AusNet Electricity Services Pty Ltd

Contingent Project Application

Bushfire Mitigation

Submitted: 31 March 2017

About AusNet Services

AusNet Services is a major energy network business that owns and operates key regulated electricity transmission and electricity and gas distribution assets located in Victoria, Australia. These assets include:

- A 6,574 kilometre electricity transmission network that services all electricity consumers across Victoria;
- An electricity distribution network delivering electricity to approximately 680,000 customers in an area of more than 80,000 square kilometres of eastern Victoria; and
- A gas distribution network delivering gas to approximately 572,000 customer supply points in an area of more than 60,000 square kilometres in central and western Victoria.

AusNet Services' purpose is 'to provide our customers with superior network and energy solutions.' The AusNet Services company values are:

- We work safely
- We do what's right
- We're one team
- We deliver

For more information visit: www.ausnetservices.com.au

Contact

This document is the responsibility of the Regulated Energy Services business of AusNet Services. Please contact the indicated owner of the document below with any inquiries.

Kelvin Gebert
AusNet Services
Level 31, 2 Southbank Boulevard
Melbourne Victoria 3006
Ph: (03) 9695 6000

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Executive summary

AusNet Services is subject to new bushfire mitigation regulations that set highly challenging performance standards at 22 zone substations. These standards can only be met by installing Rapid Earth Fault Current Limiters (REFCLs), which have not previously been implemented for bushfire reduction anywhere in the world. In addition, the project is time-critical because the regulations set establishment dates, and the Government has reinforced the importance of timely delivery by introducing significant financial penalties if the regulations are not met.

The possibility of new bushfire mitigation regulations was known at the time of the AER's final decision for the 2016-2020 electricity distribution price review (EDPR). The AER recognised that the regulations were not settled and the costs of installing REFCLs were highly uncertain. The only available cost estimates were provided in the Government's Regulatory Impact Statement (RIS), but these were not sufficiently robust to form the basis of an expenditure allowance in the AER's determination. Instead, the AER included a 'contingent project' provision, which allows the determination to be amended to include a cost allowance for the capital works when fully scoped and costed. The AERs final decision for the EDPR included three contingent projects, providing for the capital works to be approved and delivered in three tranches.

This submission is AusNet Services' tranche 1 contingent project application in relation to bushfire mitigation through REFCL installations (designated Bushfire Mitigation Project 1 in the AERs final decision for the EDPR). It is the first tranche of three possible tranches specified in the AER's final decision for the EDPR. Tranche 1 does not include any declared area projects.

The tables below summarise the expenditure and revenue requirements to deliver the contingent project and the proposed amendments to the AER's final decision for the EDPR. Table 1 shows the building block elements that comprise the incremental revenue requirement for the contingent project over the 2016-20 period.

Table 1: Contingent project revenue requirement, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020	Total
Return on capital	-	0.5	4.5	7.1	6.9	18.9
Regulatory depreciation	-	0.9	2.0	3.6	3.8	10.3
Operating expenditure	-	0.6	0.8	0.9	0.9	3.2
Revenue adjustments	-	-	-	-	-	-
Net tax allowance	-	0.1	0.2	0.4	0.5	1.3
Annual revenue requirement (unsmoothed)	**-**	**2.2**	**7.6**	**12.0**	**12.0**	**33.7**
Annual revenue requirement (smoothed)		**-**	**6.7**	**13.4**	**14.1**	**34.2**

Source: AusNet Services PTRM

Table 2 below shows our amended revenue requirement, which includes the contingent project revenue requirement.

Table 2: Amended revenue requirement, 2016-20 ($m, nominal)[1]

	2016	2017	2018	2019	2020	Total
Return on capital	217.3	230.8	252.5	270.8	287.0	1,258.4
Regulatory depreciation	103.8	88.7	94.1	96.0	102.9	485.5
Operating expenditure	230.3	240.0	251.5	262.3	273.9	1,258.0
Revenue adjustments	5.3	-6.4	-3.6	16.1	0.1	11.6
Net tax allowance	33.2	27.2	27.9	28.8	28.0	145.0
Annual revenue requirement (unsmoothed)	**590.0**	**580.3**	**622.4**	**674.0**	**691.9**	**3,158.5**
Annual expected revenue (smoothed)	**586.0**	**597.9**	**623.5**	**657.1**	**692.5**	**3,157.0**
X factor[2]	8.27%	0.30%	-1.91%	-3.00%	-3.00%	n/a

Source: AusNet Services PTRM

The amended revenue requirements reflects the following expenditure forecasts in relation to the REFCL devices installed in Tranche 1:

- Forecast capital expenditure of $108.0 million[3] ($2016), representing a 5.95%[4] increase on AER approved total capital expenditure in its recent Distribution determination for AusNet Services; and
- Incremental operating expenditure of $2.9 million[5] ($2016), representing a 0.24%[6] increase on AER approved total operating expenditure in its recent Distribution determination for AusNet Services. Approximately 47% of the proposed incremental operating expenditure in 2020 is required for testing, which is mandated by legislation.

In addition to these expenditure forecasts AusNet Services proposes accelerated depreciation of $2.7 million ($2016) for assets that shall be removed from service ahead of their expected technical and economic lives.

This contingent project application provides a detailed explanation of these expenditure requirements. It explains the measures that AusNet Services has taken to ensure that the project scope and costings comply with the prudence and efficiency requirements in the Rules. A cost benefit analysis forms a key element of AusNet Services' strategy for each capital expenditure workstream. The analysis includes a consideration of non-network alternatives and the substitution possibilities between operating and capital expenditure.

The appendices to this contingent project application provide details of the expenditure requirements for each zone substation. In each case, the forecast expenditure is reconciled

1 It should also be noted that the amended revenue requirement includes the effect of the updated annual cost of debt, in accordance with the AER's Final Determination WACC requirements.

2 The X factors from 2018 to 2020 will be revised to reflect the annual return on debt update. Under the CPI–X framework, the X factor measures the real rate of change in annual expected revenue from one year to the next.

3 Including escalation adjustments and capitalised overheads.

4 Excluding AER approved equity raising costs.

5 Including escalation adjustments.

6 Excluding debt raising costs.

with the cost estimates in the Government's RIS. In addition, strategy documents and other supporting documents are also provided to explain our approach to key workstreams, program governance and cost estimation. The supporting documents provide confidence that the forecasts presented in this contingent project application are prudent and efficient.

The unique and challenging nature of this project has necessitated a close working relationship with Powercor Australia, which is also subject to the same regulations. This cooperation has delivered substantial benefits in terms of shared understanding of the technology's operation on the network and efficient practice, particularly in relation to performance testing. It has also facilitated a deeper understanding of the capabilities of REFCL technology and the challenges in modifying current distribution networks to achieve the benefits of bushfire risk reduction.

The application includes costs that will be incurred to maintain network reliability. The extensive use of Distribution Feeder Automation developed by AusNet Services and deployed on the network significantly increases the number of switchable sections, and with REFCL implementation, additional switch upgrades and network balancing are necessary to maintain reliability.

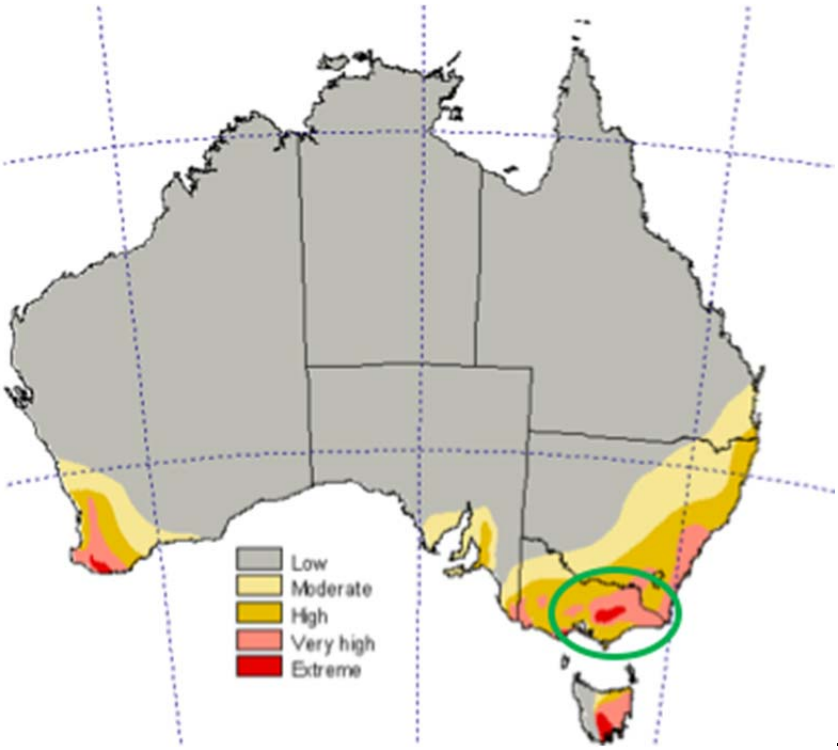
AusNet Services is confident that the expenditure forecasts in this submission comply with the Rules requirements. Accordingly, those expenditure forecasts should be accepted by the AER for the purpose of amending the 2016-20 determination to enable AusNet Services to recover the cost of this contingent project.

1 Background

1.1 Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016

AusNet Services' network operates in a unique geographical location, which is exposed to extreme bushfire risk. These conditions warrant significant investment to mitigate the bushfire risk.

Figure 1: AusNet Services' extreme bushfire risk



The 2009 Victorian Bushfire Royal Commission made several recommendations with respect to fires initiated from distribution electricity networks. Recommendation 27 called for new technology that delivered greatly reduced bushfire risk, being applied to all overhead conductors (SWER and 22kV powerlines) in high bushfire risk areas. The Royal Commission also suggested that an expert taskforce be established to advise on the best means of achieving the intent of this recommendation.

The subsequent Powerline Bushfire Safety Taskforce made its report to Government in September 2011. The Taskforce's report indicated that the optimal means of reducing bushfire risk from SWER and 22kV powerlines was a mixture of powerline replacement, automatic circuit reclosers (ACRs) on SWER lines and the selective installation of Rapid Earth Fault Current Limiters (REFCLs). The Taskforce also identified the need for further research and development, particularly as REFCLs had not been used for bushfire suppression previously.

In December 2011, the Government accepted the Taskforce's recommendations, and established the Powerline Bushfire Safety Program to determine the optimal method for deploying REFCLs for bushfire prevention. Following the completion of this research program, the Government introduced Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016 (the regulations).

