Regulatory Information Notice (RIN)

Supporting Information for Demand Management Innovation Allowance (DMIA)

2017-2018

October 2018
Prepared by Essential Energy

Contents

1 Introduction

The Demand Management Incentive Scheme (DMIS) is applied to Essential Energy by the Australian Energy Regulator (AER) through the *Demand management incentive scheme for the ACT and NSW 2009 distribution determinations* (the Determination). It aims to provide incentives for Distribution Network Service Providers (DNSPs) to conduct research and investigation into innovative techniques for managing demand so that, in the future, demand management projects may increasingly be identified as viable alternatives to network augmentation.

The Demand Management Innovation Allowance (DMIA) forms one component of the DMIS. It is a valued element in enhancing the distributors' understanding of Demand Management tools and incorporating those understandings into business process. This document outlines Essential Energy's DMIA expenditure, the benefits of the projects and the outcomes achieved.

2 Summary of Submission

In 2017-18, Essential Energy's DMIA expenditure has supported four different projects/programs that comprise ongoing projects from previous years and two new initiatives:

1. Continuation of Networks Renewed
2. Peer to Peer Review
3. Commencement of e-Grid
4. Continuation of Switched Reactors.

Total program cost for the 2017-18 financial year is $392,702 with $13,755 allocated to CAPEX, as shown in Table 1.

Table 1 DMIA Expenditure 2017-18

Name of Project	Total amount of the DMIA spent in 2017-2018		
	Operating expenditure ($ nominal)	Capital expenditure ($ nominal)	Total expenditure ($ nominal)
Networks Renewed	$107,548		$107,548
Peer to Peer Review	$34,451		$34,451
e-Grid	$236,948		$236,948
Switched Reactors		$13,755	$13,755
Total	**$378,946**	**$13,755**	**$392,702**

For detailed information, please refer to the specific project reports or contact: dmcoordinator@essentialenergy.com.au

All costs are determined using appropriate procurement systems and time recording.

2.1 Developments from previous years' DMIA

Development during the regulatory period included:

- Commencement of Networks Renewed: Joint project with the Australian Renewable Energy Agency (ARENA), University of Technology Sydney, Reposit Power and Fronius, to test battery storage systems and advanced solar inverters with eligible customers within a virtual power plant arrangement to better manage the demand for network capacity and integration of renewables in a two-year partially subsidised trial.
- Peer to Peer review to expand Essential Energy's knowledge on new and emerging technologies and technology usage trends relating to distribution level markets, while facilitating development of a potential distribution level market road map specific to Essential Energy's network.

- eGrid: Essential Energy working group and trial to investigate the reliability performance and cost/ benefit analysis of standalone power system technology as a lower cost option compared to traditional network solutions at the fringe of grid.
- Switched Reactors: Developed to reduce reactive power demands in single wire earth return (SWER) systems, thereby reducing network voltage swing, line losses and the need for larger isolation transformers, deferring or removing the need for augmentation and lowering the cost of supply to customers.
- Demand and Energy - Technology and Environment Paper: A report on customer and utility scale technologies, trials and related environmental changes that are likely to impact electricity demand and energy use within a series of defined periods.
- Demand Management Best Practice Paper: A critical assessment of the world-wide best practise processes, information and technology in electricity NNA analysis and selection with an understanding of the regulatory frameworks and incentives available.
- Conservation Voltage Reduction through the use of low voltage regulators to expand Essential Energy's knowledge in the area of a Conservation Voltage Reduction while also enabling evaluation of the potential for conservation voltage reduction techniques to reduce network peak demand as a secondary benefit in business as usual operation, i.e. changes to voltage regulation practices.
- Capacitor Package Development: Completion of standards and specifications to approach the market and guidelines for applications on the network.
- Commencement of Controlled Load initiatives: Development of a Controlled Load Algorithm and NPV of alternative Controlled Load technology.

Knowledge gained from previous DMIA projects has allowed Essential Energy to provide a more cost reflective evaluation of demand management options within Essential Energy.

- The Energy and Network Capacity project has allowed Essential Energy to capture the long-term costs of the inherently lumpy augmentation characteristics of network assets. In the past, Essential Energy has struggled to implement demand management programs based on cost effectively deferring any single network element.
- The Energy and Demand audits project showed that substantial low cost demand management options are available, and as such Essential Energy is currently moving strategies into place to take advantage of the benefits found across power factor correction and pumping loads and moving toward further research into a number of other promising demand management options which still hold a degree of uncertainty, such as standby generation, load shifting, load shedding and air conditioner efficiency.
- The Grid Interactive Inverter program highlighted the benefits of various inverter control techniques, specification requirements specific to Essential Energy's network and optimised control techniques to maximise network support. Since the commencement of the Grid Interactive inverter program, a number of other suppliers have risen to deliver similar benefits. The evaluation of such emerging products and reduced costs in addition to the known benefits continues to permit cost reflective evaluation of demand management options within Essential Energy.

This renewed business case derivation for Demand Management was reflected in Essential Energy's most recent AER submission and will continue to be reflected in policy and project considerations.

3 Networks Renewed

3.1 Summary

Networks Renewed is a joint industry project by the Institute of Sustainable Futures, Reposit Power, Fronius and Ausnet Services, and the New South Wales and Victorian Governments. Aimed at connecting over 1MW of customer and network-owned solar systems and battery storage systems, it is part-funded by the Australian Renewable Energy Agency (ARENA).

As part of the project, a combination of solar and energy storage will be installed at around 200 households or equivalent businesses. Electricity generated in excess of premises needs will be stored and subsequently used to reduce peak demand on the network.

Potentially up to half of the specified premises and installed capacity may be connected to Essential Energy's network across two locations – the NSW Mid North Coast rural towns of Collombatti, north-west of Kempsey, and Bellingen, south-west of Coffs Harbour.

The Networks Renewed project will facilitate development of a set of guidelines for future uptake to ensure this type of technology is optimally integrated and does not result in costly network expenditure. It will also enable exploration of the potential value this technology can provide on a least cost basis to address network constraints.

3.2 Background information

Traditionally, the capacity of the distribution network has been focused on supplying peak load. As the cost of renewables such as solar PV reduces, the focus is shifting towards peak generation.

The Energy Network Transformation Road Map estimates that, by 2050, 30-50 per cent of energy in the national electricity market (NEM) will be generated at the customer level, resulting in growth of two-way power flows within distribution networks. (Note: it's likely generation penetration for Essential Energy's network will be higher than that, due to connection of larger average-size generator systems – particularly solar PV.)

Based on the percentage uptake of solar PV across its customer base, Essential Energy currently leads NSW distribution network service providers.

Figure 1 presents solar PV panel capacity (excluding major generators) connected to Essential Energy's network from mid-2011 to late 2015 and shows solar PV uptake continuing to grow each year.

Figure 2 presents battery storage applications received since December 2016, which currently exceeds 1000 applications totalling more than 10MWh.

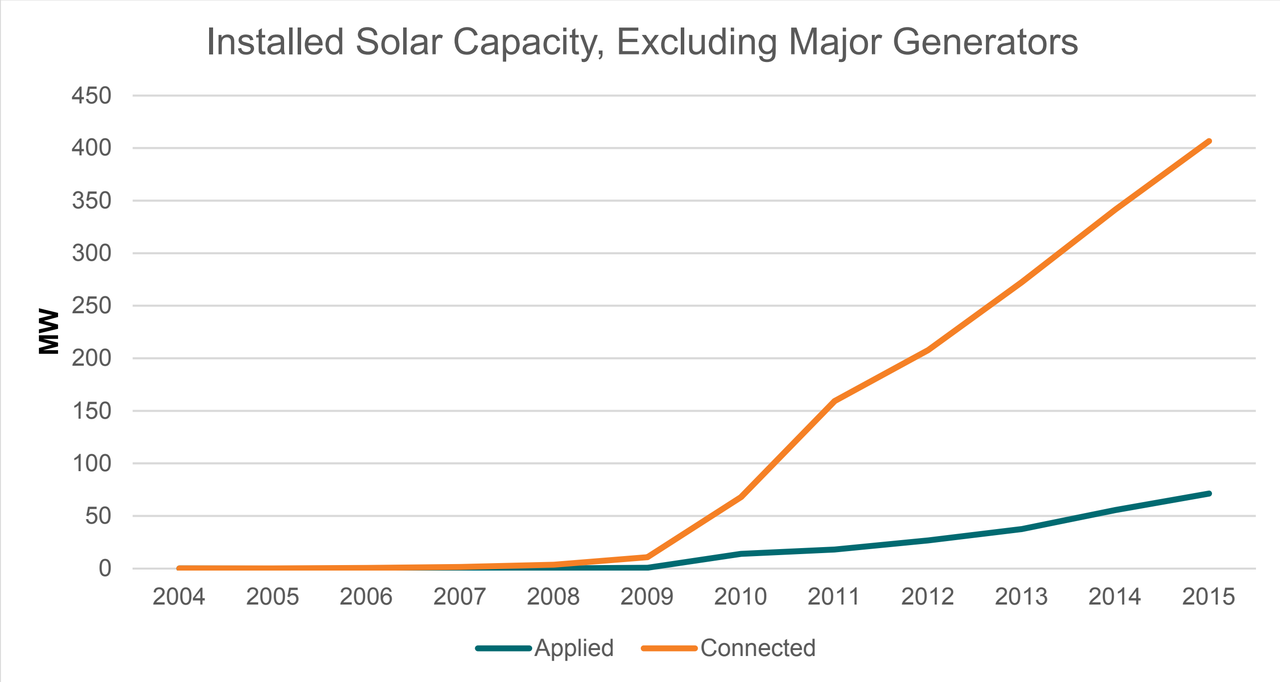


Figure 1: Installed Solar Capacity (Excluding Major Generators)

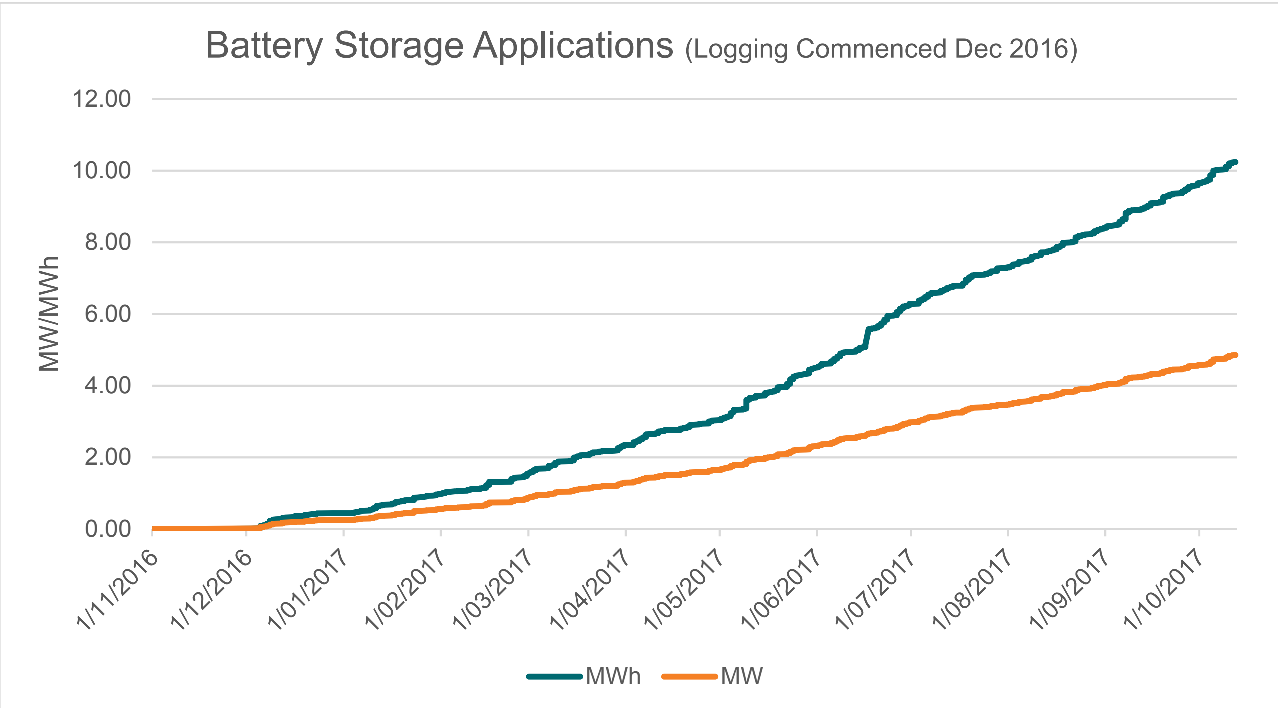


Figure 2: Battery Storage Applications

Essential Energy's electricity distribution network was planned, designed and operated to supply peak load. As it transitions to peak generation, issues such as a reduction in network utilisation are starting to emerge. As a result, in some areas additional capacity is being demanded from the distribution network.

Figure 3 presents the top ten summer demand days at a sample zone substation (which is a common summer peak demand profile exhibited across the network). While solar PV was connected during 2015-16, peak load on the zone substation has not reduced. The surrounding network must therefore still have the capacity to meet this peak load.

As peak generation increases, or minimum network demand reduces, the zone substation experiences reverse power flow. Figure 4 presents the same sample zone substation during minimum demand with reverse power flow. As shown in Figure 3 and Figure 4, utilisation of the network has reduced.

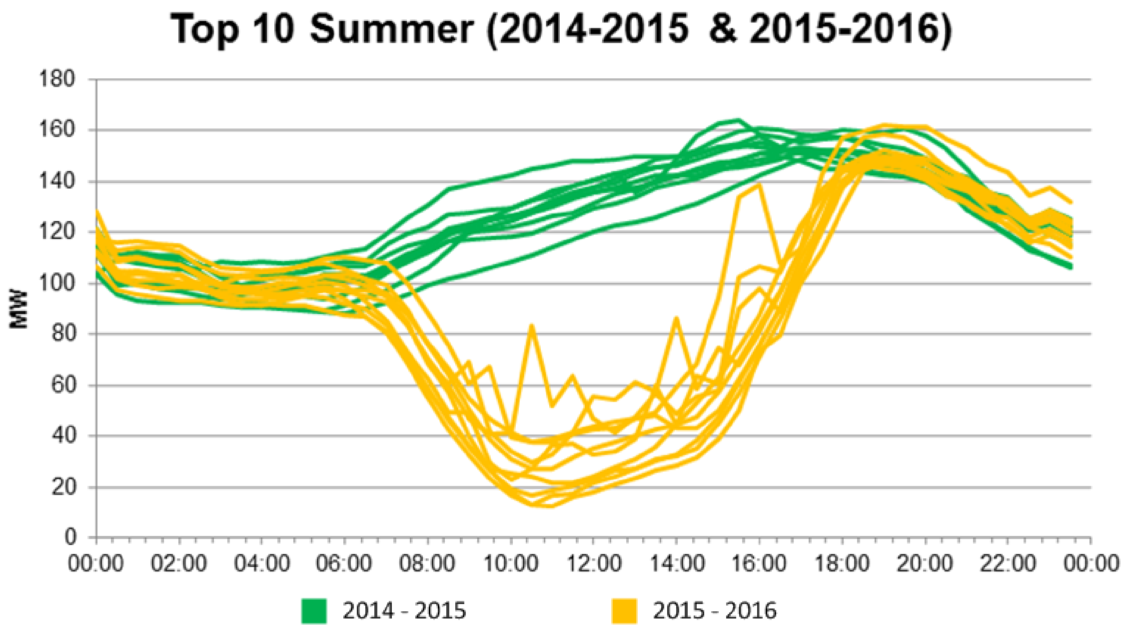


Figure 3: Sample Zone Substation before and after Solar PV connected

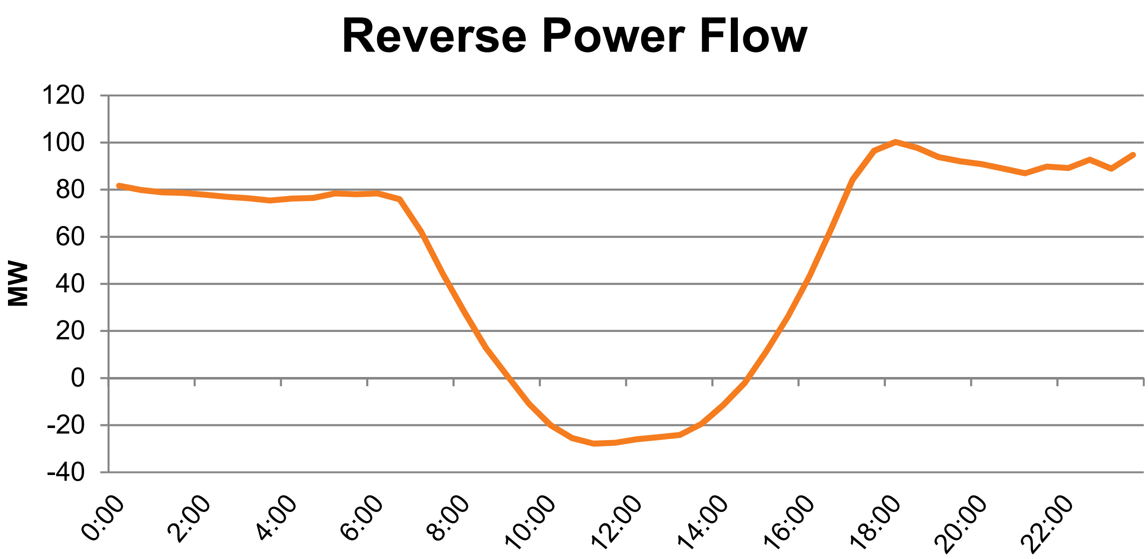


Figure 4: Sample Zone Substation – Minimum Demand

Dependent on network characteristics, a reduction in asset utilisation may result in additional capacity requirements. Referenced to Figure 5, generation results in voltage rise on the network. If combined with a reduction in network utilisation, this results in widening of the voltage envelope (due to the requirement of supplying peak load, as illustrated in Figure 3). Widening of the voltage envelope may result in challenges in achieving the required supply standards. On a voltage-constrained network, it may also result in a network constraint when supply limits cannot be maintained.

