Facilities Investment Test (NFIT). DER valuation methodologies require further development.
- Evolving business models associated with the provision of customer services such as the virtual storage product need to be tested further to ensure full customer protections and other considerations are addressed.

Technical

- Conducting manual meter reads in advance of deployment of the battery and AMI were required. Where advanced metering is available in the future, the ability to understand customers usage patterns and customise products to suit will be significantly enhanced.

Market

- Metering and settlement arrangements for the network-owned battery are not currently defined within the regulatory framework. Without resolution, a deployment at scale would have a material impact on the efficiency of the wholesale and capacity market.

DER Roadmap Considerations

Element	Consideration
Distribution Battery Storage	The use of distribution network storage is an effective model for delivering network benefits whilst providing for broader benefits within the value chain. Whilst Western Power cannot participate in energy markets directly, the ability for others, such as retailers, to utilise the storage for portfolio benefits or innovative customer products is critical in ensuring the business case is positive.
Distribution Battery Storage	The value of the services provided by a network battery to Western Power as well as any system wide benefits are not well understood. A DER valuation methodology would provide much greater investment certainty for Western Power and other parties seeking to provide similar services.
Distribution Battery Storage	Broader adoption of network storage requires further assessment of the regulatory framework, specifically the Electricity Networks Access Code, to consider asset ownership and provide revenue certainty (where appropriate).
Distribution Battery Storage	In large numbers, distribution level batteries will have a material impact on system and market operations and need to be integrated into markets effectively. Use of distribution batteries will require clearly defined metering and settlement arrangements.
Tariff Pilots	The use of community batteries for retail customer offerings requires further consideration of the incorporation of new tariff structures, including time-of-use tariffs. The cost-reflectivity of these tariffs, and discrepancies between tariffs charged to non-participants have implications for equity.
Tariff Pilots	Further consideration needs to be given to how virtual storage products can be included in retail products, including the possibility for mandatory storage products to be provided for customers with solar PV only systems, to mitigate grid impacts
DSO/DMO Function Set	Understanding how distribution connected storage participates under DSO/DMO needs further work.

21. RENeW Nexus (Peer to Peer) – Various

Start Date	November 2018	End Date	June 2019
Location	Fremantle (SWIS)	Project Type	Peer to Peer Trading

Background Information

- Curtin University, in partnership with Synergy, Western Power, Energy OS, and Power Ledger, has completed a small solar peer-to-peer (P2P) energy trading trial within the City of Fremantle. The initial trial formed part of the RENeW Nexus Project, funded by the Federal Smart Cities program.

- Partners will engage in further customer research to deepen understanding of customers' perception of value from P2P. This includes conducting a second phase of the trial with a different and larger cohort of participants from October 2019 – January 2020, and addressing some other limitations identified in the earlier trial.

Project Objectives

- To demonstrate proof of concept test for P2P electricity trading.

- To understand the value of P2P for customers and project partners.

- To trial the technological interoperability between the Power Ledger platform, Synergy, Western Power, supporting technologies and test the Power Ledger platform capability as a client P2P solution.

Approach

- Eighteen connection points participated in the trial. 13 were 'prosumers' (customers with solar PV systems that can either sell excess electricity generated, or act as a consumer) and five were 'consumers' (participants who only purchase the P2P traded electricity in the trial). The trial aimed to recruit a greater number of participants than the 18 that chose to take part, which is further explained in the customer section below. No participants had a battery and no simulations were undertaken to understand the implications of a battery (for example the impact one or more batteries could have on the P2P market).

- Power Ledger provided the trading platform, which coordinates bringing buyers and sellers together, allows trading rules such as buy and sell prices to be defined (dynamic pricing), provides trading market clearance and utilises distributed ledger (blockchain) technology to facilitate, record and verify trading.

- Western Power provided advanced meters, mobile network data communications, and metering services.

- Synergy provided secondary meters that enabled communication of real time data and, with that, dynamic pricing for trading, managed the customer relationship, contractual arrangements and support, including billing and acting as a buyer of last resort for unsold solar exports and a seller of any shortfall not supplied by peers.

- Energy OS provided the platform and application programming interface (API) integration that facilitated the real time flow of data that was subsequently fed into the Power Ledger Platform.

- Curtin University managed the recruitment of participants, the secondary meter installation process via an electrical contractor, the reporting and acquittal associated with government funding and leading research questions and outcomes.

- Tariffs were unbundled to facilitate the P2P market. Participants paid a daily supply charge attributed to both Synergy ($1.10 as a capacity charge) and Western Power ($2.20 as a network charge), plus a trading

fee charged by Power Ledger (0.05c/kWh). The Western Power network charge was set at ~9% below the average SWIS residential customer network charge.

- The traded energy prices are based on demand and supply prices set by the trial participants.

- Any electricity purchased from the Synergy when P2P energy was not available, was provided on a time-of-use tariff (5.72c/kWh off-peak and 9.9c/kWh peak period of 3pm-9pm including GST). The rates were set by reference to wholesale market prices in the preceding 12 months, adjusted for marginal loss factors. Any excess generated solar energy not traded was bought by Synergy at a default rate (4c/kWh).

Progress

- 17 of the 18 participant households experienced higher costs than if they'd been charged the A1 tariff. These financial outcomes can be explained by reference to a number of factors outlined below:

    - Because energy generation costs are a relatively small component of delivering electricity to households in the SWIS (approximately 15-20%), reduced day time generation costs were not sufficient to off-set high fixed charges and overcome the benefits of the flat A1 tariff and a REBS rate that currently over values rooftop solar generation.

    - Low consumption profiles of both prosumers and consumers in this trial. Unbundled tariffs that reflect system costs via a high fixed supply charge favour higher energy consumption because higher energy use brings down the per unit cost.

    - Suboptimal ratio of prosumers and consumers leading to limited demand of P2P energy (more electrons available than there was demand for) resulting in more rooftop solar electricity being sold to Synergy attracting a lower rate (4.0c/kWh) than REBS (7.14c/kWh). In addition, the P2P trades that did clear were on average below the REBS rate, which also relates the relative cost of the off-peak time-of-use tariff (5.72c/kWh) that was used in the trial.

Barriers and Critical Lessons

Customer

- Consumers were harder to recruit than prosumers.

- It was hoped that P2P could shift behaviour toward greater consumption to times of solar generation, thereby reducing total system cost. There was insufficient data to determine whether solar P2P trading led to material behavioural change.

- Sixty households applied to be considered for the trial and participated in several information sessions. Forty-two decided not to participate. A survey of those, showed that 10 of 13 who decided not to participate did so after it became known that their daily energy usage was not high enough to justify participation. Consequently, eighteen households decided to participate in the trial.

Regulatory

- There are no regulatory barriers for retailers to offer P2P trading within their own retail portfolio.

- Alternative arrangements between other retailers or third parties are not considered within any regulatory instruments, including metering and settlement instruments.

Technical

- Facilitating real-time P2P trading required additional hardware to be installed at customers' homes. Western Power remotely read metering infrastructure currently provides data on a daily basis and that would have been sufficient to facilitate day-behind trading. Future, planned, upgrades to metering infrastructure could reduce the time delay between trade and confirmation of trade.

- Real time metering that enables dynamic pricing is not essential for P2P. The cost and disruption of installing these additional devices (next to Western Power meters) to enable this functionality was not seen to be justified by the benefit. Even though remotely read interval meters do not necessarily provide real time data, it is an important enabling technology by offering half hourly data daily.

Market

- The prevailing A1 tariff and REBS rate are not reflective of underlying costs. Under these current market conditions, it is challenging to make a cost/value reflective P2P trading tariff relatively more attractive.

- Any export buyback rate (i.e. 4.0c/kWh in the trial) acts as a disincentive to trade at lower prices, establishing a floor unit price for solar exports in a P2P market.

- Synergy's peak and off-peak energy rates acted as ceiling for P2P pricing. Efficient and effective market trading is reliant on sufficient numbers of participating consumers, who provide the bulk of demand. In the trial there were 5 consumers and 13 prosumers. This was the inverse of the ideal market make up, which is likely to be closer to 70% consumers and 30% prosumers depending on consumption and export profiles of P2P market participants. The extension of the trial to a second and larger cohort is intended to address this deficiency.

- Under current regulations, P2P can only function within a retailer's billing portfolio as an 'off-market' transaction (i.e. not included within the wholesale market settlement processes).

DER Roadmap Considerations

Element	Consideration
Tariff Pilots, DSO/DMO	Tariff changes leading to cost reflective pricing (including the REBS rate) would be required if solar P2P trading is to be attractive and have the possibility of delivering the system scaled benefits on the SWIS.
Tariff Pilots	P2P trading currently relies on settling of P2P transactions within the retailer portfolio (off-market). This would limit P2P to customers of single retailers. To enable multi-retailer transactions, amendments to the Retail Market Operations framework including the Market Settlement and Transfer Solutions procedures and development of multiple trading relationships settings would be required.
Engagement	Participants highlighted during the information sessions held that they did not have a good understanding of how their current A1 charges are constructed. Customers stand a greater prospect of financially benefiting from P2P trading if they change their consumption to times of solar generation. Further research to determine whether and how P2P can encourage behaviour change may define education programs that will support customer behaviour change.
New Business Models	Where P2P arrangements make commercial sense, consideration needs to be given to ensure that market costs are passed through and consumer protections are retained.
Data	Any P2P arrangements will need to adhere to minimum consumer data protections.

22. Virtual Power Plant Technology Trials – Synergy

Start Date	2018	End Date	On-going
Location	SWIS	Project Type	Virtual Power Plant

Background Information

- Several VPP projects have been undertaken across Australia to date, and a wide range of companies claim to have demonstrated VPP capabilities.
- In Western Australia, the requirement for most small use customers to use Synergy as a retailer means that Synergy is uniquely positioned to capture and pass the value of VPPs to the customer.

Project Objectives

- To test available technology that will allow Synergy to manage when power is being exported into the grid and optimise the use of batteries to manage demand.
- To explore what other capabilities VPP technologies can provide, what companies are offering these services, and at what level of sophistication they operate.

Approach

- Currently there are 10 small-scale, behind-the-meter batteries utilised in the trial, each installed in conjunction with participants' solar PV systems.
    - All participants at the commencement of the trial were Synergy employees due to the experimental nature of the trial and high level of customer interaction required.
- Each battery has a management hardware installed, provided by six leading companies.

Progress

Below is a table outlining the major discovered capabilities of each VPP provider at the time of the assessment in 2018.

Feature	A	B	C	D	E	F
Controlled Battery Export	✓	✓	✓	✓	✓	✗
Controlled Battery Import	✓	✓	✓	✓	✓	✗
Frequency Response	✗	✗	✓	✗	✗	✗
Exportable Customer Data	✓	✓	✓	✗	✓	✓

Barriers and Critical Lessons

Customer

- Customer participation is necessary to create meaningful loads for scale, which requires adequate customer engagement and appropriate incentives for participation.

(Image courtesy of Synergy)

Regulatory

- There are no regulatory barriers to Synergy offering VPP services, however, the commercial business case is limited without network benefits.
    - Regulatory arrangements that enhance Western Power's ability to procure non-network solutions from such VPP services may help unlock additional value.
- Under the current regulatory framework, including the linear customer contracting model, Synergy is liable for the technical impact of all DER of non-contestable customers – Synergy would be exposed to risk if third parties are managing these assets.

Technical

- Connectivity issues for systems utilising household internet and Wi-Fi for communications may limit the potential of VPPs to provide services requiring rapid responses.
- Installation required multiple site visits as a result of limited experience of installers with batteries.
    - Vendor capabilities were low at the time of the trial; however, these capabilities are growing quickly.

Market

- A lack of network services market limits the ability for network benefits to be captured through VPPs.
    - Such a function may not need to be in the form of a new marketplace and could be as simple as bilaterally contracted non-network solutions.

DER Roadmap Considerations

Element	Consideration
DER Orchestration Pilot	VPP technology dispatching behind-the-meter will not be explicitly visible at the metering point. As such, validation of the DER response via a VPP, and all associated data collection, transfer and settlement requirements will require further consideration. Requirements for telemetry data from the DER directly will need to be established to underpin wholesale market participation and compensation.
DER Orchestration Pilot	The contracting and settlement requirements as well as customer protections for VPP providers requires further consideration. The costs and benefits of establishing the ability for customers to contract with other parties requires assessment against a retailer-led approach for VPPs.

Element	Consideration
DER Orchestration Pilot	Connectivity through the Western Power AMI mesh network may facilitate cheaper and more reliable data transfer. DER Orchestration Pilots should explore and/or test this potential opportunity, recognising likely limitations on infrastructure capability and cyber-security implications.
DSO/DMO Function Set	Opportunities to unlock value across the cost stack for the DER owner (such as through a DMO) is likely to increase uptake, however, a high level of customer participation is required to precipitate the development of markets. Developing the capability to provide and test services across the fleet will be required in advance of any market ‘go live’.

