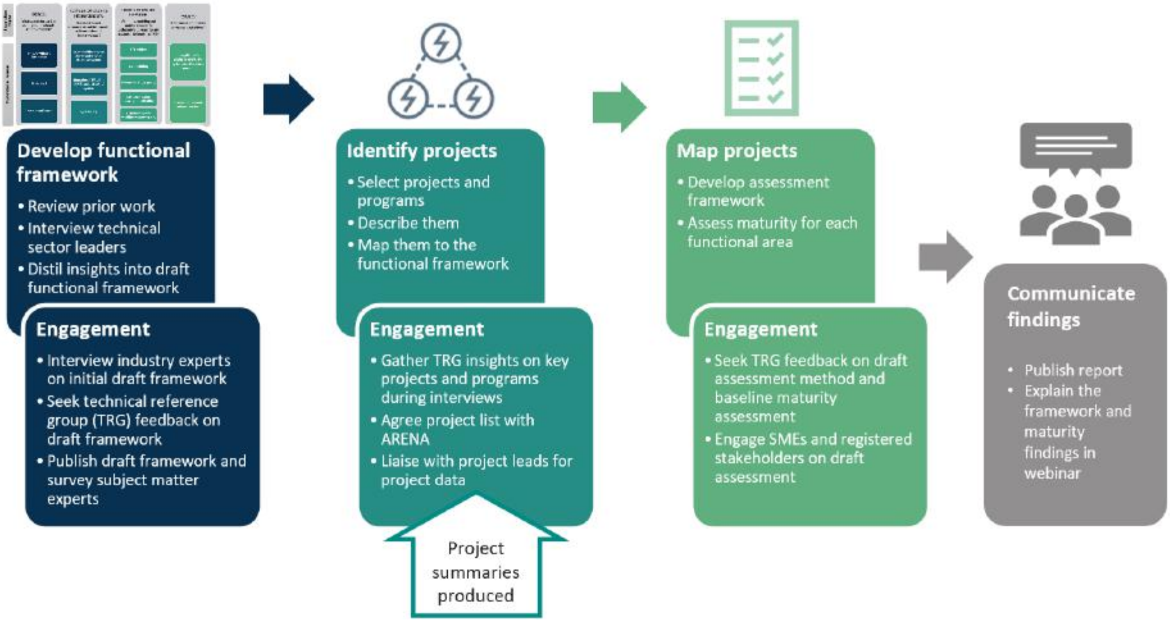
STATE OF DER TECHNICAL INTEGRATION: PROJECT SUMMARIES

Part One: Document Overview

Project context | The Australian Renewable Energy Agency (ARENA) is working with farrierswier and GridWise Energy Solutions to develop a State of Distributed Energy Resources (DER) Technology Integration Report. This project will create a functional framework for DER technology integration, that will be used to conduct a maturity assessment. It will then prepare a baseline report to better understand the contributions made towards DER technology integration by current and recent ARENA and non-ARENA projects, programs and trials. This technical integration focus will recognise but exclude the analysis of broader market, grid and customer regulation projects already being considered by other parties.

Purpose of project summaries| The project templates in this paper collate data across the chosen DER integration projects, programs and trials. This data will enable farrierswier and GridWise Energy Solutions to prepare a baseline DER technology integration maturity assessment for each of the functional areas identified in the functional framework.

Role in the project approach | This figure illustrates how these summaries fit within the project.



How these templates were prepared | The information in the project templates was provided by the contact for each project. It has not been verified by, and does not necessarily represent the views of, farrierswier, GridWise Energy Solutions or ARENA. Material changes to the information provided were only made with the agreement of the project contact.

Navigating this document | This document comprises a summary table giving a brief description of each project and a page link to the corresponding project template, and a project template for each project. The project templates set out the:

- project summary
- key project deliverables
- key project innovation
- project timing and progress
- project functional scope (giving a mapping to the functional framework)
- next steps and constraints or impediments to BAU adoption
- project partners, relationship to other projects
- links to further project information.

Part Two: Table of Projects

The information in the attached project templates was provided by the contact for each project. It has not been verified by, and does not necessarily represent the views of, farrierswier, GridWise Energy Solutions or ARENA. Material changes to the information provided were only made with the agreement of the project contact.

Project name and lead organisation	Summary of the project	Page
Addressing barriers to efficient renewable integration Lead organisation: UNSW	The project will focus on the assessment of inverter performance and modelling related to frequency control, ancillary services, and electricity market rules/operating procedures. By using bench testing, UNSW will directly test the response of a range of PV and storage inverters to disturbances of different kinds on the network. In addition, the installation of high-speed disturbance recorders on key distribution network feeders will monitor and record behaviour during power system disturbances. Results from this will provide detailed information that can be used to develop a "composite PV-load model". This model can be used by AEMO and TNSPs to more accurately represent the behaviour of load with embedded PV. This model is critical for all system security studies, including determining network stability limits, and frequency control requirements.	15
Advanced Planning of PV-Rich Distribution Networks Study Lead organisation: University of Melbourne	This project will develop analytical techniques to assess the residential solar PV hosting capacity of electricity distribution networks by leveraging existing network and customer data. This project will also produce planning recommendations to increase solar PV hosting capacity using non-traditional solutions that exploit the capabilities of PV inverters, voltage regulation devices, and battery energy storage systems.	19
Advanced VPP grid integration Lead organisation: SA Power Networks	The project aims to show how higher levels of energy exports to the grid from customer solar and battery systems can be enabled through dynamic, rather than fixed, export limits, and to test the value this can create for customers and VPP operators. The Project has implemented an interface (API) to exchange real-time and locational data on distribution network constraints ('operating envelopes') between SAPN and the Tesla SA VPP, enabling the VPP to optimise its output to make use of available network capacity.	23
AGL Virtual Power Plant Lead organisation: AGL	The AGL VPP is installing and connecting behind the meter (BTM) solar battery storage systems across 1,000 residential premises in Adelaide, to be managed by a cloud-based control system. The batteries will be able to 'talk' to each other through a cloud-based platform using smart controls, forming a connected system that will be able to operate as a 5MW solar power plant. The primary aim of the project from a knowledge sharing perspective is to understand the various value pools that BTM batteries are able to access, and what barriers may exist to their realisation.	27

Project name and lead organisation	Summary of the project	Page
Battery storage system performance standard Lead organisation: DNV GL	The objective of this project is to produce a draft performance standard for Battery Energy Storage Systems (BESS) connected to domestic/small commercial PV systems. The draft standard will comprise a series of performance testing protocols and performance-metric reporting methods for manufacturers and system integrators. This is to ensure that end users are better informed regarding the expected performance of a BESS in order to compare systems on a like-for-like basis. The draft standard will be submitted to Standards Australia.	31
Closed loop voltage control trial Lead organisation: SA Power Networks	The project is establishing voltage control techniques at zone substations to boost network hosting capacity and provide demand response services. A key goal is to determine whether closed-loop substation voltage control, which has been demonstrated successfully in Victoria, can be achieved in other states without access to ubiquitous smart meter data. The scope includes establishing capabilities to optimise network voltage by automatically controlling substation tap positions to deliver an efficient solution to increase network hosting capacity for large numbers of customers and establish capabilities that will unlock voltage-optimisation based demand management on SAPN's network. It will also demonstrate how network visibility can be enhanced by combining data from a variety of distributed data sources with data science.	34
Consumer Energy Systems Providing Cost-Effective Grid Support (CONSORT) Lead organisation: ANU	The CONSORT Bruny Island Battery Trial successfully developed and demonstrated an innovative automated control platform that enables consumers with battery systems to provide support to a constrained electricity network. At the heart of CONSORT is a platform called Network Aware Coordination (NAC). The NAC's primary task is to automatically coordinate household energy systems (in a non-intrusive way) enabling them to adhere to and alleviate network constraints. DER owners are automatically and fairly rewarded for the support they provide.	38
Decentralised Energy Exchange (deX) Program Lead organisation: Greensync	Decentralised Energy Exchange (deX) is a market-enabling digital platform that aims to provide electricity networks with better coordination and control of the increasing volume of DER in the electricity grid. deX also aims to enable consumers to get more value from their DER assets by being rewarded for participating in grid services. deX forms the layer between DER and the grid through Application Programming Interfaces (APIs). It aims to allow technology manufacturers and other platform owners to integrate their technology with deX so that consumers can register their DER. Retailers and network operators will then be able to view, coordinate and contract available DER for a variety of energy services.	41

Project name and lead organisation	Summary of the project	Page
DER impact on bulk power system operations Lead organisation: AEMO	This is an ongoing program of work focussed on the bulk power system implications of increasing DER uptake – when challenges may emerge, how these challenges might be addressed and, where necessary, mitigation measures. As penetrations increase, the aggregated impact of this fleet affects almost all core duties of the bulk system operator in some way due to performance during disturbances, ongoing reduction in the daytime system load profile, an increasingly large source of renewable generation, and an increasingly large source of generation that cannot be curtailed. The current focus, given high levels of penetration in the NEM and SWIS today, is on passive distributed PV (DPV). Work to date has mainly centred on the South Australian region given its high share of DPV generation relative to local underlying demand, and weak interconnection with the NEM – with other regions to follow. Similar work was undertaken for the South-West Interconnected System in 2019.	59
DER Integration and Automation Lead organisation: Evoenergy	The project will demonstrate how collaboration between a Distributed Energy Resources Management System (DERMS) and the GreenSync Decentralised Energy Exchange (deX) platform can unlock existing network hosting capacity to enable consumers to gain more value from their energy assets (such as solar, batteries and electric vehicles).	63
DER Integration API Technical Working Group Lead organisation: ANU	The DER Integration API Technical Working Group is comprised of organisations actively developing DER integration capabilities. These organisations are pursuing this initiative to support the development and implementation of an industry standard application programming interface (API) for programmatically sharing data amongst the organisations in the Australian electricity sector. One key output will be an agreement on the use cases for DER Integration, including who generates what data, with what specifications and who needs access to that data. The other key output will be an agreed API specification, allowing data to be programmatically transferred between parties.	66
DER Visibility and Monitoring Best Practice Guide Lead organisation: Solar Analytics as contact for industry working group	The Best Practice Guide has been developed by the DER industry to specify the data required to enable the transition of our electricity network to a high penetration DER grid. The guide aims to establish a common static and dynamic (near) real time data set collected for new DER installed behind the meter on the low voltage electricity network. It also aims to increase confidence in the quality and performance of DER through the provision of this real time system performance data to DER owners and authorised industry entities.	69

Project name and lead organisation	Summary of the project	Page
Digital Grid Futures Institute Lead organisation: UNSW	The UNSW Digital Grid Futures Institute brings together UNSW's researchers and major partners across industry, government, research institutions and the community to advance the blueprint for future energy systems globally. The Institute is undertaking a range of research on DER technology integration issues including microgrids, VPPs, the smart meter and home appliances testing lab, peer to peer trading, smart home energy management and the real time digital simulator lab.	72
Dynamic Limits DER Feasibility Study Lead organisation: Dynamic Limits	The study explored implementing dynamic operating envelopes for DER to better manage voltage and thermal constraints on electricity networks. The study examined existing approaches to managing network capacity constraints, investigated the general technical feasibility of implementing a dynamic DER control scheme, and undertook a site-specific analysis, examining implementation on feeders experiencing constraints. The focus was on the management of local network constraints so that the hosting capacity of electricity networks is unlocked, further enabling DER orchestration activities.	75
Enel X Demand response project Lead organisation: Enel X	Enel X (formerly EnerNOC) will develop a 50 MW portfolio (30 MW in VIC and 20 MW in NSW) to be used as dispatchable short notice Reliability and Emergency Reserve Trader (RERT) reserves by AEMO. The portfolio will primarily consist of Commercial & Industrial customers and the reserve provided will be from load curtailment. Enel X has installed its own metering technology (Enel X Site Server) at customer sites and will use these meters to monitor site load and remotely initiate a safe load reduction for dispatch events. Enel X customers are capable of implementing load curtailment within 10 minutes of receiving dispatch instructions from Enel X.	78
EnergyAustralia Demand Response Program Lead organisation: EnergyAustralia	The program involves the deployment of up to 20MW of demand response (DR) in NSW and 30 MW in VIC/SA. During times of critically low reserves, AEMO will call upon EnergyAustralia to deliver the reserve capacity through a combination of direct load control and behavioural demand response. EnergyAustralia is working with household, commercial and industrial customers to deliver reserve capacity. This includes emerging DR mechanisms, such as voluntary behavioural demand response, direct load control, and on-site generation and battery storage.	84

Project name and lead organisation	Summary of the project	Page
Energy Under Control Lead organisation: Flow Power	The project involves the rollout of Flow Power's kWatch® Intelligent Controller. The Controller gives customers live data feeds, alerts and integration of onsite equipment. The Controller allows participating businesses to reduce their demand in minutes when Flow Power is called on by AEMO under the Short Notice RERT. By providing SMS and email alerts, the kWatch® Intelligent Controller gives Flow Power a clear and fast communication channel with participants, who receive participation payments in addition to a revenue stream if they are called upon to shift power use. Customers have the choice to integrate equipment with the Controller, meaning the customer could control energy intensive equipment from the kWatch® portal.	87
Enhanced Reliability through Short Term Resolution Data around Voltage Disturbances Lead organisation: Solar Analytics	Increased penetration of DER are leaving power system operations vulnerable to the operating behaviour of a multitude of diverse, distributed generators. AEMO has identified a need for short time resolution data around voltage disturbances to understand DER behaviour and improve dynamic modelling. Solar Analytics will work with AEMO and Wattwatchers to develop automated data acquisition and delivery. The project aims to increase visibility and improve modelling capability in a world-first analysis of individual load and generator responses in the event of short time resolution voltage disturbances.	89
Evolve DER project Lead organisation: Zeppelin Bend	The project aims to increase the network hosting capacity of DER by maximising their participation in energy, ancillary and network service markets, while ensuring the secure technical limits of the electricity networks are not breached. The project has a strong focus on the development of working software systems that will be integrated with the operational technologies used by distribution networks, and the systems used by aggregators to manage DER under their control. Through multiple demonstrations and trials in NSW and Queensland, the project will develop new algorithms and capabilities to identify and ease congestion within the distribution network. This will be achieved through the calculation and publication of operating envelopes for all DER connected to the distribution network.	93
Expanded Network Visibility Initiative (ENVI) Lead organisation: GridQube	This initiative expands the use technology developed and demonstrated in the ARENA project "Increasing Visibility of Distribution Networks" to the entire distribution network of Queensland. At its heart sits a novel Distribution System State Estimation algorithm that draws on multiple different data sources (network asset registers, SCADA, distribution transformer monitors, AMI, premise-level measurements and statistical network usage data) to provide complete network visibility from zone substations down to every customer connection point in the network.	98

Project name and lead organisation	Summary of the project	Page
Indra Monash Smart Microgrid Project Lead organisations: Indra and Monash University	The Indra Monash Smart City will demonstrate how smart and renewable technologies can be integrated at the Monash University Clayton embedded network to maintain power quality and test market driven responses and business models. Indra's Active Grid Management platform will provide real-time monitoring and control over the grid-connected assets, and a Transactive Energy Market is being developed to orchestrate DER in response to market signals and constraints to add value to customers, market participants and the electricity grid.	103
Intelligent Switchgear Lead organisation: NOJA Power	The project aims to reduce the complexity and cost of connecting renewables to the grid and increase the hosting capacity of distribution networks by developing, demonstrating and industrialising an economical intelligent switchgear. This device can capture high-resolution real-time network data and can provide protection, control, and monitoring solutions to facilitate the connection of renewables to the grid. The Intelligent Switchgear and trial deployments will generate significantly more granular power system data than is currently available and will help improve the visibility and modelling of the power system.	107
My Energy Marketplace Lead organisation: Wattwatchers Digital Energy	Wattwatchers aims to build, operate and deploy the 'My Energy Marketplace' (MEM), a consumer-facing energy data platform, designed to securely collect, process and productise vast amounts of energy data. The MEM will deploy smart energy management solutions to 5,000 homes and small businesses plus 250 schools. It will enable consumers to participate in the evolving 'New Energy' marketplace, including aggregation for Demand Response and VPPs, and will unlock access to DER visualisation and control sourced from behind-the-meter, consumer-owned assets. The MEM will source data from Wattwatchers hardware, smart meters, inverters, EV chargers and sensors, and provide energy data software applications. It will provide aggregators, DNSPs and other services providers with access to granular consumer energy data and visibility of DER.	111
National low-voltage feeder taxonomy study Lead organisation: CSIRO	The study aims to produce the first national low-voltage network taxonomy that outlines the real-world characteristics of the distribution system. It will provide improved data required to identify nationally representative consequences on the low-voltage power system of DER integration possibilities, supporting assessment of DER integration design options. Depicting how power flows through the low voltage system will help with the design and assessment of the technologies and systems that can enable maximal uptake of DER across Australia. It will also enable users to test the value proposition of innovative technological solutions through desktop-based simulation, by highlighting how they contribute to the stability, reliability and performance of networks across Australia.	115

Project name and lead organisation	Summary of the project	Page
Network Opportunity Maps Lead organisation: University of Technology Sydney	The project creates NEM-wide online maps of electricity network constraints to help better inform network investments and increase the use of renewable energy. Developing a system that creates annually updated maps of network constraints for the entire NEM assists DER project developers target locations of the grid where renewable energy, energy storage and demand management can be cost-effective alternatives to network augmentation.	118
Networks Renewed Lead organisation: University of Technology Sydney	The project investigated pathways to increase the amount of renewable energy in Australia by paving the way for small-scale solar PV and battery storage installations to improve the quality and reliability of electricity in distribution networks. Two demonstrations focussing on voltage management recruited 90 customers in three locations across NSW and VIC under new commercial models for network-related businesses. The project tapped into new, 'smart' inverter technologies that can better control PV panels and storage, offering a suite of new business opportunities. There is an emerging perception that small-scale solar PV may negatively impact the performance of Australian electricity networks by increasing voltage variability. Networks Renewed addressed this perception and clearly demonstrated that solar PV and batteries can be a valuable resource for businesses that manage electricity networks; changing the problem into a solution.	121
Open Energy Networks Lead organisations: Energy Networks Australia and AEMO	The aim of this project was to explore the role of distribution-level markets to support DER integration and optimisation, specifically to see if a distribution market framework would be able to provide benefits to consumers in the NEM. This project leveraged the UK's Open Networks Project by starting with three strawmen of distribution market frameworks. After extensive industry consultation a fourth option was added incorporating aspects of the two most likely frameworks. The project also sought feedback from a group of key customer representatives and included a cost benefit analysis of each of the final four frameworks.	124
Optimal DER Scheduling for Frequency Stability Lead organisation: University of Tasmania	This project will investigate how best to schedule DER on distribution networks so that they are capable of providing power system frequency stability services while ensuring the distribution network always operates within technical constraints, but also while reflecting the motivations and primary functionality desired by DER owners. The project will also demonstrate, via detailed modelling, the frequency response capabilities of a range of inverter-interfaced DER and flexible loads, and the extent to which they can assist with frequency stability in power systems with decreasing conventional generation.	127

Project name and lead organisation	Summary of the project	Page
Pooled Energy Demonstration Project Lead organisation: Pooled Energy	The project provides retail electricity and swimming pool automation to pool owners as part of an on-going service. The energy consumption of the pools is managed from a central Network Operating Centre in such a way as to help off-load and stabilise the grid. The pool-automation controller enables discretionary demand management activities at the customer site. A central control system aggregates available discretionary load and performs demand management activities to assist during times of extreme electricity grid-stress.	130
Project Highgarden Lead organisation: Horizon Power	The project has installed a variety of DER technologies for households and businesses in Carnarvon, WA. Technologies include energy meter devices connected to the internet to send and receive data, solar PV, batteries and inverters with remote monitoring and control devices. Horizon Power will use collected data and customer interaction with the technology to inform new retail models that could enable and incentivise customers to participate in the provision of energy services to the grid.	133
Realising Electric Vehicle-to-grid Services (REVS) Lead organisation: ActewAGL Retail	This project seeks to unlock the full economic and grid benefits of vehicle-to-grid (V2G) services in Australia. It includes demonstration, data and analysis of the availability, reliability and performance of V2G frequency support and how this creates value for users, fleet managers, retailers, networks, the system operator, and thereby to all electricity customers. It also seeks to provide the definitive reference on current V2G capabilities, opportunities, barriers, and recommendations, including economic, technical, and social domains.	136
Renewable Integration Study – Distributed PV stream Lead organisation: AEMO	The Renewable Integration Study is the first stage of a multi-year plan to maintain system security in a future NEM with a high share of renewable resources. The Stage 1 RIS report investigates challenges to operating the power system at very high instantaneous penetrations of wind and solar generation. It recommends actions and reforms needed to keep operating the NEM securely, now and as the power system transitions. The distributed solar PV (DPV) stream of the RIS concentrated on the impact of increasing penetrations of passive DPV generation on the power system, exploring key challenges for both the distribution networks and bulk power system, how these challenges might be addressed, and 'no regrets' actions to better integrate the future DPV fleet within the bulk system in a secure manner.	139

Project name and lead organisation	Summary of the project	Page
Simply Energy Virtual Power Plant Lead organisation: Simply Energy	The project will deliver over 1,200 batteries to South Australian households. The project will employ a centrally managed network of energy storage systems installed behind the meter that can be collectively controlled to deliver benefits to households and the local community. The project will develop the GreenSync decentralised energy exchange (deX) platform to a commercial scale. The project aims to demonstrate that by integrating in a VPP the open sourced distributed energy market platform software, deX Platform, value can be generated for customers. This will be explored by using the VPP hardware and software to test the ability of the VPP to trade in the wholesale electricity market, FCAS market and in the provision of network services.	143
Townsville Community Scale Battery Storage Project Lead organisation: Yurika	Yurika is installing Queensland's first community scale, grid-connected, battery energy storage system (BESS). Located in Bohle Plains, Townsville, Yurika's 4MW / 8MWh BESS will commence operation in 2020. It will provide network support to Ergon Energy throughout Townsville's hot summer months. The system may help keep electricity prices down by allowing Ergon Energy to explore the potential to defer investment in network infrastructure in the area. In addition, the project expects to create value by charging when prices are low and discharging the stored energy back into the grid when electricity prices are higher. The system will also help maintain the frequency of the national grid by providing contingency FCAS during frequency disturbance events. The battery will add to the capacity of Yurika's Virtual Power Plant (VPP), building on the 130MW of existing capacity already supporting Queensland's Ergon and Energex networks.	147
Updated standards for demand response from residential loads Lead organisations: AEMO and Standards Australia	AEMO is actively participating in the development of standardised residential load flexibility capabilities, through the current revision of AS 4755. AS 4755 sets out minimum device level capability requirements for remotely coordinated demand response from residential household appliances and smart devices – such as air conditioners, pool pumps, hot water systems, batteries and other energy storage, as well as electric vehicle supply equipment. This is seen as a key enabler for establishing a truly 'two-sided' future power system and market by enhancing the predictability and verifiability of residential demand response, and therefore to facilitating the range of services this might be able to provide.	150

Project name and lead organisation	Summary of the project	Page
Updated standards for DER inverter capability and performance Lead organisations: AEMO and Standards Australia	This program of work covers AEMO's work to better understand DER performance requirements for secure bulk power system operation and the Standards Australia process to revise AS/NZS 4777.2. AEMO's work comprised: • Analysis of DPV disconnection behaviour from a sample of monitored systems (provided on an anonymised basis by Solar Analytics) for bulk power system disturbances during periods with levels of DPV generation. This analysis was further validated through laboratory bench testing of individual inverters conducted by UNSW Sydney. • Learnings from the 'next iteration' of uplift in smart inverter standards internationally, in particular the 2018 update to the US national standard for DER connection (IEEE 1547) and national implementations 2016 update to the European Network Code for Generators (most notably, Germany and Denmark). Many DER systems are connected to the grid using inverter energy systems, with requirements for the function and performance within the technical envelope specified in AS/NZS 4777.2: 2015 – Grid connection of energy systems via inverters, Part 2: Inverter requirements. Standards Australia is working with AEMO and a broad range of other stakeholders to revise AS/NZS 4777.2 to address the key challenges of increasing of rapid DER uptake, to ensure aggregate behaviour of these systems is aligned with wider power system objectives, as well as distribution level protection, power quality, and safety requirements.	154
Virtual power plant demonstrations Lead organisation: AEMO	AEMO currently has no visibility of how VPPs operate. This project will test a new technical specification for VPPs to deliver Frequency Control Ancillary Services in the NEM, enabling VPPs to capture new value streams that could be shared with their customers. AEMO will also augment its systems to receive operational data from VPPs to observe their behaviour, including how VPPs respond to wholesale energy market prices or deliver local network support services. AEMO will use this data to improve its operational forecasting of VPPs, and identify further changes required to integrate VPPs into market frameworks at large-scale, including potential regulatory reforms.	160

Project name and lead organisation	Summary of the project	Page
Visibility of DER Lead organisation: AEMO	AEMO's Visibility of DER report outlined how a lack of visibility of DER devices will impact two of AEMO's core responsibilities in managing the NEM: maintaining power system security and reliability and delivering information to support efficient market outcomes. It proposed regulatory changes to address information gaps. The work formed the basis for a COAG Energy Council rule change request for the development of a DER register. The AEMC made its final rule in September 2018 for AEMO to establish a register of DER in the NEM, including small scale rooftop solar and battery storage systems. AEMO launched the DER Register in March 2020. Data availability and access has also been identified as a key gap for the future integration of electric vehicles. Information on chargers, vehicles and consumer behaviour is often not collected – where data is collected, it can be spread across many organisations or government bodies with access limited due to privacy or commercial considerations. To help address this gap, AEMO is leading the DEIP EV Data Availability taskforce towards establishing a central repository (or other means) of capturing this data to facilitate informed decision making during the transition to electrified transportation	164
Voltage analysis of the LV distribution network in the Australian NEM Lead organisation: UNSW	The project involved the analysis of voltage data from 12,617 site-specific power and voltage monitoring devices throughout the low voltage network in NEM. The analysis included the correlation between voltage and PV export for different DNSPs and according to PV installation density, and the potential for PV curtailment as measured by the frequency of voltage being outside the present standard limits by PV installation density. The project also included a comprehensive literature review and recommendations regarding further work, enhancing voltage visibility and improved voltage management.	168
Western Power Community Batteries Lead organisation: Western Power	Western Power and Synergy connected a community battery (420kWh) in the City of Mandurah, Western Australia. The project accesses multiple value streams in the one solution, including network, energy market and customer offerings. The battery was installed downstream on an LV network that has high penetration of solar. This meant that the requirement to upgrade the distribution transformer has been deferred and the traditional network solution has been substituted by a solution that has additional benefits.	171

Project name and lead organisation	Summary of the project	Page
Yackandandah SWER Trial Lead organisation: Mondo	The initiative will establish a microgrid in Yackandandah to help cut energy bills for residents and help the community achieve their 100 per cent renewable energy target. The project will increase the number of houses with solar PV and batteries on a Single Wire Earth Return powerline and include control technology to manage network security. The project also measures the benefits for consumers taking part in the Sanatorium Road Microgrid – such as energy savings and more reliable supply. The project demonstrates Mondo's ability to operate a microgrid and bring value to the network by monitoring and controlling DER, as well as providing insights on data collected, and electrical engineering concepts involved in microgrid operation.	175

Part Three: Detailed Project Summaries

ARENA state of DER technical integration | project summary

Project/initiative name | Addressing barriers to efficient renewable integration

Project contact | Professor John Fletcher, UNSW

Project summary

The UNSW Addressing Barriers to Efficient Renewable Integration project is identifying and addressing the roadblocks to having high degrees of renewable energy deployment related to system integration.

The project will focus on inverter performance and the assessment of inverter performance and modelling related to frequency control, ancillary services, and electricity market rules/operating procedures. By using bench testing, UNSW will directly test the response of a range of photovoltaics (PV) and storage inverters to disturbances of different kinds on the network. In addition, the installation of high-speed disturbance recorders on key distribution network feeders will monitor and record behaviour during power system disturbances. Results from this will provide detailed information that can be used to develop a "composite PV-load model".

The composite PV-load model can be used by AEMO and Transmission Network Service Providers (TNSPs) to more accurately represent the behaviour of load with embedded PV. This model is critical for all system security studies, including determining network stability limits, and frequency control requirements. The current model used by TNSPs is outdated and in need of renewal so as to incorporate the response of rooftop PV. The model developed in this project is based on the most comprehensive testing program (internationally) of the transient response of residential PV inverters.

The project will develop models and tools to facilitate longer-term planning for efficient frequency control. These models will be released publicly to support ongoing research and analysis. Specifically, the composite PV-load model will facilitate a wide range of useful studies, applying dynamic power system modelling to further understand system security limits. This will include power system studies to optimise the dynamic response of the system when dominated by emerging technologies, such as synchronous condensers (a motor which adjusts conditions on the electric power transmission grid) and batteries.

Key project deliverables

1. Cost effective strategies for frequency management will be identified specifically as they pertain to management of rooftop PV and storage, and their response to disturbances.
2. Frequency control arrangements will be examined specifically for scenarios with high levels of rooftop PV, to manage disturbances. Renewable integration challenges specifically relating to the management of rooftop PV and storage during disturbances will be examined. Identification of barriers and solutions to the integration of renewable energy to the electricity grid based on electricity market rules, operating procedures, grid codes or other system parameters.
3. Insights and modelling outcomes specifically for the Australian electricity industry and its market arrangements, as they relate to the integration of rooftop PV and distributed storage. Collaboration with industry partners to extend their work programs into analysis of much longer term and higher renewable scenarios.

Key project innovation

The essential project innovation is the development of high-fidelity models of DER that is inverter connected and which is based on our comprehensive bench test program of PV inverters (single- and three-phase and energy storage) under transient conditions experienced when connected to the electrical grid. Inverters can react and respond to grid events in the order of 10^{-6} s. The inverter systems are capable of providing rapid response but each inverter make and model responds to network disturbances in different ways: some disconnect, some curtail and some ride through.

Our extensive benchmarking of inverter responses has allowed the distribution system to be more precisely simulated using an innovative DER-load composite model. This modelling has opened up a plethora of behaviours and responses from inverters that present serious operational challenges now to network security. This is a challenge that will continue to confound network operators and will put a technical roadblock on many of the envisaged potential DER/storage strategies currently being assessed at the small-scale (eg aggregation of generation, aggregation of storage, virtual power plants, fast frequency response strategies, microgrids, etc.) as improper inverter responses can easily lead to grid instability and blackouts. Our modelling has already been used to identify issues in South Australia.

We have also developed an open-source composite PV-load model to facilitate long term electricity system planning for efficient frequency control and power system stability under an ever-increasing portfolio of inverter-connected generation including PV and storage that is uncontrolled (currently > 1.5 million inverters).

We have also identified key challenges and solutions, priority areas of focus, research methodologies and associated modelling relating to frequency management and grid integration of massive quantities of small-scale DER (e.g rooftop PV).

Project timing and progress

Activity	Proposed Delivery	Status
Provision of a computational tool to estimate the parameters of a composite load model for power system stability studies	June 2020	In progress
An enhanced DER model for managing high levels of PV integration into the grid	June 2020	In progress
Improve Australian standards to enhance DER resilience against grid disturbances	June 2020	In progress
A new Composite PV-Load model that considers the aggregate behaviour of both DER and loads in various feeders in Australia	July 2021	In progress
A set of options and points of action for managing high levels of PV integration in Australia based on inverter testing	July 2021	In progress
A set of options for managing high PV integration based on distribution network modelling and hardware in the loop testing	November 2020	In progress
A report on the accuracy of currently used measurement devices and their impact on load model development and yearly updates	Jan 2021	In Progress

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Performing laboratory testing of commercial rooftop PV inverters against grid disturbances, benchmarking testing results to update composited PV-load model used by AEMO and provide inputs to development of updated inverter standard AS 4777.2
1.2 Grid support	Yes	Performing laboratory testing of grid supporting functions such as volt-var and volt-watt response of commercial off-the-shelf rooftop PV inverters
1.3 Protection and control functions	Yes	Performing laboratory testing of commercial rooftop PV inverters to check operation during grid disturbances, fault propagation, and temporary interruptions
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Identifying gaps in the current standards, demonstrating different responses of inverters for the same conditions, making recommendations for improving inverter response
2.2 Integration of DER within AEMO and distributors' systems	Partial	Studying propagation of voltage and frequency disturbances from the transmission to the distribution networks and analysing effects of these disturbances on low voltage connected DER
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	No	
3.2 DER modelling	Yes	Understanding impacts of grid disturbances on power from DER, will support AEMO in managing grids with high DER penetration and planning for contingencies. Creation of optimization tools to tune parameters of the composite PV-load model, based on disturbance measurement data.
3.3 Network hosting capability	Yes	Developing a composite PV-load model which will allow for more accurate assessment of DER amounts which can be hosted in the grid.
3.4 Bulk power system security and reliability	Yes	Identification of grid disturbances which propagate from the transmission to the distribution networks, which can cause unwanted disconnection or power curtailment

Functional area	Yes / No	If yes, how?
3.5 Distribution system reliability and power quality	Yes	Contributing to enhance Australian Standard AS 4777.2 ensuring that rooftop PV inverters are able to withstand grid disturbances identified during the bench testing process.
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

This work will lead to:

- Composite PV-load model publicly released supporting ongoing DER integration studies
- Enhancement of Australian standards concerning inverter-connected DER
- Reference for future projects investigating DER modelling and inverter behaviours
- A publicly available resource and a database of inverter test results that the community is free to use.