Figure 6 presents both a demand and voltage density plot for a single connection point and widening of the voltage envelope.

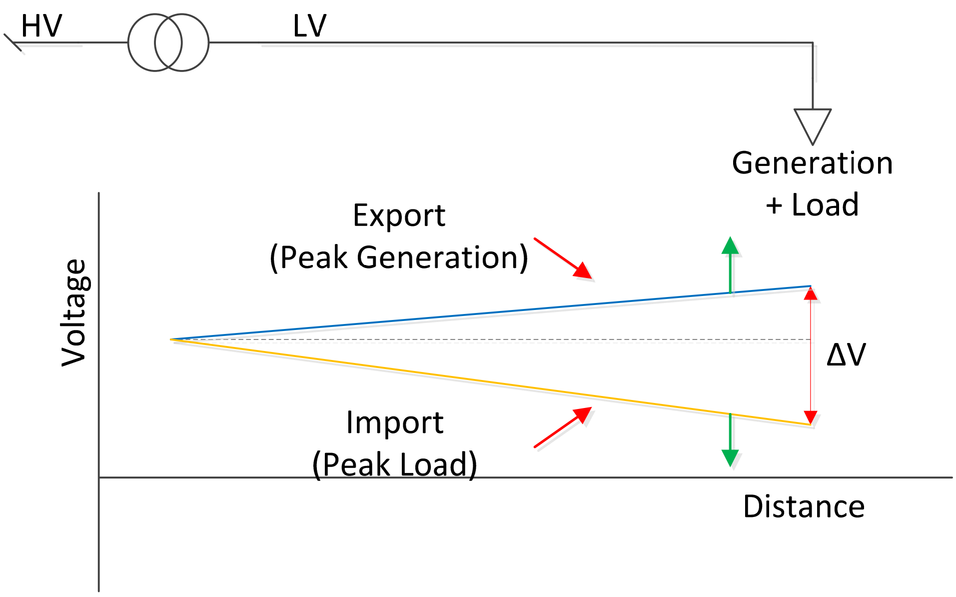


Figure 5: Peak Generation and Peak Load Widening the Voltage Envelope

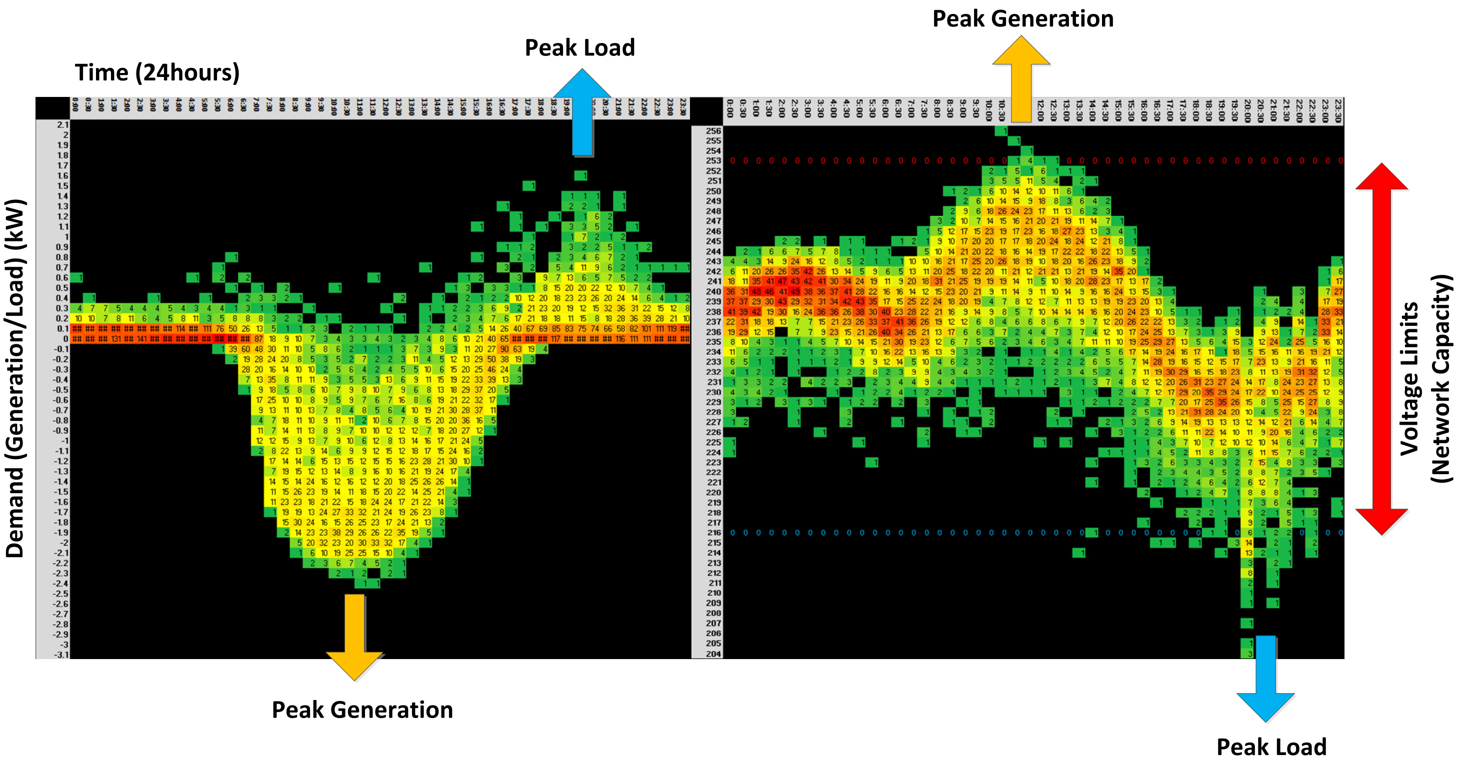


Figure 6: Demand & Voltage Density Plot illustrating Widening of the Voltage Envelope at a single Network Connection Point

Essential Energy's network (presented in Figure 7):

- by land mass covers 95 per cent of NSW
- has a total circuit length of approximately 191,000km – an equivalent total length almost five times the earths circumference
- comprises approximately 96 per cent of overhead network
- has ~75,000 km of steel conductors, with a typical resistance of 15 to 25 Ohms per km
- has ~30,000 km Single Wire Earth Return (SWER) rural lines.

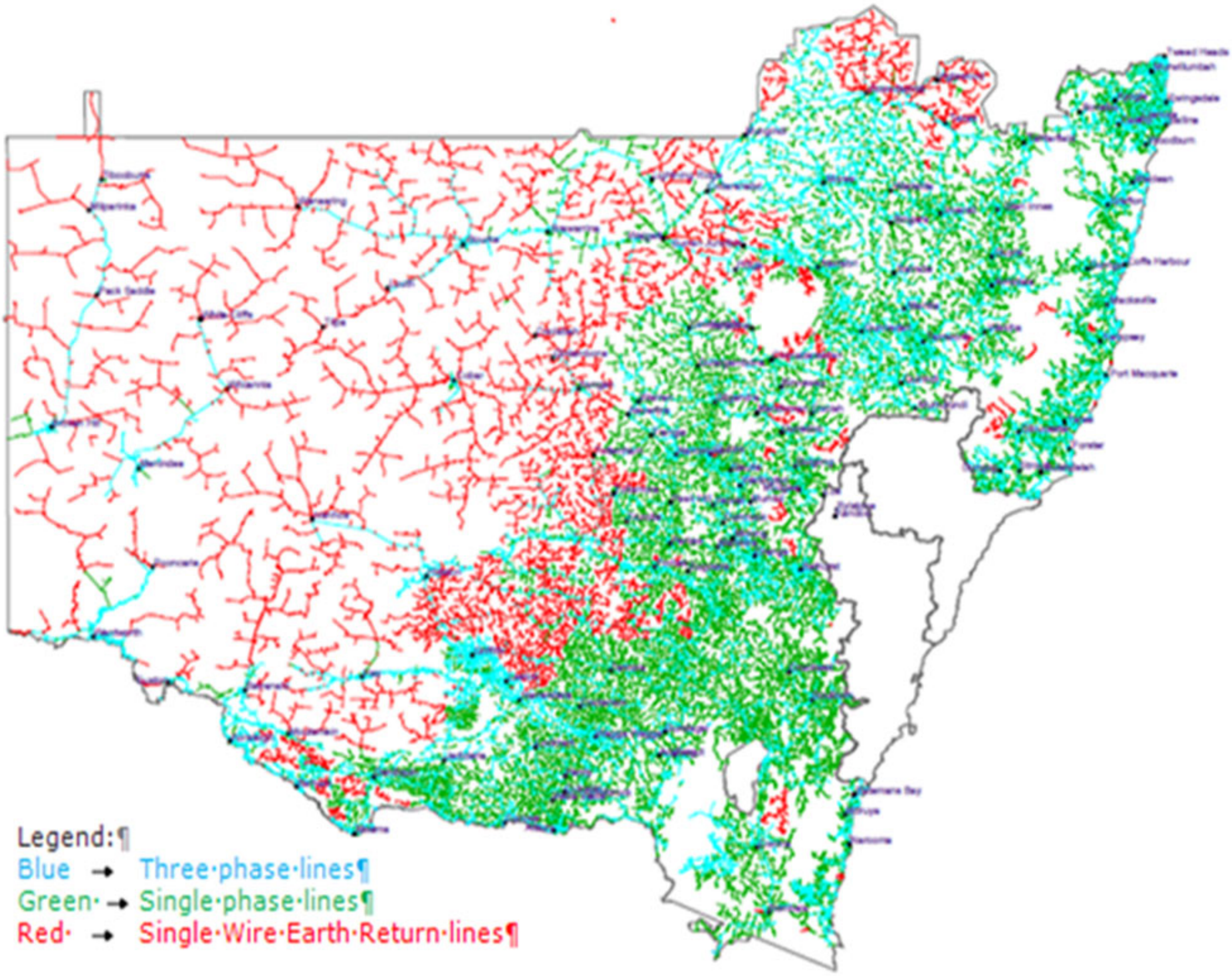


Figure 7: Essential Energy's Distribution Network

Long feeder lengths (presented in Figure 8) built using high impedance conductors result in a high impedance network. A high impedance network exhibits strong voltage correlations to load and generation and is therefore more likely to develop a voltage constraint before reaching thermal limits. With the projected uptake of generation on Essential Energy's network, it is expected that connection point voltage envelopes will continue to widen.

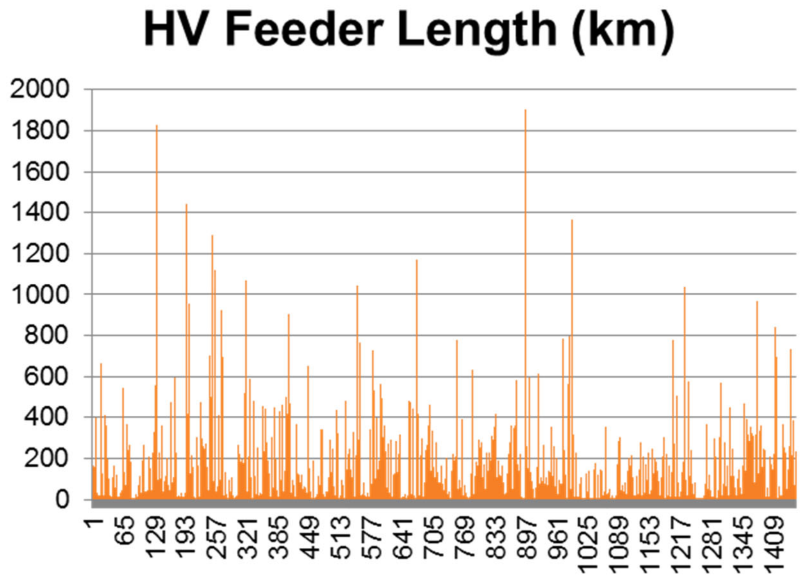


Figure 8: Essential Energy - HV Feeder Lengths

Inverters with real and reactive power control, coupled with or without battery storage, can be used to adjust power flows and significantly improve voltages, currents, utilisation, and losses on the existing infrastructure as an alternative to network augmentation.

One benefit of real power control is peak shifting, as depicted in Figure 9. This involves moving load (or generation) outside of the peak period – in doing so, total energy used is approximately the same (disregarding any efficiency losses or benefits). Referenced to the voltage envelope depicted in Figure 10, peak shifting within a voltage constrained network results in tightening of the voltage envelope. Therefore, battery storage could potentially address network constraints.

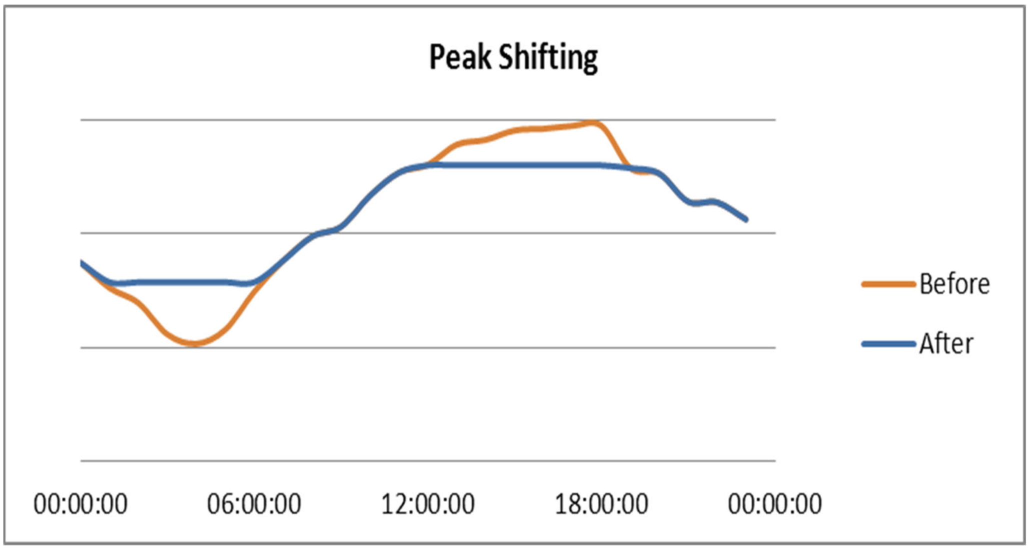


Figure 9: Peak Shifting Strategy

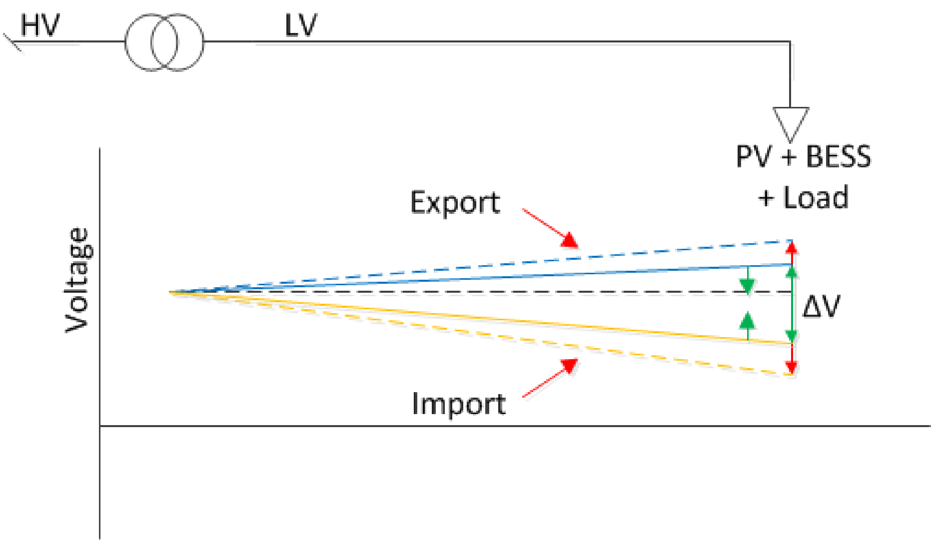


Figure 10: Tightening of the Voltage Envelope

Network benefits that can be derived from real and reactive power control through an individual inverter can be amplified by aggregating many inverters interconnected with communications technology. Figure 11 presents an example of a virtual power plant, used for peak shaving.

