Regulatory Information Notice (RIN)

Supporting Information for Demand Management Innovation Allowance (DMIA)

2011-2012

November 2012
Prepared by Essential Energy

CONTENTS

INTRODUCTION

The Demand Management Incentive Scheme (DMIS) applied to Essential Energy is set out in the Australian Energy Regulator's (AER) final decision and distribution determination for Essential Energy for the regulatory control period 1 July 2009 to 30 June 2014 (the determination). The DMIS 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.

The DMIS requires that each ACT and NSW DNSPs must submit annual reports on their expenditure under the DMIA to the AER for each regulatory year.

The annual report must include:

1. The total amount of the DMIA spent in the previous regulatory year, and how this amount has been calculated.

2. An explanation of each demand management project or program for which approval is sought, demonstrating compliance with the DMIA criteria detailed at section 3.1.3 with reference to:

    a. the nature and scope of each demand management project or program

    b. the aims and expectations of each demand management project or program

    c. the process by which each project or program was selected, including the business case for the project and consideration of any alternatives

    d. how each project or program was/is to be implemented

    e. the implementation costs of the project or program, and

    f. any identifiable benefits that have arisen from the project or program, including any off peak or peak demand reductions.

3. A statement signed by a director of the DNSP certifying that the costs of the demand management program:

    a. are not recoverable under any other jurisdictional incentive scheme

    b. are not recoverable under any other state or Commonwealth government scheme, and

    c. are not included in the forecast capex or opex approved in the AER's distribution determination for the next regulatory control period, or under any other incentive scheme in that determination (such as the D–factor scheme for NSW).

4. An overview of developments in relation to projects or programs completed in previous years of the next regulatory control period, and any results to date.

This report provides the details of Essential Energy's DMIA projects undertaken in the 2011/12 financial year as outlined above.

SUMMARY OF SUBMISSION

Essential Energy's DMIA expenditure for the 2011/12 financial year consists of one program – the "Grid Interactive Inverter Program". This program consists of five individual project applications.

1. 60kVA 3ph modular statcom
2. 60kVA 3ph energy storage and solar combination
3. 20kVA single phase modular statcom
4. 20kVA single phase modular energy Storage
5. Integration of Solar, Wind and Storage Systems into Distribution Grids for Network Support Study

The total program cost for 2011/12 was $728,365, with $231,738 being of an operating expenditure nature and $496,627 of a capital expenditure nature.

SECTION 1.5 (a)

In respect of the DMIS:

(a) provide an explanation of each demand management project or program for which approval is sought;

Background

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 current rating of elements in the supply path or 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.

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 2010-2011.

Project Detail

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

1. 60kVA 3ph modular statcom

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

2. 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.

3. 20kVA single phase modular statcom

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

4. 20kVA single phase modular energy Storage

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

5. 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

SECTION 1.5(b)

(b) explain, for each demand management project or program identified in the response to paragraph 1.5(a), how it complies with the DMIA criteria detailed at section 3.1.3 of the DMIS, with particular reference to:

Section 1.5 (b) i)

(i) the nature and scope of each demand management project or program;

Nature and scope

This 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 is currently used extensively in high power, high voltage network applications for static VAr compensation and large energy storage applications. However at the beginning of this program there is was no low cost, commercially available equivalent for low power, low voltage or single phase systems, subsequently a semi-commercialised product has become available and will be accessed against the existing product for suitability using the knowledge Essential Energy has developed during this 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 not suited to full four quadrant grid interaction to facilitate network support.

Section 1.5 (b) ii)

(ii) the aims and expectations of each demand management project or program;

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 (see attachment A).

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.

Section 1.5 (b) iii)

(iii) the process by which each demand management project or program was selected, including the business case for the demand management project and consideration of any alternatives;

Project justification

Essential Energy has a substantial rural distribution network largely 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 (See Attachment B).

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.

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.

Section 1.5 (b) iv)

(iv) how each demand management project or program was/is to be implemented;

Project implementation

The project is broken into three 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.

2. Field trial phase

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

3. General deployment phase

Utilisation 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.

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.

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.

Section 1.5 (b) v)

(v) the implementation costs of the demand management project or program, and;

Implementation costs

Overall program costs including research, development, purchase, installation, commissioning, field testing, program management and verification of network support functionality during 2011/2012 were $728,365. The estimated costs for final refinement under the Grid Interactive program for the 2012/2013 financial year are $700,000.

