ElectraNet

MANAGING THE RISK OF AC BOARD FAILURE

Project Specification Consultation Report

14 October 2019

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Executive Summary

We propose to replace 24 AC boards and associated assets as part of our continued safe and efficient maintenance of the South Australian transmission network

This Project Specification Consultation Report (PSCR) identifies the need to replace 24 Alternating Current (AC) boards together with a range of associated assets across the South Australian electricity transmission network as the most efficient solution to manage the failure risk of these assets based on their assessed condition and inherent risks.

AC boards (also called changeover boards) are important devices used to direct electricity from one or more supply sources to a number of loads at a substation. AC boards provide all substations low voltage electricity for substation plant, building services, communications, control and protection, three phase outlets and lighting. Without AC boards the substation would not be able to operate safely and securely.

The 'identified need' is to efficiently manage the risk of asset failure

The identified assets for replacement are critical to the operation of substations and therefore are required for the safe, reliable and secure operation of the transmission system.

The identified need for this project is to continue to provide safe and reliable electricity transmission services in South Australia at a prudent and efficient level of cost. Specifically, the identified need for this Regulatory Investment Test for Transmission (RIT-T) is to efficiently manage safety risks associated with AC boards that have been identified due to their age and condition.

We have classified this RIT-T as a 'market benefits' driven RIT-T as the economic assessment is not being progressed specifically to meet a mandated reliability standard but by the expected net benefits to customers.

Notwithstanding this, the South Australian jurisdictional regulations require that:

- Substations must be designed, installed, operated and maintained to be safe for the electrical service conditions and the physical environment in which they will operate[1]; and
- ElectraNet institute a system of maintenance for substation buildings, enclosures and associated plant (which includes low voltage AC plant) that includes managed replacement programs for components approaching the end of their serviceable life.[2]

ElectraNet considers this replacement program will substantially reduce the risk of non-compliance with jurisdictional requirements and that this RIT-T forms an important part of maintaining compliance with these requirements.

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

1 *South Australia Electricity (General) Regulations 2012*, Regulation 51 - Substations.

2 *South Australia Electricity (General) Regulations 2012*, Schedule 3—Requirements for substations, clause 11(2)

Asset replacement is the only credible option

The analysis has identified that there is only one technically feasible option, which is to replace the identified AC boards and associated assets. This is because AC boards play a specific and important role in enabling substations to operate and to be maintained in a safe and timely manner. Their replacement will also minimise any possible consequential effects on downstream customers associated with the failure of these assets.

The estimated capital cost of this option is approximately $20.6 million, which equates to approximately $860,000 for each of the 24 AC boards planned to be replaced.

There is no feasible role for network support solutions in addressing the identified need for this RIT-T

Network support solutions cannot credibly meet the identified need for this RIT-T. This is driven by the unique and specific role that the identified AC boards and associated assets play in the transmission of electricity and their relatively low replacement cost.

This PSCR sets out the required technical characteristics for a network support option for completeness, consistent with the requirements of the RIT-T.

Three different 'scenarios' have been modelled to deal with uncertainty

We have developed three reasonable scenarios for the economic assessment as shown in Table 1 below.

Table 1 - Summary of the three scenarios

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[3]	8.95 per cent	5.90 per cent	2.85 per cent
Avoided corrective maintenance	70 per cent of base estimates	Base estimates	130 per cent of base estimates
Reduced personal injuries	70 per cent of base estimates	Base estimates	130 per cent of base estimates
Reduced fire damage	70 per cent of base estimates	Base estimates	130 per cent of base estimates
Cost of involuntary load shedding	70 per cent of base estimates	Base estimates	130 per cent of base estimates

These describe:

- 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 potential market benefits that could be realised; and
- a 'high benefits' scenario – reflecting an optimistic set of assumptions, which represents an upper bound on potential market benefits that could be realised.

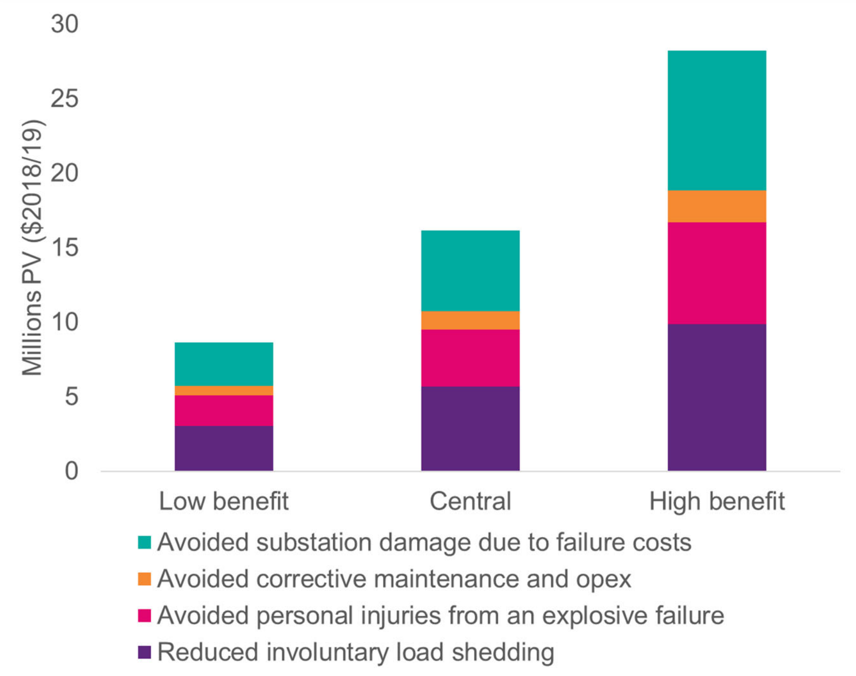
[3] Expressed on a real, pre-tax basis

Replacing the identified AC boards and associated assets as soon as possible is the preferred option[4]

The preferred option that has been identified in this assessment for addressing the identified need is Option 1, i.e. replacing the 24 AC boards and associated assets between 2020 and 2023.

The figure below provides a breakdown of benefits and demonstrates that the overall level of benefits is primarily driven by expected reductions in injuries from asset failure, involuntary load shedding and damage to other substation assets.

Figure 1 – Breakdown of present value gross economic benefits of Option 1



On a weighted-basis (i.e. weighted across the three scenarios investigated), Option 1 is expected to deliver approximately $4.5 million in net market benefits.

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

In particular, we have tested the optimal timing and the sensitivity of this timing to key variables. These sensitivity tests find that commissioning Option 1 as soon as possible is optimal and there are expected to be strong estimated net market benefits.

4 The preferred option is defined as the option that maximises net market benefits under the RIT-T framework.

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Glossary of Terms

Term	Description
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
ETC	Electricity Transmission Code
NPV	Net Present Value
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 Specification Consultation Report (PSCR) represents the first step in the application of the RIT-T to address the risk of AC board failure at certain substations in the South Australian transmission network.

This report:

- describes the identified need that we are seeking to address, together with the assumptions used in identifying this need;
- sets out the technical characteristics that a network support option would be required to deliver to address this identified need;
- outlines the credible option that we consider addresses the identified need;
- discusses specific categories of market benefit that, in the case of this RIT-T assessment, are unlikely to be material;
- presents the results of our economic assessment of the credible option and identifies the preferred option and the reasons for the preferred option; and
- sets out our basis for exemption from a Project Assessment Draft Report (PADR).

