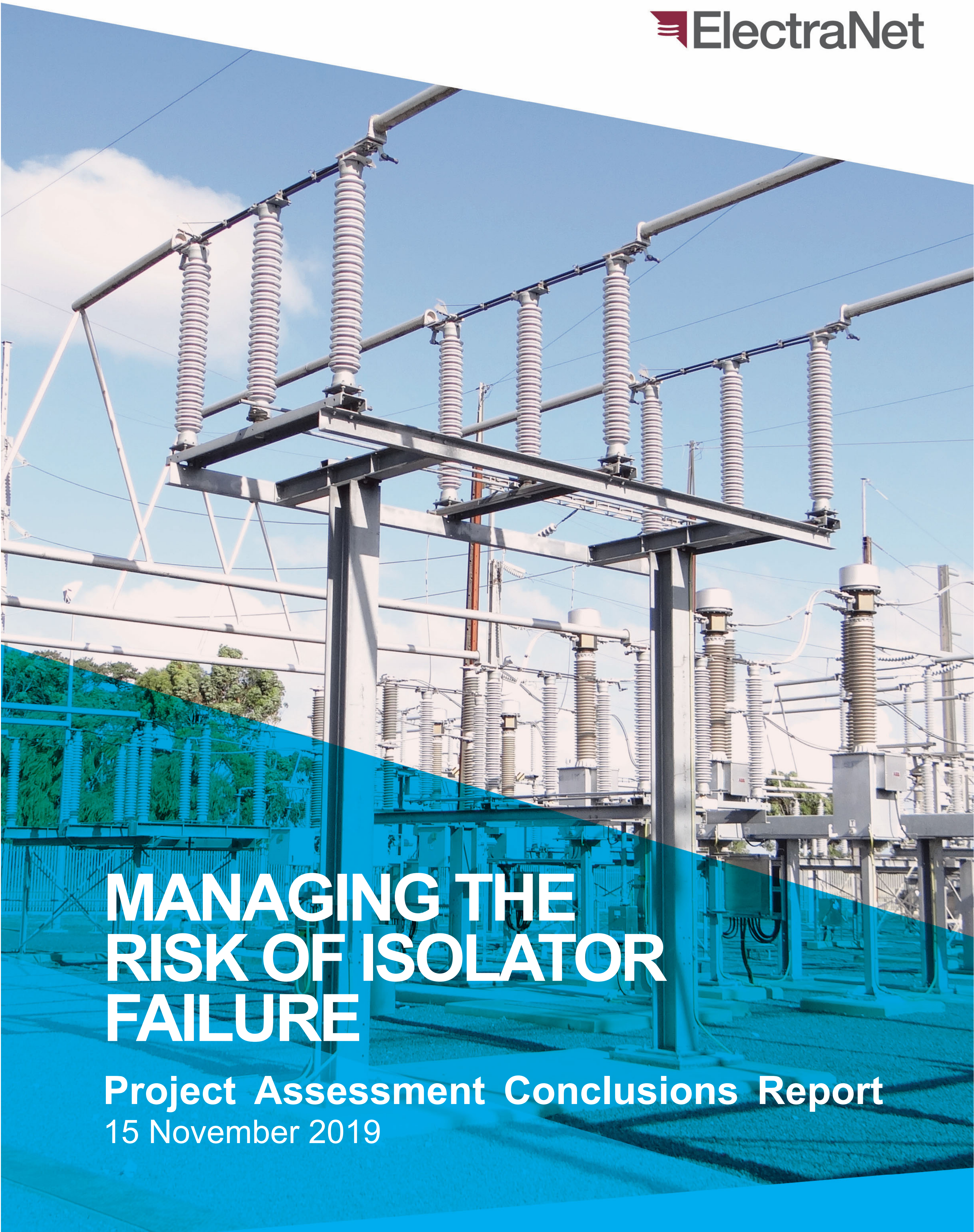

MANAGING THE RISK OF ISOLATOR FAILURE

Project Assessment Conclusions Report

15 November 2019

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Executive Summary

This report is the final stage of an investigation of the most economic option to replace or remove isolators over the next four years

This Project Assessment Conclusions Report (PACR) is the final consultation report for a Regulatory Investment Test (RIT-T)[1] investigating options to replace or remove 73 isolators and components across the South Australian electricity transmission network over the next four years.

Isolators are mechanically operated switches that isolate a part of an electrical circuit under no-load conditions. They allow circuit breakers, transformers, transmission lines and customer connection points to be safely isolated for work to be performed by field staff. The failure of an isolator may prevent the safe maintenance or return to service of plant and customer connections as the isolator may be unable to open or close when required.

The removed isolators are planned to be refurbished and disassembled to create a suitable spares inventory to allow emergency maintenance of isolators elsewhere in the network, when they fail, to be undertaken in a more timely and efficient manner.

An initial report was released in July 2019 identifying a proposed solution

A Project Specification Consultation Report (PSCR) for this RIT-T was published on 4 July 2019 and outlined how there is only one feasible option, which is a targeted replacement program to create isolator spares with a capital cost of approximately $9 million.

Other options examined included replacing all isolators that do not have manufacturing support at a capital cost of approximately $50 to $85 million, and replacement of entire substations at a capital cost of approximately $20 to $40 million per substation. It is evident both these options are significantly more costly than the proposed solution and, therefore are economically infeasible.

The creation of a spares programme for isolator equipment enables ongoing inventory support for isolators and associated equipment that remains in service and is no longer supported by the original equipment manufacturer. Furthermore, the spare components that are created from the strategically selected isolators will be able to be used at multiple sites throughout the transmission network.

The PSCR assessed different timings of this replacement option and concluded that removing and/or replacing the identified assets as soon as practicable is the preferred option on account of the avoided risk costs of isolators failing and avoiding emergency corrective maintenance.

The PSCR also outlined why there is not expected to be a feasible role for network support solutions in addressing the identified need on account of the specific role that the identified isolators play in the transmission of electricity and their relatively low replacement cost.

No submissions were received on the PSCR.

1 The Regulatory Investment Test for Transmission (RIT-T) is the economic cost benefit test that is overseen by the Australian Energy Regulator (AER) and applies to all major network investments in the National Electricity Market.

This report maintains the initial conclusion that removing and replacing the identified isolators in the next four years is the preferred option

The preferred option for addressing the identified need continues to be Option 1, i.e. replacing identified isolators, and or parts of isolators, between 2019 and 2023, for use as spares in order to continue to provide reliable electricity transmission services in South Australia at a prudent and efficient level of cost. This replacement work is estimated to have a total capital cost of $9 million ($ 2019), with no expected change to current routine operating and maintenance costs.

We have undertaken a thorough sensitivity testing exercise to investigate the robustness of the RIT-T assessment to underlying assumptions about each of the key variables. For all sensitivity tests undertaken, the preferred option remains removing and replacing the identified isolators in the next four years.

Next steps

ElectraNet intends to commence work on removing and replacing the identified isolators in late 2019.

There are 73 isolators and/or parts of isolators, at 16 substations across South Australia, that require removal and replacement. We are planning to have all assets removed or replaced by June 2023 at the latest

Further details in relation to this project can be obtained from:

Rainer Korte
Group Executive Asset Management
ElectraNet Pty Ltd

consultation@electranet.com.au

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Glossary of Terms

Term	Description
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
CIGRE	Conseil International des Grands Reseaux Electriques (International Council for Large Electric Systems)
ETC	Electricity Transmission Code
NPV	Net Present Value
NEM	National Electricity Market
NER, Rules	National Electricity Rules
PACR	Project Assessment Conclusions Report
PADR	Project Assessment Draft Report
PSCR	Project Specification Consultation Report
PV	Present value
RET	Renewable Energy Target
RIT-T	Regulatory Investment Test for Transmission
TNSP	Transmission Network Service Provider
USE	Unserved Energy
VCR	Value of Customer Reliability

1. Introduction

This Project Assessment Conclusions Report (PACR) represents the final step in the application of the RIT-T to address the risk of isolator failure at various substations in the South Australian transmission network.