The regulations require that each polyphase electric line originating from a list of selected zone substations must have the following capability in the event of a phase to ground fault:

a) *reduce the voltage on the faulted conductor in relation to the station earth when measured at the corresponding zone substation for high impedance faults to 250 volts within 2 seconds; and*

b) *reduce the voltage on the faulted conductor in relation to the station earth when measured at the corresponding zone substation for low impedance faults to —*

   (i) *1,900 volts within 85 milliseconds; and*

   (ii) *750 volts within 500 milliseconds; and*

   (iii) *250 volts within 2 seconds; and*

c) *during diagnostic tests for high impedance faults, limit —*

   (i) *fault current to 0.5 amps or less; and*

   (ii) *the thermal energy on the electric line to a maximum I^2t value of 0.1.* [7]

For AusNet Services, the regulations require each polyphase electric line originating from 22 selected zone substations to comply with the mandated performance standards by 1 May 2023.

The regulations apply a point scoring system to establish milestones for completing the required works. Each zone substation is attributed a point score from 1 to 5, with the highest value attributed to those zone substations where fire mitigation measures would provide the greatest benefit. AusNet Services is required to complete the required works to accumulate 30 points by 1 May 2019 and 55 points by 1 May 2021.

The Victorian Government is also introducing regulations that apply significant financial penalties if service performance in accordance with the timetable is not met.

1.2 A Challenging Regulatory Framework

AusNet Services has a strong record in delivering significant reductions in bushfire risk on our network across a range of programs at a reasonable cost to electricity customers. Bushfire risk reduction is a key focus of our business.

Last year the Victorian Government made the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016 (the REFCL Regulations). In the accompanying Statement of Reasons the Victorian Government noted that “the REFCL performance specifications stated in the regulations constitute a level of sensitivity and speed for network protection not previously seen in Victoria.”

The related Electricity Safety Amendment (Bushfire Mitigation Civil Penalties Scheme) Bill 2017 (the Penalties Bill) is currently before the Victorian Parliament. The Penalties Bill introduces a draconian regime for Victorian electricity distributors if they fail to comply with the standards and timeframes in the REFCL Regulations.

It is acknowledged the commissioning, operation and maintenance of REFCL devices will take connection point voltages for high voltage (HV) customers above the levels currently prescribed by the Victorian Electricity Distribution Code (the Code). AusNet Services has undertaken lengthy engagement with the Government and the Essential Services Commission (ESC) seeking to amend the Code to resolve the conflict with the REFCL Regulations.

However, AusNet Services received advice from the ESC that it does not have any firm plan to change the Code to allow networks to operate REFCLs within the Code’s voltage limits, nor will the ESC provide a letter of no action covering REFCL-related voltages outside the limits of the current Code.

[7] Other performance requirements are also specified in the definition of ‘required capacity’ in the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

Operating outside the Code exposes a network not only to disciplinary action from the ESC, but also to potential legal action from HV customers or other third parties. This presents an unacceptable risk.

While AusNet Services is committed to the REFCL program and work is well underway, we have advised the Government on numerous occasions that the hugely ambitious REFCL timeframe and performance standard are inconsistent with the technological, operational and commercial challenges that exist in relation to the REFCL program and the likely outcome will be higher costs to consumers. This is a world-first application of REFCL technology and there is currently a single worldwide supplier (a small Scandinavian company with 11 employees).

Notwithstanding our concerns with the regulatory framework, AusNet Services is committed to the REFCL rollout. At this stage the best approach to navigating the Victorian Government's contradictory regulatory framework is for AusNet Services to install isolating transformers at each of the HV customer sites where connection point voltages will be impacted by REFCL operation.

This is an extremely expensive option: this application seeks $12M to fund such equipment for Tranche 1 and our estimates suggest it will add over $84M to the cost of the REFCL program across the AusNet Services distribution network.

These higher costs are the direct result of the impractical and contradictory regulatory regime that has been put in place and will flow through to power prices for no benefit to the overwhelming majority of customers. If the Government facilitated HV end customer solutions, through code changes and funding, the cost would be much lower.

AusNet Services would prefer to take a pragmatic and proportionate approach to the REFCL program, attempting to balance fire risk and cost considerations as this new technology is implemented. Under the current regulatory framework, we are not permitted to do this.

1.3 Technology selection

The regulations prescribe a performance standard that we must meet, rather than specifying a particular technological solution. Setting performance standards or outcomes is generally preferred to input-based regulation because it provides flexibility to find more innovative and efficient ways of delivering the required outcomes.

In this instance, the mandated performance standard was based on the REFCL trials conducted by the Powerline Bushfire Safety Program (PBSP), as explained below:

> *"PBSP conducted a series of world-first trials of Rapid Earth Fault Current Limiter (REFCL) technology for use on electricity networks to reduce fire risks on bare-wire overhead powerlines.*
>
> *[…]*
>
> *Through this research, the Victorian Government and electricity distribution businesses identified and confirmed new fault detection and suppression standards required to significantly lower the risks that 22kV powerlines will start bushfires in worst bushfire risk conditions. These standards are now in force from the 1 May 2016 commencement of the Electricity Safety (Bushfire Mitigation) Amendment Regulations."* [8]

The Victorian Government also highlighted the superior performance of the REFCL technology in its factsheet 'REFCL – Introducing best knowledge and technology':

> *"In a series of world-first trials, the Victorian Government together with the electricity distribution businesses and research experts demonstrated that REFCLs can suppress arc-induced bushfire ignitions from wire-to-earth faults on 22kV powerlines.*

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[8] ` Department of Environment, Land, Water and Planning, Investing in new technology, research and development.

The technology was successfully tested under worst-case bushfire conditions, confirming critical fault detection and suppression standards, which are necessary to stop downed powerlines from starting bushfires, and further determining the optimal safety settings of these devices to reduce the risk of powerlines-started fires.

The test program demonstrated that REFCLs provide over 10-times better protection than the current best network protection technology.

These standards were mandated for 22 kV powerlines proceeding from 45 zone substations by the Government's 1 May 2016 amendments to the Electricity Safety (Bushfire Mitigation) Regulations."[9]

Manifestly, the Government's expectation is that REFCLs will be installed in response to the performance standard. While AusNet Services remains open to using alternative technologies to meet the performance standard, no such technologies are available today. In addition, given the tight timeframes for meeting the standard, the installation of REFCLs is the only feasible technological solution.

In reaching this conclusion, we note that the data and experience gained through recent trials have greatly assisted the industry in developing an understanding of the capabilities of REFCL technology and the challenges in modifying current distribution networks to achieve the benefits of bushfire risk reduction. The newness of the technology – which originated from a University project – single source supply, and first time application for the intended purpose, indicates the challenges for the project to achieve the desired outcomes.

In summary, while the regulations do not mandate the installation of REFCL technology specifically, in practice this is the only technically feasible solution currently available that could comply with the performance standard.

1.4 Contingent project

The final form of the bushfire mitigation regulation was not settled prior to the AER finalising its 2016-20 Electricity Distribution Price Review (EDPR) for the Victorian distributors. In addition, there was considerable uncertainty regarding the likely costs of meeting the proposed regulations, as AusNet Services noted in its submission to the Government's Regulatory Impact Statement (RIS):

"Based on the results of the completed trials to date, AusNet Services agrees that REFCL technology offers a means for reducing network related bushfire risk. However, the implementation of this technology to achieve this objective is far from straightforward or certain. For example, approximately 80% of the required expenditure for installing REFCLs is not for the REFCL itself but to undertake consequential network expenditure beyond the zone substation.

[…]

In Attachment A of this submission, AusNet Services explains how more detailed costing undertaken since the provision of initial cost estimates in early 2015 has provided firmer cost estimates which are approximately 30% higher than indicated in the RIS. Furthermore, these cost estimates do not include overheads, project management costs and interest during construction. It is important that the Department factors these updated cost estimates into its cost-benefit assessment."[10]

In its 2016-20 EDPR final decision, the AER acknowledged the considerable uncertainty in relation to the costs of meeting the regulations:

9 ` Department of Environment, Land, Water and Planning, REFCL – Introducing best knowledge and technology.

10 AusNet Services, submission to Department of Economic Development, Jobs, Transport and Resources, Regulatory Impact Statement on Electricity Safety (Bushfire Mitigation) Regulations 2015, 30 December 2015, pages 10 and 3.

"[..] there is substantial uncertainty as to the cost impact that will result when the Bushfire Mitigation Regulations Amendment is enacted. The discussion here has highlighted that although the RIS has helped to reduce that uncertainty, significant issues remain to be addressed. This is a symmetrical risk in that any error in setting an ex–ante forecast may result in either the service provider or customers bearing excessive costs. This risk is higher than normal because the largest element of this cost will arise from the deployment on an unprecedented scale of the new REFCL technology. Neither we nor the businesses currently have sufficient experience of this technology to be able to forecast the efficient cost of deploying the new technology with confidence."[11]

Given this uncertainty, the AER approved a contingent project to enable AusNet Services to obtain a cost allowance if the regulations were enacted and a project scope completed. The AER defined three tranches of projects, each with its own 'trigger event'. The trigger event for the first tranche is set out below:

Bushfire Mitigation contingent project 1[12]

In circumstances where a new or changed regulatory obligation or requirement (within the meaning given to that term by section 2D of the National Electricity Law) ("relevant regulatory obligation or requirement") in respect of earth fault standards and/or standards for asset construction and replacement in a prescribed area of the State is imposed on AusNet Services during the 2016–20 regulatory control period, the trigger event in respect of bushfire mitigation contingent project 1 occurs when all of the following occur:

1. *AusNet Services has identified the proposed capital works forming a part of the project, which must relate to earth fault standards and/or standards for asset construction and replacement in a prescribed area of the State and which are required for complying with the relevant regulatory obligation or requirement. The proposed capital works must be listed for commencement in the 2016–20 regulatory control period in regulations or legislation, or in a project plan or bushfire mitigation plan, accepted or provisionally accepted or determined by Energy Safe Victoria;*
2. *For each of the proposed capital works forming a part of the project AusNet Services has completed a forecast of capital expenditure required for complying with the relevant regulatory obligation or requirement;*
3. *For each of the proposed capital works forming a part of the project that relate to earth fault standards, AusNet Services has completed a project scope which identifies the scope of the work and proposed costings."*[13]

1.5 Purpose and structure of this document

AusNet Services is lodging this contingent project application for Bushfire Mitigation Project 1, because the trigger event has occurred in relation to the introduction of earth fault standards. In particular:

- As described in section 1.1, the Victorian Government has introduced regulations in respect of earth fault standards.
- Energy Safe Victoria has provisionally accepted our Bushfire Mitigation Plan, which details the required Tranche 1 capital works and their location accordance with the AER's approved trigger event. A copy of the ESV's acceptance is provided to the AER alongside this contingent project application. The Bushfire Mitigation Plan will also be provided to the AER.

