Appendix 4.16: Chamber Substation SCADA Augmentation Secondary Systems Asset Renewal Program PJR

Revised regulatory proposal for the ACT electricity distribution network 2019–24

November 2018

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Glossary

Term	Definition
ACT	Australian Capital Territory
ADMS	Advanced Distribution Management System
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ASP	Asset Specific Plan
CAPEX	Capital Expenditure
DER	Distributed Energy Resources
EV	Electrical Vehicle
FLISR	Fault Location Isolation and Service Restoration
HV	High Voltage
IED	Intelligent Electronic Device
kV	Kilovolt
LV	Low Voltage
NEL	National Electricity Law
NER	National Electricity Rules
OPEX	Operational Expenditure
PJR	Project Justification Report
PoW	Program of Work
PV	Photovoltaic
RTU	Remote Terminal Unit
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SCADA	Supervisory Control and Data Acquisition

NOTE

All analysis has been undertaken using 2017-18 real dollars unless otherwise stated. Budgeted expenditure for CAPEX & OPEX excludes indirect costs.

Document Purpose

This document is a Project Justification Report. It identifies a project to meet needs and/or opportunities within the Evoenergy electrical network, and explores a number of options to carry out the project. Each of the options are analysed and assessed on the basis of regulatory requirements, risk exposure, financial viability and alignment with organisational strategies and objectives. A recommended option is presented and costed, for consideration by Evoenergy management and stakeholders.

Audience

This document is intended for internal review by Evoenergy management and staff. As part of legislative, regulatory and statutory compliance requirements, the audience of this document is extended to relevant staff of the ACT Technical Regulator and the Australian Energy Regulator.

1 Executive Summary

This Project Justification Report investigates the options to implement SCADA monitoring and control for selected chamber substations in the Evoenergy network for the 2019-24 regulatory period. This program is in alignment with the Secondary Systems Strategy and the Quality of Supply Strategy.

The primary drivers for chamber substation SCADA augmentation are as follows:

- The switchgear used in planned HV and/or LV switchboard replacement projects incorporates numerical protection and requires supporting DC auxiliary supplies. It is critical for the safe and reliable operation of the primary equipment that the protection and DC systems have remote SCADA monitoring to detect failures that would otherwise be undetectable. Potentially having primary systems in service without operable protection presents an unacceptable safety risk to staff and the public, and would degrade network reliability.
  By implementing SCADA monitoring in conjunction with planned switchgear replacement projects we can ensure fault identification for protection, DC systems and primary systems.
- Under the NER, protection fault clearance times need to operate as necessary to prevent plant damage and meet stability requirements (NER clause S5.1a.8). SCADA monitoring of protection helps to ensure it’s available to clear faults when required.
- The ACT Utilities (Management of Electricity Network Assets Code) requires ENA NENS 09 to be implemented for arc flash hazards. SCADA control was recommended in the Evoenergy Switchboard Arc Flash Hazard Pilot Study Report prepared by Powerplan Engineers in June 2018. Remote control of switchgear will eliminate arc flash hazards by replacing the need for manual switching.
- The Arc Flash Hazard Report also highlights the need to have two staff on-site during high risk manual switching for safety reasons. Remote control of switchgear will also ensure switching costs do not increase due to new procedural requirements increasing switching from a one to two staff activity.
- Monitoring of chamber substation systems will identify and raise alarms for safety issues arising from:
    - Protection relay failure
    - Protection system trips and alarms
    - Overcharged battery systems leading to thermal runaway conditions that risks fire or explosion
    - Failed battery systems which when gone unnoticed may prevent proper operation of protection equipment
    - Condition monitoring information of switchgear such as SF6 Low alarms, which can affect the safe operation and lower the reliability of equipment
    - Transformer temperature and overload condition monitoring.
- Provision of fault passage indication to ADMS for HV feeder fault detection.
- Avoidance of additional OPEX for on-call staff and field switching by enabling remote switching.
- Benefits for Asset Management and Network Planning from the provision of enhanced system and disturbance data.

The following options have been considered, with the aim to maintain the risk associated with the operation and maintenance of chamber substations at current levels. The options considered include:

- Option 0 – Do Nothing
- Option 1 – SCADA Augmentation of existing substations currently without SCADA
- Option 2 – Strategic SCADA Augmentation in conjunction with switchboard replacement programs.

Option 2 is the preferred option and is recommended for implementation over the 2019-24 period due to its lower cost of implementation and its alignment with primary asset replacement program. Option 2 has a capex requirement of **$1,500,000** and has a positive 10 year NPV of **$1,035,426**.

2 Introduction

This document outlines Evoenergy's proposed Chamber Substation SCADA Augmentation. This is a revised report and additional information has now been included to address a number of comments raised by the AER in the draft 2019-24 regulatory determination. The following summarises the AER comments.

