Regulatory Information Notice (RIN)

Supporting Information for Demand Management Innovation Allowance (DMIA)

2012-2013

November 2013
Prepared by Essential Energy

Contents

1 Introduction

The Demand Management Incentive Scheme (DMIS) applied to Essential Energy by the Australian Energy Regulator (AER) in the *Demand management incentive scheme for the ACT and NSW 2009 distribution determinations* (the Determination) 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 be increasingly identified as viable alternatives to network augmentation.

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.

This submission provides the details of Essential Energy's DMIA projects undertaken in the 2012/13 financial year as outlined above.

2 Summary of Submission

Essential Energy's DMIA expenditure for the 2012/13 financial year consisted of six different projects/programs including;

1. Continuation of the Grid Interactive Inverter program based on the 20kVA four quadrant inverter
2. Grid Interactive Inverter program based on the 5kVA four quadrant inverter
3. Conservation Voltage reduction through the use of low voltage regulators
4. Capacitor Package Development
5. Energy and Network Capacity cost evaluation
6. Energy and Demand Audits

Total Program cost for the 2012/13 financial year is $976,600 with $321,228 allocated to CAPEX and $655,372 allocated to OPEX as follows;

Name of Project	Total amount of the DMIA spent in: 2012-2013		
	Operating expenditure ($'000 nominal)	Capital expenditure ($'000 nominal)	Total expenditure ($'000 nominal)
Grid Interactive Inverter program 20kVA based	77402.04	58612.00	136014.04
Grid Interactive Inverter program 5kVA based	82000.73	120261.00	202261.73
Conservation Voltage Reduction through low voltage regulators	54429.33	142355.30	196784.63
Capacitor Package Development	90855.60		90855.60
Energy and Network Capacity cost evaluation	255900.41		255900.41
Energy and Demand Audits	94783.58		94783.58
Total	**655,372**	**321,228**	**976,600**

For further information refer to the specific project reports.

2.1 Developments from previous years DMIA

Essential Energy's spending of the DMIA in previous years relates directly to the "Grid Interactive Inverter program 20kVA based" and "Grid Interactive Inverter program 5kVA based" projects, for further information on developments from those projects in 2012/13 refer to the project specific documentation.

3 Grid Interactive Inverter program – 20kVA four quadrant inverter

3.1 Summary

The grid interactive inverter program is a continuation of work completed in previous years under the DMIA to prove the multitude of benefits available from four quadrant inverter technology.

3.2 Background information

An electricity network has real and reactive characteristics which interact with real and reactive power flows to determine the levels of voltage, current and losses around the network. The network's capacity to deliver load or absorb generation at any point can be constrained either by the current rating of elements in the supply path or by unacceptable voltage conditions for customers. Traditional network solutions involve augmentation to increase the supply capacity through upgrading existing infrastructure or providing additional infrastructure to reduce the impedance of the supply path.

A four quadrant inverter is capable of providing a combination of real and reactive power either into or out of the network. This capability can be used to adjust power flows and significantly improve voltages, currents and losses on the existing infrastructure as an alternative to network augmentation. The outcome will be improved utilisation of existing infrastructure and avoidance or deferral of network augmentation.

3.3 Grid Interactive Program overview

A development agreement was signed with an Australian electronics design and manufacturing company in December 2008 for the production of four prototype units, one for bench testing at their premises and three for a test installation on the Essential Energy network. Some of the preliminary development costs were incurred in the 2008/2009 financial year.

During 2009/2010 a test site was established at Queanbeyan, adjacent to the Essential Energy Research and Demonstration Centre and an existing solar array and the prototype four quadrant inverters installed in February 2010. There were significant network compatibility issues observed and the units were returned to the supplier for hardware and firmware upgrades to address them.

Figure 1 Queanbeyan Inverter Installation

The units were reinstalled in June 2010 and firmware adjustments continued through to 2nd September 2010 when network stability was achieved and proof of concept demonstrated. A workshop was held with the supplier in late September 2010 and design modifications agreed for a more robust unit and additional functionality for further field evaluation on the Essential Energy distribution network.

Field testing for the upgraded 20 kVA units began in January 2012 with the replacement of the original prototype units at Queanbeyan to check functionality. This was followed by installation of two three phase statcom field trials in the Bega area in February 2012. Each of these statcom installations comprises three single phase, 20 kVAr inverters configured in statcom mode where the units provide coordinated reactive power support only and do not require a battery. Minor issues have been raised during these field trials which will continue to add positive development to the inverter program.

Figure 2 Bega / Kalaru Inverter Installation

In late 2012, on a single phase 11,000 volt feeder at Pappinbarra, near Port Macquarie, a single 20 kVA inverter and a lithium battery with 40 kWh of useable energy storage were installed, with results pending.

Figure 3 Pappinbarra Inverter Installation

Essential Energy has proven the voltage support benefits of the technology, and will continue to work towards defining the value of the multitude of benefits available and engaging with suppliers to determine the best course forward to a business as usual operation.

3.4 Program Detail

The Grid Interactive inverter program involves research, development and field testing of four quadrant inverters as an enabling technology for energy storage and reactive power support which can be utilised to avoid or defer network augmentation in the low and medium voltage distribution networks. It is a continuation and expansion on Essential Energy's DMIA program from 2011-2012

Individually the Grid Interactive Program consists of research, development and testing of

- 60kVA 3ph modular statcom

A three phase modular statcom developed for a variety of uses as outlined under benefits, with particular focus on application to lines with high reactance to resistance ratios

- 60kVA 3ph energy storage and solar combination

A three phase statcom with energy storage used for development and testing of the optimum solar PV enabling technologies and routines

- 20kVA single phase modular statcom

A single phase modular statcom developed for a variety of uses as outlined under benefits, with particular focus on application to lines with high reactance to resistance ratios

- 20kVA single phase modular energy storage

A single phase modular statcom with lithium ion energy storage developed for a variety of uses as outlined under benefits, with particular focus on application to lines with low reactance to resistance ratios

- Integration of Solar, Wind and Storage Systems into Distribution Grids for Network Support Study

The aim of this project is to develop a structured approach for infrastructure development to facilitate the integration of inverter-interfaced renewable energy resources and energy storage systems into electricity networks. With a focus on network support through:

- Grid interactive inverters used for voltage regulation and power loss minimisation through control of active and reactive power; and
- Design and analysis of graduated correction strategies associated with such systems.

3.5 Nature and Scope

The "Grid Interactive Inverter program based on the 20kVA four quadrant inverter" is a non-tariff based program to develop an enabling technology aimed at addressing specific network constraints by reducing demand on (including demand for generation export capacity) or providing reactive support to the network at the time and location of the constraint.

Four quadrant power electronics technology are currently used extensively in high power, high voltage network applications for static VAr compensation and large energy storage applications. During the initial stages of this program there was no low cost, commercially available similar technology for low power, low voltage or single phase systems, subsequently semi-commercialised products have become available and are continually assessed against the existing product to ensure the most efficient outcomes of the program.

Commercially available low voltage inverters are widely used for the connection of small scale renewable energy generation but their control methodology and design is currently not suited to full four quadrant grid interaction to facilitate network support.

3.6 Aims and Expectations

The aim of the program is to develop cost effective, flexible, low voltage, four quadrant inverters which can be used in a variety of applications to address a range of supply quality issues.

It is expected that final production cost for a single phase inverter will be in the order of $500 per kVA which compares favourably to commercially available small scale photovoltaic units offering substantially less functionality.

Energy storage costs are estimated to be $500 per kWh based on currently available lead acid technology, however it is expected that battery development for electric vehicles will ultimately provide a more cost effective alternative.

3.7 Selection

Essential Energy has a substantial rural distribution network, much of which was installed in the 1950s, 1960s and 1970s under various Rural Electrification Schemes using small section conductor on single phase and SWER construction in order to minimise cost to the customer. The capacity of these lines to supply load or absorb generation is limited.

Subsequent changes to system loads through “infilling” and increased demands of individual installations due to changes in lifestyle and price accessibility of electrical appliances has created many situations throughout Essential Energy where general voltage levels cannot be satisfactorily maintained within the allowable voltage range and short term fluctuations create increasing annoyance for customers.

Traditional network solutions include the installation of voltage regulators to address general voltage levels or conductor upgrades in situations where voltage regulation is not an effective option. Current costing for conductor upgrades is in the order of $5,000 per km for SWER and $6,000 for single phase lines and significant distances are involved if an effective improvement in voltage conditions is to be achieved.

While the initial focus of the project was on a modular 20 kVA unit to address feeder level issues the initial prototype installation demonstrated that the four quadrant capability can also be utilised for power quality improvement on low voltage systems to mitigate voltage drops due to increased circuit loading or voltage rises due to increasing levels of small scale embedded generation. The scope of the program was subsequently extended to facilitate PV connection, VAr support and energy storage at residential level.

Low voltage network solutions include conductor upgrades or additional distribution substations. Depending on the circumstances this could typically cost between $20,000 and $200,000 to address a single constraint.

Initial options considered;

1. Traditional generation

   An alternative is to use an embedded generator at the end of the affected feeder to reduce the load the feeder needs to supply but traditional generators are often difficult to implement as they have issues with noise, pollution, security and maintenance.

2. Adaptation of commercially available inverter equipment

   The use of commercially available inverters as used for the connection of small scale wind and photovoltaic generation has previously been considered. A trial installation at Lake Mungo included Xantrex 4.5 kVA inverters at a unit cost of $6,300. Significant problems were experienced in adapting the inverter operation for interactive grid support with the final configuration and the units were not considered to be suited to further development due to the lack of a suitable grid interface.

