TransGrid

Maintaining a reliable Static Var Compensator at Lismore

RIT-T – Project Assessment Conclusions Report

Region: Northern

Date of issue: 17 December 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 Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

TransGrid's analysis indicates that the control system component of the SVC at Lismore has reached a condition that reflects the end of serviceable life. This assessment followed an increase in frequency of failure of the SVC over the last few years.

Between 1 August 2018 and 28 February 2019, the SVC was unavailable for approximately 59% of the time as a result of failures of the control component. TransGrid published a Project Specification Consultation Report (PSCR) in May 2019 which noted the most recent failure of the asset at that time which resulted in the SVC being out of service between November 2018 and January 2019 for a period of 58 days. Since publication of the PSCR, a subsequent failure has occurred resulting in the SVC being out of service between August and November for a period of 27 days.

As the existing control system component is superseded by new technology at the manufacturer level and the existing technology becomes obsolete, spare parts become scarce and it is impossible to operate the SVC to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 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 positive net economic benefits, TransGrid considers this a 'market benefit'-driven RIT-T.

No submissions received in response to Project Specification Consultation Report

TransGrid published a Project Specification Consultation report (PSCR) on 27 May 2019 and invited written submissions on the material presented within the document. No submissions were received in response to this PSCR.

The PSCR presented a range of credible network options that would meet the identified need from a technical, commercial, and project delivery perspective.[1] The options are summarised in the table below.

All costs presented in this PACR are in 2019/20 dollars.

1 As per clause 5.15.2(a) of the NER.

Table E-1 Summary of the three credible options considered ($2019/20)

Option	Description	Capital cost ($m)	Operating costs ($ per year)	Remarks
Option 1	Refurbish the existing SVC control system	12.1 ± 25% (1.6m in 2019/20 9.9m in 2020/21 0.6m in 2021/22)	~44,000	Most economical and preferred option
Option 2	Complete SVC replacement	> 28	~44,000	Not progressed as uneconomical due to significant cost
Option 3	New transmission line from Dumaresq to Lismore	~ 210	~400,000	Not progressed as uneconomical due to significant cost

As part of this consultation process, TransGrid encouraged interested parties to make submissions regarding non-network options that satisfy, or contribute to satisfying, the identified need. In the PSCR, TransGrid outlined the technical characteristics required for a non-network option to address the expected involuntary load shedding when remediation options either do not proceed or are delayed.

No submissions were received regarding non-network options throughout the consultation period.

Conclusion: refurbishment of the existing SVC control system is optimal

The optimal commercially and technically feasible option presented in the PSCR — Option 1, the refurbishment of the existing SVC control system — remains the preferred option to meet the identified need.

Option 1 involves the refurbishment of the existing SVC control system. The scope of works proposed under Option 1 is outlined in section 3.2 of this PACR.

The implementation of Option 1 will bring significant net economic benefits of approximately $14.8 million. The new control system, which has expected technical life of 20 years, would fully utilise the expected technical life of the entire SVC.[2]

Moving forward with this option is the most prudent and economically efficient solution to maintain a reliable SVC at Lismore.

The estimated capital expenditure associated with this option is $12.1 million ± 25%.

The works will be undertaken between 2019/20 and 2021/22. Planning and procurement (including completion of the RIT-T) will occur between 2019/20 and 2020/21, while the delivery and replacement of the identified assets is planned to occur during 2020/21 and all works will be completed by 2021/22.