> *Evoenergy has not justified that its proposed capex for chamber substation SCADA and distribution substation monitoring (reliability capex) is reasonably likely to reflect prudent and efficient costs. This is on the basis that Evoenergy has not demonstrated how the forecast benefits were incorporated into its overall proposal. …*
>
> *We note that Evoenergy has incentives to undertake these programs under the EBSS, CESS and STPIS due to the reduced expenditures it expects to incur elsewhere. These programs would provide Evoenergy with enhanced network capability to manage the operation and planning of the network in addition to ensuring compliance with regulations. We consider that, in the absence of evidence that Evoenergy has factored these programs into the proposal, Evoenergy could appropriately fund these programs through the respective incentive schemes.*
>
> *We are open to considering further information from Evoenergy, as part of its revised regulatory proposal, to demonstrate how it has identified the benefits of this expenditure and how it has accounted for these in its overall regulatory proposal, in particular by providing:*
>
> > *• analysis showing the counterfactual – Evoenergy's proposal on opex, augex, repex, etc. in the absence of the monitoring programs.*
> >
> > *• evidence supporting the counterfactual. For example, evidence that replacement costs would have remained around historical levels in the absence of the monitoring programs.*
>
> *In support of the projects, Evoenergy provided evidence that the presence of distributed generation (solar PV) has led to an increase in substantiated complaints from customers about high voltages. 86 Notably, Evoenergy shows that, between 2012-13 and 2016-17, the number of substantiated high voltage complaints was 20–40 per year; however, this had increased to 238 complaints in 2017-18 year-to-date.*
>
> *With regard to the increase in power quality complaints, Evoenergy has suggested this is in part due to changes in customer behaviours and improved reporting processes. Nevertheless, we accept that Evoenergy will be required to incur costs to manage voltage issues, and that these costs will increase in the future. However, we do not consider the information before us provides an accurate representation of the voltage risks that Evoenergy is currently managing on its network. We invite Evoenergy to provide information on historical expenditure that demonstrates expenditure it has incurred in managing power quality risks.*
>
> *Source: AER - Evoenergy 2019-24 - Draft decision - Attachment 5 - Capital expenditure - September 2018_0*

This revised Project Justification Report for the Chamber Substation SCADA Augmentation Program seeks to answer these comments as follows:

1. The primary benefits of the program come from ensuring chamber substations can continue to be operated safely following the replacement of old switchgear and static protection with new switchgear incorporating numerical protection. Modern protection and supporting DC systems can be subject to hidden failures that represent a risk to the primary assets, system stability, and consequential risks from fires.

   In the *Do Nothing option* (installing new switchgear with numerical protection without SCADA monitoring) the risk cost will increase from current levels. The base assumption in the Evoenergy regulatory submission is the Chamber Substation SCADA Augmentation program will be approved and no allowance has been made for an increase in risk associated with their operation and maintenance.

This program maintains the cost base and current reliability, therefore funding from the EBSS, CESS and STPIS incentive programs would not apply. Conversely, STPIS penalties may apply if the program does not proceed and reliability is adversely affected by a degradation in protection system operation.

2. In the period since the original proposal was submitted Evoenergy has carried out considerable work in the understanding of arc flash hazards and required mitigations. This work followed recent serious near miss arc flash incidents that occurred in the Evoenergy network. A Switchboard Arc Flash Hazard Pilot Study was undertaken by Powerplan Engineers, and recommended the implementation of control measure including:

    a. Detailed re-alignment or upgrading of protection schemes to systematically reduce PPE boundaries
    b. Systematic evaluation of Switchboard risks leading to upgrades and replacements
    c. Implementing and using remote switching/racking and extended operating handles whenever possible.

    The Chamber Substation SCADA Augmentation program and planned switchboard replacements are a critical part of the arc flash mitigation measures and should be implemented in a coordinated program to be effective for the safe operation of the network.

The AER draft determination stated that Evoenergy had not justified that its proposed CAPEX for Chamber Substation SCADA Augmentation reflects prudent and efficient costs. Our revised proposal outlines the avoided costs and benefits of the program as well as customer benefits.

2.1 Consumer Engagement

Evoenergy conducted a consumer workshop on 7 November 2018 looking into power quality, reliability and the case for distribution substation monitoring. Evoenergy wanted to understand how consumers considered the importance and value of our approach to distribution substation monitoring as a means to delivering better power quality and reliability to consumers. Workshop participants included Energy Consumer Reference Council (ECRC) members and Evoenergy major customers. ACT Utilities Technical Regulator representatives also observed.

Large customer representatives noted they had experienced increased voltage and power quality issues over the past 12 months. Also that they are increasingly impacted by power quality issues beyond the ACT within the national energy market e.g. frequency issues.

Consumers recognised that this proposal could also help avoid unplanned outages and the length of unplanned outages experienced by consumers.

