Maintaining a reliable Static Var Compensator at Lismore

RIT-T – Project Specification Consultation Report

Region: Northern

Date of issue: 27 May 2019

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Executive summary

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining reliability of the Static Var Compensator (SVC) at Lismore. Publication of this Project Specification Consultation Report (PSCR) is the first step in the RIT-T process.

As there has been an increase in frequency of failure over the last few years, TransGrid's asset monitoring maintenance has identified that the control system component of the SVC at Lismore has reached a condition that reflects the end of serviceable life.[1] Between 1 August 2018 and 28 February 2019, the SVC has been unavailable for approximately 59% of the time as a result of failures of the control component. The most recent failure resulted in the SVC being out of service between November 2018 and January 2019 for a period of 58 days. As it is superseded by new technology at the manufacturer level and the existing technology becomes obsolete, spare parts become scarce and the reliability of the SVC will be at risk.

Identified need: maintain reliability of the SVC at Lismore

A failure of control system components would cause SVC outages and require interim voltage management solutions to be established: application of network constraints and network re-configuration. Each solution poses risks to consumers.

Application of network constraints is the first operational mechanism that is likely to be established. This approach involves dispatch constraints to be imposed in the wholesale electricity market. This mechanism is applied first as it entails less operational risk than the next voltage management solution.

Although this approach is effective in managing the voltage at Lismore, it is only viable under moderate load conditions, when load at Lismore and Mullumbimby is less than 60 MW to 90 MW (depending on system conditions). Beyond this demand, a second and different approach to managing power system security in the northern NSW area is required, more specifically, to address the risk of thermal overload on Lines 96L and 967.

To address the risk of thermal overload when the demand at Lismore and Mullumbimby increases above 60 MW to 90 MW, TransGrid can radialise[2] or re-configure the network by opening the circuit breakers on the Lismore side of Lines 96L and 967. This method allows higher transfer to Lismore across the 330kV Line 89 from Coffs Harbour and 87 from Armidale.

However, the exposure of radialising these transmission lines increases the probability of load shedding at Lismore for a trip of either of these lines. TransGrid estimates that there is a 0.24% chance of either of these lines tripping. In such an event, TransGrid would need to initiate involuntary load shedding at Lismore or Mullumbimby as last resort to manage network security.

TransGrid estimates that about 30.4 MWh of prolonged involuntary load shedding per year, valued at approximately $1.2 million per year, may result from failure or limitation of these interim voltage management solutions when the SVC at Lismore is out of service.

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[1] Electricity Networks Association. *"RIT-T Economic Assessment Handbook."* Melbourne: Electricity Networks Association, 2019. Accessed 15 March 2019. https://www.energynetworks.com.au/sites/default/files/ena_rit-t_handbook_15_march_2019.pdf

[2] Radialisation refers to switching the configuration of the network to have load centres connected to the network by only one line as opposed to the usual meshed configuration. Australian Energy Market Operator. "*Trip of Multiple Transmission Elements in the Southern NSW Area, 11 February 2017*." Melbourne: Australian Energy Market Operator, 2017. Accessed 22 February 2019. https://www.aemo.com.au//media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Trip-of-multiple-transmission-elements-in-the-southern-NSW-area.pdf

Credible options considered

In this PSCR TransGrid has identified two credible options that would meet the identified need from a technical, commercial, and project delivery perspective.[3]

Table E-1 – Summary of the credible options

Option	Description	Capital cost	Operating and maintenance cost	Remarks
Option 1	Refurbish the existing SVC control system	$11.87 million	$19,000 per year	Most economical and preferred option
Option 2	Complete SVC replacement	> $28 million	~$19,000 per year	Not progressed as uneconomical due to significant cost
Option 3	New transmission line from Dumaresq to Lismore	~ $210 million	$400,000 per year	Not progressed as uneconomical due to significant cost

Consideration of non-network options

Non-network options could technically assist in meeting the need for this RIT-T. Any non-network option would need to provide a sufficient load reduction to maintain voltage stability for the northern coast of NSW. TransGrid estimates that a total demand reduction of 10-20 MW would be required to maintain a suitable level of reactive margin. The magnitude of the requirement is dependent on the demand levels in the Lismore area, availability of Directlink poles, and transmission lines outages at any time throughout the year.

To be commercially feasible, non-network options must efficiently defer a credible network option, efficiently reduce the risk of prolonged involuntary load shedding, and provide greater net economic benefits than the network option.

TransGrid calculates that the maximum deferment benefit for Option 1 is relatively low (approximately $680,000 per year) compared to the yearly risk costs of involuntary load shedding. This translates to non-network options needing to cost below approximately $28/kW, for a minimum of 15 MW from 2019/20 to effectively address the need or defer Option 1.

As part of this consultation process, TransGrid encourages interested parties to make submissions regarding non-network options that satisfy, or contribute to satisfying, the identified need detailed in this PSCR. TransGrid considers that possible non-network options include:

- embedded generation
- energy storage (including battery system) which inject power into the grid as required
- voluntary curtailment of customer load
- permanent reduction of customer load (including energy efficiency).

[3] As per clause 5.15.2(a) of the NER.

Options assessed under three different scenarios

TransGrid has considered three alternative scenarios – a low net economic benefits scenario, a central scenario, and a high net economic benefits scenario. All involve a number of material assumptions that results in the lower bound, the expected, and the upper bound estimates for present value of net economic benefits respectively.

Table E-2 – Summary of the scenarios

Variable/Scenario	Central	Low net economic benefits	High net economic benefits
Scenario weighting	*50%*	*25%*	*25%*
Network capital costs	Base estimate	Base estimate + 25%	Base estimate - 25%
Discount rate	5.9%	7.2%	4.6%
VCR	$40/kWh	$28/kWh	$52/kWh
Demand forecast	POE50	POE90	POE10
Avoided corrective maintenance costs	Base estimate	Base estimate - 25%	Base estimate + 25%

Option 1 delivers positive net economic benefits

Option 1's weighted net economic benefits are estimated to be $7.1 million. While they are negative in the low net economic benefits scenario, TransGrid notes that this scenario is composed of extreme circumstances on every aspect of the assessment.

Most of these benefits come from the avoided prolonged involuntary load shedding, safety and environment risk cost. Figure 7-2 shows that taking into account all sensitivities, the optimal timing for the works is before 2019/20, while Figure 7-3 illustrates that for all sensitivity tests, the estimated net economic benefits of Option 1 are found to be positive and are consistent.

Table E-3 – Present value of the net economic benefits for each credible option relative to the base case, 2017/18 $m

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	3.6	-8.7	30.2	7.1

Draft conclusion

Option 1, refurbishment of the existing SVC control system, is preferred at this first stage of a formal RIT-T process undertaken by TransGrid.

The net economic benefits from Option 1, approximately $7.1 million, make it preferable over other options at this draft stage. The table below outlines the proposed program of work for Option 1.

Table E-4 – Proposed program of work for Option 1

Dismantling	Installing
The control and protection system cubicles	A completely new control system, protection system, GPS, fault recorder and HMI
The thyristor valves and valve base electronics for the thyristor controlled reactor (TCR)	A new thyristor valve and valve base electronics for the TCR
The thyristor valves and valve base electronics for the two thyristor switched capacitors (TSC)	Completely new thyristor valves and valve base electronics for the two TSCs
The cooling water system main components, the cooling pump units, valve cooling units, piping and cooling system controllers	New cooling water system main components, cooling water pump units, valve cooling units, piping and cooling system controllers

The physical delivery and replacement of the identified assets is planned to occur prior 2020/21 and all work will be completed by 2021/22.

Necessary outages of the line(s) in service will be planned appropriately in order to complete the works with minimal impact on the network.

The estimated nominal capital cost of this option is approximately $11.87 million (weighted present value of $9.6 million). Routine operating and maintenance costs are approximately $19,000 per year.

Submissions and next step

The purpose of this PSCR is to set out the reasons TransGrid proposes that action be undertaken, present the options that address the identified need, outline the technical characteristics that non-network options will need to provide, and allow interested parties to make submissions and provide input to the RIT-T assessment.

TransGrid welcomes written submissions on materials contained in this PSCR. Submissions are particularly sought on the credible options presented and from potential proponents of non-network options that could meet the technical requirements set out in this PSCR. Submissions are due on 26 August 2019.

