Northern South Australia Region Voltage Control

RIT-T: Project Specification Consultation Report

August 2016

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Executive Summary

Alinta Energy announced in June 2015 that it intended to retire the Northern Power Station (NPS) and operation of NPS ceased on 9 May 2016.

NPS provided transmission network voltage support in the Upper North, Mid North and the Eyre Peninsula regions of South Australia and its closure is expected to create significant challenges for transmission network voltage control in these regions.

Since the 2015 announcement by Alinta Energy, ElectraNet has identified potential network adequacy and security limitations resulting from the withdrawal of NPS. These studies, and a review of past operational experience, have revealed three types of limitation expected to occur under certain credible demand and generation scenarios – as summarised in the table below.[1]

These three limitations, together, comprise the identified need for this RIT-T.

Limitation	Description	Illustrative number of times relevant conditions are met
Insufficient reactive power margin (Schedule 5.1.8 of the NER)	At times of high 275 kV customer demand drawn from Davenport, moderate to high system demand, and low wind generation in the Mid North region, reactive power reserve margins may not be met at the Davenport 275 kV connection point.	38 times/year
Voltage collapse (Section 4.2.6 Schedule 5.1.8 of the NER)	When operating in certain N-1[2] conditions, the system would be at risk of voltage collapse for the loss of a second critical 275 kV line. Further, during system normal conditions (ie, all network elements in-service), switching a 50 Mvar reactor into service at Davenport at times of low wind generation in the Mid North of South Australia may cause a voltage collapse.	N-1 conditions expected for 216 hours per year (on average) During N-1 conditions, unplanned loss of a second critical 275 kV line is expected to occur at a rate of 1.47 faults/year
Over-voltage (Schedule 5.1a.4 and Figure S5.1a.1 of the NER)	Operating the Davenport 275 kV connection point voltage above 1.05 pu (which occurs for the majority of the time to mitigate against the risk of voltage collapse for 275 kV customers supplied by Davenport) is expected to result in over-voltage at times of low wind generation in the Mid North for the loss of the 275 kV customer demand drawn from Davenport at times of low system demand.	296 times/year (note that this assumes that the Para reactor or one of the Para SVCs is out of service) Most severe at times of minimum demand (currently 800 MW)

1 These limitations are also discussed in: AEMO and ElectraNet, *Update to Renewable Energy Integration in South Australia*, Joint AEMO and ElectraNet report, February 2016, p. 35.

2 The system is considered to be operating in an N-1 condition if any one network element (eg, a critical 275 kV line) is out of service.

ElectraNet uses its best endeavours to plan, develop and operate the transmission network to meet the standards imposed by the NER in relation to the quality of transmission services such that there will be no requirements to shed load to achieve these standards under normal and reasonably foreseeable operating conditions[3].

While the ETC is silent on the timeframe within which ElectraNet must meet a required standard in the event of a significant generation withdrawal, such as the closure of NPS, clause 2.11 of the ETC deals with changes in forecast agreed maximum demand and requires ElectraNet to meet the required standard within three years of the identified future breach date. ElectraNet has discussed the intent of this clause with ESCOSA and confirmed that this period should also apply in the context of the NPS closure, ie, that ElectraNet must address the identified need within three years of Alinta Energy's closure of NPS (by 9 May 2019).

ElectraNet has identified five credible options that it considers may address the identified need. A summary of these five options is provided in the table below.

Option	Indicative capital cost	Indicative O&M cost	Construction timetable; commissioning date
Option 1: Install 2x ±50-100 Mvar SVCs at Davenport	$30-50m	2% of capital cost	1-2 years; can be delivered by 9 May 2019
Option 2: Install 2x ±50-100 Mvar STATCOMs at Davenport	$30-50m	2% of capital cost	1-2 years; can be delivered by 9 May 2019
Option 3: Install small modular STATCOMs and switched capacitors at Davenport	$20-40m	2% of capital cost	1-2 years; can be delivered by 9 May 2019
Option 4: Install synchronous condensers at Davenport	$50-100m	>2% of capital cost	1-2 years; can be delivered by 9 May 2019
Option 5: Convert the existing NPS generators to synchronous condensers	Not practicable to provide at this stage	Not practicable to provide at this stage	Not practicable to provide at this stage Should there be a proponent for this option, it is expected that it can be delivered by 9 May 2019

Each of the five credible options is expected to be both technically and commercially feasible and able to be implemented in sufficient time to meet the identified need.

In order to protect the network from potential voltage collapse prior to when a credible option can be commissioned, ElectraNet put in place an interim under-voltage load shedding scheme in April 2016. ElectraNet also intends to implement a control scheme to perform automatic switching of the three 275 kV reactors at Davenport during 2016.

[3] In accordance with the quality of supply and system reliability service standards specified in the South Australian Electricity Transmission Code (ETC).

However, these measures are only considered to be interim measures because they rely on shedding load under reasonably foreseeable operating conditions, which is inconsistent with clause 2.1.1 of the South Australian Electricity Transmission Code. Therefore, they cannot be considered to meet the identified need on an ongoing basis.

ElectraNet notes that NPS has had periods of reduced operations previously, but that these were during times when wider operating conditions did not result in an unmanageable reactive power margin at the Davenport 275 kV connection point, voltage collapse or overvoltage.

ElectraNet expects that future operating conditions will increase the risk of these limitations occurring; ie, load drawn from the Davenport to Olympic Dam 275 kV transmission line is expected to increase and minimum system demand is expected to fall with the increasing penetration of solar PV in South Australia. ElectraNet therefore considers that the permanent closure of NPS, as opposed to the previous temporary shutdown of NPS, necessitates this RIT-T.

While this RIT-T is being undertaken as a reliability corrective action, ElectraNet notes that there are a number of important wider market benefits that may be generated in addressing the immediate reliability concerns. These market benefits include:

- improving frequency management in South Australia;
- mitigating against reducing fault levels in South Australia; and
- reducing constraints on Eyre Peninsula wind farms due to increased voltage limitations in this region.

These market benefits are intended to be estimated as part of the Project Assessment Draft Report (PADR) analysis for each credible option assessed.

ElectraNet welcomes written submissions on this PSCR, which are due on or before Friday, 4 November 2016. Submissions are particularly sought on the credible options presented and other non-network options.

A PADR, including full option analysis, is expected to be published by the end of February 2016.

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Glossary of Terms

Term	Description
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ETC	Electricity Transmission Code
NPV	Net Present Value
NER	National Electricity Rules
NPS	Northern Power Station
PACR	Project Assessment Conclusions Report
PADR	Project Assessment Draft Report
PSCR	Project Specification Consultation Report
RET	Renewable Energy Target
RIT-T	Regulatory Investment Test for Transmission
Rules	National Electricity Rules
TNSP	Transmission Network Service Provider
USE	Unserved Energy
VCR	Value of Customer Reliability

1. Introduction

This Project Specification Consultation Report (PSCR) has been prepared by ElectraNet in accordance with the requirements of the National Electricity Rules (NER) clause 5.16.4. It represents the first stage of the formal consultation process set out in the NER in relation to the application of the Regulatory Investment Test - Transmission (RIT-T).

In particular, this PSCR:

- describes the identified need which ElectraNet is seeking to address, together with the assumptions used in identifying this need;
- sets out the technical characteristics that a non-network option would be required to deliver in order to address this identified need;
- describes the credible options that ElectraNet currently considers may address the identified need; and
- discusses specific categories of market benefit which in the case of this RIT-T assessment are unlikely to be material.

Appendices to this PSCR provide further information in relation to the assumptions adopted for the RIT-T assessment and the results of the assessment.

1.1 Submissions and next steps

ElectraNet welcomes written submissions on this PSCR, which are due on or before Friday, 4 November 2016. Submissions are particularly sought on the credible options presented and other non-network options.

Submissions should be emailed to consultation@electranet.com.au. Submissions will be published on the ElectraNet website. If you do not wish your submission to be made publicly available please clearly specify this at the time of lodging your submission.

A PADR, including full option analysis, is expected to be published by end of February 2016.

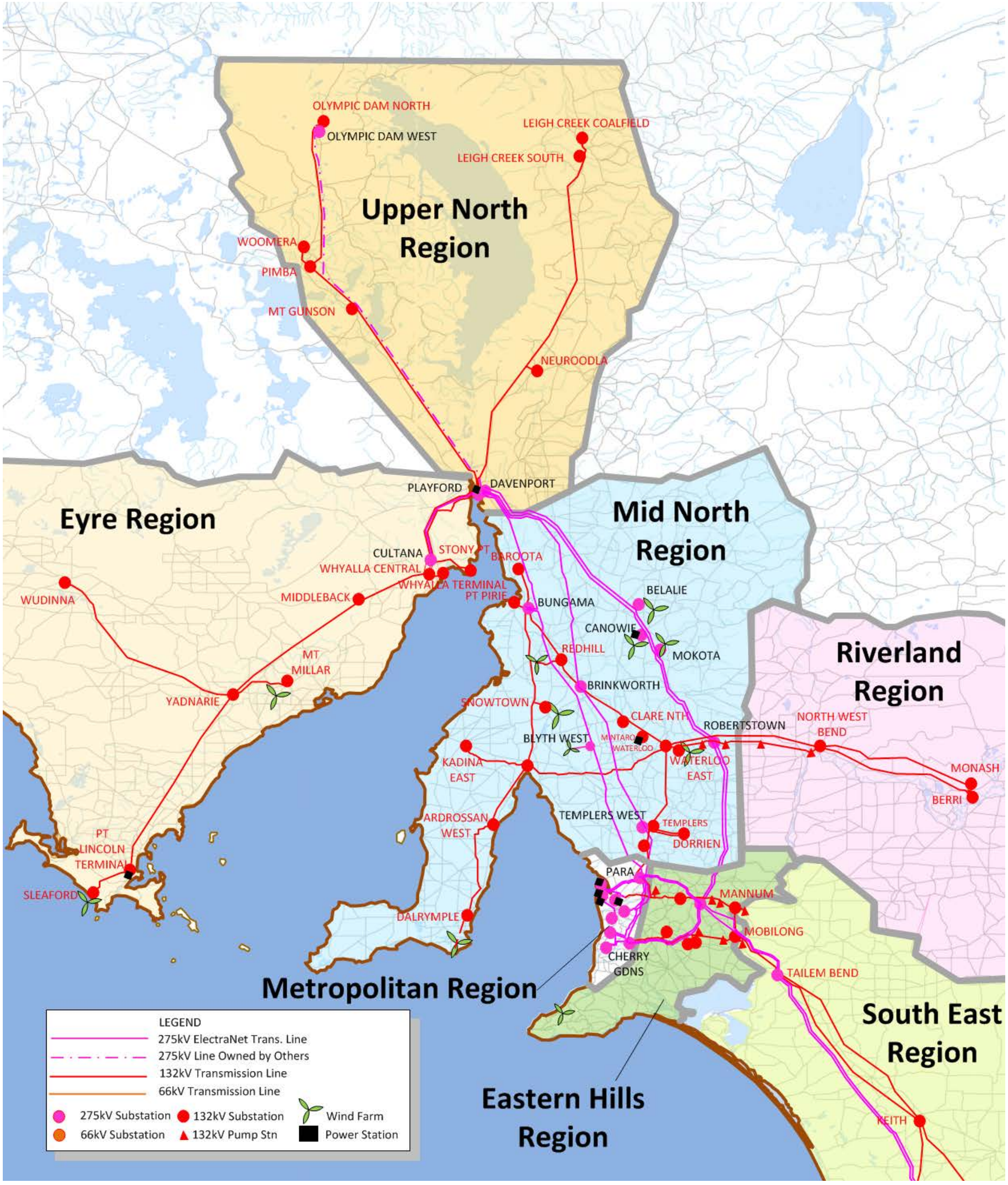
2. Background

This section provides background information on the regions affected by the closure of NPS. Specifically, it outlines the existing Upper North region, as well as the Mid North and Eyre Peninsula transmission networks. It also discusses relevant committed network developments and existing and potential generation.

2.1 Existing networks

Figure 1 presents a geographical diagram showing the Upper North region, the Mid North region and the Eyre Peninsula region – with the Davenport substation in the southern part of the Upper North region, essentially at the junction of the three regions.