3 Need/Opportunity

As identified in the Secondary Systems Strategy:

- All new chamber substations will be constructed with integrated SCADA and protection systems to the current Evoenergy standard.
- Existing chamber substations without SCADA will be assessed and considered for SCADA upgrades in conjunction with primary system replacement projects or customer driven upgrades (such as customer installation of medium scale PV).

SCADA for new chamber substations is included in the establishment project cost. Historically many chamber substations were implemented without SCADA. The substations constructed in the 1970s and 80s predated SCADA and incorporated electromechanical static protection systems that did not incorporate or require remote supervision. As substation switchgear is replaced by modern equivalents and/or customers install DER, SCADA implementation is required to monitor the primary assets and its supporting systems such as protection and DC systems.

The Chamber Substation SCADA Augmentation program outlined in this report is planned in conjunction with switchgear replacement projects outlined in the following documents:

- Distribution HV Switchboard Assembly - ASP – (SM 1132)
- Distribution LV Switchboard Assembly - ASP – (SM 1134)

The Quality of Supply Strategy responds to the impacts from disruptive technologies (such as PV, other DER and EVs) outlines the need for power quality and SCADA monitoring to be extended to lower parts of the network. The additional network data collected will be provided to ADMS for real-time tactical demand response and stored on a central repository and analysed to enhance network planning and asset management functions. This will permit visibility of asset utilisation, more informed decision making on network augmentation, and optimised asset maintenance. The Secondary Systems Strategy proposes a Distribution Network Monitoring Program and other initiatives to meet these needs and realise these opportunities.

Medium scale embedded generation installed in commercial buildings where chamber substations are located provide an opportunity for monitoring and SCADA control to assist with the overall strategy for dealing with disruptive technologies. The underlying Secondary Systems Strategy positions Evoenergy to provide detailed monitoring and nuanced control of the electricity network and assets, to maintain and enhance system stability in a dynamic environment. The enhanced monitoring and control of the network will ensure Evoenergy can maintain quality of supply and safety for our customers and protect the electricity network assets from fault conditions.

A targeted roll-out of SCADA augmentation for chamber substations is planned. This will involve chamber substation SCADA RTU installation for 4 to 6 per year as outlined in Appendix B. SCADA installation will target chamber substations in conjunction with HV and LV switchboard upgrade projects.

3.1 Quality of Supply

As highlighted in the Secondary Systems Strategy, there is an identified need for a targeted roll-out of network monitoring in the distribution network to areas of the network impacted by DER, in order to monitor and manage quality of supply, and to support network planning and deployment of non-network solutions.

Under the NER and ACT technical regulation, Evoenergy has the obligation to maintain and control the quality of supply through the distribution and transmission networks under its control.

Evoenergy's strategy for the distribution network addresses the expectation that 20% of the distribution substations will be impacted by DER and will require SCADA monitoring. The devices will be utilised to monitor the network conditions and parameters at the LV level of the network. All new chamber distribution substations will have SCADA capability from construction, and the program aims to implement SCADA for 4-6 existing chamber substations each year for the 2019-24 period.

3.2 Arc Flash Hazards

The ACT Utilities (Management of Electricity Network Assets Code) calls on ENA document NENS 09 (National guidelines for the selection, use and maintenance of personal protective equipment for electrical hazards) to be implemented for arc flash hazards. In other states and territories in Australia, NENS 09 is not mandatory, however it is likely that an Australian Standard for arc-flash will be released in the next two years.

An arc flash event occurs when a circuit interruption, fault or short circuit condition causes ionisation of the air in the vicinity of an arc fault. Large amounts of energy are typically released explosively, resulting in very high temperatures that can ignite combustible materials, vaporise metal conductors and parts, and cause severe burns and injuries that can result in death.

Incident energy, quantified in cal/cm^2, is used to measure and assess the severity of arc flash events. An incident energy of 1.2 cal/cm^2 will result in 2^{nd} degree burns to bare skin, and 8 cal/cm^2 will result in 3^{rd} degree burns.

The Evoenergy Switchboard Arc Flash Hazard Pilot Study Report prepared by Powerplan Engineers included a number of key recommendations including:

- A reduction in fault clearance times as a mitigation control for arc flash hazards. Numerical protection provides improved fault clearance performance when combined with SCADA monitoring.
- Providing remote operation of switchgear via SCADA as an elimination of possible arc flash from local operation of switchboards by electrical workers in the field.

The risk from arc flash was highlighted by an incident in Yallourn Power Station Victoria on 13 November 2018 where a worker suffered fatal injuries while operating a Circuit Breaker when an arc flash incident occurred.

The Arc Flash Hazard Pilot Study Report highlights the need to have *two staff* on-site during high risk manual switching for safety reasons. One staff can render assistance to the other in case of an arc flash incident. Remote control of switchgear will ensure switching costs do not increase due to new procedural requirements for additional switching staff. More importantly remote switching will eliminate the hazard as workers will not be in the vicinity of switchgear during switching operations, ensuring the safety of staff.