A Project Specification Consultation Report (PSCR) was released in July 2019 that described the identified need we are seeking to address, set out the technical characteristics that a network support option would be required to deliver to assist and outlined the credible option we consider addresses the identified need. The PSCR also set-out an economic assessment, along with a draft conclusion on the preferred option, as well as how ElectraNet was intending to apply the NER exemption from preparing a Project Assessment Draft Report (PADR) for this RIT-T.[2]

No submissions were received on the PSCR.

1.1 Why we consider this RIT-T is necessary

Changes to the National Electricity Rules (NER) in July 2017 extended the application of the RIT-T to replacement capital expenditure commencing from 18 September 2017.[3] Accordingly, we have initiated this RIT-T to consult on proposed expenditure related to replacing isolators, noting that none of the exemptions listed in NER apply.

The credible option discussed in this PACR has not been foreshadowed in AEMO's National Transmission Network Development Plan (NTNDP) or Integrated System Plan as the works involved do not impact on main transmission flow paths between NEM regions.

1.2 Next steps

ElectraNet intends to commence work on removing and replacing the identified isolators in late 2019.

There are 73 isolators and/or parts of isolators, at 16 substations across South Australia, that require removal and replacement. We are planning to have all assets removed or replaced by June 2023 at the latest.

Further details in relation to this project can be obtained from:

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ElectraNet Pty Ltd

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2 In accordance with NER clause 5.16.4(z1).

3 The application of the RIT-T to replacement expenditure ('repex') commenced on 18 September 2017, however, all repex projects that were 'committed' by 30 January 2018 are exempt. See paragraph 18 of the AER's RIT-T for the definition of a 'committed project'. While the planning process for replacing the identified isolators was well-advanced by 30 January 2018, the project was not yet 'committed'. Accordingly, we have subsequently initiated this RIT-T to consult on its proposed expenditure related to replace and remove the identified isolators.

2. The identified need for this RIT-T is to ensure reliable and safe supply of electricity to South Australia

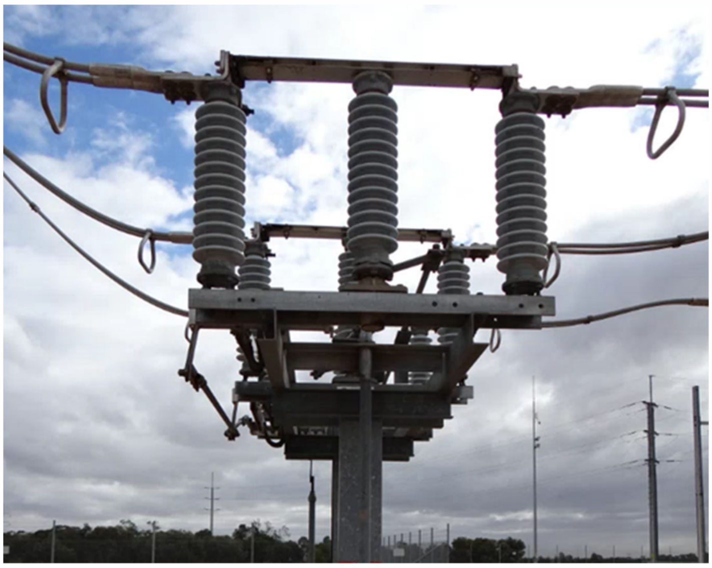
This section outlines the identified need for this RIT-T, as well as the assumptions underpinning it. It first provides some background on the identified isolators and their role in the wider transmission of electricity in South Australia.

2.1 Background to the identified need

Isolators are mechanically operated switches that isolate a part of an electrical circuit under no-load conditions. They allow circuit breakers, transformers, transmission lines and customer connection points to be safely isolated for work to be performed by field staff.

An example isolator at the Monash substation is illustrated in Figure 1.

Figure 1 - Isolator at the Monash substation

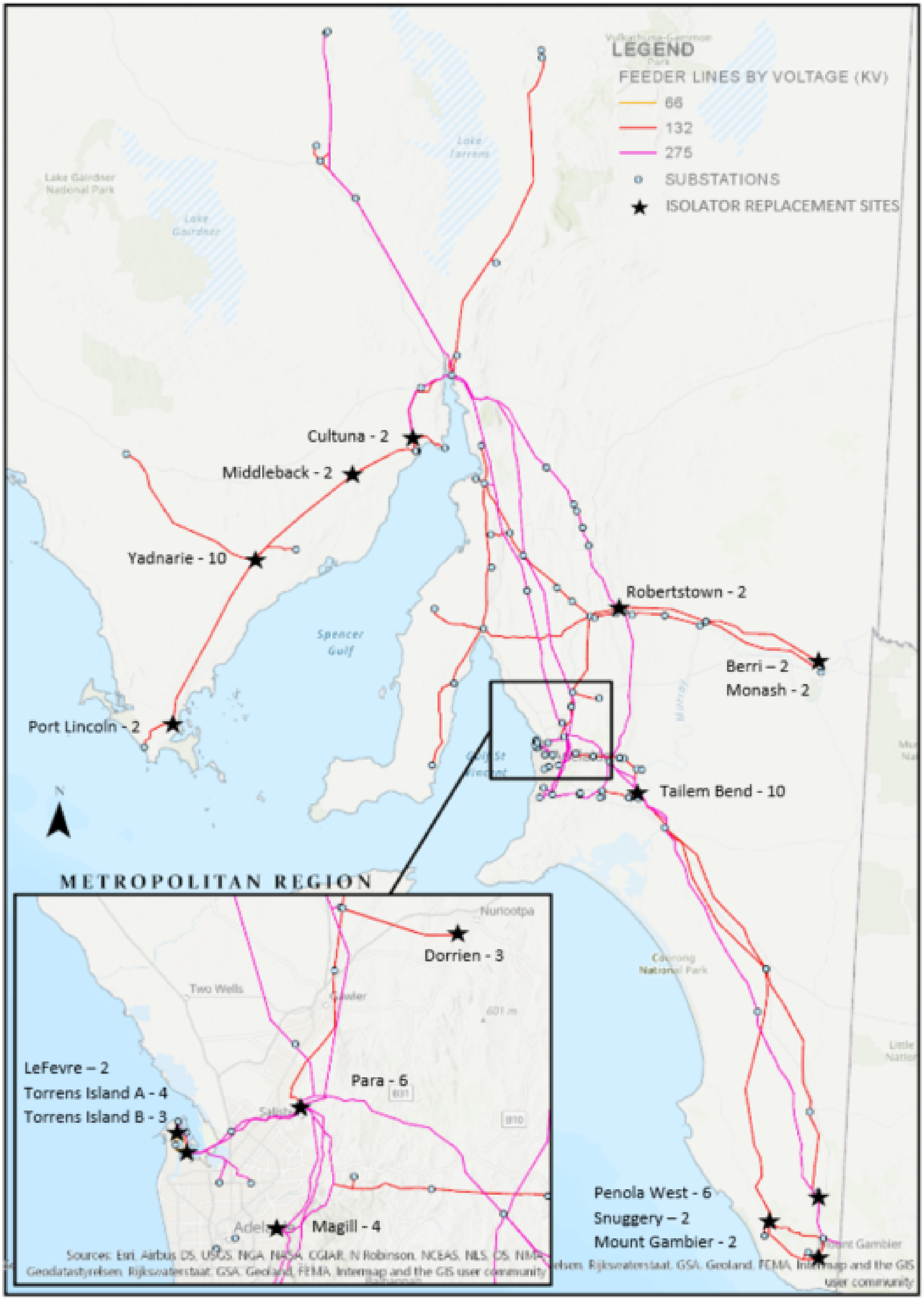


The failure of an isolator may prevent the safe maintenance or return to service of plant and customer connections as the isolator may be unable to open or close when required.