Project partners

AEMO, ElectraNet, TasNetworks

Relationship to other projects

Existing ARENA projects that closely relate to this project:

- **Enhanced Reliability through Short Time Resolution Data**: this project addresses the need for short time resolution data around voltage disturbances to understand DER behaviour and improve dynamic modelling. The project "UNSW Addressing Barriers to Efficient Renewable Integration", also aims to understand the impact of voltage disturbances DER behaviour and develop a composite PV-load model.
- **National Low-Voltage Feeder Taxonomy Study**: this project aims to create detailed models of the low voltage distribution networks. This is useful for the project "UNSW Addressing Barriers to Efficient Renewable Integration" as it investigates effects of transmission disturbances on the distribution grids, requiring accurate models of low voltage grids.

Links to further project information

https://research.unsw.edu.au/projects/addressing-barriers-efficient-renewable-integration
http://pvinvert+ers.ee.unsw.edu.au/

ARENA state of DER technical integration | project summary

Project/initiative name | Advanced Planning of PV-Rich Distribution Networks Study

Project contact |Prof Luis (Nando) Ochoa, University of Melbourne (luis.ochoa@unimelb.edu.au)

Project summary

This project will develop analytical techniques to assess the residential solar PV hosting capacity of electricity distribution networks by leveraging existing network and customer data. This project will also produce planning recommendations to increase solar PV hosting capacity using non-traditional solutions that exploit the capabilities of PV inverters, voltage regulation devices, and battery energy storage systems.

Key project deliverables

The project will focus on the following four outputs:

1. **Innovative Analytical Techniques for Solar PV Hosting Capacity Estimation.** Detailed studies on distribution networks with different residential solar PV penetrations will be performed to capture the correlations between customer data and corresponding penetrations. Results will be used to define analytical techniques to rapidly estimate the hosting capacity of networks.

2. **Traditional Solutions to increase Solar PV Hosting Capacity.** Comprehensive and realistic simulation-based studies will be performed to investigate the extent to which solar PV hosting capacity of Distribution Networks can be increased by leveraging existing DNSP-owned and controllable assets (i.e., voltage regulators with off-load or on-load tap changers) as well as replacing or upgrading conductors and/or transformers.

3. **Non-Traditional Solutions to increase Solar PV Hosting Capacity.** Comprehensive and realistic simulation-based studies will be performed to investigate the extent to which solar PV hosting capacity of distribution networks can be increased by adopting non-traditional solutions. These are based on the combination of existing and new installations of DNSP-owned controllable assets (e.g., LV on-load tap changing-fitted transformers) as well as customer-owned assets (e.g., solar PV, battery energy storage systems).

4. **Planning Recommendations.** The benefits brought by each solution, as well as potential drawbacks, will be used to produce planning recommendations that can help DNSPs reduce the cost and time involved in the long-term integration of solar PV to distribution networks, particularly in areas where substantial growth is expected.

Key project innovation

The development of analytical techniques through this project will help distribution network service providers (DNSPs) with access to smart meter data (or similar) to rapidly estimate the hosting capacity in their networks without the need for complex, time-consuming network studies or the adoption of generic assumptions. These techniques are expected to accelerate the processing of connection requests to encourage the widespread adoption of solar PV systems. Furthermore, the planning recommendations derived from the extensive and high-resolution network studies involving traditional and non-traditional solutions will provide DNSPs with numerical evidence that can help determining the most adequate alternative to ensure the quick and cost-effective integration of residential solar PV across Australia. Finally, the methodologies and techniques behind the studies will also provide the foundations for advanced planning approaches (and potentially tools) that could be used by DNSPs in the near future.

Project timing and progress

Deliverable	Title	Delivery Date	Status
Task 1 HV-LV modelling of selected HV feeders			
1	Technical Report "HV-LV modelling of selected HV feeders"	10th June 2019	Completed
Task 2 Innovative Analytical Techniques			
2	Analytical Techniques and Corresponding Algorithms to Estimate PV Hosting Capacity (Technical Report and Knowledge Transfer).	10th October 2019	Completed
3	Webinar "Innovative Analytical Techniques"	10th October 2019	Completed
Task 3 Traditional Solutions			
4	Technical Report "Traditional solutions"	10th February 2020	Completed
5	Workshop "Traditional solutions"	10th February 2020	Completed
6	International Conference Paper	10th February 2020	Completed
Task 4 Non-Traditional Solutions			
7	Technical Report "Non-traditional solutions"	10th August 2020	
8	Workshop "Non-traditional solutions"	10th August 2020	
Task 5 Cost Comparison			
9	Technical Report "Cost comparison among potential solutions"	10th November 2020	
Task 6 Consolidation of Findings			
10	Final Report and Knowledge Transfer	10th February 2021	
11	Webinar "Key Findings"	10th February 2021	
12	Workshop "Key Findings"	10th February 2021	

Deliverable	Title	Delivery Date	Status
13	International Conference Paper	10th February 2021	

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	No	
3.2 DER modelling	Yes	State-of-the-art modelling of residential solar PV, battery energy storage systems, and demand is performed in this project. This is complemented by the state-of-the-art modelling of the distribution network (three-phase modelling, integrating HV (e.g., 22 kV) and LV (400 V)) to realistically capture the corresponding interactions.
3.3 Network hosting capability	Yes	Innovative analytical techniques developed in this project will help DNSPs in understanding their networks' solar PV hosting capacity. Moreover, comprehensive analyses investigating different traditional and non-traditional solutions will help DNSPs make more informed planning decisions to increase hosting capacity.
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	By exploiting smart meter data (or similar), the innovative analytical techniques developed in this project can give DNSPs an understanding of the evolving voltage effects due to solar PV.

Functional area	Yes / No	If yes, how?
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

No issues have been identified at this stage that affects the ability of the University of Melbourne to meet the pre-defined timeframes for the completion of the study. All material produced by this project will be made publicly available.

Project partners

AusNet Services

Relationship to other projects

Distributed Energy Resources Hosting Capacity Study (Powercor Australia Ltd, ENEA). The project is related as it tries to identify technical issues in electricity networks due to solar PV and highlight potential solutions to increase the corresponding hosting capability. The project, however, is focusing only on LV networks and, therefore, does not capture the interactions with the upstream HV networks (e.g., 22kV). Potential technical issues on upstream HV networks and also on LV networks (due to higher or lower voltages at the HV-LV intergace) might be missed, thus potentially leading to over or under-estimations of Hosting Capacity.

National Low-Voltage Feeder Taxonomy Study (CSIRO). The project is related as it aims to characterize and model LV networks hence help DNSPs assess DER hosting capacity of their networks. The project, however, is focusing only on LV networks and, therefore, does not capture the interactions with the upstream HV networks (e.g., 22kV). Potential technical issues on upstream HV networks and also on LV networks (due to higher or lower voltages at the HV-LV intergace) might be missed, thus potentially leading to over or under-estimations of Hosting Capacity.

Links to further project information

1. Project Website: https://electrical.eng.unimelb.edu.au/power-energy/projects/pv-rich-distribution-networks/
2. Deliverable 1: HV-LV Modelling of Selected HV Feeders
3. Deliverable 2: Innovative Analytical Techniques
4. Webinar 1: Smart Meter-Driven Estimation of PV Hosting Capacity
5. Deliverable 3: Traditional Solutions
6. Webinar 2: Solar PV Hosting Capacity Using Traditional Solutions

ARENA state of DER technical integration | project summary

Project/initiative name | SA Power Networks Advanced VPP Grid Integration

Project contact | Bryn Williams, SA Power Networks (bryn.williams@sapowernetworks.com.au)

Project summary

The Advanced VPP Grid Integration project aims to show how higher levels of energy exports to the grid from customer solar and battery systems can be enabled through dynamic, rather than fixed, export limits, and to test the value this can create for customers and Virtual Power Plant (VPP) operators.

The Project has implemented an interface (API) to exchange real-time and locational data on distribution network constraints ('operating envelopes') between SA Power Networks and the Tesla South Australian VPP, enabling the VPP to optimise its output to make use of available network capacity.

This system has been in operation since July 2019, with the 12-month field-trial due to complete in July 2020.

Key project deliverables

1. VPP / grid integration API technical specification, co-designed with Tesla and industry, based on a minimal subset of IEEE 2030.5.

   The API specification developed by SA Power Networks for this project has been published and has also been adopted by the ARENA-funded ANU Evolve project.

2. Establishment of the ARENA DER Integration API Technical Working Group. SA Power Networks established this working group to work with industry to develop the preliminary API specification to a fully-featured Australian standard implementation of IEEE2030.5. This working group is ongoing, and is now convened by ANU.

3. Technical deliverables including model-based hosting capacity estimation engine, API, integration with Tesla VPP control system

4. Economic analysis of value able to be created for the VPP by enabling greater access to network capacity than standard static export limits

Key project innovation

The project is the first real-world demonstration of the provision by a DNSP, via an open API, of dynamic, nodal export limits (operating envelopes) to a VPP operator actively trading in the NEM. It has been the first project to demonstrate the active adaptation of dispatch limits by the VPP operator to maximise access to the energy market within distribution network constraints.

Tesla's 1,000-customer SA-VPP is the most actively operated VPP in Australia and has been operating under the dynamic export limit scheme since July 2019 while trading in wholesale energy and FCAS markets.

Project timing and progress

Activity	Proposed delivery	Status
Develop and publish DER integration API draft specification 0.1	February 2019	Completed
Formation of DER Integration API Working Group	February 2019	Completed
Publish DER integration API v1.0	July 2019	Completed
Technical implementation of hosting capacity engine, API server, backoffice systems for DER static and dynamic data, built on Microsoft Azure platform. Secure integration with Tesla VPP management system, end-to-end testing and demonstration.	July 2019	Completed
12 month real-world field trial with 1,000 customer VPP during live market and FCAS trading	July 2019 – July 2020	In progress, on track
Final knowledge sharing report, including economic analysis of value created for the VPP during the trial (CSIRO)	September 2020	On track

Project functional scope

Functional area	**Yes / No**	**If yes, how?**
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	(note: the Tesla VPP is providing grid support services, but the scope of this project is about enhancing that through better access to distribution network capacity, not in providing those services)
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Early work towards an IEEE2030.5-based API for DER/grid integration
2.2 Integration of DER within AEMO and distributors' systems	Yes	Practical demonstration of live exchange of data between DNSP and aggregator systems to enable VPP to operate with regard to the real-time state of the network
2.3 Cybersecurity	Yes	Learnings from the cybersecurity framework established for the project will inform work

Functional area	Yes / No	If yes, how?
		towards a more complete IEEE 2030.5 implementation guide
3. Understanding DER behaviour		
3.1 DER visibility	Yes	SAPN receives telemetry from all Tesla VPP batteries via the API
3.2 DER modelling	Yes	To inform hosting capacity model
3.3 Network hosting capability	Yes	SAPN has developed an initial parametric model of LV network hosting capacity for the project. This is informing future approaches to full production-scale hosting capacity models that do not rely on state estimation
3.4 Bulk power system security and reliability	No	As with 1.2, this is a goal of the Tesla VPP, but not a specific goal of this project
3.5 Distribution system reliability and power quality	Yes	Hosting capacity model is refined using PQ data measured by the DER
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	As in 1.2
4.2 Provision of localised network services	No	As in 1.2

Next steps and constraints or impediments to BAU adoption

At project completion:

- Project final report will help inform costs and benefits for both DNSPs and VPP operators of this kind of advanced VPP/grid integration.
- API integration will be extended to several other VPP aggregators in SA that have expressed interest
- SAPN is about to commence a follow-on project to extend the flexible export limit capability from batteries and VPPs to passive solar PV
- SAPN will continue to work with industry to progress from this kind of preliminary API towards a full IEEE2030.5 integration guide for Australia

Project partners

Tesla, CSIRO (research and knowledge-sharing partner)

Relationship to other projects

Related, in particular through the DER Integration API Technical Working Group with projects such as ANU Evolve, Greensync deX, AEMO VPP market trials, etc.

Links to further project information

Refer ARENA project page: https://arena.gov.au/projects/advanced-vpp-grid-integration/ A project presentation is also available on request.

ARENA state of DER technical integration | project summary

Project/initiative name | AGL Virtual Power Plant

Project contact | Greg Abramowitz, Manager Virtual Power Plants, AGL, Email GAbramow@agl.com.au

Project summary

The AGL Virtual Power Plant (VPP) is a world-leading prototype of a VPP created by installing and connecting behind the meter (BTM) solar battery storage systems across 1000 residential premises in Adelaide, South Australia, to be managed by a cloud-based control system. The batteries will be able to 'talk' to each other through a cloud-based platform using smart controls, forming a connected system that will be able to operate as a 5 MW solar power plant. The primary aim of the project from a knowledge sharing perspective is to understand the various value pools that BTM batteries are able to access, and what barriers may exist to their realisation.

Key project deliverables

The key project deliverables are:

- The installation and commissioning of 1,000 orchestratable BTM energy storage systems
- Knowledge sharing obligations, including (but not limited to):
    - Public presentations and participation in public workshops convened by ARENA
    - Knowledge sharing reports, three of which will be released publicly

Key project innovation

The AGL VPP is a centrally-managed network of battery systems installed "behind the meter" that can be controlled to deliver multiple benefits to the household, the retailer, and the local network. The battery is charged and discharged to maximise the benefits to the consumer, while ensuring that the network and retailer can also realise value from the battery during specific network or wholesale events. The ability of the VPP to realise multiple benefit streams can ultimately reduce the costs of the system to the end customer, while reducing the energy charges of all grid uses by making the most efficient use of the battery as a Distributed Energy Resource (DER).

Given the expected increase in behind-the-meter battery storage, VPP's represent an important opportunity to spread the benefits of this rapidly evolving technology to maximise value for the entire community. To do this effectively, a VPP needs to innovate in the way that technology is deployed and operated through appropriate commercial arrangements for the benefit of the customer.

At launch, AGL's VPP was the first to target all the potential value from such services. Historically, analogous services had only aimed to assist the wider energy network (by additional supply of energy). The AGL VPP broadens this value by helping customers maximise their solar consumption whilst simultaneously addressing grid volatility, which further accelerates a renewable led future. With 1,000 batteries at completion, the SA VPP is the largest of its kind operating in Australia encompassing multiple vendor technologies.

Though larger VPP programs have since been supported by ARENA or state governments, AGL's program remains unique in many respects:

- Retailer-led, the project aims to test the access and scale of multiple value streams – customer solar self-consumption, wholesale (energy and FCAS) and network services.
- The Tesla portion of the fleet is enrolled in the AEMO VPP Demonstrations, and is participating in all six contingency FCAS markets
- Multiple trials are underway with SAPN to determine the viability and value of distribution level network services provided by a VPP
- The project fleet comprises multiple hardware types managed under a single VPP-software layer (Enbala) through API integrations only.

Project timing and progress

All hardware installations were completed in Q3 2019. See Stage 1 and Stage 2 Knowledge Sharing Reports available at https://arena.gov.au/projects/agl-virtual-power-plant/. Stage 3 knowledge sharing report is expected to be published before the end of 2020.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	All devices compliant with AS4777, TS129 (SAPN Small Embedded Generator standard)
1.2 Grid support	Yes	Network support through: - peak demand management and voltage support trials - Voltage support provided to distribution networks (uncompensated) through V-Var and V-Watt power quality response modes on battery inverter systems - frequency control services in AEMO VPP demonstrations
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Each hardware vendor system has its own proprietary API communication system – this is a reflection of the maturity of the VPP industry currently. AGL are utilising Enbala (VPP software provider) to deliver consistent control capability across the whole of the mixed vendor fleet.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Participation in AEMO VPP Demonstrations from 2020

Functional area	Yes / No	If yes, how?
2.3 Cybersecurity	Yes	Data ingestion, handling, storage, and sharing compliant with AGL's (and Australia's) cybersecurity requirements
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Visibility of fleet asset behaviour across operational period 2016 – 2020 through a high granularity dataset (including 100% smart meter penetration)
3.2 DER modelling	No	Modelling performed internally, but not a focus of the project
3.3 Network hosting capability	No	Not a focus of the project
3.4 Bulk power system security and reliability	No	Not a focus of the project
3.5 Distribution system reliability and power quality	Yes	Visibility of voltage levels across VPP fleet and impact of fleet on voltage levels and customer value a focus of the project
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Assessment of physical hedge or arbitrage opportunity in wholesale energy market. Participating in AEMO VPP Demonstrations from 2020 to test FCAS capability
4.2 Provision of localised network services	Yes	Network support services for peak demand management and voltage control being trialled with SAPN

Project partners

Tesla/Solar Edge/Sunverge – hardware and software vendors

LG Chem – Hardware vendors

Stakeholder reference group:

- Australian Renewable Energy Agency (ARENA)
- SAPN (AGL sits on SAPN's DER Integration Reference Group and Customer Consultative Panel)
- Electranet
- Australian Energy Market Operator
- Australian Energy Regulator
- Australian Energy Market Commission
- Energy Consumers Australia
- St Vincent de Paul

Relationship to other projects

In 2020, AGL enrolled its VPP into the AEMO VPP Demonstrations to test accessing and sharing in wholesale value (FCAS). We see this participation as an important step in the integration of these kinds of business models into Australia's energy markets. Further information is available at https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/pilots-and-trials/virtual-power-plant-vpp-demonstrations

Links to further project information

https://arena.gov.au/projects/agl-virtual-power-plant/

ARENA state of DER technical integration | project summary

Project/initiative name | Development of a proposed performance standard for a battery storage system connected to a domestic/small commercial solar PV system

Project contact | Nishad Mendis, DNV GL

Project summary

The objective of this ARENA and Victorian Government co-funded project is to produce a draft Performance Standard (Draft Standard) for Battery Energy Storage Systems (BESS) connected to domestic/small commercial PV systems. The Draft Standard shall comprise a series of performance testing protocols and performance-metric reporting methods for manufacturers and system integrators.

This is to ensure that end users are better informed regarding the expected performance of a BESS in order to compare systems on a like-for-like basis.

Following its completion, the Draft Standard will be submitted to Standards Australia to begin the process of making it a formal Australian Standard. In the interim, the project will develop a best practice guide to be used until Standards Australia completes its own standards development process.

Key project deliverables

- A comprehensive gap analysis on existing local and international battery energy storage performance standards
- Development of a draft standard and industry best practice guide
- Development of a set of recommended criteria to select a battery management system (BMS)
- Identification of the performance hazards related to the operation of BESS
- Identification of the minimum set of information recommended to be included in material safety data sheets (MSDS)
- Development of battery capacity estimation methodology

Key project innovation

The draft standard will be application-specific, in that it will only consider battery systems intended for domestic and small-scale commercial solar + battery storage installations (up to 100 kW power and 200 kWh energy). It will also be specific to Australian climatic conditions and use cases.

Beyond that, it aims to be as widely applicable as possible and is technology agnostic. Hence, the standard will make it easier for people to understand how reliable batteries are and how they are expected to perform over their lifetime under Australian operating conditions.

Project timing and progress

June 2018-June 2020

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	No	
3.2 DER modelling	Yes	The standard will make it easier for people to understand how reliable batteries are and how they are expected to perform over their lifetime under Australian operating conditions
3.3 Network hosting capability	No	
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	No	
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

The draft standard is due to be submitted to Standards Australia in June 2020. With the large amount of work and industry liaison already put in by the consortium behind the draft, it is hoped that the adoption process will proceed relatively quickly. To support the draft standard, the consortium will also be releasing an interim best practice guide which is intended to be used until such time as the standard is released. This best practice guide will contain the same information as the draft standard, including a step-by-step description of how to carry out the necessary testing, as well as background information on how to apply for and claim compliance until the standard is released.

Project partners

CSIRO, Deakin University and Smart Energy Council

Relationship to other projects

ITP Renewables (https://batterytestcentre.com.au/)

Links to further project information

https://www.dnvgl.com/cases/australian-battery-performance-testing-standard-project-abps-project--143069

ARENA state of DER technical integration | project summary

Project/initiative name | SA Power Networks Closed Loop Voltage Control Trial

Project contact | Bryn Williams, SA Power Networks (bryn.williams@sapowernetworks.com.au)

Project summary

The project is establishing voltage control techniques at SA Power Networks' zone substations to boost network hosting capacity and provide demand response services. A key goal is to determine whether closed-loop substation voltage control, which has been demonstrated successfully in Victoria, can be achieved in other states without access to ubiquitous smart meter data.

The scope includes:

- Establishing capabilities to optimise network voltage by automatically controlling substation tap positions to:
    - Deliver an efficient solution to increase network hosting capacity for large numbers of customers.
    - Establish capabilities that will unlock voltage-optimisation based demand management on SA Power Networks' network.
- Demonstrating how network visibility can be enhanced by combining data from a variety of distributed data sources with data science, providing significant opportunities to optimise DER integration and customer experience.

The project is part-funded by the South Australian Government under the Demand Management Trials grant scheme.

Key project deliverables

1. Establish trial system in one substation area with more than 6,000 customers
2. Conduct 12 month field trial to demonstrate that the system can:
    a. Increase hosting capacity
    b. Enable demand response
3. Deliver public knowledge sharing report to share findings from the trial to inform other DNSPs of the feasibility, capability, costs and benefits of this approach

Key project innovation

Closed-loop voltage control involves changing the high-voltage setpoint at a zone substation transformer dynamically through the day in order to actively manage voltage at the customer connection point for all customers connected to that substation (typically thousands of customers). The method relies on a high level of visibility of customer voltages in the area, which can vary significantly and dynamically due to the intervening network topology, distribution of customer loads and DER and weather.

Victorian DNSPs have successfully demonstrated this method using AMI smart meters to monitor customer voltage. Outside of Victoria the Power of Choice smart meter roll out means that smart meter penetration remains low and the meter data available to networks is sparsely distributed and of variable quality, availability and cost. The key innovation in this project is to determine whether closed loop voltage control can be achieved without access to ubiquitous smart meter data, by combining a variety of different data sources including retailer smart meters, smart streetlights, grid-side monitors, customer inverters, third-party devices (e.g. the Solar Analytics home energy monitor) and weather data along with the use of data science to produce a rolling forecast of customer voltages.

Project timing and progress

Activity	Proposed delivery	Status
Technology deployment and IT platform development phase completed • Voltage control algorithm 0.1 • Initial data integrations (meters)	October 2019	Completed
System launch (advisory mode) • Hosting capacity model v1 • Voltage control algorithm v1 • Additional data integrations (transformer monitors, SCADA, weather) Field trial commence	March 2020	Completed
System launch (automatic mode) • System operating autonomously (subject to successful phase 1) • SCADA control integration • Hosting capacity model v2 • Voltage control algorithm v2	September 2020	Field trial in progress On track
Final report and project close Validation of models against other substations Findings from trial published in final report	April 2021	On track

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	Yes	Secondary goal is to demonstrate demand management capability using substation voltage changes
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Use of standard API to receive monitoring data from a variety of devices
2.2 Integration of DER within AEMO and distributors' systems	Yes	Active management of voltage using feedback from devices including some DER
2.3 Cybersecurity	Yes	Learnings from the cybersecurity framework established for the project will inform future approaches
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Project is combining data from several sources both internal and external
3.2 DER modelling	Yes	Data science used to forecast customer voltage histograms from sparse and imperfect historical data
3.3 Network hosting capability	Yes	Key aim is to increase hosting capacity by actively managing daytime voltage rise due to PV
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	Hosting capacity model is refined using PQ data measured by the DER
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	Yes	Active voltage management enabled by data from end-customer devices

Next steps and constraints or impediments to BAU adoption

At the end of this trial, if successful, SA Power Networks will plan the widespread application of advanced voltage control capabilities on our network. Applying these capabilities throughout our service area will directly benefit South Australian consumers by increasing DER hosting capacity, while reducing customer quality of supply enquiries, poor DER performance and the need for expensive augmentation to manage solar PV and VPP related issues.

The published findings from the trial will provide a basis for other DNSPs outside of Victoria to adopt the same approach. We believe this will be a key capability to enable the ongoing uptake of DER in South Australia and across the NEM and will complement other approaches such as tariffs, load shifting and flexible export limits.

Project partners

FutureGrid (high performance data platform), CSIRO (data science, research and knowledge sharing), SA Government (funding partner)

Relationship to other projects

Related to various projects that are seeking to improve LV network visibility and model hosting capacity.

Links to further project information

A project presentation is available on request.

ARENA state of DER technical integration | project summary

Project/initiative name | Consumer Energy Systems Providing Cost-Effective Grid Support (CONSORT)

Project contact | Sylvie Thiébaux, ANU (sylvie.thiebaux@anu.edu.au, project lead) / Dan Gordon (dan.gordon@anu.edu.au, contact)

Project summary

The CONSORT Bruny Island Battery Trial successfully developed and demonstrated an innovative automated control platform that enables consumers with battery systems to provide support to a constrained electricity network.

Key project deliverables

- A world first for DER coordination: distributed solving of optimal power flow in live operations. Automatic coordination of battery systems was shown to double their effectiveness in reducing consumption of diesel during peak events, at net benefit to both battery owners and the network.
- ~33% reduction in diesel consumption over all trial peaks, using a maximum of just 34 installed battery/PV systems.
- A unique and extensive body of social science and economics research on consumer attitudes to new energy technologies, network support, and how to fairly reward customers for providing this support.

Key project innovation

At the heart of CONSORT is a platform called Network Aware Coordination (NAC). The NAC's primary task is to automatically coordinate household energy systems (in a non-intrusive way) enabling them to adhere to and alleviate network constraints. DER owners are automatically and fairly rewarded for the support they provide. The trial demonstrated the use of this approach to manage high renewable penetration and other constraints at a much lower cost than is conventionally possible.

A first of its kind, fully automated control platform was developed and deployed on Bruny Island, Tasmania. The platform explicitly models the network, allowing it to calculate near-optimal control decisions whilst ensuring that the network remains within its operating constraints. This is possible because of the distributed nature of the platform, which allows it to scale to real-world network sizes.

Project timing and progress

Date	Activity
Apr 2016	Project start
Mar 2017	First battery commissioned
May 2017	First dispatch of batteries for network support
Mar-Apr 2018	First full deployment of NAC to manage network peaks and conduct research
Apr 2018 – Jul 2019	8 further peak period and extended NAC deployments, to manage network peaks and conduct research

Apr 2019	Project end

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	Yes	Orchestration of household batteries to obey and even alleviate distribution voltage and congestion constraints, making use of Reposit Power home energy management systems.
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Demonstration of API for communicating information for distributed optimisation of DER. Use of Reposit Fleet software to monitor and control a fleet of household battery systems.
2.2 Integration of DER within AEMO and distributors' systems	No	Potential for future integration.
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Use of Reposit Fleet software and API to monitor residential systems.
3.2 DER modelling	Yes	Analysis of the aggregate effect of coordinated and uncoordinated PV/battery systems on a semi-rural distribution feeder.
3.3 Network hosting capability	Limited	Demonstration of how battery coordination can increase hosting capacity by taking network constraints into account.
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Limited	Monitor voltages at participating households; understand how voltage and congestion constraints can be obeyed by jointly optimising DER.
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	Potential for future development.
4.2 Provision of localised network services	Yes	Orchestrate dispatch of residential DER to efficiently reduce voltage and thermal constraints, with possible effect of avoiding or deferring need to augment network.

Next steps and constraints or impediments to BAU adoption

Possible next steps

- Demonstration of NAC at scale, e.g. on large urban distribution feeders.
- Standardisation of API and further development so the algorithms can be scaled in the cloud.
- Development of additional capabilities, e.g. FCAS raise and lower.

Constraints and opportunities

- Adoption of distribution markets for energy, FCAS and other network services would open significant additional value streams for participants in NAC.
- Adoption of data exchange standards for DER and aggregators would facilitate BAU adoption of NAC.
- The availability of reasonable models of distribution networks, especially in a standardised form (e.g. CIM compatible), would significantly enhance the usefulness of NAC.
- The adoption of over-restrictive limits on DER as a way of avoiding network issues would limit the usefulness of NAC.

Project partners

The Australian National University, TasNetworks, Reposit Power, The University of Sydney, University of Tasmania.

Relationship to other projects

The ARENA evolve project shares similar aims to CONSORT: "*The evolve DER project aims to increase the network hosting capacity of distributed energy resources (DER) by maximising their participation in energy, ancillary and network service markets, while ensuring the secure technical limits of the electricity networks are not breached.*". An important part of EVOLVE is the provision of standardised models of distribution networks, and the development and adoption of standards for data exchange with DER aggregators; capabilities that would be important for the wider adoption of technology trialled by CONSORT.

The ARENA Optimal DER Scheduling for Frequency Stability project looks at how distributed optimisation of DER can provide FCAS, and includes as a project partner the same ANU research unit that was involved in CONSORT. It considers the option of extending NAC or similar algorithms to participation in FCAS markets.

Links to further project information

- CONSORT's ARENA web page contains basic information about the project along with all reports.
- The CONSORT Bruny Battery Trial website contains all the end of trial reports, along with much other information including academic papers and news links.

ARENA state of DER technical integration | project summary

Project/initiative name | Decentralised Energy Exchange (deX) Program

Project contact | Andree Duggan, Head of Programme, GreenSync (andree.duggan@greensync.com)

Project summary

GreenSync's Decentralised Energy Exchange (deX) is a market-enabling digital platform that aims to provide electricity networks with better coordination and control of the increasing volume of DER in the electricity grid. deX also aims to enable consumers to get more value from their DER assets (such as solar, batteries and electric vehicles), by being rewarded for participating in grid services.

Key project deliverables

- Creation of the deX Developer Centre.
- At least twelve DER OEMs undertaking deX Connect integrations.
- At least four DER types (for example, solar PV, batteries, hot water systems and electric vehicle chargers) operating on the deX platform.
- At least six DNSPs integrated with deX and utilising deX Vision capability.
- At least four DER aggregators integrated with the deX platform enabling operation of VPPs within markets.
- At least one distribution market operator within the National Electricity Market (NEM) using deX Markets.

Key project innovation

deX is a market-enabling digital platform that forms the layer between DER and the grid through Application Programming Interfaces (APIs). It aims to allow technology manufacturers and other platform owners to integrate their technology with deX so that consumers can register their DER. Retailers and network operators will then be able to view, coordinate and contract available DER for a variety of energy services.

A technology agnostic platform, deX will be open to all technology providers, networks and retailers. This creates opportunities for further innovation moving towards a transactive grid where services from DER are valued, participation increases, and overall system efficiency and reliability are maintained.

The key project areas of innovation and capabilities being targeted are:

(a) Improved ability of distribution networks to host DER at higher levels of penetration.

(b) Increased visibility, predictability or control of DER for AEMO, DNSPs or other relevant entities to optimise power system operation within secure technical limits.

(c) Demonstrated value of registration of DER, including for contracting, trading and forecasting.

(d) Increased opportunity for customers, electricity networks, market operators, government and market regulators to view DER information and influence DER operations to support the safe, reliable and economic operation of the grid.

(e) Demonstrated value of new technologies and business models for creating opportunities for market participants

(f) Improved understanding, and active knowledge sharing of, the operating requirements for DNSPs, VPPs and market operators in the context of high penetration DER and associated regulatory or market design considerations.