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.[5]

Accordingly, we have initiated this RIT-T to consult on proposed expenditure related to replacing AC boards and associated equipment, as none of the exemptions listed in NER clause 5.16.3(a) apply.

The credible option discussed in this PSCR has not been foreshadowed in AEMO's National Transmission Network Development Plan (NTNDP) or Integrated System Plan as they do not play a part in the main transmission flow paths between the NEM regions.

1.2 Submissions and next steps

We welcome written submissions on this PSCR. Submissions are due on or before 12 January 2020. Submissions should be emailed to consultation@electranet.com.au.

Submissions will be published on the ElectraNet website. If you do not want your submission to be made publicly available, please clearly specify this at the time of lodging your submission.

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5 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 AC boards and equipment 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 the identified AC boards.

Subject to submissions received on this PSCR, a Project Assessment Conclusions Report (PACR) is expected to be published by 25 March 2020.

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

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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 that underpin the RIT-T. It first provides some background on the identified AC systems and their role in the wider transmission of electricity in South Australia.

2.1 Background to the identified need

AC boards (also called changeover boards) are devices used to direct electricity from one or more supply sources to a number of loads at a substation. ElectraNet's modern main AC boards are typically designed with three ports and allow for automatic supply changeover between two alternative supplies (where both exist) and also automatic changeover for sites with an installed diesel generator.

AC boards provide all substations low voltage electricity for substation plant, building services, communications, control and protection, three phase outlets and lighting. Without AC boards the substation would not be able to operate safely and securely.

Across the transmission network, we have identified 24 AC boards for replacement based on their condition and risk to safety. In particular, we have identified:

- 8 flat panel boards;
- 7 tunnel boards;
- 4 enclosed cubicle boards with poor segregation;
- 4 enclosed cubicle boards with good segregation; and
- 1 residential-style AC switchboard.[6]

When replacing the AC boards other associated assets are also required to be replaced as these associated assets will be incompatible with the new style boards which are physically larger in size and may be in a different location in the substation. Therefore, the following associated AC system assets also require replacement (or installation) where needed as a result of replacing the above AC boards:

- incomer 415V power supply cables;
- station TF CB cubicles with lockable CBs;
- distribution boards;
- cabling to external plant and equipment;
- switchyard power boxes;
- building power boxes;
- temporary AC diesel generator connection points for the 13 sites where no permanent diesel generator is installed;

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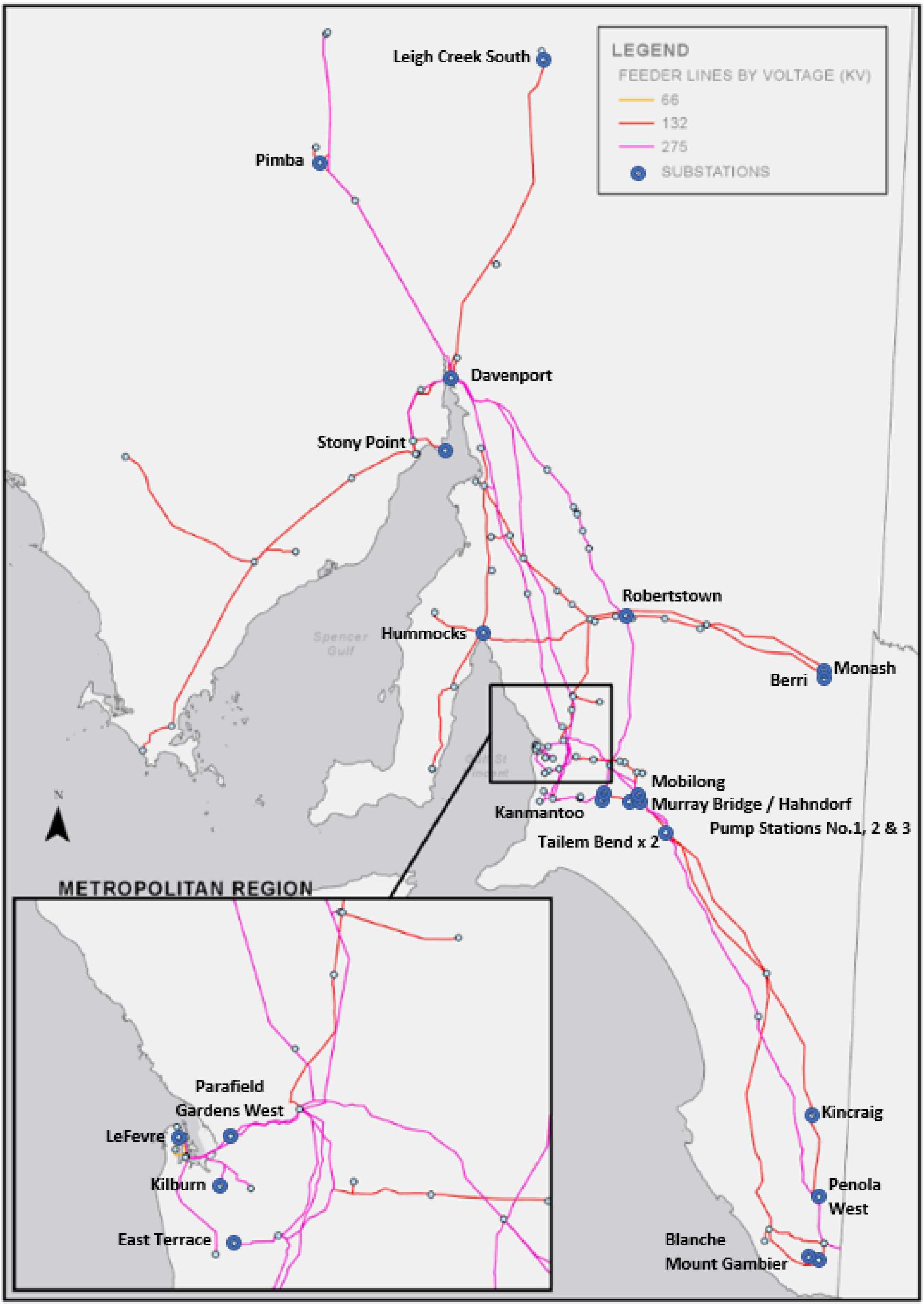
6 For the purposes of risk cost modelling, this board is considered a Flat Panel board.

- permanently connected AC diesel generators for two sites; and
- provision of clear, robust covers to existing equipment within the buildings and switchyards where exposed 230/400V terminals exist.

Wherever possible ElectraNet has sought to minimise these costs.

Figure 3 illustrates the distribution of the 23 substations where the 24 AC boards and associated assets are planned to be addressed. All substations have a single AC board identified for replacement except for Tailem Bend substation that has two AC boards planned to be replaced.

Figure 2 – Location of the AC boards that are being replaced



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These AC boards have a standard life[7] of 44.8 years and are now, on average, 41 years old. These AC boards are planned to be replaced on a one for one basis with new AC boards.

If the replacement program is not implemented, it is likely that a number of these assets will fail going forward, which could result in:

- safety concerns for substation personnel;
- the risk of involuntary load shedding on parts of the network due to the substations being damaged from a fire and without low voltage electricity necessary to control the substation; and
- damage to substation equipment if a fire occurs.

