# Maintain reliable transmission network services at Keilor Terminal Station

**Project Specification Consultation Report**

Regulatory Investment Test - Transmission

August 2020

# Important notice

## Purpose

AusNet Services has prepared this document to provide information about potential limitations in the Victorian transmission network and options that could address these limitations.

## Disclaimer

# Executive summary

AusNet Services is initiating this Regulatory Investment Test for Transmission (RIT-T) to evaluate options to maintain reliable transmission network services at Keilor Terminal Station (KTS). Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process in accordance with clause 5.16 of the National Electricity Rules (NER)[1] and section 4.2 of the RIT-T Application Guidelines[2].

KTS is owned and operated by AusNet Services and is located in Keilor northwest of Melbourne's CBD. It was commissioned in 1970 and forms part of the main Victorian 500 kV and 220 kV transmission system with transformation from 500 kV to 220 kV and 220 kV to 66 kV.

## Identified need

The assets at KTS have been in service for an extended period of time. The condition of the three 500/220 kV transformers, and a limited number of 500 kV, 220 kV and 66 kV circuit breakers and instrument transformers at KTS has deteriorated to a level where there is a material risk of asset failure, which could have an impact on electricity supply reliability, generation cost, safety, environment, collateral damage and potential costs of emergency replacements. The 'identified need' this RIT-T intends to address is to maintain reliable transmission network services at KTS and mitigate risks from asset failures.

The present value of the baseline risk costs associated with maintaining the existing assets in service is more than $165 million – the largest component of which comes from the impact on the market (generation and electricity consumers) of an asset failure at KTS. AusNet Services is therefore investigating options that could allow continued delivery of safe and reliable transmission network services to users of the main transmission network.

## Credible options

AusNet Services estimates that network or non-network investments are likely to deliver more economical and reliable solutions compared with keeping the existing assets in service and identified the following credible network solutions that could meet the identified need:

- Option 1 – Integrated replacement with like-for-like replacement of all three transformers and selected switchgear
- Option 2 – Staged replacement of one 1000 MVA 500/220 kV transformer with the replacement of the other transformers deferred

AusNet Services welcomes proposals from proponents of non-network options (stand-alone or in conjunction with a network solution), that may meet the identified need, such as:

- options that allow for the retirement or deferral of the transformers or switchgear replacements at KTS by providing local supply or demand curtailment of sufficient scale.

## Assessment approach

AusNet Services will investigate the costs, the economic benefits, and the ranking of options in this RIT-T assessment. The robustness of the ranking and optimal timing of options will be investigated through sensitivity analysis which involves variation of assumptions around the values used for the central scenario.

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[1] Australian Energy Market Commission, *"National Electricity Rule version126,"* available at https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules/current, viewed on 7 November 2019.
[2] Australian Energy Regulator, *"Application guidelines Regulatory investment test for transmission,"* available at https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf, viewed on 7 November 2019.

**This draft conclusion section is included in the Draft PSCR document for the purposes of supporting AusNet Services Transmission Revenue Reset submission. The draft conclusion indicates the most economic option of the credible options identified. When the timing is right for this RIT-T to proceed, this section will be removed and AusNet Services will seek input from the market regarding other options and will evaluate all credible options before proceeding to the PADR and PACR stages of the RIT-T.**

## Options assessment and draft conclusion

AusNet Services' cost-benefit assessment of the identified credible options indicates that the staged replacement (Option 2) is the most economic option as it provides the highest net present value economic benefits of all options as shown in Graph 1. This option will not only maintain reliable transmission network services at KTS, but also mitigates safety, environmental, and emergency replacement risk costs from deteriorating assets at KTS.