Project timing and progress

Outcome	Current Status	2021 Target
DER OEM integrations	7	12
DER types	3	4
DNSPs integrated and using deX Vision	1	6
DER aggregators integrated	1	4
deX enabled DER	934	10,000
DMO using deX Markets	0	1

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Integration of smart devices with disturbance withstand capabilities
1.2 Grid support	Yes	Integration of smart devices with grid support (FCAS) capabilities
1.3 Protection and control functions	Yes	Integration of smart devices with protection and control capabilities
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	API communications pathways from deX integrated device to vendor cloud to deX and from deX to other systems
2.2 Integration of DER within AEMO and distributors' systems	Yes	GreenSync, in partnership with Simply Energy is participating in the AEMO VPP Pilot including API integration to enable FCAS scheduling and DER forecasting.
2.3 Cybersecurity	Yes	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Customer (DER owner) permissions and API communications pathway for telemetry from deX integrated device to vendor cloud to deX and from deX to other systems (such as networks)
3.2 DER modelling	No	

Functional area	Yes / No	If yes, how?
3.3 Network hosting capability	Yes	deX is doing this in two ways. Firstly by enabling smoother DER integration (one integration can then enable communication with multiple networks), providing a pathway for improved DER visibility for networks. Secondly, we have developed the concept of 'Dynamic Connection Agreements' to target a key issue for networks and customers: customer consent for DER management and network changes to export limitations, enabling higher export in exchange for customer consent to support the grid at specified times.
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	Provision of voltage telemetry from inverters.
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Customer (DER owner) permissions and API communications pathway for energy services (and validation telemetry) from deX integrated device to vendor cloud to deX and from deX to other systems (such as a retailer controlled VPP)
4.2 Provision of localised network services	Yes	Customer (DER owner) permissions and API communications pathway for energy services (and validation telemetry) from deX integrated device to vendor cloud to deX and from deX to other systems (such as a retailer controlled VPP and/or a network system). This capability is being applied today in the Simply VPP-X project

Next steps and constraints or impediments to BAU adoption

Steps after completion of the project:

- Scaled up DER energy and information service provision, leveraging the number of assets in deX by project completion
- Scaled up adoption/pursuit of additional DER integrations
- Added and expanded capabilities of deX applications to meet needs of clients as Market Operators and System Operators - directly or via strategic alliances and partnerships with other providers.
- Software licence-based agreements for use of deX applications among existing clients and pursuit to new clients for the same.
- Further growth and client uptake of the deX applications in Australia and other markets

Project partners

deX initiative partners

There are many organisations keen to see the project succeed and who want to engage when there is the capacity or opportunity to pursue integration with the platform or sourcing of services via the platform. GreenSync has funnelled this type of interest into free-to-join deX Partnerships, via Memorandums of Understanding with organisations across Australia and globally. Today, more than 110 such partners exist.

deX technology integrations

As outlined above, a key foundational element of the deX platform and the ARENA-supported project is technology integrations of DER products with the deX API. To date, 7 such integrations have been completed with Tesla, Solar Edge, SwitchDin, Sungrow, Enphase, Metering Dynamics and GoodMeasure. Many other technologies are on a path to integration, but need a stronger driver to proceed or accelerate this activity. Such a driver is being provided for the next wave of integrations via the new South Australian project (see below).

deX projects

The project structure allows GreenSync to pursue subsequent projects in Australia to leverage the ARENA funding. The first of these projects began in March 2020 with funding support confirmed from the Government of South Australia. The new South Australia project and partner retailers, technology vendors, aggregators and others will be launched, officially, later in 2020.

Relationship to other projects

Related projects (using/developing aspects of deX)

- Simply Energy Virtual Power Plant (VPP-X) - led by Simply Energy
- DER integration and automation project - led by EvoEnergy

Complementary or similarly scoped projects

deX is multi-sided and addresses demand side, network services, technology integrations, service and product innovation. A number of other ARENA funded projects complement or are similar to specific aspects of the deX solution such as a network to DER based API for DER coordination.

Links to further project information

https://arena.gov.au/assets/2019/03/dex-consumer-insights-report.pdf

https://arena.gov.au/assets/2019/03/dex-project-progress-report.pdf

https://dex.energy/about-dex/

https://dex.energy/about-dex/about-the-technology/

http://info.dex.energy/annual-update-webinar

http://info.dex.energy/der-standards-frameworks

http://info.dex.energy/dca-discussion-paper

http://info.dex.energy/whitepaper-download

https://dex.energy/news/enphase-energy-integrates-with-dex-to-enable-smart-grid-functions/

https://dex.energy/news/greensync-wellington-electricity-deliver-new-business-model-for-electric-vehicle-charging-solutions/

https://arena.gov.au/projects/der-integration-and-automation-project/

https://arena.gov.au/projects/simply-energy-virtual-power-plant-vpp/

ARENA state of DER technical integration | project summary

Project/initiative name | DEIP EV Grid Integration Standards Taskforce

Project contact | Chris Mock, AEMO

Project summary

This project will identify relevant EV grid integration standards gaps and any international standards that may be candidates for adoption/modification to cater for the identified gaps. This will enable effective engagement and influence in relation to EV standards development in Australia and internationally. The absence of comprehensive EV grid integration standards increases the risk of an inefficient transition to electrified transportation for consumers, potentially leading to additional costs and reduced uptake of EVs. Notable standards gaps include charger performance and capability, interoperability and cybersecurity. Without standards to manage these issues, the costs associated with protecting the security and reliability of the electricity system are likely to climb as EV uptake rises. Consumers would ultimately bear the cost through inefficient network augmentation and reduced flexibility/market choice.

Equally relevant is the risk of over-regulation in this space leading to increased compliance costs and difficulties for international manufacturers launching products in the Australian market. To ensure that appropriate international standards are being identified for adoption domestically and that these standards sufficiently consider the Australian context, greater involvement in the relevant international standards committees is needed.

Key project deliverables

1. Locate gaps in the EV grid integration standards landscape in Australia where the absence of a standard may lead to negative impact on consumers
2. Catalogue international standards that may be candidates for adoption/modification to cater for the identified gaps
3. Develop a prioritised list of domestic and international standards committees where the Australian EV sector could benefit from greater engagement, and recommend suitable candidates for these committees (where possible)

Key project innovation

This work aims to address gaps in the EV grid integration standards landscape that may lead to negative impacts on electricity consumers. While many EV grid integration questions are in common with broader DER integration considerations, the focus of this group is on implications specific to EVs that are not covered in other forums.

Project timing and progress

Kickoff June 2020; targeting December 2020 delivery

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	The behaviour of the EV fleet and charging infrastructure (both charging load and V2G applications) during disturbances will be increasingly important as penetration grows. This program will consider necessary performance requirements and how they might be introduced here – including potential international standards that may be candidates for adoption.
1.2 Grid support	Yes	EVs have the potential to provide a range of grid supportive capability to assist both distribution network and bulk power system operation. The program will consider these opportunities and necessary requirements to enable them. Important considerations include: whether AS4777.2 can apply to onboard V2G inverters; as well as pathways for grid support for vehicles serving purely as load.
1.3 Protection and control functions	Yes	A level of coordination is required to ensure both safe operation of the distribution network during local network faults and secure bulk system operation during transmission-level disturbances.
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	A key focus of this work is on making both small and large EV charging 'aggregation and control' ready, and able to be integrated within home and facility/building energy management systems.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Identifying gaps in relevant EV standards, and international standards that may be candidates for adoption to fill any gaps
2.3 Cybersecurity	Yes	Identifying gaps in relevant EV standards, and international standards that may be candidates for adoption to fill any gaps
3. Understanding DER behaviour		
3.1 DER visibility	No	
3.2 DER modelling	No	
3.3 Network hosting capability	No	

Functional area	Yes / No	If yes, how?
3.4 Bulk system security and reliability	Partially	The program will consider functions and capability that will help with managing the bulk power system impacts of increasing EV penetrations, including performance during disturbances, system balancing and resource adequacy.
3.5 Distribution system reliability and power quality	Partially	Priority actions identified in this work will assist DNSPs to manage EV integration within their networks.
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

Next steps will likely include implementation/adoption of priority standards identified through this work

Project partners

AEMO is co-leading this work with the Commonwealth Department of Industry, Science, Energy and Resources. Taskforce includes DEIP EV Grid Integration Working Group members and relevant industry participants.

Relationship to other projects

The overarching DEIP EV Grid Integration Working Group aims to facilitate the efficient integration of EVs into existing networks and markets. Four taskforces are operating under the working group in 2020:

- Data Availability (led by AEMO)
- Standards (this work)
- High Capacity Tariffs and Connections (led by EV Council)
- Residential Tariffs and Incentives (led by EV Council)

Links to further project information

https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/ev-grid-integration-working-group/

ARENA state of DER technical integration | project summary

Project name | Demonstration of Three Dynamic Grid-Side Technologies

Project contact | Peter Wong, Network Technology & Measurement Manager, Jemena

Project summary

Jemena and project partners AusNet Services and University of NSW are demonstrating how increasing the visibility of LV networks can help manage grid power and voltage fluctuations. Three grid-based technologies are being assessed:

- Dynamic phase switching of customer loads on LV feeders to help mitigate localised over-voltage challenges caused by concentrated DER assets. Laboratory bench testing of customer appliances was undertaken to confirm no adverse impact due to the dynamic phase switching prior to deploying on network. Locally measured data is utilised for decision making on dynamic phase switching
- Dynamic power compensation to adjust the output voltage and mitigate load unbalance challenges at distribution transformers. Voltage issues best managed at distribution substation level are addressed here.
- Battery energy storage with Virtual Synchronous Generator (VSG) capability to mitigate potential power quality and network stability challenges caused by very high DER penetration. This is the most expensive of the three solutions but may be required in LV network with high DER penetration levels and where the first two solutions cannot effectively manage voltages.

The overall project objective is to assess the technology benefits and business case for deploying these solutions in various parts of the network (e.g. urban vs semi-urban areas). These solutions are complementary (e.g. dynamic phase switching is coarse adjustment and finer adjustment can happen through power electronics based control at distribution transformer level). However, it is to be noted that these solutions may not need to be deployed all in one location.

Grid side technologies are to be trialled. There are no BTM or customer side tech / solutions deployed.

Key project deliverables

The Project will deliver the following outcomes:

- A demonstration, at two LV network sites, of the potential of three dynamic grid-side technologies (phase switching devices, dynamic power compensation, grid battery with Virtual Synchronous Generator capability) for increasing network DER hosting capacity and improving LV network power quality.
- An assessment of the technical performance and cost-effectiveness of these technologies in increasing DER hosting capacity and improving network power quality for the demonstration network sites.
- Through associated modelling and simulation, provide analysis and conclusions regarding the expected technical potential and cost-effectiveness of the technologies to increase DER hosting capacity of distribution networks more broadly, both for each individual technology and when two or more of the technologies are used together.

Key project innovation

The technologies and control systems are commercially available products, however as far as we know, their combination and application to increase DER hosting capacity is an Australian or even a world first. As this is the first novel use of these power electronics technologies on the Australian electricity networks, the activity includes extensive modelling, simulation and bench testing at the Energy Systems Laboratory of the University of New South Wales using an expensive array of Real Time Digital Simulators (RTDS). We have also planned to study the impact of the phase switching devices on customer supply quality and customer appliances by bench testing common customer appliances. The University of NSW will provide analysis of the demonstration results and determine hosting capacity increase as a result of the technology deployment.

Project timing and progress

Project started in January 2019 and has a two-year duration. By the beginning of May 2020, Jemena and its project partners have developed the equipment specifications and completed bench testing of the effect of phase shifting operation on common household appliances (e.g. the impact of momentary power loss across the switching cycle). Data has been collected from two demonstration networks to feed into network modelling. Computer modelling for optimal placement of the new network technologies and operating parameters has been completed. Jemena and AusNet Services have worked closely with local residents and councils and have successfully installed and begun field trials of pole-mounted phase shifting devices, a power compensation device and central controllers. The containerised battery energy storage system (BESS) has just been commissioned by Jemena in early May 2020. Field trials of the three technologies will progress through to September 2020. Project completion date is early 2021.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	Yes	Supporting the grid to ensure power quality is maintained while more DER (rooftop PV) is added to the network
1.3 Protection and control functions	Yes	Controlling the operation of these grid-side technologies in response to power quality disturbances caused by DER
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	Yes	Cybersecurity principle is applied to ensure these new devices are guarded
3. Understanding DER behaviour		

Functional area	Yes / No	If yes, how?
3.1 DER visibility	Yes	Integration with SCADA system for monitoring, but no control functionalities as part of the project at the SCADA level
3.2 DER modelling	Yes	Offline modelling
3.3 Network hosting capability	Yes	
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	On the local LV distribution network only
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

A key output of the project is a business case for wider deployment of the technologies based on costs and benefits. There is learning through the trial project that will require further enhancement to equipment features and software functionalities. The adoption of the learning by equipment manufacturers will assist wider deployment but this is subject to commercial decision by the manufacturers in regard to market size for these types of equipment.

Project partners

Jemena, AusNet Services, UNSW, SGID, ARENA

Relationship to other projects

N/A. The Battery element of this project differs from other grid-side battery and community battery projects because it has a specific focus on increasing DER hosting capacity. The energy in the battery is not traded in the retail market.

Links to further project information

www.jemena.com.au/solarfriendly

ARENA state of DER technical integration | project summary

Project/initiative name | DER Enablement Project (Phase 1)

Project contact | Dean Lombard, Renew (dean@renew.org.au) and Damien Moyse (damien@renew.org.au)

Project summary

This project aimed to identify the range of technical problems associated with DER feed-in, understand the range and costs of remediation options, and – as much as possible – identify the types of approaches that deliver maximum customer benefit while remediating the problems in different types of networks and at different levels of DER penetration. This would then give guidance to consumer advocates and other stakeholders seeking to engage in the development of DER enablement policies and practices, including DNSP proposals as part of their electricity distribution price reviews (EDPRs).

Renew was project instigator and manager. A Steering Committee with representatives of network businesses, other energy businesses, market bodies, and consumer organisations guided the project. Energeia was contracted to undertake the technical analysis and modelling. Energy Consumers Australia funded the project.

Key project deliverables

1. Develop consumer principles for DER management, defining the consumer experience outcomes any recommendations should deliver
2. Identify the range of technical issues caused, exacerbated, or revealed by DER feed-in, and the efficacy and cost of remediation methods
3. Assess the applicability and cost-effectiveness of various solutions to the various problems in different types of network situations and recommend optimal approaches that deliver the consumer benefit espoused in the principles.

Key project innovation

This project identified the range of technical problems and remediation methods and collated them in the one place for the first time. It also found that much more detailed and bottom-up modelling is required to draw conclusions robust enough to guide detailed engagement in DER enablement proposals. And it found that despite the lack of detail, it was clear that adjustment of voltage output from distribution transformers is likely to be the most cost-effective first step in addressing voltage rise and increasing hosting capacity in typical networks.

Project timing and progress

Activity	*Proposed delivery*	*Actual delivery*
Establish steering committee	*June 2019*	*July 2019*
Develop consumer principles	*July 2019*	*September 2019*

Activity	*Proposed delivery*	*Actual delivery*
Publish draft Options Paper	*October 2019*	*This deliverable was split in two. A draft Problem Statement paper was completed November 2019 for consultation with the Steering Committee, and a final was published January 2020 for public consultation.*
Consult on draft Options Paper	*December 2019*	*April 2020 (targeted consultation)*
Publish final Options Paper and project final report	*April 2020*	*May 2020*

Project functional scope

Functional area	**Yes / No**	**If yes, how?**
1. Devices		
1.1 Ability to withstand disturbances	Yes	The impact of solar PV on worsening disturbances was identified, and the utility of static export limits and inverter configuration to remediate this assessed
1.2 Grid support	Yes	The role of DER in grid support functions was discussed in the technical report
1.3 Protection and control functions	Yes	The impact of solar PV on protection maloperation was identified, and the utility of static export limits, inverter configuration, network topology changes and protection scheme changes to remediate this assessed
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	The value of interoperability was discussed in the technical report
2.2 Integration of DER within AEMO and distributors' systems	Yes	The value of greater positive integration of DER with DNSPs' systems was discussed in the technical report
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	The value of DER visibility for DER management was discussed in the technical report
3.2 DER modelling	Yes	DER modelling was used in the analysis, including high-DER/low-DER sensitivities in the main modelling
3.3 Network hosting capability	Yes	The analysis was heavily focused on the most cost-effective approaches to build efficient DER hosting capacity in distribution networks

Functional area	Yes / No	If yes, how?
3.4 Bulk power system security and reliability	Yes	The Problem Statement identified a number of transmission system impacts from surplus DER exports including excessive ramp rate, thermal overloads, and reduced fault currents
3.5 Distribution system reliability and power quality	Yes	The Problem Statement identified a significant number of distribution system impacts from surplus DER exports including over-voltage, under-voltage, flicker, thermal overload, protection maloperation, under frequency shedding, phase imbalance, and forecasting error
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	The project found that assessing wholesale market impacts of DER enablement was essential in comprehensively assessing the cost–benefit of DER enablement strategies
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

A more comprehensive and sophisticated modelling and assessment approach is needed to fully examine all main issues and potential solutions, the cost–benefit relationships between different approaches in different parts of the same network, and the broader benefits to consumers from the impact of DER on energy prices. We have sought funding for a follow-up project that uses a whole-of-system model to deliver the comprehensive view needed to credibly inform DER integration approaches.

Project partners

- Energeia (technical consultant)
- Energy Consumers Australia (funder)
- We'd also like to acknowledge AusNet Services, Jemena Electricity Networks, Essential Energy, SA Power Networks, AGL, Solar Analytics, farrierswier, ARENA, St Vincent de Paul Society and Central Victorian Greenhouse Alliance for participating in the Steering Committee.

Relationship to other projects

We engaged with a number of other projects and processes as part of this project. Most significantly was ARENA/AEMC et al.'s *Distributed Energy Integration Project*, ACOSS/TEC/ECA/AEMO/ARENA/AER's *DER Pricing and Access* project, ESB's DER Integration work program, and AEMO and ENA's *Open Energy Networks* project. These are all looking at the bigger picture of DER integration – such as developing new access arrangements and pricing models, or looking at the impacts of technological changes – while this was complementary, looking in a more detailed level at the technical issues and solutions – the actual things distributors will be doing that drive costs and enable access – and the consumer experience – the way households and small businesses behave, invest, and innovate.

This project also heavily informed the analysis of the Victorian networks' DER integration proposals in the ECA-funded BSL/VCOSS/Renew project to engage with the Victorian EDPR.

It's also worth noting that our main project finding – that voltage adjustment at the LV transformer level is a low-cost and effective first step in managing DER-induced voltage rise – was in alignment with the findings of UNSW CEEM's recent project (Anna Bruce et al. 'Voltage Analysis of the LV Distribution Network in the Australian National Electricity Market', UNSW & CEEM, May 2020)

Links to further project information

https://renew.org.au/research/distributed-energy-resources-enablement-project/

ARENA state of DER technical integration | project summary

Project/initiative name | Powercor DER Hosting Capacity Study

Project contact | Praneel Pradhan, Powercor (PPradhan@Powercor.com.au)

Project summary

The project aims to demonstrate the issues faced by Australian distribution networks in maintaining security and quality of supply in the context of increasing distributed energy resource (DER) penetration. It will also assess potential mitigation options, based on analysis of implementation cost versus benefit (i.e. additional PV hosting capacity created). This will provide a basis for more informed discussion between industry and academia using actual network data and a publicly available power system analysis software.

Key project deliverables

- The completed Study
- A version of the Study suitable for public release
- A Final Report

Key project innovation

This project will further the industry's collective knowledge of the subject matter as well as establish a replicable methodology for academia in assessing DER Hosting Capacity of DNSPs using freely available software.

Project timing and progress

- The completed Study – **complete.**
- A version of the Study suitable for public release – **complete.**
- A Final Report – **in progress.**

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	

2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	No	
3.2 DER modelling	Yes	By building and running a powerflow model to represent 10 highly diverse LV networks.
3.3 Network hosting capability	Yes	By establishing a replicable methodology to assess the hosting capacity of LV networks and understanding the performance of a range of mitigation measures to increase hosting capacity in the future.
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	By identifying the mitigation measures to address power quality (voltage and thermal constraints) at a minimal cost
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

As an outcome of this study, the following general recommendations were made. Each DNSP is different and these recommendations may not necessarily apply to all DNSPs equally.

- Allow for flexible/dynamic export of PV generation
- Promote and install smarter inverters in jurisdictions that expect PV growth
- Consider other mitigation measures to complement smart meters
- Leverage additional tap range and target 230V when LV transformers are replaced
- Build power flow models for a wide variety of networks
- Explore the potential of behind the meter batteries.

Project partners

ENEA Australia.

Relationship to other projects

The **National Low-Voltage Feeder Taxonomy Study (CSIRO)** aims produce the first national low-voltage network taxonomy that outlines the real-world characteristics of the distribution system. Depicting how low voltage power flows through the system will help with the design and assessment of the technologies and systems that can maximise the hosting capacity of DER across Australia.

We have provided our learnings from modelling the 10 highly diverse LV networks to CSIRO. We have provided technical guidance to them around modelling the LV network.

The **evolve DER project (Zeppelin Bend)** aims to increase the network hosting capacity of DER by maximising their participation in energy, ancillary and network service markets, while ensuring the secure technical limits of the electricity networks are not breached.

The **Advanced Planning of PV-Rich Distribution Networks Study (University of Melbourne/AusNet)** will develop analytical techniques to assess residential solar PV hosting capacity of electricity distribution networks by leveraging existing network and customer data. This project will also produce planning recommendations to increase solar PV hosting capacity using non-traditional solutions that exploit the capabilities of PV inverters, voltage regulation devices, and battery energy storage systems.

Links to further project information

https://arena.gov.au/projects/distributed-energy-resources-hosting-capacity-study/

ARENA state of DER technical integration | project summary

Project/initiative name | DER impact on bulk power system operation

Project contact | Jenny Riesz, AEMO

Project summary

This is an ongoing program of work focussed on the bulk power system implications of increasing DER uptake – when challenges may emerge, how these challenges might be addressed and, where necessary, mitigation measures. As penetrations increase, the aggregated impact of this fleet affects almost all core duties of the bulk system operator in some way due to:

- **Performance during disturbance** – resulting in increasing contingency sizes following transmission faults due to the potential mass disconnection of DPV systems.
- **Ongoing reduction in the daytime system load profile** – impacting the availability of stable load blocks necessary for the effective operation of emergency mechanisms, load available for minimum synchronous generation levels necessary for system security and transmission network voltage control.
- **An increasingly large source of variable generation** – contributing to increasing ramping requirements for system balancing due to the daily diurnal solar profile, faster, less predictable ramps in significant PV clusters at the sub-regional level due to cloud movements.
- **An increasingly large source of generation that cannot be curtailed** – resulting in a less dispatchable power system as, unlike centralised generation, AEMO cannot curtail DPV today even under extreme, abnormal system conditions.

The current focus, given high levels of penetration in the NEM and SWIS today, is on passive distributed PV (DPV).

Work to date has mainly centred on the South Australian region given its high share of DPV generation relative to local underlying demand, and weak interconnection with the NEM – with other regions to follow.

Key project deliverables

- Ongoing investigations into the implications of increasing passive DPV generation in South Australia:
  - Findings and recommendations have been consolidated in a series of technical reports for the South Australian government.
  - This work was also highlighted in the assessment of bulk system challenges identified in the Renewable Integration Study – with respect to the criticality of DPV disturbance withstand capability and curtailability during extreme, abnormal power system conditions.
- Ongoing investigations into DER behaviour during power system disturbance events and reporting on this within power system incident reports.
- Development and ongoing refinement of DER models and methodologies for power system modelling.
- Investigations into the adequacy of emergency mechanisms as DPV generation continues to reduce system loading in the daytime, including the adequacy of under frequency loading shedding schemes (being considered as part of the 2020 Power System Frequency Risk Review) and system restart processes.

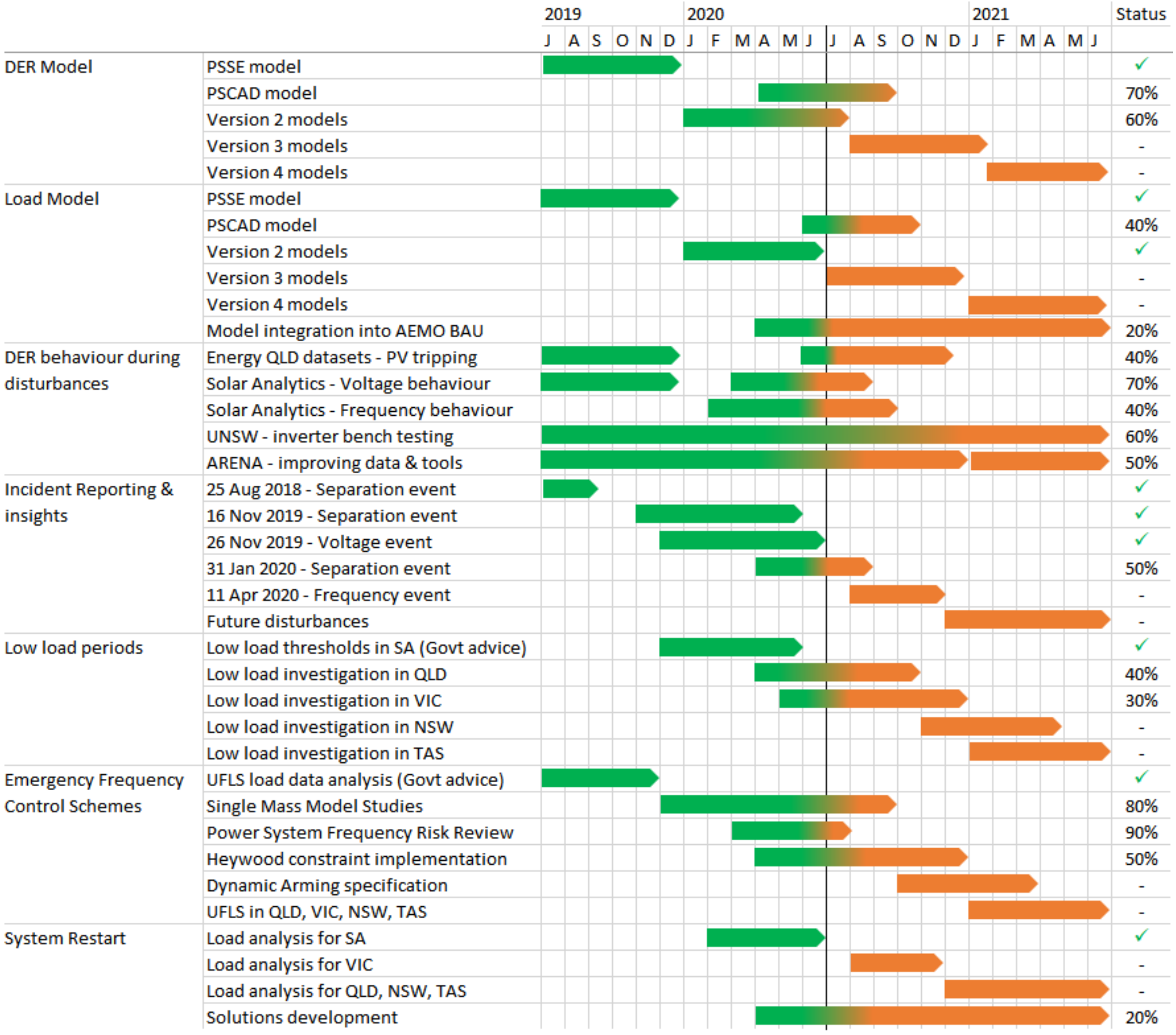
Provision has been made for other areas to be considered as they emerge, as understanding improves over time.

Key project innovation

This is the first, consolidated effort to identify the implications of increasing DER on bulk power operation in Australia. In doing so, this work has directly contributed to identifying key actions that can help with efficiently integrating DER in the future power system as penetrations increase. The intention is for this to be a BAU function of AEMO into the future.

Project timing and progress

This project is being delivered progressively during 2020-21. Key milestones and progress towards these is illustrated in the Figure below.



Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	The analysis has prioritised this to be a critical gap that needs to be addressed to securely integrate increasing levels of inverter-based DER in the power system, given the mass-disconnection risk.
1.2 Grid support	Yes	The work has also identified other autonomous response from DER inverters that could assist with different bulk power system challenges.
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	No	
3.2 DER modelling	Yes	Significant effort has gone into representing DER behaviour and impacts across various timescales within various modelling contexts: e.g. examination of load available for shedding through UFLS scheme, and the development of DER models for dynamic power system studies.
3.3 Network hosting capability	No	
3.4 Bulk power system security and reliability	Yes	This is the core focus of this task – particularly challenges to bulk power system security as DER penetrations increase.
3.5 Distribution system reliability and power quality	No	

Functional area	Yes / No	If yes, how?
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Opportunities have been identified for DER devices to provide services assisting with managing the bulk power system challenges considered.
4.2 Provision of localised network services	No	Not directly but active management of DPV and other DER in the LV distribution network is recognised as something that can assist with some of the bulk power system challenges assessed.

Next steps and constraints or impediments to BAU adoption

AEMO is considering proposals to extend this program of work to a longer term "business as usual" function within AEMO from July 2021, supporting AEMO Operations teams to integrate DER into their models and delivery of their operational functions. Budget constraints may limit the resources that can be dedicated to this objective.

Project partners

DNSPs, SA government and other parties in their 'DER taskforce', regulatory bodies.

Relationship to other projects

Analysis of system issue in SA heavily informed the findings and recommendations of the DPV component of the Renewable Integration Study.

Work to enhance understanding of DER performance through analysis of monitoring data and laboratory bench-testing has informed developed of composite DER load models for dynamic power system studies.

Links to further project information

AEMO, Integrating Utility scale Renewables and Distributed Energy Resources in the SWIS (March 2019): https://aemo.com.au/-/media/files/electricity/wem/security_and_reliability/2019/integrating-utility-scale-renewables-and-der-in-the-swis.pdf

AEMO, Technical Integration of Distributed Energy Resources (April 2019): https://www.aemo.com.au/Media-Centre/Technical-Integration-of-Distributed-Energy-Resources-Report

AEMO, Renewable Integration Study Stage 1 Appendix A: High Penetrations of Distributed Solar PV (April 2020): https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-stage-1-appendix-a.pdf

AEMO, Minimum operational demand thresholds in South Australia (May 2020): https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/sa_advisory/2020/minimum-operational-demand-thresholds-in-south-australia-review.pdf

ARENA state of DER technical integration | project summary

Project/initiative name | DER Integration and Automation

Project contact | Eddie Thanavelil, Demand Side Innovation Engineer, Evoenergy (Eddie.Thanavelil@evoenergy.com.au)

Project summary

The DER Integration and Automation Project will demonstrate how collaboration between a Distributed Energy Resources Management System (DERMS) and the GreenSync Decentralised Energy Exchange (deX) platform can unlock existing network hosting capacity to enable consumers to gain more value from their energy assets (such as solar, batteries and electric vehicles).

Key project deliverables

1. Testing the capability and outcomes of dispatching DER to avoid upstream capacity constraints with the potential benefit of deferring the need for network augmentation investment
2. Validating VPP dispatch requests against known network hosting capacities mapped in the ADMS in order to maximise exports of DER energy in response to market signals
3. Analysing the degree to which network violation from natural DER behaviour is avoided if dispatched through this system

Key project innovation

This project will use two leading industry platforms to demonstrate a coordinated approach to utilising a fleet of DERs within technical and commercial boundaries.

Project timing and progress

Milestone	Delivery Date	Status
Phase 1 – Initiate and setup	Nov 2019	Completed
Phase 2 – Design of use cases and thresholds of simulation	March 2020	Completed
Phase 3 - Integrate and Deliver - Factory Acceptance Testing (FAT) report and signoff for module integration	October 2020	On Track
Phase 4 - Completion of Testing and Delivery; and Phase 5 - Report Development and Knowledge Sharing	February 2020	On Track

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Partial	This project will look at integration of simulated DER from external parties via the GreenSync platform to map onto the DERMS module hosted on Evoenergy's network model. This will investigate and test options for how DER can effectively integrate into our energy system and how they can be used by customers to their full potential. The project is not integrating with AEMO.
2.2 Integration of DER within AEMO and distributors' systems	Partial	
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	This project will look at integration of simulated DER from external parties via the GreenSync platform to map onto the DERMS module hosted on Evoenergy's network model. Various thresholds of DER will be simulated to understand the hosting capacity of the LV model while requesting DER behaviour modulation to avoid network violation.
3.2 DER modelling	Yes	
3.3 Network hosting capability	Yes	
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	No	
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

At completion, this work will be published into the public domain where it can:

- Be leveraged by future projects.
- Give clarity on hosting capacity levels

Impediments include standards for DER integration from vendors and DNSPs, and lack of DER visibility for networks.