Section 1.5 (b) vi)

(vi) any identifiable benefits that have arisen from the demand management project or program, including any off peak or peak demand reductions;

Identifiable benefits arising

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

The first two field trials were commenced in early 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.

Section 1.5 (c)

(c) provide an overview of developments in relation to the demand management projects or programs completed in previous years, and any results to date;

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.

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 (see attachment C). 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.

Due to delays in compatible equipment an energy storage installation on a single phase 11,000 volt feeder at Pappinbarra, near Port Macquarie, comprising a single 20 kVA inverter and a lithium battery with 40 kWh of useable energy storage scheduled for installation in early 2012 will not be installed until late 2012.

Trial sites have been nominated for assessment of energy storage, reactive support, flicker mitigation and renewables connection for 8 more 20kVA inverters which (subject to any further issues arising) will finalise the 20kVA inverter research and development and move the product into business as usual as a means of deferring network augmentation and capital expenditure.

5 kVA grid interactive inverters for use at residential level will also be ready for field trial deployment in early 2013.

Section 1.5 (d)

(d) State whether the costs associated with each demand management project or program identified in the response to paragraph 1.5(a) is:

- *recoverable under any jurisdictional incentive scheme, and if so, which scheme;*
- *recoverable under any other Commonwealth or State Government scheme, and if so, which scheme; and*
- *included in the forecast capex or forecast opex allowances or any other incentive scheme (such as the D-factor scheme for NSW) approved in the AER's 2009-14 distribution determination.*

Statement

The costs associated with the four quadrant inverter project are not:

(i) recoverable under any other jurisdictional incentive scheme, and if so, which scheme;

(ii) recoverable under any other Commonwealth or State Government scheme, and if so, which scheme; and

(iii) included in the forecast capex or forecast opex allowances or any other incentive scheme (such as the D—factor scheme for NSW) approved in the AER's 2009—14 distribution determination.

ATTACHMENT A – Potential applications for the four quadrant inverter

Voltage pacification
: Providing combinations of real and reactive power to keep voltages within a given range

Renewable Energy Facilitation
: Providing combinations of real and reactive power to counteract the quality of supply effects of intermittent renewable energy generation

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

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

Generation capacity enhancement
: Use lagging reactive power to compensate for voltage rises caused by embedded generation

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

Power factor correction
: Providing reactive power to correct power factor - minimising line currents and losses

Load and voltage balancing
: Transferring real and reactive power between phases to ensure balanced supply conditions

Conservation voltage reduction (CVR)
: Controlling voltage levels to optimise energy usage and efficiency

Loss reduction
: Managing loading patterns to optimise network current flows for loss minimisation

Energy storage (community, household, PV)
: Balancing load and generation at local level to optimise network utilisation

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

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

Peak lopping
: Provide real power at peak periods to ensure network ratings are not exceeded