Figure 1: Geographical Diagram showing the existing network



The Upper North transmission network comprises a network that supplies major mining loads at BHP Billiton's Olympic Dam and OZ Minerals' Prominent Hill, as well as townships at Leigh Creek, Roxby Downs and Woomera. It also supplies a mix of agricultural, industrial, rural, urban and commercial loads in the area. It derives its supply from the Main Grid 275 kV transmission system via a 275/132 kV Davenport substation (near Port Augusta), which also supplies the region's major commercial centre.

The Upper North 132 kV network comprises two radial 132 kV lines that run from Davenport to Leigh Creek and Woomera respectively. These lines supply a number of intermediate sites along their routes and provide connection to several regional communities. In addition to the two 132 kV radial lines, there is a privately owned Pimba - Olympic Dam 132 kV line and also a privately owned Davenport to Olympic Dam 275 kV transmission line.

A 275 kV connection point was provided at Davenport in 1998 to facilitate expansion of mining operations at Olympic Dam. A privately owned 275 kV transmission line and 275/132 kV substation was constructed at Olympic Dam as part of this expansion. The 275 kV system also supplies the Roxby Downs community, located 10 km to the South of the Olympic Dam mine. In 2008 the Prominent Hill mine was also commissioned, drawing additional load from the Olympic Dam system under a negotiated arrangement between BHP Billiton and OZ Minerals.

The Mid North 132 kV sub-transmission system comprises a network that supplies major load centres at Ardrossan, Brinkworth, Clare, Kadina and Port Pirie, as well as the Barossa Valley and Yorke Peninsula regions. It derives its supply from the Main Grid 275 kV system via 275/132 kV substations located at Para (near Elizabeth), Templers West, Robertstown, Brinkworth and Bungama (near Port Pirie). There is also a connection to the 132 kV Eastern Hills sub-transmission system at Para, and to the 132 kV Riverland sub-transmission system at Robertstown.

The Mid North 132 kV system operates in parallel with the 275 kV Main Grid system that historically connected the major sources of coal-fired generation at Port Augusta with the Adelaide metropolitan load centre. The 132 kV and 275 kV networks between Adelaide and Davenport now host significant wind farm generator connections. As a consequence, power flows in the Mid North 132 kV system are not only determined by the loads that must be supplied within the region but also by flows on the Port Augusta to Adelaide 275 kV system.

The Eyre Peninsula supply area is the area southwest of Port Augusta. The Eyre Peninsula region of South Australia contains a mixture of electrical loads including agricultural, light and heavy industrial, rural, urban and commercial. The Eyre Peninsula 132 kV transmission network is characterised by long radial lines and is supplied from the Main Grid 275 kV transmission network via the 275/132 kV substation at Cultana (approximately 15 km north west of Whyalla). The major industrial centre of Whyalla is supplied from Cultana by 132 kV lines, which are operated in parallel. The remainder of the Eyre Peninsula is supplied from Cultana by radial 132 kV lines, with most of the load being supplied by the single long Cultana to Yadnarie 132 kV line. At Yadnarie, multiple radial 132 kV supply lines supply the main connection points at Wudinna and Port Lincoln.

The Eyre Peninsula region's electricity is partly derived from local wind resources and distillate fired gas turbines, with the rest being provided from generation in other regions and interstate. There are currently two wind farms located on the Eyre Peninsula, ie, Cathedral Rocks south of Port Lincoln near Sleaford (supplying 66 MW) and at Mt Millar near Cowell (supplying 70 MW) – both of these are depicted in Figure 1 above.

2.2 Committed network developments and existing generation

ElectraNet has a number of committed network projects in the Upper North, Mid North and Eyre Peninsula regions scheduled for completion in 2016 – namely:

- the Dalrymple substation upgrade project will address unrelated supply reliability requirements in the Mid North; and
- the creation of a connection point at Mount Lock to connect Hornsdale wind farm on the Davenport to Canowie 275 kV line, which will provide some voltage support to the Northern region at times when the wind farm is operating.

These projects are summarised in Table 1 below.

Table 1: Committed projects relevant to this RIT-T

Connection Point	Scope of Work	Timing
Dalrymple Substation	Install 2nd 25 MVA 132/33 kV Transformer	Nov 2016
Mount Lock	Establish 275 kV connection point on the Davenport to Canowie 275 kV line for Hornsdale wind farm	Mid 2016

In addition, a new 50 Mvar 275 kV switched reactor entered service at Para on 29 May 2016. The reactor will increase the range of the Para Static Var Compensators (SVCs) that is available to respond to system disturbances, improving the ability to dynamically control voltage levels in the Adelaide and Northern regions of the 275 kV transmission network. ElectraNet has factored the effect that the installation of a 50 Mvar 275 kV switched reactor at Para and the creation of a connection point at Mount Lock will have on voltage levels into its identification of the need for this RIT-T.

ElectraNet currently has no other committed projects in the Upper North, Mid North region or Eyre Peninsula region that will affect this RIT-T assessment.

In the Eyre Peninsula region, ElectraNet has assessed that significant lengths of conductor on the Whyalla to Yadnarie and the Yadnarie to Port Lincoln 132 kV lines are in poor condition and need to be replaced. Preliminary assessment shows that building new double circuit 132 kV lines from Cultana to Yadnarie and from Yadnarie to Port Lincoln could produce net market benefits.

In January 2013, ElectraNet published a PADR as the second stage of a RIT-T consultation on options for reinforcement of the Eyre Peninsula transmission network. At that time, it was considered that the commitment of new spot loads (eg, mining loads) in the region would determine the nature and timing of any future network reinforcement needed.

In addressing the poor conductor condition, ElectraNet would also consider the future needs of potential new mining loads on the Eyre Peninsula in the scenario analysis, which may show that there is value in building new double-circuit lines that are capable of operation at 275 kV. As the Eyre Peninsula identified need now differs significantly from the identified need previously consulted on, ElectraNet intends to commence a new Eyre Peninsula RIT-T consultation later in 2016.

ElectraNet will consider the potential impact that developments on the Eyre Peninsula may have on the scope and sizing of the credible options to address the need to improve voltage control in the northern region of South Australia.

There are currently no anticipated network developments in the other regions that will affect this RIT-T assessment.

There is no existing, grid-connected generation in the Upper North region and all load is served from other regions in South Australia and the rest of the National Electricity Market.

Existing generation on the Mid North 132 kV network includes a mixture of gas turbine plant and wind farms. The 90 MW Mintaro open cycle gas turbine (OCGT) is connected to the 132 kV system while the OCGTs at Hallett power station (total 220 MW) are connected to the 275 kV Main Grid. There is also a 50 MW distillate fired generator embedded in the SA Power Networks' 33 kV distribution network at Angaston.

There are a number existing wind farms operating in the Mid North, which are widely scattered throughout the region and connected to both the 132 kV and 275 kV networks, as outlined in the table below.

Table 2: Existing wind farms operating in the Mid North region

Mid North 275 kV Main Grid	Mid North 132 kV system
• Brown Hill (94.5 MW) • Hallett Hill (71.4 MW) • North Brown Hill (132.3 MW) • Snowtown Stage 2 (270 MW) • The Bluff (52.5 MW) • Hornsdale Stage 1 (100 MW, connected mid 2016)	• Wattle Point (90.8 MW, near Edithburgh on the Yorke Peninsula) • Snowtown 1 (98.7 MW) • Clements Gap (56.7 MW, south of Port Pirie) • Waterloo 1 (111.0 MW, east of the Waterloo area)

The Eyre Peninsula region's electricity is partly derived from local wind resources and distillate fired gas turbines, with the rest being provided from generation in other regions and interstate. The local wind farms are at Cathedral Rocks south of Port Lincoln (supplying 66 MW), and at Mt Millar near Cowell (supplying 70 MW).

ElectraNet has undertaken a range of system studies to identify potential network adequacy and security limitations resulting from the withdrawal of NPS. These studies, and a review of past operational experience, have revealed that constraints on the Cathedral Rocks and Mount Millar wind farms will become more onerous following the closure of NPS, due to increased voltage limitations in the Eyre Peninsula region. ElectraNet intends to include the market benefit of easing the constraints on these wind farms that arises from addressing the identified need as part of the PADR analysis.

There is currently interest from proponents in a number of potential generation developments in the Upper North region, including large-scale solar thermal generation at Port Augusta.[4] ElectraNet will consider all of the latest available information in conducting this RIT-T process.

[4] For example, see http://reneweconomy.com.au/2016/hewsons-solastor-promises-worlds-cheapest-247-solar-power-86282

3. Identified Need

The sections outlines the assumptions used in assessing the identified need and why ElectraNet considers reliability corrective action is necessary.[5] It also specifies the technical characteristics of the identified need that a non-network option would be required to deliver.[6]

3.1 Description of the identified need

Alinta Energy announced in June 2015[7] that it intended to retire NPS and operation of NPS subsequently ceased on 9 May 2016.[8]

NPS inherently performed an important transmission network voltage control service at the Davenport 275 kV substation in the Upper North, Mid North and Eyre Peninsula regions of South Australia. ElectraNet analysis shows that the withdrawal of NPS will create challenges for transmission network voltage control on the 275 kV Main Grid and in the Upper North, Mid North and the Eyre Peninsula regions of South Australia.

Specifically, the table below outlines the three potential network adequacy and security limitations resulting from the withdrawal of NPS that have been identified as part of system studies undertaken by ElectraNet and a review of past operational experience. ElectraNet considers that these three concerns together constitute the identified need for this RIT-T.

NPS has had periods of reduced operations previously[9], but these were during times when wider operating conditions did not result in an unmanageable reactive power margin at the Davenport 275 kV connection point, voltage collapse or overvoltage.

ElectraNet expects that future operating conditions will increase the risk of these limitations occurring, ie, load drawn from the Davenport to Olympic Dam 275 kV transmission line is expected to increase and minimum system demand is expected to fall with the increasing penetration of solar PV in South Australia. ElectraNet therefore considers that permanent closure of NPS, as opposed to the temporary shutdown of NPS, necessitates this RIT-T.

5 As required by NER clause 5.16.4(b)(2).

6 As required by NER clause 5.16.4(b)(3).

7 Alinta Energy news announcement on 11 June 2015, available at: https://alintaenergy.com.au/about-us/news/flinders-operations-announcement

8 Alinta Energy news announcement on 9 May 2016, available at https://alintaenergy.com.au/about-us/news/augusta-power-station-ceases-generation

9 For example, in April 2012, Alinta Energy announced that both Northern and Playford Power Stations would (for a transitional period) only operate from October to March – see: Alinta website, available at: https://alintaenergy.com.au/about-us/news/northern-power-station-to-operate-through-winter.

Table 3: Summary of the identified need

Component of the identified need	Overview	Illustrative number of times relevant conditions are met
Insufficient reactive power margin (Schedule 5.1.8 of the NER)	At times of high demand drawn from the Davenport to Olympic Dam 275 kV transmission line, moderate to high system demand, and low wind generation in the Mid North region, reactive power reserve margins may not be met at the Davenport 275 kV connection point.	38 times/year
Voltage collapse (Section 4.2.6 Schedule 5.1.8 of the NER)	When operating in certain N-1[10] conditions, the system would be at risk of voltage collapse for the loss of a second critical 275 kV line. Further, during system normal conditions (ie, all network elements in-service), switching a 50 Mvar reactor into service at Davenport at times of low wind generation in the Mid North of South Australia may cause a voltage collapse.	N-1 conditions expected for 216 hours per year (on average) During N-1 conditions, unplanned loss of a second critical 275 kV line is expected to occur at a rate of 1.47 faults/year
Over-voltage (Schedule 5.1a.4 and Figure S5.1a.1 of the NER)	Operating the Davenport 275 kV connection point voltage above 1.05 pu (which occurs for the majority of the time to mitigate against the risk of voltage collapse for load supplied by the Davenport to Olympic Dam 275 kV transmission line) is expected to result in over-voltage at times of low wind generation in the Mid North for the loss of the load drawn from the Davenport to Olympic Dam 275 kV transmission line at times of low demand.	296 times/year (note that this assumes that the Para reactor or one of the Para SVCs is out of service) Most severe at times of minimum demand (currently 800 MW)

ElectraNet is required to comply with quality of supply and system reliability service standards specified in the South Australian Electricity Transmission Code (ETC), which include using its best endeavours to plan, develop and operate the transmission network to meet the standards imposed by the National Electricity Rules in relation to the quality of transmission services such that there will be no requirements to shed load to achieve these standards under normal and reasonably foreseeable operating conditions.