3.3 Overview of Existing Assets

Evoenergy has 465 chamber substations within its distribution network. They are generally located on sites of high local consumption such as data centres, hospitals, large departmental complexes and apartment complexes. As outlined in the Secondary Systems Strategy, it is Evoenergy policy that all chamber substations are to be connected to the SCADA network, with monitoring capability as a minimum. All new and upgraded chamber substations are to be provisioned as SCADA capable. In total there are currently 65 chamber substations with SCADA capability.

Since 2014, the standard design for chamber substations has included motorised HV and LV switchgear, numerical HV protection, integrated LV protection, and SCADA monitoring and control. For existing sites there is a primary assets program to upgrade the LV switchboards at a rate of 4-5 per year for the next 10 years. In addition, chamber substation HV switchboards will be upgraded at the rate of 1-2 per year for the same period. It is proposed SCADA monitoring and control be extended to chamber substations in conjunction with HV and LV switchboard upgrade projects.

Other chamber substations currently without SCADA capability will be included in the chamber substation RTU installation program on a needs/risk basis including customers with medium scale embedded generation or disruptive technologies such as on-premises EV charging stations.

The new LV/HV switchgear proposed for chamber substations is provided with monitoring and control capability. Additionally, numerical protection systems are installed along with the switchgear to detect faults and isolate supply, thereby preventing unsafe conditions and damage to equipment. Protection systems are powered by DC systems in chamber substations. A key aspect of SCADA in chamber substations is to be able to detect/attend to the minor/major alarms that the DC systems present from time to time. These timely remedial actions ensure smooth and reliable operation of protection systems which in turn ensures equipment is operated within rated capacity.

Owing to the nature of chamber substations being located indoors and attached to larger buildings such as hospitals or apartment complexes, the impact and safety implications of network faults leading to fire are serious. SCADA monitoring and control is a key part of the mitigation of this risk.

3.4 Risk Summary

The following constitute the key elements of risk based on the present state of chamber substations without SCADA monitoring and control:

- Absence of SCADA Monitoring will lead to increase in fault investigation costs and force additional asset replacements costs.
- Under-utilisation or overloading of assets due to lack of real-time data, resulting in unscheduled maintenance and unforeseen network asset augmentation.
- Unsafe operating conditions from unmonitored fault conditions in protection systems, DC systems and primary systems, resulting in explosion or fire from unmonitored fault, with to potential to spread into attached buildings/complexes.
- Risk of exposure to arc flash hazards resulting from manual switching by Switching Operators.
- Financial and contractual, not meeting customer obligations,
- Legal, compliance and Regulatory Obligations

3.5 Regulatory Requirements

Extracts from regulatory compliance documents that apply to this proposed project are listed in the following sections.

3.5.1 Reliability and Security of Supply

3.5.1.1 National Electricity Law

> **National Electricity Law Chapter 7 — National electricity objective**
>
> The objective of this Law is to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to
>
> (a) price, quality, safety, reliability and security of supply of electricity; and
>
> (b) the reliability, safety and security of the national electricity system.

3.5.1.2 National Electricity Rules

National Electricity Rules 6.5.7 Forecast capital expenditure

(a) A *building block proposal* must include the total forecast capital expenditure for the relevant *regulatory control period* which the *Distribution Network Service Provider* considers is required in order to achieve each of the following (the *capital expenditure objectives*):

(1) meet or manage the expected demand for *standard control services* over that period;

(2) comply with all applicable *regulatory obligations or requirements* associated with the provision of *standard control services*;

(3) to the extent that there is no applicable *regulatory obligation or requirement* in relation to:

(i) the quality, reliability or security of supply of *standard control services*; or

(ii) the reliability or security of the *distribution system* through the supply of *standard control services*,

to the relevant extent:

(iii) maintain the quality, reliability and security of supply of *standard control services*; and

(iv) maintain the reliability and security of the *distribution system* through the supply of *standard control services*; and

(4) maintain the safety of the *distribution system* through the supply of *standard control services*.

3.5.1.3 Utilities Act 2000 (ACT)

Evoenergy has an obligation to comply with the Utilities Act 2000 (ACT) which imposes specific technical, safety and reliability obligations.

Utilities (Management Electricity Network Assets Code) Determination 2013

The Management of Electricity Network Assets Code is a technical code under Part 5 of the *Utilities Act 2000* (the Act).

5.3 Safe Design, Construction, Operation and Maintenance

(1) An electricity distributor must design, construct, operate and maintain its aerial lines, underground lines, substations, equipment and metering with reasonable care to avoid injury to any persons or damage to property or the environment and to provide a reliable and efficient power supply.