Across our transmission network, we have identified 73 isolators, and/or parts of isolators, for removal and replacement, or in some cases removal only. The removed isolators are planned to be refurbished and disassembled to create a suitable spares inventory to allow for emergency maintenance of defective isolators.

The distribution of the 16 substations where isolators are being replaced and used to create spares is illustrated in Figure 2 (nine isolators that are not represented on the map are also being removed but not replaced at Davenport, Torrens Island A, and Robertstown).

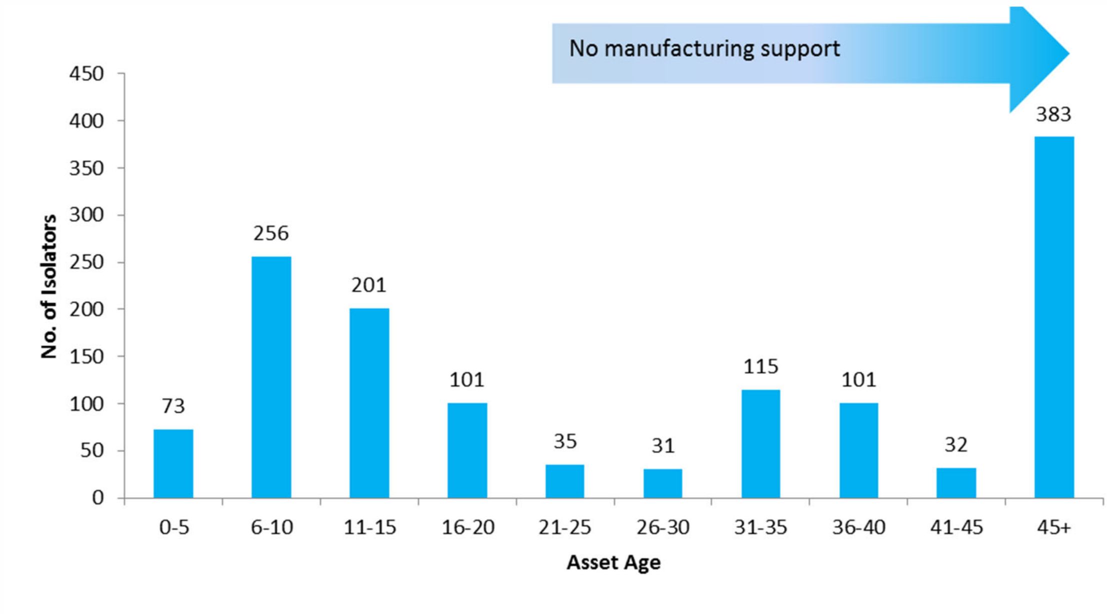
Figure 2 - Location of the isolators that are being replaced



Currently, as shown in Figure 3, we have an ageing population of approximately 700 isolators that do not have any manufacturing support as they are aged over 20 years old. If a spares program is not implemented, it is likely there will be increased replacement costs and outages as, absent spare components, the replacement of entire isolator assemblies will be required under emergency conditions.

Specifically, when spare components are not available, a new isolator will have to be retro fitted to the old isolator position incurring significantly increased costs and longer outages. Moreover, if an isolator does not operate, maintenance cannot be undertaken at the substation on transformers, lines and circuit breakers, or customer connections may not be able to be returned to service after maintenance has been undertaken.

Figure 3 - Age profile of isolators and level of manufacturing support



The average corrective maintenance unit cost for isolators differs significantly depending on whether spare components are available or not.

Specifically:

- when spare isolator components are available, this cost is approximately $30,000 for a 275 kV isolator and approximately $25,000 for a 132 kV component of an isolator; and
- without a spare, the emergency corrective maintenance cost would involve a whole new isolator and cost approximately $179,000 for a 275 kV isolator and $166,000 for a 132 kV isolator.

The creation of a spares programme for isolator equipment enables ongoing inventory support for isolators and associated equipment that remains in service and is no longer supported by the original equipment manufacturer. Furthermore, the spare components that are created from the strategically selected isolators will be able to be used at multiple sites throughout the transmission network.

The isolators we are intending to remove and/or replace in order to create spares are from the substations identified in Table 1, which also details the isolator models that the spare components can be used to repair.

Table 1 - Substations with affected isolators

Substation	Isolator models
Tailem Bend Substation	Switchgear - DBR6, ETSA - HDB
Para Substation	ALM - HCB
Robertstown Substation	ABB - DBRP275, ETSA - HDB, Taplin - 300RC
Torrens Island B Switching Station	Stanger - HCB, ALM - HCB,
Torrens Island A Substation	ALM - HCB, Switchgear - DBH4
Magill Substation	Replaced and not used as spares as model to be removed from system due to design faults
Lefevre Substation	Haycolec - 2893
Cultana Substation	ABB - DBRP132
Snuggery Substation	ABB - R145
Penola West Substation	ABB - R145
Yadnarie Substation	Hapam - EAD, ETSA - HDB
Mount Gambier Substation	ABB - R145
Berri Substation	Replaced and not used as spares as models removed from system due to design faults
Middleback Substation	Replaced and not used as spare as removing model type from the network
Dorrien Substation	ABB - R145
Monash Substation	Replaced and not used as spares as model to be removed from system due to design faults
Port Lincoln Terminal Substation	Hapam - EAD
Davenport Substation (Asset Removal only)	Taplin - 300RC

2.2 Description of the identified need for this RIT-T

The identified need for this project is to continue to provide reliable electricity transmission services in South Australia at a prudent and efficient level of cost.

Specifically, as set out in the PSCR, we consider that the costs associated with creating a spares inventory (i.e. the costs of removing and/ or replacing the isolators identified for creating spares) are more than outweighed by the cost savings compared to what would need to be incurred under the base case.

We have strategically identified isolators that are representative of approximately 80 per cent of the total population of isolators in the transmission network. The isolators that are being turned into spares can be used to replace the failed components of other in-service isolators and one isolator spare can be used to repair multiple failed isolators.

We have classified this RIT-T as a 'market benefits' driven RIT-T because, while the aim is to maintain the quality, reliability and security of supply of prescribed transmission services, the economic assessment is not specifically driven by the requirement to meet a specific mandated reliability standard (i.e. it is not being progressed as a 'reliability corrective action' RIT-T).

However, the Electricity (General) Regulations 2012[4] require that a *"system of maintenance must be instituted for substation buildings, enclosures and associated plant, equipment and lines including … managed replacement programs for components approaching the end of their serviceable life".*

A full cost benefit assessment has been undertaken, comparing the risk cost reduction benefits of asset replacement options with the cost of those options.

[4] South Australian Electricity (General) Regulations 2012, Schedule 3—Requirements for substations

3. Potential credible options to address the identified need

The analysis has identified that there is only one technically feasible option to be assessed against the base case, which is to create spare isolators from replacing current isolators in the network. This is because isolators play a specific and important role in enabling substations to operate and be maintained in a timely fashion and to minimise any consequential effects on downstream customers.

We have however investigated different assumed timings for this work in order to determine the optimal timing. This assessment is presented in section 4.5.

The option is considered to be technically and economically feasible and able to be implemented in sufficient time to meet the identified need.[5] In addition, all works are assumed to be completed in accordance with the relevant standards, with isolators being replaced with minimal modification to fit to the substation.

The PSCR set out that we do not consider network support solutions can assist with meeting the identified need for this RIT-T, driven by the unique and specific role that the identified isolators play in the transmission of electricity, as well as their relatively low emergency repair cost when spare components are available (approximately $25,000 to $30,000). Notwithstanding, the PSCR set out the required technical characteristics for a network support option for completeness, consistent with the requirements of the RIT-T.

We did not receive any submissions on the PSCR.

3.1 Option 1 – Targeted replacement and removal of isolators by 2023

Option 1 involves removing or replacing, either partially or entirely, the identified isolators in the 2019-2023 period, and creating and storing isolators and isolator components as spares.