23. Voltage Limits – Western Power

Start Date	2018	End Date	2019
Location	SWIS	Project Type	Voltage Management

Background Information

- The voltage range within which Western Power is required to design, maintain and operate its LV networks is defined in the Western Australian *Electricity Act 1945* as ±6% on nominal voltage (240 V).
- The voltage range in the *Electricity Act 1945* is out of step with the regulation in other states of Australia, which are based on average, time-based values, a lower nominal voltage and a wider voltage range.
- The ongoing installation of customer solar PV is contributing to substantial voltage variations over the course of a day on some LV networks.
- Lowering the nominal voltage to 230 V, and increasing the voltage range, will limit the need to augment Western Power's LV networks while facilitating continued uptake of DER.
- Western Power has undertaken testing to ensure that customer equipment and appliances are not affected by changes to the nominal voltage and voltage ranges.

Project Objectives

- To understand the impact of a lower nominal voltage and wider voltage ranges on customer equipment.
- To demonstrate safe operation of customer equipment at revised voltage ranges, with the intention to realise the following benefits:
  - Savings in network augmentation costs that don't improve safety.
  - Reduced number of over voltage complaints from customers.
  - Reduced number of customer claims as a result of continuous over-voltages.
  - Alignment with best practice internationally and in Australia.
  - Improved ability to host DER technologies such as electric vehicles and solar PV.

Approach

- Western Power commissioned the Australian Power Quality and Reliability Centre at the University of Wollongong to undertake a laboratory study of the performance of a significant number of common domestic appliances across a range of input voltages under controlled conditions.
- The study sought to identify any equipment failures, damage or other undesirable impacts on appliance operation associated with reducing the voltage magnitude supplied to those appliances.
- Appliance performance evaluation was undertaken in the Power Quality and Renewable Energy Laboratory at the University of Wollongong between October 2018 and February 2019.
- Modern power quality analysers were used to record key appliance performance parameters including electrical quantities, rotation speed for relevant machines, and equipment temperature.

Progress

- Overall, it has been found that no appliances failed or appeared to be damaged when subject to the range of input voltage magnitudes assessed.
    - All but one appliance appeared to operate as expected across the evaluated voltage ranges.
    - This device, a microwave, appeared under re-testing to stop operating in line with an internal protection system, rather than failing to operate.
- The limited duration of testing undertaken in this report precludes any conclusions regarding long-term impacts on customer equipment.
- Substantial benefits for the customer and network were confirmed, including:
    - over 86% of appliances had reduced energy consumption at a reduced voltage; and
    - equipment temperature was lower at reduced voltage, for all relevant measured appliances.

Barriers and Critical Lessons

Regulatory

- Changes to the *Electricity Act 1945* are required for Western Power to realise network benefits while remaining compliant with prescribed voltage ranges.

Technical

- Adjustments to distribution transformer tap positions and the voltage set-points of zone substation transformers would be required to implement any changes.
- Studies of longer duration may provide further insights into the effect of variations to voltage ranges on the life of customer equipment.

DER Roadmap Considerations

Element	Consideration
Grid Response	Hosting capacity on the LV networks are strongly linked to voltage limits, and provide a key limitation to the uptake of DER. This is likely to manifest as a material issue as the saturation of local networks increases. An expanded compliance range and associated operational procedures would provide for expanded hosting capacity.
Grid Response	Investment decisions regarding voltage management, distribution transformer tap changes and other network infrastructure will likely change following the implementation of any voltage standard change.
Customer Engagement	Potential changes to the voltage standard may require communications and education that alleviate customer concerns about appliance performance.

24. Increasing the Uptake of Solar PV in Strata Residential Developments – Various

Start Date	April 2016	End Date	April 2020
Location	White Gum Valley (SWIS)	Project Type	Peer to Peer (P2P), Microgrid.

Background Information

- Although there is a large amount of rooftop solar in Western Australia, there is limited uptake of solar and battery assets in medium/high-density residential buildings and there is no clear Australian model for how to set up them up and run them.
    - However, the *Strata Titles Act 1985* and the *Strata Titles General Regulations 1996* (STGR) can be used to allow shared ownership of assets such as solar and battery systems.
- The Increasing the Uptake of Solar PV in Strata Residential Developments project is aimed at developing governance models to allow shared solar photovoltaics (PV), battery and monitoring systems to be used in medium density apartments, tested at 50 units of the White Gum Valley (WGV) development in Perth.
    - The project is being led by Curtin University, with other project partners: Curtin University, LandCorp, Western Power, Cooperative Research Centre for Low Carbon Living Ltd, City of Fremantle and Balance Utility Solutions, with Power Ledger as technology provider.
- Under the project, developers whose projects require electricity network upgrades to manage demand, could instead install a shared solar storage system and reduce network requirements and costs. In turn, this could create a more attractive housing product.

Project Objectives

- To develop a functioning, scalable and adaptable governance model over three apartment sites at WGV and a usable set of guidelines for future medium/high-density housing.
- Demonstrate the governance models and microgrid design for solar storage systems for medium/high-density strata title urban developments.
- Examine key factors impacting market uptake for shared solar storage systems within a medium/high-scale urban strata development.
- Review the costs, benefits and risks identified governance model(s) from the perspective of all affected stakeholders.
- Investigate network implications for mainstream deployment of shared solar storage systems in a medium/high-density development.

Approach

- The project has received funding from the Australian Renewable Energy Agency (ARENA) with a total project cost of $2.59m[1].

[1] Further information on the project can be found at https://arena.gov.au/assets/2018/10/White-Gum-Valley-Project-Report.pdf

- Previously, the practice was to generally to offer behind the meter storage and simply divide the bill that comes in from the master meter. However, this is not always fair for residents with differing consumption profiles and usage times.

- Many options for managing the energy market were evaluated and one utilising Distributed Ledger Technology (DLT) was assessed as the best option.

    - DLT from technology company Power Ledger, was used in the project to measure the allocations of energy, facilitate trading and billing of energy between dwellings.

- Each of the three sites, Gen Y, SHAC and Evermore, has within it an embedded network, with all energy consumed within dwellings and common areas being behind a single connection point. A solar storage system is owned in common by the dwelling owners via the unit entitlement scheme under the *Strata Titles Act 1985*.

Summary of Engineering Details for all sites

Site	No Dwellings	Solar PV (kW)	No of Solar Panels	Battery Storage (kWhrs)
GenY	3	9	36	8
SHAC	15	20	75	40
Evermore	24	53.6	168	150

- Each dwelling is allocated a proportion of the energy generated from the system; a proportion is also set aside for the common areas. Any allocation that is not consumed can be traded with other residents P2P.

    - The P2P trading price for electricity is set by the dwelling owners, which is less than the energy retailer's electricity tariff.

- Payment for energy is made to the strata management, which is deducted from the strata levy. This enables tenants to also benefit from the system as they will also pay the strata for electricity at the price agreed by the council of owners.

- The Power Ledger platform has been used to provide all the meter reading, trading and statement of use services for each microgrid.

Progress

- The governance models were developed and implemented into three-property developments within in greenfield site, White Gum Valley. Data was collected from the project to examine the shared benefits, risks and costs between developers, owners, tenants, strata bodies and utilities. The considerations included the energy system design, billing, legal documentation for the strata and for dwelling purchasers and dwelling leases.

- The financial aspects of the governance models were studied, tested and demonstrated in three different strata lot developments. The instructions developed are adaptable and scalable for similar strata projects across Australia.

- The White Gum Valley site has served as a demonstration of the effectiveness of the governance model in enabling greater solar PV and storage to be adopted across apartment housing in Western Australia.

- On average, the three sites were able to become 80% energy self-sufficient, and the integrated solar systems demonstrated a return on investment of more than 11%.

Barriers and Critical Lessons

Regulatory

- Strong customer interest in electricity from a shared solar storage system within an embedded network.

- All consumers were better off, as the Power Ledger platform ensured they were billed appropriately and were rewarded for using less than their allocation, in that they could trade that surplus with their neighbours.

- Education is required for property developers and strata companies on the benefits of this model as opposed to existing arrangements.

Regulatory

- The governance model can be equally applicable to the building stock covered under *the Community Titles Act 2018* (commercial and mixed residential-commercial) and in fact, there may be a greater ability to monetise savings through reduced KVA charges of users from a solar storage system

- Integrated solar battery systems could have targets or become mandatory in all new builds to reduce pressure on capacity-constrained electricity networks for meeting density targets.

- If a development has surplus energy to its need, and if there is a market mechanism whereby, they could trade solar, battery or capacity energy with the market, this could provide an additional income stream to the development. Further, this could provide an additional supply of capacity and energy and deliver system benefits. Market mechanisms that facilitate this kind of trading, could also encourage larger sizing of solar storage systems and reduce the likelihood of developments disconnecting for the grid.

Technical

- There were challenges with Western Power approvals for batteries at scales used in his project. All were overcome in a collaborative way which has set a precedent for future initiatives.

- Further investigation needs to be done in quantifying benefits of deploying behind the meter generation and storage on the provision of network infrastructure. Specifically, its effects on 'Design After Diversity Maximum Demand', which is the maximum demand the electrical distribution network (local transformer) is capable of supplying expressed as an average per dwelling. This would provide a clear business case for property developers installing solar storage systems.

Market

- As the FIT for commercial-scale customers (i.e. the body corporate) is 0 c/kWh, there is a large volume of 'lost revenue', which implies greater opportunity for maximising economic benefits by incentivising P2P trading between the buildings or investing in additional storage, as a large volume of electricity was still 'sold' to grid at 0 c/kWh.

- P2P trading across the grid, between the three sites and with the market could be facilitated. Trials in this regard could quantify any system benefits that could be derived from increased co-location of generation and consumption by reducing line losses (and reliance on transmission) and encouraging more efficient deployment of rooftop solar, along with appropriate network pricing reflective of this and distance energy travels.

References

- Planning and Governance for Decentralised Energy Assets in Medium-Density Housing: The WGV Gen Y Case Study, 2017, Taylor & Francis, https://tandfonline.com/doi/full/10.1080/08111146.2017.1295935

DER Roadmap Considerations

Element	Consideration
Engagement	The project shows how solar and storage in commercial and residential strata developments can be viable and can be set up and managed. Property developers and councils may benefit from information on how this may assist in getting marginally viable sites out of the ground, i.e. reducing headworks costs due to solar storage systems, and achieving renewable energy and sustainability targets within local government authorities. Property developers may benefit to understand how this can be done from a practical perspective.
New Business Models	New arrangements allow owner-occupiers and renters (who pay their energy bill to the strata) to share in the benefits of DER. This approach overcomes the split incentive problem by allowing owners to recover the investment costs and provides tenants access to lower cost energy bills. Hybrid ownership models for energy assets which are part-owned via the body corporate and third parties, could encourage developers to include DER by lowering the capital cost.
Tariff Pilots	In future reviews, it would be helpful to look at a tariff structures that may reflect the reduction of future network augmentation costs (e.g deferred substation upgrades, potential reduced size infrastructure on replacement) and recognising the impact co-location of generation and consumption at these strata developments can have on network costs in that area. In addition, this approach could be enhanced by the trading of energy between buildings located in close proximity with appropriate network charging regimes.
DER Orchestration Pilot	Considerations for energy trading could include DER integration with essential system services markets and consideration of time-based or dynamic network pricing based on location and peak periods.

25. Wongan Hills Peer to Peer – Various

Start Date	1 July 2019	End Date	31 December 2019
Location	Wongan Hills	Project Type	Peer-to-Peer (Connected Microgrid)

Background Information

- Power Ledger is working with partners which include the Shire of Wongan-Ballidu, the Shire of Moora, CleanTech Energy, BSC Solar, Innovation Central Midland, Sonnen, and others on the P2P trading project (WHP).
- P2P trading can include solar, battery and capacity trading, whereby individual customers (or aggregated parties) can buy and sell electricity directly between each other. This trial looked at solar P2P trading and also included a battery to begin to understand the potential for battery and capacity P2P trading.
- This pilot project has shown potential financial benefits for all participants under a customised retail tariff structure.

Project Objectives

- In the context of this report, the core objectives are to supply reliable, affordable, and sustainable energy in regional Western Australia, improving the understanding of P2P energy trading in non-urban contexts.