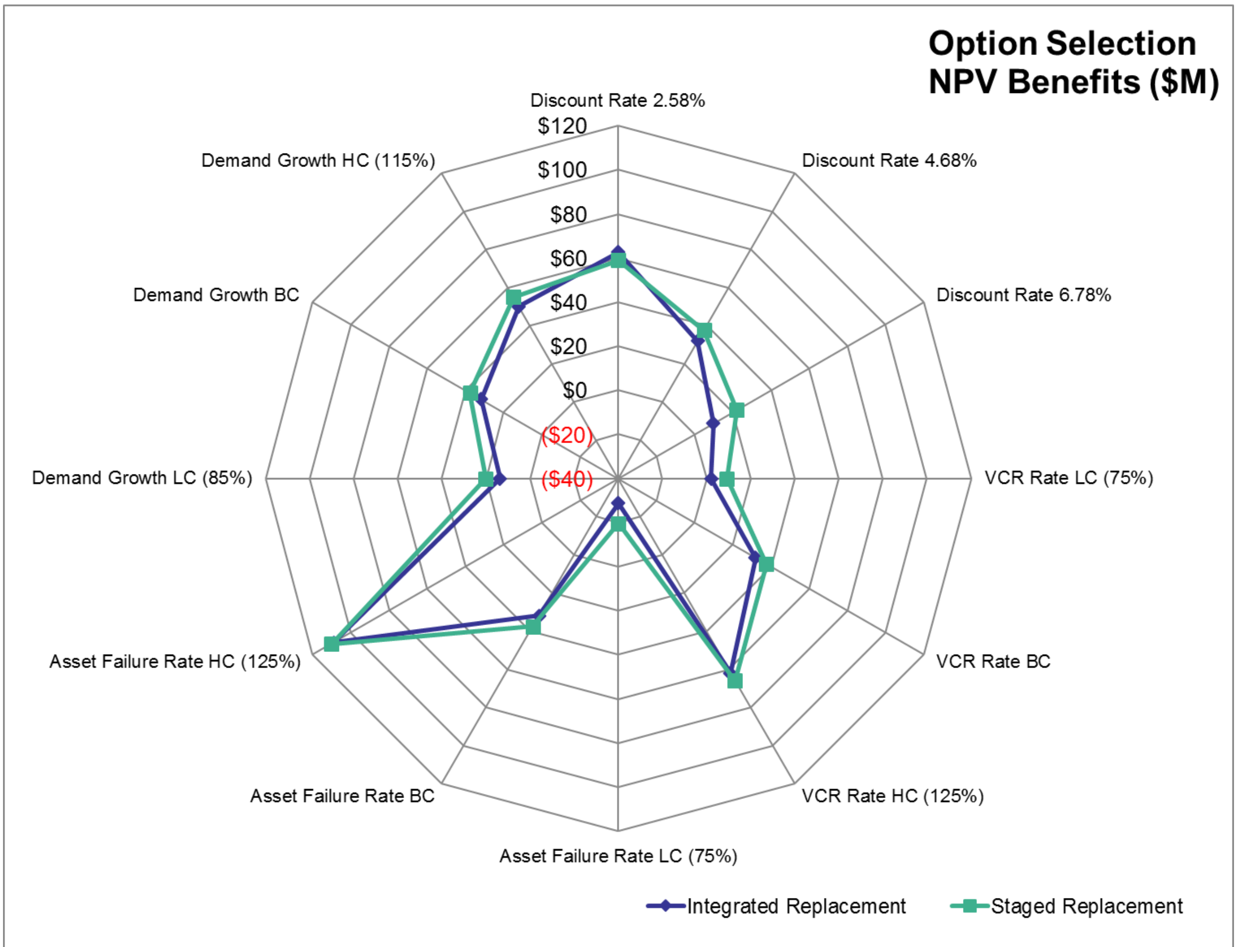


Figure 1 - Net PV economic benefits for each option in real 2020 $ million

The optimal timing of delivery of the preferred option is 2022/23.

## Submissions

AusNet Services welcomes written submissions on the topics and the credible options presented in this PSCR and invites proposals from proponents of potential non-network options.

Submissions should be emailed to rittconsultations@ausnetservices.com.au on or before XXX Date. In the subject field, please reference 'RIT-T PSCR KTS.'

Submissions will be published on AusNet Services' and AEMO's websites. If you do not wish for your submission to be made public, please clearly stipulate this at the time of lodgment.

## Next steps

Assessments of the options and responses to this PSCR will be presented in the Project Assessment Draft Report (PADR) that is intended to be published before XXX Date.

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# Tables

# 1. Introduction

AusNet Services is initiating this Regulatory Investment Test for Transmission (RIT-T) to evaluate options to maintain reliable transmission network services at Keilor Terminal Station (KTS). The three 500/220 kV transformers, and a number of 500 kV, 220 kV and 66 kV circuit breakers and instrument transformers at KTS are reaching the end of serviceable life which is driving the need for this investment.

Publication of this Project Specification Consultation Report (PSCR) represents the first step in the RIT-T process[3] in accordance with clause 5.16 of the National Electricity Rules (NER)[4] and section 4.2 of the RIT-T Application Guidelines.[5]

This document describes:

- the identified need that AusNet Services is seeking to address, together with the assumptions used in identifying this need;
- credible network options that may address the identified need;
- the technical characteristics that would be required of a non-network option to address the identified need;
- the assessment approach AusNet Services is intending to employ for this RIT-T assessment; and
- the specific categories of market benefits that are unlikely to be material in this RIT-T.

The need for investment to address risks from the deteriorating assets is presented in AusNet Services Asset Renewal Plan that is published as part of AEMO's Victorian Transmission Annual Planning Report (VAPR)[6].

## 1.1. Making submissions

AusNet Services welcomes written submissions on the credible options presented in this PSCR and invites proposals from proponents of potential non-network options. Submissions should be emailed to rittconsultations@ausnetservices.com.au on or before XXX Date. In the subject field, please reference 'RIT-T PSCR Keilor Terminal Station.'

Submissions will be published on AusNet Services' and AEMO's websites. If you do not wish for your submission to be made public, please clearly stipulate this at the time of lodgment.

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3 A RIT-T process will assess the economic efficiency and technical feasibility of proposed network and non-network options.

4 Australian Energy Market Commission, *"National Electricity Rule version126,"* available at https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules/current, viewed on 7 November 2019.

5 Australian Energy Regulator, *"Application guidelines Regulatory investment test for transmission,"* available at https://www.aer.gov.au/system/files/AER%20-%20Final%20RIT-T%20application%20guidelines%20-%2014%20December%202018_0.pdf, viewed on 7 November 2019.

6 Australian Energy Market Operator, *"Victorian Annual Planning Report,"* available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Victorian-transmission-network-service-provider-role/Victorian-Annual-Planning-Report, viewed on 7 November 2019.

# 2. Identified need

The role of KTS in providing electricity network services and the condition of key assets is discussed below. Quantification of the risk costs associated with the deterioration of these assets, and the need for the investments is also presented.

## 2.1. Transmission network services at KTS

KTS is owned and operated by AusNet Services and is located in the north west of Greater Melbourne. KTS is one of the major terminal stations in Victoria with three voltage levels – 500 kV, 220 kV and 66 kV.  KTS supplies a total of approximately 189,460 customers in the Airport West, St. Albans, Woodend, Pascoe Vale, Essendon and Braybrook areas.