3. High Voltage large scale equipment

High voltage inverters with grid interactivity are available from established companies such as ABB and Siemens but they are very expensive and not cost effective for low power applications required on weak rural feeders. Previous contact with these companies indicated that development of a suitable unit was not a high priority and any development costs would need to be recovered.

4. Develop a single phase, modular system (preferred option)

Identify a suitable partner and work with them to develop a specification and produce a prototype, modular power electronics system to provide real and reactive four quadrant operation for voltage support when used in conjunction with a suitable direct current source such as battery storage or renewable generation

3.8 Implementation

The project has been broken into three distinct stages;

1. Knowledge acquisition phase

Prototype units are developed and installed in an environment where they can be closely monitored and design improvements checked for inclusion in a production version.

During the 10/11 financial year proof of concept had been achieved with the prototype units installed at Queanbeyan and design modifications required for the production unit were agreed.

2. Field trial phase

First run production units are installed and their performance evaluated prior to approval for general use.

At the close of the 11/12 financial year substantial field trials and development towards a product suitable for general deployment were underway with final refinement work in progress in order to move the devices into the business as usual phase.

During the 12/13 financial year further monitoring and modification has been made to the units to prepare them for general deployment use.

3. General deployment phase

The utilisation of four quadrant inverters as a generic supply quality improvement technology on Essential Energy’s distribution network which may include development of incentive schemes to leverage spare network support capacity from suitable renewable energy connection equipment.

Essential Energy’s network and physical requirements on power electronic devices are fairly extreme, with temperatures in the network area ranging from 49.7°C to -23°C, as well as areas of high humidity, high levels of dust and salt spray. Essential Energy’s ideal installation locations can also be remote and difficult to access, resulting in rough transport conditions and minimal communications, electrically sites can be difficult, with spikes, sags and surges common, and a variety of frequency injection signals to contend with. These conditions have delayed the business as usual implementation of four quadrant inverters, however Essential Energy will continue to determine the most efficient means to achieve the benefits desired.

3.9 Costs

Overall program costs including research, development, commissioning and verification of network support functionality during 2012/2013 are shown in section 2 determined by the use of appropriate procurement systems and time recording.

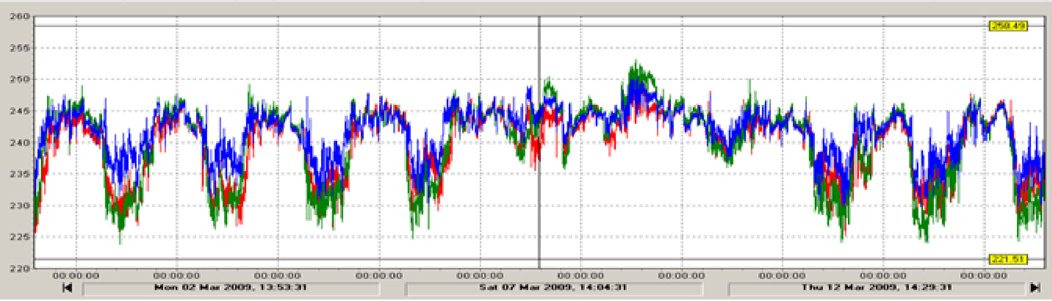
3.10 Benefits

Stage 1 of the project involved development and testing of prototype units and this was ongoing through 2009/2010. This was essentially a knowledge acquisition phase to observe the interaction of the prototype units under real network conditions and provide the basis for specification of a production unit.

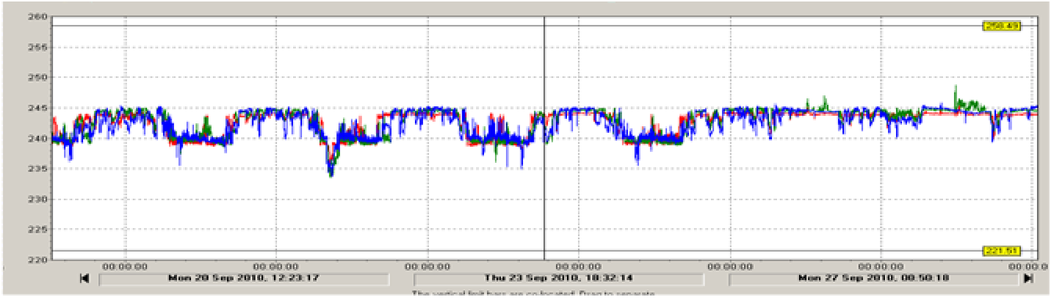
Proof of concept was attained in 2010/2011 and design enhancements agreed for Stage 2 field trials, example results are shown below.

WEEKLY VOLTAGE CHART

BEFORE – voltage range 253 to 224, Voltage unbalance 10V



AFTER – voltage range 248V to 234V, unbalance 5V
Normal voltage fluctuations still apparent away from 245V and 239V reactive power support levels



Network models were built and field projects designed to verify equipment functionality and provide the basis for development of the wider deployment strategy.

Three field trials were commenced in 2012 with further refinements and developments required for business as usual operation.

The technology benefits have been proven in the field installations, however actual business benefits will accrue when the technology is field proven and deployed as an enabler for peak reduction and reactive power support applications to avoid or defer network augmentation.

Potential benefits and applications include;

1. Voltage pacification

   Providing combinations of real and reactive power to keep voltages within a given range.

2. Real power support on long rural feeders

   On high resistance circuits store energy at light load periods and release it at peak times to reduce voltage drop on the feeder.

3. Reactive power support

   On high reactance circuits use either leading or lagging reactive power to raise or lower voltages as required.

4. Generation capacity enhancement

   Use lagging reactive power to compensate for voltage rises caused by embedded generation.

5. Motor starting compensation

The fast (sub-cycle) response and short term rating of the inverter enables it to provide reactive power to balance the fluctuations due to starting of large motors.

6. Power factor correction

   Providing reactive power to correct power factor - minimising line currents and losses.

7. Load and voltage balancing

   Transferring real and reactive power between phases to ensure balanced supply conditions.

8. Conservation voltage reduction (CVR)

   Controlling voltage levels to optimise energy usage and efficiency.

9. Loss reduction

   Managing loading patterns to optimise network current flows for loss minimisation.

10. Energy storage (community, household, PV)

    Balancing load and generation at local level to optimise network utilisation.

11. Microgrid operation

    Operation as a fast response balance between generation and load to stabilise microgrid operation.

12. Peak price generation

    Potential to store energy for release over peak price periods on the energy market to enhance asset value.

13. Peak lopping

    Provide real power at peak periods to ensure network ratings are not exceeded.

14. Reliability improvement

    Ability to operate in uninterruptible power supply (UPS) mode to improve voltage quality and sustain critical loads during power outages.

15. Local load control

    Potential to act as a signal generator for local control applications.

16. Harmonic suppression

    Acts as a “sink” for lower order harmonics through inductive coupling to the network.

17. Network monitoring

    Current and voltage measurement at the point of application.

3.11 Compliance

The “Grid Interactive Inverter program based on the 20kVA four quadrant inverter” meets the DMIA criteria under the following conditions;

1. Shifting or reducing demand for standard control services through non–network alternatives

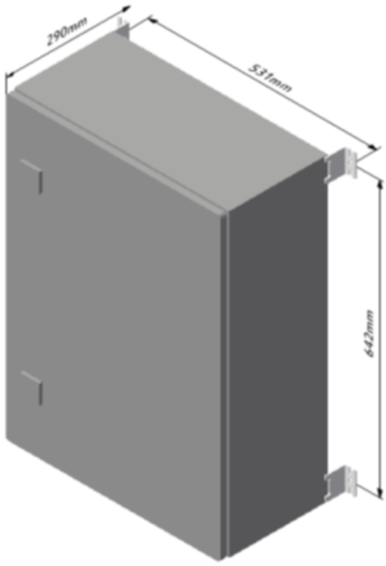
2. For use in;
    a. peak demand management projects or programs—which aim to address specific network constraints by reducing demand on the network at the location and time of the constraint

3. Innovative and designed to build demand management capability and capacity

4. Non–tariff based
    a. not recoverable under any other jurisdictional incentive scheme,
    b. not recoverable under any other state or Australian Government scheme, and
    c. not 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

5. Capex.

4 Grid Interactive Inverter program – 5kVA four quadrant inverter



4.1 Summary

The "Grid Interactive Inverter Program - 5kVA Four Quadrant Inverter" is a development from the 20kVA inverter program, as such much of this section will refer to the "Grid Interactive Inverter program based on the 20kVA four quadrant inverter". Summarily the 5 kVA grid interactive inverters were developed for use at residential level to support continued renewables generation connections without the adverse side effects currently seen in the distribution network.

4.2 Background information

Refer to section 3.2

4.3 Grid Interactive Program overview

Refer to Section 3.3

After initial developments within the 20kVA grid interactive program in 2010, it was determined that major contributions to the cost of the program and hence any future business as usual installations were;

- The relatively low volumes of devices being produced
- The installation costs involved in using Essential Energy's field assets and staff.

An opportunity also exists to use consumers own equipment/installations to provide reactive support and hence avoid "doubling up" of similar devices (i.e. residential inverters on the consumers side of the meter without reactive capabilities and four quadrant inverters on the network side of the meter).