4 Business Benefits

4.1.1 Fault Identification for protection, DC systems and primary systems

Protection systems are designed and implemented in chamber substations that protect the HV and LV. These system are DC powered, and are supplied by battery backed AC/DC chargers. Monitoring of DC supplies and battery health is an important function for consideration while installing SCADA. Monitoring to DC systems is critical for the following reasons:

- Ensure DC Supplies are active and stable so that protection systems are working and operate correctly to isolate fault conditions.
- Assists outage management functionality to minimise/optimise service restoration.
- Protection Relays provide condition monitoring capability (such as CB operating time) data which can be useful to asset managers for asset maintenance programs.

4.1.2 Benefits for System Operation

As the generation load is increasingly spread across the electricity network, there will be the opportunity for Evoenergy to act more in the role of a Distribution System Operator. As long as SCADA and communications keep in step, the advantages resulting from the increasing penetration of PV, storage batteries, EVs and other distributed generation sources connected to the electricity grid will be:

- Increased visibility of the status of energy flows within the network down to customer connection points.
- Implementation of interconnected SCADA, protection and communications systems that permit real-time network management of dynamic energy flows resulting from the expanding use of distributed energy resources.
- Ability to manage loads through control of distributed resources, enabling:
  - Peak shaving
  - Load balancing
  - Demand management over different time periods
  - Customisation of electricity supply to customers' needs
  - Continuous real-time view, enabling system control operators to make decisions on transformer and feeder loading, in the event of network re-configuration situations in planned and unplanned scenarios. The absence of monitoring would force operators to use off-line methods to determine feeder/transformer loading, which may not lead to optimal use of installed capacity.

4.1.3 Benefits for Asset Management

The current program proposes to install SCADA monitoring in existing chamber substations. This will provide data to planning and Operating Staff to allow the equipment to operate within equipment ratings and endure that overloading does not negatively shorten asset life. SCADA monitoring will assist and contribute to the following asset management objectives:

- Provide real-time and performance data to assist Asset Managers explore real-time modelling of primary assets to optimise and implement maintenance and renewal programs.
- Supports condition based maintenance of switchgear based on operation counts and accumulated fault current data.
- Primary assets need to be operated within their respective design ratings. LV switchgear is rated in line with the ratings of other assets within the substation (transformers and HV switchgear) so that no single component constrains the substation capacity. Providing

continuous real time data through SCADA will assist to operate equipment to their rated capacity.

- The utilisation of assets is driven by network demand and network configuration. Assets may be exposed to short term higher loading during contingent network configurations. Providing real time data will enhance this view to optimise utilisation in a safe way.
- One of the key drivers for HV switchboard replacement/augmentation is fault level and loading. Providing real-time SCADA data will help Asset Planning engineers to explore correct prudent options for future replacements within the network.

4.1.4 Provision of Enhanced System and Disturbance Data

The upgrading and implementation of an integrated SCADA, protection and communications network, in conjunction with the increase in embedded generation, will allow Evoenergy to implement the measurement and control technologies necessary to maintain a reliable, safe and secure electricity supply to all customers within the Evoenergy supply area.

Further advantages for the increased and detailed control of the electricity network afforded by SCADA penetration at the distribution level are:

- Real-time power quality monitoring providing the intelligence to manage impacts from disruptive technologies and permitting customer choice with energy usage, generation and storage.
- Increased safety of network during fault conditions.
- SCADA data will enable FLISR (Fault Location Isolation and Service Restoration) within the ADMS and future machine learning based on historical events.
- Provide alarm conditions such as SF6 Low Alarms, DC Supply Fail Alarms, Protection Relay Fail Alarms which will provide visibility and corrective information to on-call staff for remediation.
- Provide remote and real-time access to RTU and protection relays, to assist in fault finding in the event of system faults and outages.

4.1.5 Arc Flash Mitigation from Remote Operation of Switchgear

Installing SCADA capability in chamber substations will mitigate potential risks of arc flash hazards as the equipment can be remotely monitored and controlled, eliminating manual switching by staff.

Protection systems installed will have fast clearance times, which reduces arc flash occurrence for operational personnel. This will also result in faster restoration times, and reduces labour costs of sending additional on-call crew and electrical operating personnel to site to perform manual operations.

5 Options Assessment

Evoenergy has considered a number of options based on its Secondary Systems Strategy and Objectives.

5.1 Options

5.1.1 Option 0 – Base Case

The base case for this project is to not undertake SCADA augmentation for the existing chamber substations.