Project partners

Partners - Schneider Electric, GreenSync, Withywindle,

Knowledge Sharing Advisory - SA Power Networks, Energy Queensland Limited

Relationship to other projects

No particular relationships to other projects, but ARENA has funded GreenSync for a few other projects and there could be some synergies and functionalities that will be shared between these GreenSync projects.

Links to further project information

https://arena.gov.au/projects/der-integration-and-automation-project/

https://www.evoenergy.com.au/about-us/media-centre/2020-03-12-new-energy-market-demonstration-project

ARENA state of DER technical integration | project summary

Project / Initiative name | DER Integration API Technical Working Group

Project contact | Lachlan Blackhall, ANU (lachlan.blackhall@anu.edu.au) / Ben Weise (ben.weise@anu.edu.au).

Project summary

The DER Integration API Technical Working Group is comprised of organisations actively developing DER Integration capabilities. These organisations are pursuing this initiative to support the development and implementation of an industry standard API for programmatically sharing data amongst the organisations in the Australian electricity sector.

Key project deliverables

This group will focus on producing two key outputs:

1. An agreement on the use cases for DER Integration, including who generates what data, with what specifications (resolution, quantisation, etc…), and who needs access to that data. This will be codified in a Use Case document.

2. An agreed API specification, allowing data to be programmatically transferred between actors in the electricity system. This will be codified in an Australian implementation guide for the IEEE2030.5 standard.

Key project innovation

This activity will support the integration of DER at scale by identifying the communication standards that allow DER to integrate with both DNSP and AEMO systems. This will enhance network visibility for both DNSPs and AEMO as well as supporting important DSO and DMO use cases.

Project timing and progress

Activity	Proposed Delivery	Status
Articulation of Use Cases	September 2019	Completed.
Detail of Use Cases	December 2019	Completed.
Initial draft of Australian IEEE2030.5 implementation guide.	December 2019	Delayed. Targeting delivery by September 2020.
Final draft of Australian IEEE2030.5 implementation guide.	March 2020	Delayed. Targeting delivery by December 2020.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	

Functional area	Yes / No	If yes, how?
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Working to develop an integration guide for the IEEE2030.5 standard which supports DER Integration and interoperability.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Working to develop an integration guide for the IEEE2030.5 standard which supports DER Integration into AEMO and DNSP systems.
2.3 Cybersecurity	Partial	Extensions of the IEEE2030.5 standard could underpin identify management and DER cybersecurity.
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Utilising the outputs of this initiative will support networks and AEMO in obtaining DER visibility.
3.2 DER modelling	No	
3.3 Network hosting capability	No	
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	No	
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

At completion, this work will be published into the public domain where it can be:

- leveraged by future projects.
- adopted into Australian standards.
- referenced through future rule changes.

Project partners

AEMO, AGL, ANU, AusNet, Energy Queensland, Greensync, Horizon Power, SAPN and TasNetworks, SwitchDIn, Rheem, Wattwatchers

Relationship to other projects

This initiative is related to a large number of other projects being explored by the project partners listed above. It is not possible to exhaustively list these projects here.

Links to further project information

Supporting documentation attached:

- Working group charter.
- Current version of the DER use cases developed through this initiative.

ARENA state of DER technical integration | project summary

Project/initiative name | DER Visibility and Monitoring Best Practice Guide

Project contact | Stefan Jarnason, Solar Analytics

Project summary

This Distributed Energy Resources (DER) Visibility and Monitoring Best Practice Guide (the Guide) has been developed by the DER industry to specify the data required to enable the transition of our electricity network to a high penetration DER grid. DER includes rooftop solar, batteries, and other appliances such as Electric Vehicles (EV) chargers.

Objective 1:

To establish a common static and dynamic (near) real time data set collected for new DER installed behind the meter on the low voltage electricity network.

Target Outcomes: Provide consistent data required to equitably and cost effectively increase network hosting capacity for DER. Enable regulatory bodies, DNSPs, academics and other parties to procure and combine data from multiple sources to meet their network modelling and visibility needs – subject to appropriate commercial arrangements.

Objective 2:

To increase confidence in the quality and performance of DER through the provision of this real time system performance data to DER owners and authorised industry entities.

Target Outcomes: Enables consumers and industry participants have consistent information sources to ensure and evaluate optimal operation and system quality.

Key project deliverables

1. Industry supported best practise guide publicly available that details what data needs to be collected (includes FAQ and use cases). Done - https://www.dermonitoring.guide/
2. Incentivised trial underway in at least one jurisdiction to demonstrate the use of the Guide, use cases and progress the technical and market solutions for how the data is managed.
3. Industry developed, supported and adopted standards for how to utilise the Guide nationally for all DER.

Key project innovation

Industry agreement on what data can be captured and shared to maximise the value of DER, and pace of adoption.

Project timing and progress

1. Done
2. Started. Goal is to complete trial by end 2020
3. Very early stages. Led by AEMO. Goal is by end 2021, subject to industry input and considerations.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Harmonized data collected by DER to enable analysis from multiple providers
2.2 Integration of DER within AEMO and distributors' systems	Yes	Visibility and link to DER Register
2.3 Cybersecurity	Yes	Stage 2 of the DER Guide will address the "how", which includes how data privacy is ensured
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Harmonised standard for DER static and dynamic data
3.2 DER modelling	Yes	Data available to third parties readily
3.3 Network hosting capability	Yes	Better export limits and penetration through better visibility of the DER data in a harmonised manner
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	Where network support is required
4. Services		
4.1 Integration with wholesale energy and system security services markets	Partial	First step to making this viable
4.2 Provision of localised network services	Yes	Identify voltage and other feeder issues

Next steps and constraints or impediments to BAU adoption

1. Establish incentivised trail
2. Work with AEMO to prepare effective national standards for how this data is managed

Project partners

Solar Analytics, GreenSync, SMA, Enphase, Edge Electrons, ANU, Wattwatchers, SwitchDin, Redback, Tesla, Sonnen, Fronius

Relationship to other projects

- DER Register – link static and dynamic fields
- Project Evolve – how data is managed
- DEIP – integration of DER
- AEMO technical API working group – how data is managed
- VPP – need to align data fields

Links to further project information

https://www.dermonitoring.guide/

ARENA state of DER technical integration | project summary

Project/initiative name | UNSW Digital Grid Futures Institute

Project contact | Professor Joe Dong, UNSW; Sharon Swift, Institute Manager

Project summary

The UNSW Digital Grid Futures Institute brings together UNSW's researchers and major partners across industry, government, research institutions and the community to advance the blueprint for future energy systems globally. The Institute is undertaking a range of research on DER technology integration issues including:

- **Microgrid planning methodologies and algorithms**: study of grid capability to host DERs/microgrids, perform generator performance studies, modelling energy storage in enabling grid connections
- **Microgrid operations methodologies**: voltage control, three phase power flow, demand forecast, solar general forecast, wind forecast, electricity price forecast
- **VPP research**: forecast algorithms for solar generation (cloud coverage modelling), battery SOC optimisation, NEM price prediction, demand profile/prediction; VPP as demand side support and participate in FCAS to provide grid support
- **UNSW Smart Meter and Home Appliances testing lab**: through ARENA funding and UNSW support, we established a lab with advanced metering and power quality measurement capability to enable us to study different DER grid connection and control impacts on the operations, safety and performance of most common home appliances; the measurement system also allows for non-intrusive load monitoring which can be used to form better load modelling, identification of demand side management capability, and user energy consumption profile for marketing purposes
- **Peer to peer trading**: our ongoing research on peer to peer trading based on block chain technologies to facilitate and enable reliable energy transactions in a distribution market among prosumers to trade DER capacity
- **Smart home energy management**: algorithms to integrate home energy management considering DERs, demand side management, smart appliances, EV, and ensure human comfort levels instead of just energy saving
- **UNSW RTDS (Real Time Digital Simulator) lab**: this lab is the largest in the southern hemisphere with 18 racks to enable hardware in the loop simulation and testing for various DER grid connection and control technologies/systems/equipment
- **Zero emission community development initiative**: working with regional councils to develop zero emission community with DERs, renewables, EVs, carbon credit (planting trees), energy storage etc toward achieving zero emissions from the dedicated community/community groups
- **Condition monitoring for electrical grid assets which connects DERs**
- **Wireless power transfer for telecommunications to support smart devices**
- **Impact of autonomous and electric vehicles on the digital grid and energy consumption**, including vehicle to grid integration and interoperability
- **Integration of large scale energy storage for communities**
- **EV charging infrastructure system planning**
- **Integration of solar panels onto cars**, logging irradiance to optimise solar capture for battery top up on road vehicles
- **UNSW DGFI also funds seed projects**, some are related to DER and clean hydrogen technologies

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Modelling, stability assessment and control
1.2 Grid support	yes	Control, energy storage
1.3 Protection and control functions	yes	Various control methods to support DER hosting
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Communications and computing platform, condition monitoring, VPP
2.2 Integration of DER within AEMO and distributors' systems	Yes	Various grid connection studies
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Modelling, simulation, monitoring
3.2 DER modelling	Yes	Detailed modelling at low voltage level
3.3 Network hosting capability	Yes	Modelling, and control methods
3.4 Bulk power system security and reliability	Yes	Various stability assessment and renewable grid connection studies
3.5 Distribution system reliability and power quality	Yes	We have lab facilities, and as part of the grid connection studies, for power quality analysis
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	Except for peer to peer trading
4.2 Provision of localised network services	Yes	Microgrid (off grid microgrid/smart grid) solutions, mobile power supply techniques, independent utility model planning

Project partners

Jemena, AusNet Services, Tyree Foundation, ARC, ARENA, SMA, Goldwind, AlphaESS, Sungrow, CSIRO

Relationship to other projects

This document is a high level overall summary of the research capabilities of the key investigators associated with the institute.

The institute's researchers led the ARENA funded project "Addressing barriers to efficient grid integration", which involved testing the response of a range of PV and storage inverters to disturbances of different kinds on the network.

Links to further project information

https://research.unsw.edu.au/digitalgridfutures/

ARENA state of DER technical integration | project summary

Project/initiative name | Dynamic Limits DER Feasibility Study

Project contact | Alex Lloyd, Dynamic Limits, alex.lloyd@dynamiclimits.com

Project summary

The Dynamic Limits DER Feasibility Study explored implementing dynamic operating envelopes for distributed energy resources (DER) to better manage voltage and thermal constraints on electricity networks.

The study examined existing approaches to managing network capacity constraints, investigated the general technical feasibility of implementing a dynamic DER control scheme, and undertook a site-specific analysis, examining implementation on feeders experiencing constraints.

The focus was on the management of local network constraints so that the hosting capacity of electricity networks is unlocked thus further enabling DER Orchestration activities.

Key project deliverables

The projects' single deliverable was the release of a public report for publication on ARENA's website. The report's specific hypothesis is that the decentralised control of DER for the management of local network constraints can provide a range of benefits, in particular for regional, rural, and remote network sections. These networks were of particular focus because they capture the majority of Australia's solar irradiance while also representing the weakest network sections, with the poorest communication availability, and are resource constrained (in terms of revenue per km of network managed). , but it is to remain confidential until it is finalised and actually released.

The project reviewed existing literature and approaches to ensuring that network constraints are managed. This included a review of the impact of static limits and Volt-Var and Volt-Watt response modes under AS4777. International work (e.g. IEEE2030) and Australian initiatives (e.g. Open Energy Networks) were also reviewed to identify emerging approaches (and challenges) to the implementation of dynamic operating envelopes on distribution networks.

The feasibility of a novel control scheme was then examined. The scheme was examined both in general terms and looking at two specific potential implementations on rural and remote feeders. The project then examined the ability of the scheme to address the challenges identified by the reviewed literature and through the stakeholder consultation process.

Overall, the desktop study (which examined two rural NSW feeders) found that increases in hosting capacity of 300% or more are generally possible, with the proposed approach also offering a number of additional benefits (see below).

Key project innovation

The key innovation from the project is the finding that, for rural and regional networks, the management of dynamic DER limits is best achieved when implemented at the lowest level of the control hierarchy.

By decentralising the management of local network constraints, the control scheme is able to ensure that this control agenda is enforced, thus enabling orchestration agendas to occur without breaching the allowable network conditions.

Further, the use of the control scheme as proposed removes the need for up to date network models, provides a robust solution resilient to failure, is able to overcome challenges of tier bypassing, hidden coupling, and latency cascading, while also improving network visibility (which is a least regrets action from the Open Energy Networks initiative) and providing immediate impact for the areas where it is implemented first.

Project timing and progress

The project commenced in January of 2018 and was completed at the end of May 2020.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	The project examined how the use of intelligent DER Controllers are able to report on and enforce different responses to different disturbances
1.2 Grid support	Yes	The project examined how the dynamic DER control assists with managing network voltages
1.3 Protection and control functions	Yes	The project outlined how some network protection mechanisms (e.g. 3% voltage change rule) may affect functions
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	The project examined how the use of an Industrial IoT platform can enable backwards compatibility and improve interoperability between systems and devices.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Within DNSP/ DSO Systems, but not AEMO. The project also examined how the communication of information on DER and the network state to all stakeholders in parallel reduces cascading latency effects.
2.3 Cybersecurity	No	The project highlighted the need for additional work to be undertaken to establish clearer cybersecurity standards; current frameworks for 'self assessment' are not sufficient
3. Understanding DER behaviour		
3.1 DER visibility	Yes	The project highlighted how the use of intelligent controllers is able to improve visibility of DER behaviour.
3.2 DER modelling	Yes	The project highlights how current approaches to DER modelling are inadequate for estimating the impact of dynamic DER limits.
3.3 Network hosting capability	Yes	The project highlighted how dynamic DER limits can increase hosting capacity by about

		300% in most instances; but also highlighted the range of 'side constraints' that may continue to limit DER capacities (e.g. 3% voltage change rules, current network voltage configurations, and the exact transformer configuration)
3.4 Bulk power system security and reliability	No	Transmission level networks were beyond the scope of the project.
3.5 Distribution system reliability and power quality	Yes	Power Quality only; The project highlighted how the current implementation of 230V standards should be tightened to increase hosting capacity
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	The need for any dynamic DER limits scheme to interface with, and provide forecasts of likely availability, etc. to wholesale market participants (such as aggregators) was highlighted
4.2 Provision of localised network services	No	The project highlighted that local network constraints are best managed through the implementation of rules (i.e. import and export limits) rather than 'services' as this avoids 'hidden coupling' (i.e. one entity creating a problem another entity is then 'requested' to fix)

Next steps and constraints or impediments to BAU adoption

The next step for the project is an implementation of the scheme, with network sensors being implemented to increase network visibility and some installations implementing dynamic DER control to show the overall system efficacy and demonstrate that the benefits outlined can be actually achieved.

The primary constraint to this step is a resourcing constraint. The company will likely need to raise a round of capital to subsidise the initial implementation of the scheme.

Project partners

Essential Energy, SAGE Automation, UniSA, Opto22

Relationship to other projects

The Evolve project has a project aiming at the implementation of dynamic operating envelopes. However their approach includes the use of up to date network models and constraint engines, which is something that this project specifically attempted to exclude.

A number of other DNSPs had projects looking at a range of singular aspects (e.g. SAPN has a project, so does PowerCor / CitiPower.

Links to further project information

https://arena.gov.au/projects/dynamic-limits-der-feasibility-study/

ARENA state of DER technical integration | project summary

Project/initiative name | Demand response project

Project contact | Rando Yam, Enel X, rando.yam@enel.com

Project summary

Enel X (formerly EnerNOC) was provided with $9m of funding from ARENA and the NSW Government to develop a 50 MW portfolio (30 MW in VIC and 20 MW in NSW) to be used as dispatchable short notice reliability and emergency reserve trader (RERT) reserves by AEMO for the 3-year period from 1 December 2017 to 30 November 2020.

The portfolio will primarily consist of commercial and industrial (C&I) customers and the reserve provided will be purely from load curtailment, with no diesel back-up generators.

Enel X has installed its own metering technology (Enel X Site Server) at customer sites, and will use these meters to monitor site load and remotely initiate a safe load reduction for dispatch events. Therefore Enel X customers are capable of implementing load curtailment within 10 minutes of receiving dispatch instructions from Enel X indicating that a demand response event is commencing.

Key project deliverables

1. Develop a 20 MW demand response portfolio in NSW and 30 MW portfolio in VIC by 1 Nov 2017, to be available for dispatch by AEMO at 10 minutes notice during the 3-year project period (until 30 Nov 2020)
2. Participate in half-yearly 2-hour test events administered by AEMO of these portfolios to demonstrate ability to provide 50 MW of load curtailment – these are done prior to summer and winter each year.
3. Provide half-yearly knowledge sharing reports and data to ARENA, including evidence of successful test events, dispatch events and other key learnings during the 6 month period.

Key project innovation

As stated by ARENA, the purpose of this project is to help establish whether demand response can assist in maintaining a stable electricity grid in Eastern Australia. Enel X, is using the Enel X Site Server (ESS)[1], a highly secure, low latency communications gateway for energy management and demand response applications, to deliver its emergency reserve.

Since program commencement on 1 November 2017, we have had 75 C&I sites participate in the program. These include Enel X building in a 15-20% operational buffer on top of the original 50 MW for its NSW and VIC portfolios (to account for operational issues at customer sites during real dispatch events).

[1] https://www.enelx.com/content/dam/enel-x-na/resources/data-sheets-and-brochures/P18001-DR-Data-Sheet.pdf

All energy users have signed up to safely reduce their electricity consumption during demand response (DR) events dispatched by AEMO, and the majority agreed to the following pricing structure:

- Availability Payments – based on customers' daily availability for responding to a DR event. The units for these payments are $/MW/year.
- Energy Payments – based on the energy delivered/reduced per interval during a DR event. The units for these payments are $/MWh.

Availability Payments cover the costs of searching for, contracting, commissioning, account managing, and ensuring continuous availability of each customer facility. Energy Payments are intended to cover the short run marginal costs associated with load curtailment during DR events.

Payment terms with customers were negotiated on a case-by-case basis, depending on their individual operational requirements, size of loads, cost of reducing load, magnitude and complexity of required on-site technology and controls work, opportunity cost of other energy management strategies, and other commercial considerations.

On 24th January and 25th January 2019, AEMO dispatched our VIC portfolio on back-to-back RERT event days. For these events we had over 50 individual C&I sites in Victoria respond across the two days providing an average of 30 MW when most needed by the grid (read more on ARENA's website[2]). This 30 MW portfolio was also placed on standby by AEMO on 30th January and 31st January 2020 and available for dispatch at 10 minutes notice. Our NSW portfolio has also been put on standby for dispatch during the winter of 2018 and recently over summer 2019/20, but ultimately not dispatched.

Overall the project has demonstrated there is significant and latent potential for commercial and industrial customers to provide demand response during emergency events to help AEMO maintain grid reliability and system security.

Project timing and progress

Contracts were signed with ARENA, AEMO and NSW Government in September 2017, and within three months Enel X had built a 50 MW dispatchable portfolio by the 1 December 2017 program start date.

AEMO conducted initial commissioning tests for the two portfolios in January 2018, which Enel X successfully passed and therefore secured 25% of overall project funding.

Following these successful commissioning tests, Enel X has also successfully tested its portfolios in each half-yearly project period (usually in April/May and October/November), and provided comprehensive knowledge sharing reports to ARENA and NSW Government following each project period.

Enel X will also be providing an overarching whole-of-program report at the conclusion of the program on 30 November 2020, which will include key lessons learned, performance against program objectives, as well as opportunities to further advance demand response and renewable energy into the future.

[2] https://arena.gov.au/blog/dr-january-activation/?utm_medium=email&utm_campaign=ARENA%20WIRE%20040319&utm_content=ARENA%20WIRE%20040319+CID_f79be543858bafe39a11136d89f88df8&utm_source=enews&utm_term=Read%20more

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	Yes	Providing 50 MW of demand response during AEMO RERT events to help maintain grid reliability and system security, available for dispatch by AEMO at 10 minutes notice.
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Enel X has installed its own metering technology (Enel X Site Server) at customer sites, and will use these meters to monitor site load and remotely initiate a safe load reduction for dispatch events. Our metering hardware is designed to 'trip' loads at customer sites. More information is provided in Appendix A below.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Enel X is required to update MW capacity of its reserves in AEMO's Marketnet Portal – AEMO will use this information to determine total available reserves which in turns determines Lack of Reserve (LOR) levels for each region.
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	As noted above, Enel X is required to update MW capacity of its reserves at all times to provide AEMO with visibility of reserve levels. Enel X also uses its ESS meters for real-time monitoring of all customer sites to determine MW capacity, and uses this information to contact customers for further details regarding availability, and update AEMO's portal accordingly.
3.2 DER modelling	No	
3.3 Network hosting capability	No	
3.4 Bulk power system security and reliability	Yes	As above for point 1.2 (determined by AEMO, not the TNSPs)
3.5 Distribution system reliability and power quality	No	
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Yes, RERT is only dispatched after all AEMO attempts to address system security through

Functional area	Yes / No	If yes, how?
		price signals and market responses are exhausted. During the procurement process RERT itself is somewhat of a system security services market, where the lowest cost responses to tender (which can meet AEMO's reliability requirements) are considered and contracted by AEMO.
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

Following project completion on 30 November 2020, Enel X will work with all customer sites to determine whether their load profile is suitable for other forms of demand response, including for providing ancillary services (e.g. FCAS), RERT (if deemed required by AEMO for summer 2020/21), or network support / non-network solutions for distribution networks in NSW and VIC.

Constraints/impediments to BAU adoption:

1. Revenue certainty

Following program conclusion, without ongoing ARENA and NSW/VIC Government funding, there is less incentive to continue providing emergency demand response.

Long Notice (LN) RERT provides more certainty in terms of firm capacity payments across a whole summer, however whether AEMO requires LN RERT is a summer-to-summer proposition. AEMO has stated it will more likely procure more Short Notice (SN) RERT going forward, which does not offer any revenue certainty (only energy payments if reserves are dispatched). While this may help AEMO reduce overall RERT costs in certain summers, it may impact on customer willingness to participate – in our experience the vast majority of customers prefer a degree of revenue certainty. This in turn may only attract C&I customers who have a steep cost curve (i.e. large smelters etc.).

If customers were to only be offered SN RERT, they would only make money when the grid is going through an emergency situation, and they happen to be available for that day during summer.

2. Regulatory frameworks

There have been extremely few opportunities to provide wholesale demand response (apart from RERT over the past 3 summers). A large part of this are due to the regulatory framework and rules in place which do not naturally provide straightforward and simple ways to provide demand response to the market. To be fair, there are provisions for 'scheduled loads' to bid in the market, but these have been used on only a very small number of occasions and the requirements around bidding are very onerous to loads and aggregators.

While the Wholesale Demand Response mechanism is a welcome development, there are concerns about the overall design and whether it is difficult for less sophisticated C&I customers to participate in providing demand response to the market. Based on our experience with RERT over the past 3 summers, C&I customers and their aggregators should be able to bid in "Negawatts" (i.e. we can provide X no. of MWs of demand response over a certain number of intervals across a day).

Requiring customers and aggregators to actively monitor load on a 30-min or 5-min interval basis, and then have to bid in how much their load can drop to for every interval where they can provide DR, will be extremely difficult for those customers who do not have a flat load profile (majority of our customers).

3. Baseline methodology punitive for several C&I customers

Based on our experience with participating in RERT in both this program and outside this program, we note the standard high 10 of 10 baseline methodology with day-of-adjustment for intervals t-4 to t-1 can be very punitive for certain C&I customer loads, who would otherwise be recognised for providing valuable load reduction. Consider the following examples:

A. On an extremely hot day where AEMO has published market notices of market intervention and intention to activate RERT, a C&I makes the decision to shut-down its plant early in the day, thereby substantially lowering energy consumption reducing stress on the grid.

However the baseline methodology only looks at the site's consumption in the 4 hours to 1 hour prior to RERT event start time to determine the 'adjusted baseline' level; therefore as the site had already curtailed load prior to this 3-hour window it will not get recognised for providing any service to the grid, despite the best of intentions.

B. A temperature sensitive C&I site (e.g. Commercial building) has HVAC (air-conditioning units) make-up the majority of its energy consumption. In the prior 10 days to the RERT event day, temperatures were less warm and therefore its consumption was relatively unremarkable – however on the RERT event day, with 40 C plus temperatures its energy consumption increased by 200%.

Unfortunately AEMO's RERT baseline methodology used over last 3 summers has put a 20% cap on any day-of-adjustment uplift – therefore rather than being credited with the full amount of load drop on the day (i.e. what they were using in the t-4 to t-1 window prior to event start time which is 200% higher than normal), AEMO only measures the load drop from a level which is 20% above their average load from past 10 days. Once again, customers do not receive recognition of providing DR despite the best of intentions to relieve stress on the grid.

C. Some C&I customers can have very volatile loads, particularly those that depend on inputs such as raw materials or waste etc. One such customer being a metals recycling plant depends on metals coming through for shredding, therefore its consumption can range anywhere from 50 kW to 5 MW depending whether its high-powered shredders are running at full capacity. This customer can always respond to a RERT activation, but unfortunately is at the mercy of when the RERT event starts, and its corresponding consumption levels in the t-4 to t-1 hours prior to event start time.

For example, if the event started at 6pm, if they were at close to full consumption (i.e. shredders running at max. capacity) between 2pm-5pm they would get close to the full credit for reducing demand from ~5 MW to 0MW (5 MW result). However if the event had started earlier at say 4pm, and consumption was down during noon/lunch time (reduced average load from 12pm-1:30pm), this would severely affect their baseline which looks at consumption from 12pm-3pm. So despite them running higher all the way until prior to 4pm event start time, their DR result according to the baseline would be around 33% lower – this is despite them turning off all loads at the event start time.

Project partners

N/A

Relationship to other projects

N/A

Links to further project information

https://arena.gov.au/projects/enel-x-demand-response-project/

ARENA state of DER technical integration | project summary

Project/initiative name | EnergyAustralia Demand Response Program

Project contact | George Martin, EnergyAustralia (george.martin@energyaustralia.com.au) / Jessica Padman (jessica.padman@energyaustralia.com.au).

Project summary

EnergyAustralia's Demand Response (DR) program is one of 10 flagship projects supported by the joint ARENA and AEMO $35.7 million DR Initiative. The program began in December 2017 and involves the deployment of 18 MW of DR in NSW, increasing to 20 MW in years two and three. The program also involves 20 MW of DR in VIC/SA in year one, increasing to 30 MW in years two and three. During times of critically low reserves, AEMO will call upon EnergyAustralia to deliver the reserve capacity through a combination of direct load control and behavioural demand response.

The project sees EnergyAustralia working with household, commercial and industrial customers to deliver reserve capacity. In exchange for participating in DR events, customers are enrolled in incentive programs and receive a benefit for their efforts.

EnergyAustralia is leveraging the strengths of existing DR knowledge and technologies to provide tailor-made services to household, commercial and industrial customers. This includes emerging DR mechanisms, such as voluntary behavioural demand response (BDR), direct load control, and on-site generation and battery storage. A key success has been establishing commercial-scale BDR at multiple locations with different capabilities under a single unified platform. EnergyAustralia is also trialling the additional conversion of existing diesel gensets to 100% renewable biofuels at a commercial scale.

The program will help to provide insight into consumer engagement in demand response activities, and whether DR can assist in maintaining a stable electricity grid in the National Electricity Market.

Key project deliverables

- 50 MW of Short Notice Reliability and Emergency Reserve Trader
- Learnings captured in 6 knowledge sharing reports

Key project innovation

The success of EnergyAustralia's DR project is not committing to a specific technology, but rather leveraging the strengths of many options to fit the needs of customers. By trialling multiple, fit-for-purpose approaches, EnergyAustralia hope to unlock mutual benefits for households, larger-scale customers, and retailers alike.

Project timing and progress

Activity	Proposed Delivery	Status
Activation Test 1	January 2018	Completed
Knowledge Share Report 1	February 2018	Completed
Activation Test 2	May 2018	Completed
Knowledge Share Report 2	December 2018	Completed

Activity	Proposed Delivery	Status
Activation Test 3	November 2018	Completed
Knowledge Share 3	June 2019	Completed
Activation Test 4	May 2019	Completed
Knowledge Share Report 4	December 2019	Completed
Activation Test 5	November 2019	Completed
Knowledge Share Report 5	June 2020	In progress
Activation Test 6	May 2020	In progress. Delayed to 31 Oct due to COVID-19.
Knowledge Share Report 6	December 2020	In progress

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	The program used technology to communicate with DER devices. For example, the mass market circuit level control device program involved residential customers installing circuit-level monitoring and remote-control capable devices at their premises, where consumers receive incentives if they allow EnergyAustralia to switch off their appliances such as air-conditioners, pool pumps or other loads at the circuit level after a series of notifications. The program also developed group control capability to aggregate a large proportion of battery storage devices where, for a financial incentive, customers allow EnergyAustralia to remotely charge and/or discharge their battery into the grid after a series of notification steps. Various OEM's devices only communicate with their own platform. EnergyAustralia continues to explore ways of utilising DERs without the need for multiple platforms as this hampers the economics and operationalisation of DERs.
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	No	

Functional area	Yes / No	If yes, how?
3. Understanding DER behaviour		
3.1 DER visibility	Yes	As in 2.1 above
3.2 DER modelling	No	
3.3 Network hosting capability	No	
3.4 Bulk power system security and reliability	Yes	Exploring ways DR can support localised areas where there are constraints.
3.5 Distribution system reliability and power quality	Yes	Exploring ways DR can support localised distribution zones where there are constraints.
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Provision of demand response services to AEMO as part of the RERT
4.2 Provision of localised network services	Yes	Exploring ways DR can support localised areas where there are constraints.

Next steps and constraints or impediments to BAU adoption

At completion, a final report will be published into the public domain where it can be:

- leveraged by future projects
- referenced through future rule changes and DER market design.

This project will also form the foundation for demand response capability at EnergyAustralia for the mutual benefit of the market and energy consumers.

Project partners

AEMO, GreenSync, Redback & Wattwatchers.

Relationship to other projects

This initiative is related to a number of DR projects being explored by EnergyAustralia. These include longer term DR products for small business, commercial & industrial and residential sectors.

Links to further project information

EnergyAustralia Demand Response Program – Australian Renewable Energy Agency (ARENA)

EnergyAustralia Demand Response Program Performance Report

ARENA state of DER technical integration | project summary

Project/initiative name | Energy Under Control

Project contact | Alex Leemon, Flow Power (Alex.Leemon@FlowPower.com.au) / Nathaniel Galindo (Nathaniel.Galindo@FlowPower.com.au)

Project summary

The Flow Power Energy Under Control Demand Response (DR) project involves the rollout of Flow Power's kWatch® Intelligent Controller. The Controller gives customers live data feeds, alerts and integration of onsite equipment. When it comes to DR, the Controller allows participating businesses to reduce their demand in minutes when Flow Power is called on by AEMO under the Short Notice Reliability and Emergency Reserve Trader (RERT).

By providing SMS and email alerts, the kWatch® Intelligent Controller gives Flow Power a clear and fast communication channel with participants, who receive participation payments in addition to a revenue stream if they are called upon to shift power use. Customers have the choice to integrate equipment with the Controller, meaning the customer could control energy intensive equipment from the kWatch® portal. The program will roll out Controllers across customer sites over the next three years and then provide availability and activation payments where appropriate.

Key project deliverables

Demonstrate the viability of emergency demand response across a range of different industrial and commercial customers.

Demonstrate improvements in commercial operation with greater exposure to market signals and energy usage data.

Key project innovation

Part of the program involves integrating the kWatch® Intelligent Controller with customer sites, providing the ability for automation of customer loads in response to emergency DR requests or market signals.