Submissions should be emailed to TransGrid's Prescribed Revenue & Pricing team via RIT-TConsultations@transgrid.com.au.[4] In the subject field, please reference 'Lismore SVC project.'

At the conclusion of the consultation process, all submissions received will be published on the TransGrid's website. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement.

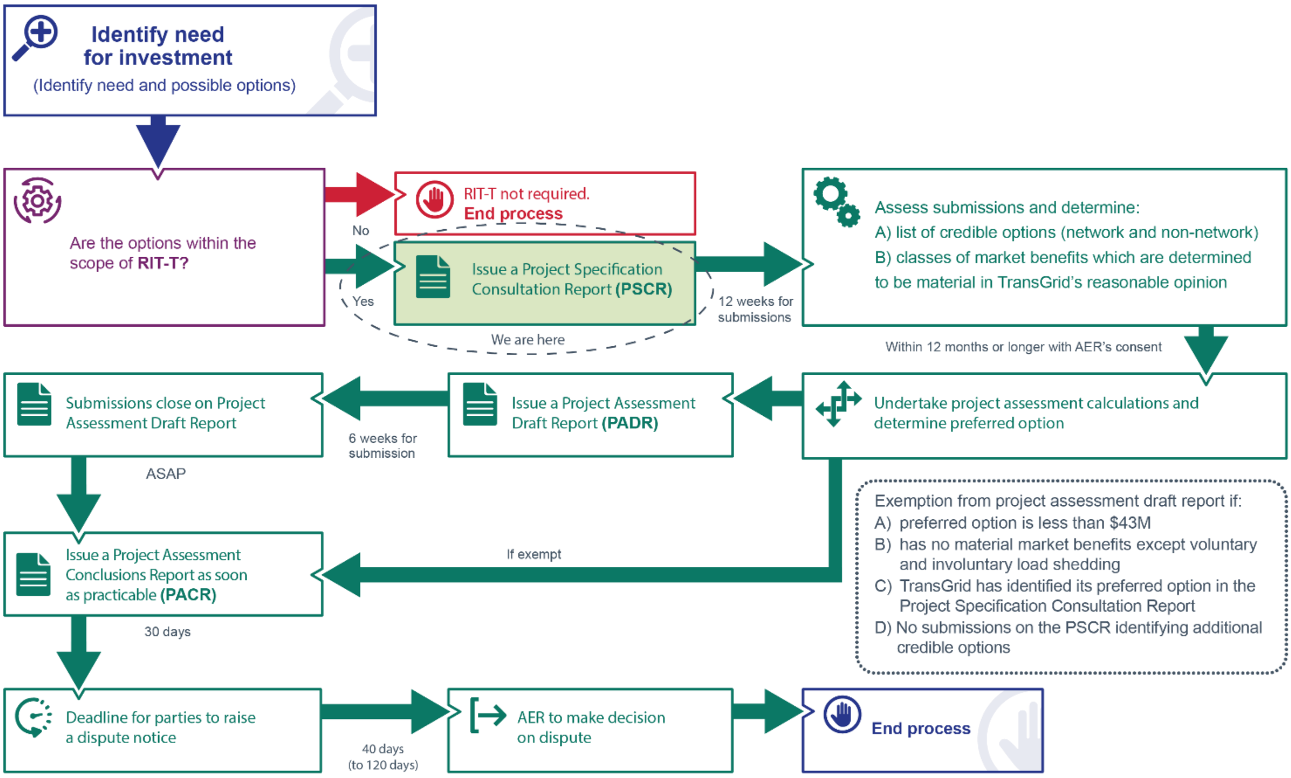
Publication of a Project Assessment Draft Report (PADR) is not required for this RIT-T as TransGrid considers its investment in relation to the preferred option to be exempt from that part of the process as per NER clause 5.16.4(z1). Therefore, the next step in this RIT-T, following consideration of submissions received via the 12-week consultation period and any further analysis required, will be publication of a Project

[4] TransGrid is bound by the Privacy Act 1988 (Cth). In making submissions in response to this consultation process, TransGrid will collect and hold your personal information such as your name, email address, employer and phone number for the purpose of receiving and following up on your submissions. If you do not wish for your submission to be made public, please clearly specify this at the time of lodgement. See section 1.2 for more details.

Assessment Conclusions Report (PACR). TransGrid anticipates publication of a PACR by 26 September 2019.

In accordance with NER clause 5.16.4(z1)(4), the exemption from producing a PADR will no longer apply if TransGrid considers that an additional credible option that could deliver a material market benefit is identified during the consultation period. Accordingly, if TransGrid considers that any additional credible options are identified, TransGrid will produce a PADR which includes a net present value (NPV) assessment of the net economic benefits of each additional credible option.

Figure E-1 – This PSCR is the first stage of the RIT-T process[5]



5 Australian Energy Regulator, *"Final determination on the 2018 cost thresholds review for the regulatory investment tests,"* accessed 15 March 2019. https://www.aer.gov.au/communication/aer-publishes-final-determination-on-the-2018-cost-thresholds-review-for-the-regulatory-investment-tests

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1. Introduction

TransGrid is applying the Regulatory Investment Test for Transmission (RIT-T) to options for maintaining reliability of the Static Var Compensator (SVC) at Lismore. Publication of this Project Specification Consultation Report (PSCR) is the first step in the RIT-T process.

As there has been an increase in frequency of failure over the last few years, TransGrid's asset monitoring maintenance has identified that the control system component of the SVC at Lismore has reached a condition that reflects the end of serviceable life.[6] Between 1 August 2018 and 28 February 2019, the SVC has been unavailable for approximately 59% of the time as a result of failures of the control component. The most recent failure resulted in the SVC being out of service between November 2018 and January 2019 for a period of 58 days. As the condition of the asset continues to deteriorate, the risk of failure of the component which enables the SVC to operate will increase.

As the existing control system component is superseded by new technology at the manufacturer level and the existing technology becomes obsolete, spare parts become scarce and it is impossible to operate the SVC to support normal operating transmission system conditions. Ability to support the transmission network is vital for power system security and reliability, therefore the condition issues affecting the Lismore SVC must be addressed.

An out-of-service Lismore SVC will increase the risk of involuntary load shedding in the Lismore area.

TransGrid has commenced this RIT-T to identify and consult on options to mitigate and alleviate the deterioration of the Lismore SVC and the risk from technology obsolescence. As investment is intended to maintain a reliable supply to Lismore area and generate net positive economic benefits, TransGrid considers this a 'market benefit'-driven RIT-T.

1.1 Purpose of this report

The purpose of this PSCR is to:

> set out the reasons TransGrid proposes that action be undertaken (that is, the 'identified need')

> present the options that TransGrid currently considers address the identified need

> outline the technical characteristics that non-network options would need to provide

> allow interested parties to make submissions and provide input to the RIT-T assessment.

[6] Electricity Networks Association. *"RIT-T Economic Assessment Handbook."* Melbourne: Electricity Networks Association, 2019. Accessed 15 March 2019. https://www.energynetworks.com.au/sites/default/files/ena_rit-t_handbook_15_march_2019.pdf