Approach

- There are 10 commercial participants in the Wongan Hills project (WHP). Four are prosumers, and six are consumers. Within the WEM electricity market, commercial customers have a contestable market, being council buildings, small businesses, and farming estates. Some were already with the retailer for the trial, others switched from other retailers to be a part of it. The pre-installed solar capacity is between 10kW and 40kW for each prosumer and one participant has a small behind-the-meter 15kWh battery system.
- The onboarding processes included information sessions with local businesses, as well as engagement with the Shire.
- Power Ledger provided the energy trading platform services to the energy retailer, where peer to peer trading was conducted within the retailer portfolio.
- The tariff structure is a combination of a retail volumetric rate (kWh), a retail daily fixed cost, and a P2P rate which includes a Power Ledger daily charge and a kWh transaction fee. For solar energy not transacted peer to peer, the retail buy-back rate is 0c/kWh.

Progress

- The savings detailed below are solely as a result of P2P trading, i.e. not from participants having installed solar and battery systems. This aspect was not evaluated as part of this trial. Savings, from P2P trading in the (first full) month of August, were between $112 to $258 per customer on the L1 tariff, and $104 for the customer on the R1 tariff. Savings over the July-October period are above $11,000 for the whole cohort (10 contestable customers) as compared for each customer's respective tariff, with an average of above $278 per customer, per month.
- In many respects, this trial is a microcosm of what the future regional renewable connected microgrids and their markets could look like. For example, like the WHP, electricity supplied through onsite renewable generation supported by energy storage (community and home energy storage systems) and an energy

trading/sharing platform, seek to enable cheaper, cleaner power while improving quality and reliability of electricity to the communities in the regions.

- When the generation and consumption of all power in regional renewable connected microgrids is close to each other, these areas could be expected to have lower transmission network needs and therefore network charges in such microgrids may be lower than conventional transmission and distribution supply systems, thus lowering the base cost of supply.

Barriers and Critical Lessons

Customer

- There was strong customer interest from both prosumers (sellers) and consumers (buyers) of energy, from the beginning and throughout the trial.

- One participant in the pilot that had multiple sites was the Shire and all of their sites had solar, so there was limited trading between this set of sites. However, the Shire owned swimming pool has 26.4kW of solar capacity, closes from March until October every year and they received 0c/kWh FIT for the energy from this asset. Whereas under the trial, they sold their excess during the pilot to neighbouring Shire of Moora's REC Centre who had no solar.

Regulatory

- Within regulated networks in the SWIS, the pricing regime does not recognise the benefits of localised energy generation and consumption. It can typically be a very high cost for network operators to service regional communities, because of the cost of long transmission and distribution lines. DER within a regional community can reduce network size requirements, the need for upgrades as well as maintenance. They can also increase system reliability, which would be costly for a network to achieve. Thus, to demonstrate a potential future state for DER in regional areas, the project had to subsidise the network charges, removing transmission costs.

- In the future, to ensure the market deploys projects in a way that delivers optimal system outcomes, network pricing needs to take account of distance that energy travels, and network congestion, in a sophisticated way.

Technical

- For those customers that did not already have one, advanced meters were included in the onboarding process and were paid for by the project. The roll-out of advanced meters with communications is necessary for energy trading as the interval data is required.

- Within this trial, Power Ledger's energy trading platform was used to facilitate the trading of energy and assist in bill production for the retailer, Cleantech Solar. Power Ledger's platform enables a low-cost way to facilitate trading and sharing of energy in near real-time between many smaller counterparties.

- The small size of the 15kWh battery meant that there is a limited opportunity for grid stability provision, however, potential energy and capacity trading from batteries is being evaluated as a part of the trial.

Market

- The current approach to network pricing contains limited use of price signals to optimise DERs that reduce network costs. Whilst location-based network pricing (rather than averaged across the SWIS) may actually result in higher network costs, in some circumstances costs could potentially be lower, for both the transmission and distribution network, if optimised alongside the DER design. Each location would need to be evaluated on a case by case basis, and further work will need to be done to evaluate these results for WHP.

- With regard to benefits to a retailer, retailers who empower customer are more likely to obtain and retain them in their portfolio. This project is seen as a model for better coordinating DER participants in the future consumer-centric market.

- The tariffs compared within the cost-benefit analysis were the L1 tariff (9 customers) and the R1 tariff (1 customer). As the FIT is 0c/kWh, there is a large volume of 'lost revenue', which implies greater opportunity for maximising economic benefits as a large volume of electricity was still 'sold' to the grid at 0c/kWh.

- As opposed to dynamic pricing for P2P energy, this trial had a fixed rate for P2P energy, which made the system easy for participants to understand. Time-based or dynamic pricing, reflective of the cost of energy at different times of the day may facilitate behaviour change and better energy system outcomes.

DER Roadmap Considerations

Element	Consideration
Tariff Pilots	WHP looks at the potential of a lower cost of network infrastructure in the future with the co-location of generation with consumption in rural areas, e.g. reduction of future transmission and distribution network usage and costs, reflected in the tariff structure. Further work will need to be done to evaluate these results for WHP against the weighted average costs across the network. In addition, the P2P trading platform has proven a way to socialise new tariff structures with customers.
Customer Engagement	This project has shown that there is strong customer engagement with P2P trading, for both prosumers and consumers, as a way of monetising their investments, increasing energy reliability and driving cost savings on energy bills.

26. Solar PV Trials – Queensland Government

Start Date	Solar for public housing trial - March 2017 Solar for rentals trial – March 2019	End Date	Solar for public housing trial - Phase 1 completed in September 2018 Solar for rentals trial – 30 June 2020
Location	Queensland	Project Type	Solar Incentives

Background Information

- Two trials have been undertaken by the Queensland Government as part of its Affordable Energy Plan - $300 million of initiatives to make electricity more affordable for residential and business customers. Under the plan, electricity prices for typical household and small business customers will remain below inflation on average over the next 2 years.

- In March 2017, the Queensland Government launched Solar for Public Housing trial to install solar panels for public housing tenants through a power purchase agreement (PPA).

- Half a million properties in Queensland are rentals, which has limited residential solar uptake – in March 2019, the Queensland Government launched a Solar for Rentals trial, to help landlords and tenants share the benefits from installing solar PV systems.

Project Objectives

- *Solar for public housing* trial:
  - To deliver electricity savings for some of the community's most vulnerable electricity customers.
  - To provide long-term savings to households on their power bills, including reduced exposure of consumers to future power price fluctuations.
  - To enable public housing tenants in detached government-owned houses to access the benefits of rooftop solar power.

- *Solar for rentals* trial**:**
  - To help landlords and tenants install solar PV systems and share the financial benefits.
  - To use the results from the trial to evaluate the costs and benefits and decide whether the program can be expanded to other areas across Queensland.

Approach

- *Solar for public housing* trial:
  - The trial is planned to deliver up to 6MW of new solar PV on up to 4,000 new solar rooftops across Queensland.[2]

[2] Queensland Government, *Solar future for public housing in Queensland*, Media Release, 10 March 2017. Accessed 28 October 2019: http://statements.qld.gov.au/Statement/2017/3/10/solar-future-for-public-housing-in-queensland

- Eligible housing tenants can enter into a solar power purchase agreement. Solar PV systems are installed at no cost by Ergon Energy, with an additional digital meter.[3]
- To test different business models, a 200kW rooftop 'solar farm' has also been installed on government-owned buildings in the remote Indigenous community of Lockhart River, to save on the cost of supplying diesel power to the community. Some of the savings will be shared with eligible public housing tenants in the community.[4]

- *Solar for rentals* trial:
  - As part of the trial, around 1,000 rebates are available for eligible landlords to install a solar system with solar monitoring technology.
    - The rental property must be currently tenanted with a rent (before solar PV installation) of no more than $350 per week.[5]
  - The rebate varies from $2,500 for systems from 3kW, to $3,500 for systems 5kW or greater.
  - Eligible landlords receive the rebate, which will cover much of the up-front cost of installing a solar and monitoring system, and a negotiated higher rental income from tenants.
  - Tenants get access to solar with no upfront cost and can use the solar system to reduce their power bills in return for a fair rent increase.

Progress

- *Solar for public housing* trial:
  - Solar panels installations on about 500 public housing homes in Rockhampton and Cairns were completed under the 'Sunny Savers trial' in September 2018. Installations in the Logan trial are expected to start by January 2020.
  - The Lockhart River rooftop solar farm was installed in late 2017.
- *Solar for rentals* trial:
  - The Queensland Government reports that there have been $660,000 in rebates claimed, 192 solar PV systems installed, and more than 580 landlords and tenants have registered their interest in the program.[6]
  - The trial will run until 30 June 2020, or when the $4 million funding has been allocated.

Barriers and Critical Lessons

Customer

- Solar PPAs can provide access to DER for households who would otherwise be unable to install it, including vulnerable customers.
- The trials give tenants the opportunity to save on their power bills and their carbon emissions. For the *Solar for rentals* trial, it is expected that a typical household could save between $400 and $500 even after a $10 per week rent increase.[7]
- The *Solar for rentals* trial offers a way to overcome split incentives for DER installation in rental arrangements – certainty of returns for landlords and access to DER for tenant bill reduction allows both parties to enjoy benefits from DER.

[3] Queensland Government, *Solar future for public housing in Queensland*, Media Release, 10 March 2017. Accessed on 28 October 2019: http://statements.qld.gov.au/Statement/2017/3/10/solar-future-for-public-housing-in-queensland
[4] Queensland Government, *Solar panel trial*, last updated: 31 July 2019. Accessed on 28 October 2019: https://www.qld.gov.au/housing/public-community-housing/public-housing-tenants/during-your-tenancy/solar-panel-trial
[5] Queensland Government, *About the trial*, last updated: 28 February 2019. Accessed on 28 October 2019: https://www.qld.gov.au/community/cost-of-living-support/concessions/energy-concessions/solar-for-rentals-trial/about-the-trial
[6] Queensland Government, *Solar rental dollars racing out the door*, Media Release, 1 October 2019. Accessed 28 October 2019: http://statements.qld.gov.au/Statement/2019/10/1/solar-rental-dollars-racing-out-the-door
[7] Queensland Government, *Solar option on the table for tenants and owners*, Media Release, 5 March 2019. Accessed 28 October 2019: http://statements.qld.gov.au/Statement/2019/3/5/solar-option-on-the-table-for-tenants-and-owners

- Customers who rent or own apartments continue to have very limited options in terms of DER.

Regulatory

- There are increasingly substantial costs associated with high bidirectional flows caused by PV exports to the grid. Some of these costs are being borne by those consumers who cannot directly benefit from solar. Government's subsidies for solar installations may exacerbate this cross-subsidisation between customers who do not own solar PV systems and those customers who do own.

Technical

- Solar systems installed at the rental property must be fitted with solar monitoring technology. At a minimum, the solar monitoring technology must give tenants the ability to see the amount of:
  - power generated by the solar system
  - solar power used at the property
  - solar power exported to the electricity grid
  - estimated or calculated bill savings from solar.
- Subsidised deployment of solar PV may lead to the accelerated penetration of DER while the grid is still not prepared for the associated system security challenges.

DER Roadmap Considerations

Element	Consideration
Tariff Pilots	Tariff structures that are not cost reflective allow cross-subsidisation between different consumer groups, thereby pushing costs generated by one consumer group onto remaining customers.
Tariff Pilots	Government programs can overcome split incentives for DER installation in rental arrangements and allow landlords and tenants to both benefit from DER.
System Operations	AEMO will need to have up to date information on DER capabilities to ensure the best possible system modelling. Any program that upgrades installed DER capability will need to incorporate communication with AEMO.

27. Solar For Rental Properties – Victorian Government

Start Date	July 2019	End Date	Ongoing[8]
Location	Victoria	Project Type	Solar Rebate

Background Information

- In August 2018, Victorian Government announced the *Solar Homes Scheme,* aiming to bring the number of homes in Victoria with solar panels to one million within ten years.
- The $1.3 billion *Solar Homes Scheme* consists of:
  - $1.24 billion for solar power systems on 650,000 homes
  - $60 million for solar hot water systems for 60,000 homes
  - $40 million to support the purchase of solar batteries for 10,000 households
  - $82 million for solar panels on 50,000 rental homes.
- From 1 July 2019, *Solar Homes Scheme* was expanded to allow renters access rebates for solar panels and solar battery storage systems. The *Solar for rental properties* scheme will also offer interest-free loans for landlords installing solar panel and batteries.

Project Objectives

- To help Victorian customers take control of their energy bills by installing solar panels.
- To help drive down energy costs and create new jobs.
- To cut Victoria's carbon emissions.

Approach

- The program will offer landlords rebates on solar PV systems (with a fixed, publicy available allocation per month) to Victorian renters. [9]
- In 2019-20, the program is planned to deliver 2,000 solar panel systems on rental properties.[10]
- The program is to be delivered in two streams:[11]
  - Stream A: open from 1 July 2019 and offers a rebate for rental properties, with the landlord paying the remaining cost of the solar system.
    - A rebate of up to $2,225 is available for rental properties.