Of the 73 existing isolators expected to be covered by this RIT-T:

- 54 are planned to be replaced and with the existing isolators created into spares;
- 9 are planned to be removed without replacement, as they are no longer required at the substation, and created into spares; and
- 10 are planned to be replaced and removed, and therefore will not be created into spares.

The creation of isolator spare components enables ongoing inventory support for the isolators that remain in service with many of the isolators currently operating throughout the network no longer supported by the original equipment manufacturer.

The estimated capital cost of this option is approximately $9 million. Routine operating and maintenance costs are not expected to be different to the base case.

5 In accordance with the requirements of NER clause 5.15.2(a).

It is estimated that the onsite construction time for each isolator to be replaced is around one week (once all planning, design, drawing etc is completed). Due to interactions with other ElectraNet operations, we consider that it will take approximately four years to address all of the 73 identified isolators. We estimate that all isolators could be addressed by 2023 under this option.

3.2 Options considered but not progressed

We have also considered whether there are other credible options that would meet the identified need. However, the identified need to manage the risk of asset failure does not lend itself to any solution other than to replace the identified isolators in order to generate spare components to maintain the remaining isolators on the most efficient basis as the only technically and economically feasible option given the unique and specific function of these assets. Consequently, we have not identified other feasible options.

One conceivable option, for example, would be to replace the entire number of isolators that now have no manufacturing support. However, the capital cost of this option is also expected to be significantly greater than the option outlined in 3.1, estimated to be $50 to $85 million for the approximately 700 isolators aged over 20 years old, and does not provide any additional market benefits. Therefore, this is not considered to be an economically feasible option.

Another option would be to replace the entire substation, as opposed to just the isolators. However, the capital cost of this option is expected to be in the order of $20 to 40 million per substation, which is significantly greater than the option outlined above and does not provide any additional market benefits. In addition, the condition of the majority of other substation assets is such that they do not require replacement in the coming years. Therefore, this is also not considered to be an economically feasible option.

In addition, as set out in section 4 below, we do not consider that network support solutions can address, or help address, the identified need.

4. Assessment of the credible options

This section outlines the assessment we have undertaken of the credible network option. The assessment compares the option against a base case 'do nothing' option.

For clarity, this section re-presents the underlying assessment in the PSCR. There were no material changes since the PSCR that would affect the finding that Option 1 is preferred.

4.1 Description of reasonable scenarios

The RIT-T analysis is required to incorporate a number of different reasonable scenarios, which are used to estimate expected net market benefits. The number and choice of reasonable scenarios must be appropriate to the credible options under consideration.

For a market benefits driven RIT-T such as this, the choice of reasonable scenarios must reflect any variables or parameters that are likely to affect the ranking of the credible options, or the sign of the net economic benefits of any of the credible options.[6]

We have developed three scenarios for this RIT-T assessment:

- a 'central' scenario reflecting our base set of key assumptions;
- a 'low benefits' scenario – reflecting a pessimistic set of assumptions, which represents a lower bound on reasonably expected potential market benefits that could be realised; and
- a 'high benefits' scenario – reflecting an optimistic set of assumptions, which represents an upper bound on reasonably expected potential market benefits.

Given that the low and high benefits scenarios are less likely to occur, the scenarios have been weighted accordingly; 25 per cent – low benefits scenario, 50 per cent – central benefits scenario, and 25 per cent – high benefits scenario.

6 AER, *Final Regulatory Investment Test for Transmission*, June 2010, version 1, paragraph 16, p. 7.

Table 2 - Summary of three scenarios considered

Key variable/parameter	Low benefits scenario	Central scenario	High benefits scenario
Capital costs	130 per cent of capital cost estimate	Base estimate	70 per cent of capital cost estimate
Commercial discount rate[1]	8.95 per cent	5.9 per cent	2.85 per cent
Avoided 'risk cost' benefit	70 per cent of base estimates	Base estimates	130 per cent of base estimates
Decommissioning costs	130 per cent of base estimates	Base estimates	70 per cent of base estimates
Emergency Corrective Maintenance	70 per cent of base estimates	Base estimates	130 per cent of base estimates

4.2 Gross benefits for each credible option

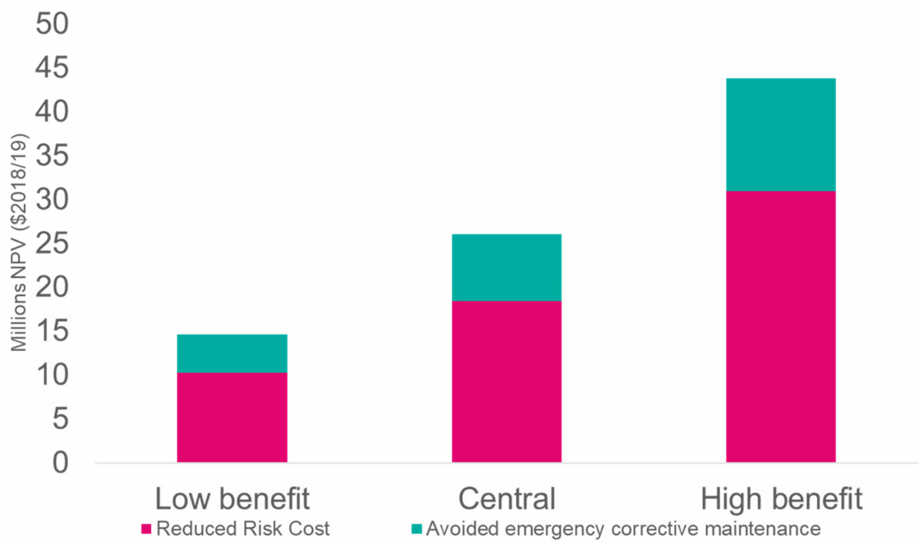
The table below summarises the gross benefit estimated for Option 1 relative to the 'do nothing' base case in present value terms. The gross market benefit has been calculated for each of the three scenarios outlined in the section above.

Table 3 - Estimated gross market benefit for each option, PV $m

Option	Low benefits scenario	Central scenario	High benefits scenario
Option 1 – Planned replacement of isolators and creation of spare isolator components by 2023	14.6	26.0	43.8

The figure below provides a breakdown of benefits, which are derived from reduced risk cost of isolator failure and the reduced time taken to resolve such failures.

Figure 4 - Breakdown of present value gross economic benefits of Option 1



4.3 Estimated costs for each credible option

The table below summarises the costs of Option 1, relative to the base case, in present value terms. These costs include the capital costs, inclusive of the terminal value of the assets, and the decommissioning costs incurred in the creation of spare isolator components. The cost has been calculated for each of the three reasonable scenarios.

Table 4 - Estimated capital cost (inclusive of terminal values and decommissioning costs) for each option, PV $m

Option	Low benefits scenario	Central scenario	High benefits scenario
Option 1 – Planned replacement of isolators and creation of spare isolator components by 2023	-8.6	-6.4	-4.0

4.4 Net present value assessment outcomes

The table below summarises the net market benefit in NPV terms for Option 1 across the three scenarios, as well as on a weighted basis. The net market benefit is the gross benefits (as set out in section 7.1 above) minus the cost (as outlined in section 7.2 above), all expressed in present value terms, note the table may not reconcile due to rounding.

The table shows that Option 1 provides a strong expected net economic benefit on a probability-weighted basis, as well as across all scenarios.

Table 5 - Estimated net market benefit for each option, PV $m [7]

Option	Low benefits scenario	Central scenario	High benefits scenario	Weighted
Option 1 – Planned replacement of isolators and creation of spare isolator components by 2023	6.0	19.7	39.8	21.3

4.5 Sensitivity testing

We have undertaken a thorough sensitivity testing exercise to understand the robustness of the RIT-T assessment to underlying assumptions about key variables.

In particular, we have tested the optimal timing of the project, and the sensitivity of this timing to key variables.