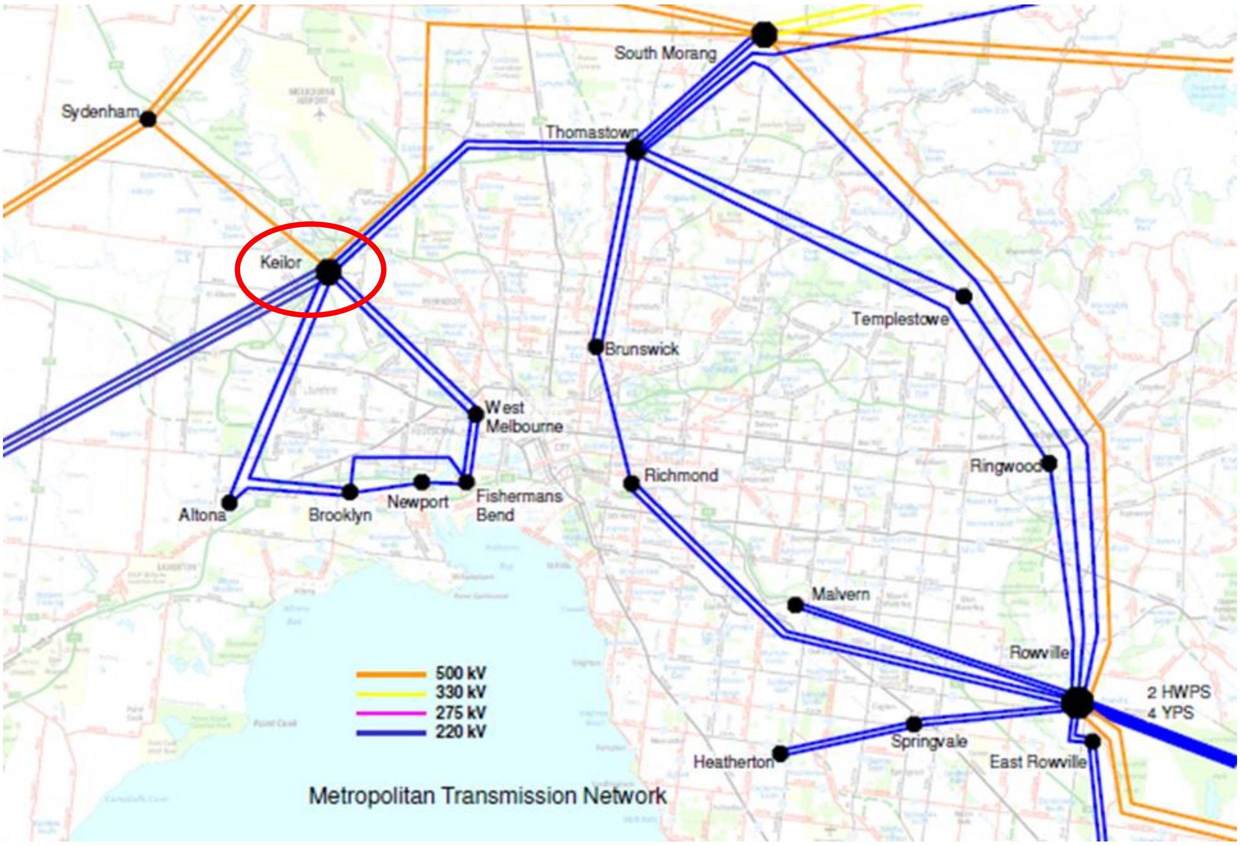


Figure 2 – KTS and metropolitan transmission network

## 2.2. Asset condition

AusNet Services classifies asset conditions using scores that range from C1 (initial service condition) to C5 (extreme deterioration) – as set out in Appendix C. The latest asset condition assessment for KTS was conducted in 2019 and reveals some assets at the terminal station are in poor condition (C4) or are rapidly deteriorating (C5). For the affected assets, the probability of failure is high, and is likely to increase further if no remedial action is taken. Table 1 provides a summary of the condition of relevant major equipment.

| Asset class | Condition scores | | | | |
|---|---|---|---|---|---|
| | C1 | C2 | C3 | C4 | C5 |
| 500/220 kV transformers | 0 | 0 | 2 | 1 | 0 |
| 500 kV circuit breakers | 0 | 3 | 3 | 1 | 0 |
| 220 kV circuit breakers | 1 | 24 | 1 | 0 | 1 |
| 66 kV circuit breakers | 0 | 5 | 18 | 1 | 1 |

**Table 1 - Summary of major equipment condition scores**

### 500/220 kV transformers

One of the three 500/220 kV transformers (A4 transformer) is in poor condition (C4). The core and windings of this transformer have been assessed as C4 condition with no opportunity to improve it by refurbishing the transformer. The bushings of the A4 transformer are also assessed as C4 condition.

### 500 kV circuit breakers

One of the seven 500 kV circuit breakers is in poor condition and approaching its end of economic and technical life. This is expected of assets that have been in service for an extended period of time.

Spares and external support for this type of circuit breaker are limited, which make refurbishment not a viable economic option.

### 220 kV circuit breakers

One of the twenty-seven 220 kV circuit breakers is in poor condition and approaching its end of economic and technical life. This is expected of assets that have been in service for an extended period of time.

Spares and external support for this type of circuit breaker are limited, which make refurbishment not a viable economic option.

### 66 kV circuit breakers

Two of the 66 kV circuit breakers are in poor or very poor condition and are approaching their end of economic and technical life. This is expected of assets that have been in service for an extended period of time.

Spares and external support for this type of circuit breaker are limited, which make refurbishment not a viable economic option.