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

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

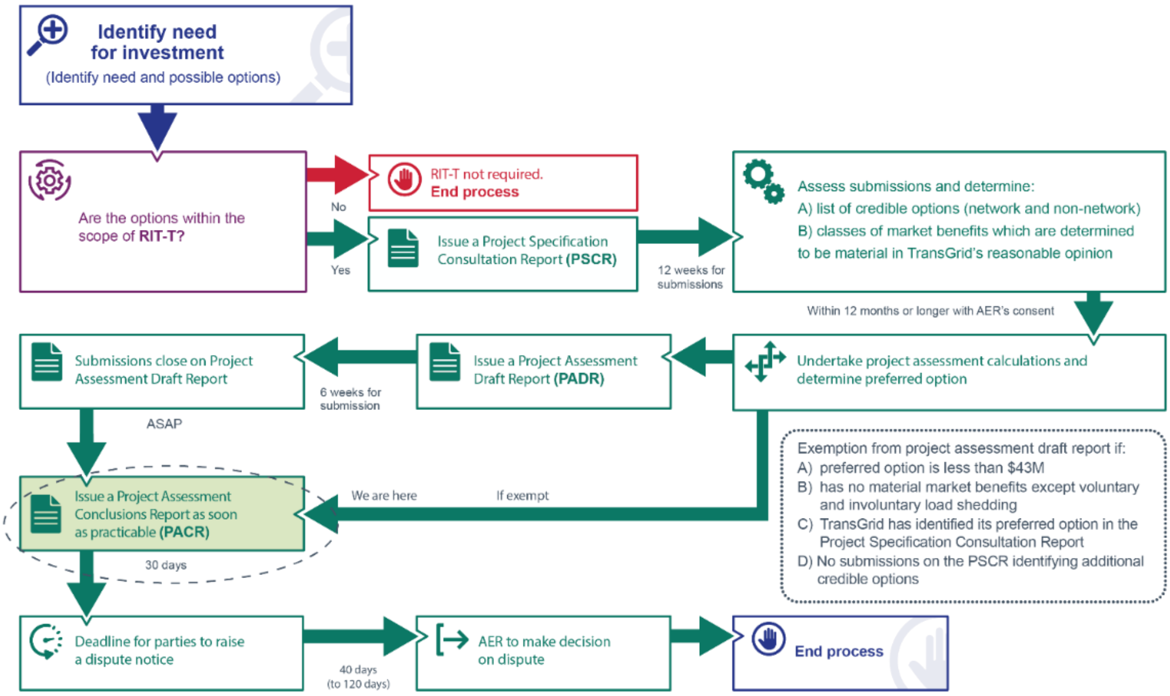
Next steps

This PACR represents the third step in a formal Regulatory Investment Test for Transmission (RIT-T) process undertaken by TransGrid. It follows a Project Specification Consultation Report (PSCR) released in May 2019. The second step, production of a Project Assessment Draft Report (PADR), was not required as TransGrid considered its investment in relation to the preferred option to be exempt from this part of the RIT-T process under NER clause 5.16.4(z1). Production of a PADR was not required due to:

> preferred option being less than $43 million
> no material market benefits except voluntary load curtailment and involuntary load shedding
> preferred option has been identified in the PSCR
> no submissions on the PSCR identifying additional credible options.

This project was exempt from producing a PADR as involuntary load shedding is the only class of benefit material to this RIT-T. This PACR represents the third stage of the consultation process for this RIT-T.

Figure E-1 This PACR is the third stage of the RIT-T process[3]



Parties wishing to raise a dispute notice with the AER may do so prior to 20 January 2020 (30 days after publication of this PACR[4]). Any dispute notices raised during this period will be addressed by the AER within 40 to 120 days, after which the formal RIT-T process will conclude.

Further details on the project can be obtained from TransGrid's Regulation team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'PACR Lismore SVC project'.

[3] Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.65. Accessed 19 November 2019. https://www.aemc.gov.au/sites/default/files/content/89fbf559-2275-4672-b6ef-c2574eb7ce05/Final-rule-determination.pdf

[4] Additional days have been included to cover public holidays.

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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 Assessment Conclusions Report (PACR) represents the final step in the RIT-T process.

The corresponding Project Specification Consultation Report (PSCR) released in May 2019 presented:

- reasons TransGrid proposed that action be taken
- credible options TransGrid considered to address the identified need
- technical characteristics required for a non-network option to address the expected involuntary load shedding when remediation options either do not proceed or are delayed
- an opportunity for proponents of potential non-network solutions to make submissions.

No submissions were received in response to the PSCR.

1.1 Purpose of this report

The purpose of this PACR[5] is to:

- describe the identified need
- describe and assess credible options to meet the identified need
- describe the assessment approach used
- provide details of the proposed preferred option to meet the identified need.

1.2 Next steps

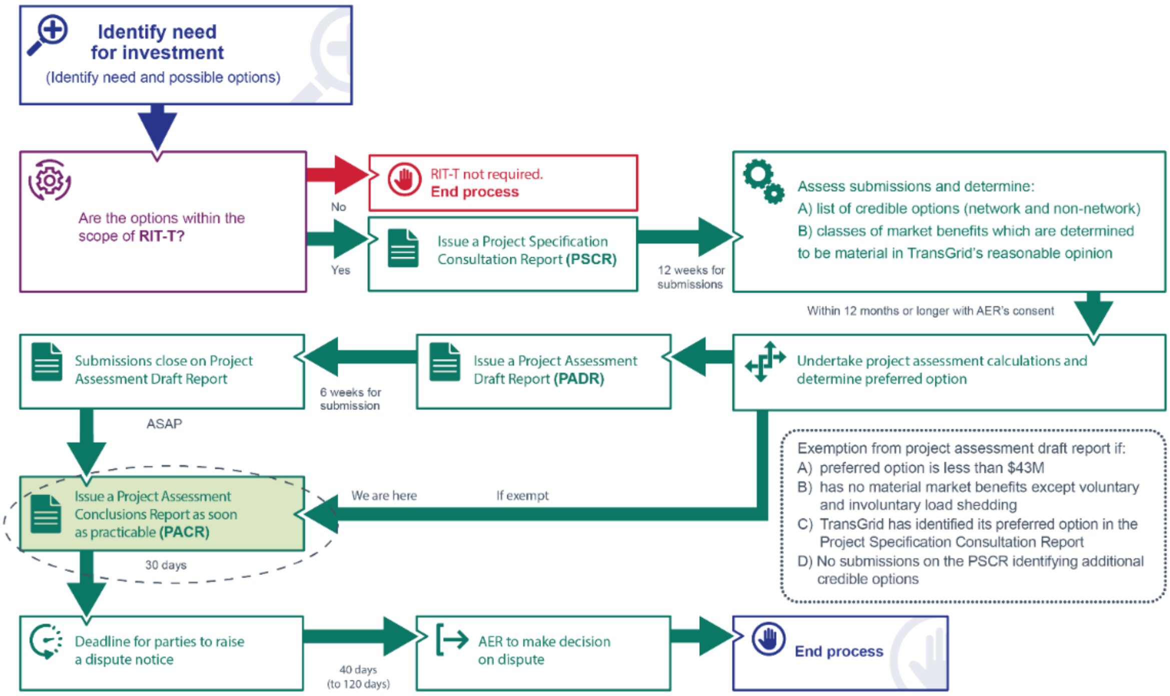
This PACR represents the third step in a formal Regulatory Investment Test for Transmission (RIT-T) process undertaken by TransGrid. It follows a Project Specification Consultation Report (PSCR) released in May 2019. The second step, production of a Project Assessment Draft Report (PADR), was not required as TransGrid considered its investment in relation to the preferred option to be exempt from this part of the RIT-T process under NER clause 5.16.4(z1). Production of a PADR was not required due to:

- preferred option being less than $43 million
- no material market benefits except voluntary load curtailment and involuntary load shedding
- preferred option has been identified in the PSCR
- no submissions on the PSCR identifying additional credible options.