[8] The *Solar for rental properties* program is part of the Victorian Solar Homes Scheme. This scheme was launched in August 2018 for a ten-year period.
[9] Solar Victoria, *Solar for rental properties*, last updated: 26 September 2019. Accessed on 28 October 2019: https://www.solar.vic.gov.au/solar-rental-properties
[10] Victoria Government, *Solar Homes Rolling Out To Even More Victorians*, Media Release, 18 June 2019. Accessed on 28 October 2019: https://www.premier.vic.gov.au/solar-homes-rolling-out-to-even-more-victorians/
[11] Solar Victoria, *Solar for rental properties*, last updated: 26 September 2019. Accessed on 28 October 2019: https://www.solar.vic.gov.au/solar-rental-properties

        - The rebate amount is paid directly to the solar provider and will be deducted from the total cost of the solar system.
    - Stream B: will offer both a rebate and an interest-free loan to landlords. Under this stream, a tenant will also contribute to the cost of the system. Stream B will open later in 2019-20.

Progress

- There is a certain allocated number of solar rebates for rental properties allocated per month. For instance, in October there were 166 rebates allocated for rental properties. As of 29 October, 113 of 166 rebates were remaining.[12]

Barriers and Critical Lessons

Customer

- The Victorian Government expects rental properties to be able to save up to $890.[13]
- The trial offers a way to overcome split incentives for DER installation in rental arrangements – certainty of returns for landlords and access to DER for tenant bill reduction allows both parties to enjoy benefits from DER.

Regulatory

- There are increasingly substantial costs associated with high bidirectional flows caused by solar PV exports to the grid. Some of these costs are being borne by those consumers who cannot directly benefit from solar. Government's subsidies for solar installations may exacerbate this cross-subsidisation between customers who do not own solar PV systems and those customers who do own.

Technical

- Subsidised deployment of solar PV may lead to the accelerated penetration of DER while the grid is still not prepared for the associated system security challenges.

DER Roadmap Considerations

Element	Consideration
Tariff Pilots	Tariff structures that are not cost reflective allow cross-subsidisation between different consumer groups, thereby pushing costs generated by one consumer group onto remaining customers.
Tariff Pilots	Government programs can overcome split incentives for DER installation in rental arrangements and allow landlords and tenants to both benefit from DER.
System Operations	AEMO will need to have up to date information on DER capabilities to ensure the best possible system modelling. Any program that upgrades installed DER capability will need to incorporate communication with AEMO.

[12] Solar Victoria, *Solar for rental properties*, last updated: 26 September 2019. Accessed on 28 October 2019: https://www.solar.vic.gov.au/solar-rental-properties

[13] Ibid.

28. Virtual Power Plant Trial – AGL

Start Date	March 2017	End Date	Trial: closed VPP: ongoing
Location	South Australia	Project Type	Virtual Power Plant

Background Information

- The South Australia electricity market is characterised by large renewable penetration, synchronous generators retiring and increasingly expensive gas generation.
- In 2017, VPPs were not considered economically viable, due to limited deployment at commercial scale and current payback for residential energy storage systems.[14]
- However, the estimated reduction in energy storage system prices is likely to make VPPs viable in the medium term.
- In March 2017, AGL launched a project to demonstrate the capability of a 5MW VPP, through the installation and orchestration of 1,000 behind-the-meter batteries in metropolitan Adelaide, South Australia.

Project Objectives

- To demonstrate the role of distributed 'smart' energy storage in enabling higher penetrations of renewables.
- To demonstrate the value that grid-connected batteries can create for a range of stakeholders when managed as part of a coordinated virtual power plant. The functionalities include solar self-consumption, network support through peak demand management and frequency control services, and a physical hedge or arbitrage opportunity in wholesale energy market.[15]
- To gain customer feedback and build customer trust towards VPP and storage systems.

Approach

- The total 5MW VPP will consist of 1,000 storage systems capable of dispatching more than 9MWh of stored energy.[16] Installation proceeded through an initially staged approach of 150, 350 and 500 energy storage systems respectively.
- The Federal Government provided $5 million through ARENA to support the project and offered strong visibility for the project in the media.[17]
- AGL trialled various storage systems during different project phases: the Sunverge One Energy Storage System had been selected as the standard hardware platform for Phase 1 of the project; and Tesla and LG Chem equipment were used from Phase 2.[18]
- To attract customers, AGL has offered attractive rates to customers and flexible contract terms, including no lock-in and exit fees. Customers were able to benefit from a subsidised installation and keep the battery

[14] For more information, see: https://arena.gov.au/projects/agl-virtual-power-plant/
[15] AGL, *Virtual power plant in South Australia*, Stage 1 milestone report, 31 July 2017, p. 4. Accessed 29 October 2019: https://arena.gov.au/assets/2017/02/VPP-SA-Public-Milestone-1-Report-Final-for-issue.pdf
[16] AGL, *Virtual power plant in South Australia*, Stage 1 milestone report, 31 July 2017, p. 2. Accessed 29 October 2019: https://arena.gov.au/assets/2017/02/VPP-SA-Public-Milestone-1-Report-Final-for-issue.pdf
[17] For more information, see: https://arena.gov.au/projects/agl-virtual-power-plant/
[18] Ibid.

equipment at no further cost in the future. Eligible customers who already have a battery installed are offered a bonus with ongoing credits for joining the VPP.

Progress

- AGL initially faced technical difficulties which led to significant installation delays. In August 2017, 700 systems had been sold, and only 250 installed.
- Demonstration dispatch events were reported to have been conducted in 2017 and 2018, monitoring the impact of the VPP on network, and individual and fleet performance.
- In its 2018 public report, AGL noted that the trial had significantly flattened the load, reduced peak network demand and reduced peak solar export in the trial area.[19]
- Despite initial technical difficulties, AGL has continued to develop the VPP. The South Australian VPP trial has converted to a longer term offering for customers.
    - In July 2019, AGL launched its VPP offer in multiple states in addition to South Australia: Victoria, New South Wales, and Queensland.
- AGL's current VPP offering follows a significantly different approach to its 2017-18 trial. AGL has opened the VPP to customers having their own battery system, and instead of offering heavily subsidised batteries, AGL now offers a $1,000 discount on battery retail prices for customers entering into a 5-year contract.[20]

Barriers and Critical Lessons

Customer

- Customers demonstrated increased solar self-consumption, leading to retail bill savings.
- AGL reports that achievement of early uptake targets and sales conversion rates demonstrated significant latent customer demand for storage.
- Challenges to recruitment included customers who received extremely favourable premium feed-in tariff (PFIT) rates from the South Australian government (PFIT of 44c/kWh, plus an additional retail buyback tariff of 6.8c/kWh).
- AGL analysed demographics of its VPP customers and found customers with typically high income and high levels of education were disproportionately represented among trial customers.

Regulatory

- AGL's VPP trial faced difficulties as a result of the PFIT in South Australia. Nearly 200 eligible customers whom expressed an interest in the program chose not to proceed because they would lose their feed-in tariff.

Technical

- In the early phases of the trial, AGL faced significant technical challenges:

[19] AGL, *Virtual power plant in South Australia*, Stage 2 Public Report, 15 June 2018, p. 15-16. Accessed 29 October 2019: https://arena.gov.au/assets/2017/02/virtual-power-plants-in-south-australia-stage-2-public-report.pdf

[20] AGL, *Customers reap rewards through AGL Virtual Power Plant*, Media Release, 12 June 2019, accessed on 29 October 2019: https://www.agl.com.au/about-agl/media-centre/asx-and-media-releases/2019/june/customers-reap-rewards-through-agl-virtual-power-plant

- In Stage 1 of the project, approximately 78% of sites required a variation to the price initially quoted to customers to account for unforeseen difficulties associated with installation (such as switchboard modifications).[21]
- Inverter disconnections due to high grid voltage present challenges for availability of systems for charging and orchestration. In Stage 1, 12.5% of the fleet experienced persistently high voltage, and over a third of installations experienced at least one disconnection due to high grid voltage. Such technical difficulties have led to increase in unavailability of battery equipment.[22]

- An export target of 3kW was not maintained reliably over one-hour dispatch periods – AGL reported grid voltage and state of charge levels (particularly on cloudy days), and high customer loads (in combination with 5kW inverter size) limited the system's ability to export 3kW.

- The average fleet load profiles were found to have significantly lower peaks, and lower solar exports to the grid (which were used to charge the battery instead).

- Batteries were directed to discharge with a target of 3kW between 5 and 6pm for a ten-day trial.

- While the trial demonstrates the benefits of BESS in reducing peak demand and increasing solar self-consumption, there is limited reported functionality of the AGL VPP battery systems to act as a VPP, that is, to actively respond to communication signals from the operator to provide grid benefits when required.
  - For example, the provision of frequency control services from the battery have not been reported on to date.

Market

- The trial has demonstrated the benefits of peak shifting but will require further demonstration of VPP functionality to participate in markets.

- It has been reported that AGL has made losses on South Australian VPP trial.[23] Further opportunities for participation in markets may provide alternative revenue streams that would justify further VPP rollout.

DER Roadmap Considerations

Element	Consideration
DER Orchestration Pilot	The demonstrated technological capability of DER to respond in a timely and accurate way to operator is yet to be fully demonstrated. The development of DER Management Use Cases for the SWIS should be explicitly included in future DER Orchestration Pilots and trials.
DER Orchestration Pilot	The contracting and settlement requirements as well as customer protections for VPP providers requires further consideration. The costs and benefits of establishing the ability for customers to contract with other parties requires assessment against a retailer-led approach for VPPs.
DER Orchestration Pilot	VPP technology dispatching behind-the-meter will not be explicitly visible at the metering point. As such, validation of the DER response via a VPP, and all associated data collection, transfer and settlement requirements will require further consideration. Requirements for telemetry data from the DER directly will need to be established to underpin wholesale market participation and compensation.

[21] AGL, *Virtual power plant in South Australia*, Stage 1 milestone report, 31 July 2017, p. 17. Accessed 29 October 2019: https://arena.gov.au/assets/2017/02/VPP-SA-Public-Milestone-1-Report-Final-for-issue.pdf
[22] Ibid, p.20.
[23] Adelaide Now, *AGL cops SA virtual power plant financial loss*, 16 September 2019, accessed 29 October 2019: https://www.adelaidenow.com.au/news/south-australia/agl-losing-on-sa-battery-scheme-but-gains-ground-as-it-plots-role-in-200bn-renewables-transition/news-story/ae68e6f3f9e7a3e16a441ea4622e27b0

Element	Consideration
Customer Engagement	Active engagement with customers regarding DER technologies, including addressing safety, operation and compensation issues, was found to be beneficial.
DER Orchestration Pilot	Further consideration is required for how more sophisticated VPP capability and automation solutions impact customers participating in VPPs, and in dispatch approaches under the DSO/DMO Function Set.
New Business Model	Consideration needs to be given to whether customers with DER be required to have a default aggregator or VPP, through which the DSO issues dispatch instructions.
Tariff Pilots	Existing premium feed in tariff compensation payments for DER could act as a barrier for storage adoption.

29. Virtual Power Plant – South Australian Government and Tesla

Start Date	January 2018	End Date	Ongoing
Location	South Australia	Project Type	Virtual Power Plant

Background Information

- In 2018, Tesla and South Australian Government announced the launching of the world's largest VPP which will include up to 50,000 households.
- The project is supported by SA Power Networks, ARENA and CSIRO. SA Power Networks is leading the project on the development of an interface to exchange real-time and locational data on distribution network constraints between SA Power Networks and the Tesla South Australian VPP.[24]
- When launched, Tesla VPP Energy Plan was the fourth VPP offering available in the South Australian market including AGL, Simply Energy and sonnenFlat.[25]
- Operating at full scale, the VPP could generate 250MW and store 650MWh.

Project Objectives

- The project objectives are:
    - lower energy prices
    - increase grid stability
    - provide protection during a grid outage
    - increase customers' visibility of their energy use
    - support South Australia's transition to a renewables-based economy.

Approach

- The project's key stakeholders are:
    - Tesla designs the VPP and is managing the installation of the solar panels and battery storage.
    - Energy Locals is the retailer that is arranging residents' supply contracts and is customers' main point of contact about their electricity supply and their bills.
    - The South Australian Government is providing $2 million grant and $20 million loan funding, through the Renewable Technology Fund, to support the trials.
- Phases 1 and 2 are being limited to SA Housing Trust properties with tenants who registered their interest in the VPP program before 1 November 2018. Phases 1 and 2 participants do not own their systems, while Phase 3 participants are system owners.