[11] AER, Final Decision, AusNet Services distribution determination 2016 to 2020, Attachment 6 – Capital expenditure May 2016, page 6-121.

[12] Similar provisions apply to the second and third tranches.

[13] AER, Final Decision, AusNet Services distribution determination 2016 to 2020, Attachment 6 – Capital expenditure May 2016, page 6-126.

- AusNet Services has prepared forecast capital expenditure for Tranche 1, as described in Chapter 4.
- The capital works for Tranche 1 are fully scoped and costed, as described in the appendices and supporting documents.

As such AusNet Services is seeking approval of the incremental capital and operating expenditure arising from Tranche 1 of the REFCL installation program, which we propose to recover through our distribution network tariffs from 1 January 2018.

It should be noted that this contingent project application does not include any costs in relation to declared areas. This document and the accompanying supporting documents provide the following information in accordance with the National Electricity Rules[14]:

- an explanation that substantiates the occurrence of the trigger event;
- a forecast of the total capital expenditure for the contingent project;
- a forecast of the annual capital and incremental operating expenditure that is reasonably required for the purpose of undertaking the contingent project;
- how the forecast of the total capital expenditure for the contingent project meets the Rule threshold;
- the intended date for commencing the contingent project (which must be during the regulatory control period);
- the anticipated date for completing the contingent project (which may be after the end of the regulatory control period); and
- an estimate of the incremental revenue which is likely to be required to be earned in each remaining regulatory year of the regulatory control period as a result of the contingent project being undertaken.

This contingent application is structured as follows:

- Chapter 2 provides a high level overview of the contingent project and its timing.
- Chapter 3 describes AusNet Services project management process, which ensures that the proposed project is appropriately scoped and costed, and delivered efficiently.
- Chapter 4 sets out the capital expenditure that AusNet Services expects to incur in delivering the contingent project.
- Chapter 5 presents the forecast incremental operating expenditure that AusNet Services will incur during the remainder of the regulatory period.
- Chapter 7 sets out the building block elements that determine the incremental revenue requirements in relation to the contingent project and the proposed amendment to AusNet Services' revenue determination. This information is supported by an updated PTRM and roll forward model, which is provided as part of this application.
- Chapter 8 lists the supporting documents that accompany this submission. These supporting documents provide important background information and explain our strategies for meeting our compliance obligations at minimum cost.
- Appendices - An appendix is provided in relation to each zone substation.

  Each appendix sets out further information on the specific issues at each location and the alternative options AusNet Services considered before selecting the preferred scope

14 NER, clause 6.6A.2(b).

of work. It includes a consideration of non-network options and substitution possibilities between operating and capital expenditure.

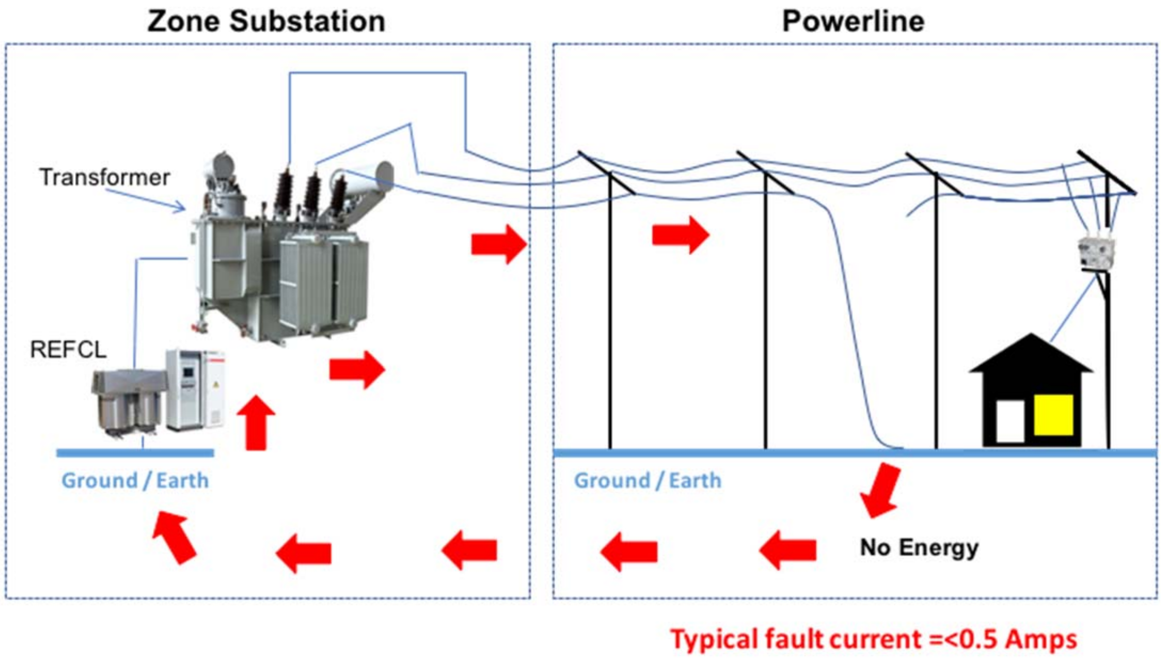
Each appendix reconciles the forecast capital expenditure with the estimates provided in the Government's RIS, and explains the reasons for any cost differences.

2 Project overview

2.1 What is REFCL technology?

AusNet Services is installing REFCL technology in 22 nominated zone substations by May 2023. It is a type of electricity network protection device, which is designed to minimise the fault current (energy) dissipated from phase to earth (wire to ground) faults on the 22kV network in order to reduce the risk of fire ignition associated with network incidents, as shown below.

Figure 2: How does REFCL technology work?



There are various types of technology that fall under the REFCL umbrella, however the only type of REFCL currently considered suitable by the Victorian Electric Supply Industry (VESI) for bushfire safety is known as the Ground Fault Neutraliser (GFN), a proprietary product by Swedish Neutral. Presently, the GFN is the only device that can meet the performance criteria of the Regulations.

REFCL technology operating at the required performance standard will minimise the risk of fire ignition associated with phase to ground faults on days of heightened fire danger, such as those experienced on Ash Wednesday and Black Saturday. Based upon a sample period of network fault data, analysis undertaken by the Government and CSIRO predict network fire related incidents associated with the nominated zone substations may be reduced by between 50-55%.

A REFCL operates when a single phase-to-earth fault occurs. Its operation causes the phase voltage of the faulted phase to be reduced to near earth potential (zero volts), thereby working to eliminate the flow of fault current. To achieve this outcome, the REFCL is tuned to the inductance of the electrical network. This compensation results in phase to ground voltage on the faulted phase reducing to near 0 volts. The healthy phases could rise from 12.7kV to 24.2kV, being 22kV plus 10 per cent.

While the REFCL is compensating for a fault, the healthy phases remain energised and customers remain on supply. However, there remains a risk that the energised phases may be in an unsafe condition depending on the nature of the network fault. Accordingly, a maximum compensating period will apply, which may be varied subject to a detailed risk assessment.

The REFCL technology is made up of 3 main components:

- Arc Suppression Coil – also known as a large inductor, which compensates for the leakage current during an earth fault.
- Residual Current Compensator – also referred to as the inverter, which is located in the zone substation control building or switchroom. It is used to reduce fault current by compensating for the active current during an earth fault
- Control Panels, which controls the equipment.

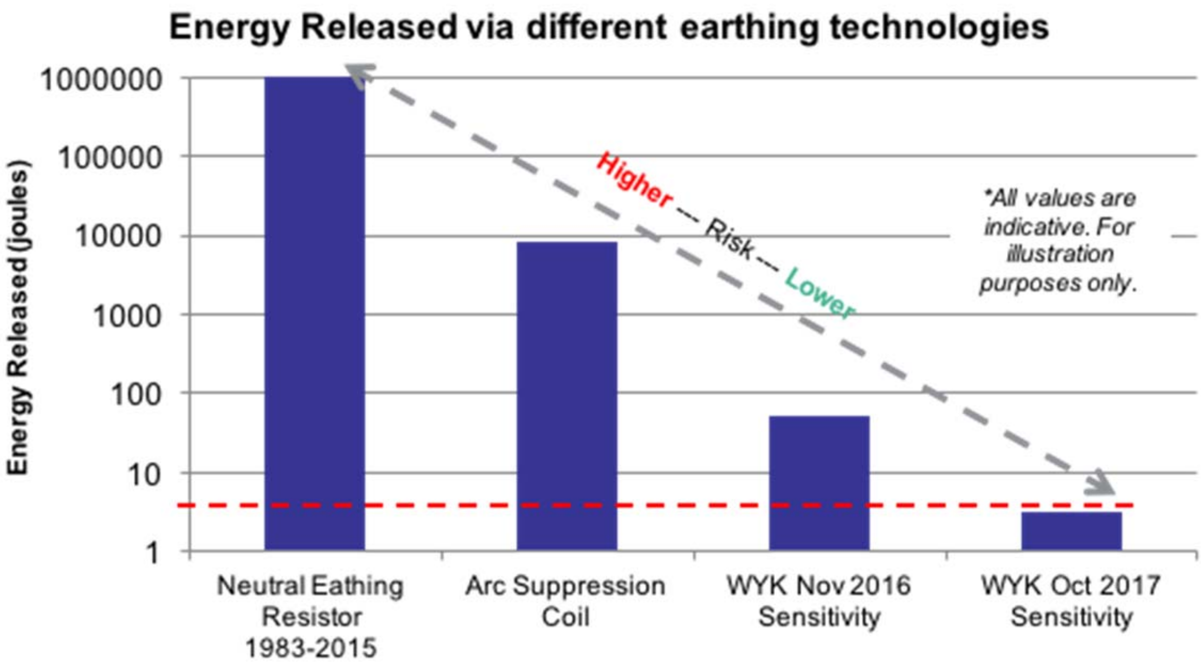
Figure 3: Three components to REFCL technology

Arc Suppression Coil/ Inductor | Residual Current Compensator/ Inverter | Control Panel

As explained in further detail below, the scope of the required works is much broader than the three components described here. This is because the installation of REFCLs requires a paradigm shift in how our network is designed, operated and maintained. As such, all components of the affected 22kV distribution network need to be reviewed to ensure that the REFCL enabled network continues to operate safely and reliably.

The potential benefit of REFCL technology is shown in the figure below. It shows how it can reduce the energy released following a fault, and thereby mitigate bushfire risk. The figure shows the performance of the Woori Yallock (WYK) REFCL installation compared to pre-existing technologies.