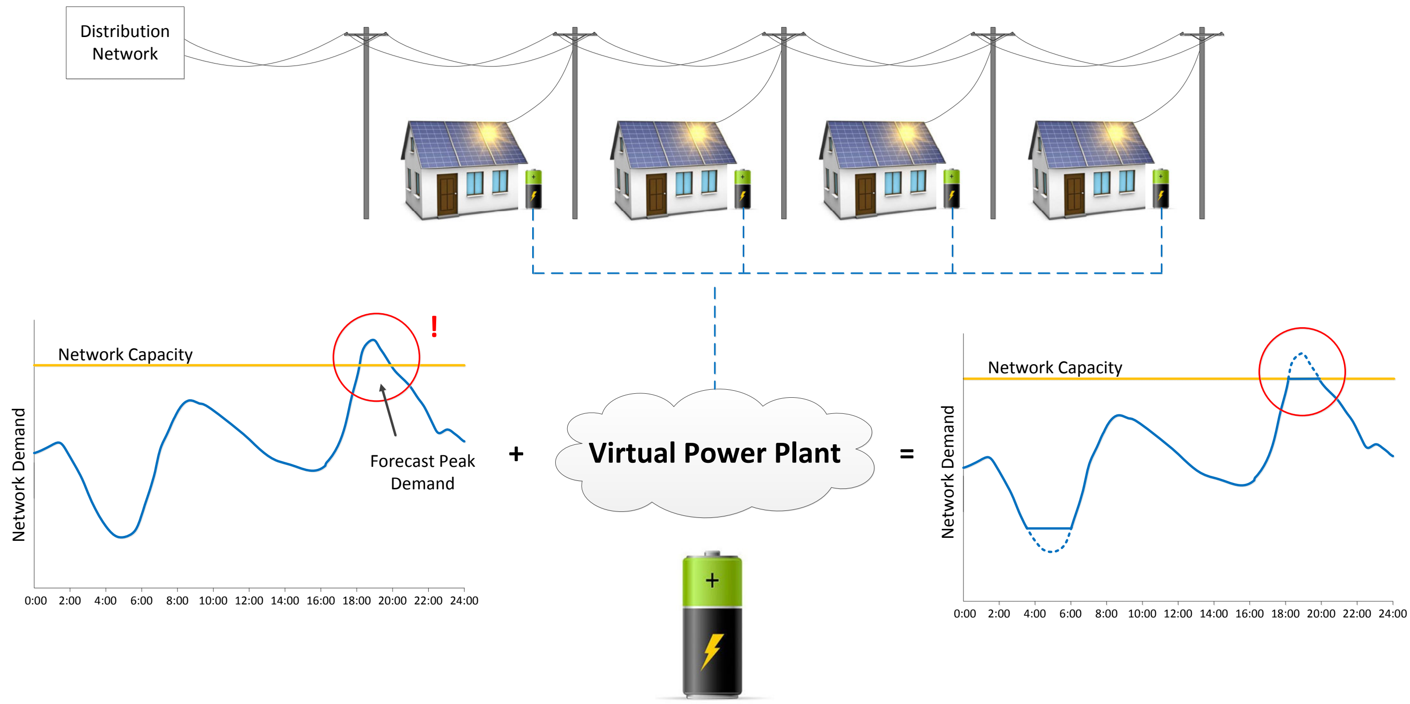


Figure 11: Peak Shaving Strategy with Aggregated Real Power through a Virtual Power Plant ([1])

[1] Solar PV House: 1 https://energig.com/cat/house/
Battery: 2. http://www.djwarehouse.com.au/products/battery-power-pack#.WEd6gtV97mE

3.3 Project Overview

Networks Renewed is a joint project with the Australian Renewable Energy Agency (ARENA), University of Technology Sydney, Reposit Power and Fronius, to assess the potential of battery storage systems and advanced solar inverters with eligible customers in a two-year, partially subsidised trial to help better manage demand for network capacity. The NSW Mid North Coast rural towns of Collombatti, north-west of Kempsey, and Bellingen, south-west of Coffs Harbour, have been selected for the trial due to the high concentration of solar customers in the area and the potential to address an emerging network constraint.

The project's two key objectives include:

- Develop a set of guidelines for future uptake to ensure such technology is optimally integrated and does not result in costly network expenditure.
- Explore the possible value such technology can provide on a least cost basis to address network constraints.

System installations will be delivered in two separate stages, with the quantity of these installations dependent on achieving the required network benefit.

During the initial pilot stage, up to 40 customers will receive subsidised installation of battery storage systems or advanced solar inverters and will retain ownership of the equipment as part of the trial. During the trial period, participants will receive payments based on the level of network support their system provides.

The trial has been designed around an open market approach, maximising customer choice, emerging market participants and the potential future energy market. Subsidies have been used to reduce system costs today comparable to that likely to be seen over the next few years.

Within the rapidly changing energy ecosystem, the key objectives of the project will help Essential Energy operate a best practice business in performance, efficiency, offering value to customers while maintaining downward pressure on network charges.

3.4 Nature and Scope

To achieve the desired outcomes, the scope will be limited to:

- modelling and simulation of networks to investigate the effect of virtual power plants on the energy capacity and delivered power quality
- literature review of virtual power plant control techniques
- subsidy design
- customer engagement plan
- contractor management plan
- network support payment design
- installation of appropriate metering equipment to monitor trial technology (if required)
- test and field trial verification of virtual power plants
- estimation of costs and benefits
- project analysis including suggested paths to business as usual programs if proven viable.

3.5 Aims and Expectations

The project aims to develop knowledge and confidence in the application of aggregated smart inverters with/without energy storage, with two key objectives:

1. Develop a set of guidelines for future uptake to ensure such technology is optimally integrated and does not result in costly network expenditure. Questions that we seek to answer include:
    a. How can greater amounts of generation be installed with minimal costs to customers?
    b. How can Essential Energy encourage generation in areas where it would be of benefit?
    c. What solutions or problems might the combination of solar and batteries bring?
    d. What solutions or problems might the aggregation of batteries by a third party bring?
2. Determine how best to implement solar and storage to address network constraints; Traditionally, when a network constraint such as the supply voltage being outside of acceptable limits arises, Essential Energy would install or replace network assets with assets able to deliver greater capacity, such as larger conductors or an additional voltage regulator. As an alternative, real power from battery storage could be used for peak shaving, while reactive power from advanced inverters could be used to better regulate network voltage simultaneously with solar PV export.

3.6 Implementation

Networks Renewed can be defined as five distinct stages:

1. Site Feasibility Studies

Based on the objectives of the project, discussions with local planners, costs associated with network monitoring and reconfiguration (if required) and anticipated measurable benefits, a list of potential trial sites was collated.

Based on network need and network modelling, relationships to real and reactive power flows were identified to refine the list down to two sites to demonstrate the benefits of real and reactive power through virtual power plants.

The two sites selected for the trial are presented in Figure 12:

1. Collomabtti (smart inverters interfaced to battery storage) – emerging network constraint on a feeder
2. Bellingen (smart inverters interfaced to solar PV only) – high solar PV penetration on a single distribution substation.

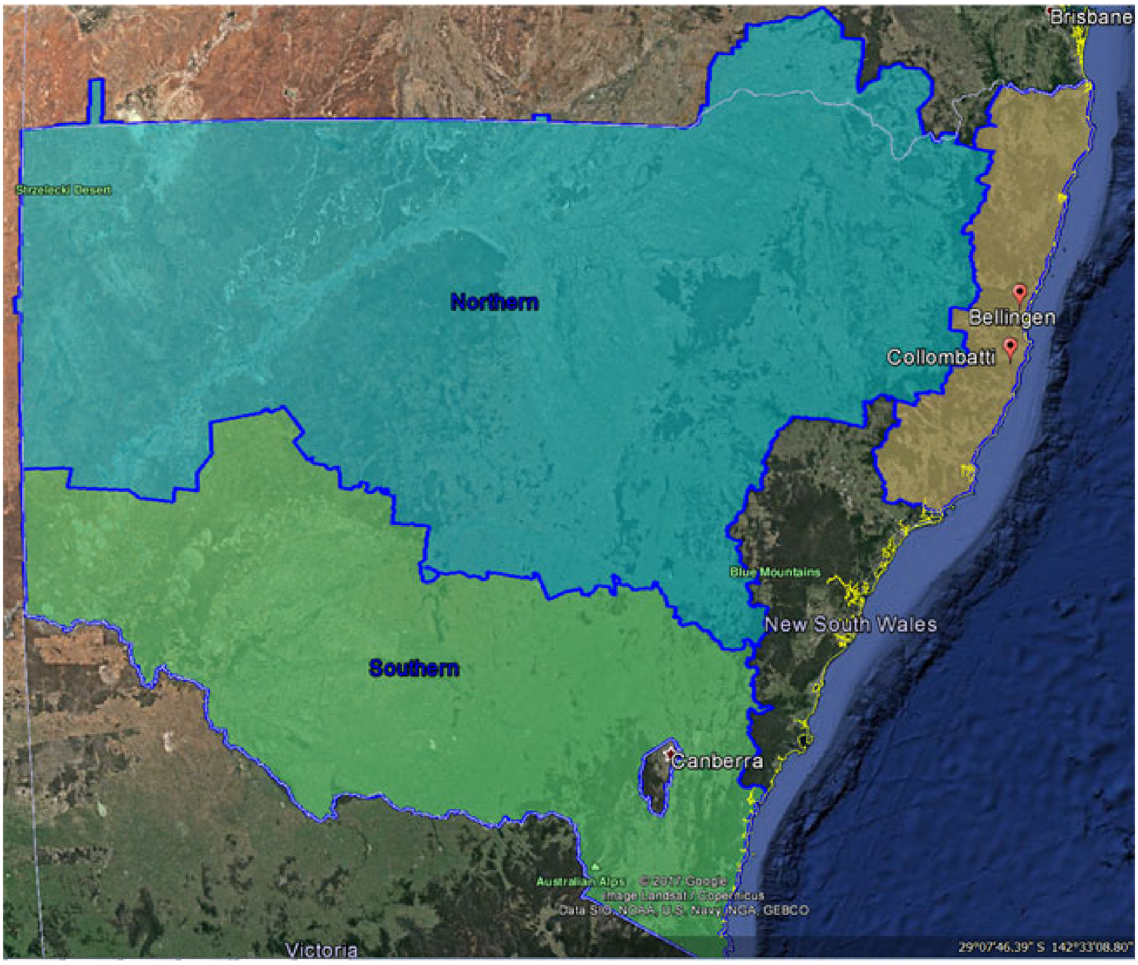


Figure 12: Essential Energy Regions and Trial Locations

2. Pilot Stage Implementation

The pilot stage of Networks Renewed included development of a subsidy, project webpages (https://www.essentialenergy.com.au/our-network/network-projects/collombatti-battery-trial , https://www.essentialenergy.com.au/our-network/network-projects/bellingen-solar-pv-inverter-trial) and Letters of Offer for each trial area.

To commence the expression of interest (EOI) process, and based on proposed network benefit, Letters of Offer were mailed to eligible customers within the two subsidy areas. A community forum was held in Collombatti on 9 December 2016 to provide an overview of the project and to answer any questions from customers regarding the trial.

In response to the initial limited number of expressions of interest received, the Collombatti pilot stage subsidy area was expanded (see Figure 13), followed by a second community forum aimed at increasing the number of trial participants.

Following a subsidy claim approval process, battery storage installations on the Collombatti feeder commenced.

Essential Energy obtained access to the Virtual Power Plant (VPP) in late August 2017. Since then, several VPP notch tests have been undertaken to gauge the effectiveness of systems installed.

The first round of EOIs and subsidy claims were received for the Bellingen trial. However, installations were delayed due to extended equipment lead time, overlapping into the Collombatti Market stage. Installations were completed in mid-2018.

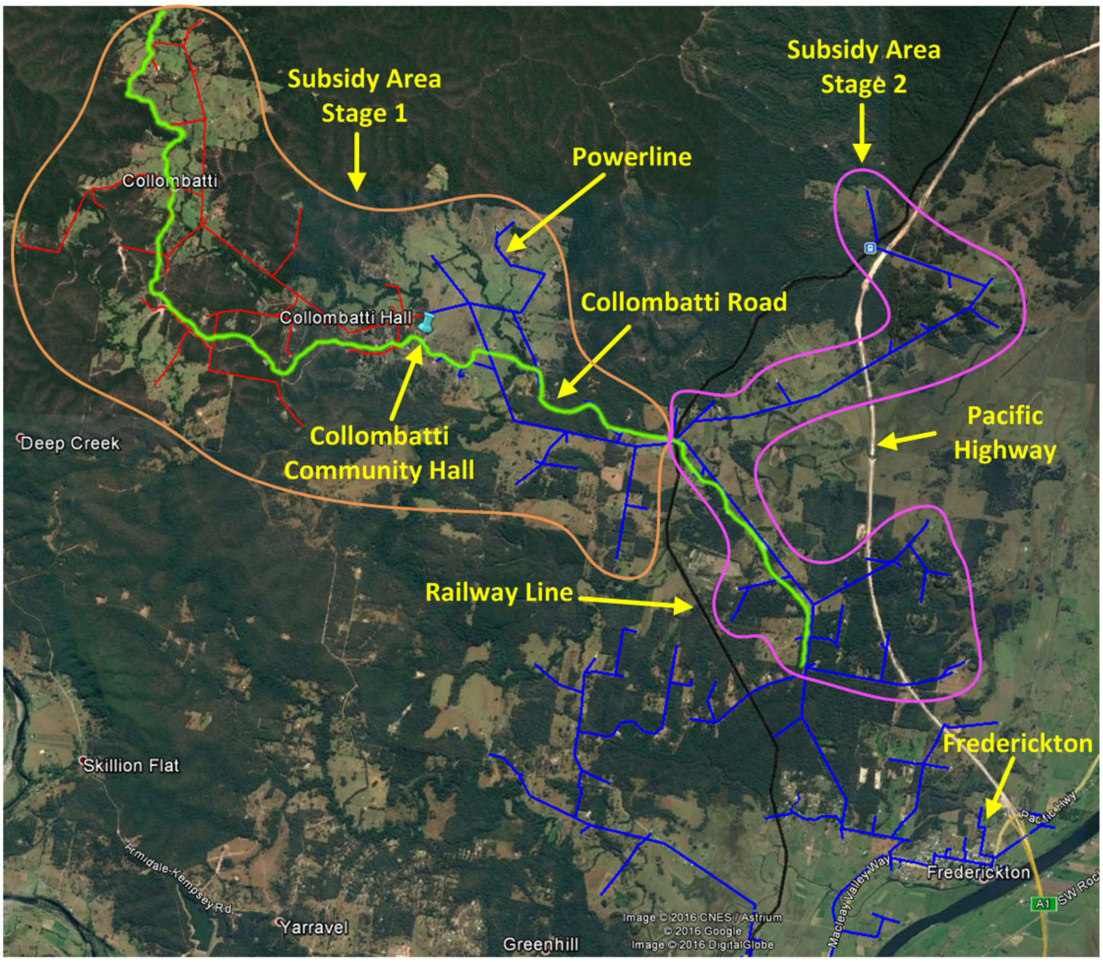


Figure 13: Collombatti Subsidy Area

3. Pilot Stage Evaluation

Recent notch test results from the Collombatti pilot stage virtual power plant have demonstrated a measurable network benefit. As shown in Figure 14, a voltage improvement of 1.73 percent was achieved. Based on the results, Essential Energy was satisfied that the reduced quantity of pilot stage systems installed compared to target is sufficient to ascertain the network benefit characteristic from aggregated battery storage, permitting optimisation and commencement of the market stage.