[24] ARENA, *Advanced VPP grid integration*, last updated on 24 August 2019. Accessed on 30 October 2019: https://arena.gov.au/projects/advanced-vpp-grid-integration/

[25] Government of South Australia, *VPP batteries bank bigger savings for SA households*, Media Release, September 2019. Accessed on 30 October 2019: https://premier.sa.gov.au/news/vpp-batteries-bank-bigger-savings-for-sa-households

- There is no cost to Housing Trust tenants to have the system installed and maintained. A participant may leave the program with no exit fees; however, the installed system will remain and will no longer provide benefits for a household.

- For Phase 3 participants the Tesla Energy Plan was designed:

  - Customers signing up to this program will retain full ownership of their systems but agree to allow Tesla to operate their batteries to maximise the value that can be generated by their system.

  - Tesla is offering South Australian customers a special rate of $3,499[26] for a 13.5kWh battery.

  - Tesla's Energy Plan will offer a rate of 31.13 cents/kWh for electricity purchased from the grid, with energy supplied by the solar or battery system free of charge.

Progress

- The VPP project is rolled out in a staged manner. The three roll-out stages are summarised below.

Phase	No of customers	Timing	Description
Phase 1	100	Completed	Government acquisition, installation and management of 100 PV and storage systems. Designed to test physical rollout, system operation and facilitate data collection for representative customers.
Phase 2	1,000	By the end of October 2019	Government acquisition, installation and management of 1,000 systems, designed to further test physical rollout, VPP operation and retailer arrangements.
Phase 3	49,000	Later 2019	Final roll-out, subject to the trials' success, program financing, and the satisfaction of both Tesla and the government in the final program design.

- Between January 2019 and September 2020, SA Power Networks is trialling locational, dynamic network constraints. By adopting locational, dynamic network constraints the interface aims to overcome the static 5kW export limit applied to households, which effectively reduces the export potential of the Tesla VPP by 50%.

Barriers and Critical Lessons

Customer

- The program has delivered 1,100 solar and battery systems to low income households.

- Depending on the type of electricity retail contract a participant was on before joining the program, a participant could save more than 20% off the Default Market Offer in South Australia.

Regulatory

- Phase 1 and Phase 2 participants are not eligible for a solar feed-in tariff as they do not own the solar system installed.

[26] This price is inclusive of GST and includes the Home Battery Scheme rebate of up to $6000. It does not include solar panels or battery and solar installation costs.

Technical

- The static 5kW export limit applied to households effectively reduces the export potential of the Tesla VPP by 50%. SA Power Networks is running a trial to introduce locational, dynamic network constraints to address the issue.

Market

- Without government support, VPP projects have limited financial feasibility.
- The VPP is expected to cost $800 million including Phase 3.
- Phase 1 was fast-tracked by a $2 million grant from the South Australian Government. Phase 2 is being supported by a $30 million loan from the South Australian Renewable Technology Fund.

DER Roadmap Considerations

Element	Consideration
DER Orchestration Pilot	The contracting and settlement requirements as well as customer protections for VPP providers requires further consideration. The costs and benefits of establishing the ability for customers to contract with other parties requires assessment against a retailer-led approach for VPPs.
DER Orchestration Pilot	VPP technology dispatching behind-the-meter will not be explicitly visible at the metering point. As such, validation of the DER response via a VPP, and all associated data collection, transfer and settlement requirements will require further consideration. Requirements for telemetry data from the DER directly will need to be established to underpin wholesale market participation and compensation.
DER Orchestration Pilot	Further consideration is required for how more sophisticated VPP capability and automation solutions impact customers participating in VPPs.
New Business Model	The dynamic management of distribution network capacity is a key requirement to unlock the full value of VPPs and other distributed energy resources. Real-time and locational data on distribution network constraints should be shared with load aggregators to optimise their output.
Grid Response	Ensuring that Western Power can actively integrate VPPs into its network operations will be important to maximise the benefits.
Grid Response	Further consideration on the extent of network modelling needed to understand and test the likely network impacts of DER and identify how network may best accommodate and compensate DER.
System Operations	AEMO will need to have up to date information on DER capabilities to ensure the best possible system modelling. Any program that upgrades installed DER capability will need to incorporate communication with AEMO.

30. Dispatchable DER in Wholesale Markets – New York

Start Date	2018	End Date	April 2020
Location	New York State, USA	Project Type	DER Management

Background Information

- At the federal and state levels, governments and system operators in the United States work on a range of initiatives to firm up DER, making it a dispatchable resource of capacity, energy and essential system services.

- In February 2017, the New York Independent System Operator (NYISO) published the *Distributed Energy Resources Roadmap for New York's Wholesale Electricity Markets* report which outlines the NYISO's vision for integrating DER into the energy, ancillary services, and capacity markets.[27]

    - This was followed by the announcement of the NYISO Pilot Program in October 2017. The pilot program will inform market design efforts and build operational DER experience.[28]

Project Objectives

- To assess the capability of DER aggregations to provide energy and ancillary services and the associated benefits to the wholesale markets, plus identify and evaluate barriers to entry of DER.

- To establish and evaluate an operational coordination framework between system operators, utilities, coordinating entities, and DER to ensure that DER can be optimise across multiple value streams.

- To understand technical capabilities and dispatchability of DER, small resources, and aggregations including to evaluate the impact of integrating DER into various software systems.

- To establish and evaluate the appropriate registration and governance processes for aggregation of small-scale DER.

Approach

- The NYISO has developed its roadmap for DER integration into the market, in which DER was grouped into three broad groups:

    - *Dispatchable DER:* DER that are able to respond to real-time signals at 5-minute intervals. This type of DER may be qualified to offer capacity, day-ahead energy and essential system services, and real-time energy and essential system services.
    - *Non-dispatchable DER:* DER that cannot respond to real-time signals. DER participating through non-dispatchable DER participation model may be qualified to provide capacity and energy.[29]
    - A third category of DER include other generators, intermittent power resources and energy storage resources. While resources in this category can be called DER, the NYISO's arrangements already permit their full participation.

[27] For more information, see: https://www.nyiso.com/documents/20142/1391862/Distributed_Energy_Resources_Roadmap.pdf/ec0b3b64-4de2-73e0-ffef-49a4b8b1b3ca

[28] For more information, see: https://www.nyiso.com/documents/20142/1393555/NYISO-Pilot-Program-Guide-Final.pdf/c9d9b101-3e17-b64c-2fb4-4cb92e06d198

[29] The only non-dispatchable DER permitted to participate in the NYISO-administered wholesale markets will be those that meet the requirements to be Special Case Resources or Emergency Demand Response Resources.

- The NYISO's roadmap focuses on real-time dispatchable DER, aggregated into a DER Coordinating Entity Aggregation (DCEA) with a minimum 100kW total capacity, connected to the same transmission node.
    - A DCEA comprises two or more mixed resource types (e.g., demand-side resources, energy storage resources, generators) which are individually under 20MW.
- To support its strategic objectives, the NYISO has established a pilot program to demonstrate the integration of innovative DER technologies and concepts into its wholesale market systems.
    - The pilot program seeks to demonstrate specific capabilities and objectives within an environment that simulates wholesale market operations but with actual dispatch control signals from the NYISO.
    - The NYISO developed a Pilot Test Environment (PTE) which is outside the wholesale market. Through the PTE, participants will submit their capability on an hourly basis. Based on capability, the NYISO will produce a day-ahead advisory schedule. Comparable to wholesale market, pilot projects will receive real-time dispatch control signals. Under the pilot, dispatchable of DER is in a parallel dispatch system running along side the wholesale market.

Progress

- The NYISO will limit initial enrollment to a maximum of five pilot projects (totalling 50MW), able to participate for a maximum of 12 months. The pilot program will be active until April 2020.
- The next stage will be software upgrades and any additional technical arrangements required to implement the DER participation model by 2021.
- At a federal level, in February 2018, the Federal Energy Regulatory Commission (FERC) made a rule to remove barriers to the participation of electric storage in the capacity, energy and ancillary services markets.
    - Specifically, the rule required each regional grid operator to revise its tariff to establish a participation model for electric storage to ensure adequate compensation for the various benefits.

Barriers and Critical Lessons

Customer

- The NYISO undertook the following steps to broaden the range of DER eligible for wholesale market participation:
    - The NYISO revised the definition of DER to permit it to be located both in front of and behind a customer meter and on either the transmission or distribution system, while still limiting DER to small resources.
    - The NYISO proposed to reduce the minimum dispatchable DER bid size from 1MW to 100kW, and to permit dispatchable DER with a capability less than 100kW to meet the new minimum bid threshold by aggregating with other dispatchable DER.

Regulatory

- The NYISO considered what metering and accounting practices are required to delineate between DER wholesale and retail activities.
    - The main concern was that electric storage resources providing retail services should not be allowed to charge at the wholesale rate, and discharge to serve a retail customer. Challenges related to the identifaction of whether storage is being used to serve local customers or participating in markets.

- In order to prevent conflicting dispatch instructions for electric storage – so that a system operator does not accept both the offer and bid of an electric storage resources – the (federal-level) FERC required each system operator to put in place market rules that prevent conflicting dispatch signals in the same market interval.

Technical

- While the NYISO was considering testing the dispatch of multi-node DER aggregations, it concluded that this approach would exacerbate transmission constraints. Instead, the NYISO focused on a single node aggregation. This constraint meant that all the DER resources to be dispatch as a single resource must be located in the same transmission area.

- The NYISO determined that only those DCEAs that are 1MW or greater are eligible to provide ancillary services because of the mathematical complexity of co-optimising energy and ancillary services for a Super Aggregation.

- A substantial level of measurement and verification has been required for DER to participate in the markets which has added costs.

- The NYISO has received feedback from DER developers that the cost of the existing telemetry requirements for wholesale market participation could be significant, and therefore may present a barrier for DER participation.

Market

- The NYISO recognised that DER would like to provide wholesale service and retail service, thereby accessing multiple revenue streams.

- Simultaneous participation is a new concept to the NYISO and is being explored to determine impacts to the markets and grid operations. While simultaneous participation has the potential to deliver greater benefits to both DER and the power system policy makers expressed concerns about over-recovery at the expense of customers through double payment of the same service.

DER Roadmap Considerations

Element	Consideration
Distribution Battery Storage	Broader adoption of network storage requires further assessment of the regulatory framework, specifically the Electricity Networks Access Code, to consider asset ownership and provide revenue certainty (where appropriate).
Distribution Battery Storage	In large numbers, distribution level batteries will have a material impact on system and market operations and need to be integrated into markets effectively. Use of distribution batteries will require clearly defined metering and settlement arrangements.
Distribution Battery Storage	The metering and settlement requirements as well as customer protections for third party models requires further consideration.
Distribution Battery Storage	The framework needs to be created to delineate between DER wholesale and retail activities. This helps to insure that combined revenue streams do not result in a resource receiving uncompetitive financial incentives akin to a ‘double payment’ for providing the same service.
System Operations	DER integration and participation at both wholesale and distribution level may raise operational challenges for the system operator. Specifically, it may be challenging to maintain system operator’s situational awareness and operational visibility of DER so that the operator can correctly reflect DER output and availability in its security analysis and dispatch processes.

Element	Consideration
System Operations	AEMO will need to have up to date information on DER capabilities to ensure the best possible system modelling. Any program that upgrades installed DER capability will need to incorporate communication with AEMO.
Distribution Network and Visibility	Greater network visibility could facilitate the aggregation of DER in the future. There could be appropriate software tools and network interface which could help parties to understand and model the value of DER by different locations.
DSO/DMO Function Set	Opportunities to unlock value across the cost stack for the DER owner (such as through a DMO) is likely to increase uptake, however, a high level of customer participation is required to precipitate the development of markets.
Data	Measurement and verification requirements are important but must be reasonable to not to act as a barrier for DER to enter the wholesale markets.

31. Network Services Purchase Agreements – Hawaii Public Utilities Commission

Start Date	2020	End Date	At least 2024
Location	Hawaii	Project Type	Virtual Power Plant

Background Information

- In January 2018, the Hawaii Public Utilities Commission (PUC) approved a portfolio of demand response programs aiming to reward and incentivise customers for using their own DER while assisting in the overall management of the electricity grid.
- The PUC decision allows utility-approved third-party partners to engage with customers willing to provide access to their DER. These third-party partners will aggregate and optimise the resulting demand response capabilities and make them available to the utility grid operators.
- The PUC has recently approved the first Grid Services Purchase Agreement between Hawaiian Electric (the utility network operator) and OATI Energy Alliance[30] for the provision of DER related services.

Project Objectives

- To provide dynamic and real-time services supporting grid operations and reliability, including frequency control, spinning reserve and operating reserves.[31]
- To offer customers opportunities to decrease their bills while supporting Hawaii's 100% clean energy goal by 2045. Customers will also receive incentives, directly from Hawaiian Electric, for their participation in the program.