Project timing and progress

Project is funded between December 2017 and December 2020, with 6-monthly reporting of milestones and achievements.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	Generalised grid support through reduction of load in response to reserve requirements
1.3 Protection and control functions	No	

Functional area	Yes / No	If yes, how?
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Real-time and near real-time visibility of customer loads in response to DR activations and market signals. Ability to measure and observe individual asset behaviour within the customer site.
3.2 DER modelling	Yes	Post-event analysis of customer load responses on a high timescale granularity (real time, or 1-5 minute metering) in response to DR activations and market signals.
3.3 Network hosting capability	No	
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	No	
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	kWatch Controller can provide signals from the wholesale energy market for customers to respond to in an automated or manual way.
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

Expand industrial and commercial DR, particularly with regards to market signal responsiveness. Expand the learnings and project beyond NSW where the DR trial is based.

Relationship to other projects

All other participants of the [ARENA Demand Response Trial.]

Links to further project information

- https://arena.gov.au/funding/demand-response/
- https://arena.gov.au/news/aemo-arena-demand-response/

ARENA state of DER technical integration | project summary

Project/initiative name | Solar Analytics – Enhanced Reliability through Short Term Resolution Data around Voltage Disturbances

Project contact | Jonathon Dore, Solar Analytics

Project summary

Increased penetration of DER are leaving power system operations vulnerable to the operating behaviour of a multitude of diverse, distributed generators. AEMO has identified a need for short time resolution data around voltage disturbances to understand DER behaviour and improve dynamic modelling. In this project, Solar Analytics will work with AEMO (customer) and Wattwatchers (hardware/firmware) to develop automated data acquisition and delivery. The project aims to increase visibility and improve modelling capability in a world-first analysis of individual load and generator responses in the event of short time resolution voltage disturbances.

Key project deliverables

Reports detailing improvements in monitoring firmware enabling collection of better quality data around grid disturbances (multiple deliverables).

Feasibility/cost/benefit study on monitoring hardware changes to further improve collection of data around grid disturbances.

Reports detailing analysis of the response of DER to grid disturbances (multiple deliverables).

Key project innovation

High quality data is costly to provide due to costs of mobile communications, storage, security, extraction and provision to industry customers. The data is most valuable around grid disturbances, which occur perhaps 10 times per year. The monitoring firmware improvements made within this project enable a buffer of high-quality data to be stored on-board the monitoring hardware. Disturbance detection is being built into the system such that this buffer can be extracted when needed and further high-quality data can be collected for some time thereafter. This allows this expensive data to be collected when it is valued and for the system otherwise to collect and store lower-quality data sufficient for other purposes, thereby keeping the whole system at a sustainable cost.

Project timing and progress

Project planned for December 2018 – June 2020. Variation currently under negotiation to extend to Dec 2020. Milestones 1-3 have been submitted on time, with 12 of 13 deliverables met. The 13th deliverable was agreed on variation to roll into the 4th and final milestone. Firmware changes and integration of these has been slightly behind schedule. Hardware feasibility study has been several months behind schedule due in part to impacts of bushfires and COVID and in part to the difficulty in long-term planning in technology start-ups. The planned extension to Dec 2020 is to accommodate this and to reduce scope of the feasibility study, which allows for increasing emphasis on other aspects of the project.

Data sharing from Solar Analytics to AEMO and analysis of this data has proceeded on schedule. This part of the project has taken greater emphasis as the findings have been significant and are contributing to changes in system planning and DER integration strategies. The planned extension allows the data sharing and analysis to continue.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	However, the drafted variation includes a feasibility analysis of integrating Solar Analytics registration with the AEMO DER Register
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Directly providing DER data around grid disturbances to AEMO. The analysis of the data helps to understand its value and build a business case for continued commercial provision of such data to AEMO and other industry bodies and from other providers.
3.2 DER modelling	Yes	The analysis by AEMO is being used to update system models and contingency planning regarding expected behaviour of DER around grid disturbances.
3.3 Network hosting capability	Yes	Without quality data to verify system models, conservative assumptions need to be made, which will likely result in excessive limitations on DER installations and capacity and curtailment of output.
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	[Confidential]
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

The findings within the project motivate continuation and further study. The firmware changes that are being integrated now can be utilised to sustainably extract high-quality data in the future. However, there is still much work to be done to optimise the triggers for capturing data to maximise the likelihood of identifying important events in real-time while managing costs. There is also further work to be done in analysing the data and processing the implications on compliance and system management. This work is the subject of a new three-year project, to be led by UNSW, which is currently under assessment by ARENA for funding. It is anticipated that commercialisation of disturbance data as a data product will be achieved during that time frame.

Project partners

AEMO

Wattwatchers Pty Ltd

Relationship to other projects

https://arena.gov.au/projects/addressing-barriers-efficient-renewable-integration/

This project, led by UNSW, involves the bench-testing of many PV inverters to assess their response to a range of possible grid disturbance scenarios. The controlled environment allows a deep inspection of responses under very-well characterised conditions, but is limited in the number of inverters it can test. On the other hand the ARP158 project assesses real disturbances and a large number of fielded systems. In the latter, the conditions and responses are less precisely known but the large numbers allow for a greater statistical picture of response, particularly with respect to actual inverter settings, which may be different to specified settings. In this way the projects are complementary, with the first going deep and the second going wide in its approach.

Links to further project information

Project milestone reports have been kept confidential at AEMO's request due to the potential market implications of the findings.

Excerpts from the knowledge sharing summaries are copied below:

- AEMO Qld-SA Separation Incident Report 2019-01-11
- Solar Analytics Blog - Distributed solar PV: what happens when things go 'bang', (guest post – Naomi Stringer, UNSW) 2019-01-14
- Solar Analytics Blog - Solar Analytics helping to build a better energy system, Dr Jonathon Dore - 2019-01-22
- Solar Analytics Blog - ARENA project announcement, Dr Jonathon Dore - 2019-02-12

The AEMO report "Technical Integration of Distributed Energy Resources" was released in April 2019, including analysis of the response of DER to significant grid disturbances. Analysis was completed by AEMO using Solar Analytics data shared with it in anticipation of this project and by UNSW using Solar Analytics data shared with it in a separate project. The report describes the current project in activities ongoing to address technical integration of DER.

The AEMO Renewable Integration Study Appendix A summarises some specific examples of the findings from the project and the implications for the system.

AEMO is preparing to publicly share findings from this analysis in the upcoming incident reports on the separation events that occurred on 16 November 2019 and 31 January 2020.

The value in Solar Analytics data around disturbances is now being recognised beyond AEMO. Immediately after the South Australia islanding event (2020-01-31), frequency and PV production data was supplied under commercial arrangement with Global-Roam, resulting in the following blog posts on WattClarity:

http://www.wattclarity.com.au/articles/2020/02/31jan2020-rooftopsolarpv/

http://www.wattclarity.com.au/articles/2020/02/31jan2020-systemfrequency/

ARENA state of DER technical integration | project summary

Project/initiative name | evolve DER Project

Project contact | Bill Tarlinton, Zeppelin Bend (bill.tarlinton@zepben.com)

Project summary

The evolve DER project aims to increase the network hosting capacity of distributed energy resources (DER) by maximising their participation in energy, ancillary and network service markets, while ensuring the secure technical limits of the electricity networks are not breached.

The evolve DER project by Zeppelin Bend is a collaboration between industry, academia and government. It has a strong focus on the development of working software systems that will be integrated with the operational technologies used by distribution networks, and the systems used by aggregators to manage DER under their control. Through multiple demonstrations and trials in NSW and Queensland, the evolve project will develop new algorithms and capabilities to identify and ease congestion within the distribution network. This will be achieved through the calculation and publication of operating envelopes for all DER connected to the distribution network.

The evolve project will show how more customers can connect solar PV and storage to the distribution network. This could mean that envisaged limitations of DER connection to electricity networks will be relaxed. In future, the evolve project could also support increased uptake of electric vehicles without major investment in the network poles and wires. Ultimately, this project will develop technologies that will allow distribution networks to evolve with the changing mix of renewables and DER.

Key project deliverables

The project is implementing a set of complex technical outcomes that will allow higher penetrations of DER to connect to distribution networks through the publishing of operating envelopes to individual DER that will, collectively, allow the DER to operate without breaching technical limits of the distribution networks.

It is difficult to break these into 3 distinct project deliverables. One possible breakdown could be:

1. **Knowledge sharing outcomes:** 5 reports providing insights and learnings into the calculation and use of operating envelopes, integration with DNSP operational technologies and the use of the IEC CIM standards for electrical network model data exchange

2. **Open source software outcomes:** A standards based and scalable framework to support the evolution and development of DER management systems, providing the following capabilities:

   a. An IEC CIM compliant data platform, with adapters to integrate with DNSP operational technologies.

   b. An implementation of the IEEE 2030.5 protocol, as designed by the DER Integration API Technical Working Group, for communicating with DER assets.

   c. User interface elements in the form of maps, trends, and tabular displays that provide visibility of network operating parameters, DER operation and how the DER is being orchestrated with operating envelopes.

3. **Demonstrations** of the efficacy of publication of operating envelopes to increase hosting capacity of DER, through various real world and simulated use cases.

Key project innovation

The primary innovation of the evolve project will be to demonstrate scalable capabilities and systems for coordinating DER throughout the distribution network. These capabilities are important for the development the Distribution System Operator (DSO) function within the electricity system. To support this, advances in data ingestion, forecasting and analysis will be demonstrated so the solution can be deployed in practical terms.

Project timing and progress

Key Deliverable	Proposed Delivery	Status
Knowledge sharing outcomes	#1 The use of the IEC CIM Model. February 2020 #2 Review of methods used to achieve the calculation of the operating envelopes. August 2020 #3 Review of methods used to implement and publish the operating envelopes. Feb 2021 #4 The qualitative and quantitative analysis of the coordination and orchestration of individual and aggregated DER. Feb 2021 #5 Challenges and solutions involved in the integration of 3rd party and cloud-based software platforms with the Operational Technologies domain of electricity distribution networks. Aug 2021	Completed On Track On Track On Track On Track
Open Source Software outcomes	First published open source software: Feb 2020 Software will continue to be developed and updated until the end of the project in Jan 2022	Delivered In progress
Demonstrations	Demonstrations will be conducted three times, and the solution is refined. Demo 1 – July 2020 Demo 2 – February 2021 Demo 3 – August 2022	On track On track On track

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	The operating envelopes concept operates in the pre 15min time domain.
1.2 Grid support	Partially	Distribution networks that wish to modify DER behaviour during short term abnormal

		operating arrangements, as an alternative to creating a network outage, to either encourage or discourage consumption and generation, and real and reactive power ratios, will be able to do so with operating envelopes. Operating envelopes are not envisaged as a mechanism for eliciting Grid Support to avoid or defer network augmentation.
1.3 Protection and control functions	No	Operating envelopes are a DER Control mechanism in the 1wk to 15 min time domain.
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Working in conjunction with other projects to develop an Australian Implementation Guide for the IEEE2030.5 standard which supports DER Integration and interoperability.
2.2 Integration of DER within AEMO and distributors' systems	Yes	A large part of the technical outworkings of the project will be a set of working integrations with DNSP systems that marshal network model and measurement data into a central repository to support the operating envelope calculations.
2.3 Cybersecurity	Yes	The DNSP partners will be performing penetration testing on the cloud hosted solution to test cybersecurity.
3. Understanding DER behaviour		
3.1 DER visibility	Yes	One of the major outcomes of the project will be to provide a consolidated view of DER to the DNSPs
3.2 DER modelling	Yes	The algorithms that underpin the Operating Envelope calculations will model the steady state impact of different penetrations of DER on the networks. Will demonstrate MV and LV load flow modelling to allow the calculation of the operating envelopes.
3.3 Network hosting capability	Yes	The algorithms that underpin the Operating Envelope calculations will support hosting capacity analysis. Will demonstrate MV and LV load flow modelling to allow the calculation of the operating envelopes.
3.4 Bulk power system security and reliability	Partial	Evolve won't be directly demonstrating this use case, however operating envelopes can be shaped for bulk power system security and reliability, providing a mechanism to constrain DER export when required.
3.5 Distribution system reliability and power quality	Yes	The algorithms that underpin the Operating Envelope calculations will support analysis of system reliability and power quality.

4. Services		
4.1 Integration with wholesale energy and system security services markets	Partial	Evolve operating envelopes create safe operating regions for DER to operate within, allowing them to access wholesale and ancillary markets without impact the distribution network. Multiple aggregator partners in the evolve project are using their aggregated DER Fleets in these markets and will access these markets with awareness of the operating envelopes. That is, their bids into the wholesale and ancillary markets will be compliant with the operating envelope and hence network aware.
4.2 Provision of localised network services	Partial	Operating envelopes are a mechanism for invoking a Reactive Power response from DER. This will be demonstrated through evolve. Further work is required to understand how this should/could be priced as a service.

Next steps and constraints or impediments to BAU adoption

The evolve project is building open source software systems that need to be adopted by DNSPs in order to live beyond the end of the project. The ANU and Zepben have committed to open source the software systems with the first components found here: https://bitbucket.org/zepben/workspace/projects/OS . Any open source software project requires ongoing development to maintain its currency, so we wish to see this work adopted and continued by other projects.

The evolve project will test the technical calculation and delivery of operating envelopes, but has not investigated the changes required to customer connections and network planning processes within Distribution Networks. For example, how are envelopes presented and communicated to residential customers planning on investing in solar or storage. Or how does network planning assess variable export limits that result from the use of operating envelopes. These aspects are equally critical to adoption.

Project partners

The Australian National University

NSW Government

DNSP Partners: Ausgrid, Essential Energy, Endeavour Energy, Energy Queensland

Aggregator Partners: Redback Technologies, Reposit, SwitchDin, Evergen

Relationship to other projects

The evolve Project work is similar to other ARENA funded projects working on dynamic hosting limits, and DER hosting capacity.

Links to further project information

https://arena.gov.au/projects/evolve-der-project/

The first Knowledge Sharing report has been submitted but not yet available on the ARENA website.

The open source code repository https://bitbucket.org/zepben/workspace/projects/OS

ARENA state of DER technical integration | project summary

Project/initiative name | Expanded Network Visibility Initiative (ENVI) (follow-up project of ARENA funded "Increasing Visibility of Distribution Networks" project)

Project contact | Olav Krause, GridQube (olav.krause@gridqube.com) / Andrew Deme (andrew.deme@gridqube.com) / Terese Milford (terese.milford@energyq.com.au)

Project summary

The Expanded Network Visibility Initiative (ENVI) expands the use technology developed and demonstrated in the ARENA project "Increasing Visibility of Distribution Networks" to the entire distribution network of Queensland. At its heart sits a novel Distribution System State Estimation (DSSE) algorithm that draws on multiple different data sources (network asset registers, SCADA, distribution transformer monitors, AMI, premise-level measurements and statistical network usage data) to provide complete network visibility from zone substations down to every customer connection point in the network.

Key project deliverables

1. State Estimation of the entire distribution system of the state of Queensland (offline using historical data with targeted areas of real-time deployment)
2. Integration of DNSP internal (e.g. models and SCADA) and externally sourced data (AMI, third-party premise level data, etc)
3. Support for the implementation of value-adding assessment and simulation functionality through APIs to mathematical functions and automated execution of Post Estimation Applications.

Key project innovation

With DSSE providing complete visibility of current and past network states and the DSSE algorithm capable of performing automated network simulations, this initiative lays the groundwork for automated performance and capacity assessments as well as operational and asset optimisation functions in retrospect, real-time and forward planning. The enabled functionalities include static and dynamic capacity assessments (e.g. to calculate static and dynamic import and export operating envelopes for customers), as well as identification, prioritisation and quantification of effective grid support services for localised network constraint mitigation.

Project timing and progress

Activity	Proposed delivery	Status
Ingestion of MV and LV network and statistical usage data from primary source databases for Energex	April 2020	Completed
Ingestion of available SCADA, distribution transformer monitor, voltage monitor and externally sourced AMI and premise-level data for Energex	Mai 2020	Completed
Export of result data from the estimation system into Energex' internal databases	June 2020	On track

Activity	Proposed delivery	Status
Ingestion of MV and LV network and statistical usage data from primary source databases for Ergon Energy	September 2020	Not started
Ingestion of Ingestion of available SCADA, distribution transformer monitor, voltage monitor and externally sourced AMI and premise-level data for Ergon Energy	October 2020	Not started
Export of result data from the estimation system into Ergon Energy's internal databases	November 2020	Not started
Targeted testing and roll-out	continuous	On track

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	Yes	Providing full distribution network visibility from available data, plus ability to perform automated simulation and assessment functions
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	No	
3.2 DER modelling	Yes	Full network visibility down to customer connection points allows automated assessment and prediction of individual and aggregate DER impact, including generation of local DER 'dispatch constraints'

Functional area	Yes / No	If yes, how?
3.3 Network hosting capability	Yes	Fully functional MV and LV state estimation Ingests SCADA, network monitor, AMI and third-party premise-level measurement data Complements available measurement data with statistical data of load and DER behaviour to provide complete network state Ability to generate local 'dispatch constraints' to support operational envelope calculation, identification, prioritisation and quantification of effective DER network support services and technical limits for local energy exchanges and markets
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	MV and LV network state estimation in near real-time provides power quality information of entire distribution network. Local dispatch constraints can include active and reactive power decision variables and technical limits on power quality parameters. This allows integrated load and DER management under local power quality and technical network limits. Representation of local dispatch constraints as inequality constraints on decision variables is compatible with standard optimisers and market engines.
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Provision of local dispatch constraints allows construction of local (sub-) markets, or integration into more centralised markets.
4.2 Provision of localised network services	Yes	MV and LV state estimation (in near real-time of on short-term forecasts) allows identification of areas requiring network support service. Local dispatch constraints provide information about effectiveness of particular DER to mitigate network constraint violations and allow for the automated prioritised (e.g. based on cost or customer impact) quantification of required services.

Next steps and constraints or impediments to BAU adoption

ENVI is an initiative to introduce Distribution System State Estimation as BAU at Energy Queensland's two DNSPs, Energex and Ergon Energy Network, for use on MV and LV networks. The progress so far has made it clear that there is no barrier to widespread adoption of offline DSSE, but that this requires changes to internal IT systems, data quality reviews and, modifications to internal processes. The DSSE functions equally as well on real-time data but the availability of real-time data state-wide is more limited as existing field devices, communications and data retrieval processes were not established with this real-time capability as a requirement. This is an area DNSPs continue to work on.

During the ARENA funded project 'Increasing Visibility of Distribution Networks' that preceded ENVI it was demonstrated that the three participating DNSPs Energex, United Energy and TasNetworks had sufficient data (model, measurement and statistical load data) to implement DSSE on MV level. This is most likely true for most other Australian DNSPs, too, as the three DNSPs had been selected for their diversity of network topologies and measurement acquisition strategies.

ENVI has already extended this to LV networks and demonstrated that a functional DSSE on LV level can be realised on the back of an MV DSSE deployment – even without additional LV measurements. It has further been demonstrated that the developed DSSE system is also capable of ingesting additional LV measurement data, be it from internal sources, AMI or other third-party sources, to further improve estimation precision.

A widespread adoption as BAU solely requires modification of internal IT structures and processes, combined with network model data quality reviews and, in some cases, quality improvements. In the cases of the three DNSPs the technology has been trialled on, it did not require extensive investment into DNSP measurement infrastructure.

Project partners

ENVI:

- Ergon Energy Network (Part of the Energy Queensland Group)
- Energex (Part of the Energy Queensland Group)
- GridQube

ARENA 'Increasing Visibility of Distribution Networks':

- Energex (Part of the Energy Queensland Group)
- United Energy
- TasNetworks
- Energy Networks Australia
- Australian Power Institute
- Springfield City Group
- Aurecon
- University of Queensland
- Queensland University of Technology

Relationship to other projects

A range of projects and companies have related and complementary work. Without trying to be exhaustive, these are the ones we are currently aware of: ANU/ZepBen Evolve (generation of operational envelopes, requires network visibility), GreenSync (DER aggregation and coordination requires network dispatch constraints), Redback (source of measurement data), Metering Dynamics (source of measurement data), Solar Analytics (source of measurement data), and many more.

Links to further project information

ENVI: GridQube website with basic technology information: https://www.gridqube.com/

'Increasing Visibility of Distribution Networks': Project page at ARENA including final reports: https://arena.gov.au/projects/increasing-visibility-of-distribution-networks/

ARENA state of DER technical integration | project summary

Project | Indra Monash Smart Microgrid Project

Project contact | German Burbano, Indra, and Scott Ferraro, Monash

Project summary

The Indra Monash Smart City will demonstrate how smart and renewable technologies can be integrated at the Monash University Clayton embedded network to maintain power quality and test market driven responses and business models.

Indra's Active Grid Management (InGRID AGM) platform will provide real-time monitoring and control over the grid-connected assets, and a Transactive Energy Market is being developed to orchestrate DER in response to market signals and constraints to add value to customers, market participants and the electricity grid.

Key project deliverables

1. Precinct Power Quality Control and Energy Management:
   - DER orchestration capability demonstrated for the embedded network, including for energy use optimisation and management of power quality issues. Improve performance and reliability of the smart embedded network model through predicting behaviour such as building loads, integrated solar forecasting and ability to remain flexible as more DERs are integrated.
2. Smart Energy City Market:
   - The Monash campus will be used as a large-scale trial to demonstrate the value of smart energy infrastructure to the various market participants. Monash Smart Energy City becomes a market participant with the Active Grid Management (AGM) platform and Precinct Energy Management System (EMS) to orchestrate assets and DERs based on market signals to achieve an optimised economic response, maintain reliability of the local and wider network, and demonstrate ability to participate in ancillary markets (FCAS). Transactive energy and peer to pool trading will be established within the smart embedded network, with building owners acting as customers connected to the AGM.
3. Living laboratory:
   - Creating a platform that enables industry to simulate and test use cases.

Key project innovation

The Indra Monash Smart City will demonstrate how a 100% renewable powered embedded network could operate reliably, and the value it could provide to customers and the broader energy network. It will show the value of smart energy infrastructure to the various market participants, and will lay the path to commercialisation for similar projects across a range of greenfield and brownfield applications. Real-time integration will facilitate the sharing of information and services amongst network companies, customers and new market players (such as aggregators).

Unlike other embedded network projects relying on centralised control from one single industrial equipment manufacturer, the Indra Monash Smart City will demonstrate the interoperability among different manufacturers and technologies to unlock opportunities for scalable smart grids with participants and providers. This is to ensure the technical and commercial solutions being developed are replicable beyond the realm of this project. Rather than duplicating existing functionality, Indra's platform will leverage the intelligence of the various systems and use its openness to standard protocols to integrate third-party technology that adds value to the platform.

Project timing and progress

Project Commencement: October 2018

Milestone 1: 31 July 2019 (Complete)

Milestone 2: 15 December 2020 (In progress and on track against deliverables)

Milestone 3: 17 December 2021 (In progress and on track against deliverables)

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Power quality system integrated into the platform that manages disturbances from within the microgrid.
1.2 Grid support	Yes	Platform has the capabilities to provide network and broader market services.
1.3 Protection and control functions	Yes	Protection and control functions are inherent to the control system of the microgrid.
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Platform is technology/device agnostic with interoperability between devices and systems inherent to the design.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Platform provides accessibility of DER services to the wider network.
2.3 Cybersecurity	Yes	Cybersecurity assessment is a key component of work and a required deliverable. Additional cybersecurity framework developed to be shared with the industry.
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Platform provides accessibility of DER assets to microgrid control system.
3.2 DER modelling	Yes	Platform allows for modelling of DERs for forecasting and simulation purposes.
3.3 Network hosting capability	No	

Functional area	Yes / No	If yes, how?
3.4 Bulk power system security and reliability	Yes	Network services and simulation capability of the platform can identify transmission system security and reliability opportunities.
3.5 Distribution system reliability and power quality	Yes	Network services and simulation capability of the platform can identify distribution system power quality and reliability opportunities.
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Platform provides accessibility of DER services to the wider network.
4.2 Provision of localised network services	Yes	Network services and simulation capability of the platform can identify localised opportunities.

Next steps and constraints or impediments to BAU adoption

- Understanding and establishing commercial model
- Obtaining network datasets for simulation purposes
- Regulatory implications
- Connection agreements

The project will see the development and trialling of the microgrid platform at the Clayton Campus. As part of a Victorian Government funded project, the commercial model for broader roll out of this system is being developed. A strategy for taking this system to market is currently under development and will be complete by June 2021.

A range of regulatory barriers to deployment have been identified and documented under the Victorian Government funded project, and is available for sharing.

As the Clayton campus is on a non-constrained part of United Energy's distribution network, further work is required to simulate the benefits that such a system can provide. Consultation is underway with industry to gather other partners and data to undertake this simulation as part of the M3 use cases.

A key question is the commercial characteristics required to make this solution feasible for broader roll out. This includes understanding the value of market/wholesale services and network services, as well as understanding the level of flexibility required, and the optimal way of delivering this, for each site. Further work is underway to refine this model based on the Clayton pilot, but further deployment at other sites may be required to get a full understanding. Our approach at present is to roll into this further deployment once/if the flexibility provided is firm enough for commercial investment.

Project partners

Indra, Monash.

Relationship to other projects

This project is similar to a number of other initiatives, such as the Bruny Island Consort project, and various VPP trials underway, in that it is working to orchestrate DER in response to market signals. It is unique in that it is working to do this factoring in power quality as well as energy quality management, and also with a strong focus on building based flexibility as well as solar, EVs and battery storage. The platform is being developed in an open fashion, so it can be shared as an industry resource.

Links to further project information

Microgrid Website

Introductory Report

Overview Video

Recent academic paper produced

Regulatory Report from Victorian Government Funded project: "Reforming the regulation of local electricity supply (including microgrids)" – available on request

ARENA state of DER technical integration | project summary

Project/initiative name | NOJA Power Intelligent Switchgear

Project contact | Neil O'Sullivan, Group Managing Director, NOJA Power (NeilO@nojapower.com.au), Mehdi Mosadeghy, Project Development Manager (MehdiM@nojapower.com.au)

Project summary

This NOJA Power Intelligent Switchgear project aims to reduce the complexity and cost of connecting renewables to the grid and increase the hosting capacity of distribution networks by developing, demonstrating and industrialising an economical intelligent switchgear. This device can capture high-resolution real-time network data and can provide protection, control, and monitoring solutions to facilitate the connection of renewables to the grid.

The Intelligent Switchgear will be deployed on the Energy Queensland and AusNet Services grids at:

1. the point of connection of a renewable energy generator in the distribution network, and
2. at the medium voltage side of the distribution network in locations with high penetration of variable renewable resources.

The Intelligent Switchgear and trial deployments will generate significantly more granular power system data than is currently available and will help improve the visibility and modelling of the power system.

Data collection, analysis and interpretation of synchrophasor data generated in the deployments (Synchrophasor Measurement Data) will facilitate better-informed system planning and real-time operations for both AEMO and distribution network service providers (DNSPs), which is expected to increase the grid's hosting capacity of renewable energy generation. It is also expected to facilitate understanding of possible advanced fault-finding protection and islanding schemes for the distribution network.

The Intelligent Switchgear developed in this Project will also consolidate various hardware and software components into a lower-cost integrated solution that can be used for network connection requests and reduce cost of connecting medium-scale generators (30kW-5MW) to the distribution network.

Key project deliverables

Design and development of the Intelligent Switchgear to enable more economic integration of renewable energy into the electric distribution grid. The controller component of the Intelligent Switchgear is referred to as the RC20-S. This controller will comply with the Australian Standard and provide renewable energy grid interface capacity across 15kV, 27kV and 38kV rated products. The controller will incorporate a Phasor Monitoring Unit to log Synchrophasor Measurement Data and new protection capabilities.

A demonstration trial with Energy Queensland and AusNet whereby a total of 50 Intelligent Switchgear units will be provided to each utility, and will be installed across 15kV, 27kV and 38kV voltage ranges to measure and log synchrophasor measurements across their distribution grids: 20 at the point of connection of a renewable energy generator with the distribution network and 80 at the medium voltage side of distribution networks primarily on feeders with existing high penetration of variable renewable resources.

Synchrophasor Measurement Data, as well as data and knowledge related to network events, generated during the trial deployment will be provided to AEMO, AusNet Services, Energy Queensland, and Knowledge

Sharing Partners, with the expectation that it will be used to develop advanced protection and control algorithms and methods to monitor, plan and operate the power system.

Key project innovation

The NOJA Power Intelligent Switchgear project will develop a range of switchgear products combined with unique controllers specifically targeting the requirements of DNSPs and reducing the connection cost of renewable energy resources. These products will manage the protection challenges associated with renewable resources integration increasing the hosting capacity of the electricity network by using dynamic protection configuration, precise wide-area measurements and real-time monitoring capabilities. This will be achieved with advanced protection schemes and with synchrophasors. This project will contribute to the Advancing Renewables Program outcomes by reducing the integration cost, increasing the value delivered by renewable energy, removing barriers to renewable energy uptake and increasing skill and knowledge relevant to renewable energy integration in Australia.

Project timing and progress

Milestone	Deliverables	Completion date	Status
Prototype Development	Finalised RC20-S hardware design Manufactured RC20-S hardware prototype	02/02/2018	Completed
Product Development	Developed and finalised RC20-S prototype Independent type testing of the prototype completed	03/08/2018	Completed
Industrialisation	Completed RC20-S industrialisation Commenced production line development PMU implemented in the controller Firmware developed and working with PMU	15/02/2019	Completed
Firmware Development	Completed firmware development, with new features and functionalities Development of new software to work with the synchrophasor data 100 units manufactured for supply to AusNet and Energy Queensland	13/12/2019	Completed
Demonstrations	100 Intelligent Switchgear units deployed in the AusNet and Energy Queensland distribution grids Data collection and sharing infrastructures completed	21/08/2020	Data collection infrastructure is completed and most of the devices will be installed on-time. However, some installations might be delayed due to bushfires and COVID-19. This has a minor impact on the project goal.

Milestone	Deliverables	Completion date	Status
Firmware Upgrade	Firmware bugs fixed Development completed based on feedbacks received from demonstrations	13/11/2020	Progressing as planned
Data Analysis	Data collected from demonstrations shared with researchers at the University of Queensland, Deakin University and AEMO to increase the knowledge related to renewable energy, to create precise models for renewables and loads and to develop innovative solutions to address network challenge	11/06/2021	Progressing as planned

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	Yes	AEMO will collaborate with universities on the development of dynamic load models and methodologies for using Synchrophasor Measurement Data to validate load and distributed generation models.
2.3 Cybersecurity	Yes	Provides secure communication paths between data collection centres. Also, part of the project is to find application for the data to be used for detecting cyber-attacks on the network.
3. Understanding DER behaviour		
3.1 DER visibility	Yes	By providing high resolution phasor measurement unit (PMU) data from DER connection points
3.2 DER modelling	Yes	By providing high resolution PMU data at connection points
3.3 Network hosting capability	Yes	This project will facilitate better-informed system planning and real-time operations for both AEMO and DNSPs, which is expected to increase the grid's hosting capacity.

Functional area	Yes / No	If yes, how?
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	By providing protection functions and power quality measurements. NOJA Power intelligent switchgear will provide protection for DERs against faults in the network. The Intelligent Switchgear will provide visibility for utilities and protection functions such as reverse power flow, RoCoF and vector shift required by networks supporting localised DER's connectivity to the grid.
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

At the moment, we are working on commercialising the new controller and adding it to our product range. We have received interests from utilities around the world regarding this product and customers are keen to place orders. We are expecting to have the product ready for the global market by the end of this year.

In terms of data analytics, after completing the project, the plan is to keep working with researchers on developing new applications for the data collected from the device and add new functionalities resulting from collaborations with researchers and utilities.