Figure 4: Benefits of REFCL technology



The performance requirements mandated in the regulations places the network electrical protection at an enhanced level of sensitivity and speed of operation which will interrupt the affected feeder following the period of compensation. The speed and sensitivity means that traditional protection schemes distributed along a feeder will not operate as they normally would to detect and isolate a faulted section of the network.

As a consequence, capital works extend beyond the immediate confines of the zone substation to ensure that the network continues to operate safety and reliably and AusNet Services maintains compliance with its Distribution Code obligations. The REFCL project therefore involves five capital expenditure workstreams, described below:

- **Zone substation works**

  Includes: REFCL installation (being the GFN) and associated equipment within the zone substation. It also includes the replacement of assets that fail during network hardening tests of the relevant high voltage network.

  Reason: In addition to installing the REFCL, additional works are required because the REFCL technology is based on a different earthing philosophy. It is essential that the zone substation operates safety and reliability in the new environment.

- **Network Balancing**

  Includes: Initially desktop and field modelling work following by: capacitor bank installations, third phase installations and re-phasing long single phase lines.

  Reason: Long single phase (two-wire) spurs teed off three-phase lines can create significant capacitive imbalance. Fire risk reduction relies on minimal capacitive imbalance on switchable sections of the network.

- **Line Hardening**

  Includes: Surge Arrestors and potential underground cable replacements.

  Reason: When an earth fault occurs, the REFCL response creates voltage stress on line equipment connected to un-faulted phases, which can lead to a second fault. In the absence of line hardening, the REFCL installation would increase fire risk rather.

- **Compatible Equipment**

  Includes: Automatic Circuit Reclosers (ACR), Voltage Regulators and Capacitor Bank replacements.

  Reason: Some widely utilised line equipment cannot be used with REFCLs. This is separate to line hardening, which is solely concerned with line equipment's over-voltage withstand capability.

- **Distribution Code compliance**

  Includes: The installation of isolating transformers to manage voltage increases at HV customer sites.

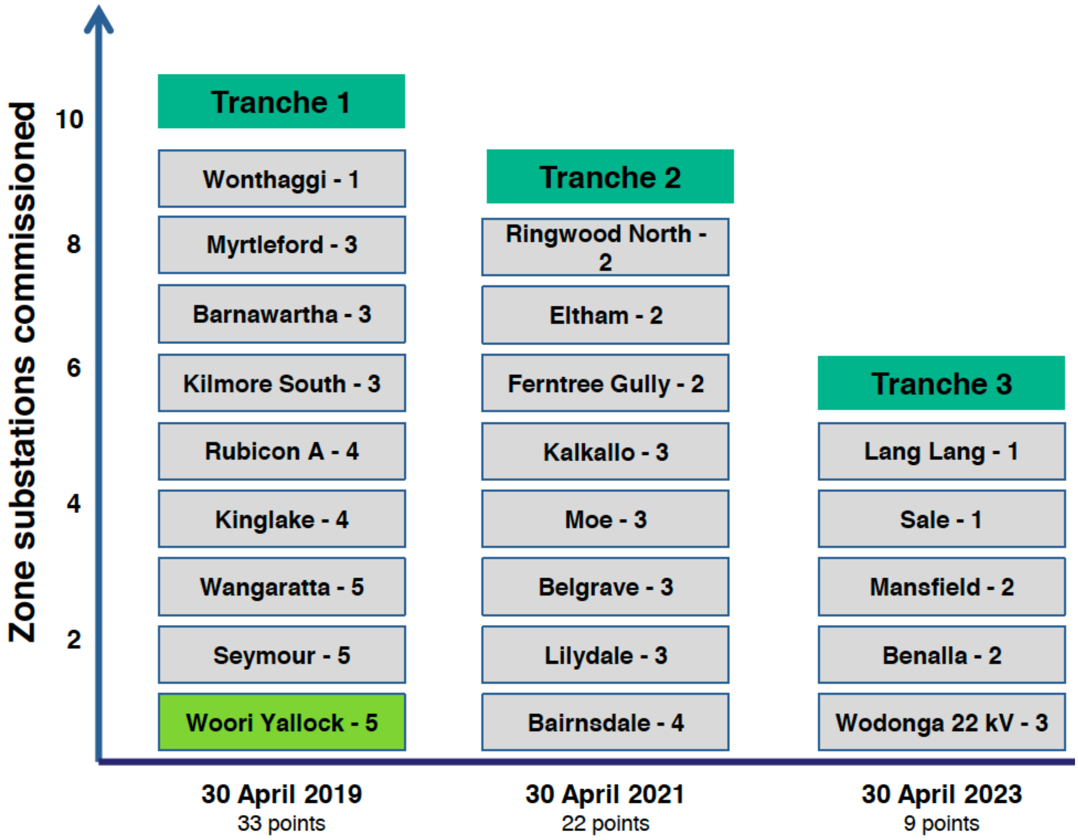
  Reason: To ensure that AusNet Services maintains compliance with the maximum permissible voltage variations specified in the Victorian Distribution Code. Non-compliance with the Code requirements would have unacceptable safety and reliability implications for HV customers and for the network.

In addition to these capital works, the project will also entail expenditure for reliability maintenance and an incremental increase in AusNet Services' operating expenditure. This contingent project application, appendices and supporting documents provide a detailed explanation of the proposed expenditure. In accordance with the contingent project provisions in the Rules, only the incremental costs associated with the trigger event are included in this contingent project application.

2.2 Project commencement

We have developed three tranches of work that would comply with the milestones prescribed in regulations, as illustrated below. As already noted, the regulations attribute points to each zone substation – with higher points allocated to those zone substations where REFCL installations will have the greatest benefit in terms of mitigating fire risk.

Figure 5: REFCL Location and Timing of Implementation



AusNet Services has been remunerated for the installation of a first REFCL at Woori Yallock (shown in green) through the EDPR. Therefore, the costs for Woori Yallock presented in this submission only relate to the installation of the second REFCL.

AusNet Services' approach to defining the contingent project in Tranches is consistent with the AER's 2016-20 regulatory determination, which explained that:

> *To minimise the risk that the appropriate capital amounts may be difficult to accurately identify our preference is deal with the capital need progressively across the next regulatory control period. This can be achieved by dealing with the contingent project program in tranches. By doing so, both the service providers and the AER, as well as stakeholders, can better identify costs as they arise in the initial tranche of projects and apply corrections based on actual outcomes to the second and any subsequent tranches of projects. Each tranche must be sized to meet the applicable materiality threshold.*[15]

This contingent application relates to Tranche 1, which must be completed by 30 April 2019 in accordance with the regulations. Given the tight timeframes, preparatory works have already commenced. Our delivery timetable is presented in section 3.4.

15 AER, Final Decision, AusNet Services distribution determination 2016 to 2020, Attachment 6 – Capital expenditure May 2016, page 6-117.

3 Project management process

3.1 Program Governance Framework

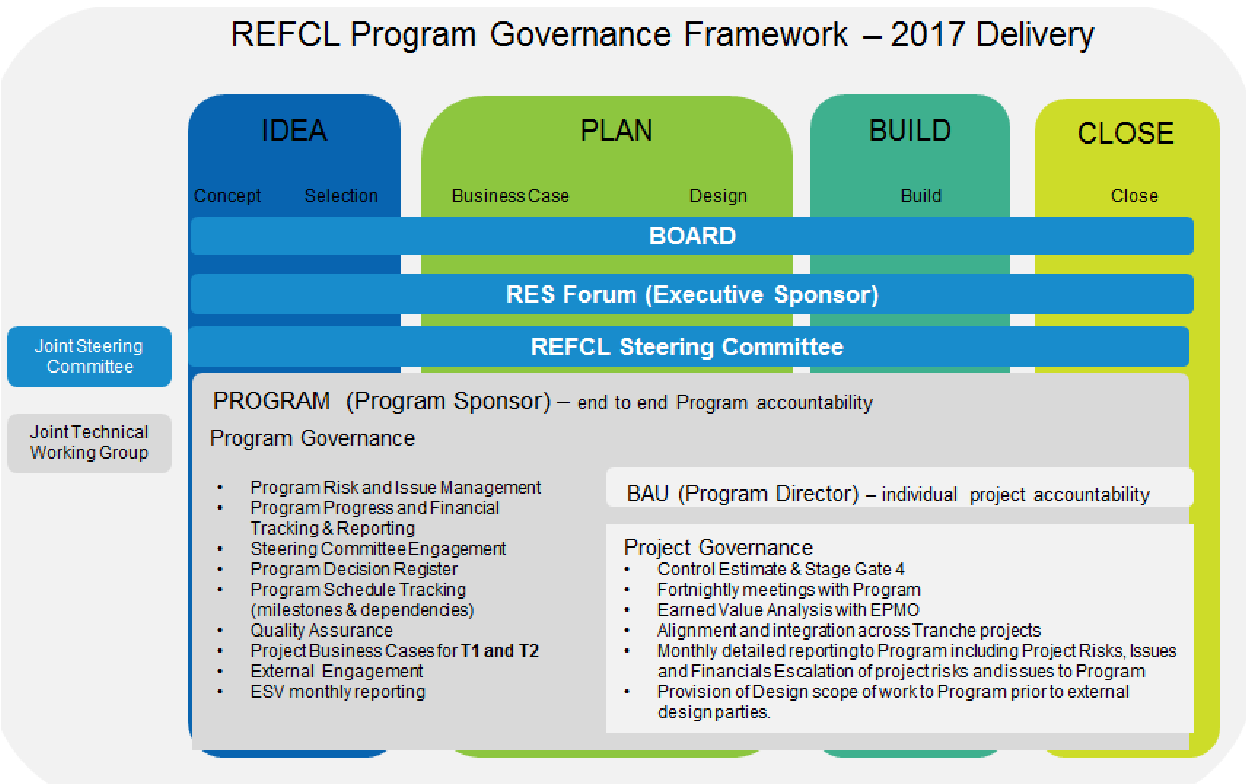
An overarching REFCL Program Governance Framework has been established to provide end-to-end program oversight and accountability for the REFCL program. The framework aligns to AusNet Services' values and commitment to mission zero with:

- Clear accountabilities, reporting and robust risk and issue management;
- Sustainable, long term, reliable, economical and workable whole of life designs;
- Delivery as per agreed timelines without compromising reliability and other service standards;
- Integration with the rest of AusNet Services' work program;
- Compliance with required obligations;
- Strong relationships with all stakeholders in order to successfully manage change;
- Development of internal capability in order to facilitate the transition to business as usual (BAU); and
- Use of BAU processes and resources where possible.

Risk management is an important aspect of the program governance framework, as the REFCL technology has never been operationalised at the performance standard required by the regulations. The potential exposure is therefore significant and must be proactively managed. Accordingly, risk workshops have been conducted in relation to all workstreams to provide a comprehensive understanding of key risks and mitigation measures.