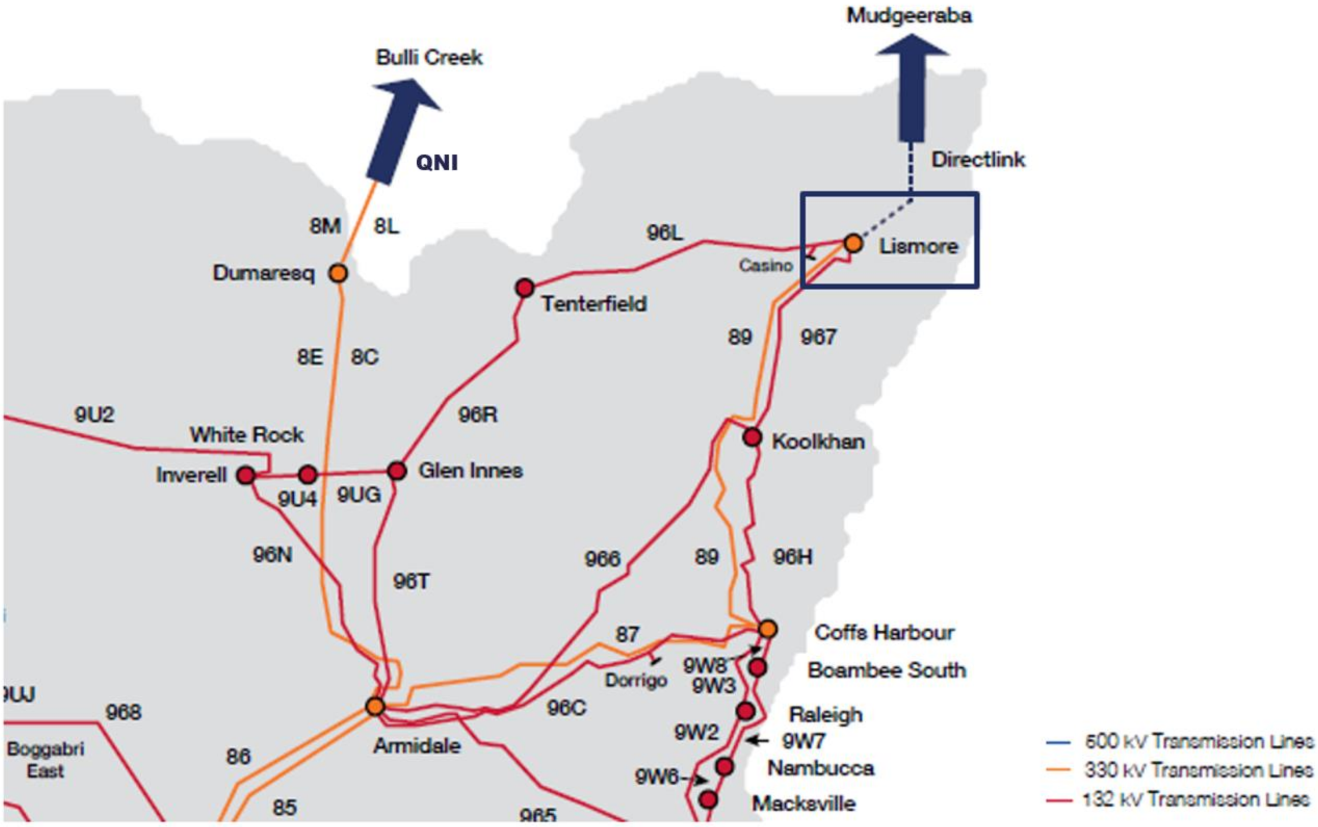
2. The identified need

TransGrid's Lismore substation was commissioned in 1992 and forms part of TransGrid's northern New South Wales network that serves Lismore and the surrounding area including Ballina, Dunoon, Ewingsdale, Lennox Head, Mullumbimby, Suffolk Park and Casino. The substation provides a connection point for Essential Energy's distribution network.

Located in the Northern Rivers region, Lismore has a growing population of over 44,000.[7] The load in Lismore is predominantly residential and industrial, while neighbouring Dunoon and Mullumbimby are predominantly agricultural and residential loads.[8] The peak load for the Lismore area is approximately 140 MW.[9]

An overview of the northern NSW transmission network is provided in Figure 2-1 below, the Lismore area referred to throughout this PSCR is outlined in blue.

Figure 2-1 – Northern NSW transmission network



Converging to Lismore substation, Lines 87 and 89 connect Armidale to Lismore via Coffs Harbour and together span approximately 300 km. Two additional 132 kV transmission lines also terminate at Lismore: Line 967 which spans approximately 90 km from Koolkhan to Lismore and Line 96L which spans approximately 122 km from Tenterfield to Lismore. These transmission lines play central roles in supplying this part of the network.

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7 Lismore's population is primed to grow by over 5,000 residents over the next 20 years. Lismore City Council. *Lismore Prospectus*. Lismore: Lismore City Council, 2018. Accessed 20 February, 2019. https://issuu.com/lismorecitycouncil/docs/lismore_prospectus_online?e=7144101/60065559

8 Australian Energy Market Operator. "AEMO Visualisations Map." Accessed 14 February 2019. http://www.aemo.com.au/aemo/apps/visualisations/map.html

9 This figure is an arithmetic sum of individual load forecasts for winter 2019 and summer 2019/20. Essential Energy. *Asset Management Distribution Annual Planning Report 2018*. Port Macquarie: Essential Energy, 2018. Accessed 14 February 2019. https://www.essentialenergy.com.au/-/media/Project/EssentialEnergy/Website/Files/Our-Network/DAPR-2018.pdf?la=en&hash=12E10DC581DAEE38038061F4596C03F6BF2EF874

In addition to connecting TransGrid's Lines 87, 89, 969 and 96L, the substation is also a connection point for Directlink which, via Terranora Interconnector, enables flow between New South Wales and Queensland in both directions.

Substantial voltage variation is a known operational challenge for this part of the network due to the considerable length and operating voltage of some of the transmission lines that service the far north coast. Voltage variations are a natural phenomenon in the power system but must be managed within limits to ensure they are not detrimental to the safe and reliable operation of the network. Typically, transmission lines that span longer distances and operate heavily loaded have higher losses and higher voltage variation at the receiving end.

To assist in managing voltage stability at Lismore, the substation also connects capacitor banks. However capacitor banks, alone, cannot effectively manage system voltage stability.

A Static Var Compensator (SVC) has also been connected at the Lismore substation since 1999 to assist in regulating voltage within an acceptable range and enable the provision of fast response reactive power following system contingencies. Capacitor banks coarsely adjust the voltage while the SVC finely tunes it, and these two types of technologies operate best in tandem and non-operation of one would lessen the effectiveness of the entire voltage management solution.

The Lismore SVC is particularly required to:

> regulate and control the Lismore 330kV voltage to the required set point under normal (steady-state) and contingency conditions
> provide dynamic, fast response reactive power following system contingencies

The primary components of the SVC (transformer, thyristors, capacitors and reactors) typically have an economic life of approximately 40 to 50 years. The control system and other secondary assets such as protection relays, control systems, AC distribution, DC supply systems, and market meters, typically have an economic life of approximately 15 to 20 years.

2.1 Description of the identified need

Between 1 August 2018 and 28 February 2019, the SVC has been unavailable for approximately 59% of the time as a result of failures of the control system component. The most recent failure resulted in the SVC unavailable for full service[10] between November 2018 and January 2019 for a period of 58 days.

Failure of the control system component would require the SVC to be taken out of service and several interim voltage management solutions be established: network constraints and network re-configuration. Each solution poses potential risks to consumers.

Application of network constraints is the first operational mechanism that is likely to be established. This involves dispatch constraints to be imposed is the wholesale electricity market.

Although this approach is effective in managing the voltage at Lismore, it is only viable under moderate load conditions, when load at Lismore and Mullumbimby is less than 60 MW to 90 MW (depending on system conditions). Beyond this demand, a different approach to managing power system security in the northern NSW area is required, more specifically, to address the risk of thermal overload on Lines 96L and 967.

During periods of high load when the demand at Lismore and Mullumbimby increases above 60 MW to 90 MW, Lines 96L and 967 do not have sufficient capacities to supply the load at Lismore if Lines 87 or 89 trip.

10 Lismore SVC can operate in a test mode (i.e. in-service, but with the network configuration for outage) after each failure until proven reliable. 'Unavailable for full service' indicates that the SVC is either out of service or in test mode.

At these times, both Lines 96L and 967 are at risk of overloading their thermal limitations under a single contingency.

To mitigate this risk of thermal overload, TransGrid can radialise[11] the network by opening the circuit breakers on the Lismore side of Lines 96L and 967. This method allows higher transfer to Lismore across the 330kV Line 89 from Coffs Harbour and 87 from Armidale.

However, the exposure of radialising these transmission lines increases the probability of load shedding at Lismore for a trip of either of these lines. TransGrid estimates that there is a 0.24% chance of either of these lines tripping. This figure is sufficiently significant that a post-contingency involuntary load shedding protocol must be established.

The post-contingency involuntary load shedding at Lismore or Mullumbimby is the last resort to manage network security. Limited load may be restored by reconnecting Lines 967 and 96L or by returning the failed line to service.

TransGrid estimates that about 30.4 MWh of prolonged involuntary load shedding per year or approximately $1.2 million per year may result from failure or limitation of these interim voltage management solutions when the SVC at Lismore is out of service.