The design of these AC boards is now non-compliant with modern good electricity industry practice and current safety standards. While AS3000 compliance is not strictly mandatory for infrastructure in South Australia, safely maintaining and operating boards of this bespoke nature also relies on the availability of highly specialised electrical workers. Familiarity and knowledge concerning the older style non-compliant boards is decreasing as the workforce ages which is expected to substantially reduce the ability to operate and maintain them safely. In accordance with good electricity industry practice, in new substations ElectraNet requires AS3000 compliant substation low voltage AC Supplies[8].

Currently, removable covers are fitted behind the panels to act as barriers to prevent accidental contact and safe work methods are used to manage the risk. Replacement of these AC boards will reduce the possibility of personal injuries and substation damage due to a fire caused by the AC board igniting and/or the fire spreading beyond the cable trays. The existing AC boards have a much higher likelihood of failure than the new replacement AC boards.

The avoidance of such failures will also create cost savings across these areas during the delivery of the program (compared to a ‘replace on failure’ strategy, which is assumed under the base case in this RIT-T assessment).

2.2 Description of the identified need for this RIT-T

The identified need for this project is to efficiently manage the safety risks associated with individual AC boards and the associated assets that are no longer compliant with modern standards.

We have assessed the condition and timing to ultimately replace these assets as part of our ongoing asset management processes. There is an increased likelihood that a number

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7 The AER considers that repex involves replacing an asset or asset component with its modern equivalent where the asset has reached the end of its *economic* life, which takes into account the age, condition, technology, safety risks and operating environment of an existing asset (see: AER, *ElectraNet transmission determination 2018 to 2023*, Attachment 6 – Capital expenditure, Draft Decision, October 2017, p. 42.). We present here the standard technical lives of the AC boards for context and note that the assessment of replacing the identified AC Boards, both in the Revenue Proposal and this RIT-T, is consistent with the concept of economic life; ie, the expenditure decision is primarily based on the existing asset's inability to efficiently maintain its service performance requirement.

8 Substation LV AC Supplies- ElectraNet Document No: 1-11-FR-04, https://www.electranet.com.au/wp-content/uploads/2018/06/1-11-FR-04-Substation-LV-AC-Supplies.pdf

of these assets will fail in coming years, potentially resulting in personal injury to electrical workers and/or the unplanned unavailability to parts of the network.

We have classified this RIT-T as a 'market benefits' driven RIT-T as the economic assessment is not being progressed specifically to meet a mandated reliability standard but by the expected net benefits to customers.

Notwithstanding this, South Australian jurisdictional regulations require that:

- Substations must be designed, installed, operated and maintained to be safe for the electrical service conditions and the physical environment in which they will operate;[9] and
- ElectraNet institute a system of maintenance for substation buildings, enclosures and associated plant (which includes low voltage AC plant) that includes managed replacement programs for components approaching the end of their serviceable life.[10]

ElectraNet considers the targeted replacement of these assets will substantially reduce the risk of non-compliance with jurisdictional requirements. ElectraNet considers this RIT-T forms an important part of complying with this requirement and, more broadly, avoids a situation of run-to-failure for the identified assets (which would not constitute a compliant management strategy).

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

2.3 Assumptions underpinning the identified need

This section summarises the key assumptions from the risk cost modelling that underpin the identified need for this RIT-T. Section 6 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 as part of this PSCR in order to test the robustness of the preferred option. These are outlined in section 7.4 below.

2.3.1 Failure modes

For the purposes of this assessment, the risk cost model focuses on five modes of failure, being:

- a personal injury from touching exposed terminals in the AC board;
- a personal injury due to the absence of a Residual Current Device and, or fault switches, because a worker makes an error;

9 *South Australia Electricity (General) Regulations 2012*, Regulation 51 - Substations.

10 *South Australia Electricity (General) Regulations 2012*, Schedule 3—Requirements for substations, clause 11(2)

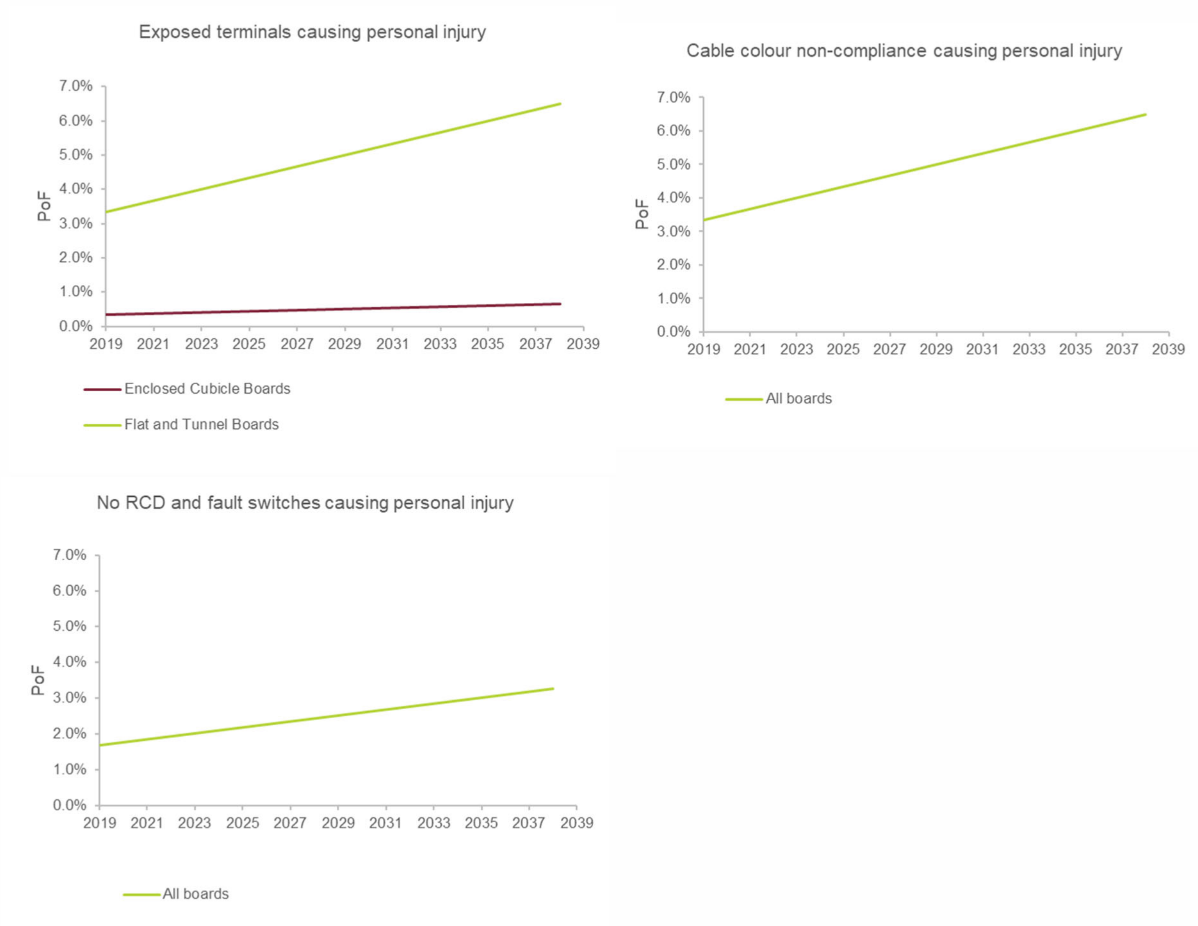
- a personal injury from non-compliant cable colouring because a worker makes an error;
- a fire igniting in the AC board from a range of defects; and
- a fire igniting in the cable trays of the AC board from a range of defects.