While the ETC is silent on the timeframe within which ElectraNet must meet a required standard in the event of a significant generation withdrawal, such as the closure of NPS, clause 2.11 of the ETC deals with changes in forecast agreed maximum demand and requires ElectraNet to meet the required standard within 3 years of the identified future breach date. ElectraNet has discussed the intent of this clause with ESCOSA and confirmed that this period should also apply in the context of the NPS closure, ie, that ElectraNet must address the identified need within 3 years of Alinta Energy's closure of NPS (by 9 May 2019).

As outlined in section 4.7.1 below, ElectraNet has put in place a number of measures to protect the network from potential voltage collapse prior to when a credible option can be

10 The system is considered to be operating in an N-1 condition if any one network element (eg, a critical 275 kV line) is out of service.

commissioned. However, as outlined in section 4.7.1, these measures are only considered to be interim measures and do not meet the identified need on an ongoing basis.

While this RIT-T is being undertaken as a reliability corrective action, there are a number of important wider market benefits that may be generated in addressing the immediate reliability concerns. These market benefits include improving frequency management related issues[11], mitigation against reducing fault levels[12] and reducing constraints on Eyre Peninsula wind farms[13]. It is intended that these market benefits will be estimated as part of the PADR analysis for each credible option assessed.

3.2 NER requirements

This section presents a summary of the NER requirements that ElectraNet is required to meet and how these are unlikely to be met at all times following closure of NPS. As noted above, the identified need can be broken down into three separate concerns, namely:

- insufficient reactive power margin at the Davenport 275 kV connection point;
- voltage collapse under certain operating conditions; and
- over-voltage during period of low wind generation.

Section 3.3 below sets out the assumptions ElectraNet has made in relation to each of these three concerns.

3.2.1 Insufficient reactive power margin

The voltage control criterion, as defined in Schedule 5.1.8 of the NER, requires a minimum level of reactive power reserve margin at connection points following the most severe credible contingency event. At Davenport, the NER reactive power reserve margin requirements correspond to a minimum reactive power margin of 30 Mvar after the closure of NPS.

System studies have identified a risk of voltage collapse for loss of the Davenport to Mount Lock 275 kV line due to an inability to provide at least 30 Mvar reactive power margin at Davenport. This is expected to occur when three independent conditions are simultaneously met – namely:

- Total South Australian system demand equal to or greater than approximately 2,000 MW.
- Total generation from wind farms in the Mid North region of South Australia less than 22% of nameplate capability.
- Total load drawn from the Davenport to Olympic Dam 275 kV transmission line above 174 MW.

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[11] Such as rapid change of frequency, large frequency deviations and FCAS requirements. For a greater discussion of these frequency management issues, please see: AEMO and ElectraNet, *Update to Renewable Energy Integration in South Australia*, Joint AEMO and ElectraNet report, February 2016.

[12] AEMO and ElectraNet, *Update to Renewable Energy Integration in South Australia*, Joint AEMO and ElectraNet report, February 2016, p. 38.

[13] ElectraNet's system studies have found that the combined output of the two Eyre Peninsula wind farms is reduced by 20 MW (by way of an intra-regional generation dispatch limit) when NPS is not in service. See: AEMO and ElectraNet, *Update to Renewable Energy Integration in South Australia*, Joint AEMO and ElectraNet report, February 2016, p. 35.

In particular, ElectraNet considers that the voltage control criterion, as defined in Schedule 5.1.8 of the NER, will be breached if all three of the above conditions are simultaneously met. Over the course of 2015, these conditions were simultaneously met 38 times.

3.2.2 Voltage collapse

Following any contingency event, AEMO must adjust operating conditions to return to a secure operating state within thirty minutes, as per section 4.2.6 of the NER. This includes meeting the voltage control criterion defined in Schedule 5.1.8 of the NER.

Davenport is currently connected to the Adelaide region of South Australia by four 275 kV lines. These lines consist of 15 line segments and have a total route length of 1,228 km.

If any one of these line segments is out of service for either a planned or unplanned outage (referred to as an 'N-1 condition'), an outage of a second line segment could, under certain operating conditions, cause voltage levels to collapse on the Davenport to Olympic Dam 275 kV transmission line. This condition would be likely to spread throughout the northern part of the South Australian transmission system and result in widespread line outages and interruption to supply.

The under-voltage load shedding scheme at Davenport that has been installed as one of the interim measures will eliminate the risk of voltage collapse spreading throughout the transmission system, albeit not on an ongoing basis (as outlined in section 4.7.1 and Appendix C). Specifically, this scheme will disconnect supply to the Davenport to Olympic Dam 275 kV line at Davenport if low voltage levels begin to develop at Davenport, thus shedding all of the demand that would have been supplied by that line to Olympic Dam, Prominent Hill and the Roxby Downs community. However, as noted in section 4.7.1, this scheme is not considered to provide sufficient support on an enduring basis.

The risk of voltage collapse is a function of both overall system demand and local wind farm generation – for example:

- during times of low system demand levels (800 MW) and a relevant N-1 condition, the risk of voltage collapse following a second critical contingency would exist if wind farm generation output in the Mid North is below 30% of nameplate capacity; while
- during times of high levels of system demand (3,200 MW) and a relevant N-1 condition, no level of wind generation output in the Mid North is able to address the risk of voltage collapse following a second critical contingency.

This indicative assessment is based on 2015 data, for which with Mid North wind generation output was below 30% of nameplate capacity for nearly half of the year.

3.2.3 Over-voltages

ElectraNet has three 275 kV 50 Mvar reactors installed at Davenport substation. At times of low system demand, voltage levels often increase on the 275 kV network. At such times, the reactors at Davenport are switched into service, to prevent voltage levels from exceeding the capability of equipment.

ElectraNet has performed studies that indicate that at times of high load drawn from the Davenport to Olympic Dam 275 kV line, switching in a 275 kV reactor at Davenport could initiate voltage collapse in the network supplied from the Davenport to Olympic Dam 275 kV line. There is a risk that this could prevent Davenport reactors from being switched in service at times when they would be needed to guard against high network voltage levels following the loss of a large single load. In particular, based on the range of system studies undertaken, ElectraNet considers that there is a risk of voltage levels exceeding limits described in Schedule 5.1a.4 and Figure S5.1a.1 of the NER following full rejection of load drawn from the Davenport to Olympic Dam 275 kV transmission line.

Specifically, based on the existing configuration of the transmission network, high voltage levels (more than 10% above nominal equipment voltage) could occur at the Davenport 275 kV bus following an unplanned outage of the Davenport to Olympic Dam 275 kV line. This potential high voltage condition only occurs at times of low levels of wind generation in the Mid North of South Australia that are concurrent with times of medium to low South Australian system demand. Over the course of 2015, such low wind generation conditions were met 296 times (however, not all of these times coincided with times of low system demand).

A new 50 Mvar 275 kV switched reactor entered service at Para on 29 May 2016. This reactor will avoid the risk of high voltage levels following an unplanned outage of the Davenport to Olympic Dam 275 kV line, when all other transmission network equipment is in service. However, at times when either the new 50 Mvar reactor or one of the SVCs at Para is unavailable, an unplanned outage of the Davenport to Olympic Dam 275 kV line could result in high voltage levels at the Davenport 275 kV bus. This would only occur if the total level of wind generation output in the Mid North of South Australia was less than 8% of its nameplate capacity, which occurs approximately 20% of the time.

ElectraNet notes that restoration of the Davenport to Olympic Dam 275 kV line following an outage may cause extremely high voltage levels at Davenport and Olympic Dam if it occurs during times of low system demand.

3.3 Assumptions made in relation to the identified need

This section describes the assumptions underpinning ElectraNet's assessment of the identified need.[14] As part of the network studies undertaken to identify the need for reliability corrective action, assumptions were made regarding:

- system demand;
- load drawn from the Davenport to Olympic Dam 275 kV transmission line; and
- generation in the Mid North region (and, in particular, wind generation).

The three components of the identified need are all sensitive to these underlying assumptions.

ElectraNet has investigated a range of South Australian system demand levels between 800 MW and 3,200 MW, consistent with the forecasts of minimum and maximum state-wide demand produced by AEMO in its 2015 National Electricity Forecast Report (NEFR).[15]

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[14] In accordance with NER clause 5.16.4(b)(2).

[15] The 2015 AEMO National Electricity Forecast Report is available at: http://www.aemo.com.au/Electricity/Planning/Forecasting/National-Electricity-Forecasting-Report

ElectraNet is required under the NER to prepare a PADR within 12 months after submissions close on a PSCR if they wish to proceed with a RIT-T.[16] For this particular RIT-T, ElectraNet intends to prepare the PADR as soon as practicable after submissions close on the PSCR. ElectraNet expects that the AEMO NEFR 2016 will be published in June 2016 and notes that it will update its load forecast assumptions as part of the PADR analysis to ensure they are consistent with the AEMO NEFR 2016.

The three components of the identified need are affected differently by the level of assumed South Australian demand. Specifically, the overvoltage concerns are expected to worsen if minimum demand decreases, while the reactive power and voltage collapse concerns are expected to worsen if maximum demand increases.

ElectraNet has assumed that maximum demand supplied at the Davenport end of the Olympic Dam 275 kV line is 186 MW. This line provides supply to BHP Billiton's operations at Olympic Dam, OZ Minerals' operations at Prominent Hill and the town of Roxby Downs. ElectraNet has consequently made assumptions regarding the distribution of load within and between these sites, which are currently being reviewed in conjunction with BHP Billiton and OZ Minerals.

The maximum demand supplied at the Davenport end of the Olympic Dam 275 kV line may increase at some point in the future. Specifically, BHP Billiton may well expand its operations at Olympic Dam,[17] which would likely substantially increase load drawn from the Davenport to Olympic Dam 275 kV line.[18] In addition, OZ Minerals has announced[19] plans to continue with its proposed Carrapateena copper gold mine project, which would also add to maximum demand supplied from the Davenport – Mt Gunson 132 kV line by an estimated 50-55 MW.[20]

ElectraNet is coordinating with both BHP Billiton and OZ Minerals to ensure that forecast maximum demands for major customers in the Upper North are as accurate as practicable and anticipates that these projects will be included in reasonable scenarios for the PADR analysis.

In addition, ElectraNet notes the possibility of Iron Road requesting connection to the Eyre Peninsula network in the future, particularly if global iron ore prices increase, which would increase the maximum demand supplied on this network. For example, as part of the RIT-T for the Lower Eyre Peninsula Reinforcement, Iron Road submitted forecasts for its Central Eyre Iron Project of 340 MW expected load, comprised of: loads in Yadnarie area

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16 As required by NER clause 5.16.4(j).

17 For example, see: The Wall Street Journal, *BHP Billiton Digs In at Vast Australian Copper Mine*, Hoyle, R., 26 May 2016, available at: http://www.wsj.com/articles/bhp-billiton-digs-in-at-vast-australian-copper-mine-1464271445; and The Australian, *BHP says Olympic Dam expansion is 'game on'*, Murdoch, S., 12 June 2015, available at: http://www.theaustralian.com.au/business/mining-energy/bhp-says-olympic-dam-expansion-is-game-on/news-story/a365b6e375acc22566257f3c89522170

18 By way of an example, in its 2009 Draft Environmental Impact Statement for the Olympic Dam Expansion, BHP Billiton estimated that the mine's electrical demand would increase over time, ultimately requiring an additional 650 MW and consuming an additional 4,400 GWh annually – see: BHP Billiton, Olympic Dam Expansion Draft *Environmental Impact Statement 2009*, p. 26. ElectraNet notes that any future proposal for demand increase may differ significantly from the 2009 proposal.

19 ABC News, *OZ Minerals flags 400 new jobs in 'cautious' Carrapateena project announcement*, 26 February 2016, available at: http://www.abc.net.au/news/2016-02-26/oz-minerals-touts-jobs-in-cautious-carrapateena-announcement/7202502

20 OZ Minerals, *Carrapateena Update – May 2016 Presentation*, 6 May 2016, page 12, available at: http://www.ozminerals.com/media/presentations-speeches/.