TransGrid considers addressing this need as a 'market benefit' driven RIT-T as the investment is to mitigate involuntary load shedding.

2.2 Assumptions underpinning the identified need

2.2.1 Depletion of available spares due to no manufacturer support for technologically obsolete components

Though repair of a failed secondary system is possible as an interim measure, the approach is not sustainable as spare components will deplete due to the technology no longer being manufactured or supported. TransGrid has only limited spares for parts of the control system expected to last not later than 2023. Once all spares are used, repair will cease to be a viable option and will render the SVC inoperable.

2.2.2 Line 87 and 89 failure rates

As the unavailability of Line 87 and 89 drives involuntary load shedding estimates, the forecast EUE is informed by the life cycle failure rate of the lines, which is a function of the line's age, length, and average failure duration. These parameters are set out in Table 2-1.

Table 2-1 – Failure rate and duration for Line 87 and 89

Average life cycle failure rate	Length of Line	Average failure duration	Unavailability per year
0.2901 per 100 km per year	135.3 km for Line 87 and 172.7 km for Line 89	23.8 hours/event	0.24 per cent

[11] Radialisation refers to switching the configuration of the network to have load centres connected to the network by only one line as opposed to the usual meshed configuration. Australian Energy Market Operator. "*Trip of Multiple Transmission Elements in the Southern NSW Area, 11 February 2017*." Melbourne: Australian Energy Market Operator, 2017. Accessed 22 February 2019. https://www.aemo.com.au//media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Trip-of-multiple-transmission-elements-in-the-southern-NSW-area.pdf

2.2.3 Prolonged involuntary load shedding forecast

TransGrid has estimated prolonged involuntary load shedding under the following potential load forecasts scenarios:

> a central forecast using 50 per cent probability of exceedance (POE50)

> a low forecast using the POE90

> a high forecast using the POE10

Under all of the forecast scenarios, TransGrid estimates involuntary load shedding if Lismore SVC is out of service.

For the central scenario, TransGrid estimates about 30.4 MWh per year of involuntary load shedding from non-operation of the SVC, or an equivalent to 2633 homes for a day.[12] This will increase over time as the failure rates if the SVC will increase. This estimate is 11.2 MWh per year and 58.5 MWh per year for the low forecast and high forecast respectively.

2.2.4 Value of customer reliability

The Value of Customer Reliability (VCR), in dollars per MWh, is used to evaluate the wider economic impact of involuntary load shedding on customers under the RIT-T.

TransGrid has applied AEMO's VCR estimate of $40/kWh[13] for the central scenario, see section 6.3.

Consistent with the 30% level of confidence on the AEMO estimates, a lower value of $28/kWh and a higher estimate of $52/kWh are also assumed for two sensitivities.

12 Based on the typical household consumption in NSW according to Australian Energy Market Commission, "*2018 Residential Electricity Price Trends*," accessed 21 January 2019. https://www.aemc.gov.au/market-reviews-advice/2018-residential-electricity-price-trends

13 Australian Energy Market Operator. "*Value of Customer Reliability Review- Final Report*." Melbourne: Australian Energy Market Operator, 2014. Accessed 15 March 2019. https://www.aemo.com.au/-/media/Files/PDF/VCR-final-report--PDF-update-27-Nov-14.pdf

3. Options that meet the identified need

TransGrid considers credible network options that would meet the identified need from a technical, commercial, and project delivery perspective.[14]

In identifying credible options, TransGrid has taken the following factors into account: energy source; technology; ownership; the extent to which the option enables intra-regional or intra-regional trading of electricity; whether it is a network option or a non-network option; whether the credible option is intended to be regulated; whether the credible option has proponent; and any other factor which TransGrid reasonably considered should be taken into account.[15]

3.1 The base case

The costs and benefits of each option in this PSCR are compared against those of a base case. Under this base case, no proactive capital investment is made to remediate the deterioration of Lismore SVC, and the asset will continue to operate and be maintained under the current regime.

The asset's risk of failure and periods of unavailability will increase as the components continue to deteriorate and limited spares are depleted. TransGrid views that required spare parts will be exhausted before 2023.

Annual maintenance costs are approximated at $114,000 per year inclusive of routine ($19,000 per year) and corrective maintenance (approximately $95,203 per year). However, the routine maintenance regime will not be able to mitigate the risk of SVC failure, which will continue to expose consumers to involuntary load shedding worth approximately $1.2 million per year.

3.2 Option 1 – Refurbish the existing SVC control system

Option 1 involves the refurbishment of the existing SVC control system. The new control system, which has expected technical life of 20 years, would fully utilise the expected technical life of the entire SVC.[16] The scope of works for Option 1 is outlined in the table below.

Table 3-1 – Proposed program of work for Option 1

Dismantling:	Installing:
The control and protection system cubicles	A completely new control system, protection system, GPS, fault recorder and HMI
The thyristor valves and valve base electronics for the thyristor controlled reactor (TCR)	A new thyristor valve and valve base electronics for the TCR
The thyristor valves and valve base electronics for the two thyristor switched capacitors (TSC)	Completely new thyristor valves and valve base electronics for the two TSCs

[14] As per clause 5.15.2(a) of the NER.

[15] As per clause 5.15.2(b) of the NER.

[16] SVC primary components typically have a technical life expectancy of 40 to 50 years

The cooling water system main components, the cooling pump units, valve cooling units, piping and cooling system controllers	New cooling water system main components, cooling water pump units, valve cooling units, piping and cooling system controllers

The physical delivery and replacement of the identified assets is planned to occur until 2020/21 and all work will be completed by 2021/22.

The estimated capital cost of this option is approximately $11.87 million. Routine operating and maintenance costs are approximately $19,000 per year.

All works under all options will be completed in accordance with the relevant standards and components shall be replaced to have minimal modification to the wider transmission assets.

3.3 Options considered but not progressed

TransGrid considers complete SVC replacement but as it will cost (>$28 million) significantly more than Option 1 without generating additional market benefits, this option is not progressed any further.

TransGrid has also considered a new transmission line from Dumaresq to Lismore would meet the identified need. This option has not been progressed due to its high estimated capital cost, ~$210 million, relative to the other options. This is 17 times higher than Option 1 but will not generate additional market benefits. The operating and maintenance cost for this option is also significantly higher at $400,000 per year.

3.4 No material inter-network impact is expected

TransGrid has considered whether the Option 1 listed above is expected to have material inter-regional impact.[17] A 'material inter-network impact' 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's suggested screening test to indicate that a transmission augmentation has no material inter-network impact is that it satisfies the following:[18]

> a decrease in power transfer capability between transmission networks or in another TNSP's network of no more than the minimum of 3% of the maximum transfer capability and 50 MW
> an increase in power transfer capability between transmission networks or in another TNSP's network of no more than the minimum of 3% 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
> the investment does not involve either a series capacitor or modification in the vicinity of an existing series capacitor.

TransGrid notes that Option 1 satisfies these conditions. By reference to AEMO's screening criteria, there is no material inter-network impacts associated with Option 1 considered.

[17] As per clause 5.16.4(b)(6)(ii) of the NER.

[18] Inter-Regional Planning Committee. *"Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations."* Melbourne: Australian Energy Market Operator, 2004. Appendix 2 and 3. Accessed 15 March 2019. https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf.pdf

4. Non-network options

Non-network options can assist if they provide greater net economic benefits than the network option.

The maximum deferment benefit for Option 1 is relatively low (approximately $680,000 per year compared to the value of the involuntary load shedding (approximately $1.2 million per year).

As part of this consultation process, TransGrid encourages interested parties to make submissions regarding non-network options that satisfy, or contribute to satisfying, the identified need detailed in this PSCR. Non-network proposals must include the information specified in this section.

4.1 Required technical characteristics of non-network options

The technical characteristics described below refer to the non-network options required to address the expected involuntary load shedding when remediation options either do not proceed or are delayed. Network support up to 20 MW will be considered on a cost-benefit basis against the reduction in involuntary load shedding.

TransGrid considers that possible non-network options include:

> embedded generation

> energy storage (including battery system) which inject power into the grid as required

> voluntary curtailment of customer load

> permanent reduction of customer load (including energy efficiency).