## 2.3. Description of the identified need

KTS is part of the main 500 kV and 220 kV transmission network, which provides major transmission network services in Victoria. KTS also supplies local demand at 66 kV. AusNet Services expects that the services that the terminal station provides will continue to be required given the transmission network developments that are foreshadowed in AEMO's Integrated System Plan[7] and the Distribution Business' Transmission Connection Planning Report (TCPR).

The poor condition of some of the components at the terminal station has increased the likelihood of asset failures. Such failures would result in prolonged outages.

Without remedial action, other than ongoing maintenance practice (business-as-usual), affected assets are expected to deteriorate further and more rapidly. This will increase the probability of asset

[7] AEMO, Draft 2020 Integrated System Plan for the National Electricity Market, 12 December 2019.

failure, resulting in a higher likelihood of an impact on users of the transmission network, heightened safety risks due to potential explosive failure of the assets, environment risks, collateral damage risks to adjacent plant, and the risk of increased costs resulting from the need for emergency asset replacements and reactive repairs. Therefore, the 'identified need' this RIT-T intends to address is to maintain reliable transmission network services at KTS and to mitigate risks from relevant asset failures.

AusNet Services calculated the present value of the baseline risk costs to be more than $165 million over the forty-five year period from 2020/2021. The key elements of these risk costs are shown in Figure 4. The largest component of the baseline risk costs comes from the monetised supply risk from the potential failure of assets.

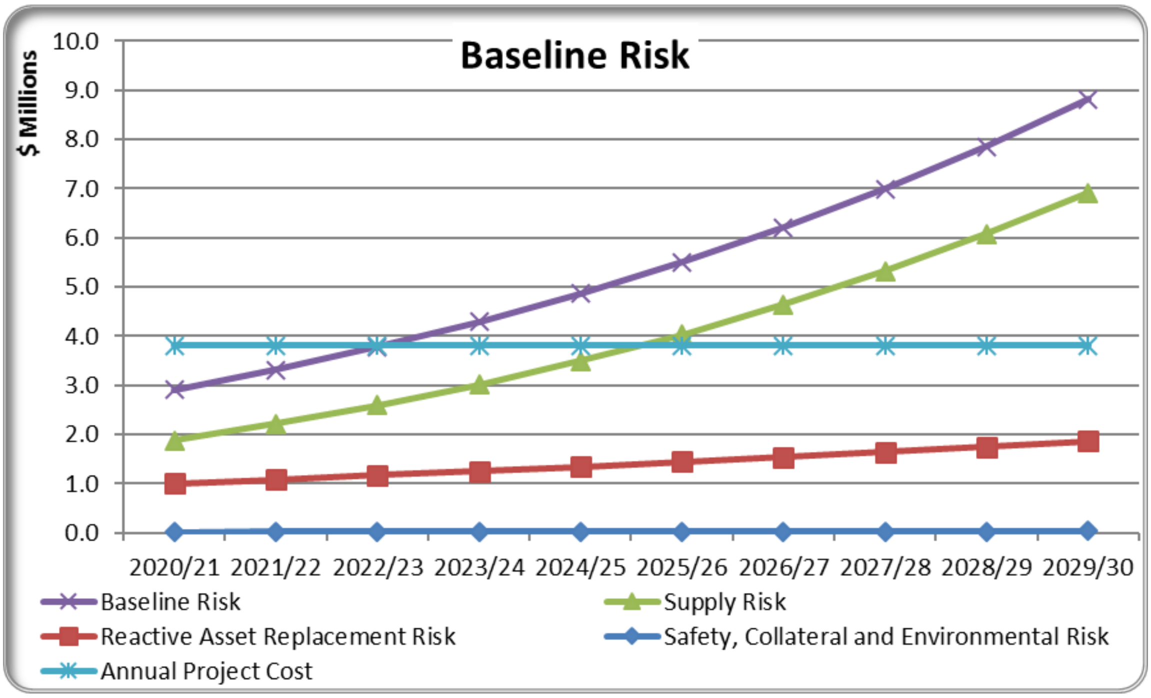


Figure 3 - Baseline risk costs

By undertaking the options identified in this RIT-T, AusNet Services will be able to maintain reliable transmission network services at KTS and mitigate safety and environmental risks, as required by the NER and Electricity Safety Act 1998[8].

### 2.3.1. Assumptions

In addition to the failure rates (determined by the condition of the assets) and the likelihood of relevant consequences, AusNet Services has adopted further assumptions to quantify the risks associated with asset failure. These assumptions are detailed in the following subsections.

#### Market impact costs

AEMO calculated the market impact cost, which mainly consists of involuntary load shedding following

[8] Victorian State Government, Victorian Legislation and Parliamentary Documents, *"Energy Safe Act 1998,"* available at http://www.legislation.vic.gov.au/domino/Web_Notes/LDMS/LTObject_Store/ltobjst9.nsf/DDE300B846EED9C7CA257616000A3571/1D9C11F63DEBA5E2CA257E70001687F4/%24FILE/98-25aa071%20authorised.pdf, viewed on 7 November 2019.

an asset failure or asset failures at KTS based on the latest Value of Customer Reliability (VCR)[9].

## Safety risk costs

The Electricity Safety Act 1998[10] requires AusNet Services to design, construct, operate, maintain, and decommission the network to minimise hazards and risks to the safety of any person as far as reasonably practicable or until the costs become disproportionate to the benefits from managing those risks. By implementing this principle for assessing safety risks from explosive asset failures, AusNet Services uses:

- a value of statistical life[11] to estimate the benefits of reducing the risk of death;
- a value of lost time injury[12]; and
- a disproportionality factor[13].

AusNet Services notes this approach, including the use of a disproportionality factor, is consistent with the RIT-T Industry Practice notes[14] provided by the AER.