This project was exempt from producing a PADR as involuntary load shedding is the only class of benefit material to this RIT-T. This PACR represents the third stage of the consultation process for this RIT-T.

[5] See Appendix A for the National Electricity Rules requirements.

Figure 1-1 This PACR is the third stage of the RIT-T process[6]



Parties wishing to raise a dispute notice with the AER may do so prior to 20 January 2020 (30 days after publication of this PACR[7]). Any dispute notices raised during this period will be addressed by the AER within 40 to 120 days, after which the formal RIT-T process will conclude.

Further details on the project can be obtained from TransGrid's Regulation team via RIT-TConsultations@transgrid.com.au. In the subject field, please reference 'PACR Lismore SVC project'.

TransGrid intends to undertake refurbishment works between 2018/19 and 2020/22. Planning and procurement will occur between 2019/20 and 2020/21 and project delivery and construction will occur in 2020/21. All works will be completed by 2021/22.

[6] Australian Energy Market Commission. "*Replacement expenditure planning arrangements, Rule determination*". Sydney: AEMC, 18 July 2017.65. Accessed 19 November 2019. https://www.aemc.gov.au/sites/default/files/content/89fbf559-2275-4672-b6ef-c2574eb7ce05/Final-rule-determination.pdf

[7] Additional days have been included to cover public holidays.

2. The identified need

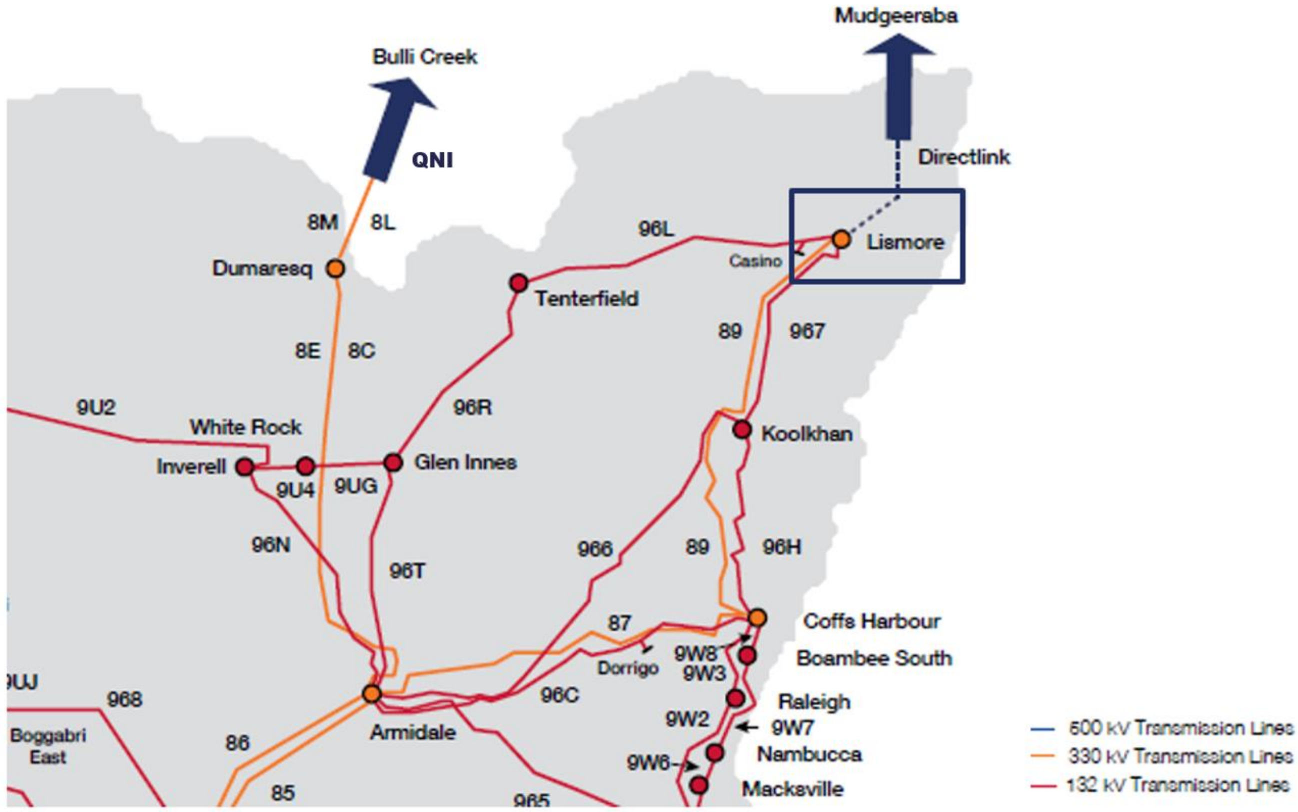
2.1 Background

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.[8] The load in Lismore is predominantly residential and industrial, while neighbouring Dunoon and Mullumbimby are predominantly agricultural and residential loads.[9] The peak load for the Lismore area is approximately 140 MW.[10]

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

Figure 2-1 Northern NSW transmission network



8 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

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

10 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

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.

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.