Approach

- OATI Energy Alliance, comprised of OATI and industry partners, will recruit customers, control behind-the-meter customer-owned DER assets, aggregate them into VPPs, and provide grid services to Hawaiian Electric.
- OATI's System Operations Centre to provide forecasting, dispatch and control to manage the real-time grid service program using secure communications.[32]
- Hawaiian Electric will pay OATI for services, who in turn will compensate the customers aggregated to support or back up the grid for reliability.[33]

[30] Open Access Technology International, Inc. (OATI), is the largest provider of software-as-a-service for grid operations in North America. OATI is the first and only Grid Services provider to Hawaiian Electric, and leads an alliance to deliver a comprehensive Grid Services program to Hawaiian Electric

[31] OATI, *Hawaiian Electric and Open Access Technology International, Inc. Partner to Create Paradigm-Shifting Grid Services Project*, Media Release, 3 April 2019. Accessed on 29 October 2019: https://www.oati.com/Newsroom/Press-Coverage/hawaiian-electric-files-gspa-project-with-puc

[32] Ibid.

[33] National Renewable Energy Laboratory, *Demand Response Compensation Methodologies: Case Studies for Mexico*, June 2018. Accessed on 28 October 2019: https://www.nrel.gov/docs/fy18osti/71431.pdf. Compensation is quoted in US dollars.

Progress

- In August 2019, the PUC approved the Grid Services Purchase Agreement between Hawaiian Electric Company and OATI.[34]

- In September 2019, Sunrun was contracted to start installation of approximately 1,000 Brightbox home batteries (totalling 4.3MW of capacity) on O'ahu Island.[35]

- In October 2019, Shifted Energy has signed an agreement to incorporate its industry-leading grid-interactive water heaters into OATI Energy Alliance. Shifted Energy will install up to 2,400 grid integrated water heating (GIEH) systems across Oahu and Maui, with a specific focus on hard-to-reach customers including low- and moderate-income, apartment dwellers, and renter communities.

- Under a five-year contract beginning in 2020, the combined GIWH systems will function as a 2.5MW VPP, making it one of the largest competitively procured GIWH deployments in the world. The units will respond in aggregate to signals from Hawaiian Electric to deliver key ancillary services such as fast frequency response, grid capacity increase and decrease.

- OATI has submitted its Grid Services Purchase Agreement for the PUC approval as part of Hawaiian Electric Companies Renewable Request for Proposal seeking to replace two aging fossil power plants: 180MW coal-fired AES Hawaii plant, which is expected to close by September 2022 and 37.6MW oil-fired Kahului Power Plant on Maui, which is expected to close by the end of 2024.

Barriers and Critical Lessons

Customer

- Under the existing arrangements, rates and other financing mechanisms are subject to approval by regulators. This provides some form of consumer protection. However, the intention is to transition to real-time pricing at a later stage.

- Hawaii has the highest electric rates in the USA and a key focus of the program is how to ensure that mechanisms are accessible for customers across a diverse set of needs

Regulatory

- The PUC approves demand response portfolio tariff structure frameworks, which includes the grid service rules and the attendant rate schedules and riders upon which the programs are to be deployed in support of the grid service rules.

    - Third-party aggregators can optimise the resulting demand response capabilities and make them available to the utility grid operators.

- The PUC has identified and approved four broad ancillary service tariff categories: Fast Frequency Response, Regulating Reserves, Replacement Reserves and Capacity – more granular or specific services can be provided under each of these tariffs.

Technical

- While the program was cost effective, it required substantial effort to administer; customer acquisition and retention was also a common challenge. Relying on commercial aggregators to handle the customer acquisition and management side of the program was found to be beneficial.

[34] OATI, *Hawaiian Electric and Open Access Technology International Plan for Innovative Grid Services Wins PUC Approval,* Media Release, 3 September 2019. Accessed on 29 October 2019: https://www.oati.com/Newsroom/Press-Coverage/hawaiian-electric-oati-plan-wins-approval

[35] Solar Power World, *Sunrun makes solar-plus-storage virtual power plant deal with Hawaiian Electric,* 4 September 2019. Accessed on 29 October 2019: https://www.solarpowerworldonline.com/2019/09/sunrun-solar-plus-storage-virtual-power-plant-hawaii/

Market

- The business case was created for third parties to enter the market and provide system services to the utility grid operators.
- In the context of the increasing amount of asynchronous generation, the establishment of the grid services market puts the value on these services securing their provision in the future.
- The program has been able to provide valuable services to the grid that both adequate reward participants while enabling greater use of renewable energy

DER Roadmap Considerations

Element	Consideration
DSO/DMO Function Set	A transparent network services marketplace may offer an efficient way to unlock the value of Direct Load Control and ensure value flows to DER owners.
DSO/DMO Function Set	Opportunities to unlock value across the cost stack for the DER owner is likely to increase uptake, however, a high level of customer participation is required to precipitate the development of markets. Developing the capability to provide and test services across the fleet will be required in advance of any market 'go live'.
DSO/DMO Function Set	In DER programs, customer acquisition and retention require substantial administrative costs and efforts. Consideration needs to be given to who is the best party to manage those administrative processes.
Data	Customer data ownership and availability requires further consideration, particularly as third-party products and services emerge.
New Business Models	AMI only provides net customer import and export information. It does not assist with understanding of underlying gross demand, and DER generation or usage. While third party meters behind the Western Power meter can provide this information, there are currently limitations on how this is used for billing purposes.
New Business Models	Extensive and transparent consultation and workshops on the development of the Grid Service Agreement aided market awareness and support for the program

32. Value of Distributed Energy Resources Mechanism – New York

Start Date	2017	End Date	On-going
Location	New York, USA	Project Type	Tariff Design

Background Information

- In 2014, the State of New York launched a long-term policy and regulatory initiative *Reforming the Energy Vision* (REV) to modernise its electricity grid and control energy prices.
- The use of net energy metering[36] in New York, while supportive of the uptake of DER, has the effect of valuing customer exports as commensurate to the value of energy provided from the grid - this approach was not seen as enough to accurately assess the true value DER provides to the system.
- In response, New York Public Service Commission (NYPSC) has developed an alternative tariff mechanism for the pricing of energy, to better reflect energy value and additional market and community benefits, including the value of reduced voided energy delivery, transmission and generation costs, and environmental benefits.

Project Objectives

- To develop a framework to quantify all the benefits of distributed energy resources and factor them into customer DER compensation mechanisms.
- To support the overall uptake of DER and support the modernisation of the electricity grid.

Approach

- The NYPSC established a valuation mechanism, which guides utilities in developing their own methodology to calculate DER value.
- The NYPSC then reviewed and approved Value of DER (VDER) mechanisms in 2017.
    - As a consequence, utilities offer varying tariff options consistent with overall objective.
- The 'value stack', used to determine the tariff offered to customers, relies on several components shown in the following table.

[36] Net metering is a billing mechanism that credits solar energy system owners for the electricity they add to the grid. For example, if a residential customer has a PV system on their roof, it may generate more electricity than the home uses during daylight hours. If the home is net-metered, the electricity meter will run backwards to provide a credit against what electricity is consumed at night or other periods when the home's electricity use exceeds the system's output. Customers are only billed for their 'net' energy use. Net Metering is common in the USA, with 41 states imposing net metering. Database of State Incentives for Renewable and Efficiency (DSIRE). Accessed on 29/10/2019, https://www.dsireusa.org/. Differences between state legislation, regulatory decisions and implementation policies mean that the mechanism for compensating solar customers varies widely across the USA

Component	Description
Energy Value	Hourly wholesale energy price.
Capacity Market Value	Monthly independent system operator capacity credit for New York.
Capacity out of market value	The difference between the market value and the total generating capacity payments made to customers as part of the scheme.
Environmental value	Price per kWh determined as the highest amongst two renewable energy standards determined by the US federal government (Tier 1 Renewable Energy Certificate, and Social Cost of Carbon).
Demand reduction value	Compensation based on the DER performance during the 10 highest usage hours, to reflected avoided centralised generation costs.
Locational system relief value	Compensation based on pre-determined rates reflecting the locational demand and generation profiles, and the congestion relief provided.
Market transition credit	Residential customers subscribing to Community Distributed Generation projects receive an additional market transition credit. This component is not available to commercial and industrial community solar customers.

- Utilities are free to determine the Marginal Cost of Service (MCOS) value, which is an estimate for their costs to service customers at different points on the grid. This MCOS is used in the calculation of two components: the Demand Reduction Value (DRV), and the Locational System Relief Value. As such, tariffs offered to consumers vary significantly amongst utilities as service costs differ.

- Unlike net metering mechanisms, VDER has multiple time-varying components, which make tariffs highly volatile. This has consequences on long-term financial certainty, both for individual households, and more importantly for DER community projects.

- The VDER mechanism was rolled out gradually. After the order implementing VDER (in 2017) and until 2020, customers can still subscribe to net energy metering compensation, however they are only able to participate in the program for no more than 20 years.[37]

Progress

- VDER compensation methods have coincided with declines in DER investment, which were estimated to be 73% lower in the first quarter of 2018, compared to the same period in 2017.[38] This led to concerns, and was the foundation for modifications to the program.
    - In June 2018, VDER was placed on hold, and kept net metering in effect for customers subscribing to community solar installations until December 2021.[39]
    - In July 2018, the State of New York Department of Public Service published two whitepapers exploring various amendments to the VDER mechanism.

[37] New York Public Service Commission, *Original Value Stack Order*, August 2017, p. 23. Accessed on 29 October 2019: https://www.nyserda.ny.gov/All-Programs/Programs/NY-Sun/Contractors/Value-of-Distributed-Energy-Resources
[38] PV Magazine, *New York's VDER gets a few tweaks*, 19 April 2019. Accessed on 29 October 2019: https://pv-magazine-usa.com/2019/04/19/new-yorks-vder-gets-a-few-tweaks/
[39] New York State Assembly, *Bill No A10474*, accessed on 29 October 2019: https://nyassembly.gov/leg/?default_fld=%250D%250A&leg_video=&bn=A10474&term=2017&Summary=Y&Actions=Y&Committee%2526nbspVotes=Y&Floor%2526nbspVotes=Y&Text=Y

- The first whitepaper focused on changing the calculation mechanism of the DRV component of the value stack, to reduce tariff volatility and reduce uncertainty for developers.[40]
- The second considered the localisation of Community Distribution Generation projects, which unlike individual households, have some control over the localisation of the project. The paper proposed increases to interim Market Transition Credit values for community solar projects, which should create significantly expanded opportunity for development.[41]

- In April 2019, an order was issued that made key amendments to the VDER mechanism.[42]

Barriers and Critical Lessons

Customer

- The VDER mechanism had the highest impact on larger customers:
  - Net energy metering feed in tariff is a more predictable tariff relative to VDER, which varies significantly over time and is based on location of projects. For larger installations relying on finance, this uncertainty let to higher financing costs and a general reluctance to invest due to uncertainty.
  - For developers with control over project location, VDER is an opportunity to look for the most rewarding points on the grid. VDER has been criticised for inefficiently incentivising such projects to choose locations.

Regulatory

- In New York State, customers cannot choose their utility. The VDER tariff is determined by the utility delivering electricity to the customer's location. Therefore, customers have little control over the VDER tariff they receive, leading to concern if utilities offer highly contrasting tariffs. which led to the April 2019 reform.

Technical

- There has been criticism that compensation mechanisms for DER should be developed with technological advancement in mind and be implemented after critical technology is widespread. Energy storage is still not widely adopted in New York State, and this is a key determinant of customer exports to the grid.

Market

- The value stack approach has attracted criticism as it lacks consideration for small emitting distributed generators. The Environmental Value component of the value stack can be positive when the project starts operations and the generator produces less emissions than centralised systems. However, it can become negative in the future as central electric systems get cleaner over time.

[40] State of New York Department of Public Service, *Draft Staff Whitepaper Regarding VDER Compensation for Avoided Distribution Cost*, 26 July 2018. Accessed on 29 October 2019: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7BBBC76B9F-BCCE-4016-93B0-9BF11B2DB9EB%7D

[41] State of New York Department of Public Service, *Staff Whitepaper on Future Community Distributed Generation Compensation*, 26 July 2018. Accessed on 29 October 2019: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7B4428EBC8-BC3E-46C3-8C11-1B9249FE4350%7D%20

[42] State of New York Public Service Commission, *Order Regarding Value Stack Compensation*, April 2019. Accessed on 29 October 2019: https://www.nyserda.ny.gov/-/media/NYSun/files/Updated-Value-Stack-Order-2019-04-18.pdf

DER Roadmap Considerations

Element	Consideration
Tariff Pilots	The compensation mechanisms for DER should be flexible enough to value additional market and community benefits, while still providing regulatory certainty for larger installations.
Tariff Pilots	Further consideration needs to be given to how incorporate locational and time-varying signals in the DER compensation mechanism without making tariffs highly volatile and uncertain which could act as a barrier to customer uptake.
DSO/DMO Function Set	Market integration, participation, and optimisation capability will take several years to mature. Pilots and trials will be required to test end-to-end operations from market dispatch to DER response.
Distribution Battery Storage	Different DER technologies offer different benefit streams to the electricity supply chain and any compensation methodology will need to have flexibility to recognise these differences.