(Port and Verran Booster Pump Station) of 50 MW and load at the Warramboo mine site of 290 MW.[21] ElectraNet notes that the need for improved voltage control at Davenport will be increased should this project go ahead.

In its assessment, ElectraNet has assumed that all existing 275 kV-connected wind farms in the Mid North region of South Australia are operating and that all gas turbine units in the Mid North of South Australia are not dispatched. ElectraNet has also assumed that the first 100 MW stage of the Hornsdale wind farm is operating as it is committed to connect in mid-2016.

For assessment of reactive power margins, ElectraNet has assumed the following voltage dependency of load before transformer on load tap changers can respond:

- Olympic Dam and Prominent Hill – active and reactive power are assumed to be independent of changes in voltage; and
- balance of South Australian demand – active power is assumed to be independent of changes in voltage, while reactive power is assumed to vary linearly with changes in voltage.

ElectraNet has requested that BHP Billiton provide increased details concerning the response of their active and reactive power demand to changes in voltage.

3.4 Required technical characteristics of non-network options

This section describes the technical characteristics that a non-network option would be required to deliver in order to address the identified need.[22]

The NER require a PSCR to include suggestions, such as:[23]

- the size of load reduction or additional supply;
- the location; and
- operating profile.

However, specifying the technical characteristics that non-network options would need to exhibit is difficult in the case of voltage control, since the exact characteristics are dependent on a range of unrelated factors. Specifically, in the case of voltage control in the northern region of South Australia, the required technical characteristics of non-network options depend on:

- system demand in South Australia;
- high demands in the Upper North, Mid North and Eyre regions; and
- generation in the Mid North region (and, in particular, wind generation).

It is therefore difficult to specify the exact technical characteristics required of non-network options, such as the size of load reduction or additional supply, the location and the required operating profile.

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21 ElectraNet, *Lower Eyre Peninsula Reinforcement RIT-T*, Project Assessment Draft Report, January 2013, p. 22.

22 In accordance with NER clause 5.16.4(b)(3).

23 NER clause 5.16.4(b)(3).

We have however outlined what variables drive each of the three different components of the identified need (ie, insufficient reactive power margin at the Davenport 275 kV connection point, voltage collapse and over-voltage), what a non-network option should be able to provide and have provided an indicative assessment of when such an option must be available.

In addition, non-network options would generally need to provide 50-100 Mvar of capacitive dynamic reactive power support, ie, in line with that being provided by the credible options outlined in section 4. This reactive support is required to have a very high availability level, which is typically achieved by installing redundant plant or over-subscription of an aggregated response.

ElectraNet encourages parties to make contact (via written submissions or otherwise) regarding the potential of non-network options to satisfy, or contribute to satisfying, the identified need outlined above.

3.4.1 Ability of non-network options to meet the insufficient reactive power margin

As outlined above, the need for a network support service to be available and/or dispatched is dependent on three variables:

- total South Australian system demand equal to or greater than approximately 2,000 MW.
- total generation from wind farms in the Mid North region of South Australia less than 22% of nameplate capability.
- total load drawn from the Davenport to Olympic Dam 275 kV transmission line above 174 MW.

Any non-network option must be made available for dispatch if:

- any two of the above conditions are met; and
- the third condition could be met within the next 30 min (based on historic fluctuations).

The non-network option must then be dispatched within 5 minutes if all three of the conditions are met.

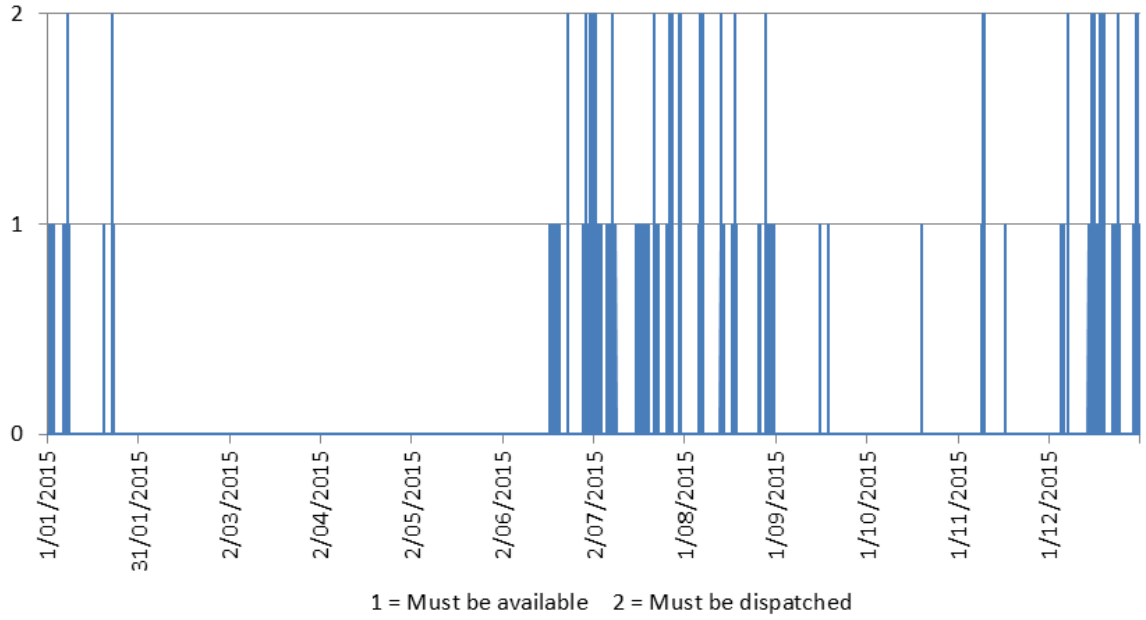
Based on observed system conditions during the 2015 calendar year, any non-network option would have needed to be available and dispatched as per the following table.

Table 4: Indicative requirements for a network support service to meet the reactive power margin, based on 2015 system conditions

Network support requirement	No. of occurrences in 2015	Total hours during 2015	Longest single event in 2015	Average duration of event in 2015
Available	70 times	207 hours	13 hours	2 hours
Dispatched	38 times	63 hours	9.5 hours	2 hours

An illustrative graph of the times when the support arrangement would have needed to be available/ dispatched during the 2015 calendar year is shown below.

Figure 2: Illustrative availability and dispatch requirements of network support services to meet the reactive power margin, based on 2015 system conditions



The required availability and dispatch frequency and duration could be significantly increased if there is a future increase in load drawn from the Davenport to Olympic Dam 275 kV transmission line, or if the amount of time during which South Australian system demand exceeds 2,000 MW increases. Conversely, the required availability and dispatch could decrease if more wind farms or other generators connect in the northern region of South Australia. The specific impact would be determined by the location and characteristics of any such demand increases or new generation connections.

3.4.2 Ability of non-network options to prevent voltage collapse

As noted in section 3.2.2 above, the risk of voltage collapse is a function of both overall system demand and local wind farm generation – for example:

- during times of low system demand levels (800 MW) and a relevant N-1 condition, the risk of voltage collapse following a second critical contingency would exist if wind farm generation output in the Mid North is below 30% of nameplate capacity; while
- during times of high levels of system demand (3,200 MW) and a relevant N-1 condition, no level of wind generation output in the Mid North is able to address the risk of voltage collapse following a second critical contingency.

Please note that this indicative assessment is based on 2015 data and that, during 2015, Mid North wind generation output was below 30% of nameplate capacity for nearly half of the year.

The under-voltage load shedding scheme at Davenport (outlined in section 4.7.1 and Appendix C) that has been installed as one of the interim measures will eliminate the risk of voltage collapse spreading throughout the transmission system. Specifically, this scheme will disconnect supply to the Davenport to Olympic Dam 275 kV line at Davenport if low voltage levels begin to develop, thus shedding all of the demand that would have been supplied by that line at Olympic Dam, Prominent Hill and Roxby Downs.

However, as noted in section 4.7.1, this scheme does not meet all the requirements of the ETC and so cannot be considered a permanent solution.

To avoid the need to guard against system voltage collapse by disconnecting supply to load drawn from the Davenport to Olympic Dam 275 kV transmission line, network support would be required at or near Davenport.

Approximately 50-100 Mvar of dynamic capacitive reactive power support (ie, able to be dispatched to the required level within a <1 sec timeframe) would need to be available whenever a single 275 kV line segment between Davenport and the Adelaide region was out of service, on a planned or unplanned basis. ElectraNet note that the support required will rise if it is to be provided on a distributed-basis.

ElectraNet further considers that active power support connected near Davenport may help to reduce the quantum of dynamic reactive power support required, but is unlikely to provide sufficient support on its own.

The following table provides an indication of the expected frequency and duration of both planned and unplanned outages on the relevant lines.

Table 5: Indicative frequency and duration of both planned and unplanned outages on the relevant lines

Unplanned outage rate	Total unplanned outage rate	Unplanned outage duration	Total unplanned outage duration	Planned outage duration	Total planned outage duration
0.12 faults per 100 km overhead line per year	1.47 faults per year	13.06 hours per fault	19.25 hours per year	14.40 hours per line segment per year	216 hours per year

Source: The reliability data presented above is based on long-term typical statistics for 275 kV lines in the ElectraNet network – see: AEMO, Review of the South Australian Electricity Transmission Code Reliability Standards, May 2015, available at: http://www.escosa.sa.gov.au/library/20150924-Elec-ReviewSATransmissionCodeExitPoints-AEMO-Report.pdf

The required availability and dispatch could be significantly increased if there is a future increase in the load drawn from the Davenport to Olympic Dam 275 kV line. Conversely, the required availability and dispatch could decrease if more wind farms or other generators connect in the northern region of South Australia. The specific impact would be determined by the location and characteristics of any such demand increases or new generation connections.

As noted above, voltage collapse concerns are expected to worsen if assumed South Australian maximum demand increases. The requirements for a non-network option may therefore become more onerous if state-wide maximum demand forecasts increase in the 2016 NEFR.

3.4.3 Ability of non-network options to prevent over-voltages

As outlined above, based on the existing configuration of the transmission network, high voltage levels (more than 10% above nominal equipment voltage) could occur at the Davenport 275 kV bus following an unplanned outage of the Davenport to Olympic Dam 275 kV line. This potential high voltage condition only occurs at times of low levels of wind generation in the Mid North of South Australia and is more severe at times of low South Australian system demand. ElectraNet notes that such outages are expected to be infrequent in nature but of potentially long duration when they do occur.

A new 50 Mvar 275 kV switched reactor entered service at Para on 29 May 2016. The reactor will avoid the risk of high voltage levels following an unplanned outage of the Davenport to Olympic Dam 275 kV line, when all other transmission network equipment is in service. However, at times when either the new 50 Mvar reactor or one of the SVCs at Para is unavailable, an unplanned outage of the Davenport to Olympic Dam 275 kV line could result in high voltage levels at the Davenport 275 kV bus. This would only occur if the total level of wind generation output in the Mid North of South Australia was less than 8% of its nameplate capacity, which occurs approximately 20% of the time.

ElectraNet considers that a non-network option would need to be available for dispatch within 30 minutes when:

- the total wind generation in the Mid North region of South Australia could reduce to below 8% of nameplate capacity within the next 30 minutes (based on observed historic fluctuations); and
- either the 50 Mvar 275 kV reactor or one of the Para SVCs is out of service.

ElectraNet notes that the last condition is expected to occur only rarely, although any outages could be for an extended period.