Each of these failure modes has different characteristics and consequent likelihoods of occurring, as is detailed in the section below. The economic assessment tests a wide range of alternate assumptions regarding the expected risk costs associated with the identified need in order to test the robustness of the identified preferred option.

2.3.2 The probability of failure modes

ElectraNet has identified that the AC boards in their current condition could cause a personal injury from three separate events. The different probabilities associated with each event and the current AC boards to be replaced are illustrated in Figure 3 which demonstrates an increased risk of possible personal injuries into the future.

Figure 3 – The different probabilities of failure associated with events causing personal injuries



These probabilities of failure have been determined from field staff and the increasing lack of familiarity and knowledge that exists concerning the older style non-compliant boards identified to be replaced as the workforce ages.

ElectraNet has also estimated the probability of failure (PoF) for a fire to occur in the AC board through extensive site visits that have assessed the current deterioration level of the insulation, build-up of flammable material (i.e. dust), and an increase in other defects in proximity to the AC boards proposed to be replaced, which could cause the cells to short out and ignite.

2.3.3 The adverse consequences resulting from failure

The potential adverse consequences resulting from the occurrence of an AC board failure include:

- the likelihood of serious personal injuries to ElectraNet personnel and electrical workers;
- periods of unserved energy to electricity customers during the time taken to establish a temporary connection in response to a failure;
- increased operating expenditure required to manage the network during an outage event;
- additional corrective maintenance costs associated with having to repair or replace the AC board in an unplanned emergency situation; and
- extensive damage due to a substation fire.

2.3.4 The likelihood and cost of negative consequences of an AC board failure

Our risk cost model, models each of the adverse effects outlined above that could occur from the identified AC assets failing. Specifically, the risk cost model individually defines a set of assumptions for the adverse effects, which allows the 'likelihood of consequence' (LoC) and 'cost of consequence' (CoC) to be estimated for asset failures.

We note that the likelihood of a personal injury from an AC board due to either touching exposed terminals, a lack of RCD and or fault switches and non-compliant cable colours has been determined based on the size of the substation. It is assumed based on standard maintenance practices that larger substations are more likely to be attended by industry workers on a regular basis and therefore have a higher LoC.

We have used the Value of Statistical Life[11] (VSL), escalated to today's dollars and multiplied by a relevant disproportionate factor, in order to quantify these avoided consequences. It has been assumed that any such events will incur additional costs such as legal, compensation and investigation costs (which have been estimated using Safe Work Australia reports).[12]

However, it has been assumed that only a small number of personal injuries will result in a fatality, as unlike our other assets AC boards are low voltage. The VSL and the additional costs for personal injuries have therefore been adjusted to represent not just a possible

[11] Department of the Prime Minister and Cabinet, *Best Practice Regulation Guidance Note Value of statistical life*, October 2018.

[12] Average Indirect Costs for work-related incidents, Australia in June 2013$, The Cost of Work-related Injury and Illness for Australian Employers, Workers and the Community: 2012-13, Safe Work Australia, p.26

fatality but also possible permanent injuries, lost time injuries and medical treatment injuries.

While one of the largest expected sources of benefit from the planned replacement comes from avoided outages following an AC board or cable tray fire, we note that most failures of AC boards will not result in an outage.

The likelihood that a fire in the AC board will cause wider adverse effects is based on the level of separation between components within the AC board and other assets at the substation. The LoC that a fire would ignite the whole AC board is estimated to be higher for tunnel or flat panel boards, than enclosed cubicle boards with poor electrical separation.

Similarly, ElectraNet estimates that the LoC for a fire in the cable trays of an AC board is likely to be significantly higher for flat panel boards, than tunnel boards and enclosed cubicle boards with poor electrical separation.

A fire igniting the whole AC board or a cable tray fire is unlikely for an enclosed cubicle board that has good electrical separation.

Losing load is considered likely at substations that are not meshed or able to be energised through alternative switching. The likelihood of losing load at substations that are meshed or can be energised through alternative switching is assumed to be very low. It is assumed if an outage did occur it would occur for 48 hours.

In calculating outage costs, the AEMO estimated value of customer reliability (VCR) of a mixed load for South Australia, escalated to 2019 dollars, has been applied for 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 of a direct connect load has been applied. All loads are based on the average load from the financial year 2017-18.

We note that, should an AC board fail, there may also be wider outages than the load we have considered and/or planned outages for operational and capital work may have to be postponed. These additional adverse effects have not been captured in our risk cost modelling but are expected to further increase the net market benefits associated with Option 1. As shown in section 7 below, estimating these additional benefits would not change the identified preferred option and so they are not considered material in the context of this RIT-T.

Unplanned outages require ElectraNet to incur further operating expenditure relating to the management of our network, including communication, legal and investigation costs. These costs have been estimated based on historical information and experience.

The costs associated with the negative consequences of an AC board failure are material assumptions for undertaking the project. We have therefore included a range of sensitivity tests on these as part of the economic assessment (see section 7.4).

3. Potential credible options to address the identified need

The analysis has identified that there is only one technically feasible option, which is to replace the non-compliant AC boards. This is because AC boards play a specific and important role in enabling substations to operate and to be maintained in a safe and timely manner and their replacement will minimise the risk of consequential supply interruptions impacting 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 7.4.

The option is considered to be technically and economically feasible and able to be implemented in sufficient time to meet the identified need.[13] In addition, all works are assumed to be completed in accordance with the relevant standards.

3.1 Option 1 – Planned replacement of AC boards by 2023

Option 1 involves planned replacement of 24 AC boards and associated assets that have been identified due to their condition and risk to safety.

These replacements are planned to occur between 2020 and 2023. These replacements are to be performed at substation locations where the asset is not already scheduled to be replaced as part of a network project during this period.

All AC board replacement assets are assumed to have the same signal output levels, ratios, etc. as the original assets, negating the requirement to modify any secondary system inputs. Some additional assets will also be replaced or added when replacing the AC boards (as set out in section 2.1).

The estimated total capital cost of this option is approximately $20.6 million. This equates to approximately $860,000 for each of the 24 AC boards planned to be replaced.

There is no incremental change in routine maintenance when the assets are replaced under Option 1 compared to the base case.

It is estimated that the replacement time for each AC board and its associated assets is around 32 weeks, to be implemented on a staggered basis, or around four years in total across the replacement program. Therefore, implementing this option would involve design and construction at multiple sites concurrently.

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 address non-compliant AC boards does not lend itself to any solution other than to replace the assets 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.

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13 In accordance with those identified in section 2.2.

One conceivable option, for example, would be to replace the entire substation, as opposed to just the AC boards. However, the capital cost of this is expected to be in the order of $20-40 million per substation (i.e., $460-940 million in total), which is significantly more than the option outlined above and does not provide any additional market benefits. In addition, the condition of other substation assets is such that they do not require replacing in coming years. Therefore, this is 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.