We have then tested the sensitivity of the total net market benefit to variations in the key factors underlying the assessment, such as for example the sensitivity of the project to increases in capital costs (all sensitivities tested are examined in 4.5.2).

[7] There has been an amendment to the PSCR benefit calculation resulting in minor variations to the low and high scenarios in this PACR.

4.5.1 Sensitivity testing of the assumed optimal timing for the credible option

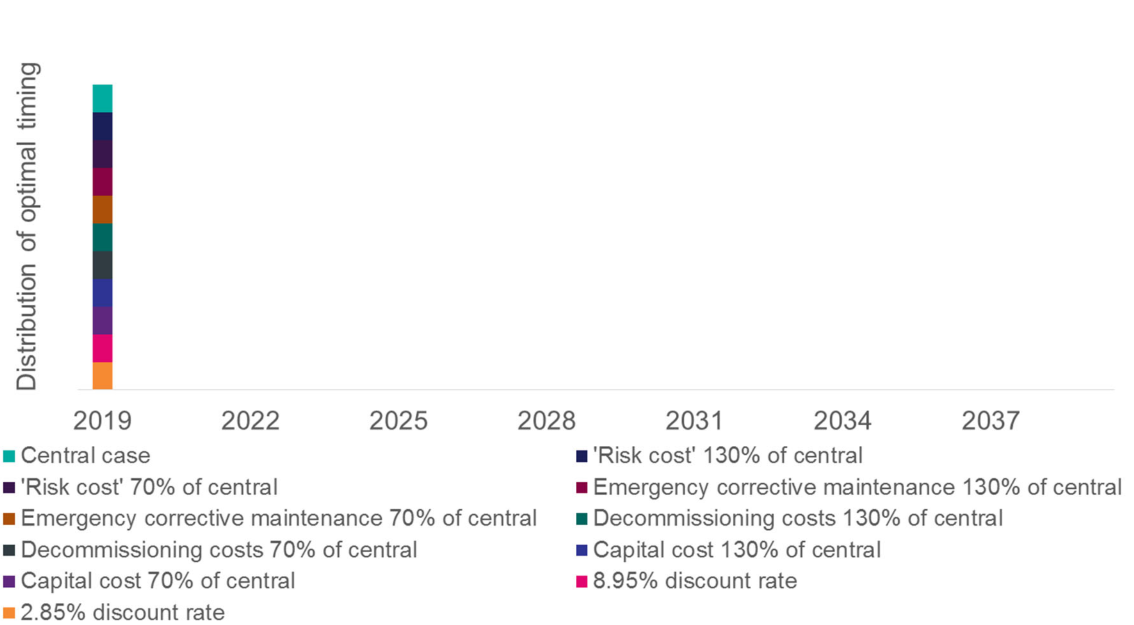
We have estimated the optimal timing for Option 1 based on the year in which the present value of the monetised service costs exceeds the present value of the replacement project costs,[8] which is consistent with when the expected NPV is maximised. This process was undertaken for both the central set of assumptions and also a range of alternative assumptions for key variables.

Figure 5 outlines the impact on the optimal commissioning year, under a range of alternative assumptions. Specifically, it shows, for each set of sensitivities/assumptions, the optimal commissioning year, i.e., the year that results in the highest expected net market benefits. For each sensitivity listed in the legend, the assumption listed is the one that is being tested in that specific sensitivity – all other assumptions are the same as they are in the central case.

The figure illustrates the optimal commissioning date is found to be that the project should be undertaken as soon as possible for all of the sensitivities investigated, i.e., under all sensitivities investigated the optimal timing remains unchanged.

Please note that the figure below shows the optimal year to *commence* the program of replacement, whilst recognising that it will take four years to complete the replacement works (i.e., the earliest all isolators can be replaced is 2023).

Figure 5 - Distribution of optimal timing for Option 1 with different key assumptions



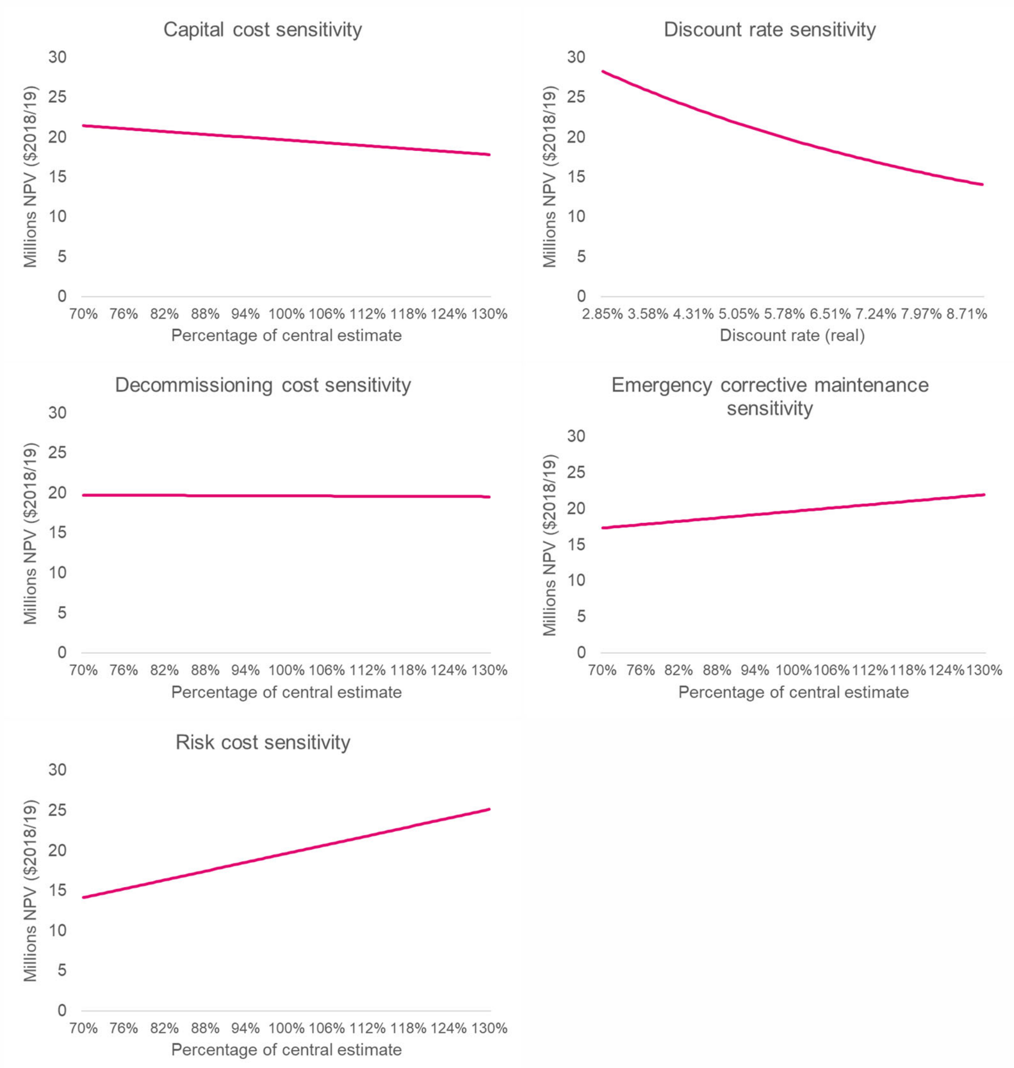
8 We note that this approach is consistent with the recently updated AER RIT-T Guidelines (see: AER, *Regulatory Investment Test for Transmission*, Application Guidelines, December 2018, p. 21).

4.5.2 Sensitivity of the overall net market benefit

We have also looked at the consequences for the credible option of ‘getting it wrong’ if the key underlying assumptions are not accurate. For example, sensitivity tests have been run on low and high avoided ‘risk cost’ benefits to ensure the robustness of the assessment.