Reliability improvement

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

Local load control

Potential to act as a signal generator for local control applications

Harmonic suppression

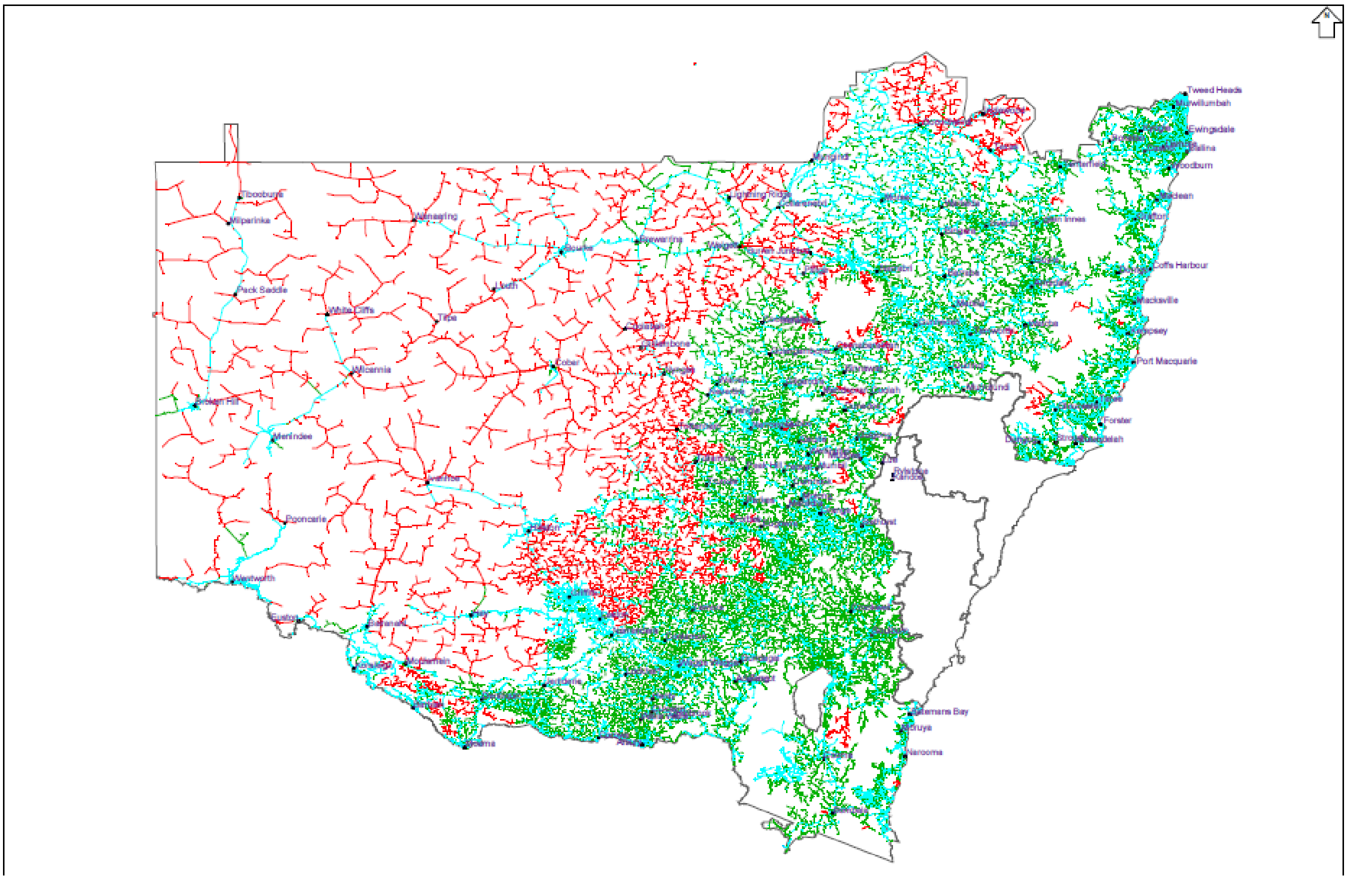
Acts as a "sink" for lower order harmonics through inductive coupling to the network

Network monitoring

Current and voltage measurement at the point of application

ATTACHMENT B – Essential Energy HV circuits

SWER – red, HV1 – green, HV3 - blue

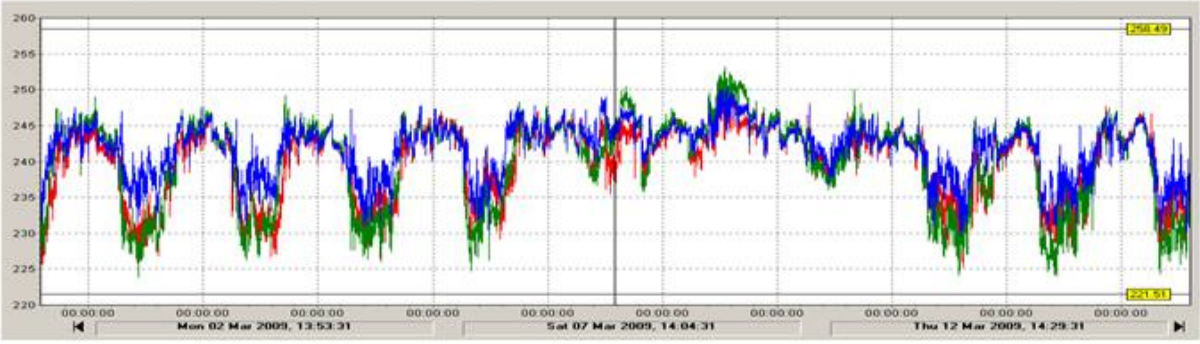


ATTACHMENT C – Proof of Concept

Influence of four quadrant inverter on voltage levels

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