Based on site feasibility studies, Table 2 presents the two trial sites selected to ascertain benefits and explore control techniques to achieve the objectives of the project. System installations were delivered in two separate stages, with the quantity of these installations dependent on achieving the required network benefit.

As shown in Table 2, the target uptake across both pilot stage sites was 40 systems, allocated to each demonstration site based on the desired outcome of achieving a clear measurable network benefit. Signing up trial participants in Collombatti has proven to be challenging but has also generated valuable learning outcomes used to optimise the market stage.

Through the pilot stage, 23 subsidy claims were received from Collombatti and 11 from Bellingen. A total of 16 systems were active within the Collombatti Virtual Power Plant, with the remaining systems experiencing communication issues.

Following measurements obtained from active systems through the pilot stage within Collombatti, further network modelling was completed to ascertain the required additional number of systems to address the emerging network constraint. This analysis assisted in refining the market stage subsidy design.

Inverter installations were completed in Bellingen . Tests similar to those performed within Collombatti will be conducted during the second half of 2018.

Table 2 – Pilot Stage

Trial Site	Configuration	Pilot Stage Target Uptake	Pilot Stage Uptake
Frederickton Feeder – Collombatti Area (emerging network constraint)	Smart inverters interfaced to Battery Storage	31	23
Single Distribution Substation within Bellingen Town	Smart inverters interfaced to Solar PV only.	9	11

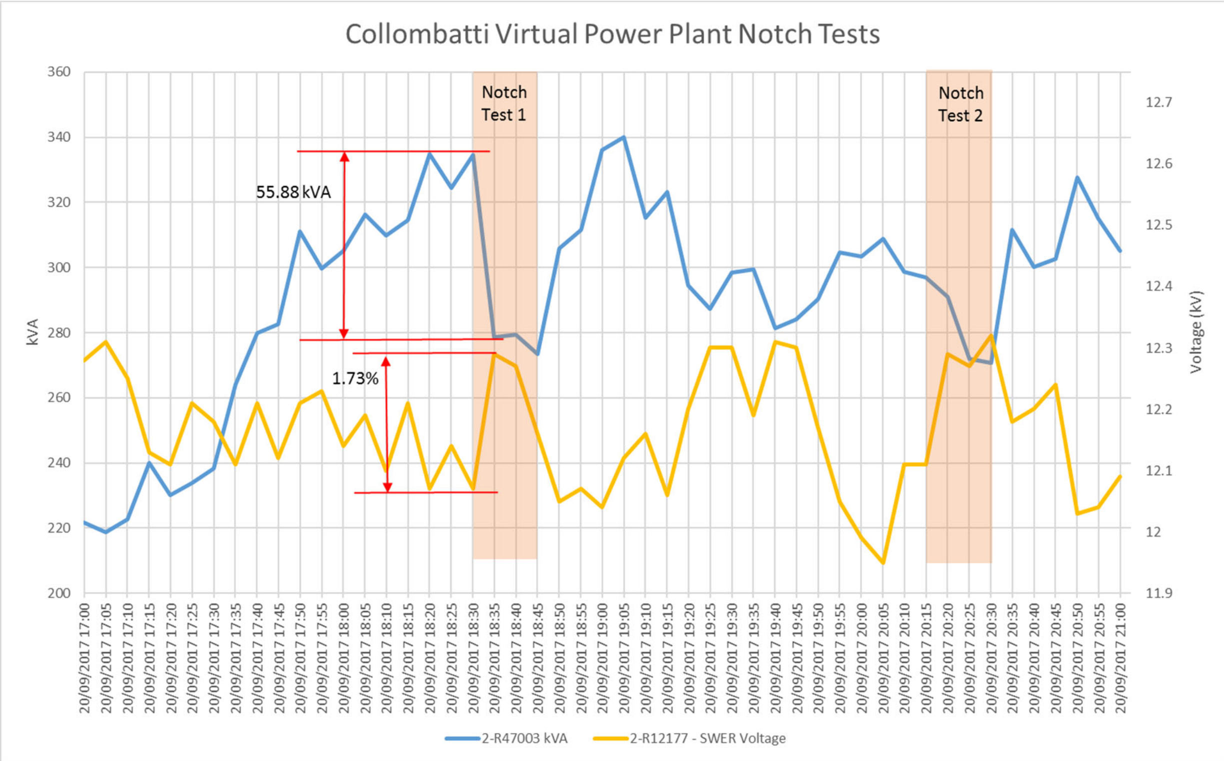


Figure 14: Collombatti Notch Test Detail

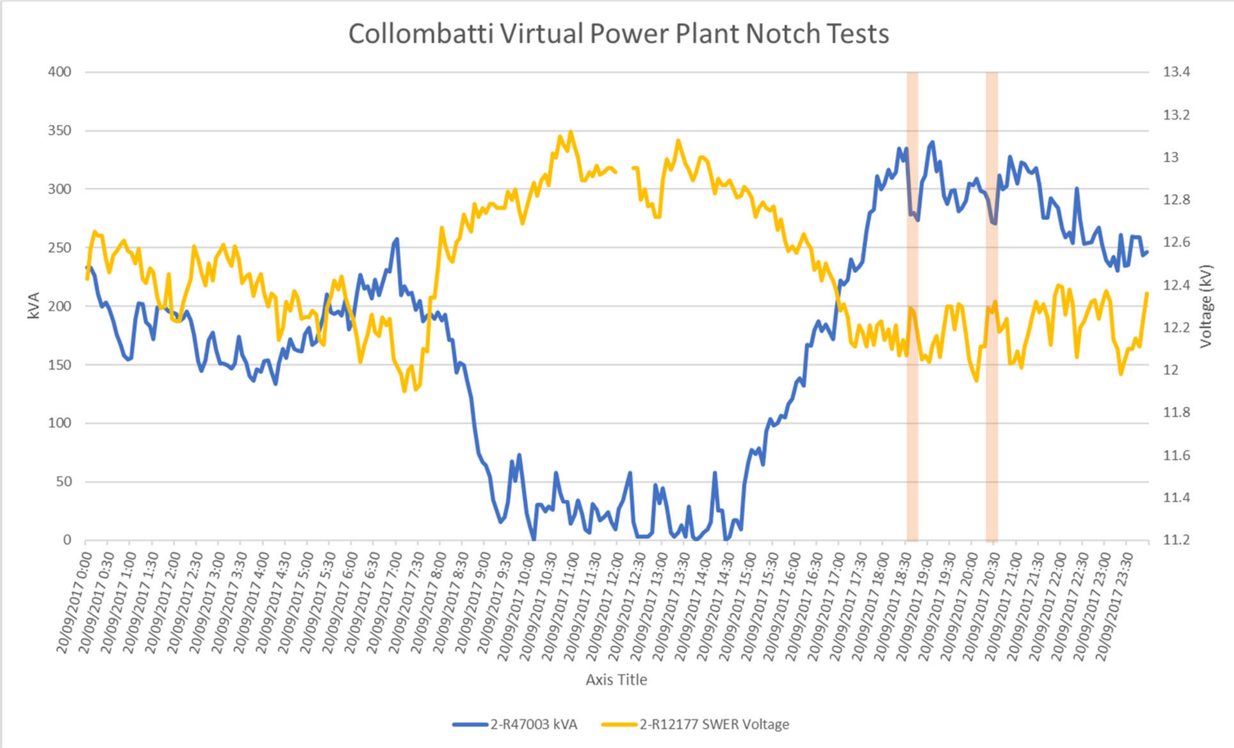


Figure 15: Collombatti Notch Tests

4. Market Stage Implementation

Once measurements were obtained from the pilot stage systems within Collombatti, further network modelling was completed to ascertain the required additional number of systems to address the emerging network constraint, and the market stage subsidy design was refined accordingly. The market stage commenced during the fourth quarter of 2017. To commence the market stage expression of interest (EOI) process, Letters of Offer were mailed to eligible customers within the two subsidy areas (shown in Figure 16) based on proposed network benefit. Following the mail out of Letters of Offer, two community forums were held in Collombatti on 6 and 7 December 2017 to provide an overview of the project and to answer any questions from customers regarding the trial.

In response to the initial limited number of expressions of interest received for the market stage, a third market stage community forum was held on 31 January 2018, with the aim of increasing the number of trial participants. Following the subsidy claim approval process, market stage battery storage installations on the Collombatti feeder commenced.

Due to equipment availability delays leading to Bellingen installations rolling into the Collombatti Market Stage, it was decided not to proceed to a market stage offer for Bellingen following the first round of EOIs and subsidy claims received. Installations were completed in mid-2018.

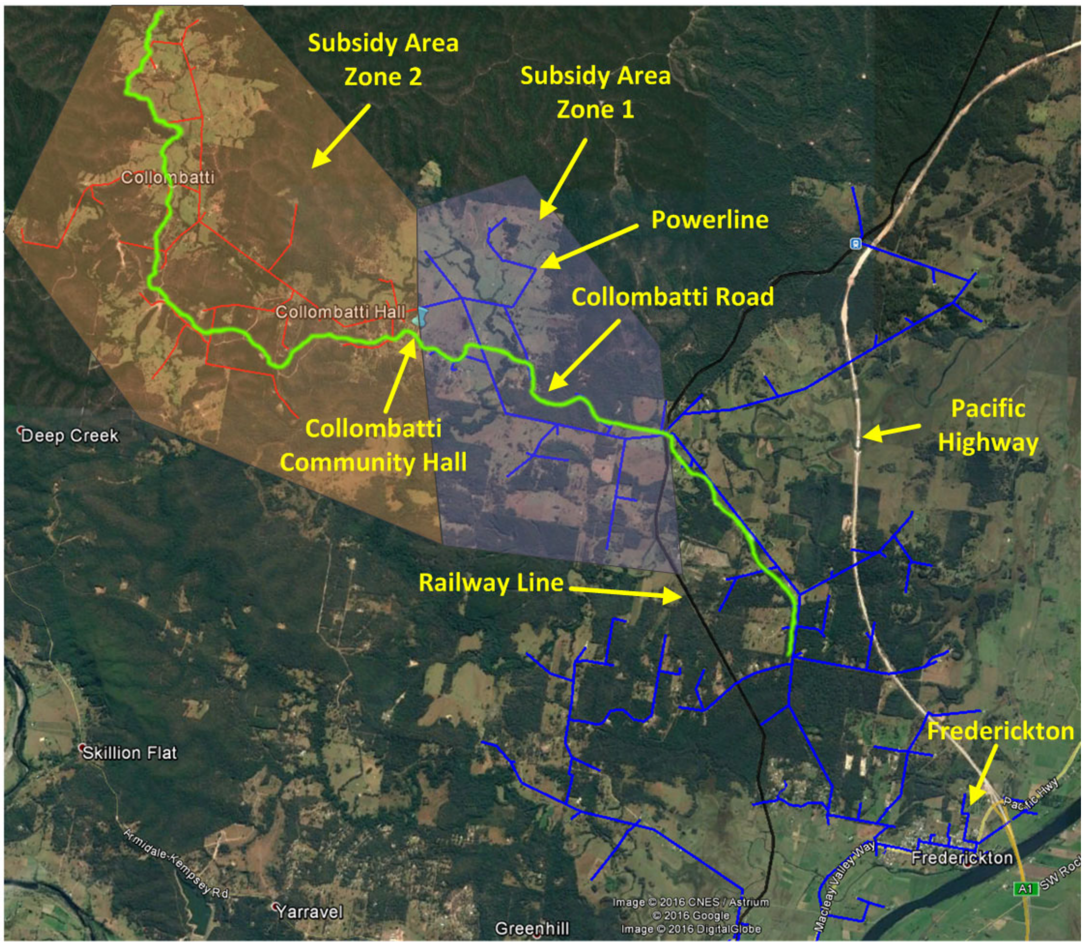


Figure 16: Collombatti Subsidy Area

As seen in Table 3 under the market stage, another seven customers in Collombatti agreed to participate in the trial, while one customer joined the Bellingen trial and two customers decided to leave.

Recent notch test results from the Collombatti market stage virtual power plant have demonstrated improved network support. Figure 17 shows a voltage improvement of 3.07 percent has been achieved from 23 systems active within the virtual power plant.

Figure 19 presents the feeder voltage profile generated from network monitoring points along the feeder. By comparing the feeder voltage profile just before and after the notch test, the approximate profile improvement can be observed, with the majority of voltage improvement exhibited on the SWER and towards the end of the three-phase steel section of the network. This supports outputs generated from modelling the network.

Table 3 – Market Stage

Trial Site	Configuration	Pilot Stage Uptake	New Market Stage Systems	Total Systems
Frederickton Feeder – Collombatti Area (emerging network constraint)	Smart inverters interfaced to Battery Storage	23	7	30
Single Distribution Substation within Bellingen Town	Smart inverters interfaced to Solar PV only.	11	1	10