3.3 There is not expected to be a material inter-network impact

We have considered whether the credible option is expected to have a material inter-regional impact.[14]

By reference to AEMO's screening test for an inter-network impact[15], a material inter-regional impact may arise if the option:

- involves a series capacitor or modification near an existing series capacitor;
- is expected to result in a change in power transfer capability between South Australia and a neighbouring transmission network; or
- is expected to increase fault levels at any substation in another TNSP's network.

As none of these criteria are satisfied for this RIT-T, ElectraNet does not consider there are any associated material inter-network impacts.

[14] In accordance with NER clause 5.16.4(b)(6)(ii).

[15] AEMO's suggested screening test for a material inter-network impact is set out in Appendix 3 of the Inter-Regional Planning Committee's Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations, Version 1.3, October 2004.

4. Required technical characteristics of network support options

We do not consider that network support solutions can assist with meeting the identified need for this RIT-T. This is driven by the unique and specific role that the identified AC system assets play in the transmission of electricity i.e., the fact that substations require the AC boards in order to operate. AC boards also have a relatively low replacement cost in comparison to the total cost of network support options that would be required to support each substation. Furthermore, if a network support option was undertaken it would not reduce the safety risks or the possibility of involuntary load shedding (i.e., those outlined in section 2 above).

This section sets out the required technical characteristics for a network support option for completeness, consistent with the requirements of the RIT-T.

4.1 Required technical characteristics for a network support option

AC boards provide all substations low voltage electricity for substation plant, building services, communications, control and protection, three phase outlets and lighting. Without AC boards the substation would not be able to operate safely and securely.

A network support option that avoids replacement of AC boards would therefore need to be able to replicate the functionality, capacity and reliability of the entire substation on an enduring basis at a cost that is lower than the network option currently under consideration.

At this point in time, we estimate that the following substations are likely to need emergency replacement of damaged assets, incur unserved energy and/or require generation support following damage caused by the failure of an AC board. Note some of these substations are more likely than others to incur unserved energy and/or require generation support.

Table 2 – Substations at risk of unserved energy and/or requiring generation support under base case

Tailem Bend	Morphett Vale East	Davenport	Kanmantoo
Murray Bridge / Hahndorf No.1	Murray Bridge / Hahndorf No.3	Murray Bridge / Hahndorf No.2	Stony Point
Pimba	Berri	Mount Gambier	Leigh Creek South
Mobilong	Kincraig	Blanche	East Terrace
Lefevre	Penola West	Monash	Kilburn
Parafield Gardens West	Robertstown	Hummocks	

The average load at these substations is approximately 21 MW. A network support option would be required to be able to meet or offset these loads in full on a continuous basis, possibly 24 hours a day, during the time taken to or restore a substation impacted by failure of an AC board. While network support options involving generation may be technically possible in some instances, such a solution at the scale required is unlikely to be economically feasible.

Any network support solution seeking to remove the need for any of the affected AC boards would also need to ensure ongoing compliance with the applicable reliability standards in accordance with the ETC.

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

The section outlines the categories of market benefits prescribed in the NER and whether they are considered material for this RIT-T.[16]

Many of the expected benefits associated with Option 1 are 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.

Only unserved energy through involuntary load shedding of these avoided costs, is considered a market benefit category under the NER.

5.1 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,[17] for South Australia, and a VCR of $6,500 for direct connections.

5.2 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.[18]

Option 1 does not address network constraints between competing generating centres and is 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:

- changes in fuel consumption arising through different patterns of generation dispatch;
- changes in voluntary load curtailment (since there is no impact on pool price);

[16] 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.

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

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

- changes in costs for parties, other than for ElectraNet (since there will be no deferral of generation investment);
- changes in ancillary services costs;
- competition benefits; and
- Renewable Energy Target (RET) penalties.

5.3 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 three 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 3 – 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.[19] 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 condition and safety risks 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.

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

6. Description of the modelling methodologies applied

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

6.1 Overview of the risk cost modelling framework

We have applied an asset 'risk cost' evaluation framework to quantify the risk cost reductions associated with replacing the identified AC boards that are primarily focused on mitigating risk as 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 and 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 applied to quantifying risk was presented as part of our Revenue Proposal for the 2018-2023 regulatory control period and continues to be applied in replacement asset decision making, including RIT-T assessments. The AER has reported it to be consistent with good industry practice and to generally reflect reasonable inputs and assumptions.[20]

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.[21]

6.2 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.

The new AC boards have standard asset lives of 44.8 years. We have taken a terminal value approach to incorporating capital costs in the assessment, which ensures that the capital cost of the replacement program is appropriately captured in the 20-year assessment period.

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

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

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 (ENA) 2019 RIT-T Economic Assessment Handbook.[22] 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.[23]

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,[24] and an upper bound discount rate of 8.95 per cent (i.e. a symmetrical adjustment upward).

6.3 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.[25]

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.

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

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

[24] 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

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

Table 4 – Summary of the three scenarios

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[26]	8.95 per cent	5.90 per cent	2.85 per cent
Avoided corrective maintenance	70 per cent of base estimates	Base estimates	130 per cent of base estimates
Reduced personal injuries	70 per cent of base estimates	Base estimates	130 per cent of base estimates
Reduced fire damage	70 per cent of base estimates	Base estimates	130 per cent of base estimates
Cost of involuntary load shedding	70 per cent of base estimates	Base estimates	130 per cent of base estimates

[26] Expressed on a real, pre-tax basis

7. 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.

7.1 Gross benefits for each credible option

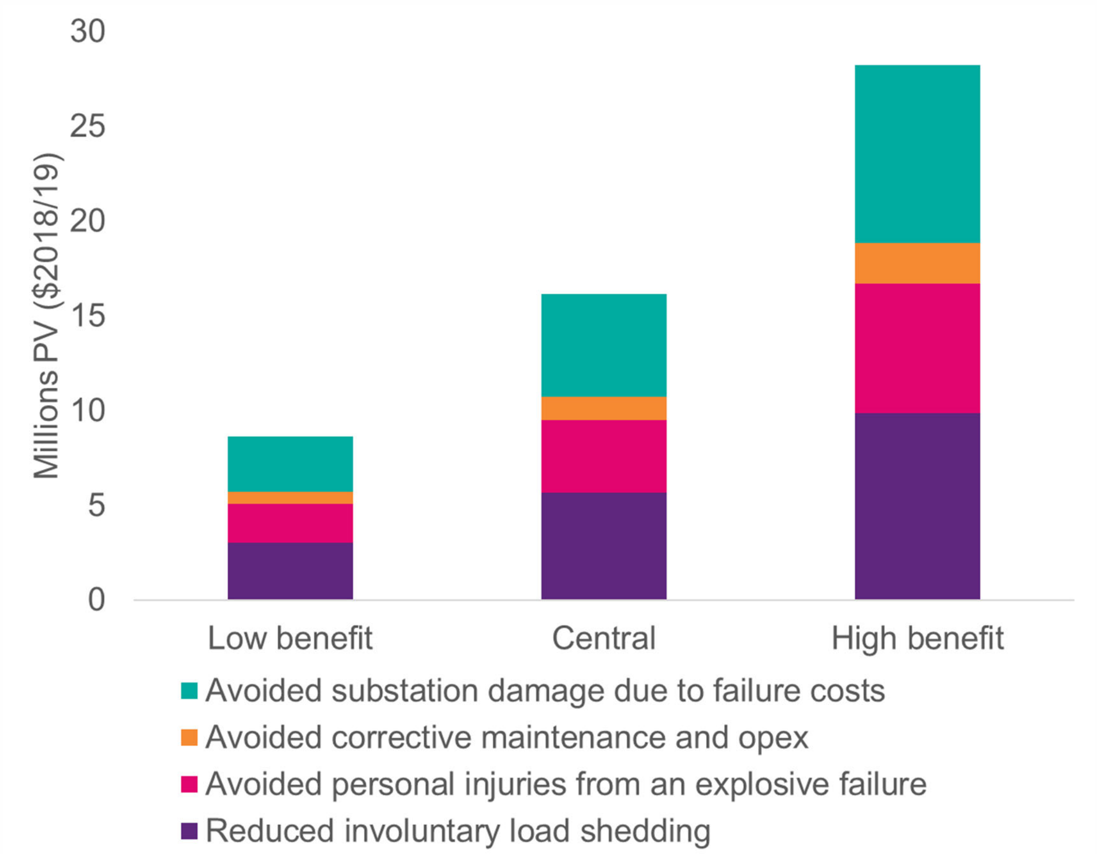
The table below summarises the gross benefit estimated for Option 1 relative to the 'do nothing' base case in present value terms. The gross market benefit has been calculated for each of the three scenarios outlined in the section above.