This options will not address the risks with operating systems without SCADA monitoring and lead to:

- Avoidable investigation costs of and additional asset replacements costs estimated at $379,506 over the 2019-24 period.
- Potential underutilisation or overloading of assets due to lack of real-time data, resulting in unscheduled maintenance and unforeseen network asset augmentation and customer outages.
- Unsafe operating conditions from unmonitored fault conditions in protection systems, DC systems and primary systems, resulting in explosion or fire from unmonitored fault, with to potential to spread into attached buildings/complexes.
- Unmitigated risks from arc flash hazards from manual switching by Switching Operators. Recent procedural changes for providing two man for high risk manual switching operations will resulting in an additional $267,444 in opex requirement over the 2019-24 period.

This option is not an acceptable solution.

5.1.2 Option 1 – SCADA Augmentation

Under this option, a mix of existing and new chamber substations will be targeted for SCADA implementation. Priority will be given to sites supplying important customers such as hospitals, defence establishments, etc.

Although this option will enhance the real-time monitoring and control of the network, it is not necessarily the most cost-effective alternative as installation will be performed in a brownfield scenario.

Benefits for this option include:

- Quality of supply monitoring
- Safety improvements with reduction of arc flash hazard, with remote SCADA control eliminating the need for manual operation by field staff at high risk sites
- Real-time monitoring of transformer load, with the opportunity for improved asset utilisation and demand management
- Real-time monitoring of equipment health and its associated AC/DC systems.

This option has a negative 5 year NPV of **-$177,780** and positive 10 year NPV of **$1,035,426**.

5.1.3 Option 2 – Strategic SCADA Augmentation

This option looks at timing the SCADA augmentation/implementation to align with LV/HV primary equipment replacement projects. The LV/HV replacement program as defined in the primary assets submission will be used to identify sites for SCADA augmentation.

It is proposed (in other programs) that 1 to 2 HV switchboards and 3 to 5 LV switchboards will be replaced each year in the 2019-24 period. Based on the switchboard replacement program, we propose to augment these substations with SCADA installation.

Please refer to Appendix B for the full list of chamber substations proposed for switchboard replacement and SCADA augmentation.

Benefits for this option include:

- Quality of supply monitoring for chamber substations where customers are installing medium scale embedded generation, EV charging and storage systems.
- Safety improvements with elimination of arc flash hazard. This is achieved in two ways. Firstly, assets with known arc flash issues are replaced when the HV/LV switchboards are replaced. Secondly, remote SCADA control eliminates the need for manual operation by field staff at high risk sites.
- Providing data for ADMS outage management functions.
- Real-time monitoring of transformer load, with the opportunity for improved asset utilisation and demand management.
- Opportunities to reduce the cost of SCADA implementation compared to Option 1 by reducing the number of planned network outages required and the amount of duplicated labour for installation and commissioning.
- Risk mitigation by monitoring for the following conditions:
  - Overcharging of substation DC battery systems leading to thermal runaway conditions that can cause fire and explosions.
  - Failed battery systems which when gone unnoticed will prevent operation of protection equipment.
  - Absence of condition monitoring information of new switchgear such as SF6 Low alarms, which affects the reliability of the equipment.

This option has a positive a 5 year NPV of **$91,738** and positive 10 year NPV of **$1,304,944**.

5.1.4 Options Evaluation

Option	Description	Capex Cost	10 Year NPV	Outcome
0	Base Case	Baseline	Baseline	Not selected as does not meet requirements. Benefits and costs for the NPV analysis of options 1 and 2 are calculated relative to the baseline counterfactual established by option 0.
1	SCADA Augmentation	$1,733,096	$1,035,426	Not selected due to higher implementation costs and does not meet some business and SCADA strategic objectives. Increases cost per site by 10-15% compared to Option 2.
2	Strategic SCADA Augmentation	$1,500,000	$1,304,944	Selected due to adherence to secondary systems strategy. Reduced cost of implementation and additional benefits. Highest NPV and lower capex requirement.

Table 1: Summary of Options

Chamber Substation SCADA Augmentation		Option 1	Option 2
Costs			
Capital		1,445,115	1,295,983
Operating		12,555	13,216
Benefits			
Fault Identification for protection, DC systems and primary systems	Lower fault finding costs	670	705
	Avoid additional outages	676,217	711,792
	Avoid additional asset replacements	316,445	322,982
Improved maximum demand and asset utilisation information	Delay augmentation costs	0	0
	Reduce augmentation costs	59,098	62,207
Prevent damage and system outages	reduce unscheduled maintenance	40,176	42,290
Safety of network during fault conditions	Mitigates unsafe network conditions	502,204	528,624
	Mitigates against damage from fault conditions which could lead to fire and damage to assets and buildings	251,102	264,312
Improved outage management in conjunction with ADMS	Reduce customer outage time	56,802	59,791
	Reduces labour and fuel costs for on-call crew	6,830	7,189
Remote operation of switchgear	Mitigates risk of arc flash hazards	96,916	102,015
	Avoidance of additional costs with two staff manual switching (arc flash mitigation that would otherwise need to be implemented)	486,635	512,236
Summary			
Net Present Costs		1,457,670	1,309,198
Net Present Benefits		2,493,096	2,614,142
Net Present Value		1,035,426	1,304,944

Table 2: NPC and NPV Summary of Options (10 Year NPV)

A scoring matrix approach is used to assess the advantages, disadvantages, risks and benefits of each of the options. Each option is given an overall score, based on the scoring criteria detailed in Table 3.