4.1.1 Nature of any load reduction or additional supply required

Any non-network option would need to provide a sufficient load reduction to maintain voltage stability for the northern coast of NSW. TransGrid estimates that to maintain a suitable level of reactive margin a total demand reduction of 10-20 MW would be required. The magnitude of the requirement is dependent on the demand levels in the Lismore area, the availability of Directlink poles, and transmission lines outages at any time throughout the year.

TransGrid has estimated the approximate level of network support required to reduce the expected unserved energy to defer the investment in Table 4-1. In deriving this estimate, we have applied a probabilistic assessment of the unserved energy, incorporating the load profile, per-pole availability of Directlink, and transmission outages.

Table 4-1 – Indicative size and duration of non-network options for the Lismore area

Parameter	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25
Forecast maximum demand summer (MW)	120	120	120	120	120	120
Load at Risk with Directlink (MW)	40	40	40	40	40	40
Load at Risk without[19] Directlink (MW)	54	54	54	54	54	54

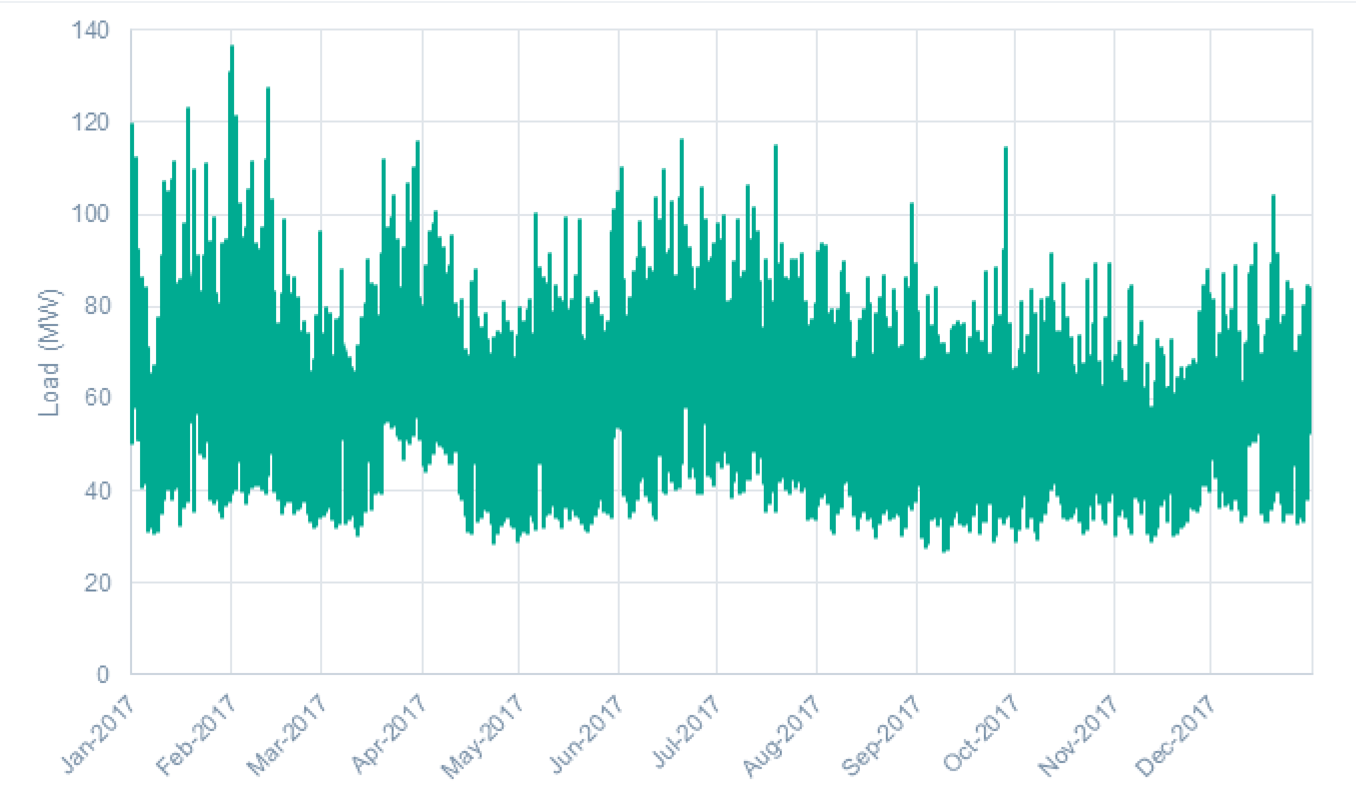
19 The impact of Directlink's individual pole's availability is taken into account by deriving weightings for different pole availability configuration using historical performance.

Parameter	2019/20	2020/21	2021/22	2022/23	2023/24	2024/25
Load at Risk without[20] Directlink and N-1 outages (MW)	65	65	65	65	65	65
DM required (MW)	10-20	10-20	10-20	10-20	10-20	10-20

The Lismore SVC is predominantly required for voltage stability during peak demand periods, which typically occur during summer. However, if Directlink poles or other transmission lines are unavailable, the Lismore SVC plays a greater role in maintaining voltage stability.

TransGrid determines that the non-network option would be required approximately 15-20 times throughout the year, for a total period of 67 hours per year when all Directlink poles are available. Without any Directlink poles available, the load reduction would be required all year round for a total of 4400 hours per year Lismore area load profile is shown in Figure 4-1.

Figure 4-1 – Lismore area load profile, calendar year 2017



4.1.2 Location of the required network support

The non-network option would need to be located in the Lismore area, with the relevant Essential Energy distribution zones listed in Table 4-2.

[20] The impact of Directlink's individual pole's availability is taken into account by deriving weightings for different pole availability configuration using historical performance.

Table 4-2 – Essential Energy zone substations

Areas			
Alstonville	Dunoon	Lennox Head	Lismore South
Ballina	Ewingsdale	Lismore 132/66kV	Lismore University
Ballina 132kV	Kyogle	Lismore East	Mullumbimby

4.2 Cost of non-network options

To be commercially feasible, non-network options must efficiently defer a credible option, efficiently reduce the risk of prolonged involuntary load shedding, and have higher net economic benefits than the network option.

The total cost of the non-network option will be evaluated against the reduction in the cost of prolonged involuntary load shedding that it is able to address.

TransGrid calculates that the maximum deferment benefit for Option 1 is relatively low (approximately $680,000 per year) compared to the yearly risk costs of involuntary load shedding. This translates to non-network options needing to cost below approximately $28/kW, for a minimum of 15 MW from 2019/20 to effectively address the need and defer Option 1.

4.3 Information to be included in non-network option proposals

The proposed option must be large enough collectively to reduce the loading on the transmission network during line outages. To manage a complex portfolio of demand management of sufficient scale, we require the proposed options to provide a minimum aggregated capacity of 5 MW. TransGrid may choose to select a subset of non-network options it determines to be most economical and reliable.

The proposed options must be reliably dispatched, immediately in a post-contingent scenario, using proven technology. Over a sustained period, a longer day ahead notification period is likely.

The table below sets out the parameters that TransGrid request parties nominate in any proposal.

Table 4-3 – Parameters description

Parameter	Description
Block ID	Block Identifier (eg Block 1) of non-network option
Block capacity	Discrete amount of the non-network option (reduced load or additional supply) capacity in kW. Sum of block capacities must meet a minimum requirement of 5 MW. TransGrid may choose to select a subset of blocks it determines that is most economical and reliable to dispatch.
Location	For new generation solutions, details of the proposed sites for the new generators
Availability period	Period for that block is available within the operating profile (months/days/hours)
Call notice period	Minimum period of time before the block can be dispatched

Parameter	Description
Establishment fee	Setup payment that applies to a block
Availability fee	A fee per month for a block to be made available to be dispatched
Indicative dispatch Fee	Fee for a block to be dispatched per MWh
Timeframe for project delivery	When the block of DR will be available for dispatch
Communications	Proposed dispatch communications protocol with TransGrid's control room
Metering	Metering equipment installed or to be installed to measure and record the data to be verified

Proposals and queries relating to non-network options should be emailed to RIT-TConsultations@transgrid.com.au or by telephone to 02 9284 3354.