Table 5 – Estimated gross market benefit for each option, PV $m

Option	Low benefits scenario	Central scenario	High benefits scenario
Option 1 – Planned replacement of AC boards by 2023	8.6	16.2	28.2

The figure below provides a breakdown of benefits and shows that the overall level of benefits is primarily driven by expected reductions in injuries from asset failure, involuntary load shedding and damage to other substation assets.

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



7.2 Estimated costs for each credible option

The table below summarises the capital costs of Option 1, relative to the base case, in present value terms.

Table 6 – Estimated capital cost for each option, PV $m

Option	Low benefits scenario	Central scenario	High benefits scenario
Option 1 – Planned replacement of AC boards by 2023	-17.4	-12.9	-7.8

7.3 Net present value assessment outcomes

The table below summaries 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.

The table shows that Option 1 provides a strong expected net economic benefit on a probability-weighted basis, as well as under the central and high scenarios.

While the low benefits scenario shows negative expected market benefits, this scenario is considered highly unlikely since it is comprised of the lower bound of each expected net market benefit applied simultaneously. As outlined in section 6.3, the low scenario includes 30 per cent higher capital costs, a commercial discount rate of 8.95 per cent and 70 per cent lower benefits (across all types of benefits).

We have also been conservative in our modelling approach and have not included the additional adverse effects discussed in section 2.3.4 that would be avoided under Option 1, and thereby add to the net benefits of the Option 1.

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

Option	Low benefits scenario	Central scenario	High benefits scenario	Weighted
Option 1 – Planned replacement of AC boards by 2023	-8.8	3.2	20.4	4.5

7.4 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.

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

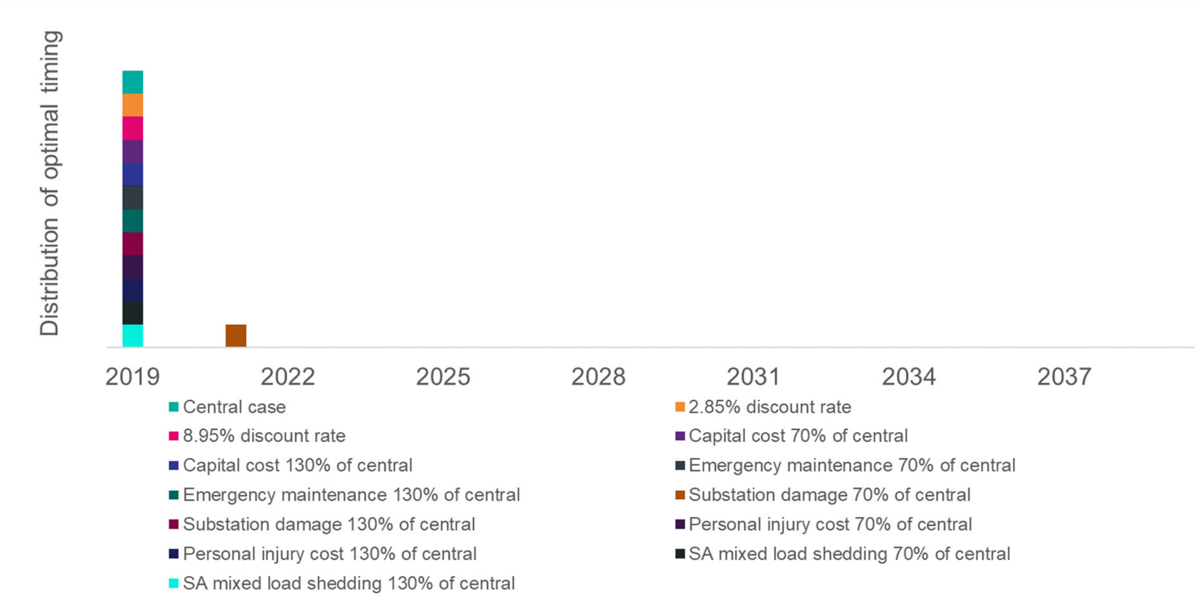
We have estimated the optimal timing for Option 1 based on the year in which the present value of the benefits exceeds the present value of the replacement project costs,[27] which is consistent with when the expected NPV is maximised. This process was undertaken for both the central set of assumptions and also a range of alternative assumptions for key variables.

The figure below outlines the impact on the optimal year to commence the program, under a range of alternative assumptions. Specifically, it shows, for each set of sensitivities/assumptions, the year that results in the highest expected net market benefits, all else being equal.

The figure illustrates that the optimal date is found to be in 2019 for all of the sensitivities investigated, except for the sensitivity where substation damage costs are reduced to 70 per cent of the costs estimated in Option 1, where the optimal date is found to be 2021.

It is noted 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 AC boards can be replaced is 2023).

Figure 5 – Distribution of optimal timing for Option 1 under different key assumptions