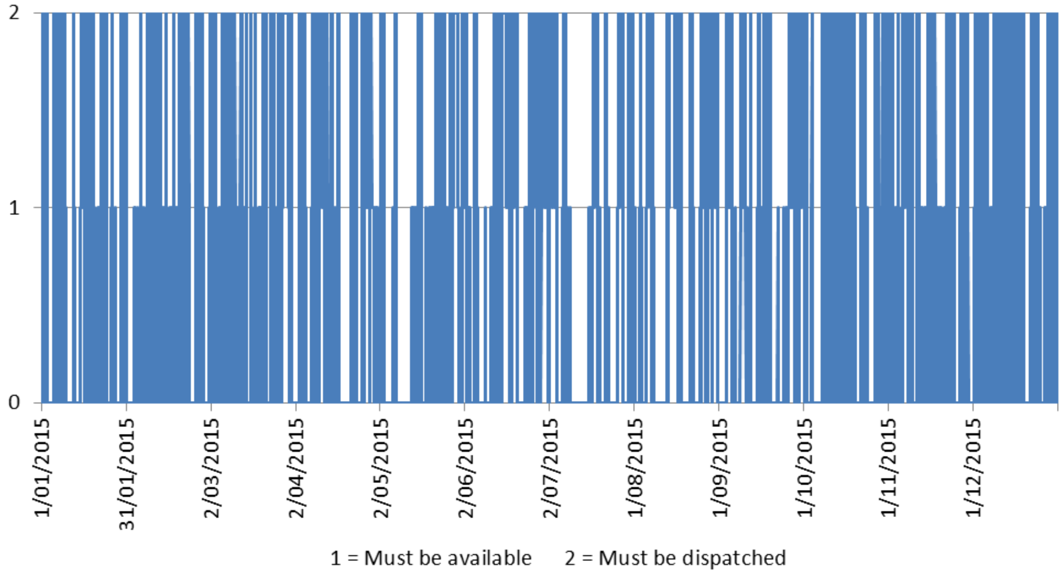
Based on observed system conditions during the 2015 calendar year, any non-network option would have needed to be available and dispatched as per the following table. ElectraNet notes that the figures in the table below assume that the Para reactor or one of the Para SVCs is out of service.

Table 6: Indicative requirements for a network support service to avoid potential over-voltage, based on 2015 system conditions (assuming the Para reactor or one of the Para SVCs is out of service)

Network support requirement	No. of occurrences in 2015	Total hours during 2015	Longest single event in 2015	Average duration of event in 2015
Available	340 times	3,797 hours	81.5 hours	11.5 hours
Dispatched	296 times	1,708 hours	51 hours	6 hours

An illustrative graph of the times when the non-network arrangement would have needed to be available/dispatched during the 2015 calendar year is shown below. As noted above, the figure below assumes that the Para reactor or one of the Para SVCs is out of service.

Figure 3: Illustrative availability and dispatch requirements of network support services to avoid potential over-voltage, based on 2015 system conditions (assuming the Para reactor or one of the Para SVCs is out of service)



ElectraNet notes that this indicative analysis is based on the level of wind generation only. The non-network option would only need to be available/dispatched if the low wind condition coincided with an outage of one of the critical pieces of reactive plant, eg, the Para reactor or one of the Para SVCs.

The required availability and dispatch could be significantly increased if there is a future increase in the load drawn from the Davenport to Olympic Dam 275 kV line. Conversely, the required availability and dispatch could decrease if more wind farms connect in the northern region of South Australia. The impact would be influenced by the location and characteristics of any such demand increases or new generation connections.

In addition, as noted above, ElectraNet considers that the over-voltage concerns are expected to worsen if assumed South Australian minimum demand decreases, as has been forecast in the 2016 NEFR.

3.5 Requirement to apply the RIT-T

ElectraNet is required to apply the RIT-T to this investment, as none of the exemptions listed in NER clause 5.16.3(a) apply.

ElectraNet has classified this project as a reliability corrective action because the existing network will not be able to provide the required level of reliability under the NER.

The network options discussed in section 4 have not been foreshadowed in AEMO's 2015 National Transmission Network Development Plan (NTNDP) as these options do not play a part in the main transmission flow paths between the NEM regions.

However, the proposed network options, in conjunction with the recently installed 50 Mvar 275 kV reactor at Para, will address the identified emerging NSCAS gap for absorbing reactive power capability at times of minimum system demand that was identified in section 5.1 of the 2015 NTNDP.

4. Potential credible options to address the Identified Need

This section provides a description of the five credible options ElectraNet has identified as part of the PSCR.[24] A summary of these five options is provided in the table below.

Table 7 Summary of potential credible options

Option	Indicative capital cost	Indicative O&M cost	Construction timetable; commissioning date
Option 1: Install 2x ±50-100 Mvar SVCs at Davenport	$30-50m	2% of capital cost	1-2 years; can be delivered by 9 May 2019
Option 2: Install 2x ±50-100 Mvar STATCOMs at Davenport	$30-50m	2% of capital cost	1-2 years; can be delivered by 9 May 2019
Option 3: Install small modular STATCOMs and switched capacitors at Davenport	$20-40m	2% of capital cost	1-2 years; can be delivered by 9 May 2019
Option 4: Install new synchronous condensers at Davenport	$50-100m	More than 2% of capital cost	1-2 years; can be delivered by 9 May 2019
Option 5: Convert the existing NPS generators to synchronous condensers	Not practicable to provide at this stage	Not practicable to provide at this stage	Not practicable to provide at this stage Should there be a proponent for this option, it is expected that it can be delivered by 9 May 2019

Each of the five credible options is expected to be both technically and commercially feasible and able to be implemented in sufficient time to meet the identified need.[25] ElectraNet has put in place a number of interim measures to ensure the identified need is met between when the NPS was closed and when a credible option can be commissioned (as outlined in section 4.7.1 below).

The five credible options each provide dynamic reactive support for the northern region of South Australia.

The amount of dynamic capacitive (positive) reactive support is likely to be set by the need to avoid voltage collapse due to the occurrence of a second critical contingency when already operating in a relevant N-1 condition as described in sections 3.2.2 and 3.4.2.

ElectraNet's studies indicate that 50 Mvar of capacitive reactive support is needed to address this aspect of the identified need for existing levels of system and major customer demand, and will also meet the identified need to increase reactive power reserve margin. The requirement for dynamic capacitive reactive support is expected to increase for any future increases in system demand or in the demand drawn from the Davenport to Olympic Dam 275 kV line.

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[24] As required by NER clause 5.16.4(b)(5).

[25] In accordance with the requirements of NER clause 5.15.2(a).

The amount of dynamic inductive (negative) reactive support will be set by the need to avoid overvoltage under conditions as describes in sections 3.2.3 and 3.4.3. ElectraNet's studies indicate that 50 Mvar of inductive reactive support is needed to address that aspect of the identified need for existing levels of minimum system demand and maximum demand drawn from the Davenport to Olympic Dam 275 kV line. The requirement for dynamic inductive reactive support is likely to increase for any future decreases in system minimum demand or for any increases in demand drawn from the Davenport to Olympic Dam 275 kV line.

The actual range of dynamic reactive support required from each credible option is expected to vary slightly, based on the differing technical characteristics of each option. Detailed analysis of the technical requirements and resulting cost for each option will be performed before publication of the Project Assessment Draft Report.

All of the five presented credible options consist of equipment that may at times require lengthy outages for maintenance or refurbishment. ElectraNet therefore considers that good electricity industry practice requires that each option should include sufficient redundancy to enable the identified need to be met whilst allowing for a lengthy outage of any one item of plant.

This section also discusses the other options considered by ElectraNet, and the reasons why these are not considered to be credible options for the purpose of this RIT-T assessment.

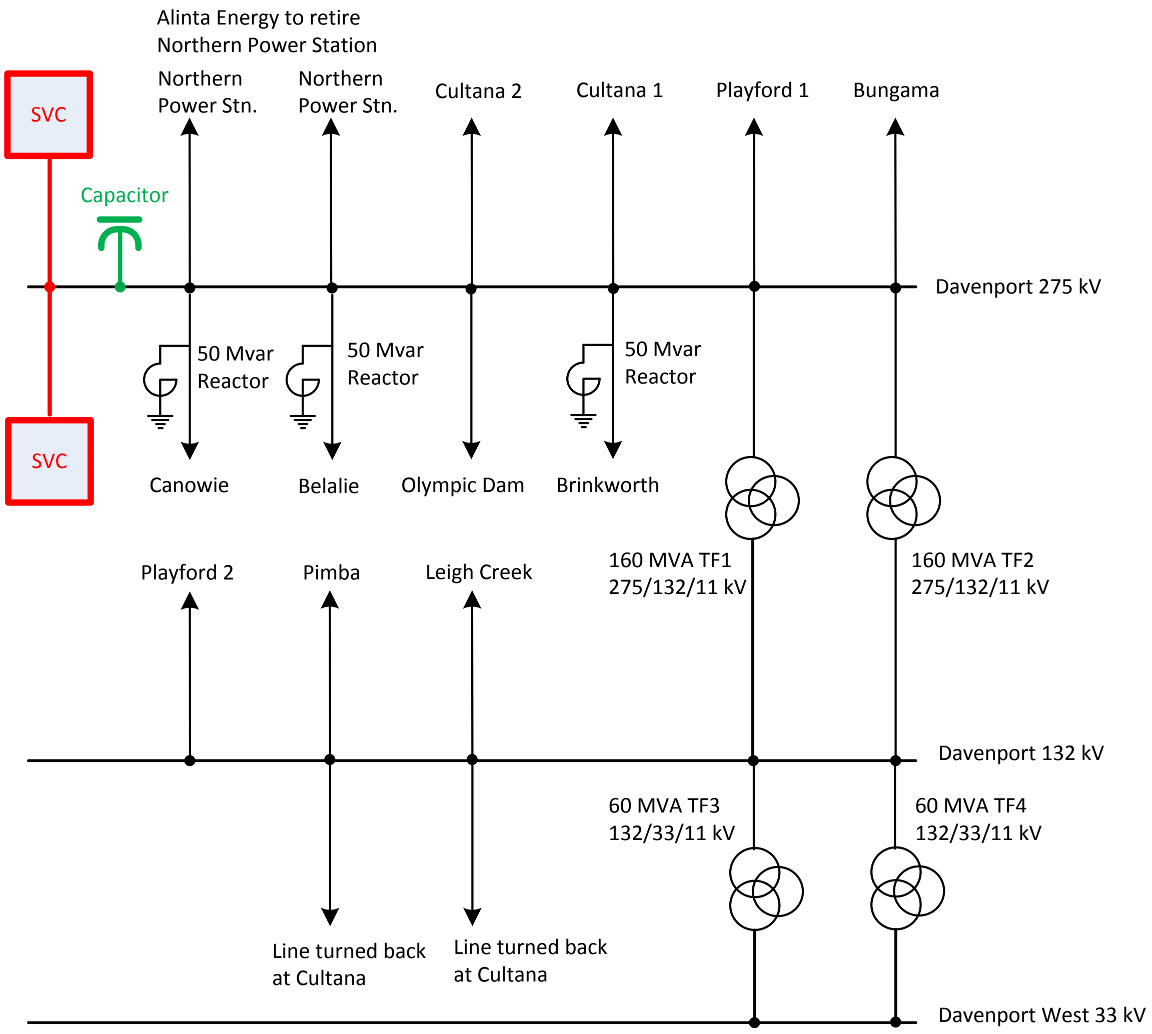
4.1 Option 1: Install two ±50-100 Mvar SVCs at Davenport

Option 1 is to install two ±50-100 Mvar SVCs at the Davenport substation.

SVCs are a power electronics device that consist of one or more thyristor switched capacitors with a thyristor controlled reactor. The positive and negative dynamic reactive capabilities of an SVC can be asymmetrical, which can provide some opportunity for cost saving. SVC capability increases and decreases with the square of the operating voltage level. For example, a reduction in the operating system voltage to 90% would reduce SVC capability to 81%. This may increase the size of reactive support required for this option to meet the identified need compared to the other credible options.

Figure 4 below presents an electrical representation of the Davenport substation with these two SVCs included. Existing assets are shown in black, augmented assets are shown in red and possible future extensions are shown in green.

Figure 4: Davenport substation configuration under Option 1



Capital costs for this option are estimated to be between $30-50 million. The scope and estimate are currently being refined and will be updated in the PADR. Annual operating and maintenance costs are estimated to be about 2% of the capital cost.

ElectraNet estimates that the construction timetable for Option 1 is approximately 1-2 years, with commissioning possible by 9 May 2019.