2.2 Description of the identified need

As part of the Network Asset Risk Assessment Methodology[11], TransGrid's analysis indicates that the control system component of the SVC at Lismore has reached a condition that reflects the end of serviceable life. This assessment followed an increase in frequency of failure of the SVC over the last few years.

Between 1 August 2018 and 28 February 2019, the SVC was unavailable for approximately 59% of the time as a result of failures of the control component. TransGrid published a Project Specification Consultation Report (PSCR) in May 2019 which noted the most recent failure of the asset at that time which resulted in the SVC being out of service between November 2018 and January 2019 for a period of 58 days. Since publication of the PSCR, a subsequent failure has occurred resulting in the SVC being out of service between August 2019 and November 2019 for a period of 27 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.

[11] Refer to Appendix B – B.1 for a summary of TransGrid's Risk Assessment Methodology.

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. 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[12] 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 30.8 MWh[13] of prolonged involuntary load shedding per year or approximately $1.2 million[14] per year may result from failure or limitation of these interim voltage management solutions when the SVC at Lismore is out of service. This increases over time as the failure rate of the SVC increases.

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

TransGrid’s analysis concludes that the weighted net economic benefits under Option 1 are estimates at $14.8 million. Most of these benefits come from avoided costs associated with prolonged involuntary load shedding, safety and environmental risks. Categorised as ‘market-benefit’-driven under the RIT-T, the proposed investment will enable TransGrid to maintain a reliable SVC at Lismore.

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12 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

13 Probability based involuntary load shedding in Lismore region.

14 The cost of load shedding is calculated by using AEMO VCR value. See Appendix B – B.5

3. Options that meet the identified need

In identifying the refurbishment of the existing line as a credible option, TransGrid took the following factors into account: energy source; technology; ownership; the extent to which the option enables intra-regional or inter-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]

Of the credible options considered[16] and summarised in Table 3-1, the optimal timing for the most efficient option (Option 1: the refurbishment of the existing SVC control system) that meets the identified need to mitigate the asset risks is before 2021/22.

TransGrid did not receive any responses to the PSCR.

All costs presented in this PACR are in 2019/20 dollars.

Table 3-1 Summary of the credible options ($2019/20)

Option	Description	Capital costs ($m)	Operating costs ($ per year)	Remarks
Option 1	Refurbish the existing SVC control system	12.1 ± 25% (1.6m in 2019/20 9.9m in 2020/21 0.6m in 2021/22)	~44,000	Most economical and preferred option
Option 2	Complete SVC replacement	> 28	~44,000	Not progressed as uneconomical due to significant cost
Option 3	New transmission line from Dumaresq to Lismore	~ 210	400,000	Not progressed as uneconomical due to significant cost

3.1 Base case

The costs and benefits of each option in this PACR were compared against those of a base case[17]. Under this base case, no proactive capital investment is made. Lismore SVC will continue to operate and be maintained under the current regime.

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15 In accordance with the requirements of NER clause 5.15.2(b).

16 As per clause 5.15.2(a) of the NER.

17 As per the RIT-T Application Guidelines, the base case provides a clear reference point for comparing the performance of different credible options. Australian Energy Regulator. *"Application guidelines Regulatory Investment Test for Transmission - December 2018."* Melbourne: Australian Energy Regulator, 2018. Accessed 1 August 2019. 22. https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf

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

Annual maintenance costs are approximated at $117,000 per year inclusive of routine operating expenditure[18] (approximately $44,000 per year) and corrective maintenance (approximately $97,000 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. This increases over time as the failure rate of the SVC increases.

Table 3-3 provides the breakdown of routine operating expenditure for the Base Case.

Table 3-2 Operational expenditure breakdown for Lismore SVC under Base Case ($ 2019/20)

Item	Expenditure
Monthly SVC Inspections	10.40k
Quarterly SVC Inspections	7.59k
Yearly SVC Inspection	26.00k
Total	**43.99k**

3.2 Option 1 – Refurbishment of 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.[19] The scope of works for Option 1 is outlined in the table below. Table 3-3 summarises the refurbishment works under Option 1.

Table 3-3 Refurbishment works for Lismore SVC under 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

18 The planned operating costs included in the NPV analysis presented in this PACR are comprised of routine maintenance costs for all options and reactive maintenance costs for the base case only. The routine maintenance costs include routine inspections but do not include costs associated with remediating defects detected during inspection. The severity of defects are expected to increase if a technically and commercially feasible option is not implemented in sufficient time to meet the identified need.

19 SVC primary components typically have a technical life expectancy of 40 to 50 years

The estimated capital cost associated with this option is approximately $12.1 million ± 25%. A breakdown of the estimated capital cost of Option 1 is shown in Table 3-4.

Table 3-4 Capital expenditure breakdown for Lismore SVC under Option 1 (2019/20 $m)

Item	Expenditure
SVC Control and Cooling System (dismantling and removal of existing equipment and installation of new system)	12.1
Total	**12.1 (± 25%)**

Routine operating and maintenance costs for Option 1 are approximately $44,000 per year (the same as the base case) – a breakdown of these costs is provided in Table 3-3. Corrective maintenance costs are expected to be negligible under Option 1.

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

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

The primary driver for the identified need is to maintain a reliable SVC at Lismore. Three other options to address the need were considered but were not progressed as they were not viable when assessed against the preferred option.

Table 3-5 summarises the reasons the following credible options were not progressed further.