5. Materiality of market benefits

5.1 Reduction in involuntary load shedding

Involuntary load shedding is where a customer's load is interrupted from the network without their agreement or prior warning. TransGrid determines there is reduction in potential prolonged involuntary load shedding by implementing Option 1.

TransGrid has employed Essential Energy DAPR's[21] forecast load over the assessment period to quantify the prolonged involuntary load shedding by comparing forecast load to network capabilities based upon aggregate transmission line failure and mean time to repair, consistent with IPART's methodology.

5.2 Other wholesale market benefits are not expected to be material

The AER has recognised that if the credible options considered will not have an impact on the wholesale electricity market, then a number of classes of market benefits will not be material in the RIT-T assessment, and so do not need to be estimated.[22]

TransGrid determines that the credible options considered in this RIT-T will not have an impact on the wholesale electricity market, therefore considers that the following classes of market benefits are not material for this RIT-T assessment:

- changes in fuel consumption arising through different patterns of generation dispatch
- changes in voluntary load curtailment (since there is no impact on pool price)
- changes in costs for parties other than the RIT-T proponent
- changes in ancillary services costs
- changes in network losses
- competition benefits
- Renewable Energy Target (RET) penalties.

5.3 No other categories of market benefits are material

In addition to the classes of market benefits listed above, NER clause 5.16.1(c)(4) requires TransGrid to consider the following classes of market benefits, listed in Table 5-1, arising from each credible option.

The same table sets out the reason TransGrid considers these classes of market benefits to be immaterial.

[21] Essential Energy. "*Asset Management Distribution Annual Planning Report 2018*." Port Macquarie: Essential Energy, 2018. Accessed 15 March 2019. https://www.essentialenergy.com.au/-/media/Project/EssentialEnergy/Website/Files/Our-Network/DAPR-2018.pdf?la=en&hash=12E10DC581DAEE38038061F4596C03F6BF2EF874

[22] Australian Energy Market Operator. *"Power System Security Guidelines, 31 December 2018."* Melbourne: Australian Energy Market Operator, 2018. Accessed 20 March 2019. https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715---Power-System-Security-Guidelines.pdf

Table 5-1 – Reasons non-wholesale market benefit categories are considered immaterial

Market benefits	Reason
Differences in the timing of expenditure	Option 1 is being undertaken to mitigate rising risk due to deteriorating asset condition and as the SVC is an existing asset, material market benefits will neither be gained nor lost due to timing of expenditure.
Option value	TransGrid notes the AER's view that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available is likely to change in the future, and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[23] TransGrid also notes 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. TransGrid notes that no credible option is sufficiently flexible to respond to change or uncertainty. Additionally, a significant modelling assessment would be required to estimate the option value benefits but it would be disproportionate to potential additional benefits for this RIT-T. Therefore, TransGrid has not estimated additional option value benefit.

[23] Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018. Accessed 15 March 2019. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

6. Overview of the assessment approach

As outlined in section 3.1, all costs and benefits considered have been measured against a base case.

The analysis presented in this RIT-T considered a 20-year period, from 2018/19 to 2038/39. TransGrid considers that a 20-year period takes into account the size, complexity and expected service life of the options and provide a reasonable indication of the costs and benefits over a long outlook period. Since the capital components have asset lives greater than 20 years, TransGrid has taken a terminal value approach to ensure that the capital costs of those assets are appropriately captured in the 20-year assessment period.

TransGrid has adopted a central real, pre-tax 'commercial'[24] discount rate of 5.9%[25] as the central assumption for the NPV analysis presented in this report. TransGrid considers that this is a reasonable contemporary approximation of a commercial discount rate, consistent with the RIT-T.

TransGrid has also tested the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 4.60% equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PSCR,[26] and an upper bound discount rate of 7.2% (a symmetrical adjustment upwards) are investigated.

6.1 Approach to estimating project costs

TransGrid has estimated the capital costs of the options by using scope from similar works. TransGrid considers the central capital costs estimates to be within ± 25% of the actual costs.

Routine operating and maintenance costs are based on similar to works of similar nature.

Reactive maintenance costs under the base case considers the:

> level of corrective maintenance required to restore assets to working order following a failure
> probability and expected level of network asset faults.

In either credible option, the asset failures are less frequent and restoration costs are reduced.

6.2 Three different 'scenarios' have been modelled to address uncertainty

RIT-T assessments are based on cost-benefit analysis that includes assessment under reasonable scenarios which are designed to test alternate sets of key assumptions and their impact on the ranking and feasibility of options.

TransGrid has considered three alternative scenarios, summarised in Table 6-1, to address uncertainty – namely:

> a 'low net economic benefits' scenario, involving a number of assumptions that gives a lower bound and conservative estimates of net present value of net economic benefits
> a 'central' scenario which consists of assumptions that reflect TransGrid's central set of variable estimates that provides the most likely scenario

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24 The use of a 'commercial' discount rate is consistent with the RIT-T and is distinct from the regulated cost of capital (or 'WACC') that applies to network businesses like TransGrid.

25 Electricity Networks Association. *"RIT-T Economic Assessment Handbook."* Melbourne: Electricity Networks Association, 2019. Accessed 15 March 2019. https://www.energynetworks.com.au/sites/default/files/ena_rit-t_handbook_15_march_2019.pdf

26 See TransGrid's Post-tax Revenue Model (PTRM) for the 2018-23 period, available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/transgrid-determination-2018-23

- a 'high net economic benefits' scenario that reflects a set of assumptions which have been selected to investigate an upper bound of net economic benefits.

Table 6-1 – Summary of the scenarios

Variable/Scenario	Central	Low net economic benefits	High net economic benefits
Scenario weighting	*50%*	*25%*	*25%*
Network capital costs	Base estimate	Base estimate +25%	Base estimate -25%
Discount rate	5.9%	7.2%	4.6%
VCR	$40/kWh	$28/kWh	$52/kWh
Demand forecast	POE50	POE90	POE10
Avoided corrective maintenance costs	Base estimate	Base estimate - 25%	Base estimate + 25%

TransGrid considers that the central scenario is most likely since it is based primarily on a set of expected assumptions. TransGrid has therefore assigned this scenario a weighting of 50%, with the other two scenarios being weighted equally with 25% each.

7. Assessment of credible options

7.1 Estimated gross benefits

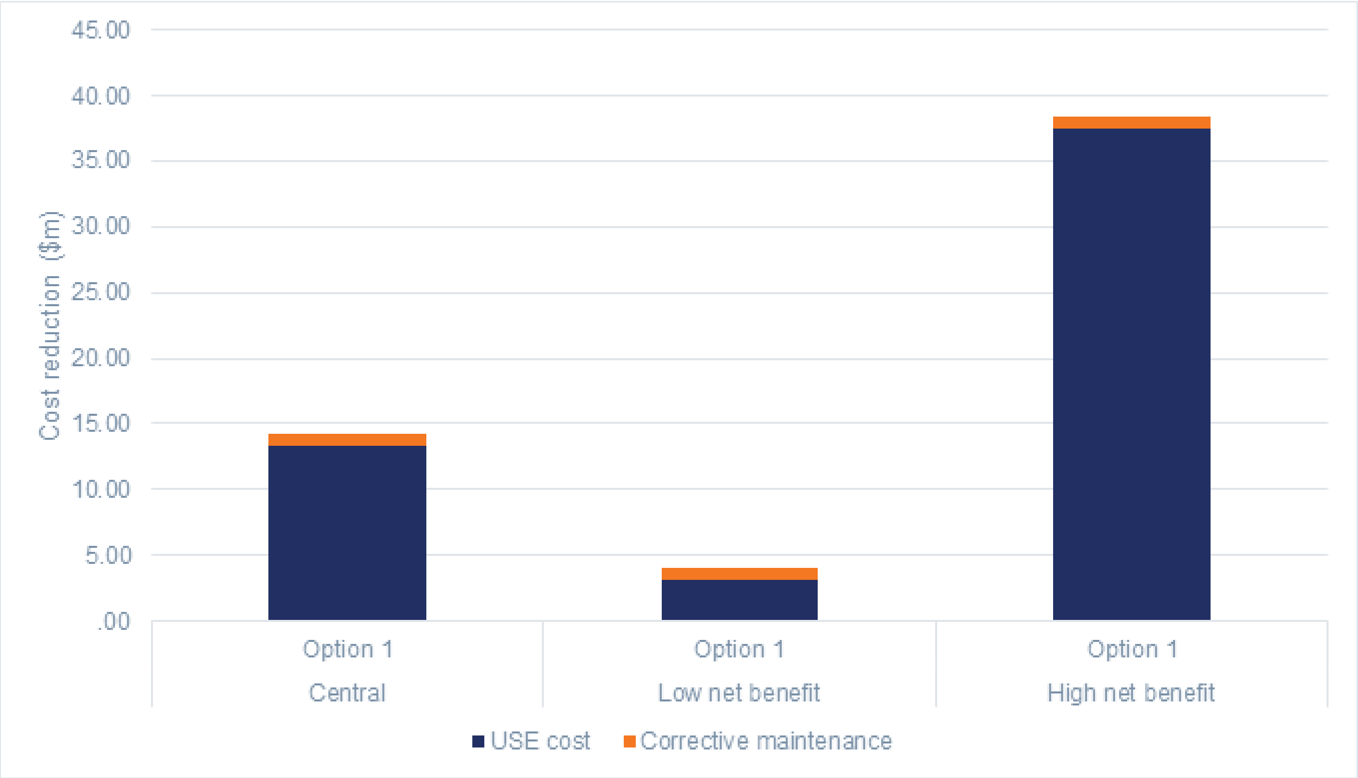
Table 7-1 below summarises the present values of gross economic benefits estimated for each credible option under the three scenarios.