## Financial risk costs

There is a lasting need for the services that KTS provides, therefore the failure rate-weighted cost of replacing failed assets (or undertaking reactive maintenance) is included in the assessment.[15]

## Environmental risk costs

Environmental risks from plant that contains large volumes of oil, which may be released in an event of asset failure, is valued at $100,000 per event.

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[9] In dollar terms, the Value of Customer Reliability (VCR) represents a customer's willingness to pay for the reliable supply of electricity. The values produced are used as a proxy, and can be applied for use in revenue regulation, planning, and operational purposes in the National Electricity Market (NEM). Australian Energy Market Operator, *"Value of Customer Reliability,"* available at https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Value-of-Customer-Reliability-review, viewed on 7 November 2019.

[10] Victorian State Government, Victorian Legislation and Parliamentary Documents, *"Energy Safe Act 1998,"* available at http://www.legislation.vic.gov.au/domino/Web_Notes/LDMS/LTObject_Store/ltobjst9.nsf/DDE300B846EED9C7CA257616000A3571/1D9C11F63DEBA5E2CA257E70001687F4/%24FILE/98-25aa071%20authorised.pdf, viewed on 7 November 2019.

[11] Department of the Prime Minister and Cabinet, Australian Government, *"Best Practice Regulation Guidance Note: Value of statistical life,"* available at https://www.pmc.gov.au/resource-centre/regulation/best-practice-regulation-guidance-note-value-statistical-life, viewed on 7 November 2019.

[12] Safe Work Australia, "The Cost of Work-related Injury and Illness for Australian Employers, Workers and the Community: 2012-13," available at https://www.safeworkaustralia.gov.au/system/files/documents/1702/cost-of-work-related-injury-and-disease-2012-13.docx.pdf, viewed on 7 November 2019.

[13] Health and Safety Executive's submission to the1987 Sizewell B Inquiry suggesting that a factor of up to 3 (i.e. costs three times larger than benefits) would apply for risks to workers; for low risks to members of the public a factor of 2, for high risks a factor of 10. The Sizewell B Inquiry was public inquiry conducted between January 1983 and March 1985 into a proposal to construct a nuclear power station in the UK.

[14] Australian Energy Regulator, *"Industry practice application note for asset replacement planning,"* available at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/industry-practice-application-note-for-asset-replacement-planning, viewed on 7 November 2019.

[15] The assets are assumed to have survived and their condition-based age increases throughout the analysis period.

# 3. Credible network options

AusNet Services will consider both network and non-network options to address the identified need caused by the deteriorating assets at KTS.

The network options AusNet Services has identified are presented below and the technical requirements that a non-network option would have to provide are detailed in the next chapter.

## 3.1. Option 1 – Integrated replacement

Option 1 consideres like for like replacement of all three 750 MVA 500/220 kV transformers and selected switchgear in a single integrated project. The estimated capital cost of this option is $144 million.

## 3.2. Option 2 – Staged replacement

Option 2 is a staged replacement option to assess whether it would be more economic to stage the asset replacement investment over two stages that are more than five years apart.

The first stage replaces the A4 transformer with a 1000 MVA 500/220 kV transformer and selected switchgear that are in poor or very poor condition.

Stage 2 replaces the remaining two 500/220 kV transformers with one 1000 MVA 500/220 kV transformer.

The estimated capital cost of the first and second stage of this option is $71 million and $80.3 million respectively.

## 3.3. Material inter-regional network impact

The proposed asset replacements at KTS will not change the transmission network configuration and none of the network options considered are likely to have a material inter-regional network impact. A 'material inter- regional network impact' is defined in the NER as:

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

AEMO's screening test for material inter-network impact [16] of a transmission investment is described as follows:

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

AusNet Services assessment of these criteria is that there is no material inter-regional network impact associated with any options considered.

[16] Inter-Regional Planning Committee, *"Final Determination: Criteria for Assessing Material Inter-Network Impact of Transmission Augmentations,"* available at https://www.aemo.com.au/-/media/Files/PDF/170-0035-pdf.pdf, viewed on 7 November 2019.

# 4. Non-network options

AusNet Services welcomes proposals from proponents of non-network options that could be implemented on a stand-alone basis or in conjunction with a network option to meet or contribute to meeting the identified need for this RIT-T.

AusNet Services will evaluate identified non-network options based on their economic and technical feasibility, but considers that it is unlikely that non-network solutions will be technically feasible alternatives given that KTS is part of the main transmission extra high voltage backbone with 500 kV and 220 kV transmission lines being switched at KTS.

Proposals for non-network solutions should be emailed to rittconsultations@ausnetservices.com.au by XXX Date.

# 5. Assessment approach

Consistent with the RIT-T requirements and practice notes on risk-cost assessment methodology[17], AusNet Services will undertake a cost-benefit analysis to evaluate and rank the net economic benefits from various credible options.

AusNet Services proposes to undertake this assessment over a 45-year period.

All options considered will be assessed against a business-as-usual case where no proactive capital investment to reduce the increasing baseline risks is made.

Optimal timing of an investment option will be the year when the annual benefits from implementing the option become greater than the annualised investment costs.

## 5.1. Proposed analysis and input assumptions

The robustness of the investment decision and the optimal timing of the preferred option will be tested by a sensitivity analysis. This analysis involves variation of assumptions from those employed under the Central scenario.

## 5.2. Material classes of market benefits

NER clause 5.16.1(c)(4) formally sets out the classes of market benefits that must be considered in a RIT-T. AusNet Services estimates that the classes of market benefits that are likely to be material include changes in involuntary load shedding, and changes in fuel consumption arising through different patterns of generation dispatch.