The five figures in Figure 6 illustrate the estimated net market benefits for each option if the five separate key assumptions in the central scenario are varied individually. Importantly, for all sensitivity tests shown below, the estimated net market benefit of Option 1 is found to be strongly positive.

Figure 6 - Sensitivity testing of the NPV of net market benefits



While the sensitivities in Figure 6 show that the results are most sensitive to the avoided risk costs and avoided emergency corrective maintenance costs, we note that Option 1 would still have positive net market benefits if one of these categories of benefit were removed entirely.

In addition, we find that the modelled failure rate implicit in the risk cost modelling would need to be reduced by approximately 75 per cent of the central estimate in order for there to be zero estimated net market benefits under the central scenario.

ElectraNet considers that the expected net market benefits of Option 1 have been demonstrated to be robust to a range of alternate assumptions.

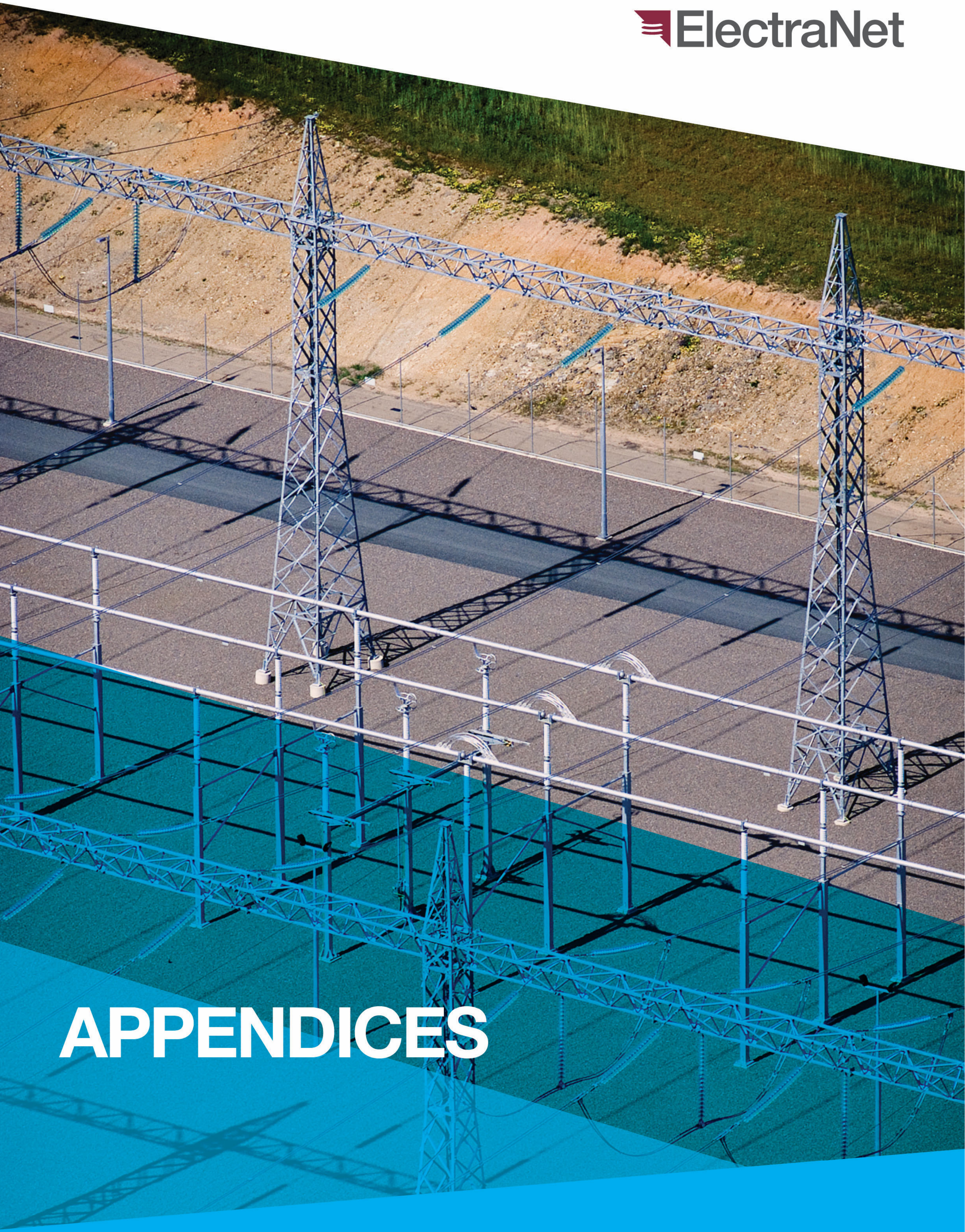
5. Final conclusion on the preferred option

The preferred option that has been identified in this assessment to meet the identified need is Option 1, which is to create spare isolators by replacing or removing selected isolators in the network. This option is described in section 3 and is estimated to have a capital cost of $9 million.

Option 1 is the preferred option in accordance with NER clause 5.16.1(b) because it is the credible option that maximises the net present value of the net economic benefit to all those who produce, consume and transport electricity in the market.

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

ElectraNet intends to commence work on removing and replacing the identified isolators in late 2019. There are 73 isolators and/or parts of isolators, at 16 substations across South Australia, that require removal and replacement. We are planning to have all assets removed or replaced by June 2023 at the latest.



APPENDICES

Appendix A Compliance checklist

This section sets out a compliance checklist which demonstrates the compliance of this PACR with the requirements of clause 5.16.4(v) of the Rules.

Rules clause	Summary of requirements	Relevant section(s) in PACR
5.16.4(v)	The project assessment conclusions report must include:	-
	(1) the matters detailed in the project assessment draft report as required under paragraph (k)	See below.
	(2) a summary of, and the RIT-T proponent's response to, submissions received, if any, from interested parties sought	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, Appendix E & Appendix F
	(4) a detailed description of the methodologies used in quantifying each class of material market benefit and cost;	Appendix E
	(5) reasons why the RIT-T proponent has determined that a class or classes of market benefit are not material;	Appendix E
	(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 & 5