Table 3-5 Options considered but not progressed

Option	Description	Reason(s) for not progressing
Option 2	Complete SVC replacement	TransGrid considered complete SVC replacement but as it will cost (>$28 million) significantly more than Option 1 without generating additional economic benefits, this option was not progressed any further.
Option 3	New transmission line from Dumaresq to Lismore	TransGrid considered a new transmission line from Dumaresq to Lismore would meet the identified need. This option was not 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 economic 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 is expected to have material inter-network impact[20]. 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[21]:

- 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 impact associated with Option 1 considered.

3.5 Non-network options

As part of this consultation process, TransGrid encouraged interested parties to make submissions regarding non-network options that satisfy, or contribute to satisfying, the identified need. In the PSCR, TransGrid outlined the technical characteristics required for a non-network option to address the expected involuntary load shedding when remediation options either do not proceed or are delayed.

No submissions were received regarding non-network options throughout the consultation period.

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20 As per clause 5.16.4(b)(6)(ii) of the NER.

21 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. Materiality of market benefits

The section outlines the categories of market benefits prescribed in the NER and whether they are considered material for this RIT-T.[22]

4.1 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[23] 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.

4.2 Other wholesale electricity market benefits are not 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 therefore do not need to be estimated.[24]

TransGrid determines that the credible options considered in this RIT-T will not have an impact on the wholesale electricity market and 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.

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22 The NER requires that all classes of market benefit identified in relation to the RIT-T are included in the RIT-T assessment, unless the TNSP can demonstrate that a specific class (or classes) is unlikely to be material in relation to the RIT-T assessment for a specific option – NER clause 5.16.1(c)(6). See Appendix A for requirements applicable to this document.

23 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

24 AER, *Final Regulatory Investment Test for Transmission Application Guidelines*, 18 September 2017, pp. 13-14. This was also reiterated in the recently updated AER RIT-T Guidelines, see: AER, *Final Regulatory Investment Test for Transmission Application Guidelines*, December 2018, pp.39.

4.3 No other classes 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 4-1, arising from each credible option.

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

Table 4-1 Reasons non-wholesale market benefit classes 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.[25] 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.

[25] 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

5. Overview of the assessment approach

This section outlines the approach that TransGrid has applied in assessing the net economic benefits associated with refurbishing the existing SVC control system at Lismore.

The analysis presented in the PSCR for this RIT-T was undertaken using an earlier discount rate[26] for the high and low benefit scenario and was undertaken using a price base of 2018/19 dollars which was current at the time of publication. The output of the NPV analysis has been converted to 2019/20 dollars. The timing of the capital costs have also been updated from being commissioned in 2020/21 to being commissioned in 2021/22.

All costs presented in this PACR are in 2019/20 dollars.

5.1 Overview of the assessment framework

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

The analysis presented in this RIT-T considered a 20-year period, from 2019/20 to 2040/41. TransGrid considers that a 20-year period takes into account the size, complexity and expected service life of the options and provides a reasonable indication of the costs and benefits over a long outlook period.

TransGrid adopted a central real, pre-tax 'commercial'[27] discount rate of 5.90% 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 also tested the sensitivity of the results to discount rate assumptions. A lower bound real, pre-tax discount rate of 2.85% equal to the latest AER Final Decision for a TNSP's regulatory proposal at the time of preparing this PACR[28], and an upper bound discount rate of 8.95% (a symmetrical adjustment upwards) were investigated.

5.2 Approach to estimating project costs

TransGrid 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 were based on similar works of similar nature.

Reactive maintenance costs under the base case considered the:

> level of corrective maintenance required to restore assets to working order following a failure

> probability and expected level of network asset faults.

The asset failures were less frequent and restoration costs were reduced in all credible options.

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[26] The commercial discount rate is calculated in the Energy Network Australia's (ENA) RIT-T Economic Assessment Handbook available at https://www.energynetworks.com.au/rit-t-economic-assessment-handbook Note the lower bound discount rate of 2.85% is based on the most recent final decision for a TNSP revenue determination which was TasNetworks in April 2019.

[27] 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.

[28] See TasNetworks' Post-tax Revenue Model (PTRM) for the 2019-24 period, available at: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/tasnetworks-determination-2019-24/final-decision

6. Assessment of credible options

There were no material changes since publication of the PSCR that affect the preference of Option 1.

The assessment compares the costs and benefits of the option to a base case where no proactive capital investment is made to remediate the deterioration of the Lismore SVC, and the asset will continue to operate with an increasing level of risk and be maintained under the current regime.

The analysis presented in the PSCR for this RIT-T was undertaken using an earlier discount rate for the high and low benefit scenario and was undertaken using a price base of 2018/19 dollars which was current at the time of publication. The output of the NPV analysis has been converted to 2019/20 dollars. The timing of the capital costs have also been updated from being commissioned in 2020/21 to being commissioned in 2021/22.

All costs presented in this PACR are in 2019/20 dollars.

6.1 Assessment under three different scenarios to address uncertainty

The assessment was conducted under three net economic benefits scenarios. These are plausible scenarios which reflect different assumptions about the future market development and other factors that are expected to affect the relative economic benefits of the options being considered. All scenarios (low, central and high) involve a number of assumptions that result in the lower bound, the expected, and the upper bound estimates for present value of net economic benefits respectively.

Table 6-1 Summary of scenarios

Variable/Scenario	Central	Low benefit scenario	High benefit scenario
Scenario weighting	*50%*	*25%*	*25%*
Network capital costs	Base estimate	Base estimate +25%	Base estimate -25%
Discount rate[29]	5.90%	8.95%	2.85%
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 therefore assigned this scenario a weighting of 50%, with the other two scenarios being weighted equally with 25% each.