The figure below depicts the REFCL Project Governance Framework.

Figure 6: REFCL Project Governance Framework



A REFCL steering committee has been established with members including key general managers, the program manager and delivery manager. The committee is accountable for the successful delivery of a functioning REFCL system across the 22kV electricity distribution network, in accordance with the regulated schedule and performance criteria. The committee:

- provides strategic and operational direction and support;
- acts as an escalation point for decision-making; and
- actively monitors the Program's critical risks and their mitigations, issues, budget and schedule.

The committee has been regularly meeting since March 2016.

In terms of the expenditure forecasts presented in this contingent project application, the REFCL Program Governance Framework provides strong evidence that the project is well managed with project risks identified and managed effectively. Further information on our governance arrangements can be provided to the AER on request.

3.2 Project scope

AusNet Services' objective is to ensure that the forecast expenditure for this contingent project is prudent and efficient[16]. For the purposes of this contingent project, we define prudent and efficient as follows:

- *Prudent* means undertaking works to comply with the mandated earth fault standards with the intention of mitigating bushfire risk to the maximum extent possible without compromising safety.
- *Efficient* means delivering the works at the lowest possible cost to customers, including the expected costs of unserved energy during construction and following the establishment of the GFN.

To ensure that AusNet Services' project scope is prudent and efficient, for each workstream a specific cost-benefit analysis is conducted which:

- Describes the investment need;
- Identifies the alternative credible engineering options at that location;
- Determines the costs and risks associated with each option; and
- Selects the lowest cost, prudent option having regard to safety and performance risks.

The cost-benefit assessment described above is consistent with the Regulatory Investment Test for distribution (RIT-D)[17]. In accordance with the RIT-D principles specified in the Rules[18], AusNet Services cost-benefit analysis:

- is proportionate to the scale and likely impact of each option; and
- is applied in a predictable, transparent and consistent manner.

The cost-benefit analysis determines AusNet Services' strategy for each workstream, ensuring that the preferred option will deliver the most prudent and efficient outcome. The possibility of non-network options or operating and capital expenditure substitution are also considered.

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[16] Clause 6.6A.2(f)(2) refers to the *capital expenditure criteria*, which refer to the efficient and prudent costs of meeting the *capital expenditure objectives*.

[17] The REFCL project is also subject to a separate RIT-D process, although it relies on the costs benefit analysis presented in this contingent project application and supporting documents.

[18] Clause 5.17.1(c).

The following supporting documents are provided to explain our strategy in relation to the workstreams described in section 2.1:

- *Network Balancing Strategy*;
- *Line Hardening Strategy*;
- *Compatible equipment - Line Voltage Regulator Strategy*; and
- *Compatible Equipment - Automatic Circuit Recloser Strategy*.

In addition, a separate appendix has been provided for each zone substation, which provides a more detailed explanation of the forecast total works for each zone substation, including the costs of complying with the Victorian Electricity Distribution Code. Each appendix also reconciles AusNet Services' total forecast expenditure for each zone substation with the earlier estimates provided in the Government's Regulatory Impact Statement (RIS) in November 2015[19].

AusNet Services is confident that our approach ensures that the scope of work and the resulting expenditure forecasts are prudent and efficient, in accordance with the capital and operating expenditure criteria in the Rules, each of which are addressed in Chapters 4and 5[20].

3.3 Project cost estimates and unit rates

Project cost estimates are prepared as part of AusNet Services' standard approach to developing, managing and reporting projects and programs of works in accordance with defined project execution procedures and practices. AusNet Services' estimates are founded on the following five key principles:

1. All projects are to be project managed in accordance with AusNet Services' project execution procedures & practices.
2. For Business Case investment approval and implementation, P90[21] estimates provide confidence in processes of project priority, affordability and strategic fit. However, the costs presented in this contingent project application are P(50) estimates[22], i.e. expected cost, which excludes project risk and uncertainty covered by management reserve provision in a business case.
3. Estimates are subject to reviews and a sign-off process based on consistent clear lines of responsibility and accountability that will ensure costing standards and controls are applied.
4. Regular system reviews are conducted to encourage and facilitate continuous improvement.
5. Project learnings are shared to increase corporate knowledge.

The unit costs assumed for GFNs reflect the outcome of AusNet Services' negotiations with the manufacturer, Swedish Neutral. The sole supply risk exposes AusNet Services to the possibility of unbudgeted cost increases. Risk mitigation measures are in place to minimise this risk, but it is important to recognise that the risk cannot be eliminated entirely. The cost estimates

19 ACIL Allen Consulting, Report to the Department of Economic Development, Jobs, Transport and Resources, Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, 17 November 2015.

20 Clause 6.6A.2(f).

21 A detailed cost estimate that has a 90% confidence factor of not being exceeded by cost at project completion.

22 The costs presented in this submission also exclude the written down value of assets that need to be replaced prior to end of life. While the written down value of these assets are project costs, and included in the business case,

presented in this application exclude any contingency for higher than expected procurement costs.

Unit rates for other works are primarily based on the rates incurred in recently completed work. These unit rates therefore reflect the efficient costs of delivering similar projects in AusNet Services' network area.

Work is delivered utilising an efficient combination of competitively tendered and internal resources. Pre-qualified panels of design and installation service providers have been established by competitive tender and ensure that providers have the skills and resources to undertake the required work in a safe and competent manner and can comply with works management processes.

Further information on AusNet Services' cost estimating process are provided in the supporting document, *Cost Estimating, Program Delivery & Unit Rates*, which accompanies this contingent project application. AusNet Services' actual unit rates are confidential, and are provided to the AER on that basis.

3.4 Efficient delivery

The timetable for Tranche 1 is provided below:

REFCL Site – commissioned
Woori Yallock – 1 October 2017
Rubicon A – 1 October 2017
Barnawartha – 1 October 2017
Wonthaggi – 1 October 2018
Kinglake – 1 August 2018
Wangaratta – 1 October 2018
Seymour – 1 October 2018
Myrtleford – 1 October 2018
Kilmore South – summer 18/19

AusNet Services has implemented a number of initiatives to ensure that the REFCL project is delivered efficiently, as discussed below.

3.4.1 Standard Designs

AusNet Services utilises a number of standard designs and modular construction to aid the delivery of zone substation projects. For example, a standard modular 22 kV switchboard has been utilised in zone substation construction and rebuild projects. This switchboard has a number of advantages over the installation of stand-alone switchgear, including the ability to fabricate and fit the building off-site in a factory and to readily relocate the switchboard should it no longer be required in its current location.

To deliver the REFCL program, the standard switchboard has been modified to ensure the circuit breakers are rated for REFCL operation and to include measuring transformers capable of detecting low fault currents. The use of a pre-assembled switchboard speeds delivery of the program because the switchboard utilises a standard design and is assembled off-site by a supplier and delivered complete to site (already fitted with all the components and accessories such as air-conditioning). This reduces the design and on-site construction effort leading to more efficient and faster project delivery.

3.4.2 Shared experience

The operation of REFCLs to mitigate bushfire risk has not been undertaken elsewhere other than in Victoria and so no knowledge relating to the installation or operation of the REFCL exists. AusNet Services and Powercor are both required to address the voltage reduction performance standards mandated in the regulations. The businesses have therefore been sharing information on the installation and operation of their respective units to increase expertise and reduce the probability of unplanned customer interruptions.

In addition, Powercor and AusNet Services have shared the results of tests such as surge arrestor testing to reduce the time and cost of testing a statistically significant sample.

3.4.3 Leveraging existing contracts and relationships

Delivery of the program in the required timeframe would not be possible without using existing contracts and relationships. The procurement of equipment relies on established contracts with suppliers and enables the use of standard equipment such as the 22 kV switchboards. Additionally, the pre-qualified service providers (described below) will be used to deliver on-site work.

3.4.4 Resourcing

Our approach is to employ a combination of in-house and outsourced resources to optimise the overall project costs while meeting the delivery timetable. Additional external resources will be engaged to meet the peak workload. These additional resources are not retained when the volume of work reduces, following the completion of the REFCL program, ensuring that internal resources are always fully occupied.

The establishment of pre-qualified panels of service providers using a competitive process ensures efficient costs and appropriate quality of services provided. In addition, the cost and time taken to engage resources on a project is reduced. The use of different labour sources also allows benchmarking comparisons to reduce the risk of cost blowouts, which are not uncommon for large capital projects such the REFCL program, especially given the untested nature of the technology.

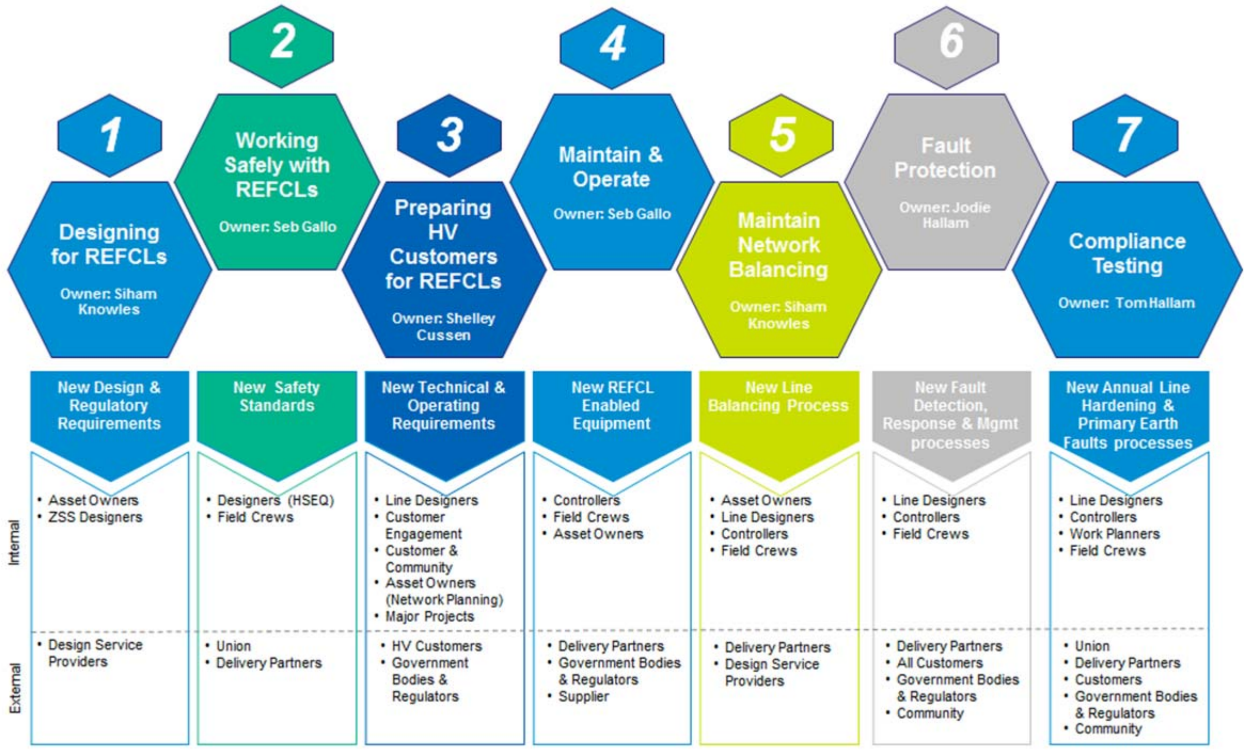
3.5 Change management

The installation of REFCLs will have wide-ranging operational implications across the distribution business. For example:

- Safety practices will need to recognise that the network can operate at higher voltages. As a consequence, line workers will need Protective Personal Equipment that is rated for these higher voltages.
- Additional planner and resonant earthing protection engineering specialists will be required to ensure that the network remains in balance. This issue is discussed in further detail in section 4.3.
- Annual testing is required to ensure that the REFCLs will operate as intended.