Project partners

AEMO, AusNet Services Ltd, Energy Queensland Ltd, Deakin University, University of Queensland

Relationship to other projects

As part of this project, universities are working on the following research projects with NOJA Power:

- UQ Research Fellowship Project: PMU based Condition Monitoring of Critical Equipment in Modern Distribution Networks
- UQ PhD Project: Improving Situational Awareness in Active Distribution Networks Using Synchrophasor Measurement Data
- Deakin PhD Project: Applications of Phasor Measurement Unit (PMU) in Enhancing Power System Operation with High Penetration of Distributed Generation (DG)

Links to further project information

https://arena.gov.au/projects/noja-power-intelligent-switchgear/

ARENA state of DER technical integration | project summary

Project/initiative name | My Energy Marketplace (MEM)

Project contact | Murray Hogarth, Director of Communications and Community Networks, Wattwatchers Digital Energy (murray@wattwatchers.com.au) / Grant Young, Chief Innovation Officer, Wattwatchers Digital Energy (grant@wattwatchers.com.au)

Project summary

Wattwatchers aims to build, operate and deploy the 'My Energy Marketplace' or MEM, a consumer-facing energy data platform, designed to securely collect, process and productise vast amounts of energy data.

The MEM is a 3-year, $8.2M, Australia-wide project to deploy smart energy management solutions to 5000 homes and small businesses, plus 250 schools, backed by a $2.7M ARENA grant which subsidises consumer participation.

It will enable consumers to participate in the evolving 'New Energy' marketplace, including aggregation for Demand Response and VPPs, and will unlock access to DER visualisation and control sourced from behind-the-meter, consumer-owned assets.

Key project deliverables

The MEM deployment project will:

- nationally roll-out Wattwatchers energy monitoring hardware and software packages to thousands of homes and small businesses, and hundreds of schools
- develop and deploy the MEM, with input from industry and market representatives. The MEM will source data from Wattwatchers hardware, smart meters, inverters, EV chargers and sensors, and provide energy data software applications
- provide aggregators, distribution network services providers and other services providers with access to granular consumer energy data and visibility of distributed energy resources (DER).

Key project innovation

By completing the project, Wattwatchers will:

- demonstrate how an energy data platform can deliver value and savings to end users and ultimately become a sustainable business model
- provide end users and services providers valuable information about energy consumption and generation, to increase the value of DER and to improve the integration of renewables into the grid
- increase understanding and awareness of cybersecurity risks and data privacy management.

Project timing and progress

The project officially began in October 2019, although finalisation of the Funding Agreement with ARENA was not confirmed until 19 December 2019. It is a three-year project, officially ending in November 2022, with six-monthly milestones in April and October each year. The first six-monthly milestone report (Milestone 1) has been lodged with ARENA but is not yet finalised at the time of submitting this document.

Currently the project is progressing well, although is under budget for Milestone 1 due to factors including COVID-19 impacts.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Wattwatchers devices log data internally and 'catch up' with the cloud server after disruptions such as power and/or communications outages.
1.2 Grid support	Yes	Wattwatchers devices provide monitoring data for real-time visibility of DER and other electrical circuits; the ability to remotely switch loads (i.e. for demand response/load control); and the ability to integrate with other hardwares such as inverters, smart meters, PLCs, digital weather stations, environmental sensors, gas and water pulse meters, EV chargers.
1.3 Protection and control functions	Yes	As above and also potential for supporting solar export control and storage options.
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Wattwatchers API is an integration-friendly, industry-standard RESTful interface.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Wattwatchers is part of the AEMO DER API Tech Working Group.
2.3 Cybersecurity	Yes	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Real-time granular data from multiple circuits at one or many sites through the cloud.
3.2 DER modelling	Yes	Real-time granular data to support modelling
3.3 Network hosting capability	Yes	Real-time voltage and frequency data
3.4 Bulk power system security and reliability	No	Wattwatchers operates on the low-voltage network only. Such data-driven visibility may flow through to transmission level
3.5 Distribution system reliability and power quality	Yes	Real-time voltage and frequency measurements
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Wattwatchers is integrating with the GreenSync Decentralised Energy Exchange (deX) and will target integration with an AEMO API. We also are engaged with other initiatives including EVOLVE, Power Ledger and LO3 Energy's Exergy platform

		project.
4.2 Provision of localised network services	Partially	Wattwatchers is part of the Byron Local Microgrid project with Enova Energy, Essential Energy, UNSW and the NSW Government. We also are the lead partner for a major grant proposal to the Australian Government's Regional and Rural Community Reliability Fund - Microgrids (announcement of successful applicants is pending, with proposed partners including UTS ISF, Latrobe Valley Authority, Federation University and the Heyfield Community Resource Centre in Victoria).

Next steps and constraints or impediments to BAU adoption

The long-term objective is a sustainable business model for a standalone energy data company.

Project partners

Australian National University (ANU), Accurassi (Knowledge-Global Pty Ltd), Cogniss (2and2 Pty Ltd), Solar Schools (iWeb Solutions Pty Ltd)

Relationship to other projects

Enhanced reliability through short term data around voltage disturbances - https://arena.gov.au/projects/enhanced-reliability-through-short-time-resolution-data-around-voltage-disturbances/ - Project led by Solar Analytics, with AEMO and Wattwatchers as partners

AEMO-ARENA Demand Response - https://arena.gov.au/news/aemo-arena-demand-response/ - Wattwatchers has been a technology provider to projects led by Energy Australia and AGL Energy

ANU Battery Storage and Grid Integration Program - https://cecs.anu.edu.au/battery-storage-and-grid-integration-program - via DER Integration API Technical Working Group & 3-year PhD project (Energy Analytics) https://cecs.anu.edu.au/research/student-research-projects/phd-project-energy-analytics-battery-storage-and-grid-integration

Byron Bay Arts and Industrial Estate Microgrid - Case Study https://energy.nsw.gov.au/media/1896/download

CRC-P - Integrated Smart Home Energy Management, Control and Data Visibility https://www.grants.gov.au/?event=public.GA.show&GAUUID=7F359F40-D559-4E78-72C3410DBFF03558

Fairwater Living Lab - residential heat pump project https://arena.gov.au/projects/residential-heat-pump-study/

https://arena.gov.au/projects/solar-analytics-monitoring-better-energy-outcomes/ - Project led by Solar Analytics, which own-brands Wattwatchers devices as its 'Solar Smart Monitors', which are being deployed via this project.

Links to further project information

https://wattwatchers.com.au/my-energy-marketplace/

https://arena.gov.au/projects/wattwatchers-my-energy-marketplace/

At the time of responding, Wattwatchers' first milestone report (Milestone 1) including the first major knowledge sharing (Lessons Learnt) report has been submitted to ARENA as a draft, but has not been finalised.

ARENA state of DER technical integration | project summary

Project/initiative name | National low-voltage feeder taxonomy study

Project contact | Gavin Cross, CSIRO (gavin.cross@csiro.au)

Project summary

The National Low-Voltage Feeder Taxonomy (NLVFT) Study aims to produce the first national low-voltage network taxonomy that outlines the real-world characteristics of the distribution system. It will thereby extend the state-of-the-art of DER modelling. In particular, the study will provide improved data required to identify nationally representative consequences on the low-voltage power system of DER integration possibilities, supporting assessment of DER integration relevant design options.

Depicting how power flows through the low voltage system will help with the design and assessment of the technologies and systems that can enable maximal uptake of DER across Australia. It will also enable users to test the value proposition of innovative technological solutions through desktop-based simulation, by highlighting how they contribute to the stability, reliability and performance of networks across Australia.

Key project deliverables

This project will produce the first national low-voltage network taxonomy that clearly articulates the real-world characteristics of the distribution system in relation to the impact of higher levels of solar PV penetration. The grid stands to benefit from efficiently deployed and exploited demand response and distributed storage resources. It also provides the ability for industry to test how their distributed energy technologies interact with, improve and add value to Australia's low voltage networks.

- Integrate demand response models that modify the base customer load profiles into the LV taxonomy power-flow models. Demand response models will describe the potential change in load based on specific demand response signals and will draw on outputs and data developed through the National Energy Analytics Research (NEAR) research program.
- Publish the final LV taxonomy power-flow models for free and unfettered use by the energy sector through the NEAR platform. Publication of these models and a comprehensive review of project outputs as a whole will be delivered through project-end workshops and presentations, focussed on ensuring uptake and application of the National LV Feeder Taxonomy.

Key project innovation

The National Low-Voltage Feeder Taxonomy Study project reduces barriers to renewable energy uptake by providing datasets and tools to move towards evidence-based hosting capacity limits. By providing rich low-voltage network data for free to the wider community, the project grows the capacity for industry, researchers and decision makers to explore the relationship between emerging distributed renewable energy technologies and the operation and performance of Australia's electricity distribution system.

Project timing and progress

The study is due to conclude early 2021.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	Partial	Representativeness of case-study feeders for understanding significance of DER grid support capability
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Indirectly	Representativeness of case-study feeders for understanding aspects of DER visibility
3.2 DER modelling	Yes	Representativeness of case-study contexts for understanding the direct consequences of alternative DER integration options
3.3 Network hosting capability	Indirectly	Representativeness of case-study feeders for understanding DER integration aspects of network hosting capability
3.4 Bulk power system security and reliability	Partial	May improve representativeness of understanding of low voltage system behaviour relevant to transmission system impacts
3.5 Distribution system reliability and power quality	Indirectly	Representativeness of case-study feeders for understanding DER integration aspects of distribution system reliability and power quality
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	Partial	

Next steps and constraints or impediments to BAU adoption

The National Low-Voltage Feeder Taxonomy Study is a desktop study with a written report. Outputs are the report and several representative LV models for the Australian LV network.

Project partners

Energy Networks Australia, Ausgrid, AusNet Electricity Services, Western Power, Endeavour Energy, Energy Queensland, Essential Energy, Horizon Power, SA Power Networks, TasNetworks.

Links to further project information

https://arena.gov.au/projects/national-low-voltage-feeder-taxonomy-study

ARENA state of DER technical integration | project summary

Project/initiative name | Network Opportunity Maps

Project contact | Ed Langham, Institute for Sustainable Futures, University of Technology Sydney (edward.langham@uts.edu.au)

Project summary

The Mapping Network Opportunities for Renewable Energy (now 'Network Opportunity Maps') project creates NEM-wide online maps of electricity network constraints to help better inform network investments and increase the use of renewable energy.

The Institute for Sustainable Futures (ISF) at the University of Technology Sydney (UTS) in partnership with Energy Networks Australia develops annually updated maps and makes them freely available online.

The absence of clear, consistent and timely data about network constraints, costs and potentially avoidable investment across the Australian National Electricity Market (NEM) has been a major obstacle to the development of renewable and other decentralised energy projects in Australia.

Developing a system that creates annually updated maps of network constraints for the entire NEM assists DER project developers target locations of the grid where renewable energy, energy storage and demand management can be cost-effective alternatives to network augmentation.

Key project deliverables

Annually updated NEM-wide online maps with (increasingly) downloadable CSV and spatial content to allow industry to use in their own workflows: http://nationalmap.gov.au/renewables/

Key project innovation

Downloadable and visualised data to identify DER opportunities to address network constraints that is *standardised across NEM jurisdictions*.

Project timing and progress

ARENA project completed. Now integrated as standard annual process by Energy Networks Australia for data updates. Inputs and outputs continue to evolve to meet industry data needs.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	Provides data feedback loop for emerging market service providers to connect with network grid support needs
1.3 Protection and control functions	No	

Functional area	Yes / No	If yes, how?
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	No	
3.2 DER modelling	Partial	Provides information to assist DER modelling
3.3 Network hosting capability	Yes	New Generation Connection Capacity layer shows capacity to support new supply (mostly for regional areas) and planned developments extend analysis into local network limitations
3.4 Bulk power system security and reliability	Yes	To the extent that planned transmission investments call for support influencing security & reliability (e.g. MVAr support)
3.5 Distribution system reliability and power quality	No (Pending)	Planned developments extend analytics on reliability and power quality performance in regional areas to identify opportunities
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	Yes	Provides granular vision of the 'stack' of upstream transmission network opportunities down to the local zone substation and/or feeder level.

Next steps and constraints or impediments to BAU adoption

Diverging and more complex data use cases between distribution and transmission network opportunities. Integration with emerging DER marketplaces.

Project partners

Energy Networks Australia (and its NEM-based members); CSIRO Data61. Foundational partners included NSW Trade and Investment, Ergon Energy, ElectraNet.

Relationship to other projects

None noted.

Links to further project information

Direct link to maps: http://nationalmap.gov.au/renewables/ (Add 'Network opportunities')

ENA site: https://www.energynetworks.com.au/network-opportunity-maps

ARENA project page: https://arena.gov.au/projects/mapping-network-opportunities-for-renewable-energy/

ARENA state of DER technical integration | project summary

Project/initiative name | Networks Renewed

Project contact | Dr Geoff James, University of Technology Sydney (Geoffrey.James@uts.edu.au)

Project summary

The Networks Renewed project investigated pathways to increase the amount of renewable energy in Australia by paving the way for small-scale solar photovoltaic (PV) and battery storage installations to improve the quality and reliability of electricity in Australia's distribution networks. Two demonstrations focussing on voltage management recruited 90 customers in three locations across NSW and VIC under new commercial models for network-related businesses.

There is an emerging perception that small-scale solar PV may negatively impact the performance of Australian electricity networks by increasing voltage variability. Networks Renewed addressed this perception and clearly demonstrated that solar PV and batteries can be a valuable resource for businesses that manage electricity networks; changing the problem into a solution.

Networks Renewed pioneered an innovative use of mass distributed solar and storage in Australia. The Institute for Sustainable Futures at UTS partnered with electricity network businesses Essential Energy in NSW and AusNet Services and United Energy in VIC, Reposit Power, the Australian Photovoltaic Institute (APVI), and the NSW and VIC Governments, to bring the idea of a truly smart electricity grid closer to reality.

Two commercial-scale demonstrations of controlled solar PV and energy storage were implemented – one in the mid north coast of NSW and the other in Yackandandah, VIC. The project tapped into new, 'smart' inverter technologies that can better control PV panels and storage, offering a suite of new business opportunities.

The project examined technical alternatives for providing network support using smart inverters, and the value propositions that will make them attractive to businesses and customers. The practical, market-scale demonstrations were large enough to achieve meaningful improvements to power quality and generate sufficient market revenues to develop a business case for future projects.

Key project deliverables

The major outcomes were:

- The demonstrations proved that both solar and batteries can support network voltage, using the real and reactive power capabilities of their inverters, providing realistic alternatives to network-side voltage solutions.
- Good results were obtained for participating customers, who were all better off as a result of participating in the demonstrations, and for the two network businesses, including performance data to help determine the network value of voltage support provided by customers.
- Key shortcomings were identified including the lack of a scalable customer approach, the indirect interface with regular network operations, and the arbitrary determination of payments made to customers for services delivered. These informed the development of a Service Life Cycle necessary to make this a mainstream approach for voltage regulation.

Key project innovation

Two aggregation businesses provide fleet management interfaces to the network businesses, making voltage support services available as an ongoing facility, and mediating rewards to participating customers in an end-to-end business model. The project approached customers by adopting and training existing solar/storage providers, and created one of the first, if not the first, contract for the provision of voltage regulation services from an independent aggregator of distributed energy resources.

Project timing and progress

The project ran from August 2016 to April 2019, finishing with roadshow presentation in four capital cities across Australia, which served to disseminate the project outcomes.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	Yes	Voltage regulation through dispatch of real and reactive power from customer solar and storage inverters.
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Using two aggregation platforms to present distributed customer inverter capacity for dispatch by network businesses.
2.2 Integration of DER within AEMO and distributors' systems	Yes	One aggregation platform allows customer batteries to participate in the FCAS markets by responding to frequency events.
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Customer load, generation, and voltage data made available through the aggregation platforms.
3.2 DER modelling	No	
3.3 Network hosting capability	No	
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	Voltage regulation services mitigated the impact of customer solar on distribution network voltage envelopes.

Functional area	Yes / No	If yes, how?
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	Yes	A workable precedent for using smart solar and storage inverters to provide voltage regulation services.

Next steps and constraints or impediments to BAU adoption

With the project's success, all Australian network businesses now have a workable precedent for using smart inverters for network support services themselves, or contracting third parties to provide these services independently. This was socialised with different network service providers through knowledge sharing roadshows at the end of the project.

The next step is progressing this technical solution to a viable mainstream option. Networks Renewed created a practical understanding of all the moving parts needed for customers to provide support for the electricity grid Australia needs.

Project partners

Reposit Power, Essential Energy, Mondo, AusNet Services, Australian PV Institute, United Energy

Relationship to other projects

Project Symphony is now being proposed to ARENA by Western Power, with Synergy, AEMO, and research partners. The proposed Project will demonstrate the coordination and dispatch of an aggregated portfolio of DER, using various DER technology types such as rooftop solar PV, community, commercial and household battery storage, commercial and household load control including EV chargers, electric hot water systems, air-conditioners and pool pumps. Project Symphony is a critical implementation requirement of the DER Roadmap that was tabled to the WA Minister for Energy in December 2019. The Service Life Cycle developed through consultation as a knowledge sharing activity of Networks Renewed has served as the basis of the project work package design for Project Symphony.

Links to further project information

Project reports and articles are available at:

https://arena.gov.au/projects/networks-renewed/

https://www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/our-research/energy-futures/networks-renewed

ARENA state of DER technical integration | project summary

Project/initiative name | Open Energy Networks (OpEN)

Project contact | Dr Jill Cainey, Energy Networks Australia

Project summary

The aim to this project was to explore the role of distribution-level markets to support DER integration and optimisation, specifically to see if a distribution market framework would be able to provide benefits to consumers in the NEM. This project leveraged the UK's Open Networks Project by starting with three strawmen of distribution market frameworks. After extensive industry consultation a fourth option was added incorporating aspects of the two most likely frameworks. The project also sought feedback from a group of key customer representatives and included a cost benefit analysis of each of the final four frameworks.

Key project deliverables

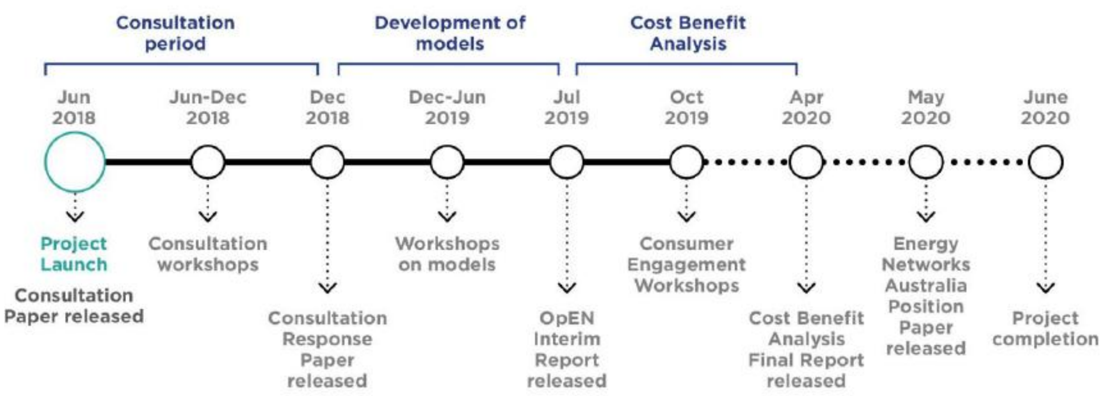
1. Creation of four potential frameworks of integrating DER through distribution markets and industry/consumer consultation.
2. A thorough cost benefit analysis for each of the four frameworks
3. A position paper outlining project findings

Key project innovation

Explored the potential for distribution markets to optimally incorporate DER, creating four novel market frameworks to explore the roles and responsibilities of various parties and the communications required to deliver a functional distribution market. Having created four frameworks, these were then assessed for the costs and benefits to consumers of implementing distribution markets. The project has contributed to the wider industry through by providing insights so that all stakeholders are able to discuss the appropriateness of distribution markets to deliver benefits to all Australians.

Project timing and progress

Figure 2. Project timeline



The OpEN project commenced in June 2018 and was due to be completed in November 2019.

An interim capabilities report was published in July 2019 and detailed the "least regrets" actions that could (and are) be taken today to deliver benefits, before committing to the implementation of distribution markets. The Cost Benefit Analysis is complete but unpublished. The final version was provided to the OpEN project in April 2020 but has yet to be approved for public release by AEMO. Energy Networks Australia published a position paper in May 2020.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	In the Interim Report we mapped out a series of milestones that would be required to support distribution markets
2.2 Integration of DER within AEMO and distributors' systems	Yes	The project mapped out a conceptual Smart Grid Architecture Model (SGAM) blueprint of how each framework might work
2.3 Cybersecurity	No	We did not specifically explore this topic in depth, but did consider it one of the milestone capabilities required
3. Understanding DER behaviour		
3.1 DER visibility	Yes	In the Interim report and ENA position paper one of the "no regrets" actions was that even without implementing distribution markets, there would be a clear need and benefit for increased network visibility
3.2 DER modelling	No	The project did not undertake detailed DER modelling. This is expected to be part of future trials and pilots.
3.3 Network hosting capability	Yes	As mentioned in 3.1 Network visibility is required to support hosting capacity. The Required Capabilities Report included three components of network hosting capacity: network visibility, state estimation or constraint development, and communication of these constraints (dynamic operating envelopes).
3.4 Bulk power system security and reliability	Yes	One of the benefits of distribution markets was to explore how transmission system security and reliability could be supported

Functional area	Yes / No	If yes, how?
3.5 Distribution system reliability and power quality	Yes	Assessment of how distribution markets might act as a signalling mechanism to support this function
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Testing different ways that an ecosystem of these services could be implemented and by whom (depending on framework)
4.2 Provision of localised network services	Yes	Assessment of how, depending on the framework, services could be procured directly by DNSPs, AEMO or another 3rd party

Next steps and constraints or impediments to BAU adoption

As explored further in the ENA position paper (link below) there are a range of issues

- There are actions that all participants can take now to maximise benefits, minimise costs and preserve optionality;
- DNSPs are already delivering new approaches (e.g. dynamic constraint information), but increased distribution network visibility is a key requirement to deliver the new approaches outlined in OpEN, but also in many other non-distribution market DER integration and optimisation projects;
- Trials of distribution markets will be required to test the theoretical concept in the reality of the system to ensure that the approach is practical, deliverable and that it is something consumers desire.

Project partners

AEMO

Relationship to other projects

- ESB Post 2025 two-sided markets consultation paper
- AEMC Distribution markets consultation paper
- South Australian VPP project
- ARENA DER portfolio
- ARENA DEIP program

Links to further project information

Further information can be found on our project website:

https://www.energynetworks.com.au/projects/open-energy-networks/

ARENA state of DER technical integration | project summary

Project/initiative name | Optimal DER Scheduling for Frequency Stability

Project contact | Evan Franklin, University of Tasmania, evan.franklin@utas.edu.au

Project summary

This project will investigate how best to schedule distributed energy resources (DER) on distribution networks so that they are capable of providing power system frequency stability services while ensuring the distribution network always operates within technical constraints, but also while reflecting the motivations and primary functionality desired by DER owners. The project will also demonstrate, via detailed modelling, the frequency response capabilities of a range of inverter-interfaced DER and flexible loads, and the extent to which they can assist with frequency stability in power systems with decreasing conventional generation.

Key project deliverables

- Detailed understanding of frequency response characteristics of power systems under different scenarios with high levels of renewable generation and with a range of DER devices providing primary frequency response.
- The development of optimisation software designed to coordinate fleets of DER on distribution networks, enabling them to provide an aggregated quantity of reserve capacity so as to be able to respond to frequency events.
- A proposed methodology to allow aggregated DER fleets to participate in frequency control ancillary service markets, while always respecting network-constraints

Key project innovation

The primary innovation of this project is to develop and demonstrate, via modelling and simulation, a method using distributed optimisation algorithms to schedule fleets of DER on distribution networks so that they can provide a desired level of frequency-reserve while ensuring operation of network remains within constraints at all times. This is a major extension to the functionality of an advanced distribution network management system platform called Network Aware Coordination (NAC), which was developed and successfully demonstrated in the ARENA CONSORT project. The project will also develop and apply innovative power electronics DER models in dynamic power system simulations, in order to provide deeper understanding of the frequency response capabilities that different amounts of DER can provide in power systems with high levels of renewable generation.

Project timing and progress

Date	Activity
Feb 2019	Project start
March 2020	Mid-project milestone report – dynamic DER device models developed and preliminary system simulations performed, ongoing development of network-aware coordination with frequency reserve algorithms, aggregator market interaction approaches proposed and under development.

Feb 2021	Project end

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Limited	Some dynamic simulations demonstrating DER response and contribution to frequency response under selected faulty conditions.
1.2 Grid support	Yes	Orchestration of DER to provide frequency support, remaining distribution network voltage and power flow capacity constraints.
1.3 Protection and control functions	Yes	Modelling dynamic behaviour of DER devices in responding to / controlling system frequency.
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	Limited	Via precursor CONSORT project technology.
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Via precursor CONSORT project technology.
3.2 DER modelling	Yes	Dynamic frequency response of several different DER types, via modelling of DER power electronics in lumped power system dynamic simulations.
3.3 Network hosting capability	Limited	Demonstration of how DER coordination with frequency reserve scheduling can be managed on networks with hosting capacity constraints.
3.4 Bulk power system security and reliability	Yes	Frequency stability
3.5 Distribution system reliability and power quality	Limited	Monitor voltages at participating households; understand how voltage and congestion constraints can be obeyed by jointly optimising DER.
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Approaches for DER aggregator participation being proposed and developed.
4.2 Provision of localised network services	Yes	Via precursor CONSORT project technology.

Next steps and constraints or impediments to BAU adoption

Possible next steps

- Demonstration of frequency response scheduling on a real, constrained distribution network
- Demonstration of NAC approach, including frequency scheduling, at scale, e.g. on large urban distribution feeders.
- Development of DER dynamic modelling and simulations including full transmission networks, disaggregated generation and load, via Real-Time-Simulator and / or including Hardware-in-the-loop approaches.
- Further development of market interface approach, and integration with AEMO market systems, ideally via trials with deployed system and VPP operator

Constraints and opportunities

- Adoption of distribution markets for energy and FCAS and other network services would open significant additional value streams for participants in NAC.
- Adoption of primary frequency control standards and market mechanisms would incentivise fast acting DER to participate
- The availability of reasonable models of distribution networks, especially in a standardised form (e.g. CIM compatible), would significantly enhance the usefulness of NAC.
- Distribution network operators currently have little incentive to support and coordinate provision of frequency stability services from within their networks; multiple aggregators on one network require distribution network level oversight.
- The adoption of over-restrictive limits on DER as a way of avoiding network issues would limit the usefulness of NAC in providing frequency stability services.

Project partners

University of Tasmania, The Australian National University, TasNetworks.

Relationship to other projects

The ARENA CONSORT project, concluded in April 2019, is very closely related. It included three of the same organisations as this current project (UTAS, ANU and TasNetworks) and some of the same core researchers at each organisation. This current project builds directly onto the approach and software developed as part of the CONSORT project.

The ARENA evolve project shares some similar aims to this project: "*The evolve DER project aims to increase the network hosting capacity of distributed energy resources (DER) by maximising their participation in energy, ancillary and network service markets, while ensuring the secure technical limits of the electricity networks are not breached.*".

Links to further project information

Project ARENA web page contains basic information about the project along with all reports.

ARENA state of DER technical integration | project summary

Project/initiative name | Pooled Energy Demonstration Project

Project contact | Chris Cheadle, Pooled Energy

Project summary

The Pooled Energy Demonstration Project provides retail electricity and swimming pool automation to pool owners as part of an on-going service. The energy consumption of the pools is managed from a central Network Operating Centre in such a way as to help off-load and stabilise the grid. It is an enabling technology for intermittent renewable energy sources such as wind and sun.

Key project deliverables

- Creation of a demand-management capable pool-automation controller
- Creation of a central, demand aggregation and management supervisory control server
- Pooled Energy customer growth to a total of 3000 customers.

Key project innovation

Pooled Energy has developed a distributed control system, which in addition to enabling best-in-class pool automation for customers, has also enabled proven discretionary load shed during periods of grid stress. Discretionary load shed/increase is achievable down to specific geolocations to deliver highly targeted grid assistance which is critical towards the goal of increasing variable renewable generation such as home solar PV.

Project timing and progress

Project commenced in January 2018 and is intended to run until end of 2021.

Since commencement, Pooled Energy has developed a best-in-class pool-automation controller, which, in addition to the significant customer benefits of pool-automation, enables discretionary demand management activities at the customer site. Pooled Energy has also developed a central control system which aggregates available discretionary load and performs demand management activities to assist during times of extreme electricity grid-stress.

During the ARENA project, customer count has grown to 1700 customers – an increase of 1200 customers, which has significantly increased the discretionary load available for demand management and modulation (DM&M) activities.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	

Functional area	Yes / No	If yes, how?
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Pooled Energy is building an interface to be OpenADR 1 compliant to enable DM&M activities to be requested by partner organisations.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Pooled Energy is building an interface to be OpenADR 1 compliant to enable DM&M activities to be requested by partner organisations
2.3 Cybersecurity	Yes	Pooled Energy's DM&M network is made up of connected customer nodes, all communicating with the network operations centre via a highly encrypted VPN network.
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Pooled Energy's network of connected sites monitors each pool's energy consumption and contribution to the energy grid load
3.2 DER modelling	Yes	Pooled Energy's vast history of trends of all customer pool energy loads allows for the modelling of efficient pool runtimes vs grid stress/usage
3.3 Network hosting capability	No	
3.4 Bulk power system security and reliability	Yes	Pooled Energy has developed a vast network of DM&M participating devices on an encrypted VPN which demonstrate that a far more secure method of managing DM&M activities is possible than ripple-injection/audio-frequency-injection control. Pooled Energy's unique discretionary load aggregation and DM&M activities support the grid when under stress by shedding, or adding discretionary load during times of generation > load mismatch, in a targeted, geolocation specific manner.
3.5 Distribution system reliability and power quality	Yes	As in 3.4 above
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

Customer growth from 1700 customers to 3000 customers

Links to further project information

https://arena.gov.au/projects/pooled-energy-demonstration-project/

ARENA state of DER technical integration | project summary

Project/initiative name | Project Highgarden (Horizon Power Business Model Pilot Project)

Project contact | David Edwards, Horizon Power

Project summary

The project has installed a variety of Distributed Energy Resource (DER) technologies for households and businesses in Carnarvon, Western Australia. Technologies include energy meter devices connected to the internet to send and receive data (i.e. as part of the 'internet of things'), solar PV, batteries and inverters with remote monitoring and control devices. Horizon Power will use collected data and customer interaction with the technology to inform new retail models that could enable and incentivise customers to participate in the provision of energy services to the grid.

Key project deliverables

The Project Highgarden objectives (stated here) are to:

- **PV fluctuation data processing and analysis** - Data processing was implemented on the Wattwatcher data with the objective of finding numerical values for parameters previously derived probabilistically, and used by Horizon Power in determining hosting capacity. These parameters are the output fluctuation factor, and diversity factor of solar PV impacted by cloud events. These parameters were used in determining the amount of PV generation that can be accommodated in the Carnarvon network without causing stability issues due to cloud shading on the PV arrays.
- **Voltage data analysis** - A further focus of the project work was on voltages observed at the 82 NETT Wattwatcher locations within the low voltage (LV) networks in Carnarvon to identify and quantify the correlation between the overvoltage event occurrences and the PV generation profile.
- **Assessment of Virtual Power Plant Model** – Phase 2 has deployed battery systems to be controlled and monitored through the Reposit cloud platform.

Key project innovation

The areas of innovation in this project are:

- In Phase 1, the development of a monitoring and control system for solar PV and energy storage with the objective to:
  - explore operational risks with high penetration of DER;
  - employ controls to manage DER in a microgrid to support Horizon Power's high penetration DER future assumptions;
  - enable a reduction in peak demand or peak export; and
  - increase DER hosting capacity and penetration of renewable energy into the network.
- In Phase 2, deployment of new combined solar PV and battery systems as well as a 'Reposit Box' DER controller allowing Horizon Power to monitor and control their DER systems through aggregation into a VPP established in the Reposit cloud platform.

Project timing and progress

Milestone 1 – Jan 2018:

Risk management and community consultation planning, customer onboarding and commence data acquisition

Milestone 2 – Oct 2018:

Infrastructure deployment and DER management system development

Milestone 3 – October 2019:

Experiments and data science

Milestone 4 – estimated March 2021 – (COVID-19 delayed):

Reporting and knowledge sharing

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	The ability of participating DER to respond to voltage and frequency disturbances was monitored
1.2 Grid support	No	Experiments with reactive power support have been conducted using inverter settings
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	The solar PV and battery inverters from multiple vendors were procured for this project. Solar Analytics, Wattwatchers and Reposit monitoring and control systems deployed.
2.2 Integration of DER within AEMO and distributors’ systems	No	
2.3 Cybersecurity	No	Cybersecurity of DER aggregation and VPP technology managed by project partners
3. Understanding DER behaviour		
3.1 DER visibility	Yes	A key objective of the project was to gain near real-time visibility of the deployed DER.
3.2 DER modelling	Yes	DER and parts of the distribution network were modelled to assess operational impacts.