## 5.3. Other classes of benefits

Although not formally classified as classes of market benefits under the NER, AusNet Services expects material reduction in: safety risks from potential explosive failure of deteriorated assets, environment risks from possible oil spillage, collateral damage risks to adjacent plant, and the risk of increased costs resulting from the need for emergency asset replacements and reactive repairs by implementing any of the options considered in this RIT-T.

## 5.4. Classes of market benefits that are not material

AusNet Services estimates that the following classes of market benefits are unlikely to be material for any of the options considered in this RIT-T:

- Changes in costs for parties, other than the RIT-T proponent – there is no other known investment, either generation or transmission, that will be affected by any option considered.
- Changes in ancillary services costs – the options are not expected to impact on the demand for and supply of ancillary services.
- Competition benefits – there is no competing generation affected by the limitations and risks being addressed by the options considered for this RIT-T.
- Option value – as the need for and timing of the investment options are driven by asset deterioration, there is no need to incorporate flexibility in response to uncertainty around any other factor.

[17] Australian Energy Regulator, *"Industry practice application note for asset replacement planning,"* available at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/industry-practice-application-note-for-asset-replacement-planning, viewed on 7 November 2019.

# 6. Options assessment and sensitivity analysis

This section details the analysis of the costs and benefits from the network options considered in this RIT-T. Any credible option that may arise from submissions in response to this PSCR will be assessed and presented as part of the next step of this RIT-T.

All the options assessed will deliver a forecast reduction in market impact cost, safety risks, environment risks, collateral risk and risks of replacement if the asset failed.

The robustness of the investment decision is tested using a range of input assumptions as described in Table 2. The sensitivity analysis involves variations of assumptions from those used for the base case.

Table 2 - Input assumptions used for the sensitivity studies

| Parameter | Lower Bound | Base Case | Higher Bound |
|---|---|---|---|
| Asset failure rate | AusNet Services assessment – 25% | AusNet Services assessment | AusNet Services assessment + 25% |
| Demand forecast | AEMO 2019 Transmission Connection Point Forecasts - 15% | AEMO 2019 Transmission Connection Point Forecasts | AEMO 2019 Transmission Connection Point Forecasts + 15% |
| Value of customer reliability | Latest AER VCR figures - 25% | Latest AER VCR figures | Latest AER VCR figures + 25% |
| Discount rate | 2.58% - the WACC rate of a network business | 4.68% - the latest commercial discount rate | 6.78% - a symmetrical adjustment upwards |

Figure 4 demonstrates that the total risk cost reduction outweighs the total capital, operating and maintenance costs for all options under most scenarios where input variables are varied one at a time. Of the options considered, Option 2 has the greatest net economic benefits.