To overcome the issues highlighted above and to work toward evaluation of the opportunities available a development agreement was signed with an Australian electronics design and manufacturing company in mid-2011 for the production of a number of 5kVA four quadrant inverters for testing purposes.

During 2012/2013 a number of 5kVA four quadrant inverters were delivered and tested to the proposed technical specifications and appropriate Australia Standards, as an outcome of this testing some modifications have been requested.

A single test site was established in Port Macquarie at the Clearwater Zone Substation to perform longevity and functionality tests, this site has performed near faultlessly with no known issues above what was raised during the initial testing.

Testing and refinement of the product towards a final determination of the value of the benefits to Essential Energy and a defined specification will continue throughout 2013/14.

4.4 Nature and Scope

Refer to section 3.5

4.5 Aims and Expectations

Refer to section 3.6

4.6 Selection

Refer to section 3.7

While the initial focus of the project was on a modular inverter units to address feeder level issues the initial prototype installation demonstrated that the four quadrant capability can also be utilised for power quality improvement on low voltage systems to mitigate voltage drops due to increased circuit loading or voltage rises due to increasing levels of small scale embedded generation. The scope of the program was subsequently extended to facilitate PV connection, VAr support and energy storage at residential level.

Low voltage network solutions include conductor upgrades or additional distribution substations. Depending on the circumstances this could typically cost between $20,000 and $200,000 to address a single constraint.

Initial options considered;

1. Traditional generation

An alternative is to use an embedded generator at the end of the affected feeder to reduce the load the feeder needs to supply but traditional generators are often difficult to implement as they have issues with noise, pollution, security and maintenance.

2. Adaptation of commercially available inverter equipment

The use of commercially available inverters as used for the connection of small scale wind and photovoltaic generation has previously been considered. A trial installation at Lake Mungo included Xantrex 4.5 kVA inverters at a unit cost of $6,300. Significant problems were experienced in adapting the inverter operation for interactive grid support with the final configuration and the units were not considered to be suited to further development due to the lack of a suitable grid interface.

3. High Voltage large scale equipment

High voltage inverters with grid interactivity are available from established companies such as ABB and Siemens but they are very expensive and not cost effective for low power applications required on weak rural feeders. Previous contact with these companies indicated that development of a suitable unit was not a high priority and any development costs would need to be recovered.

4. Develop a single phase, modular system (preferred option)

Identify a suitable partner and work with them to develop a specification and produce a prototype, modular power electronics system to provide real and reactive four quadrant operation for voltage support when used in conjunction with a suitable direct current source such as battery storage or renewable generation

4.7 Implementation

The project has been broken into three distinct stages;

1. Knowledge acquisition phase

Prototype units are developed and installed in an environment where they can be closely monitored and design improvements checked for inclusion in a production version.

During 2012/2013 a number of 5kVA four quadrant inverters were delivered and tested to the proposed technical specifications and appropriate Australia Standards, as an outcome of this testing some modifications have been requested.

A single test site was established in Port Macquarie at the Clearwater Zone Substation to perform longevity and functionality tests, this site has performed near faultlessly with no known issues above what was raised during the initial testing.

Clearwater Zone Substation 5kVA four quadrant inverter (atypical) installation

2. Field trial phase

First run production units are installed and their performance evaluated prior to approval for general use.

3. General deployment phase

The utilisation of four quadrant inverters as a generic supply quality improvement technology on Essential Energy's distribution network which may include development of incentive schemes to leverage spare network support capacity from suitable renewable energy connection equipment

4.8 Costs

Overall program costs including research, development, purchase, installation, testing, commissioning and verification of network support functionality during 2012/2013 are shown in section 2 determined by the use of appropriate procurement systems and time recording.

4.9 Benefits

Actual business benefits will accrue when the technology is field proven and deployed as an enabler for peak reduction and reactive power support applications to avoid or defer network augmentation
Potential benefits and applications include those referenced in section 3.10;

4.10 Compliance

The "Grid Interactive Inverter program based on the 5kVA four quadrant inverter" meets the DMIA criteria under the following conditions;

1. Shifting or reducing demand for standard control services through non–network alternatives

2. For use in;
    a. Broad-based demand management projects or programs and/or
    b. specific network constraints by reducing demand on the network at the location and time of the constraint

3. Innovative and designed to build demand management capability and capacity

4. Non–tariff based
    a. not recoverable under any other jurisdictional incentive scheme,
    b. not recoverable under any other state or Australian Government scheme, and
    c. not 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

5. Capex.

5 Conservation Voltage Reduction through the use of low voltage regulators

5.1 Summary

The project “Conservation Voltage Reduction through the use of low voltage regulators” has been developed in order to;

Evaluate the technical requirements and performance characteristics of conservation voltage reduction (CVR) in the Essential Energy network

> Build Essential Energy’s technical knowledge for further development in the areas of power quality rectification, remote control, CVR and small scale generation
> Evaluate the reliability, usability and functionality of three phase low voltage regulators

5.1 Background information

Conservation voltage reduction (CVR) is a lowering of voltage at the customer connection point in order to increase end use efficiency, lower peak demand, lower energy use and decrease losses without adversely power quality. CVR is currently implemented in some commercial premises for financial benefit under the name of “voltage optimisation”.

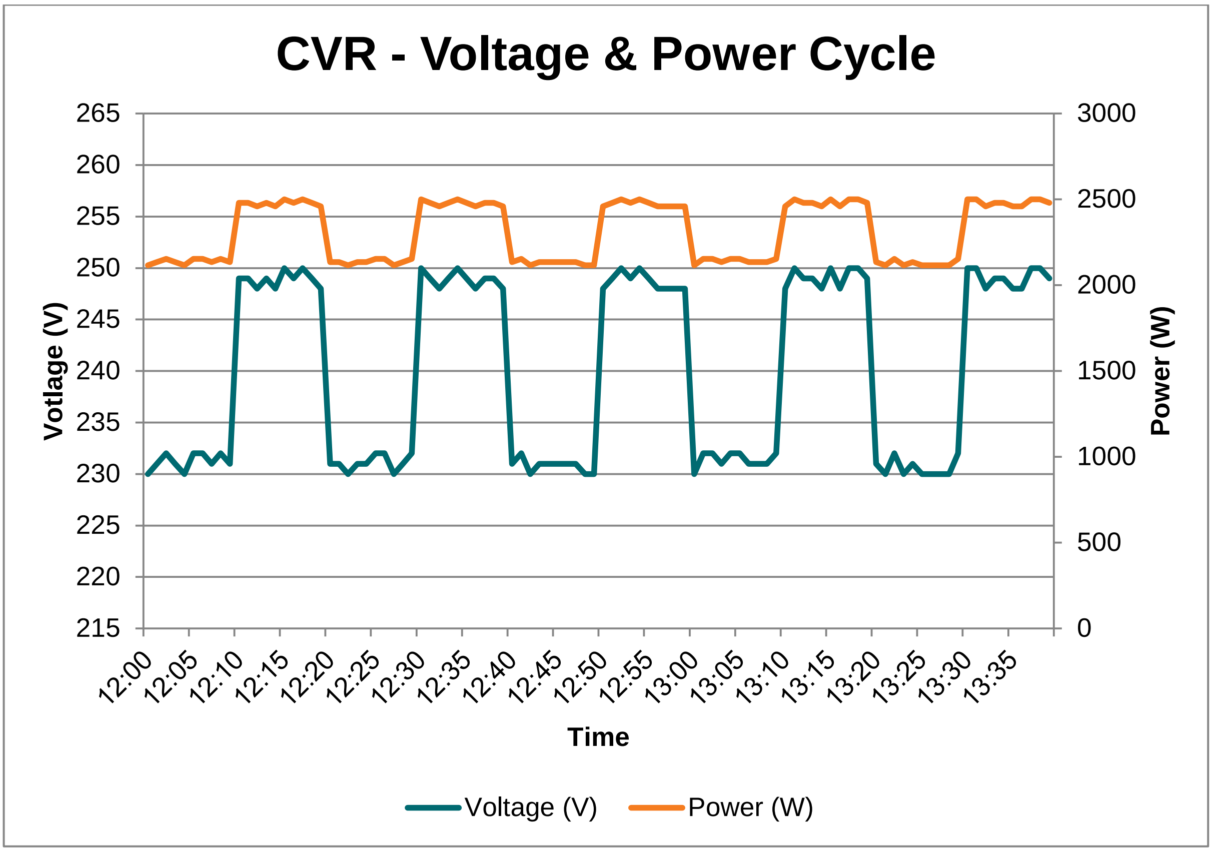


Figure 5.1: Pulse Train Voltage & Power Response

CVR a relatively unused concept for most utilities due to a number of technical issues in its implementation, instead CVR's main proponents are those in the energy efficiency sector.

The CVR factor or CVRf is the percentage change in energy for a given percentage change in voltage i.e.

$$\frac{\%\ \Delta\ \text{energy}}{\%\ \Delta\ \text{voltage}}$$

The CVRf can also be expressed in terms of kW, kVAr demand reduction as;

$$\frac{\%\ \Delta\ X}{\%\ \Delta\ \text{voltage}}$$

Where X is kW or kVAr, however unless explicitly stated CVRf refers to the change in energy.

Numerous studies have been completed on CVR with many stating the average CVRf for both demand and energy to be around 1.0 or slightly below. A CVRf of above zero is beneficial (ignoring fixed energy requirements) to a customer who is charged on kWh or on kW as any reduction in voltage, will decrease power.