29 Available at https://www.energynetworks.com.au/rit-t-economic-assessment-handbook Note the lower bound discount rate of 2.85% is based on the most recent final decision for a TNSP revenue determination which was TasNetworks in April 2019.

6.2 Estimated gross benefits

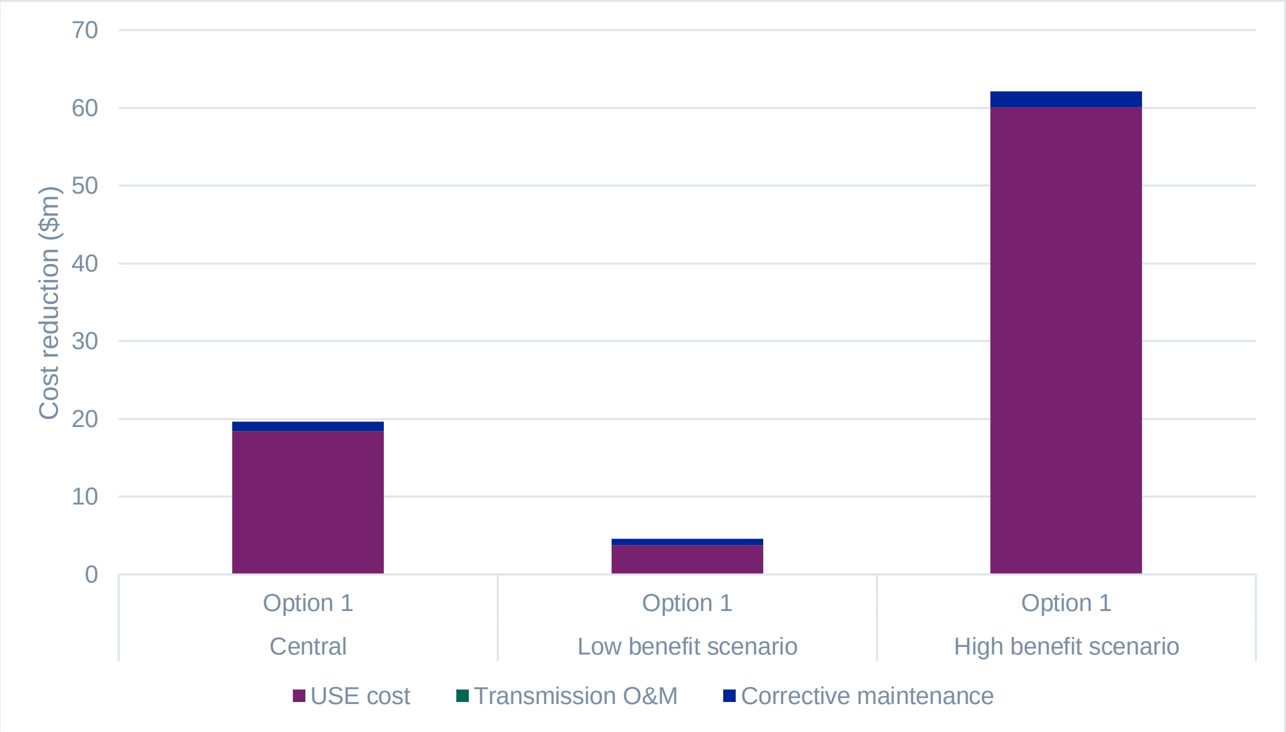
Table 6-2 summarises the present value of the gross benefit estimates for Option 1 relative to the base case under the three scenarios. It shows that in all scenarios, positive gross benefits result from implementing Option 1. These expected costs are weighted based on the probability of the event occurring.

Table 6-2 Gross benefits from credible options relative to the base case, present value ($m 2019/20)

Option/scenario	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	19.4	4.4	61.9	26.3

Figure 6-1 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 6-1 Components of gross benefits of credible options, present value ($m 2019/20)



6.3 Estimated costs

Table 6-3 summarises the present value of costs of Option 1 relative to the base case under the three reasonable scenarios.

Table 6-3 Costs of credible options relative to the base case, present value ($m 2019/20)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	11.5	14.0	8.9	11.5

6.4 Estimated net economic benefits

Table 6-4 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.

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

On a weighted basis, Option 1 will deliver $14.8 million in net economic benefits.

Table 6-4 Net economic benefits relative to the base case, present value ($m 2019/20)

Option	Central	Low benefit scenario	High benefit scenario	Weighted value
Scenario weighting	*50%*	*25%*	*25%*	
Option 1	7.9	-9.6	53.0	14.8

6.5 Sensitivity testing

TransGrid undertook a 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 discount rates.

6.5.1 Step 1 – Sensitivity testing of the optimal timing

The optimal timing for Option 1 is the year in which the NPV of net economic benefits is maximised. The following key sensitivities were undertaken on the central case:

> 25 per cent increase/decrease in the assumed network capital costs

> higher and lower discount rates (8.95% and 2.85%)