Change management is therefore an important aspect of the project implementation, as illustrated in the figure below.

Figure 7: Change management for implementation of the REFCL Project



AusNet Services' REFCL Change Management Strategy provides the framework to address how we will manage and integrate each of the seven change risks. This includes how we will:

- Conduct the overall change management approach for the REFCL program;
- Optimise audience buy-in;
- Embed the change and ownership;
- Build capability;
- Minimise business disruption; and
- Manage and mitigate change resistance.

This will be achieved through conducting:

- Engagement: Involving stakeholders in problem solving or decision making and listening to what they need, then incorporating that into the Program Change in order to increase their commitment to the change.

- Communication: Effectively and consistently sending information to stakeholders to build awareness and understanding of the change.
- Organisation Design / Operating Model: Ensure roles, jobs and teams are aligned to effectively support the new technology and to have clear accountability and ownership.
- Training: Understand what learning and performance support is needed to enable users to confidently perform their job in the new environment to enable knowledge, confidence and adoption.
- Business Readiness: Outline how do we intend to prepare the business for the change to enable a successful transition and to enable continuous improvement.
- Measuring Change Effectiveness: Outline how we will measure the effectiveness of the change strategy.

For the purposes of this contingent project application, it is appropriate to capture the costs of implementing the REFCL program noting its broad impact across the business and the importance of effective change management.

4 Forecast capital expenditure

4.1 Introduction

As already noted, there are five categories of direct capital expenditure in the REFCL installation program:

- Zone substation works;
- Network balancing;
- Line hardening;
- Compatible equipment; and
- Victorian Distribution Code compliance.

In addition to these five categories, capital expenditure is required to manage the program and to maintain the reliability of the network.

The purpose of this chapter is to provide a high level description of the required work for each of these categories. The planning reports for each zone substation (which are provided as appendices) explain how these workstreams are implemented at each location and the expenditure forecasts. In addition, strategy documents are also provided as supporting documents to explain our approach to network balancing, line hardening and compatible equipment.

A more technical summary of the impact of the REFCL installation on the existing network is provided in the *REFCL Equipment Building Block Functional Description*, which is provided as a supporting document to this contingent project application.

4.2 Zone substation works

The following type of work is typical of the investment required at most Tranche 1 zone substations:

- Specification, procurement and installation of a Ground Fault Neutraliser (GFN), including an Arc Suppression Coil (ASC), Residual Current Compensation (RCC) and control system.
- Specification, procurement and installation of a neutral bus switchboard. The introduction of the GFN requires a neutral bus which enables different earthing arrangements to be automatically configured. This enables remote earthing and protection scheme selection depending on network and weather conditions.
- Upgrade of the existing station service transformers and changeover boards. This work is required because the alternating current (AC) supply requirement dramatically increases due to the GFN installation.
- Testing and potential replacement of cable equipment incapable of operating at elevated voltages.
- Replacement and extension of existing protection and control equipment with equipment capable of operating in several modes including resonant earthing and traditional earth fault modes. Additional protection and control systems are also required to protect the newly installed REFCL equipment.
- Prior to commissioning the GFN, network hardening tests involve the process of lifting voltages (using the GFN) in a healthy three phase powerline network (phase by phase)

to check network readiness for future states of REFCL operation. During this activity, there is an increased likelihood of asset failures. These tests are necessary to ensure the GFN can operate without causing line and station equipment to fail, potentially resulting in a fire start. We would replace any assets that fail during the testing process, and a forecast cost has been included in the zone substation works.

In addition to the above work, location specific work may be required. For example, in some instances land purchase is required because the existing footprint of the zone substation is inadequate for the installation of the required equipment. As already noted, a cost benefit analysis is conducted for each zone substation to ensure that the selected scope of work is prudent and efficient.

4.3 Network balancing

In order to meet the performance standards in the regulations, capacitive balance must be maintained. Capacitive imbalance will negatively affect REFCL performance because:

1. It increases residual current, i.e. ground fire risk.
2. It increases the standing level of neutral voltage, i.e. it constrains fault detection sensitivity.

As fire risk reduction relies on low residual fault current, capacitive imbalance can pose a risk to fire safety and so must be managed. In Victoria, long single phase (two-wire) spurs teed off three-phase lines can create significant capacitive imbalance.

In broad terms, the potential actions to balance network capacitance include:

- Two-wire spur lines must be connected to the three phase network in a way that limits capacitive imbalance, i.e. the phases to which each spur line is connected must be selected for capacitive balance, not just load balance.
- Balancing capacitance can be added by installing pole-mounted capacitors along feeders, e.g. on the third phase at a tee-off pole where a long two-wire spur leaves a feeder.
- Improved fault detection algorithms with increased tolerance to imbalance also have a potential role in addressing the potential impact of imbalance.

To satisfy the legislated performance criteria the network leakage current will need to be at a minimum under normal operating conditions. The leakage current required will vary site to site however the target is less than 0.1A. Our approach is to achieve this outcome through a combination of:

- Performing single-phase spur and distribution substation phase transpositions;
- Installing a balancing capacitor bank at the beginning of single phase spur sections;
- Installing LV balancing capacitor banks on the three-phase backbone; and
- In a small number of cases adding a third conductor to the beginning of a single-phase spur section (practical for cable) and converting that cabled section to three-phase.

As explained in our Network Balancing Strategy, we tested three alternative options before selecting the preferred approach, which is the lowest cost solution. The volume of work will be site specific, dependant on total 22kV line length and the existing out of balance.

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA) involves a combination of ACR operations plus the use of adjacent feeders to supply feeder sections downstream of a faulted section. The DFA philosophy and technology developed by AusNet Services is unique and plays an important role in maintaining network reliability. AusNet Services remains uniquely placed in applying this technology broadly across the distribution network to provide reliability benefits to customers. The introduction of REFCLs affects the operation of DFA, such that each ‘automated switching zone’ in a DFA scheme must be both capacitively balanced and able to detect faults (this capability impacted).

The use of DFA significantly increases the number of automated switching zones, which is a feeder section delineated by sectionalising switches such as Automatic Circuit Reclosers (ACRs). As a consequence, AusNet Services’ total network balancing and switch upgrade costs are affected by AusNet Services’ historic investment decision to implement DFA in order to maintain reliability. The decision to install DFA was efficient, as is the need to undertake the additional work to address the capacitive imbalance that results from the REFCL program.

4.4 Line hardening

AusNet Services’ tranche one total line surge arrestor population is 30,858 units at 12,117 sites. As explained below, 40 per cent of these surge arrestors are not capable of operation at 24.2kV (22kV plus 10 per cent) and must be replaced as part of this contingent project.

When an earth fault occurs on a REFCL-protected network, overvoltage on un-faulted phases occurs and can lead to failure of line surge arrestors not rated for operation at such a high level of overvoltage. Such equipment failure constitutes a second earth fault on the network, termed a ‘cross-country fault’ because it is usually remote from the initial fault and is always on one of the un-faulted phases subject to over-voltage stress caused by REFCL response.

REFCLs can only deal with multiple earth faults if they are all on a single phase. With a cross-country fault, the network has a two-phase-to-earth fault and high currents will flow in both fault locations. To avoid this potentially catastrophic situation suspect surge arrestor types must be replaced.

Powercor and AusNet Services jointly conducted tests to determine the whether some existing types of surge arrestors are capable of withstanding 24.2kV. Testing has concluded that two particular types of line surge arrestors that make up 60% of the population of AusNet Services’ line surge arrestor fleet do not need replacing as they are capable of withstanding the increased voltages associated with the operation of a REFCL.

The costs of replacing surge arrestors in relation to each zone substation installation will depend on the number and type of surge arrestors at that location. In aggregate, however, 40 per cent of the population of surge arrestors will be replaced.

4.5 Compatible equipment

Some network equipment is not compatible with REFCL operation and must be upgraded or replaced with equipment that is compatible. This is a separate issue to the network hardening testing, described in section 4.2 above, which is solely concerned with the capability of the equipment to withstand the increased voltage. In contrast, incompatible equipment can prevent correct REFCL operation and may produce dangerous network conditions with a REFCL in service.

For example, the controllers on voltage regulators along feeders need to be upgraded or replaced because they currently work independently for each phase, leading to imbalance in phase capacitance which generates residual current in the network. If this equipment is not upgraded, it may trigger REFCLs to operate when they should not. AusNet Services has prepared a strategy document ‘*Compatible Equipment - Line Voltage Regulator*’, which is provided as a supporting document, to explain why the proposed upgrade and replace approach minimises the costs of complying with the regulations.

A further significant issue arises in relation to existing earth fault protection, which are non-directional. The devices act when they detect earth fault current flow without information on its direction, i.e. whether the fault is ‘upstream’ or ‘downstream’ of them. This is not a problem in non-REFCL networks, since all earth fault currents flow only one way – from the zone substation to the fault.

With a REFCL in service, however, earth fault current flows back into the zone substation from un-faulted feeders before a portion (the uncompensated residual current) flows out along the faulted feeder to the fault. Using non-directional feeder earth fault relays with a REFCL in service will lead to tripping of healthy feeders or whole groups of feeders. Similarly, the earth fault protection in pole-mounted ACRs must also be directional.

To address this issue, AusNet Services will replace unsuitable ACRs on feeders connected to REFCLs with new ACRs that have reverse power flow capability. In addition, the new ACRs have more sensitive earth fault detection capability to assist in locating faults when a REFCL operates.