Summary of Considerations for DER Roadmap

The Roadmap considerations identified for each project in this Stocktake have been consolidated into the table below.

Each consideration has been mapped to a relevant DER Roadmap Element, for ease of reference.

Inverter Standards

Element	Consideration
Inverter Standards	Autonomous functions can be updated through the Western Power *Network Integration Guideline* but require extensive customer and industry engagement. This should be factored into any planned upgrades into the future.
Inverter Standards	Many existing inverters installed in recent years will have now mandatory capabilities sitting dormant within their firmware. It is possible for many existing inverters with this dormant functionality to be retrospectively upgraded, however the costs (including any likely incentives for customers) and effectiveness of this upgrade requires further consideration and scoping.

Distribution Battery Storage

Element	Consideration
Distribution Battery Storage	Broader adoption of network storage requires further assessment of the regulatory framework, ensuring that it does not create barriers to entry for technologies such as electric storage; and all services those technologies are technically capable of providing are valued and could be dispatched.
Distribution Battery Storage	Different DER technologies offer different benefit streams to the electricity supply chain and any compensation methodology will need to have flexibility to recognise these differences.
Distribution Battery Storage	In large numbers, distribution level batteries will have a material impact on system and market operations and need to be integrated into markets effectively. Use of distribution batteries will require clearly defined metering and settlement arrangements.
Distribution Battery Storage	The framework needs to be created to delineate between DER wholesale and retail activities. This helps to ensure that combined revenue streams do not result in a resource receiving uncompetitive financial incentives akin to a ‘double payment’ for providing the same service.
Distribution Battery Storage	The metering and settlement requirements as well as customer protections for third party models requires further consideration.
Distribution Battery Storage	The use of distribution network storage is an effective model for delivering network benefits whilst providing for broader benefits within the value chain. Whilst Western Power cannot participate in energy markets directly, the ability for others, such as retailers, to utilise the storage for portfolio benefits or innovative customer products is critical in ensuring the business case is positive.
Distribution Battery Storage	The value of the services provided by a network battery to Western Power as well as any system wide benefits are not well understood. A DER valuation methodology would provide much greater investment certainty for Western Power and other parties seeking to provide similar services.

DER Orchestration Pilot

Element	Consideration
DER Orchestration Pilot	Connectivity through the Western Power AMI mesh network may facilitate cheaper and more reliable data transfer. DER Orchestration Pilots should explore and/or test this potential opportunity, recognising likely limitations on infrastructure capability and cyber-security implications.
DER Orchestration Pilot	DER management capability is dependent on the demonstrated capability of DER to respond in a timely and accurate way. The development of DER Management Use Cases for the SWIS should be explicitly included in future DER Orchestration Pilots and trials.
DER Orchestration Pilot	Due to the fast response required in isolated microgrids, communications infrastructure used by Horizon Power may be over-specified relative to the needs of a larger system such as the SWIS. Definition and testing of DER response and latency requirements within the SWIS should be explicitly included in future DER Orchestration Pilots and trials.
DER Orchestration Pilot	Further consideration is required for how more sophisticated VPP capability and automation solutions impact customers participating in VPPs, and in dispatch approaches under the DSO/DMO Function Set.
DER Orchestration Pilot	Potential opportunity to use Western Power's radio mesh network for cheaper and more reliable control communications and data transfer.
DER Orchestration Pilot	The contracting and settlement requirements as well as customer protections for VPP providers requires further consideration. The costs and benefits of establishing the ability for customers to contract with other parties requires assessment against a retailer-led approach for VPPs.
DER Orchestration Pilot	The demonstrated technological capability of DER to respond in a timely and accurate way to operator is yet to be fully demonstrated. The development of DER Management Use Cases for the SWIS should be explicitly included in future DER Orchestration Pilots and trials.
DER Orchestration Pilot	The development of DER Management Use Cases was critical to informing the required technical outputs of installed DERs (for example, validating frequency support capability of installed DER). The development of DER Management Use Cases for the SWIS should be explicitly included in future DER Orchestration Pilots and trials.
DER Orchestration Pilot	The unit costs for appliance control is reducing with improvements in both the cost and ease of installation of control devices. Over time, these assets could provide aggregated services, including localised distribution network services. Aggregation of such devices should be considered in the development of DER aggregator registration and accreditation requirements and market participation opportunities (including market participation pilots and trials).
DER Orchestration Pilot	VPP market participation work will have to consider how embedded networks might integrate and participate in energy and ESS markets, acknowledging the 'single connection point' nature of the embedded network with multiple DERs behind it.
DER Orchestration Pilot	VPP technology dispatching behind-the-meter will not be explicitly visible at the metering point. As such, validation of the DER response via a VPP, and all associated data collection, transfer and settlement requirements will require further consideration. Requirements for telemetry data from the DER directly will need to be established to underpin wholesale market participation and compensation.

Element	Consideration
DER Orchestration Pilot	Considerations for energy trading could include DER integration with essential system services markets and consideration of time-based or dynamic network pricing based on location and peak periods.

Grid Response

Element	Consideration
Grid Response	The economic regulation of Western Power's network planning approaches such as use of the GTEng to support decision making is uncertain and may require further assessment and reform of the economic regulation process.
Grid Response	Changes to nominal voltage and ranges under the Electricity Act 1945 may reduce the urgency and value of OLTC program expansion.
Grid Response	Development of the GTEng is likely to impact investment decisions in network infrastructure or pursuit of non-network solutions. Facilitation of net market benefits capability within the GTEng requires further scoping.
Grid Response	Hosting capacity on the LV networks are strongly linked to voltage limits, and provide a key limitation to the uptake of DER. This is likely to manifest as a material issue as the saturation of local networks increases. An expanded compliance range and associated operational procedures would provide for expanded hosting capacity.
Grid Response	Investment decisions regarding voltage management, distribution transformer tap changes and other network infrastructure will likely change following the implementation of any voltage standard change.
Grid Response	The full recovery of advanced meters and communications infrastructure was not approved for the current Western Power Access Arrangement period (AA4) and was funded instead by the State Government.
Grid Response	Future rollout of advanced metering beyond Western Power's current Access Arrangement will require review and possible amendment of the Electricity Networks Access Code.
Grid Response	The supplementary benefits of OLTC functionality, such as maximising solar hosting capacity, for Western Power's power quality program will require modelling and validation to support wider rollout under the existing regulatory regime.
Grid Response	Ensuring that Western Power is able to actively integrate VPPs into its network operations will be important to maximise the benefits.

Network Investment Process

Element	Consideration
Network Investment Process	Community storage initiatives rely on multiple revenue streams to be cost-effective, including providing network services where a network need is identified. Regulatory requirements for publishing network opportunity maps and valuing the services the battery can provide the network would help underpin business cases for the future deployment of BESS.
Network Investment Process	The assessment of the value and costs of non-network solutions requires further consideration, particularly for early projects being undertaken prior to the development of organisational capability and systems.

Element	Consideration
Network Investment Process	The economic regulation of Western Power's network investment may lead to uncertainty in the recovery of non-network solutions costs, where network needs do not emerge as forecast. This may require further assessment and reform of the economic regulation process.

Planning for Electric Vehicle Integration

Element	Consideration
Electric Vehicle Integration	Acceleration of EV uptake is beneficial for customers, GTEs and the State. Incentivising charging at times of high solar generation may maximise this benefit.
Electric Vehicle Integration	Advanced capabilities emerging on new chargers and work undertaken as part of AS4755 will assist with allowing dynamic management and load management. Vehicle-to-grid (V2G) capability, while still in its infancy, is emerging and needs to be considered as part of planning.
Electric Vehicle Integration	Public charging facilities do not currently cater for V2G. This may change in the future.
Electric Vehicle Integration	There are multiple charging plug configurations in use by EVs internationally and no Australian standard in place.
Electric Vehicle Integration	Understanding how customers use EV charging stations will inform wider deployment of the facilities and planning by Western Power for likely locations of new installations.

System Operations

Element	Consideration
System Operations	AEMO will need to have up to date information on DER capabilities to ensure the best possible system modelling. Any program that upgrades installed DER capability will need to incorporate communication with AEMO.
System Operations	Consideration will need to be given to how large microgrids and embedded networks with high levels of DER participate in system restart arrangements and how they are modelled.
System Operations	DER integration and participation at both wholesale and distribution level may raise operational challenges for the system operator. Specifically, it may be challenging to maintain system operator's situational awareness and operational visibility of DER so that the operator can correctly reflect DER output and availability in its security analysis and dispatch processes.

Tariff Pilots

Element	Consideration
Tariff Pilots	Government programs can overcome split incentives for DER installation in rental arrangements and allow landlords and tenants to both benefit from DER.
Tariff Pilots	Tariff structures that are not cost reflective allow cross-subsidisation between different consumer groups, thereby pushing costs generated by one consumer group onto remaining customers.

Element	Consideration
Tariff Pilots	The tariff targets night-time periods for Electric Vehicle charging. It would be beneficial to trial an alternate tariff structure providing incentives to charge during low daytime demand hours, as a mechanism to mitigate system security risks that emerge from high solar generation conditions and low daytime loads.
Tariff Pilots	Customers have shown an ability and willingness to change their consumption profile in response to the price signal from time-of-use tariffs.
Tariff Pilots	Changes in underlying tariff structure, including increases in fixed daily supply charge, have material impacts on the vulnerable customer cohort. Complimentary schemes to review and assist vulnerable customers are critical alongside tariff structure changes.
Tariff Pilots	Existing premium feed in tariff compensation payments for DER could act as a barrier for storage adoption.
Tariff Pilots	Further consideration needs to be given to how incorporate locational and time-varying signals in the DER compensation mechanism without making tariffs highly volatile and uncertain which could act as a barrier to customer uptake.
Tariff Pilots	Further consideration needs to be given to how virtual storage products can be included in retail products, including the possibility for mandatory storage products to be provided for customers with solar PV only systems, to mitigate grid impacts
Tariff Pilots	Implementation was not only dependent on AMI but may require additional investment beyond the standard AMI capability (due to higher data flows). This is likely to be a major limiting factor in the SWIS in the near term.
Tariff Pilots	MyPower provides a demonstrated case where tariffs can be brought into line with underlying costs. As a result of this, the tariff signals customer behaviour and DER investment that benefits both the customer and the system, as well as provides for revenue certainty for Horizon Power.
Tariff Pilots	MyPower specifically targeted the summer peak, incentivising both load reduction and load shifting during summer months. Consideration of how the price signal would be designed to incentivise load shifting during critical system low months (typically during spring and autumn) as well as areas with both winter and summer peaking profiles will be required.
Tariff Pilots	New business models that utilise customer DER may extract value from tariff structures that are not cost reflective, thereby pushing costs onto remaining customers.
Tariff Pilots	P2P trading currently relies on settling of P2P transactions within the retailer portfolio (off-market). This would limit P2P to customers of single retailers. To enable multi-retailer transactions, amendments to the Retail Market Operations framework including the Market Settlement and Transfer Solutions (MSATS) procedures and development of multiple trading relationships settings would be required.
Tariff Pilots	The AMI deployment will deliver a minimum of 238,000 metering installations to June 2022, representing approximately 20% of the customer base. Tariff approaches that are dependent on interval data will require alignment with the AMI deployment profile, or consideration of any additional costs for tariff approaches that drive additional metering installations.
Tariff Pilots	The compensation mechanisms for DER should be flexible enough to value additional market and community benefits, while still providing regulatory certainty for larger installations.
Tariff Pilots	The development of innovative retail products including real-time and/or daily energy use feedback to consumers relies on interval data derived from AMI.