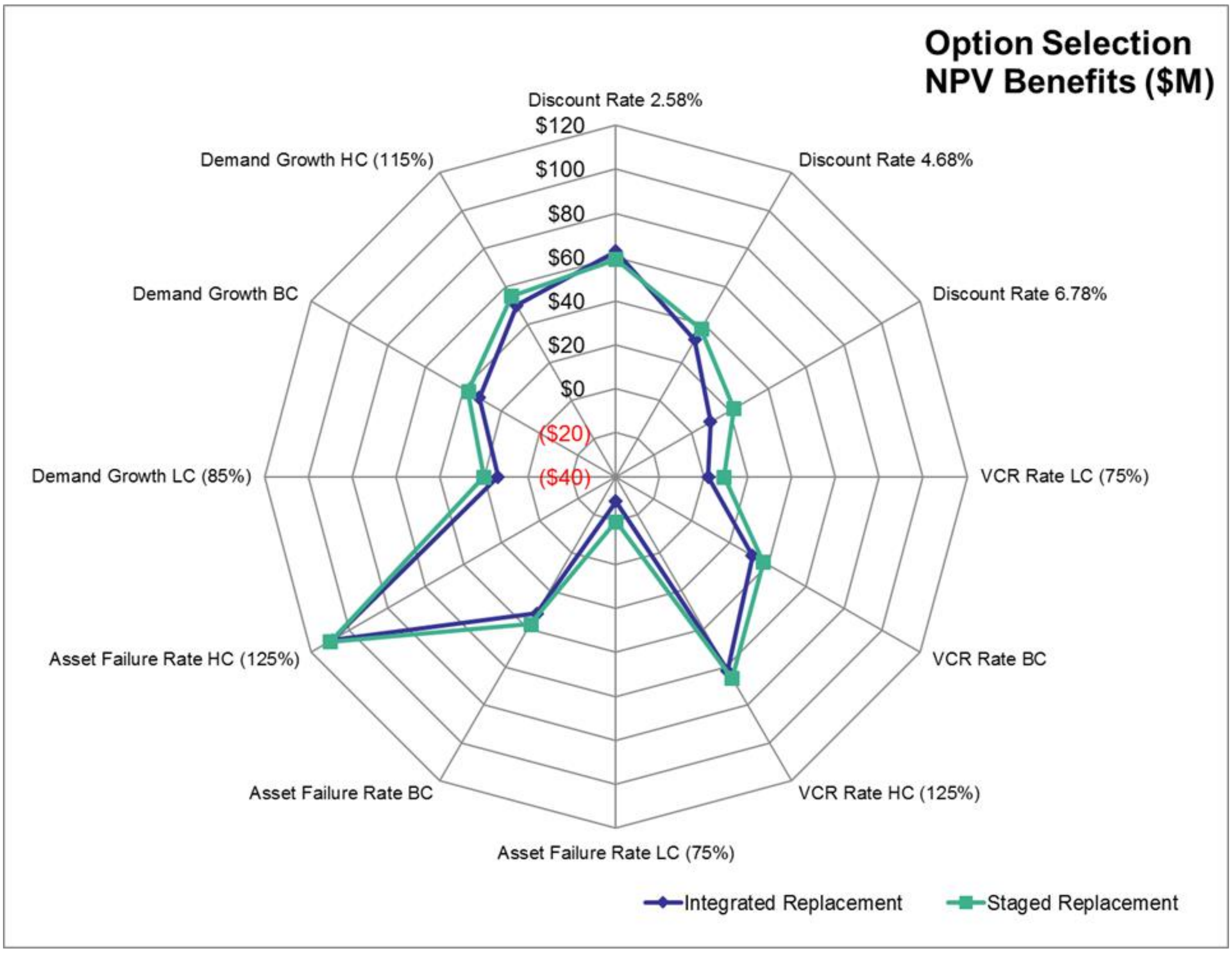


**Figure 4 – Net PV economic benefits for each option in real 2020 $ million**

## Sensitivity of optimal timing

Figure 5 shows that optimal timing of the preferred option is 2022/23 and that the economic timing falls inside the 2022 to 2027 revenue period for all sensitivity studies.

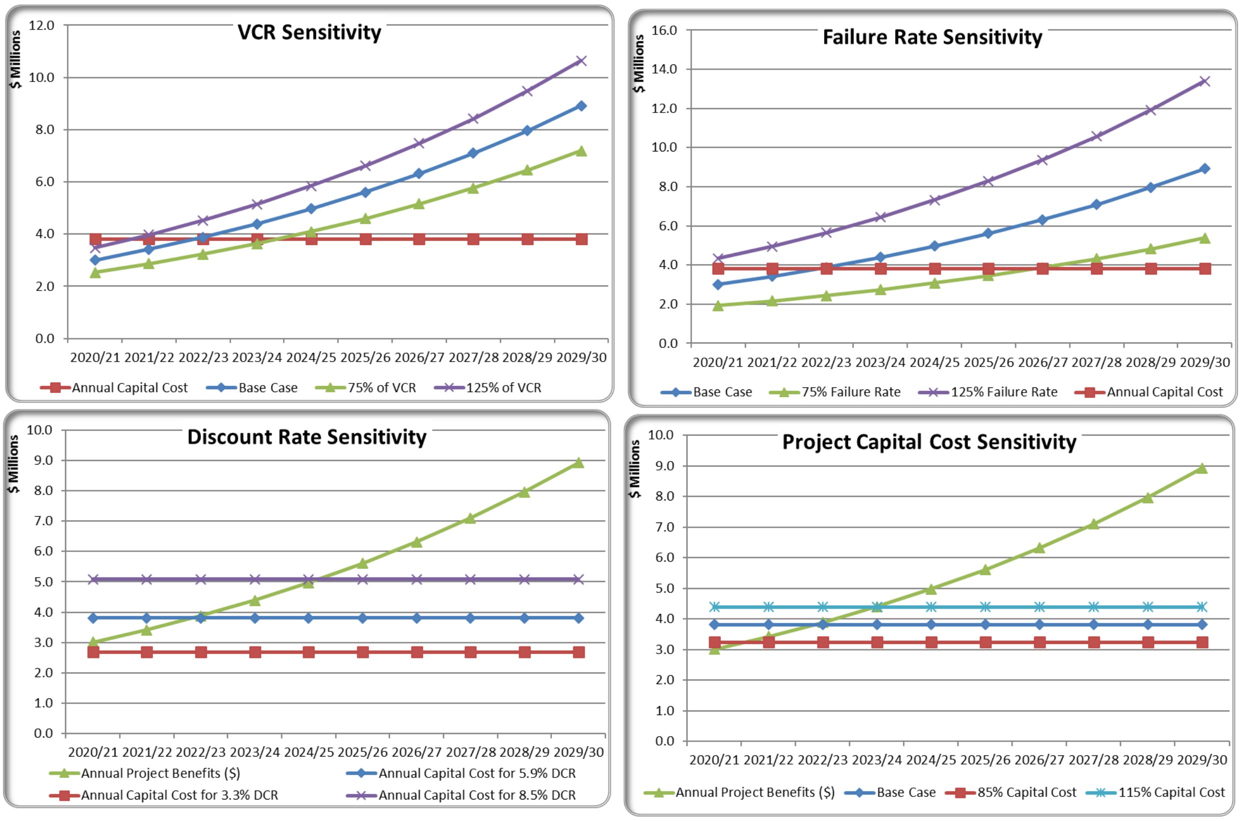


**Figure 5 - Sensitivity of the optimal timing with respect to variation of key parameters**

# 7. Draft conclusion and next steps

Option 2 is the most economical option to maintain reliable transmission network services at KTS and mitigate risks from asset failures.

This preferred option involves the following scope of work delivered in a single integrated project:

- Replacement of the A4 transformer with a 1000 MVA 500/220 kV transformer and selected switchgear that are in poor or very poor condition

The estimated capital cost of this option is $71 million.

Based on AusNet Services' preliminary analysis, this option is economical to proceed as soon as possible. However, to allow for construction lead time, this option is expected to be commissioned in 2023/24.

## Submissions

AusNet Services welcomes written submissions on the topics and the credible options presented in this PSCR and invites proposals from proponents of potential non-network options.

Submissions should be emailed to rittconsultations@ausnetservices.com.au on or before XXX Date. In the subject field, please reference 'RIT-T PSCR KTS.'