A CVRf of greater than one (i.e. where current decreases with voltage) or a negative CVRf (where voltage can be increased to decrease current) is required to be of direct benefit to a distributor whose lines and losses are related to current rather than energy or power. The addition of a voltage regulator provides a separation between the HV voltage levels and LV voltage levels and changes the interaction from the HV voltage to one of constant power. Conservation Voltage Reduction through the use of low voltage regulators project overview;

The chosen device to investigate the CVRf theories outlined above is a three phase low voltage regulator, the benefits of using such a device are;

- Connected at LV, therefore trials can be small and with minor impacts to Essential Energy's business as usual operations
- The three phase regulator, once brought into the operational environment can be used in other sites for correction of voltage issues that would have required costly augmentation
- Allows the creation of a "constant power" LV network, thereby mitigating the issues outlined above

Whilst the main aim of the project is a thorough understanding of CVR, CVRf and its implementation (innovation), the project has a secondary aim of evaluating the three phase regulator for business as usual use (building of capability) and determining the value of CVR when used as a secondary function, with this in mind it is planned that the Conservation Voltage Reduction through the use of low voltage regulators project will consist of the following;

- One three phase low voltage regulator installed for testing of CVR in a residential area
- One three phase low voltage regulator installed for testing of CVR in a commercial area
- One three phase low voltage regulator installed for testing of CVR in an industrial area
- Five three phase low voltage regulators installed for evaluation as a business as usual tool for voltage support, with CVR as the secondary consideration.

5.2 Nature and Scope

The Conservation Voltage Reduction through the use of low voltage regulators project is a non-tariff based project with the following objectives;

- Evaluation of the technical requirements and performance characteristics of conservation voltage reduction (CVR) in the Essential Energy network
- Building Essential Energy's technical knowledge for further development in the areas of power quality rectification, remote control, CVR and small scale generation
- Evaluation of the reliability, usability and functionality of three phase low voltage regulators

To complete the above objectives, the project will include the acceptance testing, soak and functionality testing of a three phase low voltage regulator (in both voltage support and CVR functions), to determine the business as usual cost effectiveness (i.e. the calculation of total installed cost and benefits) of the product and to bring the documentation around the product up to the level required for business as usual use. Given these desired outcomes the low voltage regulator development and testing will be limited to the following;

- CVR functionality
- The physical installation
- The configuration
- The operational aspects
- The network impacts
- The total known package costs
- Internal standards for installation and maintenance
- Education on product use

While testing development is to be limited to the above items, issues, risks and learnings will be unlimited in nature.

5.3 Aims and Expectations

The aim of the program is to test CVR at low voltage, in order to allow a separation between HV and LV voltages. Longer term if successful, the completion of this project will allow Essential Energy to provide the business case for CVR at low voltage, and through previous research completed compare this to the benefits of CVR at HV, develop programs for the conservation of energy where economically viable, and defer network augmentation through either the reduction of demand through the use of CVR or the implementation of low voltage regulators to support the voltage at times of peak demand, with energy conservation as the secondary benefit.

5.4 Selection

Conservation Voltage Reduction is considered to be an effective tool in the conservation of energy, however for the reduction of network loads (current) ideally a separation between LV and HV voltages would exist to ensure the benefits of CVR are available in the HV feeder.

Initial options considered;

1. Single phase low voltage regulators

Single phase low voltage regulators are already used by Essential Energy to maintain voltages in constrained areas. Essential Energy has a firm appreciation of the costs involved in these installations, and due to the relatively high installed costs compared to the small loads passed through the device (typically one or two customers) it is not considered economical to install single phase low voltage regulators for the primary use of implementing CVR. Additionally installation and data from the existing single phase low voltage regulator installations is atypical, as the short distance between the installed single phase regulators and the customers has meant that taking into account the voltage drop and losses between the regulator and the customer has not been a major issue.

2. The use of LV reactive compensation

The use of low voltage reactive compensation can provide voltage regulation, but with the regulation comes the possibility of increased losses as power factor strays away from unity. It could be possible to constrain the reactive compensation in such a way as to ensure losses are not increased and that voltage regulation for the purpose of CVR is maintained, however the complexities and development involved would be far beyond what Essential Energy could hope to achieve in the timeframe scheduled for this project. The use of LV reactive compensation for voltage regulation in order to achieve CVR is not the preferred option at this stage, however it has been highlighted for consideration as a future project should this project prove successful.

3. High Voltage Regulation

High voltage regulation with the use of HV regulators and zone substation load drop compensation is already implemented on many of Essential Energy's feeders and high voltage distribution capacitors are in the initial stages of being used in business as usual situations. CVR for use in conserving energy can be implemented on some of these feeders provided monitoring or analytics are used, however in theory the peak current reductions for CVR on the HV feeder are minimal compared to using CVR on the low voltage side, that said the cost should also be significantly less, it will be part of learnings of this project to determine whether, given the differences in benefits achieved at HV and LV where CVR is most cost effective to implement.

4. Distribution Transformer regulation

HV transformers use on-load tap changers to regulate voltage at the zone substation or on the HV feeder. On-load tap changers require a degree of maintenance and monitoring to ensure adequate operation and lifetime, the costs involved with this work and the additional capital cost of on-load tap changers has largely precluded their use on distribution transformers, however recent developments claim maintenance free on-load tap changers for distribution networks offering a potential opportunity for future CVR implementation. Essential Energy currently has in service approximately 130,000 distribution transformers which would likely rule out any large scale roll-out, nor would not be considered to be cost effective to remove and replace transformers for the trial period. However as a transformer requires an upgrade or reaches the end of serviceable life, then it may be cost effective to replace it for the purposes of CVR, if this project proves successful the business case for regulating low voltage transformers will be evaluated.

5. Low Voltage 3ph regulators

Low voltage regulators provide the decoupling between LV and HV voltages required for the optimal demand reductions (current). It is estimated that low voltage three phase regulators will provide a greater benefit/cost ratio than a single phase regulator due to the increased capacity for load being serviced and similar requirements for installation. Low voltage regulators will allow all objectives to be met with minimal intrusion into business as usual systems and therefore lower costs, low voltage regulators are also predicted to have business use outside of this project in deferring voltage constraint based augmentations. Therefore this is the preferred solution.

5.5 Implementation

The project has been broken into three distinct stages;

1. Knowledge acquisition phase

Unit/s are installed in a workshop environment where design, settings, control and communications can be closely monitored, reviewed and any issues raised immediately with the supplier.

The completion of this work is expected during the 13/14 financial year.

2. Field trial phase

Three units will be installed in field locations offering voltages at the higher end of the acceptable range, thereby allowing the greatest improvement and measurement of CVR potential. These installations will be across three load types of commercial, residential and industrial.

Five units will be installed in field locations suffering from voltages outside of the acceptable range as this best represents the business as usual use for low voltage regulators. The potential for implementation CVR will be measured and the benefits calculated.

The completion of this work is expected during the 13/14 financial year.

3. Business as usual readiness

At the completion of the field trail conclusions will be drawn on the effectiveness of CVR in the Essential Energy area, and of the three phase regulator as a cost effective means of performing the CVR function. If the business case proves viable, then further evaluation will be undertaken to ensure the most cost effective implementation of CVR.

Finally an evaluation on the three phase regulator installations will also take place to ensure any issues or risks raised during the project are implemented before claiming the specific device as business ready.

5.6 Costs

Overall project costs thus far are shown in section 2 including research, purchasing and testing of two three phase low voltage regulators by appropriately qualified staff.

5.7 Benefits

Due to the project being in the initial stages, minimal project benefits have been delivered, however a number of anticipated benefits are highlighted below;

- Knowledge acquisition in the area of conservation voltage reduction
- Evaluation of the potential for conservation voltage reduction as a secondary benefit in business as usual operation
- Avoid network augmentation through reducing/limiting peak demand and improved power quality
- Increase end use efficiency and equipment life
- Decrease network losses
- Facilitating the integration of distributed generation into the grid
- 3 phase voltage balancing
- Improve power factor
- Improving network visibility via remote monitoring and control

5.8 Compliance

The "Conservation Voltage Reduction through the use of low voltage regulators" project meets the DMIA criteria under the following conditions;

1. Project undertaken to meet customer demand by shifting or reducing demand for standard control services through non–network alternatives.

2. For use in;
   a. broad–based demand management projects or programs and/or
   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. Innovative and designed to build demand management capability and capacity.

4. Non–tariff based.
   a. not recoverable under any other jurisdictional incentive scheme,
   b. not recoverable under any other state or Australian Government scheme, and
   c. not 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.

5. Capex

6 Capacitor Package Development

6.1 Summary

The Capacitor Package Development project was initiated based on the outcomes of a trial pole top capacitor bank project completed in 2011/12. The 2011/12 pole top capacitor bank installation was used to alleviate a specific voltage constraint and in doing so defer capital investment, this trial was therefore considered to be outside of the DMIA.

The project “Capacitor Package Development” has been created in order to develop standards and guidelines for use of distribution pole top capacitor banks, such that a broad scale roll-out could be implemented in the future with a minimum of technical issues.