Element	Consideration
Tariff Pilots	The MyPower tariff structure incentivises solar PV plus battery storage uptake over solar PV-only installations. Customers who have recently installed solar, or those seeking to install solar only systems, will experience significantly lengthier payback periods under the MyPower tariff structure than under existing tariffs.
Tariff Pilots	The use of community batteries for retail customer offerings requires further consideration of the incorporation of new tariff structures, including time-of-use tariffs. The cost-reflectivity of these tariffs, and discrepancies between tariffs charged to non-participants have implications for equity.
Tariff Pilots	The use of time-of-use tariffs (and theoretically, other tariff structures) can enhance the customer value proposition for additional innovative energy service offerings. This is particularly relevant where automation (e.g. in the operation of the community battery) and behaviour change can be used to flatten load profiles and increase network utilisation.
Tariff Pilots	MyPower remains a complex tariff arrangement for consumers and is dependent on real-time feedback to customers triggering a response to reduce peak demand. Tariff pilots should consider complexity of deployment at a larger scale relative to other design options.
Tariff Pilots,	Tariff changes leading to cost reflective pricing (including the REBS rate) would be required if solar P2P trading is to be attractive and have the possibility of delivering the system scaled benefits on the SWIS.
Tariff Pilots	Where a default buyback scheme is in place, P2P market prices do not appear to drive any further financial value to customers. Enabling opportunities for DER to provide enhanced services to the market (including essential system services) is likely to provide for better outcomes for all customers. P2P trading may be more relevant if tariff changes (including to the REBS rate), leads to cost reflective pricing.
Tariff Pilots	WHP looks at the potential of a lower cost of network infrastructure in the future with the co-location of generation with consumption in rural areas, e.g. reduction of future transmission and distribution network usage and costs, reflected in the tariff structure. Further work will need to be done to evaluate these results for WHP against the weighted average costs across the network. In addition, the P2P trading platform has proven a way to socialise new tariff structures with customers.
Tariff Pilots	In future reviews, it would be helpful to look at a tariff structures that may reflect the reduction of future network augmentation costs (e.g deferred substation upgrades, potential reduced size infrastructure on replacement) and recognising the impact co-location of generation and consumption at these strata developments can have on network costs in that area. In addition, this approach could be enhanced by the trading of energy between buildings located in close proximity with appropriate network charging regimes.

Distribution Network and Visibility

Element	Consideration
Distribution Network and Visibility	Greater network visibility could facilitate the aggregation of DER in the future. There could be appropriate software tools and network interface which could help parties to understand and model the value of DER by different locations.

Element	Consideration
Distribution Network and Visibility	Greater network visibility could facilitate the deployment of this solution in other locations, facilitating reliability improvements at minimal cost.
Distribution Network and Visibility	The development of the GTEng will have implications for future visibility requirements and may supersede other visibility improvements. Development of Distribution Visibility Requirements and Strategy documentation outlining requirements and existing capabilities across the entire distribution network is necessary to ensure efficient investment.
Distribution Network and Visibility	The nature of outages at Perenjori made it suitable for the use of a BESS – improved visibility of the distribution network will facilitate better understanding of the benefits of BESS in other locations on the distribution network, and will facilitate more efficient, targeted infrastructure investment.
Distribution Network and Visibility	Visibility facilitates better targeted investment to manage voltage issues, allowing for continued DER uptake. OLTC provides visibility of electrical quantities (such as active and reactive power flows, and current) through the transformer, which facilitates better network management.

DSO/DMO Function Set

Element	Consideration
DSO/DMO Function Set	A transparent network services marketplace may offer an efficient way to unlock the value of Direct Load Control and ensure value flows to DER owners.
DSO/DMO Function Set	Customer contracting arrangements need to be considered in light of the longer-term DSO interactions and likelihood of dispatch and curtailment of customer DER. Dynamic connection agreements require development, and interaction with existing customer contracts (supply contract, REBS contract) should be considered, and where appropriate, duplication removed.
DSO/DMO Function Set	Further consideration needs to be given to the potential proliferation of embedded networks, including consequences for DSO, DMO and the role of the network service provider.
DSO/DMO Function Set	In DER programs, customer acquisition and retention require substantial administrative costs and efforts. Consideration needs to be given to who is the best party to manage those administrative processes.
DSO/DMO Function Set	Management of islanded microgrids needs to be considered as part of DSO/DMO functions and capabilities. Specific requirements and procedures may need to be developed for these scenarios.
DSO/DMO Function Set	Market integration, participation, and optimisation capability will take several years to mature. Pilots and trials will be required to test end-to-end operations from market dispatch to DER response.
DSO/DMO Function Set	Opportunities to unlock value across the cost stack for the DER owner (such as through a DMO) is likely to increase uptake, however, a high level of customer participation is required to precipitate the development of markets. Developing the capability to provide and test services across the fleet will be required in advance of any market ‘go live’.
DSO/DMO Function Set	Opportunities to unlock value across the cost stack for the DER owner is likely to increase uptake, however, a high level of customer participation is required to

Element	Consideration
	precipitate the development of markets. Developing the capability to provide and test services across the fleet will be required in advance of any market 'go live'.
DSO/DMO Function Set	Participation of customers and aggregators or VPPs is critical to the development of a DSO. Consistency in the approach to interoperability standards for DER vendors to integrate with DERMS providers will be required at a national level.
DSO/DMO Function Set	The outcomes of the Carnarvon trial will inform how the DSO may interact with individual customer DER, and identify other prerequisites for the establishment of DSO, such as enabling technology.
DSO/DMO Function Set	There are no evident single providers currently able to supply the suite of functions required for a DSO – the development of a DSO is likely to require time for the vendor market to mature, and leverage hybrid solutions of multiple specialised services.
DSO/DMO Function Set	Understanding how distribution connected storage participates under DSO/DMO needs further work.

Data

Element	Consideration
Data	Customer data ownership and availability requires further consideration, particularly as third-party products and services emerge.
Data	Measurement and verification requirements are important but must be reasonable to not to act as a barrier for DER to enter the wholesale markets.
Data	Any P2P arrangements will need to adhere to minimum consumer data protections.

New Business Models

Element	Consideration
New Business Models	Consideration needs to be given to whether customers with DER be required to have a default aggregator or VPP, through which the DSO issues dispatch instructions.
New Business Models	The dynamic management of distribution network capacity is a key requirement to unlock the full value of VPPs and other distributed energy resources. Real-time and locational data on distribution network constraints should be shared with load aggregators to optimise their output.
New Business Models	AMI only provides net customer import and export information. It does not assist with understanding of underlying gross demand, and DER generation or usage. While third party meters behind the Western Power meter can provide this information, there are currently limitations on how this is used for billing purposes.
New Business Models	Customer protections and licencing arrangements require further consideration for embedded network projects.
New Business Models	Ensuring customer protections are maintained under future business models that incorporate community batteries warrants further consideration.
New Business Models	Extensive and transparent consultation and workshops on the development of the Grid Service Agreement aided market awareness and support for the program
New Business Models	New billing arrangements offer a path to DER-based bill reduction for customers in affordable housing areas but have implications for customer protections and

Element	Consideration
	requirements from licencing frameworks. For example, consideration of data measurement and validation under new business models requires consideration.
New Business Models	Where P2P arrangements make commercial sense, consideration needs to be given to ensure that market costs are passed through and consumer protections are retained.
New Business Models	New arrangements allow owner-occupiers and renters (who pay their energy bill to the strata) to share in the benefits of DER. This approach overcomes the split incentive problem by allowing owners to recover the investment costs and provides tenants access to lower cost energy bills. Hybrid ownership models for energy assets which are part-owned via the body corporate and third parties, could encourage developers to include DER by lowering the capital cost.

Customer Engagement

Element	Consideration
Customer Engagement	Active engagement with customers regarding DER technologies, including addressing safety, operation and compensation issues, was found to be beneficial.
Customer Engagement	Customer offerings, such as real-time or near real-time visibility of usage and prices, and monthly billing, as well as broad-based education are extremely important complimentary measures to support tariff changes. This is particularly relevant when customer bills increase.
Customer Engagement	Customers who are made aware of the hosting capacity limitations of the network display some willingness to have their DER orchestrated in order to receive benefits from DER. Broad-based education of the impacts of solar PV on electricity supply have set expectations in Carnarvon (see below) and Onslow.
Customer Engagement	Despite receiving notifications requesting that customers reduce consumption, customers were not observed to change their behaviour – the use of incentives or expanded customer education programs may deliver improved outcomes.
Customer Engagement	Potential changes to the voltage standard may require communications and education that alleviate customer concerns about appliance performance.
Customer Engagement	The P2P concept may not create any additional value – it provides for value exchange, which may transfer costs between parties. Customers require education on the costs underpinning tariffs (the value stack) including the value of their excess solar generation.
Customer Engagement	This project has shown that there is strong customer engagement with P2P trading, for both prosumers and consumers, as a way of monetising their investments, increasing energy reliability and driving cost savings on energy bills.
Customer Engagement	Participants highlighted during the information sessions held that they did not have a good understanding of how their current A1 charges are constructed. Customers stand a greater prospect of financially benefiting from P2P trading if they change their consumption to times of solar generation. Further research to determine whether and how P2P can encourage behaviour change may define education programs that will support customer behaviour change.

Element	Consideration
Engagement	The project shows how solar and storage in commercial and residential strata developments can be viable and can be set up and managed. Property developers and councils may benefit from information on how this may assist in getting marginally viable sites out of the ground, i.e. reducing headworks costs due to solar storage systems, and achieving renewable energy and sustainability targets within local government authorities. Property developers may benefit to understand how this can be done from a practical perspective.

Glossary

Term	Definition
AA4	Western Power Access Arrangement 4, for the period 2017-2022.
AEMO	Australian Energy Market Operator
AMI	Advanced Metering Infrastructure AMI typically includes smart meters (that measure bidirectional energy flows, in shorter time intervals), upgraded communications networks (to transmit large volumes of data), and requisite data management systems.
ARENA	Australian Renewable Energy Agency
AS/NZS 4755.3:2016	Australian Standard AS 4755 – Demand response capabilities and supporting technologies for electrical products. This Standard details requirements of Demand Response Modes for Energy Storage Systems (AS/NZS 4755.3) and the requirements for Demand Response Enabling Devices (AS/NZS 4755.6).
AS/NZS 4777.2:2015	Australian Standard AS 4777 – Grid Connection of Energy Systems via Inverters. This Standard specifies the electrical installation requirements (AS4777.1) and the inverter performance requirements (AS4777.2) for inverters connected to the electricity distribution network.
BESS	Battery Energy Storage System
Behind-the-meter	Any technology located on the customer's side of the customer-network meter.
Contestable Customers	Customers that consume greater than 50MWh of electricity per annum, who can choose their electricity retailer.
DER	Distributed energy resources, or 'DER', are smaller–scale devices that can either use, generate, or store electricity and form a part of the local distribution system, which serves homes and businesses. DER can include renewable generation, energy storage, electric vehicles (EVs), and technology to manage load at the premises. These resources operate for the purpose of supplying all or a portion of the customer's electric load and may also be capable of supplying power into the system or alternatively providing a load management service for customers.
DERMS	Distributed Energy Resource Management System The software or platform which facilitates the coordination of DER. DERMS can receive information and send instructions to DER, which can enable load and voltage management.
DLC	Direct Load Control
DMO	Distribution Market Operator The function of a distribution level market operator, as distinct to the wholesale market operator.
DSO	Distribution System Operator: • A Distribution System Operator (DSO) enables access to the network, securely operates and develops an active distribution system comprising networks, demand, and other flexible distributed energy resources (DER).

	• Expanding of the network planning and asset management function of a DNSP, the DSO enables the optimal use of DER on distribution networks to deliver security, sustainability and affordability in the support of whole system optimisation.
ESS	Essential System Services, formerly known as Ancillary Services
EV	Electric Vehicle
FIT	Feed-in Tariff The Western Australian State Government offered eligible customers a subsidy of up to 40 cents per kWh of excess solar energy exported back to the grid. The scheme was open to applications from 1 July 2010 to 1 August 2011 and was offered for 10 years.
Front-of-the-meter	Any infrastructure located on the distribution network side of the customer meter (i.e. not behind-the-meter)
Microgrid	Small-scale power grids that can either operate independently of a main electricity network or complement it to improve reliability.
NFIT	New Facilities Investment Test
Non-contestable Customers	Non-contestable customers are those who consume 50MWh or less of electricity per annum and includes most residential households and small businesses in Western Australia. In the SWIS, only Synergy can supply non-contestable customers.
NSP	Network Service Provider
OLTC	On Load Tap Changer
PPA	Power Purchase Agreement
P2P	Peer-to-Peer
REBS	Renewable Energy Buyback Scheme
Solar PV	Solar photovoltaic generation systems
SWIS	South West Interconnected System
Time-of-use tariff	A retail tariff structure that includes different variable charges for energy depending on the time of day the energy is consumed by the customer.
VPP	Virtual Power Plant VPPs are the notional entities comprised of aggregated and controlled DER components, which can provide generation and system support functions, and participate in energy markets (like traditional generators).
V2G	Vehicle-to-grid An electric vehicle to grid system allows an electric vehicle to send power (i.e. discharge its battery) to the grid or to control charging of its battery in response to changing grid conditions.