Appendix B Definitions

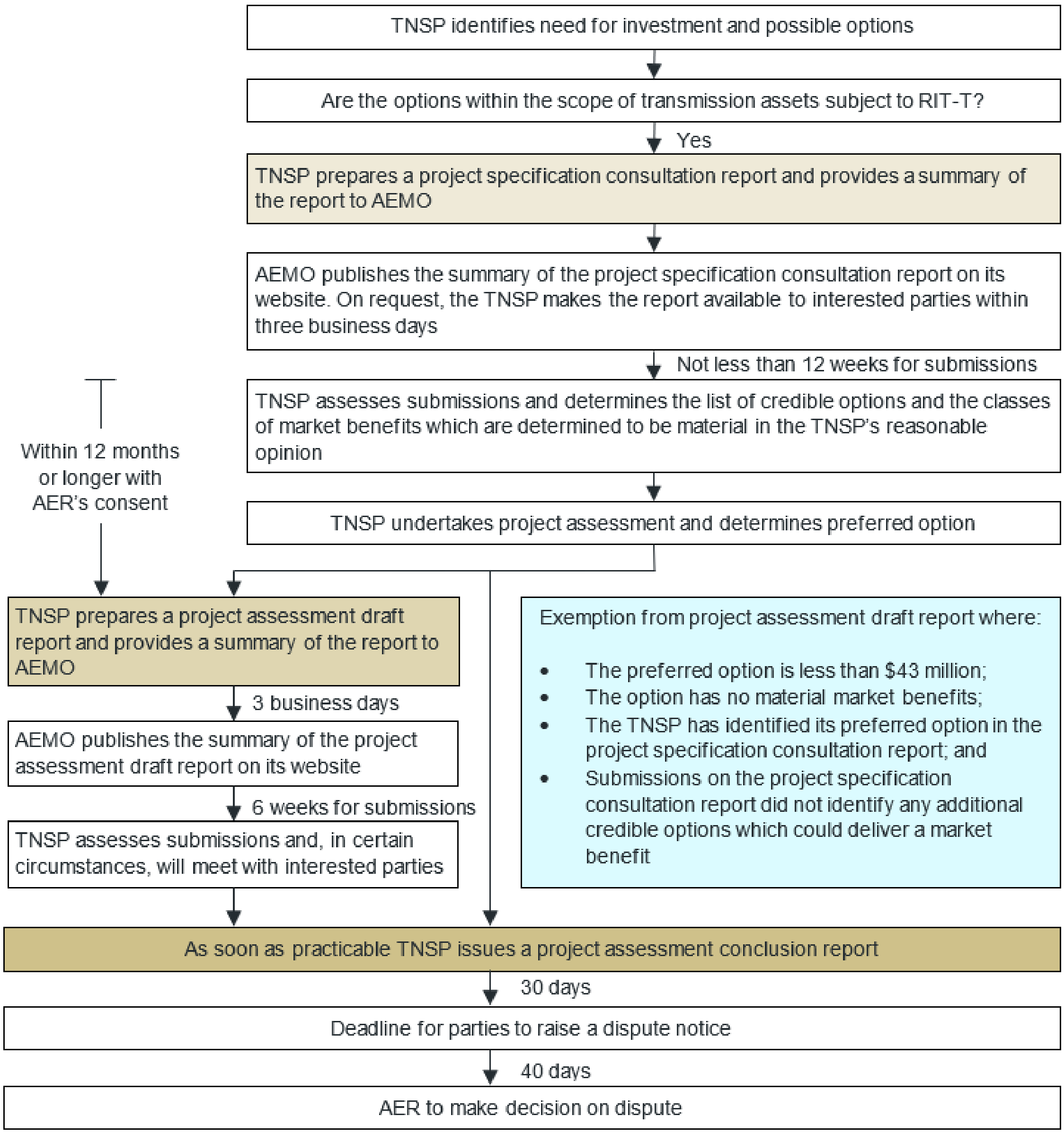
All laws, regulations, orders, licences, codes, determinations and other regulatory instruments (other than the Rules) which apply to Registered Participants from time to time, including those applicable in each participating jurisdiction as listed below, to the extent that they regulate or contain terms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

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

Appendix C Process for implementing the RIT-T

For the purposes of applying the RIT-T, the NER establishes a typically three stage process, ie: (1) the PSCR; (2) the PADR; and (3) the PACR. This process is summarised in the figure below (in gold), as well as the criteria for PADR exemption that this RIT-T has applied (in blue).

Figure 7 - The RIT-T assessment and consultation process



Appendix D Assumptions underpinning the identified need

This appendix summarises the key assumptions from the risk cost modelling and other key assumptions that underpin the identified need for this RIT-T. Appendix F provides further detail on the general modelling approaches applied, including additional detail on the risk cost modelling framework.

In light of the uncertainties inherent in all assumptions, we have undertaken a range of sensitivity and 'threshold' tests in order to test the robustness of the preferred option. These are outlined in section 4 above.

D1 Failure modes

For the purposes of this assessment, the risk cost model when an isolator fails focuses on four modes of failure, being:

- contact failure – the current path (contacts, rotating heads or joints) or commutating contact components have failed on the isolator;
- control failure – the fuses, thermostats, monitoring devices (including sensors) have failed on the isolator;
- insulation failure – the main insulation to earth including support and drive insulators, pull rods, etc. have failed on the isolator; and
- operating mechanism failure – the motor drive on the isolator has failed due to a kinematic chain, motor, pump, control elements, actuator and damping, or mechanical transmission component failure.

Each of these failure modes have different characteristics and consequent likelihoods of occurring, as is detailed in the section below.

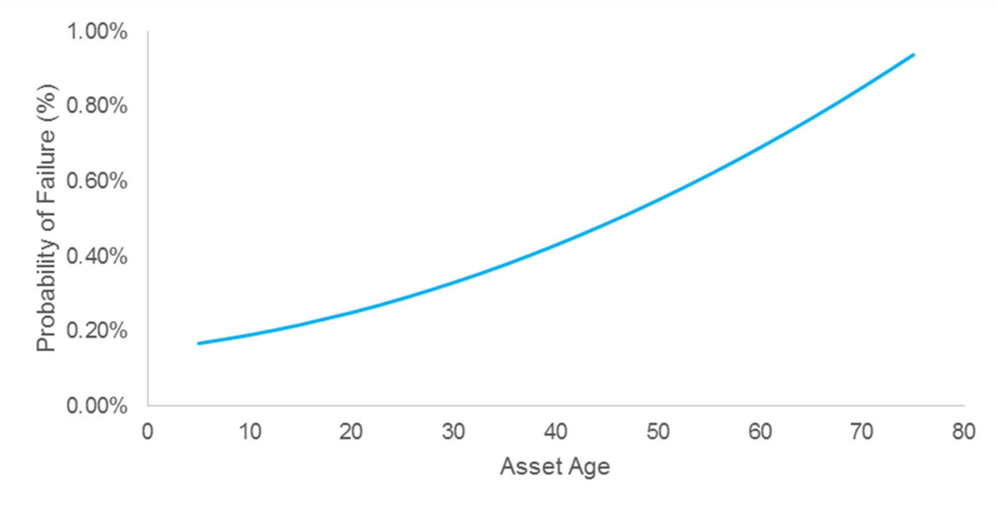
D2 The probability of isolators failing

The probability of isolator failure is estimated by considering the asset's age and historical asset failure data from CIGRE's *Final Report of the 2004 – 2007 International Enquiry on Reliability of High Voltage Equipment, Part 3 – Disconnectors and Earthing Switches*.

CIGRE is a global technical forum for large electric systems and is composed of researchers, academics, engineers, technicians, suppliers, market and system operators and other decision makers.

The probability of failure is modelled based on a polynomial equation and increases as the assets age (a graph of the probability of isolator asset failures by asset age is shown in Figure D.8 below).

Figure D.8 - Probability of isolator asset failures given asset age



Therefore, we will be required to manage increasing isolator asset failures as we have a large proportion of isolators over the age of 30 years, when the probability of isolator asset failure begins increasing.

When an isolator fails and there are no spares available an emergency replacement is required. Only some critical isolators based on the substation and location within the substation are likely to cause an immediate outage.

If an isolator fails it is due to one of four different failure modes with the likelihood of each failure mode based on the CIGRE data. The likelihood of the different failure modes is detailed in Table D.1 below.

Table D.1 - Isolator failure modes

Failure Mode	Likelihood of failure mode
Contact failure	10.58%
Control failure	35.10%
Insulation failure	12.53%
Operating mechanism failure	41.80%

D3 The adverse effects of an isolator failure and not having available isolator spares

Our risk cost model has individually identified isolators that have the potential to cause immediate adverse effects. The probability of failure associated with each of these assets has been determined with the potential adverse consequences resulting from an isolator spare being unavailable including:

- additional corrective maintenance costs associated with having to replace the entire damaged isolator and other equipment in an unplanned emergency situation, rather than components of the isolator when spare components are available (as described in section 2.1).
- prolonged periods of unserved energy for electricity customers for select isolators during the time taken to restore (or fully replace) an isolator(s) on a reactive basis in the absence of spare parts;

  - this is particularly likely to be the case for isolators located in radial substations, radial lines and some exit lines;
  - for isolators located in other parts of the network, an outage will only occur when there is also a separate outage of a transformer; and
- generation support costs for select isolators to maintain reliability of supply to customers for extended outages greater than 48 hours;

Each of these adverse effects is incorporated in the risk model.

Outage durations for isolators are based on the typical time to change out and commission a new isolator, with and without a spare. The outage to replace an isolator with a spare is identified as 6 hours, without a spare identified as 5 days (which would likely result in a 2 day outage whilst generation support is mobilised with generation support provided for the remaining 3 days of the outage).