6.2 Background information

Distribution feeder capacitors are highly utilised assets for many utilities within the US power system, and are increasingly being used within Australia in order to;

- Supplement substation power factor correction: In brownfield substations it can be prohibitively expensive to install extra capacitor banks and breakers in order to reduce current on the subtransmission feeder, installing capacitor banks on the distribution network avoids these costs whilst also providing additional benefits due to its proximity to the load.
- Provide an alternative to substation capacitors: As above.
- Manage distribution voltage profiles: Capacitors provide a voltage boost by either supplying reactive power requirements closer to the load or by the capacitive volt-ampere-reactives (VARs) travelling through the network inductance to upstream loads. Switched capacitors serve to regulate voltage on a feeder, having the ancillary benefit of reducing the number of operations of voltage regulators, both line

(and to a lesser degree) substation on-load-tap-changers. This reduces the required maintenance on both regulators and tap-changers.

> Increase network capacity: Figure 1 illustrates the extra capacity that can be released by correcting the power factor of a feeder, as an example if the power factor on the feeder at peak load is at 0.8, then an additional 25% of feeder capacity is available (not including reduced losses or increased voltage).
> Reduce line losses: By cancelling the reactive power drawn by loads with low-power factor, capacitors decrease the upstream line current required to supply these loads and significantly lower I^2R losses.

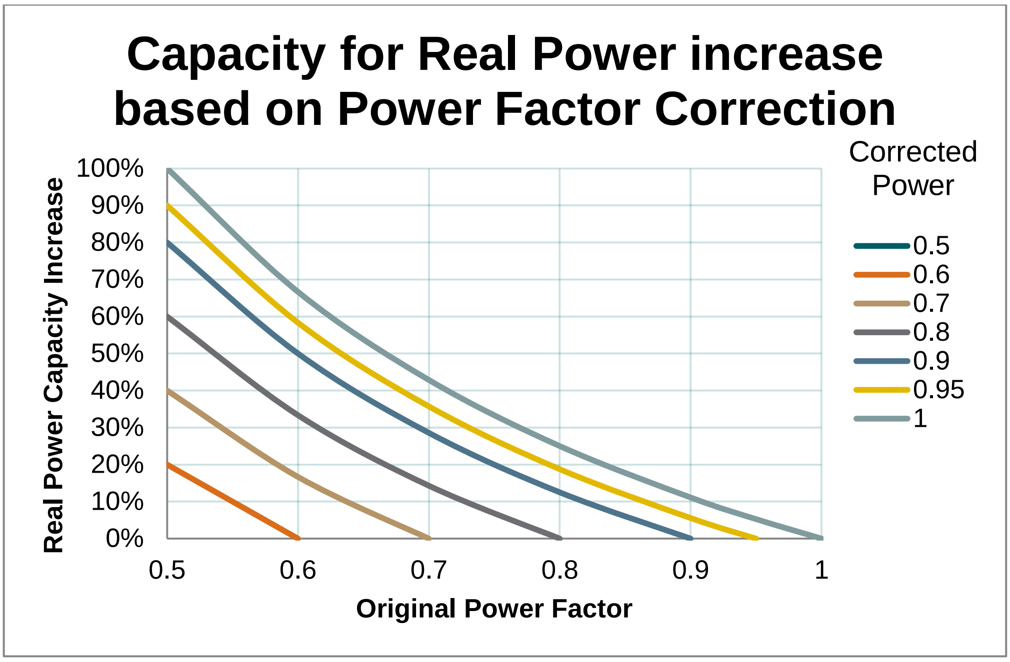


Figure 2 - Example of capacity increase through the correction of Power Factor

Simplified Theory of Capacitors

Capacitors work by storing energy. They are a relatively simple device; two metal plates sandwiched around an insulating dielectric. When charged to a given voltage, opposing charges fill the plates on either side of the dielectric. The strong attraction of the charges across the very short distance that separates the plates creates a strong electric field (electrostatic field) enabling the storage of energy. Having this field also means that capacitors oppose changes in voltage, hence it is also important to note that the charge on the plates does not change instantaneously; rather there is a time constant associated with charging and discharging capacitors.

In an AC power system capacitors don't store their energy very long – just one half cycle. As each half cycle a capacitor charges up and then discharges its stored energy back into the power system. The net real power (excluding losses) is zero. Every half cycle the capacitor will exchange reactive power with the (typically local) loads on the system that have a poor power factor. This benefits the system as the reactive power (seen as extra line current) does not have to be transmitted from the generators through kilometres of line and multiple transformers and this in turn frees up generators and upstream lines to generate and distribute greater amounts of real power.

Essential Energy's experience with Capacitors

Capacitors are installed, maintained and utilised within around 180 of Essential Energy's Zone Substations with relatively few issues, however the installation of distribution feeder capacitor banks within Essential Energy's network has been limited and sporadic. The reasons for the limited installation of distribution capacitor banks include;

- A number of potential issues that can arise if capacitor banks are incorrectly applied to the distribution network including;
  - Amplification of harmonics
  - Amplification/attenuation of frequency injection signals, this point is of considerable issue to Essential Energy due to the vast array of frequencies used in the installed frequency injection systems.
  - Switching transients (exacerbated historically by the number of single phase switches on the network)
  - Concern over leading power factors
  - Over voltages
  - Additional losses (where control settings are incorrect)
- A lack of understanding around the multitude of benefits of a distribution feeder capacitor installation and therefore underestimating the value of a capacitor bank installation during NPV analysis.
- A general lack of experience/knowledge in distribution capacitor banks, which creates a disincentive to install and an easy point of blame should any network issues arise (which will inevitably occur if the potential issues are not understood).

6.3 Capacitor Package Development overview

In 2011/12 a trial capacitor bank installation was completed at Clarencetown, confirming the expected costs and benefits and highlighting the outstanding issues for wider implementation, subsequently the Capacitor Package Development project was created in order to overcome the remaining issues and provide the appropriate training and education for business as usual use.

Figure 3 - Clarencetown trial capacitor bank installation

6.4 Nature and Scope

The “Capacitor Package Development” project is a non-tariff based program to develop internal standards, guidelines and manuals for the use of power factor correction technology aimed at addressing specific network constraints by reducing demand on, or providing reactive support to the network at the time and location of the constraint.

Therefore the desired outcome for the “Capacitor Package Development” project is a robust package covering design, installation and operation which will allow the implementation of distribution capacitor banks across the Essential Energy network with minimal development on behalf of the end user. The robust package outlined above will include;

- Robust capacitor bank standard/s at various voltages and sizes (minimal variations)
- Maintenance plans
- Operational manuals
- Installation/specification manuals for use by the planning department
- Education of the end users (including planning and field staff)

6.5 Aims and Expectations

The aim of the “Capacitor Package Development” project is to develop a robust capacitor information package covering design, installation and operation which will allow the implementation of distribution capacitor banks across the Essential Energy network with minimal development on behalf of the end user.
As HV distribution capacitors are already a mature technology, it is not expected that a great deal of cost reduction will occur in the future external to Essential Energy, however it is anticipated that internally there will be substantial cost reductions available as the final installed cost for distribution capacitors are expected to be under $100 per kVAr.

The low anticipate $/kVAr figure will therefore allow for substantial cost effective voltage improvements on long lines and peak demand and loss reductions in poor to moderate power factor areas particularly in high loss distribution networks as shown in case study D8 of “Energy Efficiency Opportunities in Electricity Networks - Findings of industry trials for the extension of the EEO Program to network businesses” prepared by Energeia in consultation with the Department of Resources, Energy and Tourism.

6.6 Selection

There is little doubt that power factor correction is a cost effective alternative to network augmentation however there are quite a number of options on how to implement power factor correction for the greatest benefits and least cost. The options for installation of power factor correction were reviewed by Essential Energy as below;

1. Installation of capacitor banks at Zone Substation level

Installation of capacitor banks at the zone substation is already undertaken by Essential Energy, however they can be cost prohibitive to upgrade in a physically constrained environment or to install in a brownfields site, on-top of this zone substation capacitors offer the least benefit of the possible options. Due to these cost implications it is proposed that Zone Substation capacitor bank installations occur only where substantial ancillary costs are not present, i.e. that Essential Energy continues to install power factor correction at zone substations where it is cost effective to do so, however alternatives offering greater benefits do exist with minimal cost implications, and hence this is not the preferred solution for this project.

2. Installation of pole-top distribution capacitors

Installation of pole-top distribution capacitors provide substantial additional benefits over the zone substation installations, in demand reductions, voltage improvements and loss reduction, particularly on very long lines, whilst in theory the use of capacitors in pole-top configurations should not add greatly to the cost equation. This is the preferred solution.

3. Installation of distributor owned low voltage capacitors

Installation of capacitors on the low voltage system has the additional benefits of reducing losses and peak demand in the low voltage feeder, however by greatly decreasing the size of the load able to be connected off the capacitor (i.e. if 100% of load comes from the zone substation, 20% through any particular feeder and 1% through any particular distribution transformer by moving the installation to the distribution transformer we have decreased the reactive power flowing through the point of common coupling) we have greatly increased the number (and therefore cost) of installations required if we wish to avoid any adverse impacts. Due to these cost implications it is not proposed that distributor owned power factor correction be utilised in the low voltage network for bulk power factor correction at this stage, however should substantial developments occur that would alter the cost or benefit structure of the proposed solutions this should be re-evaluated.

4. Incentivising customers to perform their own power factor correction, through the use of tariffs and metering

Currently many of Essential Energy's customers pay for their customer classes' average impact on demand, hence price signals are for the most part blurred through the use of energy as a surrogate for demand, with some customers paying more than their fair share, and others paying less than their fair share.