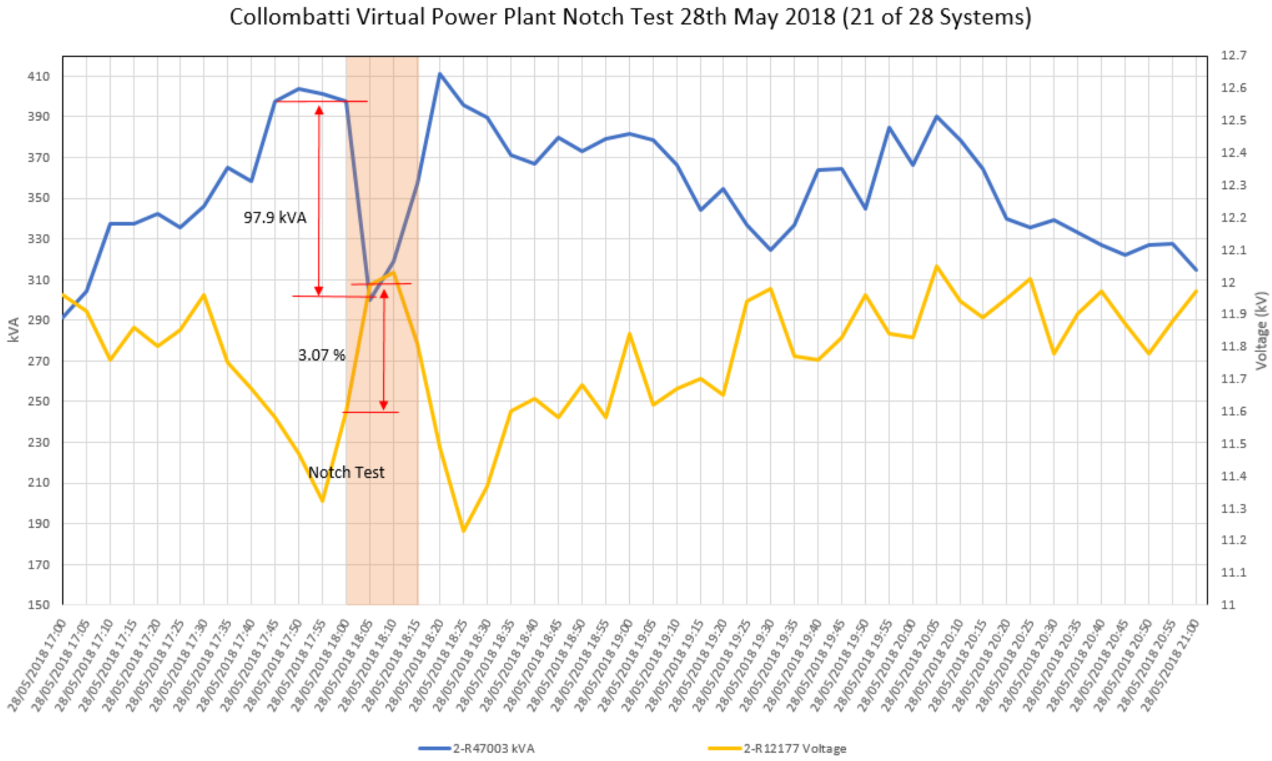


Figure 17: Collombatti Notch Test Detail

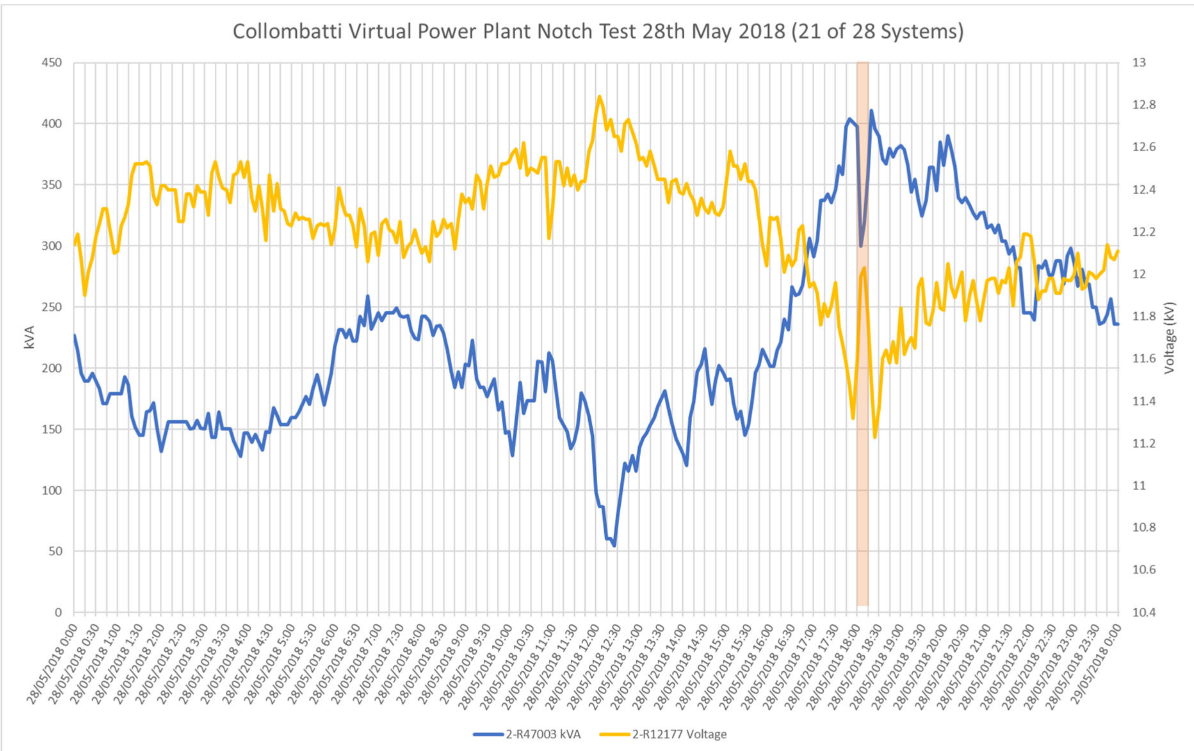


Figure 18: Collombatti Notch Tests

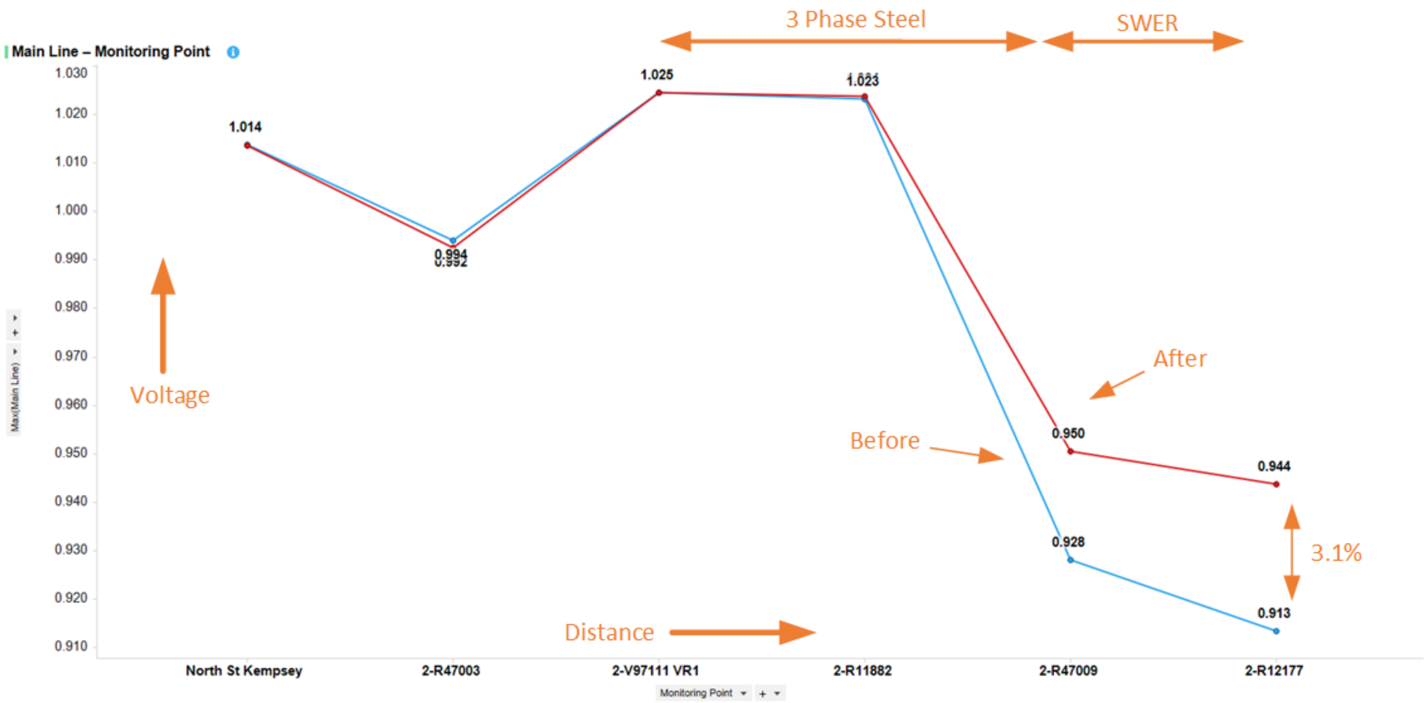


Figure 19: Feeder Voltage Profile - Notch Test

Due to the delay of system installations within Collombatti and Bellingen, it is planned to continue the trial over this coming 2018-2019 summer to ensure the virtual power plant output can be maintain during both extreme weather and the network peak demand period. In addition, the control technique will continue to be optimised, including:

- develop a local control algorithm to back up global control during communication outages
- explore the potential of reactive power further supporting real power voltage support
- reduce bid price to optimiser to lower solution cost (risk/cost trade-off)
- due to challenges reaching target uptake to address the emerging network constraint, explore the cost of an optimally placed network storage unit and/or diesel generation with the aim of testing an economic, prioritised dispatch algorithm to achieve an overall lower cost hybrid solution compared to the traditional network option, to address the emerging network constraint
- investigate the seven sites experiencing communication issues.

5. Total Project Evaluation

Following market stage implementation, a detailed evaluation will be completed in line with the stated project key objectives:

- Development of a set of guidelines for future uptake to ensure such technology is optimally integrated and does not result in costly network expenditure.
- Ascertain the possible value such technology can provide on a least cost basis to address network constraints.

To date, challenges and lessons learned have been logged and will help improve current policies and strategies to drive efficient use of existing assets, unlock value, support the uptake of renewables, place downward pressure on network charges, while also providing insight to the wider market regarding the possible future energy environment driven by the long-term interest of customers.

At a high level, project learnings to date include:

Customer

- support once understood (customer-centric solution)
- opportunity needs to be easily understood
- customer owned/contribution model adds complexity to achieving target uptake
- wider application requires significant customer education/engagement.

Tariffs and Connection standards

- To support the implementation of such solutions and to drive efficient use of the network a shift from static to dynamic connection standards is required.
- In addition to optimising connection standards a shift towards cost reflective tariffs is required to drive efficient use of the network, this is particularly important with automatic control based on financial instruments.

Network (Technical)

- improved network visibility, both from real time and higher resolution historical data
- effective at managing network voltage
- due to a network designed, planned and operated for peak load, emerging issues from generation growth include (within trial areas):
    - abnormal asset operation resulting in amplification of existing network issues
    - reverse power flow conditions difficult to detect due to historical network monitoring configuration. (as depicted in Figure 20)
- challenging to achieve optimised placement through a subsidy area approach (i.e. minimise support characteristic: V%/$).
- communication challenges, particular towards extremes of network
- requires fail-safe mode (in development) to back up control during event of communications failure
- wider deployment requires automatic dispatch (i.e. development of a constraint engine/Distribution System Operator (DSO) platform).

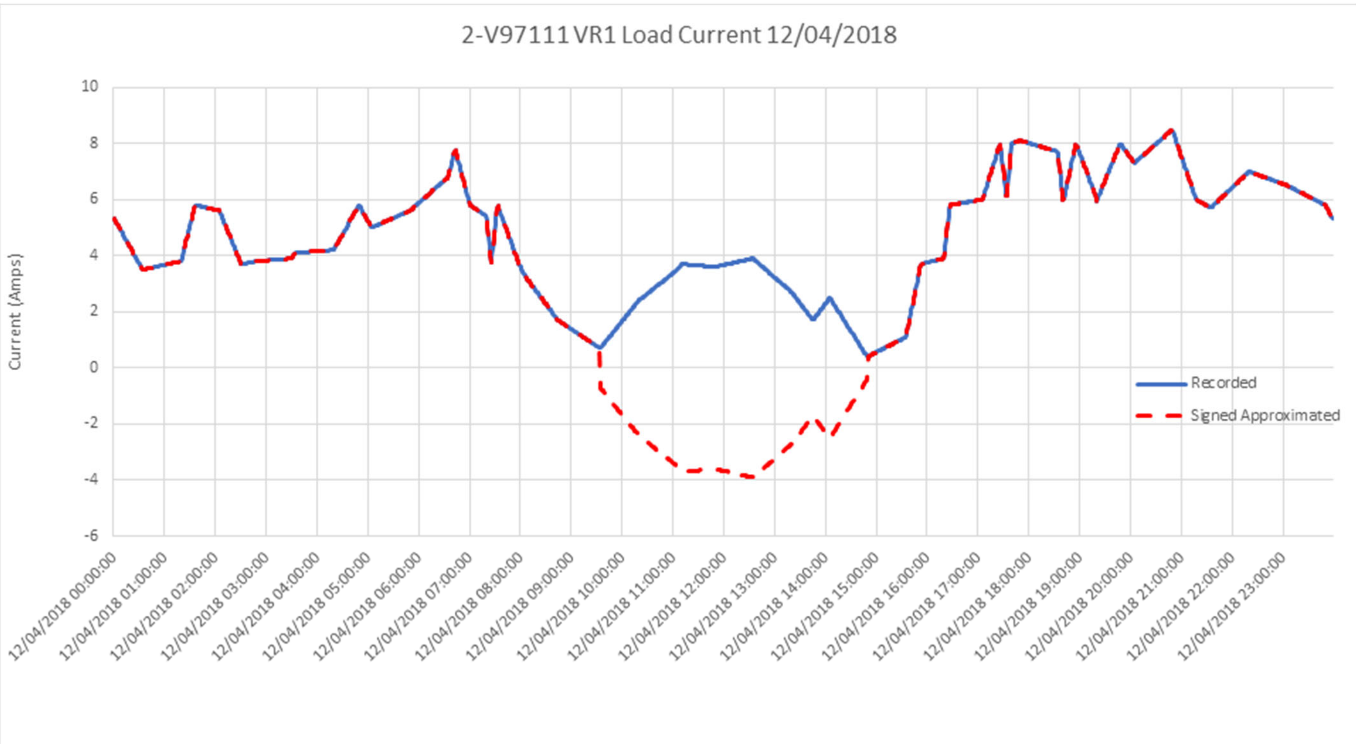


Figure 20: Reverse Power Flow

3.7 Benefits

Undertaking the Networks Renewed project will facilitate development of a set of guidelines for future uptake to ensure such technology is optimally integrated and does not result in costly network expenditure, while also permitting exploration of the potential value such technology can provide on a least cost basis to address network constraints.

A number of anticipated benefits are highlighted below;

- Confidence in the use of innovative technology solutions such as virtual power plants which may then be used to meet legislated power quality standards more efficiently than traditional network investment or as a means of deferring network investment.
- Understanding of the control structures available for virtual power plants and their relative costs, benefits and issues.
- A tool for use in the economic deferral of network investment, through the reduction of demand and losses.
- Avoid network augmentation through reducing/limiting peak demand and improved power quality.
- Decrease network losses.
- Facilitating the integration of distributed generation into the grid.
- Improving network visibility via remote monitoring and control.

4 Peer to Peer Review

4.1 Summary

In late July 2017, a consultant was engaged to facilitate a peer to peer workshop exploring Essential Energy's potential role in the changing energy landscape where a significant number of customers employ, or seek to employ, distributed energy resource (DER) such as rooftop solar PV, home batteries and electric vehicles.

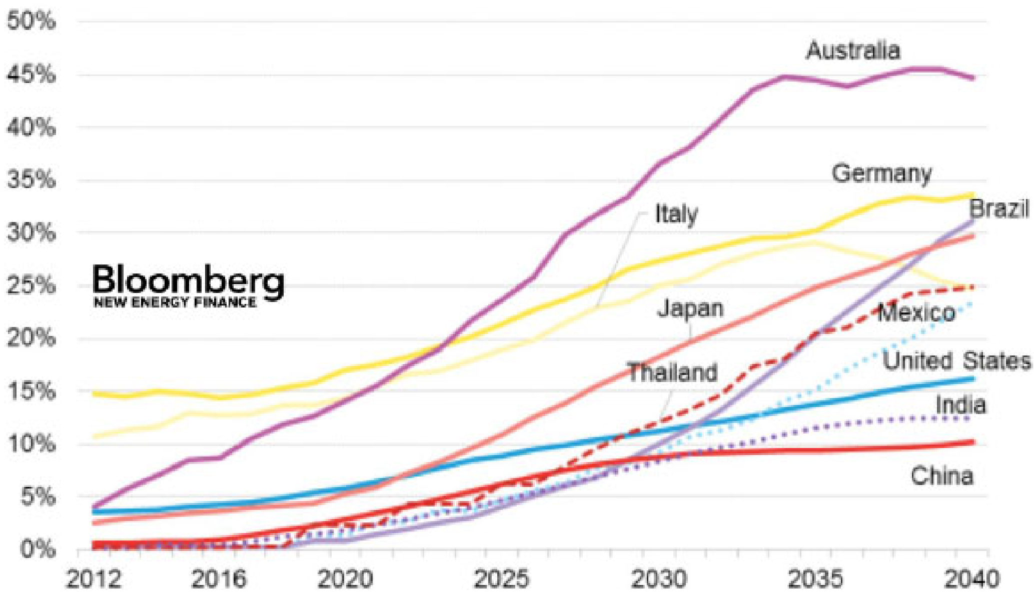
Understanding Essential Energy's potential role in peer to peer (P2P) trading and distributed energy markets will help quantify challenges and opportunities to optimise internal strategies, and drive change within the broader energy market for the long-term interest of customers within the NEM.

4.2 Background information

The energy market is currently experiencing one of its largest transformations since its creation, presenting both challenges and opportunities to existing and new market participants. To adapt to such changes in the long-term interest of customers within the NEM, it's important that Essential Energy takes a proactive approach to identifying market challenges and opportunities today and into the future. This will enable Essential Energy to optimise its Demand Management strategy to drive both internal and broader energy market initiatives.

Over the past five years, consumer uptake of rooftop solar PV has been very strong and is forecast to continue along this growth trajectory, along with other distributed energy technologies such as home batteries, electric vehicles and demand response. This creates an opportunity for facilitating technologies such as peer-to-peer (P2P) energy trading and distribution level markets (DLM), while also providing improved customer products and experience. Globally, energy markets are adapting to greater penetrations of DER and the markets which can leverage these technologies for both customers and utilities.