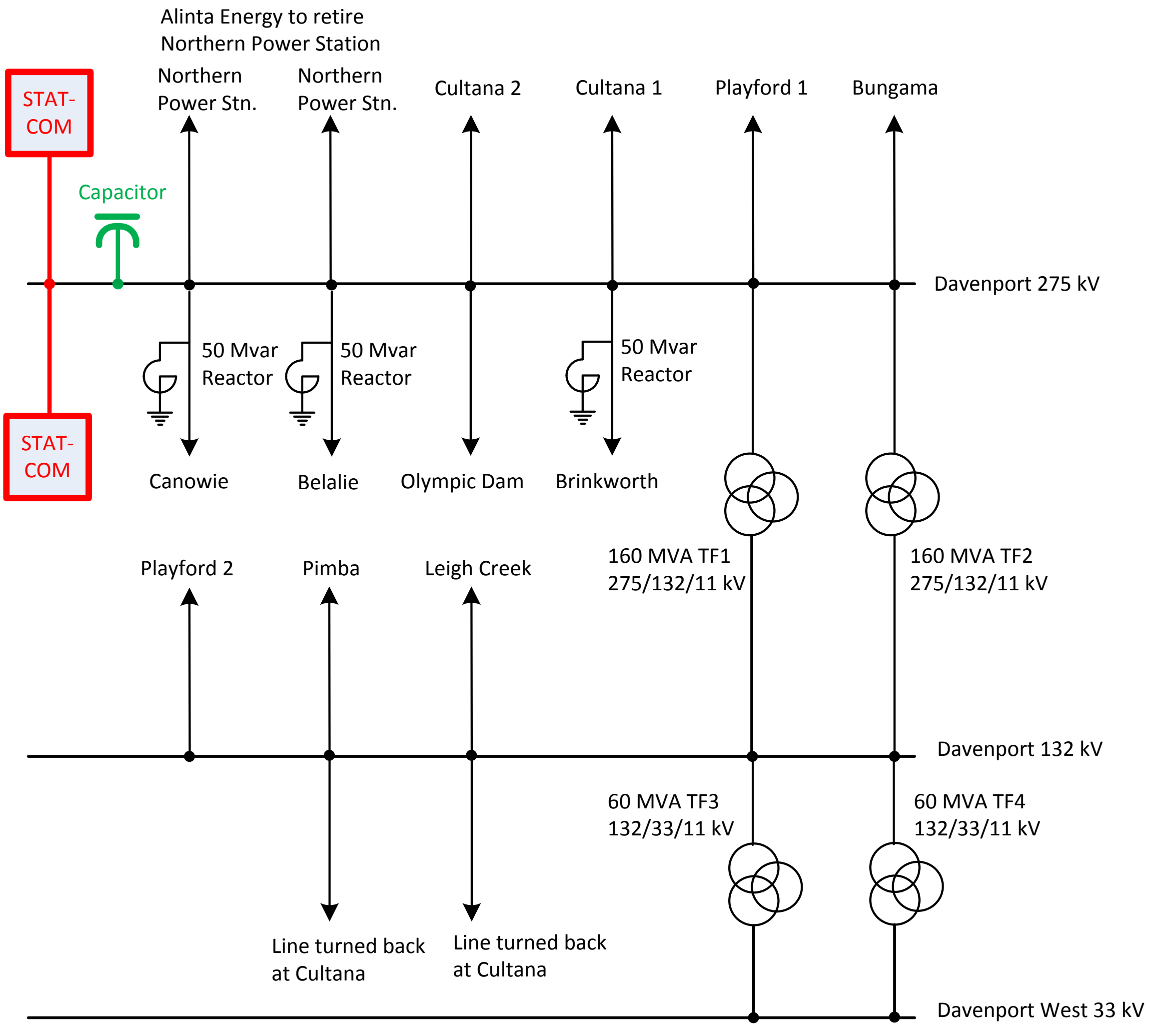
4.2 Option 2: Install two ±50-100 Mvar STATCOMs at Davenport

Option 2 is to install two ±50-100 Mvar STATCOMs at the Davenport substation.

STATCOMs are power electronics devices that consist of an IGBT controlled voltage source. They have a symmetrical positive and negative reactive power capability. STATCOM capability increases and decreases linearly with operating voltage. For example, a reduction in operating system voltage to 90% would reduce STATCOM capability to 90%. This may reduce the size of reactive support required for this option to meet the identified need compared to option 1.

Figure 5 below presents an electrical representation of the Davenport substation with the installation of the two STATCOMs included. Existing assets are shown in black, augmented assets are shown in red and possible future extensions are shown in green.

Figure 5: Davenport substation configuration under Option 2



Capital costs for this option are estimated to be between $30-50 million. The scope and estimate are currently being refined and will be updated in the PADR. Annual operating and maintenance costs are estimated to be about 2% of the capital cost.

ElectraNet estimates that the construction timetable for Option 2 is approximately 1-2 years, with commissioning possible by 9 May 2019.

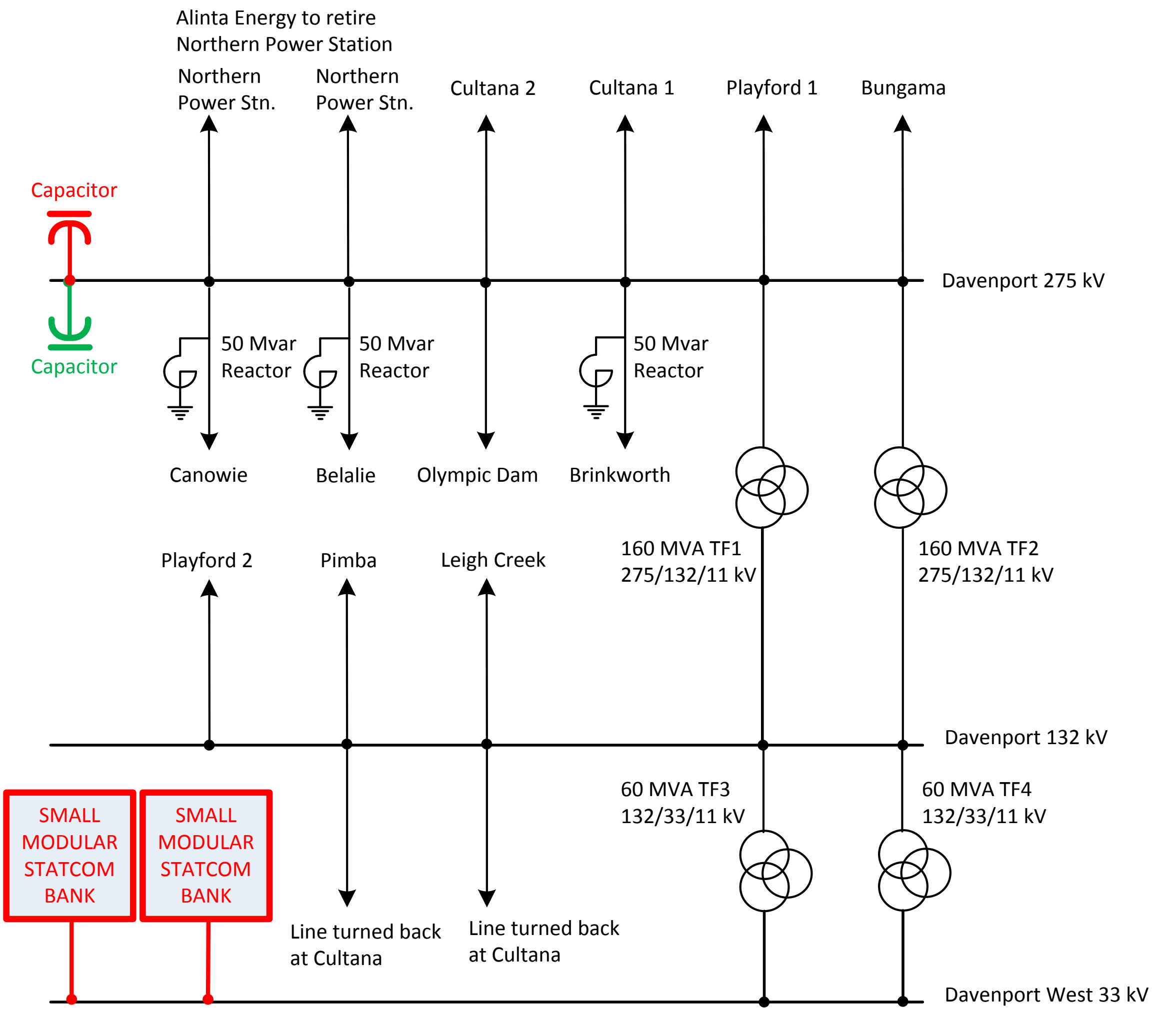
4.3 Option 3: Install small modular STATCOMs and switched capacitors at Davenport

Option 3 is to install two banks of small modular STATCOMs (50-100 Mvar total short-term dynamic capability) and switched capacitors (50-150 Mvar total) at the Davenport substation.

Small modular STATCOMs are based on the same operating principle as larger STATCOMs, but can come with a short-term overload capability. This often means that small modular STATCOMs with a smaller steady-state capability can be used in conjunction with switched capacitor banks to in effect provide a much larger amount of dynamic reactive support. It is expected that this may enable this option to meet the identified need with a smaller total STATCOM capacity, which may allow for a lower cost solution than the other options. This possibility will need to be fully assessed with potential suppliers during the detailed options assessment in the PADR.

Figure 6 below presents an electrical representation of the Davenport substation with the small modular STATCOMs and switched capacitors included. Existing assets are shown in black, augmented assets are shown in red and possible future extensions are shown in green.

Figure 6: Davenport substation configuration under Option 3



Capital costs for this option are estimated to be between $20-40 million. The scope and estimate are currently being refined and will be updated in the PADR. Annual operating and maintenance costs are estimated to be about 2% of the capital cost.

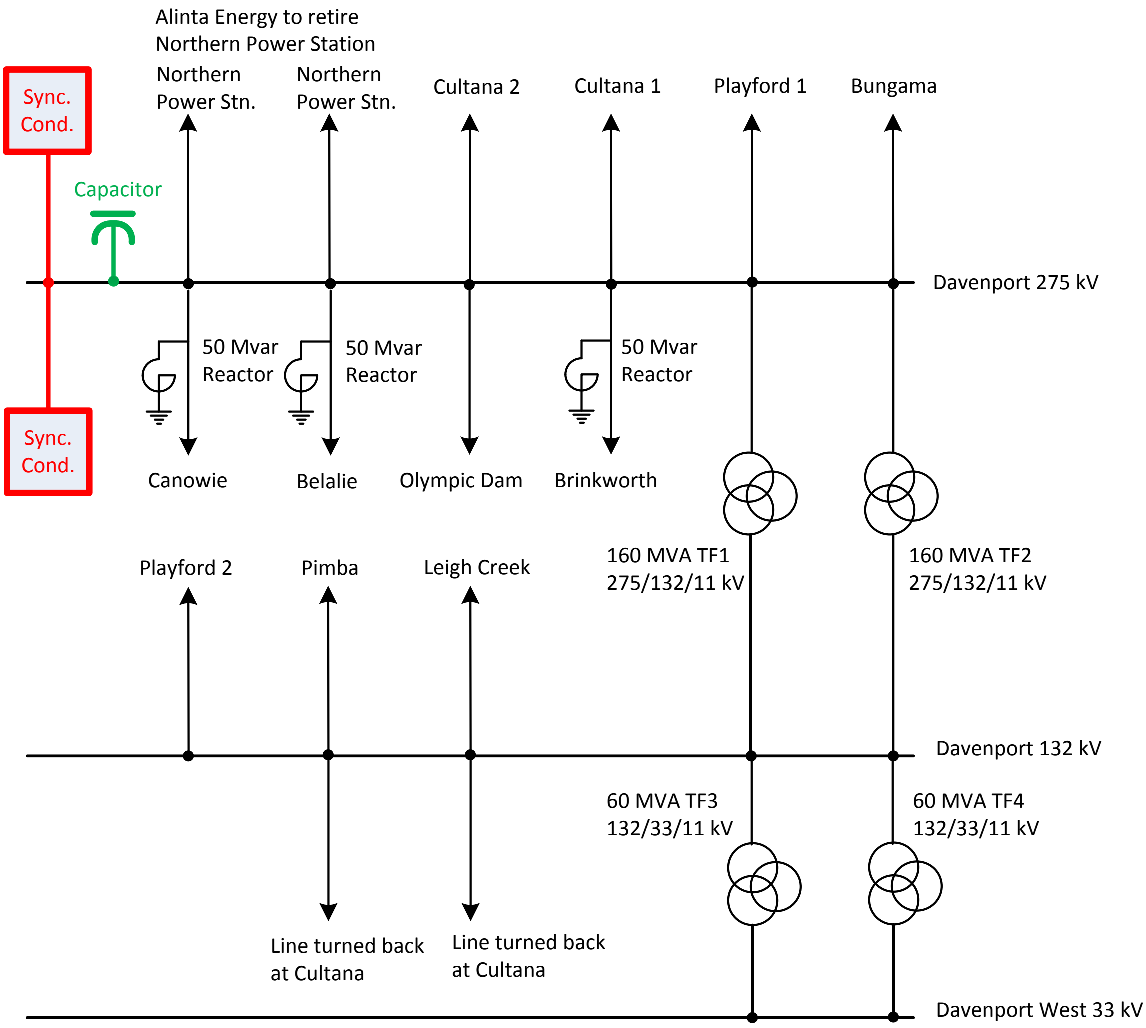
ElectraNet estimates that the construction timetable for Option 3 is approximately 1 – 2 years, with commissioning possible by 9 May 2019.