Criteria	Criteria and Weighting
Cost	*Accuracy of the cost estimate prepared for the project. 30% weighting.*
Project Objective	*The extent to which the proposed solution meets the requirements of the project. 20% weighting.*
Schedule	*The risk associated with meeting the required project completion date. 20% weighting.*
Risks	*The extent to which the proposed project provides mitigation/controls to risks identified. 20% weighting.*
Benefits	*The extent to which the proposed project meets the immediate scope requirements and the associated business benefits identified in this document. 10% weighting.*

Table 3: Scoring Matrix Criteria

	Criteria					
	Cost	Project Objective	Schedule	Risks	Benefits	Overall Score
Criteria Weighting	30%	20%	20%	20%	10%	100%
Option 1 – SCADA Augmentation	1	2	2	2	2	**57%**
Option 2 – Strategic SCADA Augmentation	2	3	2	3	2	**80%**

Scoring Key			
0	Fatal flaw	1	Unattractive
2	Acceptable	3	Attractive

Table 4: Scoring Matrix

The scoring matrix shows that Options 1 and 2 both meet the project need through SCADA augmentation, with Option 2 being the more attractive option.

Option 1 is not the preferred option for the following reasons:

- It involves a higher cost of implementing the SCADA than Option 2. Efficiencies from aligning SCADA augmentation with planned switchgear replacement would not be realised.
- It involves hardwiring to existing installations and running inter-panel cabling. This is more difficult in existing substations, and would involve potential outage to the customer or use of temporary generator supply.
- Greater engineering time and effort is required to engineer modifications to existing switchgear.
- Additional labour is required to update drawings and documentation for hardwired solutions, compared with numerical protection solutions when combined with HV/LV switchboard replacement (Option 2).
- When LV/HV switchboards are upgraded with numerical protection at a later stage as part of primary asset replacement, additional costs would be incurred to integrate with SCADA. The additional cost incurred is in the order of 10% to 15% per site above Option 2.
- It will increase the number of planned network outages required and the amount of duplicated labour for installation and commissioning.

5.2 Recommendation

Option 2 has been determined as the preferred option and is recommended for implementation. It has a positive 10 year NPV of **$1,035,426** and has the lowest capex requirement of **$1,500,000**.

Appendix A Financial Analysis

A.1 Option 1 10 Year Analysis

Chamber Substation SCADA Augmentation												
Year		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**Present Value**
Annual Installations		4.6	4.6	4.6	4.6	4.6	0	0	0	0	0	
Total Installed		4.6	9.2	13.8	18.4	23	23	23	23	23	23	
Costs												
Capital		346,619	346,619	346,619	346,619	346,619	0	0	0	0	0	1,445,115
Operating		460	920	1,380	1,840	2,300	2,300	2,300	2,300	2,300	2,300	12,555
Benefits												
Fault Identification for protection, DC systems and primary systems	Lower fault finding costs	25	49	74	98	123	123	123	123	123	123	670
	Avoid additional outages	24,776	49,551	74,327	99,102	123,878	123,878	123,878	123,878	123,878	123,878	676,217
	Avoid additional asset replacements	75,901	75,901	75,901	75,901	75,901	0	0	0	0	0	316,445
Improved maximum demand and asset utilisation information	Delay augmentation costs	0	0	0	0	0	0	0	0	0	0	0
	Reduce augmentation costs	2,165	4,331	6,496	8,661	10,826	10,826	10,826	10,826	10,826	10,826	59,098
Prevent damage and system outages	reduce unscheduled maintenance	1,472	2,944	4,416	5,888	7,360	7,360	7,360	7,360	7,360	7,360	40,176
Safety of network during fault conditions	Mitigates unsafe network conditions	18,400	36,800	55,200	73,600	92,000	92,000	92,000	92,000	92,000	92,000	502,204
	Mitigates against damage from fault conditions which could lead to fire and damage to assets and buildings	9,200	18,400	27,600	36,800	46,000	46,000	46,000	46,000	46,000	46,000	251,102
Improved outage management in conjunction with ADMS	Reduce customer outage time	2,081	4,162	6,243	8,325	10,406	10,406	10,406	10,406	10,406	10,406	56,802
	Reduces labour and fuel costs for on-call crew	250	500	751	1,001	1,251	1,251	1,251	1,251	1,251	1,251	6,830
Remote operation of switchgear	Mitigates risk of arc flash hazards	3,551	7,102	10,653	14,204	17,754	17,754	17,754	17,754	17,754	17,754	96,916
	Avoidance of additional costs with two staff manual switching (arc flash mitigation that would otherwise need to be implemented)	17,830	35,659	53,489	71,318	89,148	89,148	89,148	89,148	89,148	89,148	486,635
Summary												
Costs		347,079	347,539	347,999	348,459	348,919	2,300	2,300	2,300	2,300	2,300	1,457,670
Benefits		155,651	235,400	315,149	394,898	474,648	398,746	398,746	398,746	398,746	398,746	2,493,096
Net		-191,429	-112,139	-32,850	46,439	125,728	396,446	396,446	396,446	396,446	396,446	1,035,426