By using price signals which relate relatively poorly to the cost of supply, manufacturers of end-use equipment and customers themselves have limited incentive to ensure that end-use equipment has a minimal impact on the network or the costs of the network. To avoid customers paying more or less than their fair share, and to provide an incentive to reduce overall network costs, ideally customers should pay for their true impact on the cost structure of Essential Energy's assets, i.e. customers would pay for the impact of their demand, in terms of kVA (both kW and kVAr).

Currently Essential Energy is not in a position to bring demand type pricing to the majority of customers, nor does it believe the majority of customers have enough understanding of power factor or its impacts on demand to respond appropriately, therefore this is not the preferred option at this point in time. The AER is beginning to regulate the above inequalities and lack of education through the implementation of the "Power of Choice" and as this regulation moves through to implementation Essential Energy will be able re-evaluate the potential of moving more customers to a position of greater cost reflectivity.

6.7 Implementation

The project has been broken into three distinct stages;

1. Knowledge acquisition phase

The multitude of issues relating to the use of distribution capacitors was researched and tabulated, along with the functional requirements of our internal process regarding switching, safety, SCADA, maintenance, etc. This work was completed during the 2012/13 financial year.

2. Simulation and development phase

Options to overcome the fore mentioned issues have been developed, simulated to ensure their usefulness and will be canvassed amongst stakeholders. Specifications and guidelines for general use within Essential Energy's network area are currently being developed and once finalised will be reviewed by the appropriate stakeholders to ensure compatibility with the existing network infrastructure and operations. Completion of this work is scheduled for the 2013/14 financial year.

3. General deployment phase

The utilisation of distribution capacitors as an alternate technology for demand reductions on Essential Energy's distribution network will require appropriate training through all levels of the supply chain as well as familiarisation with the appropriate specifications and guidelines on distribution capacitor bank usage. This training and education will take place toward the end of the 2013/2014 financial year.

6.8 Costs

Overall program costs including research, development, and simulation in the development of a robust distribution capacitor package during 2012/2013 are shown in section 2 determined by the use of appropriate procurement systems and time recording.

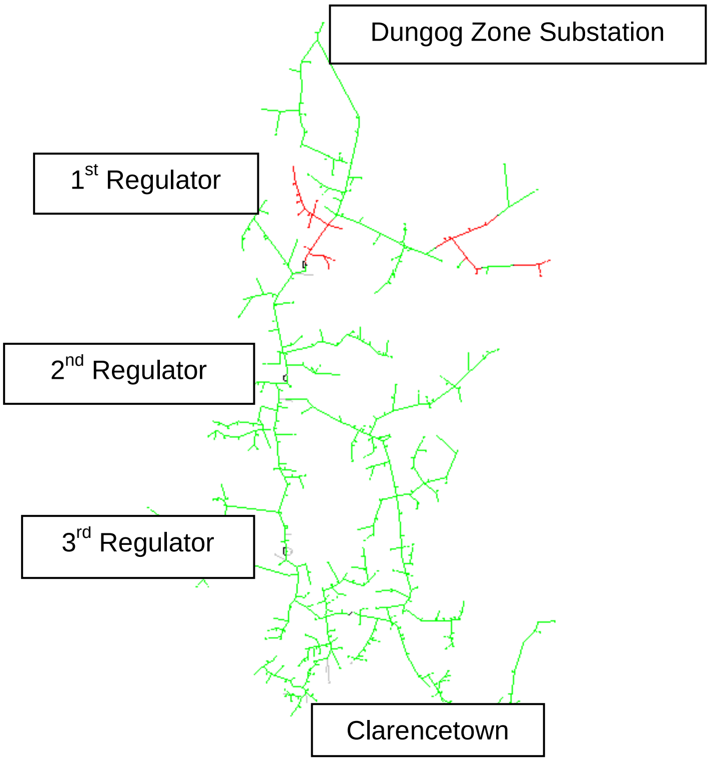
6.9 Benefits

Through the completion of the Capacitor Package Development project, Essential Energy will have built demand management capability and capacity, specifically in the use of distribution capacitors, in doing so distribution capacitors will become business as usual items for use in Essential Energy's network area. The use of distribution capacitors offers significant benefits to voltage, peak demand and loss reduction as shown in the examples below;

Example 1.

Peak load before any recent augmentation on the Clarencetown feeder out of Dungog Zone Substation (top of picture) was approximately 4.9 MVA, with 2MVA supplying the Clarencetown load some 30km from the Zone Substation through three series regulators.

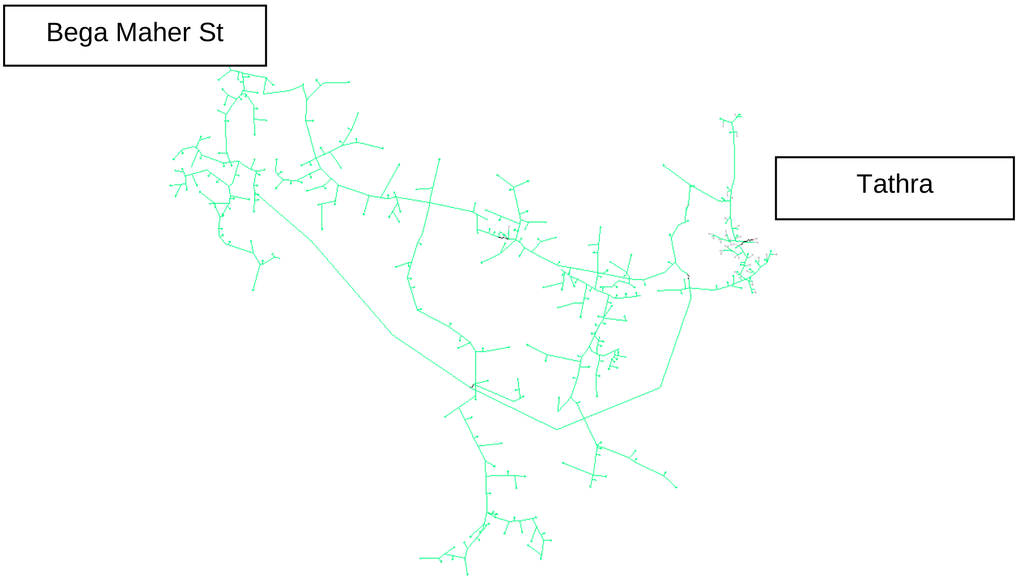
Concerns were raised over low voltage issues before the first and second regulators as well as over the thermal capacity of the mainline through to Clarencetown.



The table below shows the benefits of installing two 300kVAr capacitor banks in Clarencetown.

	Original	2x 300kVAr Capacitor Banks	Unit reduction
ZS kVA	4,911	4,360	551
1st regulator kVA	3,802	3,470	332
2nd regulator kVA	3,227	2,971	256
3rd regulator kVA	2,065	1,943	122
Minimum Voltage p.u.	0.89	0.91	-0.02
Losses (peak) kW	853	688	165
Estimated annual losses (MWh)	2,241	1,808	433

Example 2.
Peak load before any recent augmentation on the Tathra feeder out of Bega Maher St Zone Substation (top of picture) was approximately 4.2 MVA, with 2MVA supplying the Tathra load at the end of the feeder (split into northern and southern feeder legs) some 20km from the Zone Substation.



The table below shows the benefits of installing two 300kVAr capacitor banks in Tathra.

	Original	2x 300kVAr Capacitor Bank	Unit reduction
ZS kVA	4,225	3,942	283
Regulator kVA	1,455	1,350	105
Northern Tathra kVA	749	678	71
Southern Tathra kVA	1,344	1,212	132
Minimum Voltage p.u.	0.95	0.98	-0.03
Losses (peak) kW	209	181	28
Estimated annual losses (MWh)	549	476	74

6.10 Compliance

The Capacitor Package Development project meets the DMIA criteria under the following conditions;

1. Shifting or reducing demand for standard control services through non–network alternatives.
2. For use in;
   a. Innovative and 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. Designed to build demand management capability and capacity.
4. Non–tariff based.
   a. not recoverable under any other jurisdictional incentive scheme,
   b. not recoverable under any other state or Australian Government scheme, and
   c. not 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.
5. Opex

7 Energy and Network Capacity cost evaluation

7.1 Summary

The "Energy and Network Capacity cost evaluation" project was developed in order to provide a more cost reflective evaluation of demand management measures within Essential Energy and to enable the business case and use of broad-based demand management initiatives.

7.2 Background information

Essential Energy has the responsibility of distributing electricity according to the Electricity Association of NSW 'Code of Practice – Electricity Service Standards' and the applicable Australian Standards whilst also minimising the present value cost of meeting those standards and maximising the net benefit to consumers, generators and other market participants.

The growth category in table 1 consists of all capital expenditure required to augment network capacity in order to meet increasing demand. As can be seen in table 1.1.1, "Growth" is the main influence on Essential Energy's "Total system capital expenditure" at roughly 43% for the regulatory period 2009-2014.

$M (2008 - 09)	2009-10	2010-11	2011-12	2012-13	2013-14
System related					
Asset renewal/replacement	138	155	165	173	183
Growth	249	275	291	302	314
Reliability and quality of service enhancement	165	179	185	188	191
Environmental, safety and statutory obligations	36	39	42	43	45
LESS: Productivity Gains	(3)	(7)	(7)	(7)	(8)
Total system capital expenditure	**584**	**642**	**675**	**699**	**725**

Figure 4 – Forecast System Capital Expenditure 2009-2014

The relationship between electricity end use and growth expenditure;

Consumer loads have an incremental effect on the overall and local diversified demand and the true cost of providing a given overall network capacity is made up of the sum of many augmentations in separate parts of the network over indefinite lengths of time.