4.4 Option 4: Install new synchronous condensers at Davenport

Option 4 is to install new synchronous condensers, each with dynamic reactive power capability in the range of 50-100 Mvar, at the Davenport substation.

Figure 7 below presents an electrical representation of the Davenport substation with the new synchronous condensers included. Existing assets are shown in black, augmented assets are shown in red and possible future extensions are shown in green.

Figure 7: Davenport substation configuration under Option 4



Capital costs for this option are estimated to be between $50-100 million. The scope and estimate are currently being refined and will be updated in the PADR. Annual operating and maintenance costs will be assessed during the detailed options assessment, and are currently estimated to be more than 2% of the capital cost.

This option will also increase the rotating inertia of the South Australian electricity system, which may have the effect of providing additional benefits compared to those provided by options 1 – 3, by:

- contributing to system fault levels, which may become increasingly valuable at times of low conventional generation in South Australia; and
- reducing the rate of change of frequency (ROCOF) that may otherwise occur in South Australia following an unplanned loss of the Heywood AC interconnector between South Australia and Victoria.

The assessment of these potential benefits will be presented in the PADR.

ElectraNet estimates that the construction timetable for Option 4 is approximately 1-2 years, with commissioning possible by 9 May 2019.

4.5 Option 5: Convert the existing NPS generators to synchronous condensers

Option 5 involves converting the existing NPS generators to synchronous condensers.

Figure 8 (next page) presents an electrical representation of the Davenport substation with the conversion of the existing generators to synchronous condensers at NPS included. Existing assets are shown in black, augmented assets are shown in red and possible future extensions are shown in green.

ElectraNet is currently working with Alinta to undertake a joint feasibility study to investigate this option further. Consequently, ElectraNet do not consider it practicable at this stage to provide indicative capital and operating costs for this option until the joint study is completed.

ElectraNet also do not consider it practicable at this stage to provide a construction timetable or commissioning date for this option given it would depend on a third party deciding to convert the existing NPS generators to synchronous condensers.

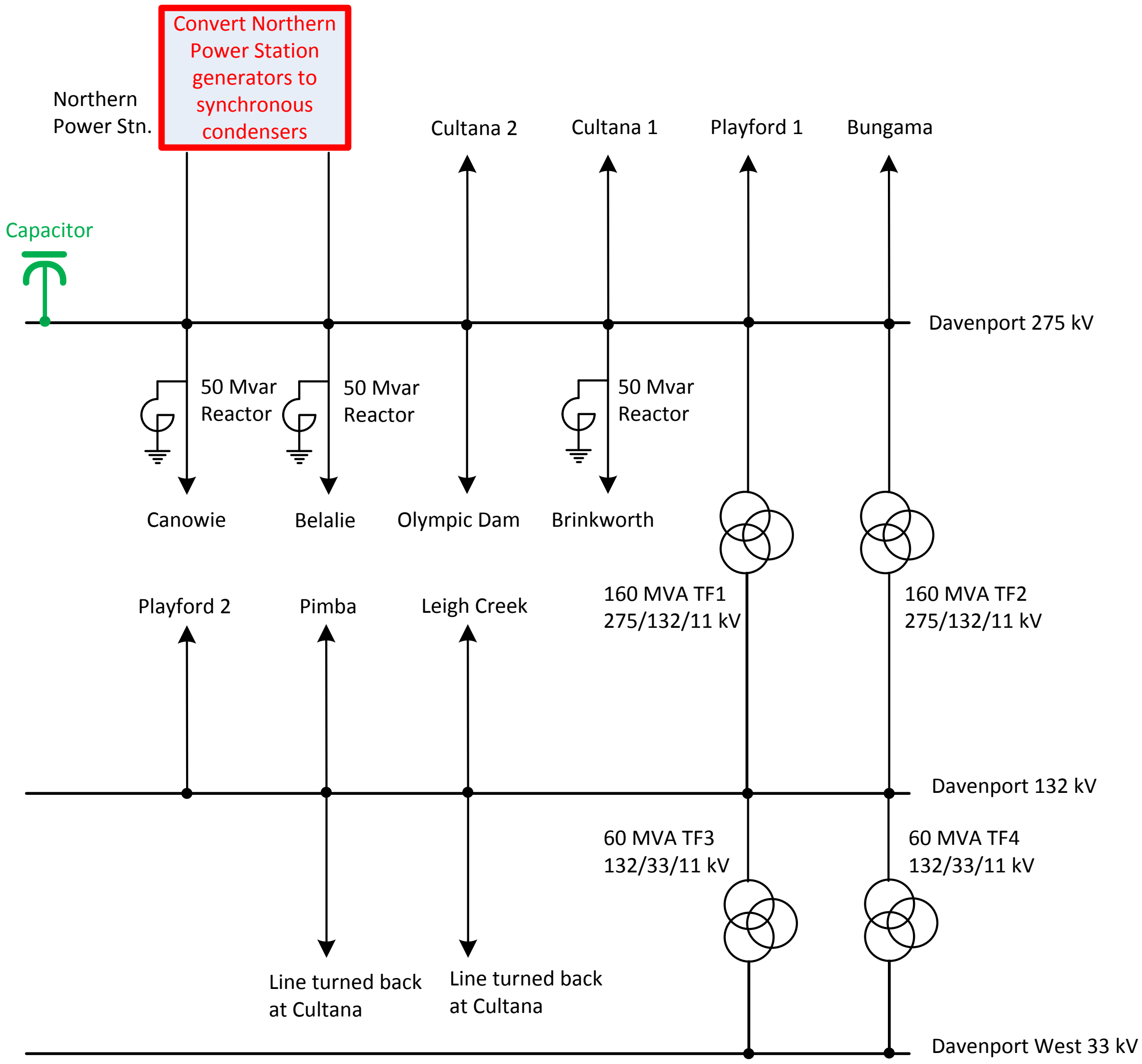
However, there is currently no formal proponent for this option. If a proponent does not come forward then this option will not be included as a credible option in the PADR NPV analysis.

Similar to Option 4, this option will increase the rotating inertia of the South Australian electricity system, which may have the effect of providing additional benefits compared to those provided by options 1 – 3, by:

- contributing to system fault levels, which may become increasingly valuable at times of low conventional generation in South Australia; and
- reducing the rate of change of frequency (ROCOF) that may otherwise occur in South Australia following an unplanned loss of the Heywood AC interconnector between South Australia and Victoria.

The assessment of these potential benefits will be presented in the PADR.

Figure 8: Davenport substation configuration under Option 5



4.6 Non-network options

Section 3.4 sets out the technical characteristics that a non-network option would be required to deliver.

ElectraNet considers that non-network options that may meet the identified need include a new generator at or near Davenport, generation support provided by existing generators near Davenport, and a demand reduction scheme to reduce load on the Davenport to Olympic Dam 275 kV line under necessary system conditions. However, such a demand reduction scheme could only be considered as an interim measure until a more permanent solution is implemented due to the impacts on the Prominent Hill and Olympic Dam operations.

No specific non-network options have been identified by ElectraNet at this stage.

ElectraNet would be interested to hear from any parties that can provide non-network option on the associated costs of providing these services, whether they can in fact meet the identified need (ie, the technical characteristics required of a non-network solution outlined in section 3.3 above) and when they could be implemented by.

4.7 Options considered but not progressed

This section discusses additional options which ElectraNet has considered but does not consider technically and/ or economically feasible, and therefore which are not considered to be credible options.

In addition, section 3.4 sets out the required technical characteristics that a non-network option would be required to deliver in order to meet the identified need.

4.7.1 An under-voltage load shedding scheme and an automatic switching scheme

ElectraNet implemented an under-voltage load shedding (UVLS) scheme in April 2016, to avoid the risk of voltage collapse at Davenport 275 kV that would otherwise exist under N-1 conditions in the Northern SA Region. The UVLS scheme has been designed to sense an under-voltage condition at Davenport 275 kV, and disconnect the 275 kV line from Davenport to Olympic Dam to shed the Olympic Dam, Prominent Hill and Roxby Downs loads within a pre-determined time.

ElectraNet is also implementing a control scheme that will perform automatic switching of the three 275 kV reactors at Davenport, to mitigate the risk of high voltage levels following operation of the UVLS scheme. The switching scheme has been designed to detect an overvoltage condition at Davenport 275 kV and automatically switch the three reactors into service, one at a time, in a pre-determined time frame (coordinated with the UVLS scheme), until an acceptable voltage level has been achieved. This control scheme is expected to be in place by the end of 2016.

Appendix C provides more detail on these interim measures.

ElectraNet does not consider that these measures are sufficient to address the identified need and consequently, together, do not constituent a technically feasible option.[26] Specifically, the following render these schemes as technically infeasible options:

- the insufficient reactive power margin is not addressed; and
- the over-voltage need only gets partially addressed.

Further, the following ETC requirement would not be met:[27]

> "Subject to the service standards specified in this clause 2, a transmission entity must use its best endeavours to plan, develop and operate the transmission network to meet the standards imposed by the National Electricity Rules in relation to the quality of transmission services such that there will be no requirements to shed load to achieve these standards under normal and reasonably foreseeable operating conditions."

The UVLS scheme that has been implemented is designed to shed the significant loads of Olympic Dam, Prominent Hill and Roxby Downs loads for relevant N-1 conditions. These conditions arise for reasonably foreseeable operating conditions and ElectraNet

[26] The AER RIT-T Guidelines state that an option is technically feasible if the TNSP reasonably considers that there is a high likelihood, that the option (if developed) will provide the services that it is assumed it will provide, while also complying with all mandatory requirements in relevant laws, regulations and administrative requirements. See: AER, *Final Regulatory Investment Test for Transmission Application Guidelines*, June 2010, version 1, page 10.

[27] ESCOSA, *ETC TC/08*, 29 October 2015, clause 2.1.1.

considers that the UVLS scheme does therefore not fully satisfy the requirements of clause 2.1.1 of the ETC.

Also, ElectraNet's forecasts and system studies indicate that the following are expected to increase the identified need into the future:

- forecast decreasing minimum state-wide demand levels; and
- that maximum demand supplied at the Davenport end of the Olympic Dam 275 kV line may increase at some point in the future.

4.7.2 Northern Interconnector

As described in ElectraNet's 2016 Transmission Annual Planning Report, ElectraNet is currently considering the economic and technical feasibility of a new interconnector between South Australia and the eastern states. This could be achieved by building a new single or double circuit 275 kV line from Robertstown to Monash, and establishing a new interconnector to New South Wales. Alternative routes for a new interconnector could be from Tungkillo in South Australia to Horsham in Victoria, or a 500 kV high capacity interconnector (HVAC or HVDC) from Davenport in South Australia to Mount Piper in New South Wales. ElectraNet has commenced a feasibility study and expects to issue a PSCR considering the need and options for an additional interconnector in the second half of 2016.

A high capacity interconnector between Davenport and Mount Piper could contribute to meeting the identified need for improved voltage control in the northern region of South Australia. Whilst the timetable to establish such an interconnector would likely be a number of years, ElectraNet will consider the latest available information regarding new interconnector scope and timing in performing the options analysis to address the identified need for this RIT-T.

4.7.3 Widespread demand reduction scheme

ElectraNet considered the implementation of a widespread control scheme to reduce demand on Eyre Peninsula, in Upper North and in Mid North under necessary system conditions.

However, it is not considered that that this option can address identified need under all relevant system conditions and, in particular, during times of low demand in these areas as there is not expected to be sufficient load available to include in the scheme. ElectraNet therefore considers that such a scheme is not considered a credible option.