Table 7-1 – Present value of the gross economic benefits for each credible option relative to the base case, 2017/18 $m

Option/scenario	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	13.2	3.0	37.5	16.8

The figure below provides a breakdown of benefits estimated for Option 1, showing almost all the benefits for the option is generated by reduced risk of prolonged involuntary load shedding in the Far North Coast.

Figure 7-1 – Breakdown of gross economic benefits of Option 1 relative to the base case, PV 2017/18 $m



7.2 Estimated costs

Table 7-2 summarises the present value of costs of Option 1 relative to the base case under the three scenarios net of costs.

Table 7-2 – Present value of costs of Option 1 relative to the base case, PV 2017/18 $m

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	9.6	11.8	7.3	9.6

7.3 Estimated net economic benefits

Table 7-3 summarises the present value of the net economic benefits for Option 1 across the three scenarios and the weighted net economic benefits. These net economic benefits are the differences between the estimated gross benefits less the estimated costs.

Option 1 is found to have the positive net economic benefits for the central and high net economic benefits scenarios. While the net economic benefits are negative under the low net economic benefits scenario, TransGrid notes that this scenario comprises an extreme combination parameters including low avoided involuntary load shedding and high capital costs. Any divergence from the assumptions on the low net economic benefits scenario will only increase the estimated net economic benefits

On a weighted basis, Option 1 will deliver approximately $7.1 million in net economic benefits.

Table 7-3 – Present value of the net economic benefits for each credible option relative to the base case, 2017/18 $m

Option	Central	Low net economic benefits	High net economic benefits	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	3.6	-8.7	30.2	7.1

7.4 Sensitivity testing

TransGrid has undertaken thorough sensitivity testing exercise to understand the robustness of the conclusion to underlying assumptions about key variables. These are implemented in stages.

> Step 1 – tests the sensitivity of the optimal timing of the project ('trigger year') to different assumptions on key variables

> Step 2 – once a trigger year is determined, tests the sensitivity of the NPV of net economic benefits to different assumptions on key variables such as lower or higher involuntary load shedding risks.

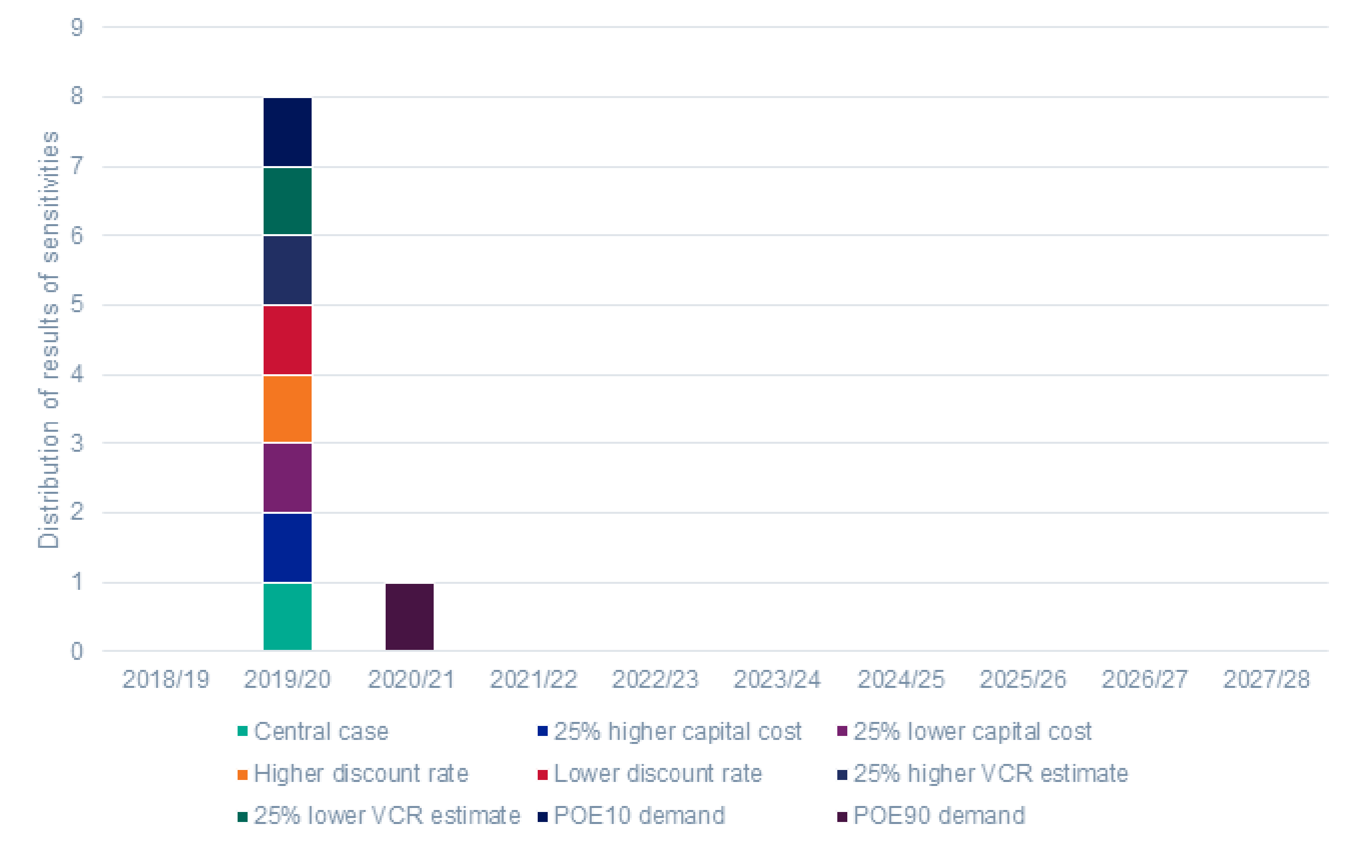
7.4.1 Step 1 – Sensitivity of optimal timing

The optimal timing for Option1 is the year in which the NPV of net economic benefits is maximised. Shown on Figure 7-2, the optimal timing is 2019/20 and is found to be invariant between the central set of assumptions and a range of alternative assumptions for the following key variables:

> a 25% increase/decrease in the assumed network capital costs
> higher and lower discount rates (7.2% and 4.60%)
> higher and lower demand forecasts (POE10 and POE90)

The figure below illustrate the distribution of the optimal commissioning year for each of the options under for the sensitivities set out above.