As shown in Figure 21, looking forward, rooftop solar and other forms of behind the meter (BTM) DER such as battery storage and automated demand response devices will become more prevalent with some forecasting 45 per cent of Australia's capacity being behind the meter by 2040. This puts Australia on track to become the world's most decentralised grid by a considerable margin.



Decentralisation ratio by country[15]

Figure 21: Decentralisation ratio by country

The rapid uptake of DERs is creating both challenges and opportunities for the national electricity market and with Australia at the forefront of decentralisation, emphasises the need to develop a strategy for DER integration.

Essential Energy is particularly well placed to leverage DERs with its extensive regional, fringe-of-grid network and high existing installed base of distributed generation, with the highest percentage uptake of small-scale renewables by customer base in New South Wales. Based on recent research linked to the Electricity Network Transformation Roadmap, the potential long-term network value is significant, with modelling showing the savings from orchestrated DER in the order of $16.2b by 2050.

4.3 Project Overview

In late July 2017, a consultant was engaged to facilitate a peer to peer workshop exploring Essential Energy's potential role in the changing energy landscape where a significant number of customers employ, or seek to employ, distributed energy resource (DER) such as rooftop solar PV, home batteries, and electric vehicles. Understanding Essential Energy's potential role in peer to peer (P2P) trading and distributed energy markets will help quantify challenges and opportunities to optimise internal strategies, while also driving change within the broader energy market for the long-term interest of customers within the NEM.

Over the three-day workshop, subject matter experts (SMEs) from demand management, regulatory, customer engagement and planning departments participated in a number of sessions facilitated by an external peer to peer industry expert, with the aim of developing a high-level road map specific for Essential Energy in the developing P2P environment.

The workshop sessions included:

1. **Overview of current market and potential trajectories**
   One of the key enablers to DLMs is the growth of the Internet of Things (IoT) (see Figure 22). Such growth, at declining cost, positions the IoT as one of industry's mega trends fuelling the rapidly changing energy ecosystem. Examples include smart thermostats to control heating and cooling, permitting automated demand response, and configurable inverters interfaced to solar PV and battery storage that can be dispatched into the market.

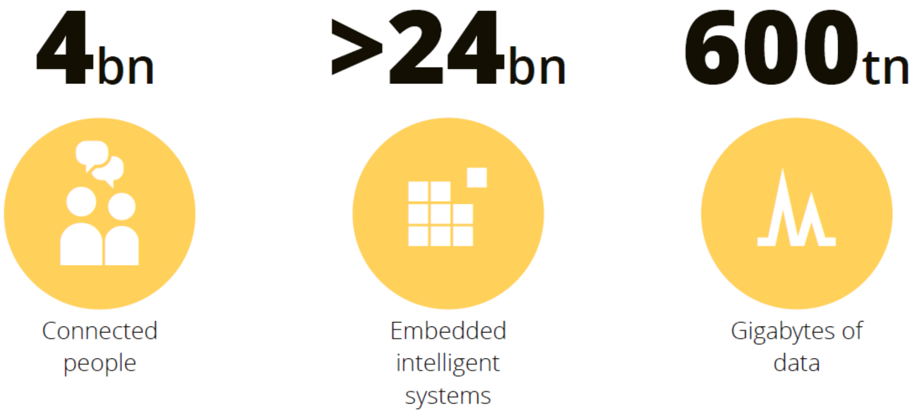


Figure 22: The growth of the Internet of Things (IoT)

2. **Force Field Analysis**
   During this session, a number of proposals for and against change were highlighted, discussed and ranked from highest to lowest influence on the development of DLMs. Figure 23 presents the high-level forces that were identified to be both driving Essential Energy's business towards DLM, as well as pushing against Essential Energy's ability to respond to this shift.

A customer focus emerged as the key force for change, which includes reducing costs for Essential Energy which would flow through to lower network charges for customers. A policy and political environment focus emerged as the key force against change, driven by the current complex energy debate that has contributed towards market confusion on what future changes are required. This has restricted regulatory change, even when those changes are broadly beneficial.

This emphasises the need for industry to take a proactive approach and lead the required change, educating policy makers and government to work towards the right outcomes and at the right time for the long-term interest of customers.

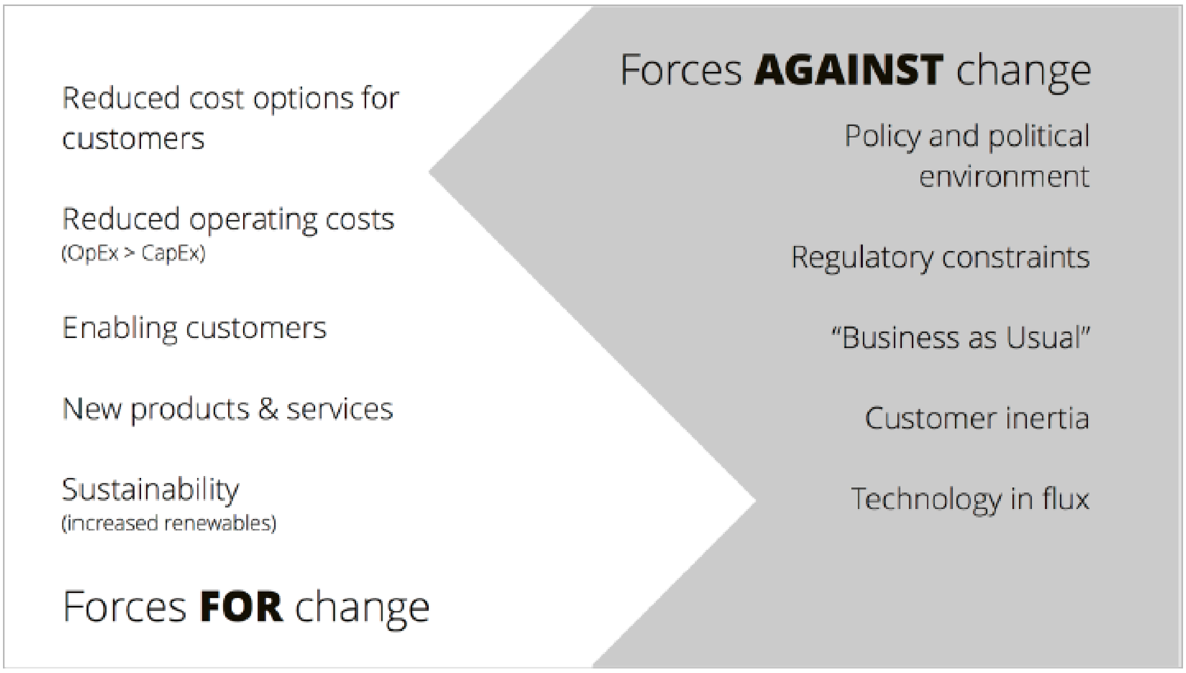


Figure 23: Force Field Analysis (DLM)

3. **Prioritised Opportunity Spaces**

   A number of potential scenarios within the growing DLM environment were explored, with opportunities identified and prioritised to enable a 'deeper dive' in follow-up sessions. Opportunities included:

   1. **Tariff innovation**

      To drive more efficient use of existing network assets, unlocking value while guiding the uptake of future DER where economic – i.e. develop DLM markets in areas of the network where it drives least cost market solutions.

   2. **Customer engagement and connections**

      Educating opportunities such as network and market support revenue streams and innovative connection standards to enable and incentivise the uptake of active DER that can participate in such markets.

   3. **Data services**

      Identified as foundation work to enable transactive energy, publishing of operating envelopes, planning forecasts and real time for operations.

   4. **Aggregator**

      Emerging market participants empowering customers to access DLM revenue streams.

5. **Communications system**
   Identified as foundation work to link DERs to platforms and DLMs.

6. **Outcome valuation**
   One of the biggest challenges, and therefore opportunities, lies in assessing the value of BTM DER. Such is dependent on tariff innovation, data services and aggregation outlined above, quantifying the benefit of BTM dispatch of supply and demand is complex, but important for delivering the value of customers resources back to them under any DLM model.

4. Strategic Activity Stack

From the identified 'prioritised Opportunity Spaces', a strategic activity stack was created to help identify what opportunities should be acted on and when. As shown in Figure 24, the yellow horizontal stack presents areas that should be acted on in order, as each builds upon the other. For example, all aspects of the stack rely upon reliable, accurate, granular data. Functioning 'Data Services' are required before BTM dispatch is possible. Similarly, tariff optimisation is not possible without clarity on the value of various outcomes and actions to Essential Energy's business and customers. The columns in grey present areas that need to be developed and refined while moving through the stack (i.e. in parallel). For example, customer engagement is required during foundation work but must be continuously optimised when progressing through the stack. Similarly, policy and regulation updates will be required through the development of distribution level markets, while one critical way in which these services are exposed and leveraged is via a platform/API.

The intent is to signal where effort applied by Essential Energy will be fruitful regardless of how the DLMs develop, ensuring that Essential Energy is prepared to take advantage of opportunities as they arise in the long-term interest of customers.

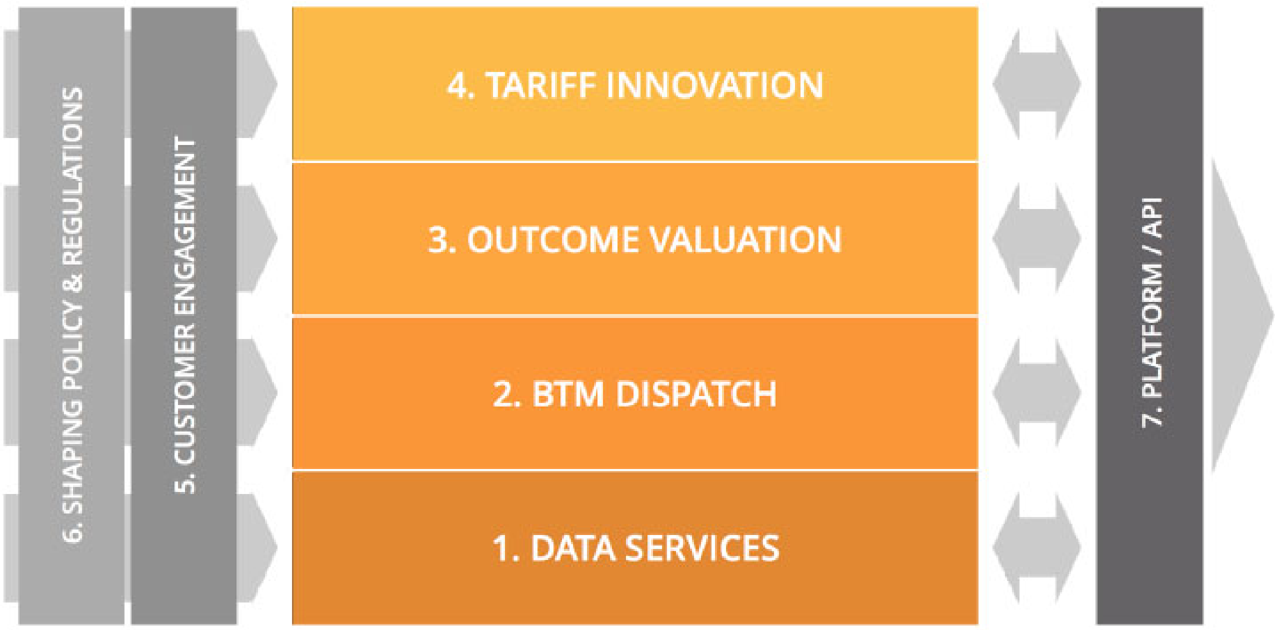


Figure 24: Strategic Activity Stack

5. Next actions

Following the development of the strategic value stack, potential next actions were explored, including:

1. **Customer engagement layer over new or existing trials**
   Evaluate propensity and interest in DLM-style activities. This could include a combination of qualitative research activities (e.g. customer interviews and other methods) in addition to quantitative methods (such as surveys).

2. **Digital tools supporting connection application and approvals process**
   To improve the visibility of connecting DER resources while simplify the process for installers and customers, a potential 'digitized fast track' approval could be explored to incentivise improved data collection, i.e. auto register DER, potentially through an API.
3. **Scenario mapping on tariff innovations by DER type**
   Explore the potential of electric vehicle-specific, residential battery storage, and automated controlled load tariffs.
4. **Real-time pricing prototyping**
   Dynamic pricing based on network operating envelopes to guide DER.
5. **Developing constraint equations**
   A key input to inform innovative tariff structures such as cost-reflective pricing is the development of constraint equations to define operating envelopes.
6. **Testing tariff/outcomes efficacy with customers**
   Linked to points 1 to 4 above, continuously and iteratively engage customers to validate the value proposition back to end customers.

4.4 Nature and Scope

The objective of the workshop was for Essential Energy's key stakeholders to collaboratively develop a stronger understanding of:

- The potential for P2P markets to benefit Essential Energy and its customers
- The framework and operation of P2P markets, including:
  - current and future technical challenges, e.g. data, customer connectivity
  - innovative products from P2P markets that Essential Energy might seek to develop
- Options for Essential Energy to participate in P2P markets as both a DNSP and in other capacities
- Impacts on Essential Energy's business with varying levels of engagement in P2P markets, including consideration of risks, rewards, timing, regulation and technological advancement.

4.5 Aims and Expectations

The minimum key deliverable is the provision of a report, reference documentation, workshop facilitation and any supporting models covering the objectives of the project while also provide recommendations on specific items for further research and development.

4.6 Selection

Essential Energy undertook a review of industry experts and businesses to identify the best candidate to lead the three-day workshop and put together a final report and presentation to meet the objectives of the project. The successful applicant was agreed by the project steering committee

4.7 Implementation

The approach taken to identify, forecast and report on peer to peer market challenges and opportunities comprised the following steps:

- literature review of current state of peer to peer markets

- three-day workshop with Essential Energy subject matter experts (SMEs) across demand management, regulatory, customer engagement, and planning departments facilitated by the external peer to peer industry expert
- final report
- final presentation.

4.8 Benefits

The Peer to Peer workshop has expanded Essential Energy's knowledge on new and emerging technologies and technology usage trends relating to distribution level markets. It has also facilitated the development of a potential distribution level market road map specific to Essential Energy's network and helped understand where further work through potential pilots and trials may help refine this road map.

This will help Essential Energy optimise internal strategies to achieve a best practice business in performance, efficiency, offering value to customers, while maintaining downward pressure on network charges. It will also help Essential Energy drive required changes, which may include technology and non-technology-based initiatives, within the broader energy market for the long-term interest of customers within the NEM.

5 eGrid

5.1 Summary

Essential Energy is conducting a prototype test of a Stand-Alone Power System (SPS) at Bulahdelah on the NSW Mid North Coast. The system comprises a solar PV array, battery bank, inverters, and a back-up diesel generator.

The prototype has been implemented as Essential Energy's first step in investigating a network scale islanding solution to provide non-grid connected energy solutions. These solutions could support a reduction in network charges overall, while maintaining or improving the electricity experience for customers on the fringe of the grid.

5.2 Project Overview

The potential of SPS technology to supply the energy needs of fringe-of-grid, high cost-to-serve customers, while meeting reliability standards and driving down total network costs, was highlighted by Western Power's submission to the AEMC dated September 2016.

In this submission, Western Power proposed the definition of network services be broadened to include non-grid connected solutions such as SPS, so that DNSP's could capitalise such assets in their RAB, recover the investment cost on a standard control tariff basis and thereby provide such solutions to fringe-of-grid customers at an affordable cost. Cost savings in respect of avoided powerline maintenance and refurbishment, fault and emergency, and vegetation management could be passed on to all network customers via the standard pricing framework.

The AEMC issued a request dated June 2017 for submissions in respect of a Rule Change in accordance with Western Power's submission. Essential Energy submitted a response dated July 2017 supporting the Rule Change as proposed by Western Power. In a subsequent letter to the AEMC dated September 2017, Essential Energy estimated that non-grid connected energy solutions could be deployed to up to 8,430 of its customers in the next ten years, resulting in avoided distribution network expenditure of $513M (indicative only and noted as being highly dependent on Asset Stranding process, customer buy-in and locations identified as being suitable for SPS).

Recent developments in technology, regulation and customer attitudes have created an opportunity for Essential Energy to trial non-grid connected energy supply solutions. As a Regional DNSP with a network of short and long rural powerlines characterised by low customer numbers, energy dissipation over powerline distance and a high cost-to-serve, Essential Energy is in a position to proactively contribute to the regulatory decision-making process, collaborate with other DNSPs and become a market leader in the design, implementation and certification of utility grade, non-grid connected energy solutions.