On the other hand, network augmentations to build the required capacity once a constraint is reached takes place through lumpy augmentations and extensions at different levels throughout the network - subtransmission, high voltage, low voltage mains and substations.

In these circumstances, whereby the expenditure is large, lumpy and a single network element, while the growth is small, incremental and effects the entire electricity supply chain, the economic deferral of a single network augmentation is both difficult to justify and a false representation of the true value to all market participants.
Energy and Network Capacity cost evaluation overview;

The task set for the "Energy and Network Capacity cost evaluation" was the development of models and methodologies which allow the true value of demand reductions in business case development.

In early 2012 a request for proposal was developed and sent to a number of potential suppliers, based on proposals returned a consultant was chosen and services procured in mid-2012.

During mid to late 2012 the models and methodologies were developed which have allowed Essential Energy to more accurately view the cost of growth in all levels of its network. The work completed thus far has also highlighted the significant data issues hindering the implementation of such models in more detailed, location specific views.

These models and methodologies have allowed the development of broad-based demand management business cases, the evaluation and confirmation of existing broad-based programs such as hot water load control, and the development of new concepts around the cost of demand growth.

In the coming years Essential Energy will move toward implementing these models and methodologies in all related business decisions, such that the most cost effective implementation of network and non-network solutions can be assured.

7.3 Nature and Scope

The “Energy and Network Capacity cost evaluation” project is a non-tariff based program to build the capabilities and capacity required to construct meaningful demand management business cases.
Essential Energy engaged a suitable consultant to design, build and implement a model capable of determining the average long run marginal cost at each level of the network and the average cost of capacity at each network level, it was hoped that the model would also be able to determine these values across time and location, however the granularity of the available data has limited this output. As a secondary requirement, a methodology was developed around the valuation of location specific demand management incorporating specific upstream demand reductions. The consultant also delivered descriptions, guidelines and manuals to allow for updating and maintenance of the models.

7.4 Aims and Expectations

The aim of the Energy and Network Capacity cost evaluation project was to develop more cost reflective valuations of demand and demand reduction, this aim has been accomplished through the development of previously specified models and methodologies.

It is expected that from this information Essential Energy will be able to more accurately implement the cost/benefit decisions relating to peak demand reductions over the coming years, such as for ;

- Broad-based demand management business cases
- Project specific demand management business cases
- Embedded generation business cases/benefits
- Input into network pricing

7.5 Selection

The development of business cases for demand management, particularly in the development of broad-based business cases, requires substantial information and analysis on the benefits of achieving peak demand reductions across a broad area, this type of information was previously not available to Essential Energy in any firm or quantifiable form. The requirements to build demand management business cases is known, i.e. the benefit in $/kVA of a demand reduction at a particular point or on average across the network, the options are therefore limited to various methods of obtaining this value.

Initial options considered to gather this information included;

1. Use of overall growth expenditure and overall peak demand growth

The simple use of overall growth expenditure and high level overall peak demand growth in calculating the benefits of demand reduction, while having a very low cost, gives poor accuracy and does not include many of the additional costs of servicing/maintaining additional network investment. A calculation at the overall level also leaves much to be desired in assessing the cost in particular areas, given that the cost to supply the variety of areas in Essential Energy’s network was expected to be substantially different this was not the preferred solution.

2. Use of network pricing methodology (“Cost of Supply”) models

As per Essential Energy’s “Annual network prices report 1 July 2013 – 30 June 2014”; Essential Energy’s cost of supply model aims to provide equitable outcomes with prices averaged by customer class, as a result of this the model does not take into account the marginal cost of supply to specific areas. Given that the cost to supply the variety of areas in Essential Energy's network was expected to be substantially different this was not the preferred solution.

3. Specific growth expenditure and specific peak demand growth per area

The use of specific growth expenditure and specific peak demand growth per area allows for the further analysis required in determining the cost to supply a particular network area, the cost of servicing/maintain the additional network investment could also be brought into the model overcoming many of the deficiencies of the previous options. This was therefore the preferred solution.

7.6 Implementation

The project has been broken into three distinct stages;

1. Development Stage

   The unique skill set to develop the required models incorporating economics, finance and engineering, along with the resourcing required and the desire for the models to have substantial independence from any particular business unit meant that best course of action was to engage a consultant with sufficient skill and expertise to undertake such development.

   In the 2011/2012 financial year a consultant was engaged and data mining and development of the required models began incorporating a multitude of variables to provide the most accurate representation of peak demand benefits, these included the following developments;

   - Mapping of regions and linking of regions to bulk supply points
   - Network system and financial assumptions
   - Peak demand by system level tables and coincidence factors
   - Growth cost of capacity by system level
   - Growth Operating and Maintenance costs by system level
   - Growth capex by system level
   - Non growth capex by system level
   - Transmission costs
   - Peak demand for BSPs and zone substations
   - Tariff calculations
   - Links between Bulk Supply Point peak demand projections and lower level peak demands
   - Links between Zone substation peak demand projections and lower level peak demands
   - Links between Subtransmission data and capex data
   - Links between optimised depreciated value projections and Regulated Asset Base
   - Low voltage allocation of peak demand and specific expenditure
   - System growth cost floor (to account for currently unplanned works)
   - Distribution loss factors linkages
   - Power factor projections

The required development of the above items highlighted the fragmentation of data experienced in Essential Energy's systems and also the requirement to develop stronger linkages between systems to enable a better understanding of the cost to supply peak demand in particular areas.

The first payments for delivery of the models were made in the 2012/2013 financial year. In 2012/2013 a model was delivered which derived the benefits of peak demand reductions in terms of $/kVA including;

- The components of the marginal cost at the low voltage level contributed by each system level
- The marginal cost at each system level
- The components of the average cost at low voltage level contributed by each system level.

- The average cost at each system level
- The cumulative components of the marginal cost at all system levels

2. Specific Deployment Stage

   In 2012/2013 the developed models where used to;

   - Evaluate the cost/benefit of the existing load control system
   - Evaluate the viability of and develop the business case for broad based power factor correction programs
   - Evaluate the viability of and develop the business case for promoting the load control system through increased hot water load control
   - Evaluate the viability of and develop the business case for promoting the load control system through increased pool pump load control
   - Evaluate the viability of and develop the business case for air conditioner based load control

3. General deployment phase

   In the coming years Essential Energy will move towards using the modelled figures to influence all appropriate business decisions, such as specification of loss values in standard constructions, determination of possible network tariffs and evaluation of specific network projects.

   Essential Energy will also work towards firming the assumptions used in the model and correcting the issues related to sourcing of the currently fragmented data thereby moving the model into a more automated, easy to maintain model, through the linkage of systems and reporting where possible.

7.7 Costs

Overall program costs including research and development of the appropriate models during 2012/2013 are shown in section 2 determined by the use of appropriate procurement systems and time recording.

7.8 Benefits

The development of an appropriate measure for the benefits of demand reductions has in turn allowed for the development of broad-based demand reduction business cases, the long term benefits being a substantial increase in the level of demand management able to be implemented and the inclusion of appropriate peak demand information into a multitude of business decisions.

7.9 Compliance

The “Energy and Network Capacity cost evaluation” meets the DMIA criteria under the following conditions;

1. Shifting or reducing demand for standard control services through non–network alternatives.

2. For use in;

   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 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

3. Innovative, designed to build demand management capability and capacity and explore potentially efficient demand management mechanisms

4. Non–tariff based.

a. not recoverable under any other jurisdictional incentive scheme,
b. not recoverable under any other state or Australian Government scheme, and
c. not 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.

5. Opex

8 Energy and Demand Audits

8.1 Summary

The Energy and Demand Audits project was developed in order to analyse the minor changes consumers can make to processes and equipment which benefit both the consumer and the network.

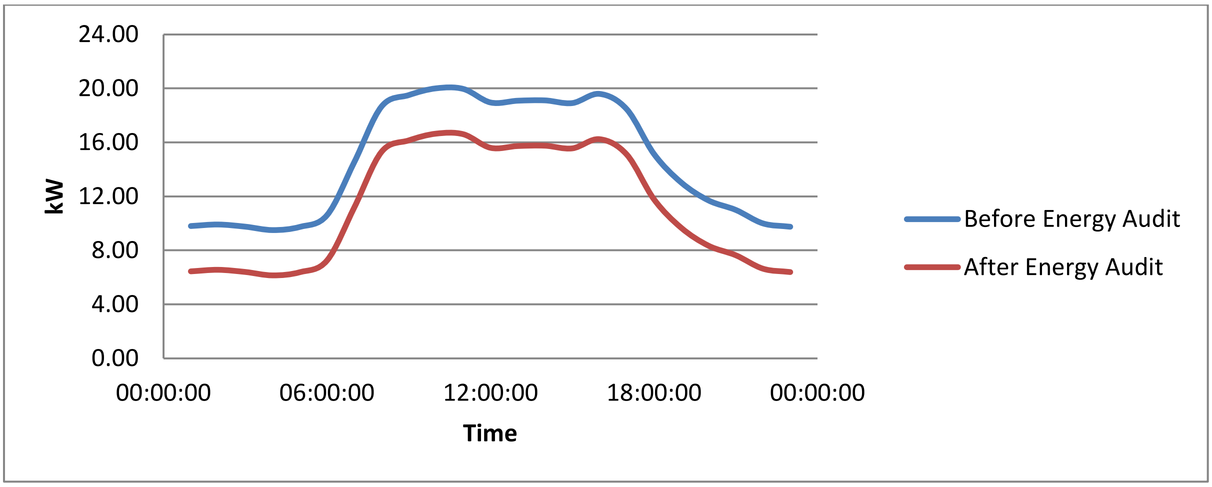
The project is similar to that suggested in the “Demand Management and Planning Project” (DMPP) final report (completed under the auspices of a Management Committee comprising the NSW Department of Planning, Energy Australia and TransGrid), June 2008; “It is recommended that the NSW Government considers requiring all State owned network operators to conduct platform studies similar to the DMPP, with a focus on establishing a data base of opportunity areas and developing project facilitation arrangements”.