7.4.2 Sensitivity of the overall net market benefit

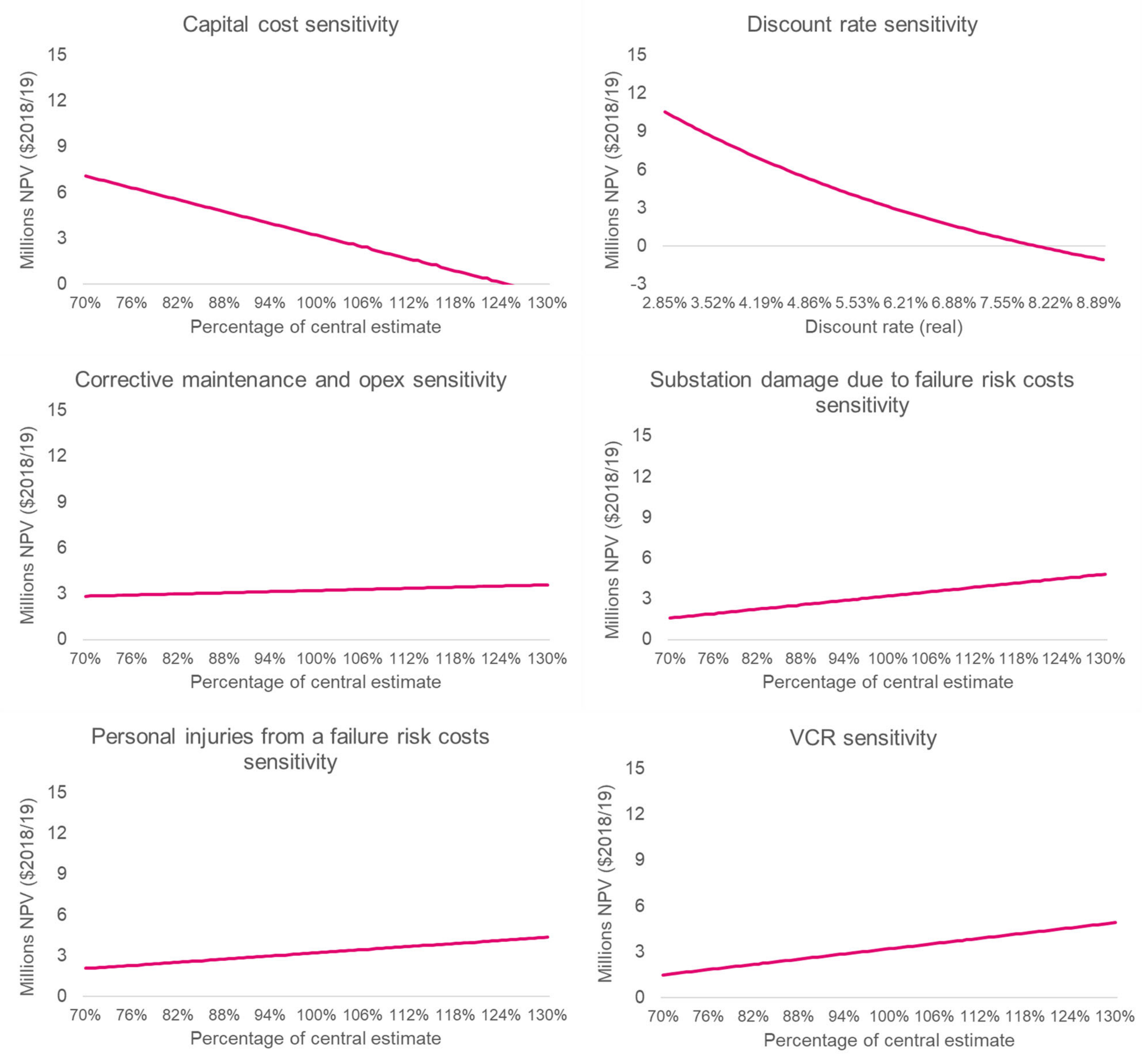
We have also looked at the consequences for the credible option of 'getting it wrong' if the key underlying assumptions are not accurate.

The six figures below illustrate the estimated net market benefits for each option if the six separate key assumptions in the central scenario are varied individually. Importantly, for

27 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).

all sensitivity tests shown below, with the exception of high discount rates and high capital costs, the estimated net market benefit of Option 1 remains strongly positive.

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



The table below demonstrates the 'threshold' values for each of the key assumptions in the economic assessment, i.e., how much would each key assumption need to be changed by for Option 1 to no longer have positive net market benefits.

Table 8 – Threshold values for key assumptions for Option 1 to no longer have positive net market benefits

Key variable/parameter	Threshold value
Capital cost	125% of central estimate
Discount rate (real, pre tax)	8.02%
Value of customer reliability	43.5% of central estimates
Corrective maintenance	No value
Substation damage	40.5% of central estimate
Personal injury risk cost	16.5% of central estimate

In addition, we find that the modelled failure rate implicit in the risk cost modelling would need to fall to approximately 80 per cent of the central estimate in order for there to be zero estimated net market benefits under the central scenario.

ElectraNet does not consider that any of these threshold values can be reasonably expected and, thus, considers that the expected net market benefits of Option 1 have been demonstrated to be robust to a range of alternate assumptions.

8. Draft conclusion and exemption from preparing a Project Assessment Draft Report

The preferred option that has been identified in this assessment for addressing the identified need, as detailed in section 7, is Option 1, i.e. replacing the identified AC boards and associated assets between 2020 and 2023. This option is described in section 3 and is estimated to have a capital cost of $20.6 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.

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

- if the estimated capital cost of the preferred option is less than $43 million;
- if the TNSP identifies in its PSCR its proposed preferred option, together with its reasons for the preferred option and notes that the proposed investment has the benefit of the clause 5.16.4(z1) exemption; and
- if the TNSP considers that the proposed preferred option and any other credible options in respect of the identified need will not have a material market benefit for the classes of market benefit specified in clause 5.16.1(c)(4), except for market benefits arising from changes in voluntary and involuntary load shedding.

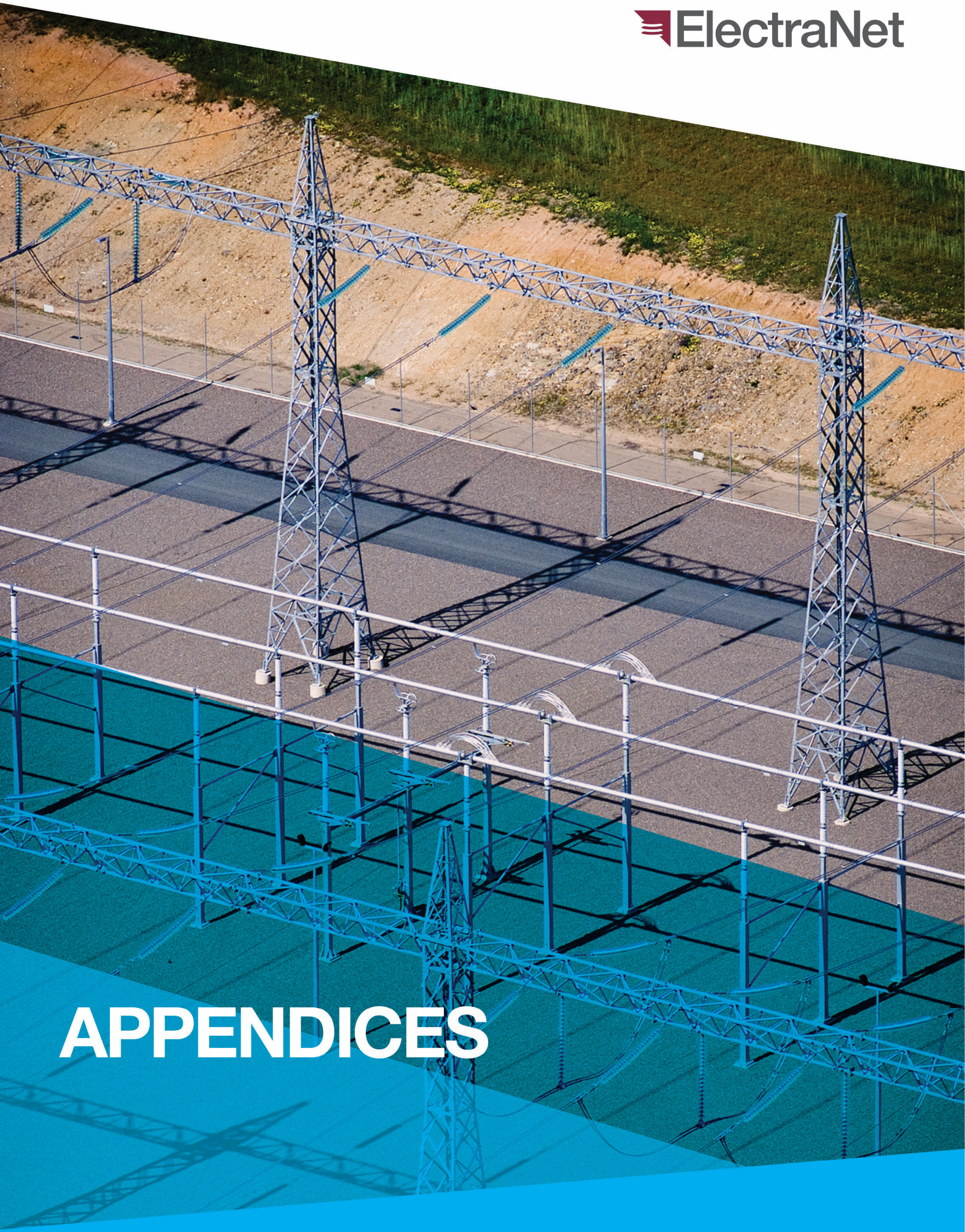
We consider that its investment in relation to Option 1 is exempt from producing a PADR under NER clause 5.16.4(z1) on the basis of meeting the criteria above.