Functional area	Yes / No	If yes, how?
3.3 Network hosting capability	Yes	Another key objective of this project was to evaluate the ability of the local distribution network to increase hosting capacity by implementing appropriate control and monitoring protocols.
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	The project assessed the impact of solar PV and battery systems on voltage fluctuations and related power quality issues.
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

Knowledge sharing internally to ensure the transfer of learnings to key stakeholders and strategy development within Horizon Power

Project partners

Horizon Power, Murdoch University, Wattwatchers, Solar Analytics, Reposit Power

Relationship to other projects

https://horizonpower.com.au/our-community/projects/onslow-distributed-energy-resource-der-project/

Horizon Power is working with Intyalheme in the NT to share project learnings into the Alice Springs Future Grid Project https://arena.gov.au/blog/alice-springs-testbed-future-nem/

Horizon Power is a project partner in the RACE for 2030 CRC and will be transferring knowledge from the Carnarvon DER trials into the CRC https://www.racefor2030.net.au/

Links to further project information

https://arena.gov.au/projects/horizon-power-business-model-pilot/

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

https://horizonpower.com.au/carnarvonder/

https://utilitymagazine.com.au/a-balancing-act-managing-networks-with-high-levels-of-distributed-energy/

https://www.mediastatements.wa.gov.au/Pages/McGowan/2019/07/Horizon-Power-wins-a-Silver-in-prestigious-APEC-awards.aspx

ARENA state of DER technical integration | project summary

Project/initiative name | ActewAGL Retail- Realising Electric Vehicle-to-grid Services Project

Project contact | Todd Eagles, ActewAGL Retail (Todd.Eagles@actewagl.com.au)

Project summary

The Realising Electric Vehicle-to-Grid Services (REVS) project seeks to unlock the full economic and grid benefits of vehicle-to-grid (V2G) services in Australia.

Key project deliverables

Development and demonstration workstream

- Certification of compatibility between the Vehicle and the V2G compatible charger
- Demonstration of feasibility of V2G frequency support in the NEM at scale
- Data and analysis of the availability, reliability and performance of V2G frequency support and how this creates value for users, fleet managers, retailers, networks, the system operator, and thereby to all electricity customers

Knowledge sharing workstream

- The definitive reference on current V2G capabilities, opportunities, barriers, and recommendations, including economic, technical, and social domains
- Rigorous forecasts and roadmaps for V2G in the Australian context throughout the adoption curves of utility and distributed renewable energy and EVs to very high penetrations
- Data, analysis, standards and recommendations from the lab testing of V2G capabilities throughout adoption curves of renewable energy and EVs to very high penetration levels

Key project innovation

Bi-directional inverters are a mature technology, but are only now beginning to be offered as commercially viable and wall mounted devices. While the technology used in this project is not fundamentally different to that used in smaller studies, the key point here is to validate the technology in an Australian application, understand the differences and similarities to other markets whilst attempting to determine the revenue opportunity for all stakeholders (customers, OEMs and fleet managers and procurers) in today's environment and throughout the adoption curves of renewable energy and EVs. The REVS project will deliver the first comprehensive analysis of the challenges and opportunities of V2G services in the Australian market and will forecast and stress test future scenarios to lay out the recommended roadmap to realise the full potential of these services at scale.

Project timing and progress

Activity	Proposed Delivery	Status
Procurement of the vehicles and the V2G chargers	July 2020	Completed
Provision of test data demonstrating V2G system capabilities of the test unit Knowledge share report 1	January 2021	In progress

Activity	Proposed Delivery	Status
Delivery and installation of all vehicles and charging stations Provision of frequency injection test data for the aggregated system Knowledge share report 2	May 2021	In progress
V2G system bidding into AEMO Knowledge share report 3	November 2021	In progress
Final Knowledge sharing report	January 2022	In progress

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Understanding how an EV fleet connected to V2G capable chargers can respond to frequency disturbances via an aggregation platform.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Visibility of the operation of the V2G chargers and the relevant connection points made available to AEMO during the participation in the VPP Demonstrations program.
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	AEMO will have visibility of the assets during the participation in the VPP Demonstrations program.
3.2 DER modelling	Yes	Analysis of the availability, reliability and performance of V2G frequency support.
3.3 Network hosting capability	Partially	The local DNSP will assess the integration of the V2G infrastructure into the local network.
3.4 Bulk power system security and reliability	Yes	Provision of contingency FCAS services to the NEM.
3.5 Distribution system reliability and power quality	No	

Functional area	Yes / No	If yes, how?
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Provision of contingency FCAS services to the NEM.
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

If the demonstration is successful, ActewAGL will explore to expand the FCAS market participation capability to other EV fleets and residential customers.

The key constraints for wide spread adoption will be the high cost to acquire the V2G capable hardware and the current network rules and operation requirements on installing DER within local networks.

Project partners

ACT Government, The Australian National University, Evoenergy, Jet Charge, Nissan and SG fleet.

Relationship to other projects

The REVS project intends to provide FCAS services under the AEMO VPP Demonstrations.

Links to further project information

Not available at this stage.

ARENA state of DER technical integration | project summary

Project/initiative name | Renewable Integration Study - Distributed PV stream

Project contact | Rama Ganguli, AEMO

Project summary

The Renewable Integration Study (RIS) is the first stage of a multi-year plan to maintain system security in a future National Electricity Market (NEM) with a high share of renewable resources. The Stage 1 RIS report (published on 30 April 2020) investigates challenges to operating the power system at very high instantaneous penetrations of wind and solar generation - with analysis undertaken on AEMO's Integrated System Plan projected futures for 2025.

It recommends actions and reforms needed to keep operating the NEM securely, now and as the power system transitions. AEMO looks forward to engaging with stakeholders to refine and progress the recommended actions, including assessing the potential roles of both existing and emerging technologies.

The distributed solar PV (DPV) stream of the RIS concentrated on the impact of increasing penetrations of passive DPV generation on the power system, exploring:

- Key challenges for both the distribution networks and bulk power system
- How these challenges might be addressed
- 'No regrets' actions to better integrate the future DPV fleet within the bulk system in a secure manner.

Key project deliverables

- Consolidated view of the technical challenges associated with increasing levels of renewable generation in the NEM.
- Recommend actions that would help to address these challenges so that power system security can be maintained as VRE penetrations increase.
- Engagement with policy makers, market bodies, consumer groups, market participants and other key stakeholders on findings and progression of recommended actions.

Key project innovation

- Consolidated view of the trajectory of technical issues associated with increasing penetrations of passive DPV generation - from local clustering in the LV distribution network up to the aggregate impacts in the bulk system.
- An evidence base to make the case for action and the promotion of achievable actions to maximise the value of the future DPV fleet.
- An explicit focus on the ongoing secure operability of the bulk power system as DPV penetrations continue to increase - and actions required to achieve this.

Project timing and progress

Oct-2019: RIS international review

Apr-2020: RIS stage 1 report published

Ongoing: industry engagements on RIS stage 1 findings and recommendations, consultation with industry, formulation of implementation plans for key recommendations, scoping for RIS Stage 2.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Examines the impact of mass DPV disconnection on power system security and recommends changes to inverter standards to address this risk.
1.2 Grid support	Yes	Identifies ways autonomous grid support from DPV and storage inverters can contribute to various bulk power system requirements.
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Explicit focus on remote disconnection of DPV systems in the context of last resort, DPV generation curtailment necessary during extreme, abnormal system conditions. Also discuss the role and opportunity for more fine-tuned control and coordination to enable efficient DER integration into the future.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Core focus on both DNSPs' ability to operate their networks and AEMO's ability to operate the bulk power system with increasing shares of passive DPV generation.
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	No	
3.2 DER modelling	No	
3.3 Network hosting capability	Yes	Examination of technical challenges impacting distribution network DPV hosting capacity and mitigation measures.
3.4 Bulk power system security and reliability	Yes	Detailed treatment of the trajectory of bulk power system challenges associated with increasing DPV uptake across a plausible range of uptake scenarios out to 2025.
3.5 Distribution system reliability and power quality	Partially	Qualitative review and survey of the reliability and quality of supply challenges DPV uptake is contributing to across the distribution networks.

Functional area	Yes / No	If yes, how?
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

The primary risk is associated with the operational implications if the RIS recommendations are not progressed. AEMO considers that, if this was the case:

- There would be significant system integration costs associated with managing the bulk system impacts of increasingly large shares of DPV generation – given their passive, uncontrollable nature and mass-disconnection risk.
- In some regions, system security risks that cannot be feasibly managed operationally, potentially leading to widespread supply disruption.
- Moratoriums and other restrictions would need to be applied to new DPV installations in some regions.

Project partners

Extensive consultation with local DNSPs on distribution network implications, with SAPN and EQ representation on expert panel.

Detailed review from the Electric Power Research Institute (EPRI) to capture learnings and opportunities for us, from an international perspective.

Relationship to other projects

This RIS recommends:

- Improvements to bulk power system disturbance withstand and grid support requirements for DPV inverter, as set out in AS/NZS 4777.2
- Fast-tracking short duration voltage disturbance ride through requirements for DPV inverters in SA.
- DPV generation curtailment capability at the device-level nationally
- DPV generation curtailment scheme to be implemented in South Australia ASAP

Links to further project information

AEMO RIS project page: https://aemo.com.au/en/energy-systems/major-publications/renewable-integration-study-ris

RIS stage 1 publication:

- Main report: https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-stage-1-appendix-a.pdf
- DPV appendix: https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-stage-1-appendix-a.pdf
- DPV appendix webinar, slides and video available on the AEMO RIS project page: https://aemo.com.au/energy-systems/major-publications/renewable-integration-study-ris

RIS international review:

- Main report: https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/future-energy-systems/2019/aemo-ris-international-review-oct-19.pdf
- EPRI report – Activation of DER in the Energy Market: https://aemo.com.au/-/media/files/electricity/nem/der/2019/standards-protocols/epri-activation-of-der-in-the-energy-market-report.pdf
- EPRI report – International Review of Residential PV Feed-in Management: https://aemo.com.au/-/media/files/electricity/nem/der/2019/standards-protocols/epri-pv-feed-in-management-report.pdf

ARENA state of DER technical integration | project summary

Project/initiative name | Simply Energy Virtual Power Plant

Project contact |Ryan Wavish, Simply Energy

Project summary

The Simply Energy Virtual Power Plant (VPP) project will deliver over 1200 batteries to South Australian households. This represents up to 6.5 MW of residential energy storage.

The Simply Energy VPP project will employ a centrally managed network of energy storage systems installed behind the meter that can be collectively controlled to deliver benefits to households and the local community. Customers can expect better value from their renewable energy solution and the local network will have more distributed energy resources from which to draw from, which in turn improves reliability, particularly at times of peak demand and system instability.

The project will develop the GreenSync decentralised energy exchange or "deX" platform to a commercial scale. The innovative deX platform will provide an energy marketplace that changes the way electricity is produced, used, stored and traded.

Individual customers will benefit from reduced power costs as they are able to increase the amount of rooftop solar power they consume by storing the solar-generated energy and using it later when they would otherwise be consuming power from the grid. Some of the energy storage systems are also able to provide backup power in the event of an outage.

While it is hard to be specific as everyone's electricity consumption patterns are different, under this offer, an average customer with a 5kW solar PV system can expect to save about 40% per cent on the cost of a battery and about 20 per cent off their electricity bills.

Key project deliverables

The project is focused on increasing the value of renewable energy to the grid using VPP technology. The project aims to demonstrate that by integrating in a VPP the open sourced distributed energy market platform software, deX Platform, value can be generated for customers. This will be explored by using the VPP hardware and software to test the ability of the VPP to trade in the wholesale electricity market, Frequency Control Ancillary Services (FCAS) market and in the provision of network services. The key outcomes are expected to be improved understanding of:

- Battery storage based VPP installations including:
  - costs of equipment and integration of distributed energy market platforms;
  - customer expectations, preferences and system operation;
  - technology readiness and commercialisation readiness levels;
  - performance characteristics of VPP technology deployed; and
  - operating within physical constraints of local networks.
- The current and potential future marketplace for VPP technology.
- The roles of the aggregator, distribution system operator (DSO) and distribution market operator (DMO) in the distributed energy market; including with customers, market operations, reliability of systems, market security, market parameters and constraints.

- The ability of a distributed energy market platform to support forecasting the impact of distributed energy resources (DER) on the operation of the interface between the distribution and transmission systems.
- The impact of distributed energy marketplaces on existing energy markets (e.g. the wholesale market and FCAS market).

The key outputs of the activity, including knowledge sharing deliverables are:

- Establishment of an up to 6.5MW VPP;
- Further development of the deX Platform; and
- Provision of publicly available information on the activity including benefits and lessons learnt and the progress towards more widespread use of distributed energy market platforms and the roles and responsibilities of aggregators, the DSO and DMO.

Key project innovation

The project has been designed to extend the scale and complexity of a VPP business model and integrate it with the open-sourced deX to facilitate the development of a new distributed energy resource (DER) market. The use of the deX platform is expected to enable the VPP to access greater value for customers, while also giving customers greater choice. In addition, providing network businesses with greater visibility of the DERs on their network, increasing the efficiency, reliability and security of the system. The functionality of the deX platform will be extended to integrate with a wide range of technology vendors and customer types and, be configured to, and integrated with, the local network conditions to accommodate the requirements of the Distribution System Operator (DSO) and the Distribution Management Operator (DMO).

Project timing and progress

Stage 1 Establishment and initial deployment | During Stage 1, which ran from February 2018 to March 2020, the project acquired initial residential customer targets to participate in the VPP and commenced installation of residential equipment. The project tested out several VPP customer offers to determine what resonated with customers, as well as different sales models to determine the best approach to reach, attract and acquire VPP customers. This stage also involved the further development of the deX Platform developing and testing the full scope of functionality and testing of the VPP to provide value streams, as well as the production of the first of three Knowledge Sharing reports.

Stage 2 Completion of sales and installation | The project is currently in Stage 2 which will conclude at the end of June 2020. In this stage the project is finalising the acquisition of customers to achieve the 1200 plus participation targets. The second Knowledge Sharing report has been produced and the project continues to undertake testing on the VPP's ability to provide value streams.

Stage 3 Conclusion | The final Knowledge Sharing report will be produced. A five-year monitoring process will be undertaken, and the final Economic Benefits calculation will be made and provided to ARENA.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	No	
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Understanding how a fleet of residential energy storage systems from multiple manufacturers can respond to market signals as a single VPP.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Visibility of each of the assets is made available to the distributor and AEMO via the Decentralised Energy Exchange (deX Vision). Distributors also have opportunity to mediate dispatches in areas of the network that is known to be subject to congestion.
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Distributors and Market Operators are able to gain visibility via the deX Vision web interface.
3.2 DER modelling	No	
3.3 Network hosting capability	No	Indirectly, the project should assist in this area. The combination of DER visibility and ability to mediate dispatches by a distributor should assist a distributor in assessing whether the network can host more DER.
3.4 Bulk power system security and reliability	Yes	Frequency Control Ancillary Services from Residential Energy Storage Systems will be trialled during the project
3.5 Distribution system reliability and power quality	Yes	The deX system allows a distributor and VPP operator to contract network services from a VPP operator when network congestion is forecast.
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	The project will trial providing Frequency Control Ancillary Services.
4.2 Provision of localised network services	Yes	Localised network services will be trialled by in the project (where available).

Next steps and constraints or impediments to BAU adoption

Simply Energy intends to continue to develop and test the commerciality of VPPs in a post subsidy environment some of the key constrains which may limit the widespread adoption of VPPs include:

- **Market constraints** – which limit the ability for VPPs to trade and therefor limit commerciality or value which can be obtained from VPPs access to markets, commerciality, customer value.
- **Physical constraints** – which limit the ability of the DER to export to the local grid, high local voltage and fixed export limits contribute to reduction in opportunities to capture value.
- **Technical constraints** – With many different DER and VPP technologies, which provide customers with options, integration, support and maintenance costs of the software platforms can be significant.
- **Customer value** – With high costs to acquire some home storage DERs, returns on investment can often be prohibitive for customers to enter the market.

Project partners

- GreenSync Pty Ltd
- South Australian Power Networks
- Tesla Motors Australia Pty Ltd
- Australian Energy Market Operator Limited
- Marchment Hill

Relationship to other projects

AEMO VPP Demonstrations – This project tests a new technical specification for VPPs to deliver Frequency Control Ancillary Services (FCAS) in the NEM, enabling VPPs to capture new value streams that could be shared with their customers. The functionality developed as part of the AEMO VPP Demonstrations project is required to enable the VPPx project to test and assess the FCAS market capabilities of the VPP, which is one of the key outcomes of the VPPx project.

Links to further project information

VPPx Knowledge Sharing Report https://arena.gov.au/assets/2019/06/simply-energy-vppx.pdf

ARENA state of DER integration technology | project template

Project/initiative name | Townsville Community Scale Battery Storage Project

Project contact | James Miller-Randle, Yurika (james.miller-randle@yurika.com.au)

Project summary

Yurika is installing the state's first community scale, grid-connected, battery energy storage system (BESS). Located in Bohle Plains, Townsville, Yurika's 4MW / 8MWh BESS will commence operation in 2020.

Yurika's Community Scale Battery will provide network support to Ergon Energy throughout Townsville's hot summer months. The system may help keep electricity prices down by allowing Ergon Energy to explore the potential to defer investment in network infrastructure in the area.

In addition, the project expects to create value by charging when prices are low and discharging the stored energy back into the grid when electricity prices are higher. The system will also help maintain the frequency of the national grid by providing contingency Frequency Control Ancillary Services during frequency disturbance events.

The 4MW / 8MWh Community Scale Battery will add to the capacity of Yurika's Virtual Power Plant (VPP), building on the 130MW of existing capacity (the equivalent of around 38,500 homes) already supporting Queensland's Ergon and Energex networks.

Key project deliverables

Battery System and HV Infrastructure Installed

The site construction, installation of the Tesla Powerpack system and HV electrical infrastructure and the distribution network connection were completed in early 2020. These site works were accomplished in under 4 months and relied heavily on local Townsville resources.

System Commissioned and Operational

Yurika has been working closely with its partners to commission the system in preparation for full operation. This process is to ensure the BESS will operate in a manner that ensures safety and reliability for the network.

Key project innovation

As the first HV grid connected BESS of this scale in Queensland, this project represents a key learning opportunity for Yurika, Energy Queensland and AEMO. The experience gained by all parties in facilitating this battery connection will directly support the integration of DER at a similar scale in the distribution network in Queensland.

The Yurika BESS will also add to the growing knowledge of the role batteries can play in supporting network and system stability.

Project timing and progress

Deliverable	Proposed Delivery	Status
Site Civil Construction	November 2019	Completed
Electrical Installation	January 2020	Completed
HV Network Connection	February 2020	Completed
Battery Commissioning	Mid 2020	In Progress

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	Yes	The Yurika BESS shall provide grid support to mitigate any shortfalls in local energy demand. Offsetting potential network investment.
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	Yes	A pioneer project for connecting community scale storage to the distribution network.
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	No	
3.2 DER modelling	No	
3.3 Network hosting capability	No	
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	No	
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Yurika intends to participate in the contingency ancillary services markets. The system will also indirectly response to wholesale energy market pricing.
4.2 Provision of localised network services	Yes	Network support agreement

Next steps and constraints or impediments to BAU adoption

The next steps for the Townsville Community Scale Battery project will see the system commissioned and begin full operation. With this milestone achieved focus will turn to tailoring the operating philosophy to respond to wholesale market signals and provide local grid support. At the same time Yurika will be developing the technical capability of the BESS to participate in the contingency FCAS market.

The key barriers faced by the project to date are:

- The inherent uncertainties associated with integrating an emerging technology into the grid
- Suitability of existing market participant categories for sub 5MW battery systems wishing to participate in the wholesale energy and ancillary services markets
- Suitability of tariff structures to incentivise DER technologies that can provide network benefits

Project partners

Tesla, QGE Group, Aurecon, EPEC group, Titan ICT, Tyree Transformers, Lazzaroni Electrical, Energy Queensland

Relationship to other projects

Yurika intends to use to the Townsville Community Scale Battery to add to its Virtual Power Plant (VPP). The 4MW/8MWh BESS will build on the existing 130MW capacity of Yurika's emerging VPP offering.

Links to further project information

Community Newsletter

ARENA state of DER technical integration | project summary

Project/initiative name | Updated standards for demand response from residential loads

Project contact | Steven Humphries, AEMO

Project summary

AEMO is actively participating in the development of standardised residential load flexibility capabilities, through the currently ongoing revision of AS 4755. AS 4755 sets out minimum device level capability requirements for remotely coordinated demand response from residential household appliances and smart devices – such as air conditioners, pool pumps, hot water systems, batteries and other energy storage, as well as electric vehicle supply equipment.

This is seen as a key enabler for establishing a truly 'two-sided' future power system and market by enhancing the predictability and verifiability of residential demand response, and therefore to facilitating the range of services this might be able to provide, such as:

- Reduced peak demand and reduced wholesale energy cost of meeting peak demand
- Greater system resilience responding to challenges of weather dependent renewable energy
- Greater local network resilience especially as DER saturation increases
- Ability to provide network or flexibility services to offset network augmentation investment
- Load increases to manage minimum demand or peak solar generation flexible capabilities

Key project deliverables

Development of a draft new version of AS 4755.2 is underway and is expected to be open for public consultation Q3 2020.

Key project innovation

Providing a consensus document for the minimum demand response capabilities of a range of residential appliances including minimum information sets to enact these capabilities and requirements (e.g. cyber security) testing regimes, labelling and documentation.

Project timing and progress

A Consultation Regulation Impact Statement (RIS) on a similar proposal was published in 2013. Although this proposal received a generally positive response during public consultations at the time (incorporated in a draft Decision RIS in 2014), this was not progressed further nor submitted to the COAG Energy Council for decision.

In December 2018, the COAG Energy Council agreed that the previous work undertaken in 2013/14 should be revisited, updated and reconsidered for regulation through the Greenhouse and Energy Minimum Standards (GEMS) process.

South Australia proposed this work to the COAG Energy Council in December 2018 and is the Project Lead for this work on behalf of the Energy Equipment Efficiency (E3) Program.

The updated standard has been drafted and is currently planned for public comment in the coming months.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	Yes	Device level requirements for controllable demand response from a range of residential appliances – enabling the provision of a variety of 'grid support' services in the future.
1.3 Protection and control functions	Yes	The minimum device capabilities include mandatory Demand Response Modes for remote such as modes to reduce to no load, or minimal load and/or reduce or no discharge of energy to grid
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Yes	Standardises minimum device level requirements for predictable, verifiable response from devices and necessary communications.
2.2 Integration of DER within AEMO and distributors' systems	Yes	Provides device capability to enable aggregated demand response but further work is required for BAU integration within AEMO and DNSP systems and processes.
2.3 Cybersecurity	Yes	The new draft of AS4755.2 has a mandatory cyber security requirement.
3. Understanding DER behaviour		
3.1 DER visibility	Yes	The standard includes minimum data requirements at the device level. Some form of consolidation (e.g. through a central register) would be required to maximise the potential opportunity.
3.2 DER modelling	Partially	Sets the minimum capabilities which can be used to better model and plan for opportunities from residential demand response in solution feasibility studies into the future.
3.3 Network hosting capability	Partially	Device capability recognised as a key enabler for residential demand response to support/improve this.

Functional area	Yes / No	If yes, how?
3.4 Bulk power system security and reliability	Partially	Device capability recognised as a key enabler for residential demand response to support/improve this.
3.5 Distribution system reliability and power quality	Partially	Device capability recognised as a key enabler for residential demand response to support/improve this.
4. Services		
4.1 Integration with wholesale energy and system security services markets	Partially	Makes possible at the device level, aggregated provision of demand response but requires participation frameworks and business models to emerge.
4.2 Provision of localised network services	Partially	Makes possible at the device level, aggregated provision of demand response but requires participation frameworks and business models to emerge.

Next steps and constraints or impediments to BAU adoption

- Draft of AS 4755.2 is currently finalising with EL-054 committee and will enter styling before the draft will be open for public consultation Q3 2020 (9 week period)
- The decision of COAG Energy Council was that the adoption of nationally applicable, public, non-proprietary standards for demand response for air conditioners (ACs), electric storage water heaters, pool pump controllers and electric vehicle (EV) chargers intended for residential use will be mandatory. These types of equipment will need to comply with AS4755 suite of standards with some equipment by as early as June 2023.
  - air conditioners (ACs) (June 2023)
  - pool pump controllers (July 2024)
  - electric storage water heaters (July 2023), and
  - electric vehicle (EV) supply equipment (July 2026) .
- The decision of COAG Energy Council is to develop an E3 technical working group to review if there is an equivalent international standard if there is one that provides equivalent capabilities to AS/NZS 4755 by mid-2022.
- COAG Energy Council also agreed to the investigation by E3 of the options, cost, benefits, advantages and disadvantages of requiring demand response capabilities meeting public, non-proprietary standards for:
  - Photovoltaic (PV) inverters within the scope of AS/NZS 4777.2; and
  - Controllers for grid-connected electrical energy storage systems (including residential scale batteries) within the scope of AS/NZS 4755.3.5.

Project partners

Extensive cross-industry participation within Standards Australia process.

Relationship to other projects

AS/NZS 4777.2 revision interlinkage with AS 4755 demand response modes, utilised for DPV generation curtailment.

Electric vehicle technical integration – requirements for EV charging.

Note: the Queensland distribution businesses Peaksmart demand response program is an example of a BAU implementation of localised network services from residential appliances using AS4755 capability.

Links to further project information

AEMO information page: https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/standards-and-connections/as-4755-demand-response-standard

Energy Equipment Efficiency (E3) Program, Demand Response Capabilities for Selected Appliances Public Consultation Sessions, August 2019: https://www.energyrating.gov.au/sites/default/files/documents/Smart%20Appliances%20RIS%20Project%20-%20Public%20Consultation%20Sessions%20-%20Australia.pdf

ARENA state of DER technical integration | project summary

Project/initiative name | Updated standards for DER inverter capability and performance

Project contacts | Jenny Riesz and Taru Veijalainen, AEMO; Kara Chan and Suba Ananth, Standards Australia; Nigel Wilmot, EL-042 Chairperson

Project summary

In 2017, AEMO commenced a program of work to better understand DER performance requirements for secure bulk power system operation. This was initiated by the increasingly significant aggregate impact of distributed PV (DPV) during small and large disturbances in the power system. It comprised:

- Analysis of DPV disconnection behaviour from a sample of monitored systems (provided on an anonymised basis by Solar Analytics) for bulk power system disturbances during periods with levels of DPV generation. This analysis was further validated through laboratory bench testing of individual inverters conducted by UNSW Sydney.
- Learnings from the 'next iteration' of uplift in smart inverter standards internationally, increasingly focussed on the autonomous responses of inverters to bulk power system events (in addition to local distribution network factors) – in particular: the 2018 update to the US national standard for DER connection (IEEE 1547) and national implementations 2016 update to the European Network Code for Generators (most notably, Germany and Denmark).

Many DER systems are connected to the grid using inverter energy systems, with requirements for the function and performance within the technical envelope specified in **AS/NZS 4777.2: 2015 – Grid connection of energy systems via inverters, Part 2: Inverter requirements**.

Standards Australia is working with AEMO and a broad range of other stakeholders to revise AS/NZS 4777.2 to address the key challenges of increasing of rapid DER uptake, to ensure aggregate behaviour of these systems is aligned with wider power system objectives, as well as distribution level protection, power quality, and safety requirements. Improving the integration of increased penetrations of inverter connected DER at both the local and bulk power system level will in turn facilitate greater capacity for electricity networks hosting DER.

Key project deliverables

Standards Australia key deliverables:

The technical committee EL-042 – Renewable Energy Power Supply Systems and Equipment is undertaking a revision of AS/NZS 4777.2. The key areas of revision will look at:

- Disturbance Withstand Capability
- Grid Support
- Protection and control function coordination
- Improved and new testing procedures for improved compliance
- Other editorials and identified issues.

AEMO key deliverables:

- Extensive consultation with industry to develop proposed changes to AS/NZS 4777.2 for the connection of small-scale inverters within LV distribution networks.

- An evidence base for proposed changes to inverter performance requirements during bulk power system disturbances:
  - Most critically, evidence of significant disconnection during short duration voltage disturbances - a significant 'common mode' of disconnection for large quantities of DPV inverters in SA today.
  - Evidence is also now also accumulating with respect to disconnection behaviour of larger commercial and industrial DPV systems connected within the LV and MV network.
- Specific learnings incorporated within AEMO's planning and operational analysis:
  - Ongoing post-event assessment of DPV inverter performance during power system incidents – which is now a BAU component of incident reporting for events occurring in periods with significant levels of DPV generation online.
  - Development of 'composite load models' better representing DER behaviour (both temporally and spatially) in dynamic power system studies are used to determine whether the power system remains stable for credible faults and other power system disturbances.
    - AEMO uses dynamic models extensively to examine system stability in a wide range of operational conditions, validate planned transmission network development, assess the system security impact of new market participant connections, and develop operational constraints.

Subsequent stages of AEMO work for consideration, currently being scoped and better defined, include:

- Device level interoperability: this is intended to be progressed separately to the autonomous capabilities currently being considered through a subsequent amendment to AS/NZS 4777 (at this stage planned for 2023) specifying device level communication protocol interoperability and specific smart inverter functions under consideration.
- Compliance uplift: has been identified (by AEMO, DNSPs, aggregators and other parties) as a significant problem today and, if no action is undertaken, a major risk with respect to the adoption and implementation of new DER inverter device-level performance requirements. This encompasses several aspects, including: OEM device capability and 'factory settings', installation practices, monitoring and auditing of performance, as well as actions taken post installation such as firmware/settings updates. AEMO is actively working with industry, the ESB, CER, and the other market bodies on how this might be improved.
  - One area of active focus currently is the potential for better utilisation of different 'disconnected' monitoring/other data sets to identify non-compliance across different OEMs and installers.

Key project innovation

- Evidence-based approach to assessing the need - including the novel utilisation of Solar Analytics data from a sample of installed PV systems triangulated with measured system data during disturbances, supported by laboratory bench testing across the range of plausible power system disturbances.
- Strong international engagement and learnings derived from comparable international standards improvement processes from other jurisdictions planning for very high DER penetrations.
- Wide consultation with key industry partners (including DNSPs, OEMs and CEC) and other stakeholders prior to garner support and build relationships prior to the commencement of a formal AS/NZS 4777.2 revision process.
- The revision of AS/NZS 4777.2 will aid AEMO and other stakeholders to optimise inverter behaviour during disturbances and assist with appropriate levels of grid support. The benefits include managing DER integration so that networks can derive the full benefits of their PV systems while the risks to the stability of the power system are lowered.

Project timing and progress

AEMO's proposed changes to AS/NZS 4777.2 – developed through extensive engagement with DNSPs, OEMs, were outlined in the Technical Integration of DER report, published in April 2019. This formed the basis of an AEMO submission to Standards Australia to review AS/NZS 4777.2 in May 2019.

The Standards Australia technical committee EL-042 accepted this proposal in June 2019. The revision process commenced in September 2019.

The following timeline for the revision of AS/NZS 4777.2 is based on an aggressive timeframe and does not follow normal Standards Australia processes:

- Submission of Committee Draft to SA – June 2020
- Editing, addressing queries, styling – June/July 2020
- Target Public Comment period – July 2020 - September 2020 (9 weeks)
- Resolution of Public comments – September/October 2020
- Editing, addressing queries, styling – October 2020
- Review and endorsing the draft for balloting by committee – October/November 2020
- Ballot – November 2020 (2 weeks period)
- Ballot resolution if necessary – December 2020
- Publication approval process (SA and SNZ Council approval) – January/February 2021
- Publication – March 2021

Note: Opportunities to expedite parts of the process are constantly being considered, with earlier publication aimed for earlier during Q1 2021 where possible. Given the urgency of the mass DPV disconnection risk in South Australia, AEMO is actively working with the SA government to progress testing of LVRT capability to enable certification of some portion of the current DPV inverter fleet prior to the national standard updating, applying to only new installs.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Evidence-based approach to assess bulk power system disturbance withstand performance uplift necessary for DER inverters, aligned with international developments.
1.2 Grid support	Yes	Evidence-based assessment of grid support capability and better technical specification to allow for this capability to be better utilised within the future power system.