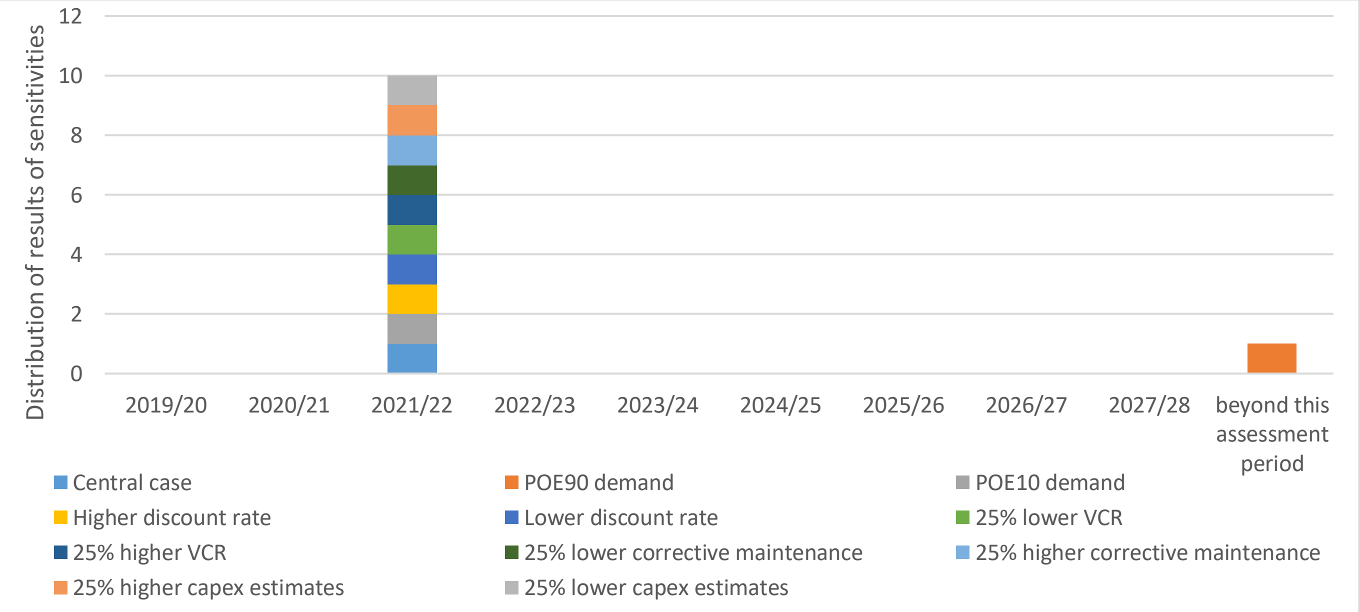
> higher and lower VCR estimates

> higher and lower demand forecasts (POE 10 and POE 90)

> Higher and lower corrective maintenance.

Shown on Figure 6-2, the optimal timing is 2021/22 and is found to be invariant between the central set of assumptions and a range of alternative assumptions (with the exception of the lower demand forecast (POE90) sensitivity which has a negative net economic benefit). While the optimal commissioning date is beyond the sensitivity assessment period for the lower demand forecast (POE90) sensitivity, TransGrid considers it extremely unlikely that the estimate of demand would fall to this POE90 level.

Figure 6-2 Distribution of optimal timing for Option 1 under each sensitivity



6.5.2 Step 2 – Sensitivity of the overall net economic benefit

TransGrid also conducted sensitivity analysis assuming the optimal timing and same sensitivities established 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, except for the low demand scenario (POE90). While it also shows that the results are most sensitive to the demand, TransGrid considers it extremely unlikely that the estimate of demand would fall to this POE90 level.

Figure 6-3 Sensitivity of the net economic benefits from Option 1 ($m 2019/20)

7. Final conclusion on the preferred option

The optimal commercially and technically feasible option presented in the PSCR, refurbishment of the existing SVC control system, remains the preferred option to meet the identified need. Option 1 will deliver approximately $14.8 million in net economic benefits and is the most prudent and economically efficient solution to maintain a reliable SVC at Lismore.

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[30].

The estimated capital expenditure associated with Option 1 is $12.1 million ± 25%. Routine and operating maintenance costs are approximately $44,000 per year.

The works will be undertaken between 2019/20 and 2021/22. Planning and procurement (including completion of the RIT-T) will occur between 2019/20 and 2020/21, while the refurbishment works including delivery and installation will be complete by 2021/22.

The analysis undertaken and the identification of Option 1 as the preferred option satisfies the RIT-T.

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

Appendix A – Compliance checklist

This appendix sets out a compliance checklist which demonstrates the compliance of this PACR with the requirements of the National Electricity Rules version 129.

Rules clause	Summary of requirements	Relevant section(s) in PACR
5.16.4 (b)	The project assessment conclusions report must set out:	–
	(1) the matters detailed in the project assessment draft report as required under paragraph (k); and	See below.
	(2) a summary of, and the RIT-T proponent's response to, submissions received, if any, from *interested parties* sought under paragraph (q).	NA
5.16.4(k)	The project assessment draft report must include:	–
	(1) a description of each credible option assessed;	3
	(2) a summary of, and commentary on, the submissions to the project specification consultation report;	NA
	(3) a quantification of the costs, including a breakdown of operating and capital expenditure, and classes of material market benefit for each credible option;	3, 4, 5, 6
	(4) a detailed description of the methodologies used in quantifying each class of material market benefit and cost;	4, 5, 6
	(5) reasons why the RIT-T proponent has determined that a class or classes of market benefit are not material;	4
	(6) the identification of any class of market benefit estimated to arise outside the *region* of the *Transmission Network Service Provider* affected by the RIT-T project, and quantification of the value of such market benefits (in aggregate across all regions);	NA
	(7) the results of a net present value analysis of each credible option and accompanying explanatory statements regarding the results;	4
	(8) the identification of the proposed preferred option;	5
	(9) for the proposed preferred option identified under subparagraph (8), the RIT-T proponent must provide: (i) details of the technical characteristics; (ii) the estimated construction timetable and commissioning date; (iii) if the proposed preferred option is likely to have a *material inter-network impact* and if the *Transmission Network Service Provider* affected by the RIT-T project has received an augmentation technical report, that report; and (iv) a statement and the accompanying detailed analysis that the preferred option satisfies the *regulatory investment test for transmission*.	3, 4, 6