AusNet Services' 'Compatible Equipment - Automatic Circuit Recloser Strategy' provides further information on the rationale for the planned scope of work and the alternative options that were considered.

4.6 Victorian Distribution Code compliance

As already explained, the operation of a REFCL following a single phase fault will lead to an increase in voltage levels on the healthy phases. In the absence of installing isolating transformers on AusNet Services' network, the following outcomes would eventuate:

- REFCL operation results in voltage variations at the HV customers' supply points that exceed the level specified in clause 4.2.2 of the Victorian Electricity Distribution Code; and
- HV customers would be exposed to a potentially unsafe and unreliable electricity supply.
- Any resulting failure of HV customer's equipment during REFCL operation would induce a cross country fault negating any fire mitigation effect on the phase affected by the first fault as the REFCL attempted to compensate for the second fault. This situation is highly likely to result in a fire ignition at the site of the first fault.

Such outcomes would not be prudent, efficient or acceptable from a safety perspective. To address these implications of REFCL operation, AusNet Services proposes to install isolating transformers at HV customer connection points in the Tranche 1 program subject to this contingent project application, so that the voltage at HV customers' supply points remain within the variation limits specified in the Victorian Electricity Distribution Code.

AusNet Services considered whether other options, including 'non-network options' could deliver a lower cost outcome. Conceptually, a lower cost solution may be possible if HV customers undertook works on their electrical assets to enable them to withstand higher voltage variations. However, this approach raises the following safety and reliability concerns:

- The voltage variation at the HV customers' point of supply would still exceed the levels specified in the Victorian Electricity Distribution Code; and
- AusNet Services would need to be confident that the customers' equipment could withstand the increased voltages before commissioning the REFCL. Such assurances may be difficult to obtain, with consequential delays in delivering the REFCL program.

In relation to the first point, AusNet Services has sought an amendment to the Victorian Electricity Distribution Code to increase the existing permissible voltage variations. Such an amendment may enable alternative solutions that would not expose HV customers and AusNet Services to unacceptable safety and reliability risks. However, the Essential Services

Commission has made it clear that it does not intend to amend the Victorian Electricity Distribution Code to address the voltage variation issue[23].

In relation to the second point, AusNet Services has considered whether it could relocate the existing HV customer supply points, which may entail the purchase of HV customers' existing electrical assets, to ensure that any remedial work is undertaken to an appropriate standard and forms part of AusNet Services' regulated distribution network. Some of the customer HV assets comprise extensive internal reticulation systems.

Our desk top analysis of HV customers' installations indicates that such a significant change in the existing supply arrangements would be impractical because it exposes both parties to unacceptable commercial risks. While the acquisition of HV customers' electrical assets may have the potential to address safety and reliability risks associated with higher voltage variations, it is most unlikely to be achievable in the timeframes specified in the regulations. Furthermore, AusNet Services would require an assurance from the AER that the costs of acquiring HV customers' assets could be included in the regulated asset base and recovered through distribution charges. This issue is unlikely to have a straightforward supportive resolution.

AusNet Services also notes that the regulatory framework does not impose any obligations on HV customers to upgrade or modify their assets to withstand voltage variations outside those set out in the Victorian Electricity Distribution Code. AusNet Services' engagement with HV customers has highlighted their strong reluctance to incur costs in upgrading or modifying their electrical assets to accommodate the REFCL installation program. In effect, HV customers argue that the REFCL installation program is creating the need to change pre-existing supply arrangements that are working well, and therefore the costs of any modification should form part of the REFCL project.

AusNet Services is mindful that the Victorian Government has introduced regulations that impose substantial financial penalties if the REFCL installations are not completed in accordance with the timeframes mandated by the regulations. Any solution other than the installation of isolating transformers could not be achieved in the timeframes, even if the impediments to an alternative solution could be resolved.

AusNet Services will continue to work with the Victorian Government, the ESC and HV customers to investigate the feasibility of lower cost solutions for Tranches 2 and 3. However, it is evident from the above discussion that there are no credible alternative options, including non-network options, to the installation of isolating transformers for Tranche 1.

4.7 Program management costs

AusNet Services has incurred costs developing this regulatory proposal and will incur further costs related to the proposal during the AER review. In addition some tools and test equipment will be replaced. These program management costs will be capitalised. Costs associated with the development of the application include drafting of the proposal and attachments and reviewing the technical supporting information, project management, corporate including legal review of matters relating to the submission, and providing further information and detail to the AER during the review process.

Additional costs will also be incurred to facilitate network operations. The introduction of the REFCL devices imposes higher voltage conditions on existing installed lines infrastructure. Where in the past equipment had to be designed to withstand phase-to-ground voltages up to 12.7kV, REFCL networks need to be able to withstand 24.2 kV. Some of the tools and equipment that AusNet Services uses for operating and maintaining the network is not rated to

23 Essential Services Commission, Electricity Distribution Code Compliance and REFCLs, letter to Andrew Griffin, AusNet Services, dated 7 February 2017.

handle these higher voltages. It is therefore not safe to continue using this equipment for operations and maintenance activities. The equipment which will require replacement includes:

- Mid-span isolators – 16,000 units
- Rigid hoppers – 1890 units
- Line cut-out tools – 1010 units

4.8 Expenditure factors to be considered by the AER

The Rules require the AER to consider a number of operating and capital expenditure factors in its assessment of the forecast expenditure in the contingent project application. These expenditure factors include:

- the substitution possibilities between operating and capital expenditure;
- whether the expenditure forecast is consistent with any incentive schemes that apply to the distributor;
- the extent the expenditure forecast is referable to arrangements with a person other than the distributor that do not reflect arm's length terms; and
- the extent the distributor has considered, and made provision for, efficient and prudent non-network alternatives.

It is useful to comment on each of these factors in turn.

4.8.1 Substitution possibilities between operating and capital expenditure

The capital works are driven by an obligation to comply with new performance standards that apply to each polyphase electric line originating from a list of specified zone substations. As explained in section 1.3, the installation of REFCL technology is the only feasible method that is capable of complying with the regulations. At this highest level, there are no substitution possibilities in relation to the proposed project.

However, feasible alternative options are available in determining the strategies for the particular workstreams (such as network balancing) and the scope of the station works as we move beyond the immediate task of installing the GFNs. These alternative options are considered in our cost benefit analysis for the workstream strategies and station works, which are detailed in the supporting documents and appendices. In some instances, the feasible options include different mixes of operating and capital expenditure, and therefore reflect substitution possibilities.

The incremental operating expenditure activities in relation to the contingent project application are discussed in Chapter 5 and the supporting document, *Operational Requirements*. The nature of many of these activities (such as testing, document updates and reporting) is such that there are no substitution opportunities between operating and capital expenditure. The only substitution possibility relates to network balancing, where the selected capital works option involves lower operating expenditure compared to other feasible options.

4.8.2 Consistency with the incentive schemes – reliability impacts

The impact of REFCL installation on network reliability was discussed in the AER's final decision for AusNet Services' 2016-20 EDPR. At that time, the Victorian Government suggested that a tougher Service Target Performance Incentive Scheme (STPIS) target should apply, arguing that REFCL operation would deliver reliability improvements. In relation to this matter, the AER's final decision stated:

"The Victorian Government submission stated that there are reliability benefits associated with the installation of rapid earth fault current limiters (REFCLs) and that the AER must take into consideration any potential revenue increments that the distributor will receive under the STPIS.

Submissions by Victorian distributors (except for United Energy who provided no comment) disagreed with the Victorian Government. In summary, they stated that:

They do not anticipate a material improvement in supply reliability, in fact, they envisaged a possibility that reliability may deteriorate rather than improve as a result of the deployment of REFCL devices in the electricity distribution network.

AusNet Services submitted that it was inappropriate to assume any reliability benefits will result from the REFCL program because of the introduction and then integration of REFCL into AusNet Services network. Further, AusNet Services stated that the REFCL installation program will cause significant interruptions to customer supply, in the short term. It submits that these interruptions will be required to undertake network hardening and balancing, which requires disconnection and reconfiguration of the network at points along the entire length of the affected power lines.

On balance, we consider that there is no evidence to suggest that reliability will improve because:

- AusNet Services intends to operate REFCL on total fire ban days and as such reliability will worsen rather than improve because of the operations of the devices.

- most REFCL devices are expected to be installed late in the 2016-20 regulatory control period therefore it is likely reliability benefits will be realised after 2020.

- there is some uncertainty about the precise impacts of REFCLs in the more immediate period on reliability such that precise adjustments to the scheme would be problematic."[24]

More recently, AusNet Services has found that reliability has been affected adversely during REFCL testing. In relation to the STPIS, clause 3.3 of the scheme allows particular events to be disregarded when calculating the revenue increment or decrement under the STPIS scheme. AusNet Services considers that the adverse reliability outcomes from testing are excluded by virtue of clause 3.3.

A further reliability issue arises in relation to the impact of the REFCL installation on the existing Distribution Feeder Automation (DFA) scheme. As mentioned in section 4.3, the DFA scheme requires each automated switching zone to be capacitively balanced, and fault detection capability within the automated switching zones to be maintained. Additionally, the DFA algorithm operating within the SCADA system is not compatible with REFCL technology, and needs to be rewritten.

Therefore, unless DFA capability is rectified, customers will suffer a degradation in reliability outcomes as a result of the REFCL installation program. This issue is specific to AusNet Services' network, reflecting the substantial investments in DFA that have been made to achieve current levels of reliability.

AusNet Services considers that clause 3.3(7) of the STPIS would provide for an adjustment to the STPIS revenue increments and decrements, if the DFA scheme is not rectified. However, the better outcome for customers is for AusNet Services to undertake the necessary work to update the DFA scheme in order to avoid the degradation in reliability that would otherwise occur.

This contingent project application includes the investment costs of rectifying the DFA in order to avoid the degradation in reliability. This includes the following work:

- replacement of sectionalisers: these are switches designed to interrupt load current, but not fault current. Similarly to the ACRs (which are designed to interrupt fault current) there are a number of sectionalisers which do not have the requisite detection sensitivity

24 AER, final decision, AusNet Services distribution determination 2016 to 2020 Attachment 11 – Service target performance incentive scheme, May 2016, pages 11-21 and 11-22.

to support the DFA scheme when a REFCL is in operation and will need to be replaced; and

- DFA algorithm design: the DFA algorithm interprets real time network status data and devises the switching sequence to isolate a faulted switching zone and restore supply to the maximum number of customers achievable, typically within a period of 1 minute. The algorithm will require redesign and proving to incorporate the operation of the REFCL.

The estimated number of switches requiring change and total costs to rectify the DFA schemes to ensure reliability is maintained are set out in Table 3 below.