Functional area	Yes / No	If yes, how?
1.3 Protection and control functions	Yes	Considered in some detail – in particular, in the context of aspects that overlap between requirements for safe distribution network operation and bulk power system disturbances.
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	Communications-enabled interactions identified as a next step following uplift in autonomous capability.
2.2 Integration of DER within AEMO and distributors' systems	No	Not yet but identified as a next step.
2.3 Cybersecurity	No	Not yet but identified as a next step.
3. Understanding DER behaviour		
3.1 DER visibility	No	Not directly however relevant settings for autonomous disturbance and grid support capability are being captured in the DER register – which will enhance predictability of the aggregated response of DER during small and large power system events.
3.2 DER modelling	Partially	Not directly but recognises the role of better defined, fit-for-purpose standards in facilitating more accurate representation in dynamic power system models – enhancing the predictability of the aggregate impact of DER during bulk power system disturbances.
3.3 Network hosting capability	Yes	Proposed changes, most notably mandating (previously voluntary, not enabled by default) autonomous voltage regulation grid support from inverters will enable DNSPs to host more DPV generation by assisting with managing voltage profiles in the LV network.
3.4 Bulk power system security and reliability	Yes	Proposed changes are directly aimed at maintaining power system security in the long term as inverter-based DER uptake continues.
3.5 Distribution system reliability and power quality	Yes	Several aspects of the AS/NZS 4777.2 revision relate to DNSP power quality considerations and management of the LV network.
4. Services		
4.1 Integration with wholesale energy and system security services markets	Partially	Better specification of technical requirements for autonomous grid support functions (both capability and how that capability is validated and tested) will help unlock potential opportunities for DER to participate in future bulk system service markets.

Functional area	Yes / No	If yes, how?
4.2 Provision of localised network services	Partially	Better specification of technical requirements for autonomous grid support functions (both capability and how that capability is validated and tested) will help unlock potential opportunities for DER for the individual / aggregated provision of services in the LV distribution network.

Next steps and constraints or impediments to BAU adoption

- Recommended changes to AS/NZS 4777.2 are subject to the Standards Australia industry consensus process in the drafting and timelines. AEMO is collaborating closely with industry in this process. Once developed, there are potential limitations as Standards are voluntary documents, and only mandatory if called up in regulation. Governance arrangements around future implementation are currently being considered by the ESB and market bodies..
- Issues to be considered in subsequent stages of AEMO work include: requirements for larger commercial and industrial DPV systems connected within the LV and MV network (from tens of kW to MW scale), improving compliance with DER technical performance requirements and device-level communications interoperability requirements.
- Compliance with standards has been identified as a significant risk and has been prioritised as a key focus area for AEMO going forward strategically with industry in the implementation of new requirements, as well as general governance of DER technical standards.

Project partners

- Australasian Fire and Emergency Service Authorities Council
- Australian Energy Council
- Australian Energy Market Operator
- Australian Industry Group
- Australian PV Institute
- Better Regulation Division
- Clean Energy Council
- Clean Energy Regulator
- Communications, Electrical and Plumbing Union - Electrical Division
- Consumer Electronics Suppliers Association
- Consumers Federation of Australia
- CSIRO
- EL-054 Liaison
- Electrical Compliance Testing Association of Australia
- Electrical Regulatory Authorities Council
- Electrical Safety New Zealand Inc
- Electricity Engineers Association of New Zealand Inc
- ElectroComms & Energy Utilities Industries Skills Council
- Energy Efficiency & Conservation Authority of New Zealand
- Energy Networks Australia
- Engineers Australia
- Fire and Emergency New Zealand
- Institute of Electrical and Electronics Engineers
- Institute of Electrical Inspectors
- Joint Accreditation System of Australia & New Zealand

- Master Electricians Australia
- National Electrical and Communications Association
- Office of the Technical Regulator (SA)
- Smart Energy Council
- Solar Energy Industries Association Inc
- Standards New Zealand
- Sustainable Electricity Association New Zealand
- Sustainable Energy Association
- The University of New South Wales
- Wellington Electrical Association Inc.
- WorkSafe New Zealand

Relationship to other projects

Solar Analytics data provided through ARENA project "Enhanced Reliability through Short Time Resolution Data"

UNSW inverter bench testing partly funded by ARENA project "Addressing Barriers to Efficient Renewable Integration"

AS 4755 updates – AEMO and Standards Australia "Updated standards for demand response from residential loads" project

The DER Integration API Technical Working Group is developing an agreed API specification that will be codified in an Australian implementation guide for the IEEE 2030.5 standard for aggregator to DER devices.

Links to further project information

AEMO (April 2019) Technical Integration of DER report: https://www.aemo.com.au/-/media/Files/Electricity/NEM/DER/2019/Technical-Integration/Technical-Integration-of-DER-Report.pdf

AEMO AS4777.2 revision information page: https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/standards-and-connections/as-nzs-4777-2-inverter-requirements-standard

Solar Analytics DPV monitoring data:

- ARENA project page:: https://arena.gov.au/projects/enhanced-reliability-through-short-time-resolution-data-around-voltage-disturbances

UNSW Sydney inverter bench testing:

- Inverter Bench Testing Results at http://pvinverters.ee.unsw.edu.au/
- ARENA project page: https://arena.gov.au/projects/addressing-barriers-efficient-renewable-integration/

Standards Australia Drafts Open for Public Comment (AS/NZS 4777.2 Grid connection of energy systems via inverters, Part 2: Inverter requirements Comment close date 10-09-2020): https://sapc.standards.org.au/sapc/public/listOpenCommentingPublication.action

ARENA state of DER technical integration | project summary

Project/initiative name | AEMO VPP Demonstrations

Project contact | Matt Armitage, AEMO

Project summary

A virtual power plant (VPP) broadly refers to an aggregation of resources (such as decentralised generation, storage and controllable loads) coordinated to deliver services for power system operations and electricity markets. AEMO currently has no visibility of how VPPs operate. This project will test a new technical specification for VPPs to deliver Frequency Control Ancillary Services (FCAS) in the NEM, enabling VPPs to capture new value streams that could be shared with their customers.

AEMO will also augment its systems to receive operational data from VPPs to observe their behaviour, including how VPPs respond to wholesale energy market prices or deliver local network support services. AEMO will use this data to improve its operational forecasting of VPPs, and identify further changes required to integrate VPPs into market frameworks at large-scale, including potential regulatory reforms.

Key project deliverables

The AEMO Virtual Power Plant Demonstrations project objectives (stated in the final design document) are to:

- Understand whether VPPs can reliably control and coordinate a portfolio of resources to stack value streams relating to FCAS, energy, and possible network support services
- Develop systems that provide AEMO with operational visibility of VPPs to understand their impact on power system security, local power quality, and how they interact with the market
- Assess current regulatory arrangements affecting participation of VPPs in energy and FCAS markets, and inform new or amended arrangements where appropriate
- Provide insights on how to improve consumers' experience of VPPs in future
- Understand what cyber security measures VPPs currently implement, and whether VPP cyber security capabilities should be augmented in future.

Key project innovation

The areas of innovation in this project relate to AEMO:

- testing a new technical specification for Distributed Energy Resources (DER) to deliver FCAS, potentially facilitating more competition to deliver these services at a lower cost to consumers
- developing its systems to receive operation data from VPPs so that AEMO can observe VPP behaviour and learn what changes are required (either to regulatory setting or operational processes) to integrate VPPs into the NEM at large-scale.

Participating VPPs are also innovating in the following areas:

- Technical delivery of FCAS
- Value stacking FCAS, responding to energy spot prices and possible network support services

- Commercial business models/offers to consumers
- Data exchange
- Forecasting
- Market participating, bidding, etc

Project timing and progress

VPP Demonstrations launch – 31 July 2019

Current scheduled end date – 30 September 2020

Currently seeking to extend the Demonstrations to 30 June 2021, project to conclude August 2021

Progress:

- Currently two VPPs participating (Energy Locals/Tesla and AGL), with 1 application in progress
    - Target was to reach 5 participants by the end of the first 12 months
    - 1 MW threshold, slower than anticipated uptake of residential battery storage/VPPs and COVID-19 has meant lower than anticipated participation
- Data received so far has delivered valuable insights – see KS#1 report here

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Ability of VPPs to respond to contingency frequency events
1.2 Grid support	Yes	As above
1.3 Protection and control functions	No	Not participating in a protection/control scheme
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	Partly	Aims to address: Can multiple technologies be part of the same VPP portfolio for market participation? Established and participating in the API working group to try and align various APIs being developed across the industry to facilitate data sharing between VPPs/aggregators and DNSPs/AEMO Does not address: Can customers easily switch between VPP operators/retailers?
2.2 Integration of DER within AEMO and distributors' systems	Yes	As above – point on API integrations. AEMO is not seeking to share data with DNSPs in this project.

Functional area	Yes / No	If yes, how?
2.3 Cybersecurity	Yes	One of the five stated objectives of the VPP Demonstrations relates to cyber security. We are addressing it by requiring participants to complete a CS questionnaire that is a "lite" version of the AESCSF questionnaire. This will be used to understand how VPPs address cyber security risks and whether any uplifts are required, and it will feed into AEMO's DER minimum standards rule change work
3. Understanding DER behaviour		
3.1 DER visibility	Yes	This project provides AEMO, for the first time, operational visibility of VPPs through a rich data set outlined in the VPP Demonstrations Data Specification
3.2 DER modelling	Yes	Data received is helping AEMO develop modelling/analysis to draw insights on: - Operational forecasting of VPPs - Long term forecasting for customer behaviour when part of a VPP, value of being part of VPP and potential future uptake of VPP participation - Market Dynamics – how much revenue can VPPs earn through market participation and how could this drive future uptake (depending on how it is shared with customers)
3.3 Network hosting capability	No	Distribution network limits are not considered in FCAS enablement (or energy dispatch). Data specification and KS reports will explore whether VPPs are being impacted by local network power quality (e.g. voltage) issues, or whether concentrated response within a particular area is impacted local power quality (causing instantaneous voltage issues)
3.4 Bulk power system security and reliability	Yes	Supporting system security (frequency) by responding to contingency events
3.5 Distribution system reliability and power quality	Partly	As above 3.3
4. Services		
4.1 Integration with wholesale energy and system security services markets	Yes	Testing DER FCAS specification Observing how VPPs respond to energy spot prices
4.2 Provision of localised network services	Partly	No direct knowledge/delivery of these services but will ask VPPs whether they have any contracts for local network services and try to observe behaviour in the data

Next steps and constraints or impediments to BAU adoption

AEMO is working through a transition plan to establish how to embed the insights from the VPP Demonstrations into business as usual. At a high level this would involve:

- Conducting a DER consultation/review of the Market Ancillary Services Specification (MASS) to consult on embedding the VPP Demonstrations FCAS Specification (or a version of it amended to incorporate insights from the VPP Demonstrations) into the MASS for ongoing delivery of contingency FCAS from DER.
- Integrating learning from the VPP Demonstrations on participant categories for FCAS/energy into appropriate regulatory reforms processes – e.g. Two Sided Markets
- Considering what level of data would provide AEMO with sufficient operational visibility of VPPs, and how this should be obtained outside of the VPP Demonstrations.

Project partners

No other partners, but current participants include Energy Locals/Tesla and AGL. Further participants are expected to join in the coming months if an extension is approved.

Relationship to other projects

AGL VPP (ARENA funded) – is participating in the VPP Demonstrations

Links to further project information

https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/pilots-and-trials/virtual-power-plant-vpp-demonstrations

ARENA state of DER technical integration | project summary

Project/initiative name | Visibility of DER

Project contact | Luke Barlow, AEMO

Project summary

AEMO's Visibility of DER report, undertaken as part of our Future Power System Security program, was published in January 2017. The report outlined how a lack of visibility of DER devices will impact two of AEMO's core responsibilities in managing the NEM: maintaining power system security and reliability and delivering information to support efficient market outcomes. It proposed potential regulatory changes required to address information gaps, including initial options for the collection of data, recognising the need for further consideration and consultation on these.

The work formed the basis for a COAG Energy Council rule change request for the development of a DER register, submitted to the AEMC in October 2017. Following its industry consultation process, the AEMC made its final rule in September 2018 for AEMO to establish a register of DER in the NEM, including small scale rooftop solar and battery storage systems. AEMO launched the DER Register formally in March 2020.

Data availability and access has also been identified as a key gap for the future integration of electric vehicles. Information on chargers, vehicles and consumer behaviour is often not collected – where data is collected, it can be spread across many organisations or government bodies with access limited due to privacy or commercial considerations. To help address this gap, AEMO is leading the DEIP EV Data Availability taskforce towards establishing a central repository (or other means) of capturing this data to facilitate informed decision making during the transition to electrified transportation.

Key project deliverables

- The Visibility of DER report identified the different AEMO operational and information provision functions impacted by the lack of visibility of DER and the technical and market consequences of not having adequate visibility as penetrations increase into the future.
- Close collaboration with industry to demonstrate the need for a DER register, identify what data should be collected and how it should be implemented, and establish defined roles and responsibilities for this implementation.
- Delivery of the NEM DER register storing static site-level DER device data requested by Network Services Providers from qualified electrical contractors and solar installers at the time of the DER installation.
- Close collaboration with industry (via the DEIP EV Data Availability taskforce) to undertaking a gap analysis to identify EV data needs from an energy sector perspective, prioritise addressing these needs and assess potential collection mechanisms and storage/delivery options for an EV data repository.

Key project innovation

The development and implementation of a workable and effective data collection framework to enable DER visibility. Globally (as far as we are aware) the NEM DER register is the first initiative explicitly built to capture information on residential-scale DER systems in a systematic way, at the time of installation.

Efforts with industry, through the DEIP EV Data Availability taskforce are aimed at establishing a similar process for EV data: establishing data needs and priorities, assessing collection mechanisms and delivery options and establish implementation pathways.

Project timing and progress

AEMO launched the DER register in March 2020.

Work is currently underway, using a number of different program models and data sets from the CSIRO NEAR program (including satellite imagery) to help validate the data within the DER register.

Full integration of DER Register data within AEMO's planning and operational processes in progress.

The DEIP EV Data Availability taskforce commenced in June 2020, targeting December 2020 for gap analysis of EV data needs from an energy sector perspective and assessment of potential collection mechanisms and storage/delivery options for an EV data repository.

Work is currently underway for the introduction of a DER Register in Western Australia. This is a collaboration between AEMO, Western Power and the Western Australian Government, and will be launched in 2021.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Static DER device settings data pertinent to this is being collected within the DER register.
1.2 Grid support	Yes	Static DER device settings data pertinent to this is being collected within the DER register.
1.3 Protection and control functions	Yes	Static DER device settings data pertinent to this is being collected within the DER register.
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	Addressing visibility gaps to enable better informed decision making as DER penetrations increase, through the consistent collection of static data at the time of installation.
3.2 DER modelling	Yes	The data collected will enable better representation, at an appropriate level of granularity / aggregation for the modelling of DER behaviour and impact in the distribution network and bulk power system.

Functional area	Yes / No	If yes, how?
3.3 Network hosting capability	Yes	Provides DNSPs with a consistent source of data, directly to their own systems, of the precise location of DER and other pertinent data about each installation.
3.4 Bulk power system security and reliability	Yes	Enables better planning of both the aggregate energy contribution from DER for system balancing, as well as the behaviour of these devices during abnormal system conditions in the power system.
3.5 Distribution system reliability and power quality	Yes	Enables better planning for and management of increasing levels of DER within the LV distribution network and understanding of the technical operating envelope therein.
4. Services		
4.1 Integration with wholesale energy and system security services markets	Partially	Could be an enabler for this in the long-term.
4.2 Provision of localised network services	Partially	Could be an enabler for this in the long-term.

Next steps and constraints or impediments to BAU adoption

- Full integration of DER Register data with AEMO's existing operational processes is in progress.
- Establishing visibility of other forms of DER into the future – e.g. electric vehicles, demand response.
  - The DEIP EV Data Availability taskforce aims to identify data needs and scope requirements for EVs. Subsequent steps will include efforts to build and implement identified data capture and storage priorities in accordance with industry needs
- Note: Real-time data visibility not currently included. Several initiatives underway to enhance/enable this for larger DER and aggregations.

Project partners

DER register: DNSPs, DER OEMs, CEC, CER, electrical contractors and installers

DEIP EV Grid Integration Working: includes various industry stakeholders but the key groups for this process include EV vehicle and charging OEMs and the DNSPs.

Relationship to other projects

Information in the DER register has several uses internally within AEMO including analysis of DPV behaviour during system events and modelling the dynamic performance of the DER fleet.

The EV Data Availability Taskforce sits within the overarching DEIP EV Grid Integration Working Group aiming to facilitate the efficient integration of EVs into existing networks and markets. The other taskforces under this working group include:

- Standards (co-led by AEMO and DISER)
- High Capacity Tariffs and Connections (led by EV Council)
- Residential Tariffs and Incentives (led by EV Council)

Links to further project information

AEMO (Jan 2017) Visibility of DER report: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/2016/AEMO-FPSS-program----Visibility-of-DER.pdf

AEMC (Sep 2018) DER register rule change consultation process: https://www.aemc.gov.au/rule-changes/register-of-distributed-energy-resources

AEMO DER Register implementation: https://aemo.com.au/en/energy-systems/electricity/der-register

ARENA Electric Vehicle Grid Integration Working Group: https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/ev-grid-integration-working-group/

ARENA state of DER technical integration | project summary

Project/initiative name | Voltage Analysis of the LV Distribution Network in the Australian National Electricity Market

Project contact | Robert Passey, UNSW (r.passey@unsw.edu.au)

Project summary

This project involved the analysis of voltage data from 12,617 site-specific power and voltage monitoring devices throughout the low voltage network in NEM. The following analysis was undertaken for each jurisdiction:

- The averaged maximum and minimum voltages over 2019, separated into suburban inner regional, outer regional and remote.
- The spread in frequency of occurrence of the maximum and minimum voltages, again for different regions.
- The spread in maximum and minimum voltages over a 24 hour period averaged for each season.
- A voltage duration curve including each customer for the maximum and minimum voltages as well as the 95th and 5th percentiles.
- The correlation between voltage and PV export, also separated into different DNSPs and according to PV installation density.
- The potential for PV curtailment as measured by the frequency of voltage being outside the present Standard limits, also by PV installation density.

It also included a comprehensive literature review and recommendations regarding further work, enhancing voltage visibility and improved voltage management.

Key project deliverables

The key project deliverables were the report 'Voltage Analysis of the LV Distribution Network in the Australian National Electricity Market' and a public webinar on 6 May 2020 attended by over 100 people. We have also recently been asked to present on this work at the Clean Energy Council's Distributed Energy Directorate on the 10 June 2020.

Key project innovation

Although similar analyses had been undertaken in Australia before, these have been for a limited number of systems and/or over a limited time period.

Project timing and progress

The project was completed in May 2020.

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	No	
1.2 Grid support	Yes	By illustrating how PV reduces the occurrence of low voltage events
1.3 Protection and control functions	No	
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	No	
3. Understanding DER behaviour		
3.1 DER visibility	Yes	By showing the correlation between PV generation and voltage on the LV network
3.2 DER modelling	No	
3.3 Network hosting capability	Yes	By showing the correlation between PV generation and voltage on the LV network, and by showing how voltage changes in the absence of PV
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	By showing the correlation between PV generation and voltage on the LV network, and by showing how voltage changes in the absence of PV
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

The report, webinar and slides are publicly available https://prod-energycouncil.energy.slicedtech.com.au/lv-voltage-report, and as above, we have been asked to present on this work at the Clean Energy Council's Distributed Energy Directorate on the 10 June 2020.

The report includes 6 recommendations for further analysis, 5 for improved voltage visibility and 14 for improved voltage management.

Project partners

Solar Analytics

Relationship to other projects

This is an ongoing area of work at CEEM, UNSW, with related work available here http://www.ceem.unsw.edu.au. It is likely to be related to a large number of other projects.

Links to further project information

https://prod-energycouncil.energy.slicedtech.com.au/lv-voltage-report

ARENA state of DER technical integration | project summary

Project/initiative name | Western Power Community Batteries

Project contact | Revana Boodhrajj, Western Power

Project summary

In October 2018 Western Power and Synergy connected a community battery (420kWh) in the City of Mandurah, Western Australia. The project is unique in that it accesses multiple value streams in the one solution. These values include network, energy market and customer offerings. The strategic rationale was to integrate storage into the grid in the most cost-effective manner with the vision of reducing energy costs to Synergy and Western Power for the benefit of all consumers. The battery was installed in a green open space (i.e. park), downstream on an LV network that has high penetration of solar. This meant that the requirement to upgrade the distribution transformer has been deferred and the traditional network solution has been substituted by a solution that has additional benefits.

The market and retail benefits are being realised through a gentailer in Synergy. The customer recruitment, despite implementation challenges, was completed promptly and ahead of expectations. To date, the majority of the customers are saving on this new product. The community response has been overwhelmingly positive – customers are requesting this option in their community and developers are hoping to include it in their projects.

Western Power has since installed 10 batteries, with another two so far having a customer facing product. By the end of June 2020, Western Power will have 13 community batteries totalling around 6MWh.

The major challenge in this project is developing a business model that can realise the benefits from all value streams and can positively involve all stakeholders: network, generator, retailer, customer and community. This includes how to optimise battery operations to maximise this value. The lessons learnt from this trial will shape the commercialisation of utility storage in the SWIS. Community Batteries is a positive first step in developing a structure that can deliver this at scale, where all stakeholders can win.

Key project deliverables

1. Support the grid by extending the life of under stress distribution transformers and supporting network voltage
2. Understand customer appetite for shared storage, e.g. approximate market share forecast
3. Understand how to optimise batteries to maximise the complementary and competing use cases
4. Develop a business model that can access the value streams that batteries can deliver to create a positive business case for future expansion

Key project innovation

1. Network: placement and specification of batteries to increase hosting capacity for renewables
2. Business model: incorporate batteries into network planning toolkit at a discounted cost. This includes developing a model that can access to maximise the complementary and competing use cases, effectively subsidising the cost and increasing the viability
3. Product: create a new customer facing product that increases choice in the storage area

Project timing and progress

Complete:

- Ten batteries energised
- Three batteries have a customer facing product

Next steps:

- Energise 3 more batteries in June 2020
- Add a customer product for the ten remaining batteries (Q3 2020)
- Optimise battery operation to maximise value streams (ongoing)
- Develop business case for expansion (Q3 2020)
- Advance operation and communications of the fleet (2020-2021)

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Community battery is able to withstand voltage and frequency disturbances in line with Western Power's requirements.
1.2 Grid support	Yes	The Community battery provides voltage support (Volt-VAR settings of the battery) in line with Western Power's requirements
1.3 Protection and control functions	Yes	Protection and control is coordinated with local Western Power distribution network.
2. Communications and Interoperability		
2.1 Interoperability between devices and between devices and systems	No	This is being investigated as part of our trials and roll-out and will need to consider DER and Energy policy WA guidelines.
2.2 Integration of DER within AEMO and distributors' systems	Partial	The community battery is remotely to be controlled and monitored through manufacturer portal. Western Power is determining the control, monitoring and system requirements for the community battery fleet. Initial discussions on AEMO integration have occurred, further required on best method – being partly addressed with Energy Policy WA
2.3 Cybersecurity	Yes	Cybersecurity principles in line with Western Power's policies and principles are applied.

Functional area	Yes / No	If yes, how?
3. Understanding DER behaviour		
3.1 DER visibility	Partial	Western Power has visibility of the community battery fleet operation. TBA on how we share more broadly
3.2 DER modelling	Yes	Project learnings feeding into Western Power's DER team and into WA's DER roadmap
3.3 Network hosting capability	Yes	Is currently helping in areas where deployed
3.4 Bulk power system security and reliability	Yes	Assessment on this area is ongoing
3.5 Distribution system reliability and power quality	Yes	Batteries currently have Volt-Var setting switched on and are helping power quality. Assessment on this area is ongoing
4. Services		
4.1 Integration with wholesale energy and system security services markets	Partial	Currently accessing through notional wholesale meter, but ongoing discussion with Energy Policy WA are developing future best practice
4.2 Provision of localised network services	Yes	Well progressed

Next steps and constraints or impediments to BAU adoption

Next steps:

- Energise 3 more batteries in June 2020
- Add a customer product for the ten remaining batteries (Q3 2020)
- Optimise battery operation to maximise value streams (ongoing)
- Develop business case for expansion (Q3 2020)
- Advance operation and communications of the fleet (2020-2021)

Project partners

Synergy – retailer

Tesla – battery supplier for first 13 batteries

West Australian Alternate Energy - installer

Energy Policy WA

Various Local Government Authorities (Shires)

Relationship to other projects

- Evolution of the network towards a more modular grid that includes microgrids
- DER Roadmap
- Distribution Services Operator
- Regulatory change

Links to further project information

https://westernpower.com.au/our-energy-evolution/projects-and-trials/powerbank-community-battery-storage/

https://westernpower.com.au/our-energy-evolution/projects-and-trials/perenjori-network-battery/

https://www.bigmarker.com/esb1/Community-scale-batteries-webinar

https://www.mediastatements.wa.gov.au/Pages/McGowan/2020/05/Western-Power-community-battery-unlocks-Kalgoorlies-solar-future.aspx

ARENA state of DER technical integration | project summary

Project/initiative name | Yackandandah SWER Trial

Project contact | Shadman Haque, Mondo (shadman.haque@mondo.com.au)

Project summary

Mondo and its delivery partner Solar Integrity is working with TRY and DELWP for the development of a microgrid project in Yackandandah. The initiative will establish a microgrid on Sanatorium Road in Yackandandah to help cut energy bills for residents and help the community achieve their 100 per cent renewable energy target. The project will increase the number of houses with solar PV and batteries on a Single Wire Earth Return (SWER) powerline and include control technology to manage network security. The project also measures the benefits for consumers taking part in the Sanatorium Road Microgrid – such as energy savings and more reliable supply.

The Hutson isolation transformer on the south west side of the Yackandandah is connected to SWER powerline that services 33 households primarily on Twist Creek road, but also includes Kirby Flat road, No 1 road, Bells Flat road, Service Basin road and Tarrant lane. Solar Integrity have installed Distributed Energy Resources (DER) across 9 properties connected to the SWER line, as well as Ubi only monitoring on another 2 sites. The Mondo Platform and Ubi control system is currently monitoring and controlling 43.5kW of PV generation and 106.6 kWh of battery storage connected to the Hutson ISO transformer. Additionally, 5 heat pumps have been installed, which will have a significant impact on decreasing the power demanded from the grid currently caused by electric hot water systems.

This project demonstrates Mondo's ability to operate a microgrid and bring value to the network by monitoring and controlling DER, as well as providing insights on data collected, and electrical engineering concepts involved in microgrid operation.

Key project deliverables

The Mondo Platform provides a centralised source of control and monitoring for the microgrid. The data, which plays a significant role in controlling and monitoring the microgrid, is uploaded from the Ubi device to the Mondo platform and aggregated to support various aspects of the microgrid trial. Mondo's Ubi device enables DER control at the household level, monitors solar generation and maximises renewable self-consumption for each home. The aggregated power flow, voltage monitoring, battery temperature and system status form part of Mondo's initial observations for the Microgrid. Control algorithms that are developed throughout the trial will be implemented through the Mondo Platform and executed via field deployed Ubi devices. The algorithms will be set up and updated remotely, allowing for adjustments to be updated easily and frequently if required.

Key Deliverables:

- Sharing of Solar Generation
- Load Monitoring & Control
- Voltage Control
- Reduction in peak demand
- Customer bill savings

- Economic value to the network

Key project innovation

Mondo has developed a new platform to provide an aggregated view of the microgrid. The MyUBi Portal is designed for individual sites, it allows customers to view their energy data and allows Mondo to apply settings and control for single sites at a time. It does have the scalability to allow for aggregation of data and control for a large number of customers that would be expected for a microgrid.

Mondo Ubi can be used to monitor solar generation for a site as well as provide what portion was consumed vs exported back to the grid. Mondo Platform can aggregate customers into groups and provide monitoring at the microgrid level. A core feature of the Mondo Platform is the ability to remotely dispatch commands to Ubi devices and use them to control inverters and loads.

Project timing and progress

Milestone Name	Milestone Start Date	Milestone End Date	Milestone Status
Milestone 1 - Project Establishment and Customer Engagement	10/06/2019	10/06/2019	Completed
Milestone 2 - Project Delivery (Household Enrolment and Microgrid Contracts)	10/06/2019	21/10/2019	Completed
Milestone 3 - Project Delivery (Household Equipment Installation and Control Work)	21/10/2019	3/02/2020	Completed
Milestone 4 - Project Delivery (Network Monitoring and Microgrid Operational)	3/02/2020	6/05/2019	Completed
Milestone 5 - Project Monitoring	6/05/2019	16/11/2020	In Progress
Milestone 6 - Project Monitoring and Completion	16/11/2020	17/05/2021	Not Commenced

Project functional scope

Functional area	Yes / No	If yes, how?
1. Devices		
1.1 Ability to withstand disturbances	Yes	Project participants have a battery backup system, in the event of a grid outage it will be observed how the participants perceive the outage given their backup supply.
1.2 Grid support	Yes	The project aims to observe the potential for behind the meter DER assets to impact the grid. This includes voltage regulation and peak load reduction at the SWER network isolation transformer
1.3 Protection and control functions	Yes	Mondo Platform has specialised control functions which are acted on by the Mondo Ubi
2. Communications and Interoperability		

Functional area	Yes / No	If yes, how?
2.1 Interoperability between devices and between devices and systems	Yes	The Mondo Ubi integrates with an array of devices. For this project, the Mondo Ubi was integrated with Fronius Primo solar inverters and Selectronic battery inverters. Communication was established with the inverters via Modbus protocol, this allows monitoring and control of the devices.
2.2 Integration of DER within AEMO and distributors' systems	No	
2.3 Cybersecurity	Yes	The Mondo Platform and Mondo Ubi both have cybersecurity protections to keep customer data safe.
3. Understanding DER behaviour		
3.1 DER visibility	Yes	The Mondo Platform displays customers energy data in near real-time
3.2 DER modelling	Yes	Modelling of solar and battery assets was undertaken to calculate customer benefits as well as ability to impact the SWER network
3.3 Network hosting capability	Yes	Voltage issues are a major constraint for SWER networks, resulting in limited solar penetration. This project addresses the need for intelligent control of solar and battery assets to increase solar hosting capacity on the SWER network
3.4 Bulk power system security and reliability	No	
3.5 Distribution system reliability and power quality	Yes	BTM DER potential to impact SWER network power quality will be tested
4. Services		
4.1 Integration with wholesale energy and system security services markets	No	
4.2 Provision of localised network services	No	

Next steps and constraints or impediments to BAU adoption

The project has the potential to be used as a model for other communities to increase local renewable energy generation and alternative models for SWER line upgrades. In some rural areas, SWER lines experience voltage rises during the day, when the rises in voltage occur outside the acceptable thresholds Ubi can identify when batteries have the capacity to store excess energy and divert power to those, thus bringing voltages back within range. Voltage drops occurring during night-time may be resulting when electric storage water heaters were switching on. To help manage this via Ubi, a small amount of power from the customers' batteries can be fed back into the network in order to bring the voltage back up into the acceptable range. This can be looked at accordingly in future.

Project partners

Mondo, Solar Integrity, TRY, DELWP

Relationship to other projects

Ben Valley SWER Project – 2018

This project consists of 14 installations to create a fully operational mini grid on a SWER line in the AusNet Services network area. The research project was partially funded by ARENA and is a project in partnership between University of Technology Sydney, AusNet Services and Mondo Power. Solar Integrity were the chosen installation delivery partner, completing the sales and installation processes.

The project aimed to integrate solar, battery and Ubi to assist in creating grid harmony by managing voltage rises and drops in a SWER scenario, creating greater energy security for those living on the SWER, less/no power interruptions, and less maintenance costs for the network provider.