# Appendix A - RIT-T assessment and consultation process

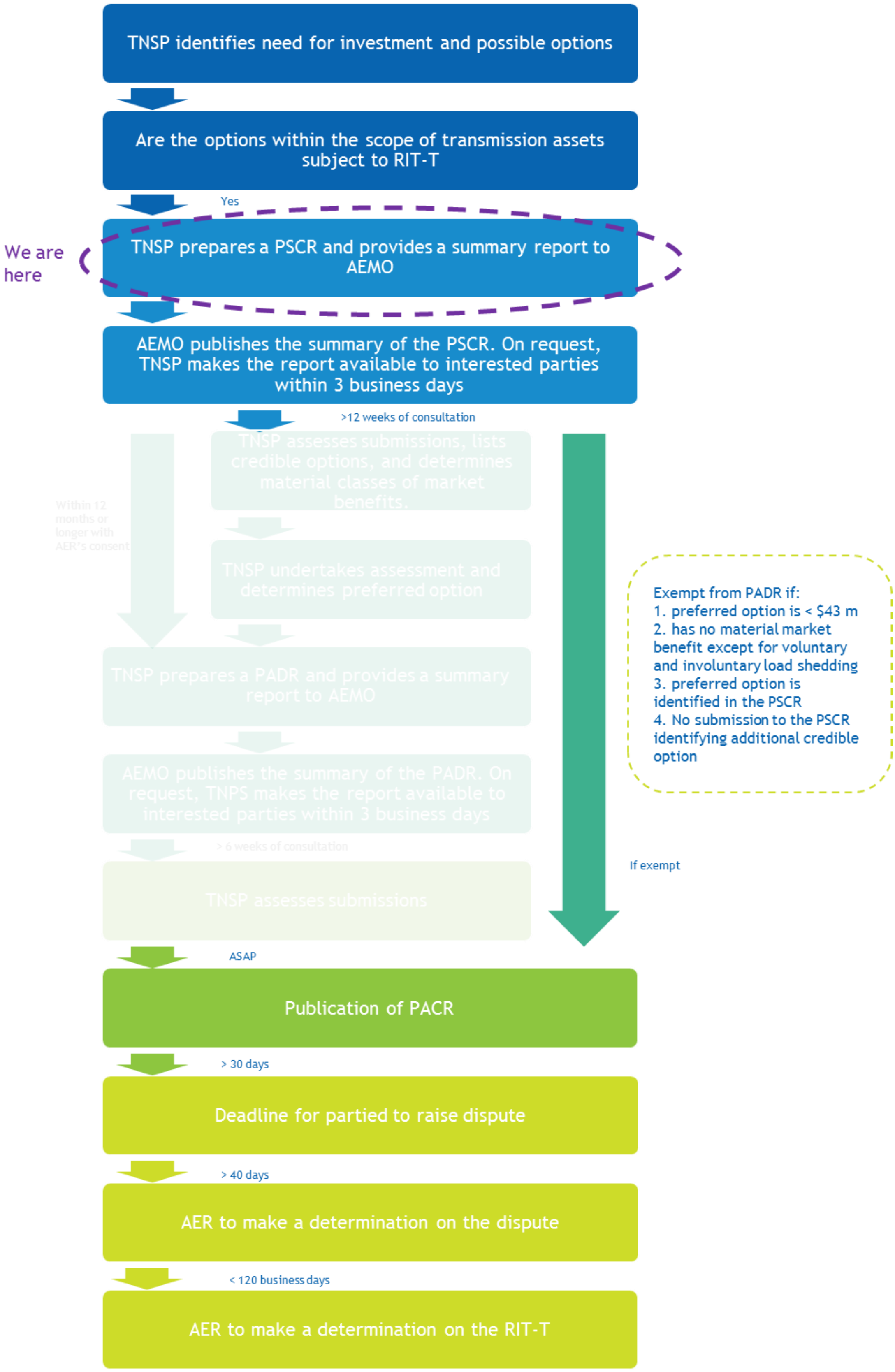


**Figure 6 - RIT-T Process**

# Appendix B - Asset condition framework

AusNet Services uses an asset health index, on a scale of C1 to C5, to describe asset condition. The condition range is consistent across asset types and relates to the remaining service potential. The table below provides an explanation of the asset condition scores used.

| Condition score | Likert scale | Condition description | Recommended action | Remaining service potential (%) |
|---|---|---|---|---|
| C1 | Very Good | Initial service condition | No additional specific actions required, continue routine maintenance and condition monitoring | 95 |
| C2 | Good | Better than normal for age | | 70 |
| C3 | Average | Normal condition for age | | 45 |
| C4 | Poor | Advanced deterioration | Remedial action or replacement within 2-10 years | 25 |
| C5 | Very Poor | Extreme deterioration and approaching end of life | Remedial action or replacement within 1-5 years | 15 |

**Figure 7 - Condition scores framework**

## Asset failure rates

AusNet Services uses the hazard function of a Weibull two-parameter distribution to estimate the probability of failure of an asset in a given year. The asset condition scores are used to establish a condition-based age which is used to calculate the asset failure rates using a two-parameter Weibull Hazard function (h(t)), as presented below.

$$h(t) = \beta . \frac{t^{\beta-1}}{\eta^{\beta}}$$

**Equation 1: Weibull Hazard Function**

where:

t = Condition-based age (in years)

η = Characteristic life (Eta)

β = Shape Parameter (Beta)

Hazard functions are defined for the major asset classes including power transformers, circuit breakers, and instrument transformers. All assets in the substation risk-cost model use a Beta (β) value of 3.5 to calculate the failure rates. The characteristic life represents that average asset age at which 63% of the asset class population is expected to have failed.

The condition-based age (t) depends on the specific asset's condition and characteristic life (η).