4.8 Material inter-regional impact

In accordance with NER clause 5.16.4(b)(6)(ii), ElectraNet has considered whether the credible options above are expected to have a material interregional impact.

A 'material inter-network impact', which is defined in the NER as:

> *"A material impact on another Transmission Network Service Provider's network, which may include (without limitation): (a) the imposition of power transfer constraints within another Transmission Network Service Provider's network; or (b) an adverse impact on the quality of supply in another Transmission Network Service Provider's network."*

AEMO currently defines the criteria for material inter-network impact. AEMO's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following:[28]

- a decrease in power transfer capability between the transmission networks or in another TNSP's network of no more than the minimum of 3 per cent of the maximum transfer capability and 50 MW;
- an increase in power transfer capability between transmission networks of no more than the minimum of 3 per cent of the maximum transfer capability and 50 MW;
- an increase in fault level by less than 10 MVA at any substation in another TNSP's network; and
- the investment does not involve either a series capacitor or modification in the vicinity of an existing series capacitor.

ElectraNet notes that the credible options set out in this PSCR involve neither a series capacitor nor modification in the vicinity of an existing series capacitor. Neither are the options discussed above expected to result in a material change in power transfer capability between South Australia and neighbouring transmission networks. In addition fault levels are not expected to increase by more than 10 MVA at any substation in another TNSP's network.

As a consequence, by reference to AEMO's screening criteria, there are no material inter-network impacts associated with the credible options included in this PSCR.

[28] The screening test is set out in Appendix 3 of the Inter-Regional Planning Committee's Final Determination: Criteria for Assessing Material InterNetwork Impact of Transmission Augmentations, Version 1.3, October 2004.

5. Materiality of market benefits for this RIT-T assessment

The NER requires that all categories of market benefit identified in relation to the RIT-T are included in the RIT-T assessment, unless the NSP can demonstrate that a specific category (or categories) is unlikely to be material in relation to the RIT-T assessment for a specific option.[29]

Under NER clause 5.16.4(b)(6)(iii), the PSCR should set out the classes of market benefit that the NSP considers are not likely to be material for a particular RIT-T assessment.

5.1 Changes in costs for parties, other than ElectraNet

ElectraNet does not at this stage consider that any of the credible options for this RIT-T will change the costs for parties, other than ElectraNet, due to:

- differences in the timing of new plant;
- differences in capital costs; or
- differences in the operating and maintenance costs.

In particular, ElectraNet does not consider that any of the credible options will alter the locational decisions of generators in the NEM. ElectraNet also considers that none of the credible options will result in additional costs to SA Power Networks.

5.2 Option value

ElectraNet notes the AER's view that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available in the future is likely to change and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[30]

ElectraNet also note the AER's view that appropriate identification of credible options and reasonable scenarios captures any option value, thereby meeting the NER requirement to consider option value as a class of market benefit under the RIT-T. ElectraNet will incorporate several reasonable scenarios in conducting the RIT-T analysis, which reflect differences in the future level of expected spot load development, amongst other factors.

For this RIT-T assessment, the estimation of any option value benefit over and above that already captured via the scenario analysis in the RIT-T would require a significant modelling assessment. At this stage of the assessment, ElectraNet considers that the additional modelling would be unlikely to affect the outcome of the analysis, and so would be disproportionate. ElectraNet therefore has not estimated any additional option value market benefit as part of the quantification of market benefits presented for the RIT-T assessment at this stage.

ElectraNet will continue to monitor and assess the materiality of modelling option value as part of this RIT-T going forward, particularly in the light of any changes made to the reasonable scenarios included in the analysis following the firm commitment of additional spot load.

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[29] NER clause 5.16.1(c)(6).

[30] AER, *Final Regulatory Investment Test for Transmission Application Guidelines*, June 2010, version 1, p. 39 & 75.

Northern South Australia Region Voltage Control

Appendices

August 2016

Appendix A Checklist of compliance clauses

This section sets out a compliance checklist which demonstrates the compliance of this PSCR with the requirements of clause 5.16.4(b) of the Rules version 80.

Rules clause	Summary of requirements	Relevant section(s) in PSCR
5.16.4 (b)	A RIT-T proponent must prepare a report (the project specification consultation report), which must include:	-
	(1) a description of the identified need;	3
	(2) the assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, why the RIT-T proponent considers reliability corrective action is necessary);	3.3
	(3) the technical characteristics of the identified need that a non- network option would be required to deliver, such as: (i) the size of load reduction of additional supply; (ii) location; and (iii) operating profile.	3.4
	(4) if applicable, reference to any discussion on the description of the identified need or the credible options in respect of that identified need in the most recent National Transmission Network Development Plan;	NA
	(5) a description of all credible options of which the RIT-T proponent is aware that address the identified need, which may include, without limitation, alterative transmission options, interconnectors, generation, demand side management, market network services or other network options;	4.1 – 4.5
	(6) for each credible option identified in accordance with subparagraph (5), information about: (i) the technical characteristics of the credible option; (ii) whether the credible option is reasonably likely to have a material interregional impact; (iii) the classes of market benefits that the RIT-T proponent considers are likely not to be material in accordance with clause 5.16.1(c)(6), together with reasons of why the RIT-T proponent considers that these classes of market benefit are not likely to be material; (iv) the estimated construction timetable and commissioning date; and (v) to the extent practicable, the total indicative capital and operating and maintenance costs.	4 & 5

Appendix B Definitions

All laws, regulations, orders, licences, codes, determinations and other regulatory instruments (other than the Rules) which apply to Registered Participants from time to time, including those applicable in each participating jurisdiction as listed below, to the extent that they regulate or contain terms and conditions relating to access to a network, connection to a network, the provision of network services, network service price or augmentation of a network.

A comprehensive list of applicable regulatory instruments is provided in the Rules.

Applicable regulatory instruments	
AEMO	Australian Energy Market Operator
Base case	A situation in which no option is implemented by, or on behalf of the transmission network service provider.
Commercially feasible	An option is commercially feasible if a reasonable and objective operator, acting rationally in accordance with the requirements of the RIT-T, would be prepared to develop or provide the option in isolation of any substitute options. This is taken to be synonymous with ‘economically feasible’.
Costs	Costs are the present value of the direct costs of a credible option.
Credible option	A credible option is an option (or group of options) that: 1. address the identified need; 2. is (or are) commercially and technically feasible; and 3. can be implemented in sufficient time to meet the identified need.
Economically feasible	An option is likely to be economically feasible where its estimated costs are comparable to other credible options which address the identified need. One important exception to this Rules guidance applies where it is expected that a credible option or options are likely to deliver materially higher market benefits. In these circumstances the option may be “economically feasible” despite the higher expected cost. This is taken to be synonymous with ‘commercially feasible’.
Identified need	The reason why the Transmission Network Service Provider proposes that a particular investment be undertaken in respect of its transmission network.
Market benefit	Market benefit must be: a) the present value of the benefits of a credible option calculated by: i. comparing, for each relevant reasonable scenario: A. the state of the world with the credible option in place to B. the state of the world in the base case, **And** ii. weighting the benefits derived in sub-paragraph (i) by the probability of each relevant reasonable scenario occurring. b) a benefit to those who consume, produce and transport electricity in the market, that is, the change in producer plus consumer surplus.
Net market benefit	Net market benefit equals the market benefit less costs.
Preferred option	The preferred option is the credible option that maximises the net economic benefit to all those who produce, consume and transport electricity in the market compared to all other credible options. Where the identified need is for reliability corrective action, a preferred option may have a negative net economic benefit (that is, a net economic cost).
Reasonable scenario	Reasonable scenario means a set of variables or parameters that are not expected to change across each of the credible options or the base case.

Appendix C Interim measures

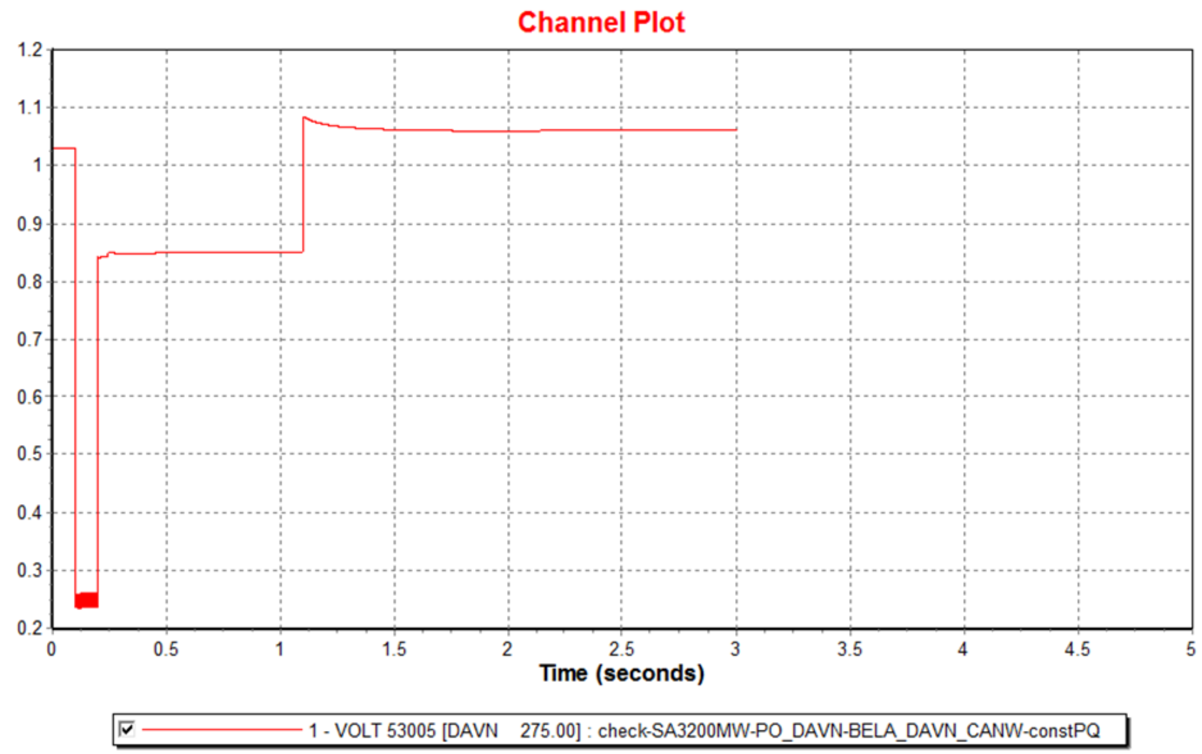
ElectraNet is currently undertaking a number of interim measures given the timing of the NPS closure, ie, before any of the credible options can be commissioned. An overview of each of the measures is provided below.

Under-voltage load shedding

As an interim measure ElectraNet implemented an under-voltage load shedding (UVLS) scheme in April 2016, to avoid the risk of voltage collapse at Davenport 275 kV that would otherwise exist due to the potential reactive power margin deficiency there. This risk if not addressed had the potential to cause widespread power outages under certain network conditions.

The UVLS scheme has been designed to sense an under-voltage condition at Davenport 275 kV, and disconnect the 275 kV line from Davenport to Olympic Dam to shed the load on the Davenport to Olympic Dam 275 kV line within a pre-determined time. This operational voltage control scheme will enable fast voltage recovery at Davenport 275 kV to eliminate the risk of voltage collapse therefore avoiding widespread power outages under relevant contingency events until the outcome of the RIT-T is determined.

The following figure shows an example of the effect of the UVLS scheme's operation to restore Davenport 275 kV voltage levels, for a given network configuration and contingency condition.



Automatic switching of Davenport reactors

In conjunction with the UVLS scheme, ElectraNet is implementing a control scheme that will perform automatic switching of the three 275 kV reactors at Davenport, to mitigate the risk of high voltage levels following operation of the UVLS scheme. If not addressed, extended exposure to high voltage levels could damage equipment and present a hazard to personnel.

The switching scheme has been designed to detect an overvoltage condition at Davenport 275 kV and automatically switch the three reactors into service, one at a time, in a pre-determined time frame (coordinated with the UVLS scheme), until an acceptable voltage level has been achieved.

This automatic reactor control will provide voltage regulation at Davenport 275 kV to eliminate the risk of an extended overvoltage condition, avoiding damage to equipment and ensuring the continuing safety of personnel. This control scheme is expected to be in place later in 2016.