Appendix B – Assumptions underpinning the identified need

This appendix summarises the key assumptions and data from the risk assessment methodology that underpin the identified need for this RIT-T and the assessment undertaken for the Revenue Proposal.[31]

As part of preparing its Revenue Proposal for the current regulatory control period, TransGrid developed the Network Asset Risk Assessment Methodology to quantify risk for replacement and refurbishment projects. The risk assessment methodology:

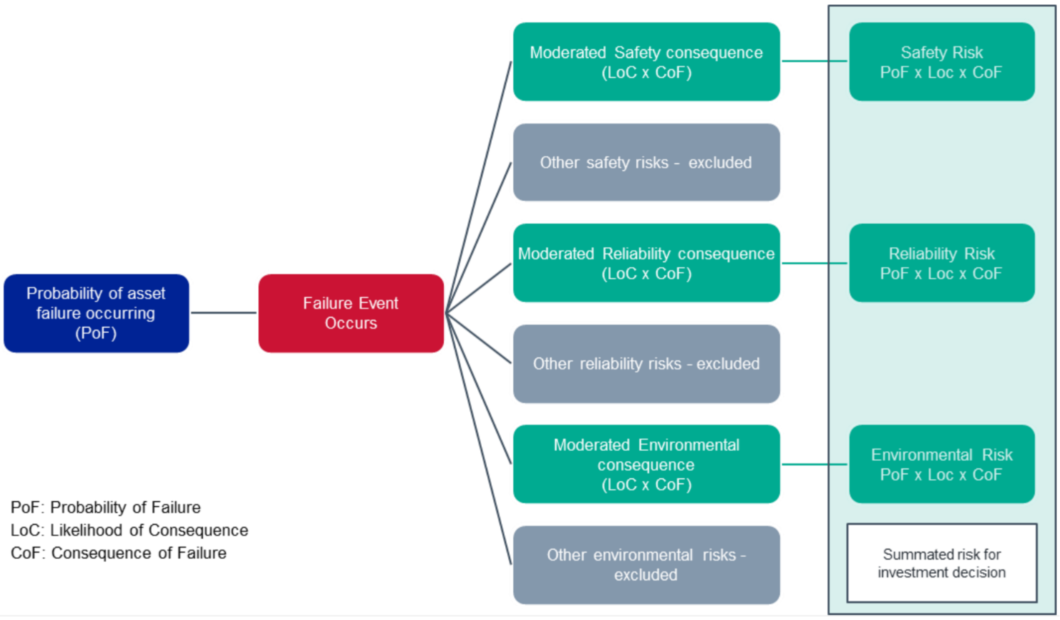
> uses externally verifiable parameters to calculate asset health and failure consequences
> assesses and analyses asset condition to determine remaining life and probability of failure
> applies a worst-case asset failure consequence and significantly moderates this down to reflect the likely consequence in a particular circumstance
> identifies safety and compliance obligations with a linkage to key enterprise risks.

B.1 Overview of risk assessment methodology

A fundamental part of the risk assessment methodology is calculating the 'risk costs' or the monetised impacts of the reliability, safety, environmental and other risks.

Figure B-1 below summarises the framework for calculating the 'risk cost', which has been applied on TransGrid's asset portfolio considered to need replacement or refurbishment.

Figure B-1 Overview of TransGrid's 'risk cost' framework



The 'risk costs' are calculated based on the Probability of Failure (PoF), the Consequence of Failure (CoF), and the corresponding Likelihood of Consequence (LoC).

31 For additional information on the risk assessment methodology, refer to pages 63-69 of TransGrid's Revised Regulatory Proposal for the period 2018-23, available at: https://www.aer.gov.au/system/files/TransGrid%20-%20Revised%20Revenue%20Proposal%20-%201%20December%202017.pdf

In calculating the PoF, each failure mode that could result in significant impact is considered. For replacement planning, only life-ending failures are used to calculate the risk costs. PoF is calculated for each failure mode based on 'conditional age' (health-adjusted chronological age), failure and defect history, and benchmarking studies. For 'wear out' failures, a Weibull curve may be fitted; while for random failures, a static failure rate may be used.

In calculating the CoF, LoC and risks, TransGrid uses a moderated 'worst case' consequence. This is an accepted approach in risk management and ensures that high impact, low probability (HILP) events are not discounted. The approach excludes the risk costs of low impact, high probability (LIHP) which would result in lower calculated risk.

B.2 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.

B.3 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 the table below.

Table B-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 (Line 87) 172.7 km (Line 89)	23.8 hours/event	0.24 per cent

B.4 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 30.9 MWh per year of involuntary load shedding from non-operation of the SVC, or an equivalent to 2633 homes for a day[32]. This will increase over time as the failure rates of the SVC increase. This estimate is 11.4 MWh per year and 59.3 MWh per year for the low forecast and high forecast respectively.

[32] 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

Figure B-2 Involuntary load shedding (base case)

B.5 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[33] for the central scenario. 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.

33 $38.35/kWh adjusted for inflation. Australian Energy Market Operator. "Value of Customer Reliability Review- Final Report." Melbourne: Australian Energy Market Operator, 2014.30. Accessed 14 November 2019. https://www.aemo.com.au/-/media/Files/PDF/VCR-final-report--PDF-update-27-Nov-14.pdf