The objective of the SPS prototype is to test and understand the load management capability, reliability gains and cost / benefits of non-grid connected energy technology. While the investment in the prototype is deliberately limited in terms of scope and cost (i.e. a single customer connection site), it will provide Essential Energy with the critical learnings and insights to effectively contribute to the current round of consultations by the AEMC in respect of alternative energy solutions as requested by the COAG Energy Council.

5.3 Nature and Scope

Essential Energy established a working group in June 2017 to investigate the performance and cost/ benefit of SPS technology as a means of satisfying the demand of customers on the fringe of the grid.

The working group-initiated collaboration with Western Power and Horizon Power who are the leading DNSP's with respect to SPS in the Australian market. Horizon Power has implemented several SPS sites to date and intends to deploy multiple sites in FY18-19. Essential Energy and Horizon Power collaborated closely in respect of the prototype to ensure the installation of a utility grade SPS unit that would not compromise reliability whilst leveraging the knowledge and economies of scale generated by Horizon Power's procurement program.

It should be noted that experience of the SPS contestable market to date has provided examples of poor customer outcomes in terms of site load profiling, product quality and system performance, e.g. inadequate number of solar

PV panels installed, resulting in under-charging of batteries and excessive reliance on the back-up diesel generator.

The prototype site at Bulahdelah was selected as it will allow Essential Energy to understand the costs of the design, installation, and operation of SPS throughout the full seasonal cycle in a high-rainfall, flood-prone, bush-fire prone, densely vegetated, and difficult to access location.

The operational phase of the SPS prototype includes the testing and optimisation of communications from the SPS to Essential Energy's Network Control Centre to facilitate real-time reporting of system performance, including alerts and alarms. Just as importantly, it will test the customer experience of SPS in terms of satisfying the customer's demand throughout the full seasonal cycle and how SPS must be configured to cost-effectively meet the DNSP's reliability obligations to the customer given their demand profile. Figure 25 presents the SPS prototype and the pre-existing powerline easement.

Figure 25: SPS prototype and powerline easement.

The SPS prototype remains the property of, and is maintained by, Essential Energy. The customer's house remains connected to the National Energy Grid so that Essential Energy may continue to honour its licence agreements within the current Regulatory framework.

The prototype is directly enhancing:

(a) Essential Energy's understanding of SPS technology as a Demand Management (DM) tool

(b) Essential Energy's ability to incorporate such learnings into its network planning process.

Criteria	Bulahdelah SPS Prototype
Reliability of supply	Test and optimise the performance of SPS technology throughout the full seasonal cycle to satisfy the demand of a fringe of grid customer at a level that meets or exceeds current reliability obligations.
Variability of demand	Test the capability and capacity of a utility grade SPS specification with a fringe of grid customer whose site occupancy and demand are variable throughout the trial period.

5.4 Aims and Expectations

The table below outlines the key measures that will need to be achieved to establish the SPS prototype trial as being successful.

Key indicator	Objective Category	Measure	Pass Level
Essential Energy has a matrix developed that matches skills needed in the end to end (E2E) life-cycle of the SPS to Essential Energy's current role profiles. Any gaps are quantified and, where viable, a vendor relationship identified.	Skills development	Matrix mapping skills needed, to roles – validated by Horizon Power (HP)	100% coverage
Essential Energy has the design, procurement, installation, commissioning and running costs of the SPS documented.	Cost/Benefit analysis	All running costs are captured on I/O	100% coverage
Essential Energy has an Operations Manual that outlines all process needed to support the E2E lifecycle of the SPS units.	Operational Process developed for scale.	All key tasks have been documented, assigned roles and success levels	Signed off by Horizon Power
Post Implementation Review documenting all lessons learnt concerning the E2E process.	Operational Process developed for scale.	Document created	100% coverage
Reliability of the customers' power remains as good or better than being connected to our distribution network	Power Quality	Reliability SPS vs existing powerline. EE SPS vs HP SPS	As good or better
Units run as efficiently as the average of the Horizon Power Units	Configuration optimal - cost minimization	Average running cost of Essential SPS v HP SPS	+/- 10% diesel consumption
We have acquired a least one customer reference.	Demonstration of customer satisfaction	1 internal reference	100% coverage
We have a customer engagement pack that is standardised.	Customer Management	Standardized information packages complete	100% coverage mapped to HP
We have a FAQ developed that covers all major issues brought up in the SPS prototype trial measured by comparing the issue log to the FAQ.	Customer Management	FAQ compared to issue log	100% coverage

5.5 Selection

Essential Energy's working group identified and ranked several potential sites for SPS, based on a range of criteria including network profile, network performance, network planning, bush-fire category, fringe of grid location, customer / demand profile and cost / benefit analysis.

The site selected at Bulahdelah met all the above criteria and is a very good example of a fringe of grid customer for the following reasons:

- The SPS site is at the end of a 5.5 km spur that is classed as low customer density (i.e. one customer every 2km or more) as there are only two connection points on the spur.
- It is difficult to access due to the terrain and a poor-quality access track, making the location and rectification of faults on the powerline time-consuming, difficult and potentially dangerous, particularly during storm conditions at night. The (SAIDI) performance of the powerline often exceeds the standard for the relevant powerline category due to the time it takes crews to access the powerline and identify the source of faults.
- Figure 26 presents the access track through the National Park to the powerline and SPS.
- The site is located close to a lake shore with access frequently inhibited by heavy rain and flooding.
- The powerline traverses a heavily vegetated National Park that is often subject to storms resulting in frequent unplanned outages. Most faults are caused by storm events that up-root trees due to the saturated ground conditions and cause large branches to fall and damage the powerline.
- The powerline traverses an area which is a high bush-fire zone (P1), presenting the risk of the powerline causing fires e.g. of a cross-arm fails, resulting in a conductor dropping to the ground and igniting vegetation – see details in respect of two fires as per below.
- The site is intermittently occupied by the customer and therefore generates minimal electricity demand and revenue however Essential Energy is required under its current licence conditions to maintain the powerline to ensure the reliability and quality of supply.
- The cost of maintaining the powerline is disproportionality higher than any revenue derived, particularly given the high cost of cutting vegetation along the powerline easement, resulting in high cross subsidisation by Essential Energy's customer base.

The fire-prone nature of the area is demonstrated by two fires in the last ten years that had the potential to destroy the powerline and completely cut off supply to the two customers on the powerline spur as follows:

- Fire #1 – In 2008, a fire was caused by a broken cross-arm in the National Park area. Fortunately, the surrounding area was quite wet at the time, with the fire only burning out approximately ten acres. There was no damage to property or livestock.
- Fire #2 – In the summer of 2012/13, there was a large fire in the area which was not caused by the powerline. The fire impacted Essential's network and burnt down three poles. Essential's crews were unable to access the area for four days until the all-clear to enter was provided by National Parks and Essential's Network Control Centre. Only the two connections on the powerline spur were affected.

Figure 26: Access Track to powerline and SPS

5.6 Implementation

The timeline for the implementation and operation of the SPS prototype is:

Phase	Date
Pre-evaluation & site selection including site data logging	01/07/2017 – 30/09/2017
Site scoping & planning	01/10/2017 – 31/01/2018
Installation & commissioning	01/02/2018 – 18/05/2018
Operation, optimisation & customer surveys	19/05/2018 – 31/03/2019
Lessons learnt & project close	01/04/2019 – 30/06/2019

5.7 Benefits

The benefits that will be derived from the SPS prototype will be as follows:

- **Reliability** – understand the capability of SPS to meet or exceed current reliability obligations under different environmental and operating scenarios so that the inherent constraints of SPS as an energy solution in meeting customer demand are understood and modelled. By way of example, during a significant storm event in the Bulahdelah area in late May 2018, soon after the SPS was commissioned, the powerline to the SPS was impacted up-stream by vegetation. It took Essential Energy's crew approximately four hours to locate the fault, during which time 30 customers were without power supply, whilst the supply from the SPS, located at the very end of the powerline, was not impacted.
- **Customer experience** – obtain a full understanding of the factors impacting the customer experience of SPS by testing various operating scenarios throughout the seasonal cycle in close collaboration with the

customer so that we can obtain the customer's insights and recommendations, e.g. closing down sections of the battery bank at different times in the seasonal cycle to simulate storage variability and even failure, so we can better understand SPS performance under different environmental conditions and how this impacts the customer's experience and their appetite for non-grid connected energy solutions.

- **Customer engagement** – develop the best practice process for engaging customers who are connected to the network and to whom a DNSP has an existing supply and reliability obligation, in respect of non-grid connected energy solutions, by putting the customer at the centre of the trial to understand their fears, doubts and uncertainties prior to SPS installation and their experiences of SPS in satisfying their electricity demand once operational.
- **Regulatory** – provide first-hand experience of SPS technology, operation and customer experience so that Essential Energy may make informed, customer-centred submissions to the AEMC and AER in respect of non-grid connected solutions, i.e. a test that is not limited to a technical / network focus, so that the trial provides a foundation for customer-informed decisions in respect of NEM regulatory framework going forward.
- **Technology** – knowledge and experience of the scoping, design, installation, commissioning, operation and maintenance of an SPS and how the design of the SPS can be optimised to satisfy customer demand while driving down costs over the long term. Figure 27 presents the SPS prototype operation on 11 and 12 August 2018.
- **Integration** – knowledge and experience of the technical challenges of integrating SPS into the DNSP's network and its monitoring systems to provide real-time remote visibility of system performance, break-downs, fuel supply, etc.
- **Support** – clear understanding of the impact of break-down response and scheduled maintenance of the SPS in respect of costs, inventories, manning levels and skills through comparing SPS performance versus powerline performance from the customer and DNSP points of view.
- **Financial** – detailed understanding of the costs of SPS so that Essential Energy can competently forecast potential long-term savings from SPS for individual SPS customers, for all customers on the NEM through a standard pricing framework and for DNSPs, e.g. compare the costs of maintaining and refurbishing powerlines that traverse distance and terrain to supply power to dispersed customers to that of maintaining SPS and supplying fuel at those dispersed customer locations.
- **Safety** – understand improvements to safety for Essential Energy staff through not having to search for faults along powerlines, particularly at night during storm events, but rather receiving real-time information direct from the SPS in respect of the nature and cause of a system fault and being able to drive direct to the location of the SPS to perform fault rectification and restoration of power.
- **Environmental** – understand SPS performance and customer experience in a zone subject to high rainfall, frequent cloud cover and numerous unplanned power interruptions due to vegetation infringements in the powerline corridor.
- **Network risk** – facilitate a graduated low risk / low cost approach to understanding the evolution of the energy ecosystem in respect of 'islanding' or 'network fragmentation' by starting with a SPS prototype for a single customer.
- **Public risk** – understand the benefits of installing SPS and de-commissioning powerlines, both of which are subject to regulatory determination, in terms of the reduction in Essential Energy's risk of starting fires, and the associated potential for litigation, whilst increasing public safety.
- **Network evolution** – facilitate an orderly and risk-managed transition to non-grid-connected energy solutions to generate network savings that can be passed onto all customers across all segments. Essential Energy needs to conduct trials of SPS technology so that it has the policy framework, resources and skills to manage this network transition, whether it be deemed a contestable market activity or not.

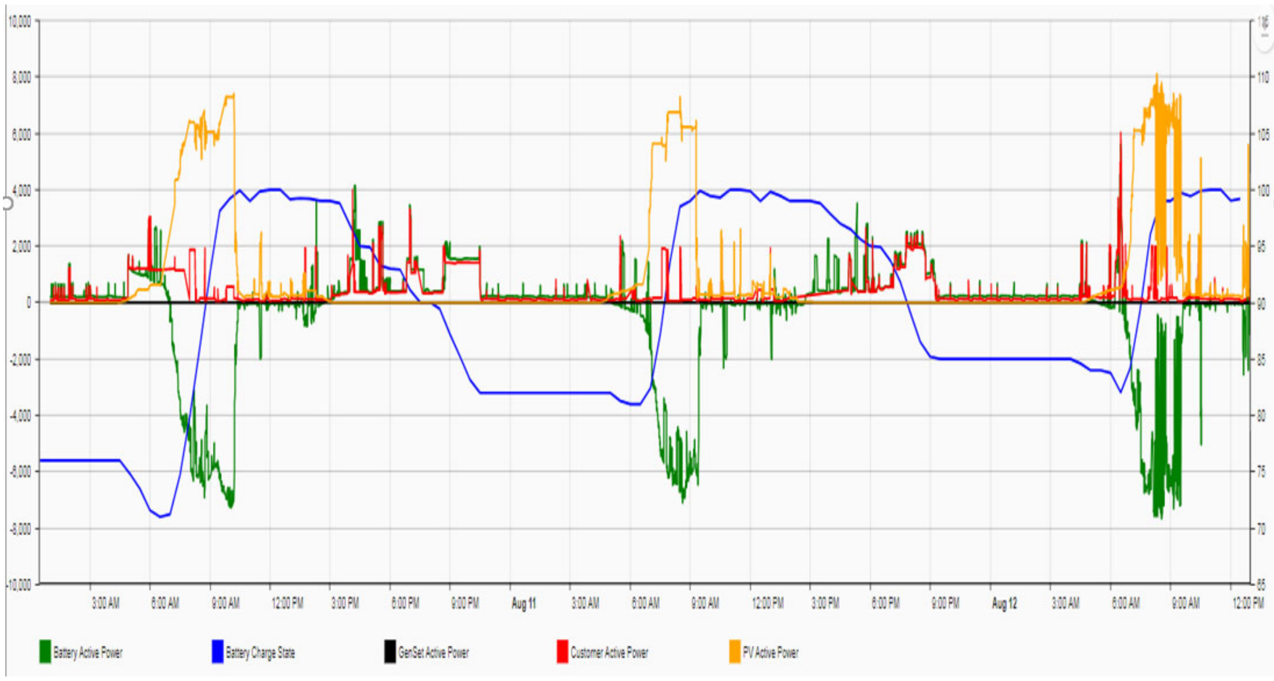


Figure 27: SPS prototype operation 11 & 12 August 2018

6 Switched Reactors

Figure 28: Nyngan SWER Switched Reactor

6.1 Summary

The switched reactor project has been developed to reduce reactive power demands in single wire earth return (SWER) systems, thereby reducing network voltage swing, line losses and the need for larger isolation transformers, deferring or removing the need for augmentation and lowering the cost of supply to customers.

6.2 Background information

Single wire earth return (SWER) feeders are a highly cost-effective method of distributing power over large areas with low load density. However, due to their long line length, the augmentation cost for SWER feeders can be prohibitively high for the load served.

One issue with SWER systems is their propensity for voltage rise due to charging currents, long line lengths and high impedance of the conductors and supplying source. In order to counteract charging currents, shunt reactors are applied to the SWER feeder to reduce line losses and minimise isolation transformer sizes. Essential Energy has approximately 340 SWER lines and 250 reactors in service.

Reactors allow voltages to be reduced to acceptable levels and line losses to be reduced at low load periods. However, as network demand increases, voltages can be brought down below acceptable levels during high load periods, resulting in the need for augmentation as the voltage envelope is pushed further and further between voltage rise at low load periods and low voltage at high load periods.

6.3 Switched Reactors project overview

In 2012-13, Essential Energy signed a memorandum of understanding and began consultation with an external university-based research group with strong industry ties to evaluate potential methods of deferring expenditure on SWER feeders.

Augmentation expenditure on SWER feeders is largely related to voltage swing (as described in section 6.2) or thermal limitations through the isolation transformer. Technical analysis, which included equipment such as capacitor banks, switched reactors and statcoms, was completed by the university group and reviewed by Essential Energy. Cost benefit analysis was completed by Essential Energy. Analysis indicated that switched reactors would provide the most cost-effective solution when taking into account the longer term benefits of decreased losses and reduced upstream demands.

In 2013-2014, Essential Energy placed an order for five switched reactors to trial in a constrained location, and began development of the product with the manufacturer, with a number of revisions being made. Subsequently, the unit design has been finalised, factory acceptance testing, integration to Essential Energy's SCADA system, site designs and installation and commissioning procedures at the switched reactor sites have been completed.

Figure 29 presents the results of the notch test during the field commissioning phase, where '1' on the right vertical axis corresponds to the switch in the closed position (reactor in service) and '0' to the open position (reactor out of service).