Figure 7-2 – Distribution of optimal project commissioning year for Option 1 under each sensitivity

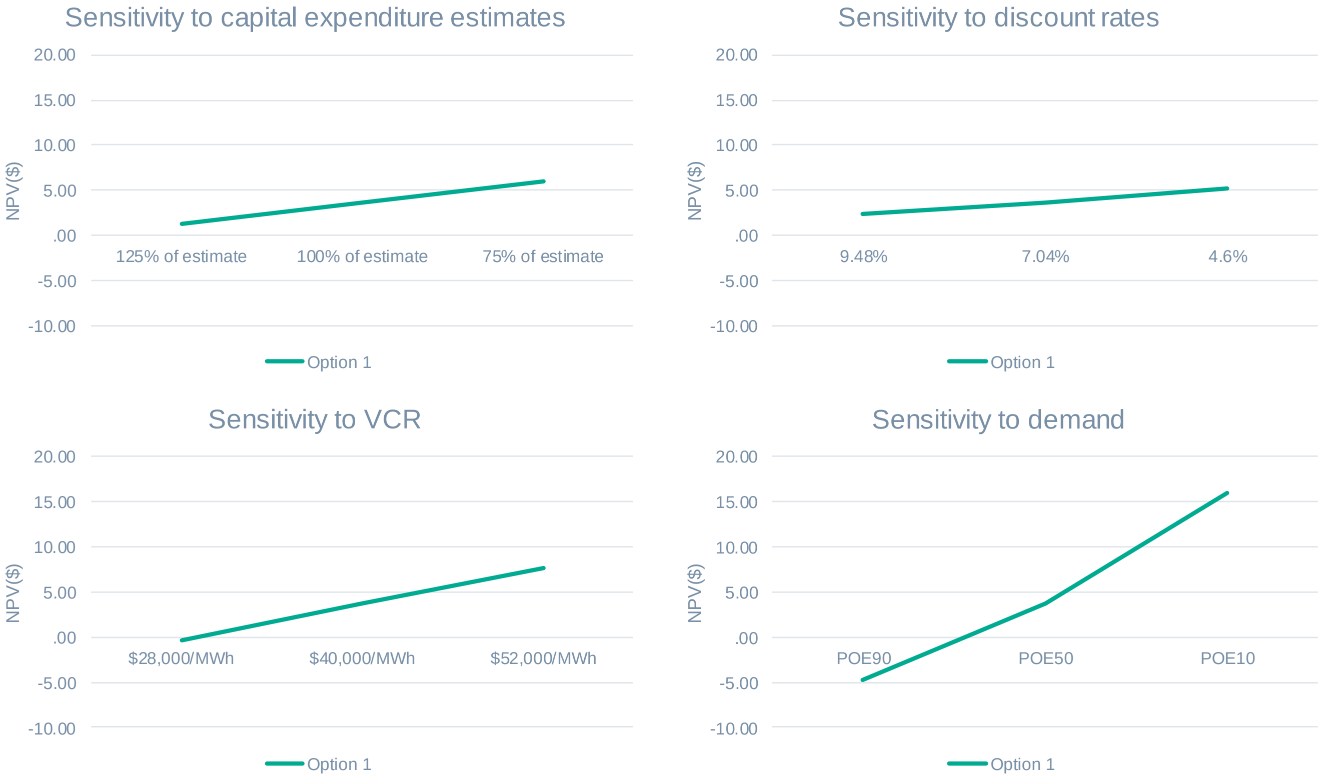


7.4.2 Step 2 – Sensitivity of the overall net market benefit

TransGrid has also conducted sensitivity analysis around the NPV of the net economic benefits assuming the optimal timing established in Step 1. TransGrid has investigated the same sensitivities as in Step 1.

The figures below illustrate that for all sensitivity tests, the estimated net economic benefits of Option 1 are found to be positive and are consistent. While it also shows that the results are most sensitive to the demand, TransGrid considers it extremely unlikely that the central estimate of demand would fall to this level.

Figure 7-3 – Sensitivities of net present value of net economic benefits of each option from the central case



8. Draft conclusion

The significant net economic benefits from Option 1, refurbishment of the existing SVC control system, are approximately $7.1 million. This makes Option 1 preferable over other options at this draft stage.

Option 1 involves the refurbishment of the existing SVC control system. The new control system, which has expected technical life of 20 years, would fully utilise the expected technical life of the entire SVC.[27]

The refurbishment work will be undertaken over the three-year period until 2020/21, with all works will be completed by 2021/22. The table below outlines the proposed program of work for Option 1.

Table 8-1 – Proposed program of work for Option 1

Dismantling:	Installing:
The control and protection system cubicles	A completely new control system, protection system, GPS, fault recorder and HMI
The thyristor valves and valve base electronics for the thyristor controlled reactor (TCR)	A new thyristor valve and valve base electronics for the TCR
The thyristor valves and valve base electronics for the two thyristor switched capacitors (TSC)	Completely new thyristor valves and valve base electronics for the two TSCs
The cooling water system main components, the cooling pump units, valve cooling units, piping and cooling system controllers	New cooling water system main components, cooling water pump units, valve cooling units, piping and cooling system controllers

The estimated nominal capital cost of this option is approximately $11.87 million (weighted present value of $9.6 million). Routine and operating maintenance costs are approximately $19,000 in 2018/19.

Publication of a Project Assessment Draft Report (PADR) is not required for this RIT-T as TransGrid considers its investment in relation to the preferred option to be exempt from that part of the process as per NER clause 5.16.4(z1). Therefore, the next step in this RIT-T, following consideration of submissions received during the 12-week consultation period and any further analysis required, will be publication of a Project Assessment Conclusions Report (PACR). TransGrid anticipates publication of a PACR by 26 September 2019.

TransGrid determines that this project is exempt producing a PADR as involuntary load shedding is the only class of market benefit material to this RIT-T.

TransGrid welcomes written submissions on materials contained in this PSCR. Submissions are due on or before 26 August 2019. Submissions should be emailed to TransGrid's Prescribed Revenue & Pricing team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'Lismore SVC project.'

NER clause 5.16.4(z1) provides for a TNSP to be exempt from producing a PADR for a particular RIT-T application, in the following circumstances:

(a) if the estimated capital cost of the preferred option is less than $43 million;

(b) if the TNSP identifies in its PSCR its proposed preferred option, together with its reasons for the preferred option and notes that the proposed investment has the benefit of the clause 5.16.4(z1) exemption; and

[27] SVC primary components typically have a technical life expectancy of 40 to 50 years

(c) if the TNSP considers that the proposed preferred option and any other credible options in respect of the identified need will not have a material market benefit for the classes of market benefits specified in clause 5.16.1(c)(4), with the exception of market benefits arising from changes in voluntary and involuntary load shedding.

TransGrid considers that the preferred option is exempt from producing a PADR under NER clause 5.16.4(z1).

In accordance with NER clause 5.16.4(z1)(4), the exemption from producing a PADR will no longer apply if TransGrid considers that an additional credible option that could deliver a material market benefit is identified during the consultation period.

Accordingly, if TransGrid considers that any additional credible options are identified, TransGrid will produce a PADR which includes an NPV assessment of the net economic benefits of each additional credible option.

Should TransGrid consider that no additional credible options were identified during the consultation period, TransGrid intends to produce a PACR that addresses all submissions received including any issues in relation to the proposed preferred option raised during the consultation period.[28]

[28] As per clause 5.16.4(z2) of the NER.

Appendix A – Compliance checklist

This appendix 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 111.

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;	2
	(2) the assumptions used in identifying the need (including, in the case of proposed reliability corrective action, why the RIT-T proponent considers reliability corrective action is necessary);	2
	(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;	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;	3
	(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 inter-network 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 benefits are not likely to be material; (iv) the estimated construction timetable and commissioning date; and	3 & 5

	(v) to the extent practicable, the total indicative capital and operating and maintenance costs.	
5.16.4(z1)	A RIT-T proponent is exempt from paragraphs (j) to (s) if: 1. the estimated capital cost of the proposed preferred option is less than $35 million (as varied in accordance with a cost threshold determination); 2. the relevant Network Service Provider has identified in its project specification consultation report: (i) its proposed preferred option; (ii) its reasons for the proposed preferred option; and (iii) that its RIT-T project has the benefit of this exemption; 3. the RIT-T proponent considers, in accordance with clause 5.16.1(c)(6), that the proposed preferred option and any other credible option in respect of the identified need will not have a material market benefit for the classes of market benefits specified in clause 5.16.1(c)(4) except those classes specified in clauses 5.16.1(c)(4)(ii) and (iii), and has stated this in its project specification consultation report; and 4. the RIT-T proponent forms the view that no submissions were received on the project specification consultation report which identified additional credible options that could deliver a material market benefit.	8