Table 5: Option 1 10 Year Analysis

A.2 Option 2 10 Year Analysis

Chamber Substation SCADA Augmentation												
Year		**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**Present Value**
Annual Installations		5	6	5	6	1	0	0	0	0	0	
Total Installed		5	11	16	22	23	23	23	23	23	23	
Costs												
Capital		500,000	327,273	281,818	336,364	54,545	0	0	0	0	0	1,295,983
Operating		500	1,100	1,600	2,200	2,300	2,300	2,300	2,300	2,300	2,300	13,216
Benefits												
Fault Identification for protection, DC systems and primary systems	Lower fault finding costs	27	59	85	117	123	123	123	123	123	123	705
	Avoid additional outages	26,930	59,246	86,176	118,492	123,878	123,878	123,878	123,878	123,878	123,878	711,792
	Avoid additional asset replacements	82,501	99,002	82,501	99,002	16,500	0	0	0	0	0	322,982
Improved maximum demand and asset utilisation information	Delay augmentation costs	0	0	0	0	0	0	0	0	0	0	0
	Reduce augmentation costs	2,354	5,178	7,531	10,356	10,826	10,826	10,826	10,826	10,826	10,826	62,207
Prevent damage and system outages	reduce unscheduled maintenance	1,600	3,520	5,120	7,040	7,360	7,360	7,360	7,360	7,360	7,360	42,290
Safety of network during fault conditions	Mitigates unsafe network conditions	20,000	44,000	64,000	88,000	92,000	92,000	92,000	92,000	92,000	92,000	528,624
	Mitigates against damage from fault conditions which could lead to fire and damage to assets and buildings	10,000	22,000	32,000	44,000	46,000	46,000	46,000	46,000	46,000	46,000	264,312
Improved outage management in conjunction with ADMS	Reduce customer outage time	2,262	4,977	7,239	9,953	10,406	10,406	10,406	10,406	10,406	10,406	59,791
	Reduces labour and fuel costs for on-call crew	272	598	870	1,197	1,251	1,251	1,251	1,251	1,251	1,251	7,189
Remote operation of switchgear	Mitigates risk of arc flash hazards	3,860	8,491	12,351	16,982	17,754	17,754	17,754	17,754	17,754	17,754	102,015
	Avoidance of additional costs with two staff manual switching (arc flash mitigation that would otherwise need to be implemented)	19,380	42,636	62,016	85,272	89,148	89,148	89,148	89,148	89,148	89,148	512,236
Summary												
Costs		500,500	328,373	283,418	338,564	56,845	2,300	2,300	2,300	2,300	2,300	1,309,198
Benefits		169,185	289,706	359,890	480,411	415,247	398,746	398,746	398,746	398,746	398,746	2,614,142
Net		-331,315	-38,667	76,472	141,847	358,402	396,446	396,446	396,446	396,446	396,446	1,304,944

Table 6: Option 2 10 Year Analysis

Appendix B Costing of Proposed Chamber Substations

Table 7 provides a list and costing estimates of proposed chamber substations for SCADA augmentation (in alignment with primary HV/LV switchboard replacement as specified in Option 2).

Asset Type / Substation Number	Financial Year					Comments
	19/20	20/21	21/22	22/23	23/24	
[redacted]						
[redacted]	$81,818					3 transformer sub
[redacted]		$54,545				
[redacted]				$54,545		
[redacted]			$54,545			
[redacted]						
[redacted]	$54,545					
[redacted]				$54,545		
[redacted]			$54,545			
[redacted]	$218,182					8 transformer sub
[redacted]			$54,545			
[redacted]	$63,636		$63,636	$63,636		7 transformer sub
[redacted]					$54,545	
[redacted]		$54,545				
[redacted]				$54,545		
[redacted]			$54,545			
[redacted]		$54,545				
[redacted]				$54,545		
[redacted]		$54,545				
[redacted]		$54,545				
[redacted]	$81,818					3 transformer sub
[redacted]		$54,545				
[redacted]				$54,545		
TOTAL:	**$500,000**	**$327,273**	**$281,818**	**$336,364**	**$54,545**	

Table 7: Proposed List of Sites for SCADA augmentation with HV/LV Switchboard Replacement