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

Accordingly, if we consider that any additional credible options are identified, we will produce a PADR which includes an NPV assessment of the net market benefit of each additional credible option.

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

[28] In accordance with NER clause 5.16.4(z2).



APPENDICES

Appendix A Compliance checklist

This section sets out a compliance checklist which demonstrates the compliance of this PSCR with the requirements of clause 5.16.4(b) of the NER version 124.

Rules clause	Summary of requirements	Relevant section(s) in PSCR
5.16.4 (b)	A RIT-T proponent must prepare a report (the project specification consultation report), which must include:	–
	(1) a description of the identified need;	2.2
	(2) the assumptions used in identifying the identified need (including, in the case of proposed reliability corrective action, why the RIT-T proponent considers reliability corrective action is necessary);	2.3
	(3) the technical characteristics of the identified need that a non- network option would be required to deliver, such as: (i) the size of load reduction of additional supply; (ii) location; and (iii) operating profile;	4
	(4) if applicable, reference to any discussion on the description of the identified need or the credible options in respect of that identified need in the most recent National Transmission Network Development Plan;	1.1
	(5) a description of all credible options of which the RIT-T proponent is aware that address the identified need, which may include, without limitation, alterative transmission options, interconnectors, generation, demand side management, market network services or other network options;	3
	(6) for each credible option identified in accordance with subparagraph (5), information about: (i) the technical characteristics of the credible option; (ii) whether the credible option is reasonably likely to have a material inter-network impact; (iii) the classes of market benefits that the RIT-T proponent considers are likely not to be material in accordance with clause 5.16.1(c)(6), together with reasons of why the RIT-T proponent considers that these classes of market benefit are not likely to be material; (iv) the estimated construction timetable and commissioning date; and (v) to the extent practicable, the total indicative capital and operating and maintenance costs.	3 & 5

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

Appendix B Definitions

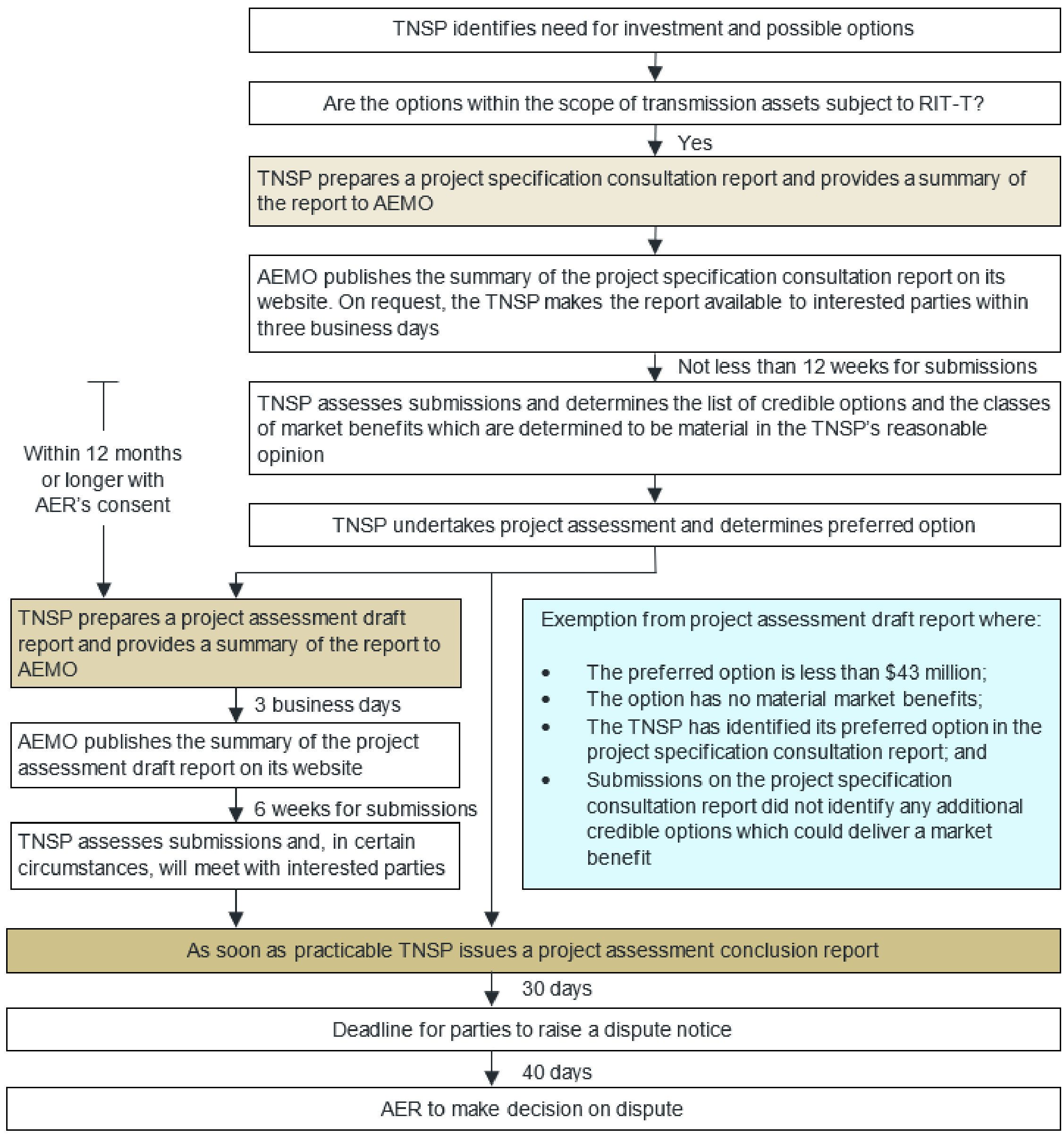
All laws, regulations, orders, licences, codes, determinations and other regulatory instruments (other than the NER) which apply to Registered Participants from time to time, including those applicable in each participating jurisdiction as listed below, to the extent that they regulate or contain terms 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 is seeking to apply (in blue).

Figure 7 The RIT-T assessment and consultation process



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