In calculating outage costs, the risk cost model assigns the average load from the individual substations where the isolator in the network is located. The substation's average load is based on the financial year, 2017-18. The average load for each substation where outages are considered is approximately 8.9 MW.

The AEMO estimated value of customer reliability (VCR) for a mixed load in South Australia, escalated to 2019 dollars of $37,000, has been applied to all connection points when the connection point is not directly connected to a customer. When the connection point is directly connected to a customer the value of customer reliability for a direct connection load of $6,500 has been applied.

Generation support cost assumptions have been sourced from existing contracts ElectraNet has with providers of these services.

The costs associated with reducing service interruptions, network support and corrective maintenance are the material factors underlying the assessment. We have therefore included a range of sensitivity tests on these as part of the economic assessment.

Furthermore, costs associated with postponing planned outages for operational and capital work when an isolator fails have not been quantified in our risk cost model. These are potential additional consequences of an isolator failure.

Appendix E Materiality of market benefits for this RIT-T assessment

The appendix outlines the categories of market benefits prescribed in the NER and whether they are considered material for this RIT-T.[9]

The bulk of the benefit associated with Option 1 is captured in the expected costs avoided by each option (i.e., the avoided expected costs compared to the base case). As described above, these include avoided risk costs.

Of these avoided costs, only unserved energy through involuntary load shedding is considered a market benefit category under the Rules, as discussed further below.

E1 Avoided involuntary load shedding is the only relevant market benefit

We consider that the only relevant market benefit for this RIT-T relates to changes in involuntary load shedding. The expected unserved energy under the base case has been estimated as part of our risk cost modelling framework, which is avoided under Option 1.

The benefit associated with the reduction in unserved energy is valued using VCR, expressed in $/MWh. A VCR measure estimates the value customers place on having reliable electricity supplies. The risk cost modelling has applied a VCR value of approximately $37,000/MWh for mixed loads, which is an escalation of the value sourced from AEMO's 2014 Value of Customer Reliability Review,[10] for South Australia, and a VCR of $6,500 for direct connections.

E2 Market benefits relating to the wholesale market are not material

The Australian Energy Regulator (AER) has recognised that if the credible options considered will not have an impact on the wholesale 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.[11]

Neither credible option addresses network constraints between competing generating centres and are therefore not expected to result in any change in dispatch outcomes and wholesale market prices.

We therefore consider that the following classes of market benefits are not material for this RIT-T assessment for Option 1:

- 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 for ElectraNet (since there will be no deferral of generation investment);

[9] The NER requires that all categories of market benefit identified in relation to the RIT-T are included in the RIT-T assessment, unless the TNSP can demonstrate that a specific category (or categories) is unlikely to be material in relation to the RIT-T assessment for a specific option – NER clause 5.16.1(c)(6). Under NER clause 5.16.4(b)(6)(iii), the PSCR should set out the classes of market benefit that the RIT-T proponent considers are not likely to be material for a particular RIT-T assessment.

[10] AEMO, *Value of Customer Reliability Review for South Australia*, September 2014, p. 31 and p. 40.

[11] AER, *Final Regulatory Investment Test for Transmission Application Guidelines*, December 2018, p. 32.

- changes in ancillary services costs;
- competition benefits; and
- Renewable Energy Target (RET) penalties.

E3 Other classes of market benefits are not expected to be material

In addition to the classes of market benefits listed above, NER clause 5.16.1(c)(4) requires us to consider the following classes of market benefits in relation to each credible option: differences in the timing of transmission investment; option value; and changes in network losses.

We consider that none of the four classes of market benefits listed above are material for this RIT-T assessment for the reasons set out below. We do not consider that there are any other classes of market benefits, which are material for the purposes of this RIT-T assessment.

Table E.2 - Reasons why non-wholesale market benefit categories are considered immaterial

Market benefit category	Reason(s) why it is considered immaterial
Differences in the timing of transmission investment	Option 1 does not affect the timing of other unrelated transmission investments (i.e. transmission investments based on a need that falls outside the scope of that described in section 2). Consequently, the market benefits associated with differences in the timing of unrelated transmission investment are not material to the RIT-T assessment.
Option value	The AER has stated that option value is likely to arise where there is uncertainty regarding future outcomes, the information that is available in the future is likely to change and the credible options considered by the TNSP are sufficiently flexible to respond to that change.[12] None of these conditions apply to the present assessment. The AER has also stated the 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. Changes in future demand levels are not relevant for this RIT-T, since the need for and timing of the required investment is being driven by asset condition rather than future demand growth. As a result, it is not relevant to consider different future demand scenarios in undertaking the RIT-T analysis.
Changes in network losses	Given Option 1 maintains the same network capacity as current at the same location, there are not expected to be any differences in network losses.

[12] AER, *Final Regulatory Investment Test for Transmission Application Guidelines*, December 2018, p. 95.

Appendix F Description of the modelling methodologies applied

This appendix outlines the methodologies and assumptions we have applied to undertake this RIT-T assessment.

F1 Overview of the risk cost modelling framework

We have applied an asset ‘risk cost’ evaluation framework to quantify the risk cost reductions associated with the creation of spare components that are primarily focused on mitigating risk as an input to economic evaluation and options analysis.

The ‘risk cost reductions’ have been calculated as the product of:

- probability of failure (PoF) of an asset, which is the probability of a failure occurring based on asset failure history information and industry data;
- likelihood of consequence (LoC), which is the likelihood of an adverse consequence of the failure event based on historical information, statistical factors and assumptions; and
- cost of consequence (CoC), which is the estimated cost of the adverse consequence based on modelled assumptions.

These three variables allow the expected risk cost benefits to be quantified and an assessment against the cost of doing so to be undertaken. Avoided risk cost values are the difference between risk costs incurred under the base case and Option 1.

The approach we continue to apply to quantifying risk was presented as part of our Revenue Proposal for the 2018-2023 regulatory control period. The AER has reported it to be consistent with good industry practice and to generally reflect reasonable inputs and assumptions.[13]

More detail on the key inputs and assumptions made for individual asset risk cost evaluations can be found in ElectraNet’s asset risk cost modelling guideline.[14]

F2 The discount rate and assessment period

The RIT-T analysis has been undertaken over a 20-year period from 2019 to 2038, which considers the size, complexity and expected life of each option to provide a reasonable indication of its cost.

While the isolators have asset lives greater than 20 years, we have taken a terminal value approach to incorporating capital costs in the assessment, which ensures that the capital cost of each option is appropriately captured in the 20-year assessment period.

We have adopted a real, pre-tax discount rate of 5.9 per cent as the central assumption for the NPV analysis presented in this report, consistent with Energy Network Australia’s

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[13] AER, *ElectraNet transmission determination 2018 to 2023*, Draft Decision, Attachment 6 – Capital expenditure, October 2017, p. 4.

[14] Available at https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/electranet-determination-2018-23/proposal#step-50979.

(ENA) 2019 RIT-T Economic Assessment Handbook.[15] We consider that this is a reasonable contemporary approximation of a 'commercial' discount rate (a different concept to a regulatory WACC), consistent with the RIT-T.

The RIT-T requires that sensitivity testing be conducted on the discount rate and that the regulated real, pre-tax weighted average cost of capital (WACC) be used as the lower bound discount rate in the sensitivity testing.[16]

We have therefore tested the sensitivity of the results to changes in this discount rate assumption, and specifically to the adoption of a lower bound discount rate of 2.85 per cent,[17] and an upper bound discount rate of 8.95 per cent (i.e. a symmetrical adjustment upward).

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15 ENA, *RIT-T Economic Assessment Handbook*, 15 March 2019, p. 67.

16 AER, *Final Regulatory Investment Test for Transmission*, June 2010, version 1, paragraph 15, p. 7.

17 This is equal to WACC (pre-tax, real) in the latest Final Decision for a transmission business in the NEM, see: https://www.aer.gov.au/networks-pipelines/determinations-access-arrangements/tasnetworks-determination-2019-24/final-decision

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