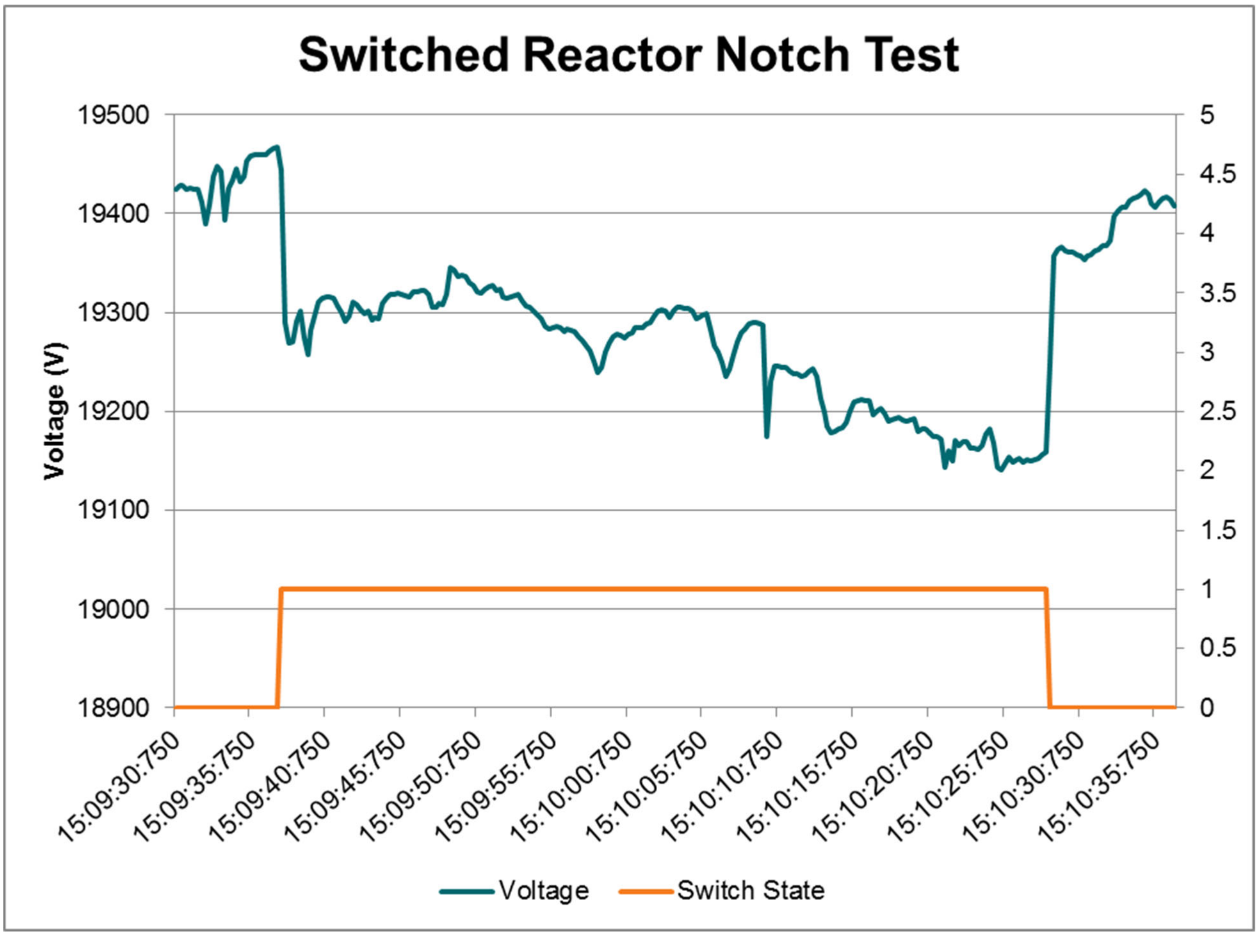


Figure 29: Switched Reactor Notch Test

Data collection and analysis commenced late 2014-15, identifying a normal operating voltage range for all the monitored locations on the feeder. An example daily profile is presented in Figure 30.

Switched reactor voltage thresholds, time delays and hysteresis settings were then chosen based on this analysis to minimise unnecessary switching operations and were programmed to operate automatically beginning 2015-16.

The data collected since the reactors were activated has confirmed the voltage improvements expected from early simulations, with the furthest switched reactor providing the greatest benefit, reducing the network voltage along the entire feeder as shown in Figure 31.

During late 2016-2017, the Switched Reactor controllers were returned to the manufacturer for hardware upgrades to improve the devices' resilience to lightning impulses. Early in 2017-2018, the controllers were reinstalled in the field, with both optimisation of the switching routine and device longevity testing undertaken throughout the remainder of 2017-2018.

Once testing is complete, should the anticipated benefits be reached at an efficient cost, then Essential Energy will go to market with a specification in 2018-19.

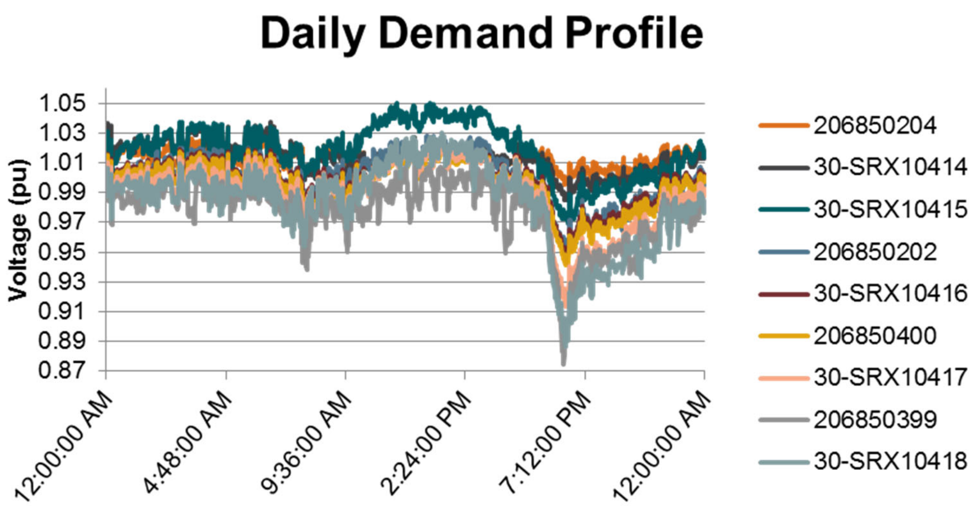


Figure 30 Nyngan network Voltage profile before Switched Reactors were placed in service

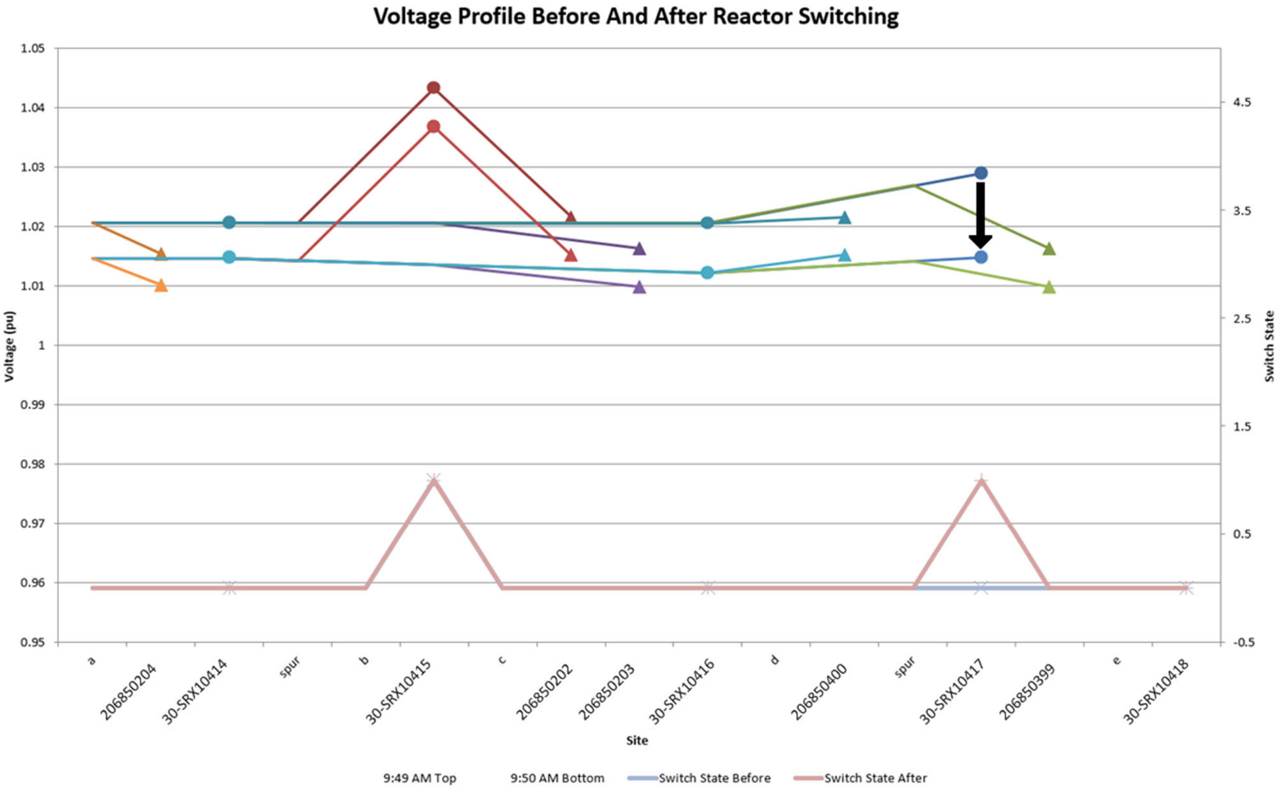


Figure 31 Nyngan network - 30-SRX10417 switch event

6.4 Nature and Scope

The Switched Reactor project is a non-tariff-based project involving the combination of two existing, widely used pieces of equipment (reactors and switches) with the addition of specifically developed control algorithms and ancillary technology.

The scope of the project is limited to:

- design, modelling and simulation of SWER networks to investigate the effect of new equipment proposals on the energy capacity and delivered power quality
- estimation of costs and benefits
- conceptualise, design, simulate and investigate the proof of concept equipment
- purchase of the equipment to carry out field trials
- physical installation
- test and field trial verification of equipment
- project analysis, including suggested paths to business as usual programs if proven viable.

6.5 Aims and Expectations

The Switched Reactor project aims to develop confidence in the application of controlled switching to SWER line reactors, and knowledge in the following areas:

- physical installation
- configuration of the controls
- operational aspects
- network impacts
- estimated package costs .

It will also provide confirmation on the cost effectiveness of reducing peak demand through the use of switched reactors.

6.6 Selection

Given the information sought (set out in section 0), specific to Essential Energy's network area the following options were considered:

1. Customer based power factor correction

Customer based power factor correction can be some of the cheapest demand reductions available. However, it is not particularly relevant to SWER feeders and was not the preferred solution for a number of reasons, including;

- Individual customers on SWER feeders generally have relatively low individual demands and therefore due to the applicable tariffs, minimal financial incentive to install power factor correction equipment or more generally control their network demands. Essential Energy does not currently believe that relatively low demand or energy usage customers have enough information to enable the use of appropriate demand-based tariffs.
- Customer based power factor correction may help correct voltage issues at high loads. However, it has little reference to power factor of the line when the power factor is caused by capacitive charging currents.

2. Embedded Generation with/without energy storage

Uncontrolled embedded generation is unable to reliably provide the peak demand reduction / voltage control required. Controlled embedded generation in the form of a controlled generator or with energy storage can meet the requirements of the project, however the indicative costs are much higher than the preferred solution with little reduction in reactive power flows. For these reasons, this was not the preferred solution.

3. Capacitor banks

Capacitor banks can be used to control voltage levels on SWER feeders if this is the primary concern. However, due to the nature of SWER feeders and the capacitive charges present on such feeders, they will also tend to increase currents and losses along the SWER feeder. For these reasons, this was not the preferred solution.

4. Switched reactors

Reactors already exist on the Essential Energy network and have relatively few issues. Their standard sizing allows for distributed locations, which in turn provides the greatest reduction in losses and demand. They are connected to the high voltage network and therefore can be controlled directly from voltage and or power factor. For these reasons, switched reactors were the preferred solution.

6.7 Implementation

The Switched Reactor project can be defined as three distinct stages:

1. Simulation and Development

   Refer to section 6.3

2. Implementation and Evaluation

   Refer to section 6.3

3. General deployment phase

   Refer to section 6.3

6.8 Benefits

With the field installation completed late 2014-15 and the devices set to automatically operate in early 2015-16, a large amount of data has been gathered. With the revised hardware reinstalled early 2017-2018 on the network and some specific scenarios tested, there will be enough data available to evaluate the expected benefits. A number of anticipated benefits are highlighted below:

- Confidence in the use of innovative technology solutions such as switched reactors which may then be used to meet legislated power quality standards more efficiently than traditional network investment or as a means of deferring network investment.
- Understand the control structures available for switching of a tool kit of network elements and their relative costs, benefits and issues.
- A tool for use in the economic deferral of network investment, through reduction of demand and losses.
- Avoid network augmentation through reducing/limiting peak demand and improved power quality.
- Increase end use efficiency and equipment life.
- Decrease network losses.
- Facilitate the integration of distributed generation into the grid.
- Improve power factor.
- Improve network visibility via remote monitoring and control.

7 Compliance Summary

As per section 3.1.3 of the Determination, projects under the DMIS must meet the following criteria;

1. Demand management projects or programs are measures undertaken by a DNSP to meet customer demand by shifting or reducing demand for standard control services through non–network alternatives, or the management of demand in some other way, rather than increasing supply through network augmentation.

2. Demand management projects or programs may be:
   a. broad–based demand management projects or programs—which aim to reduce demand for standard control services across a DNSP's network, rather than at a specific point on the network. These may be projects targeted at particular network users, such as residential or commercial customers, and may include energy efficiency programs; and/or reduce demand for standard control services across a DNSP's network, rather than at a specific point on the network.
   b. peak demand management projects or programs—which aim to address specific network constraints by reducing demand on the network at the location and time of the constraint.

3. Demand management projects or programs may be innovative, and designed to build demand management capability and capacity and explore potentially efficient demand management mechanisms, including but not limited to new or original concepts.

4. Recoverable projects and programs may be tariff or non–tariff based.

5. Costs recovered under this scheme:
   a. must not be recoverable under any other jurisdictional incentive scheme,
   b. must not be recoverable under any other state or Australian Government scheme, and
   c. must not be included in forecast capital or operating expenditure approved in the distribution determination for the next regulatory control period, or under any other incentive scheme in that determination.

6. Expenditure under the DMIA can be in the nature of capex or opex. The AER considers that capex payments made under the DMIA should be treated as capital contributions under clause 6.21.1 of the NER and therefore not rolled into the regulatory asset base at the start of the subsequent regulatory control period. However the AER's decision on the treatment of capex will only be made as part of the subsequent distribution determination.

Section 3.1.4.1 of the Determination requires that each ACT and NSW DNSPs must submit to the AER annual reports on their expenditure under the DMIA for each regulatory year.

The following table provides the details of Essential Energy's DMIA projects undertaken in the 2015/16 financial year as outlined above.

Table 4 - Details of Essential Energy's DMIA projects undertaken in the 2017-18 financial year

Name of Project	The projects outlined meet the DMIA criteria under the following conditions;						
	1. Meets demand needs other than through increasing network supply through augmentation ?	2a. Relevant to broad–based programs?	2b. Relevant to specific network constraints ?	3. Innovative? Designed to build demand management capability and capacity? Explores potentially efficient demand management mechanisms?	4. Is the project tariff or non–tariff based/	5. Yes/No, the costs allocated to the project are; a/b. not recoverable under any other jurisdictional, state or Australian Government scheme c. not be included in forecast capital or operating expenditure	6. Is the expenditure capex or opex in nature?
Networks Renewed	Yes	Yes	Yes	Yes	Non-tariff	Yes	Opex
Peer to Peer Review	Yes	Yes	Yes	Yes	Non-tariff	Yes	Opex
eGrid	Yes	Possibly	Yes	Yes	Non-tariff	Yes	Opex
Switched Reactors	Yes	Possibly	Yes	Yes	Non-tariff	Yes	Opex/Capex