8.2 Background information

Consumer based demand reductions based on permanent, one-off cost solutions can offer utilities long term deferral of network augmentation, however large one-off cost solutions are often too expensive to be justified on the benefits of single network augmentation, it is therefore important to derive the benefits of solutions from a multitude of angles, in order to provide cost effective demand reductions.

Energy audits are a common, cost effective tool for decreasing consumers energy consumption, with the outcome/s of the energy audit (e.g. replacement of certain items/plant) normally being justified on commercial returns to the customer through the reduction of energy costs (by way of retail pricing initiatives).

However it is important to note that energy reductions do not necessarily translate into proportional peak demand reductions (the main concern to an electricity network) e.g. the diagram below shows an energy reduction of 6.74kWh/day or 2.4MWh per year, however the peak demand reduction is only 0.29kW.



8.3 Energy and Demand Audits project overview

In 2010/11 Essential Energy investigated the cost/benefit of completing a similar study to the DMPP in the Essential Energy network area (in light on the DMPP outcomes), unfortunately the cost involved in sourcing the information sought through large energy/demand audits is too cost prohibitive (up to $30,000) to perform on a large scale with no anticipated near term benefits, the concept was therefore sent back to the drawing board to determine a more cost effective means of sourcing similar information. On review of the options available it was determined that a more cost effective solution may be available if Essential Energy was able to implement a supplementary demand audit on the back of energy audits already being completed, this was further investigated in consultation with a number of energy auditors and deemed to be a viable solution.

In 2011/2012 Essential Energy partnered with Transgrid (who through their DMIA will be funding 50% of the final project cost) and two service providers operating within the Essential Energy network area who were offering Energy Audits to commercial and industrial consumers. Essential Energy then worked with these two service providers to create an Energy and Demand Audit.

By the end of the 2012/13 financial year a total of 10 audits had been completed with approximately 101 demand management initiatives investigated.

Preliminary results have been compiled and they show that substantial benefits are available to both the consumers involved and the network. Strategies and programs are currently being constructed to take advantage of the results and move the benefits into business as usual operation.

8.4 Nature and Scope

Due to the large cost involved in energy and demand audits, Essential Energy sought suitable partners operating within the Essential Energy network area and worked with them to develop a supplementary audit component (i.e. the demand component of the "Combination Energy and Demand Audit") which was then able to provide an assessment of the potential for and likely cost of network demand management applications.

During the audit project;

- The customers (commercial and industrial) usage patterns are recorded and/or observed, preferably at a machine/process level as well as at an overall level, along with any external influencing factors e.g. temperature, production process timing, etc. The customers premise are then evaluated for all efficiency and demand reduction/load shifting possibilities
- Individual audit reports on the potential improvements in efficiency, power factor and load curtailment for each facility is developed along with the cost and payback period based on existing retail tariffs.
- A project report is to be developed by Essential Energy personnel based on the collated individual audit reports and consisting of;
  - Project outcomes
  - Recommendations for further research
  - Typical price profiles for demand reductions based on audits in general and by particular item replacement for various customer classes
  - The most common inefficiencies, poor power factor customer types, and peak demands.
  - The individual demand reduction items with the quickest payback to the customer based on existing retail tariffs.
  - Possible mechanisms for incentivising the uptake of audit outcomes
- Demand reduction strategies and programs based on outcomes of the energy and demand audits with typical costs for various customer classes throughout Essential Energy's footprint will be developed.

8.5 Aims and Expectations

The aim of the "Energy and Demand Audits" project is to gain the following information for use in future location specific and broad based demand management programs and projects;

- A typical price profile for demand reduction energy audits and by particular item replacement, for various customer classes
- The most common inefficiencies, poor power factor customer types, and peak demands found in energy and demand audits in Essential Energy's network
- The individual demand reduction items with the quickest payback
- Demand reduction strategies and programs based on outcomes of the energy and demand audits with typical costs for various customer classes throughout Essential Energy's footprint.

Through the acquisition of this knowledge it is expected that Essential Energy will be able to deliver more cost effective customer specific demand reductions to the benefit of all customers.

8.6 Selection

Given the information sought (set out in section 8.5), specific to Essential Energy's network area the following options were considered;

1. Demand Audits

Demand audits within Essential Energy's network area are the most direct way to source the information required and provide site specific information should a demand management project become applicable to a particular area, however demand audits are costly to perform with minimal benefits in the near term and possibly difficult to implement without customers educated on the merits of such an audit. Therefore this was not the preferred solution.

2. Use of demand audit information from sites outside of Essential Energy's network area

Demand audit information is available from projects such as the DMPP, however without additional information there is little way to correlate with any confidence the information acquired with the Essential Energy network area. Additionally using information acquired external to the business removes any development of internal experience in developing business relationships with appropriate vendors and vendors requirements, it also removes any site specific information that may have been used at a later date. Therefore this was not the preferred solution.

3. Combination Energy and Demand Audits

By joining a supplementary demand audit with existing energy audits in the Essential Energy network area substantially decreased costs are available with similar acquired knowledge, while this method does reduce the ability to target audits at particular locales or customers this ability was not deemed essential to objectives of the project. Therefore this was the preferred solution.

8.7 Implementation

The "Energy and Demand Audits" project has been broken into three distinct stages;

1. Audit development

In consultation with a number of energy auditors, a combined energy and demand audit was first deemed to be a viable solution.

Essential Energy partnered with two service providers operating within the Essential Energy network area who were offering Energy Audits to commercial and industrial consumers. Essential Energy then worked with these two service providers to create and review an energy and demand audit.

2. Audit Implementation

By the end of the 2012/13 financial year a total of 10 audits had been completed with approximately 101 demand management initiatives investigated, it expected that by the end of the project roughly twice the number of audits will have been delivered.

Preliminary results have been compiled and they show that substantial benefits are available to both the consumers involved and the network. Strategies and programs are currently being constructed to take advantage of the results and move the benefits into business as usual operation.

3. General deployment phase

During the general deployment stage Essential Energy will implement the strategies and programs based learnings and achieve the benefits found in the initial stages of the project.

8.8 Costs

Overall program costs including research, development and implementation of the audits during 2012/2013 are shown in section 2 determined by the use of appropriate procurement systems and time recording

8.9 Benefits

Stage 1 of the "Energy and Demand Audits" project involved development of a demand audit, indirectly this has provided auditors with education around the drivers for network expansion, and the benefits of demand reductions, internally it has grown Essential Energy's experience with customer facing service providers and the specific requirements of energy/demand auditors.

Stage 2 of the project has thus far achieved a total of 10 completed audits, with approximately 101 demand management initiatives investigated; it expected that by the end of the project roughly twice the number of audits will have been delivered.

Preliminary results have been compiled and they show that substantial benefits are available to both the consumers involved and the network as shown below. Strategies and programs are currently being constructed to take advantage of the results and move the benefits into business as usual operation.

Including 1 year customer benefit					
	$/kVA				
	Average	Max	Min	Median	No of investigations
Load Shedding	$ 95	$ 310	-$ 8	$ 45	24
Power Factor Correction	$ 144	$ 679	-$ 22	$ 97	9
Fuel Switching	$ 358	$ 500	$ 216	$ 358	2
Load Shifting	$ 1,531	$ 3,333	$ 43	$ 1,374	4
Embedded Generation	$ 1,885	$ 5,684	$ 2	$ 1,621	12
Energy Efficiency	$ 3,725	$ 41,941	-$ 209	$ 2,009	48

Including 4 years customer benefit					
	$/kVA				
	Average	Max	Min	Median	No of investigations
Power Factor Correction	-$ 936	-$ 282	-$ 2,783	-$ 826	9
Fuel Switching	$ 57	$ 500	-$ 387	$ 57	2
Load Shedding	$ 84	$ 310	-$ 280	$ 45	24
Energy Efficiency	$ 1,768	$ 32,764	-$ 4,238	$ 249	48
Load Shifting	$ 1,239	$ 3,333	$ 43	$ 790	4
Embedded Generation	$ 909	$ 3,075	$ 2	$ 587	12

- Note: Above estimated costs are for implementation only, i.e. no incentive payments or fuel costs are included.

While the benefits thus far have been in terms of knowledge, experience and development, it is expected that substantial financial and environmental benefits could be achieved in the near future as strategies and programs are rolled into business as usual operation.

8.10 Compliance

The "Energy and Demand Audits" meets the DMIA criteria under the following conditions;

1. Shifting or reducing demand for standard control services through non–network alternatives.

2. For use in;

    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 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

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. Innovative and designed to build demand management capability and capacity and explore potentially efficient demand management mechanisms.

4. Non–tariff based

    a. not recoverable under any other jurisdictional incentive scheme,
    b. not recoverable under any other state or Australian Government scheme, and
    c. not 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.

5. Opex.