Table 3: Forecast Reliability expenditure and units requirements, $m, $2016

	2016	2017	2018	2019	2020	Total
Network Reliability improvement Expenditure forecast (Direct)	-	2.3	5.6	-	-	7.9
Forecast no. of switches		49	119			168

Source: AusNet Services, forecast expenditure excludes cost escalation adjustments

The operation of the other economic regulatory regime incentive schemes are unaffected by the contingent project. For example, AusNet Services notes that the contingent project costs will be excluded from the Efficiency Benefit Sharing Scheme and Capital Expenditure Sharing Scheme.

The implications of REFCL operation on the Victorian Government F-Factor Scheme has been accounted for through Order in Council, F-Factor Scheme Order 2016, gazetted on 22 December 2016. This amends the target ignition risk units for financial year 2019/20.

4.8.3 Related parties

As noted above, the AER is required to consider the extent the expenditure forecast is referable to arrangements with a person other than the distributor that do not reflect arm's length terms. AusNet Services' related party arrangements were described in detail in Appendix 1C of the Regulatory Proposal for the 2016-20 period. AusNet Services confirms that there are no related party margins in the capital expenditure forecasts presented in this contingent project application.

4.8.4 Non-network alternatives

As discussed in section 4.6, AusNet Services has considered non-network alternatives in relation to addressing the higher voltage variations at HV customers' supply points. For the purposes of Tranche 1, a non-network solution is not feasible.

The nature of the other capital expenditure workstreams – being station works, network balancing, line hardening and compatible equipment – is such that there are limited opportunities for non-network alternatives. In particular, much of the work is focused on ensuring that AusNet Services' network is capable of continuing to provide safe and reliable distribution services with REFCLs in service. Inevitably, the issues to be resolved necessitate capital works in relation to AusNet Services' network assets, rather than non-network solutions.

Nevertheless, in each appendix AusNet Services has explicitly considered whether there are any non-network alternatives to the proposed works.

4.9 Prudent and efficient – satisfying the capital expenditure criteria

AusNet Services recognises that the AER must consider whether the forecast expenditure in relation to this contingent project is prudent and efficient, in accordance with the capital expenditure criteria in the Rules[25], taking into account the capital expenditure factors in the context of the contingent project (as discussed in section 4.8).

In the context of this project, we interpret prudent and efficient as follows:

- *Prudent* means undertaking works to comply with the mandated earth fault standards with the intention of mitigating bushfire risk to the maximum extent possible without compromising safety.
- *Efficient* means delivering the works at the lowest possible cost to customers, including the expected costs of unserved energy.

As explained in chapter 3 of this contingent project application, our approach to this project ensures that the required works are efficiently scoped and costed.

The project scope has been developed by considering the alternative engineering solutions that are available to address the identified investment need, while costs are determined using our standard project costing approach.

Project risks have been identified and processes put in place to manage them effectively. We have also examined the change management implications of the project to ensure that the project impacts on the business are properly understood and included in the project costings. In terms of project management, we have a comprehensive program governance arrangement in place.

This chapter 4 has provided a brief overview of the 5 categories of work that comprise the contingent project. Each area is supported by a more detailed paper explaining the why particular engineering options have been selected in terms of efficiency (i.e. lowest cost) and prudency, which includes safety and compliance considerations.

In summary, AusNet Services is confident that it has adopted a comprehensive and rigorous approach to this project which will ensure that the resulting expenditure forecasts '*reasonably reflect the capital expenditure criteria*' in the Rules, as required by clause 6.6A.2(f)(2).

4.10 Summary of forecasts

Table 4 below summarises our capital expenditure for each zone substation and each of the five workstreams, noting that the Victorian Electricity Distribution Code costs were not costed in the Government's RIS. To facilitate a like-for-like comparison, the Distribution Code compliance costs are shown separately.

25 Clause 6.6A.2(f)(2).

Table 4: Summary of Direct capital expenditure requirements, $m, $2016

	Items costed in the RIS					Not costed in the RIS
	Zone substation	Network Balancing	Line Hardening	Compatible equipment	RIS Total	Distribution Code
Woori Yallock 2	3.9	1.0	1.5	0.7	7.0	1.2
Rubicon A	4.2	1.5	1.6	0.4	7.7	3.5
Barnawartha	3.8	0.9	0.4	0.1	5.1	2.4
Kinglake	7.1	0.8	0.4	0.4	8.7	-
Seymour	9.7	3.4	2.1	0.6	15.8	2.4
Wangaratta	8.0	3.8	2.5	1.2	15.6	2.4
Wonthaggi	3.6	3.0	1.8	1.2	9.6	1.2
Myrtleford	3.4	1.2	1.0	0.4	6.0	-
Kilmore South	3.0	1.6	0.8	0.5	5.8	1.2
Total	**46.6**	**17.1**	**12.1**	**5.6**	**81.3**	**14.2**

Source: AusNet Services, excludes cost escalation adjustments

The table shows that AusNet Services' total capital expenditure for the workstreams that were costed in the RIS is $81.3 million (real $2016). An additional $14.2 million (real $2016) is required to address the Victorian Electricity Distribution Code compliance issues, which were not costed in the RIS, producing a total cost of $95.5 million (real $2016).

In addition to the above capital expenditure requirements for each zone substation AusNet Services has included a forecast of other program costs as shown in Table 5 below.

Table 5: Summary of Contingent Project capital expenditure requirements, $m, $2016

	2016	2017	2018	2019	2020	Total
Zone Substations works	6.9	56.2	32.4	0.1	-	95.5
Network Reliability improvements	-	2.3	5.6	-	-	7.9
Live line equipment purchases	-	0.2	0.4	-	-	0.6
Program management office costs	-	0.5	-	-	-	0.5
Total	**6.9**	**59.2**	**38.4**	**0.1**	**-**	**104.5**

Source: AusNet Services, excludes cost escalation adjustments and capitalised overheads

4.11 Benchmarking analysis

AusNet Services has benchmarked its expenditure forecasts against the cost estimates in the Government's RIS. The comparison is complicated by the significant passage of time, analysis and testing that has occurred since the RIS estimates were published in November 2015. Inevitably, AusNet Services' forecasts are substantially more robust than those presented in the RIS. Nevertheless, it is important to explain the cost differences.

The benchmarking shows that AusNet Services' median zone substation cost is $7.7 million (real $2016) (Rubicon A) compared to the RIS average of $6.7 million[26] (real $2016). The primary reason for the higher cost zone substations is that the RIS did not contemplate a number of cost items, including:

- Procurement of land;
- Rebuilding of the zone substation;
- the need to install multiple GFNs; and
- Installation of switchboards.

In the appendices to this contingent project application, AusNet Services has therefore provided a detailed analysis of the costs for each zone substation and the reasons for the differences from the RIS estimate. A summary of the reasons for the differences in costs for the workstreams identified in the RIS, which excludes Distribution Code compliance, is presented in the table below.

[26] For comparison purposes the 2015 Victorian Government RIS estimates have been escalated by actual inflation and presented in real $2016.

Table 6: Reasons for cost differences compared to Government RIS ($m, 2016)

	AusNet Services Forecast[27]	RIS estimate[28]	Primary reasons for cost differences
Woori Yallock 2	7.0	NA	Not costed within the RIS. A second REFCL was required because the required performance could not be achieved with one REFCL due to increased capacitance of network. Further balancing and surge arrestor works are required.
Rubicon A	7.7	6.0	The RIS estimate excluded costs associated with necessary zone substation works and network balancing.
Barnawartha	5.1	3.5	The RIS estimate excluded costs associated with necessary zone substation works and network balancing.
Kinglake	8.7	4.1	The RIS estimate excluded costs associated with necessary zone substation works and network balancing. In addition, 22kV switchgear had to be replaced at the zone substation, and additional land had to be purchased to accommodate the REFCL and associated equipment.
Seymour	15.8	9.4	Substantial balancing costs are forecast. Significant site works are required to create room for two REFCLs and associated equipment. AusNet Services' forecast includes removal and replacement of 22kV switchgear to provide the necessary space at the site.
Wangaratta	15.6	9.8	Substantial balancing costs are forecast. Zone substation works include installation of two REFCLs, replacement of 3 outdoor CBs due to existing condition and their likely inability to withstand REFCL operation. These costs were not included in the RIS estimate.
Wonthaggi	9.6	5.8	The RIS estimate excluded costs associated with necessary zone substation works and substantial network balancing.
Myrtleford	6.0	4.6	The RIS estimate excluded costs associated with necessary zone substation works and network balancing.
Kilmore South	5.8	NA	Not costed within the RIS. Kilmore South runs as two small zone substations (north and south). Work is required to convert these to one station, so the REFCL can serve the entire KMS network. Existing REFCL software needs to be upgraded to Bushfire Mitigation performance specification. Further balancing and surge arrestor works are required.
Average	**9.0**	**6.2**	

Source: AusNet Services, excludes cost escalation adjustments

27 These costs exclude the Distribution Code compliance works in order to provide a like-for-like cost comparison with the RIS estimates.

28 Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 74 & 75. The source RIS estimates are expressed in present value terms and real $2015. For comparison purposes in Table 6 the RIS estimates have been escalated by actual inflation and presented in real $2016.

As noted in the table above, AusNet Services' cost forecasts exceed the RIS estimate principally because the RIS under-estimated or excluded costs associated with necessary zone substation works and network balancing. Specifically, additional zone substations works that were not included in the RIS estimate are:

- Neutral bus switchboard – This is required for effective year-round protection of the network. Balancing bushfire risk reduction with network reliability requires multiple operating modes with differing earthing arrangements. A neutral bus switchboard facilitates these arrangements.
- REFCL backup protection and interface control systems – Protection and control equipment must operate in several earthing fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal-operation.
- Testing the REFCL – As part of the project commissioning it will be necessary to fully test the functionality of the REFCL to ensure that it is capable of operating to meet the Regulations. The capital cost of REFCL installation includes the first instance of insulation and compliance tests to demonstrate the correct operation of the device.
- Community engagement plan - This in required due to the number of outages forecast for the community and the new network insulation tests, which in the short term are expected to produce unfavourable reliability outcomes for customers.

Additional network balancing works omitted from the RIS estimate include:

- Work required to achieve the performance criteria in each automatic switching zone - This involves a combination of additional capital works including adding balancing capacitors, unbonding cable installations and adding a third phase conductor to balance each section. The RIS included phase rotations alone as the only network balancing cost, and this will not achieve the performance required by the Regulations.
- Works needed to maintain balance – These include replacing fuses with solid links where fuse operation will lead to out of balance, potential non-compliance with the Regulations, and possible REFCL mal operation.

A more detailed reconciliation between our forecast capital expenditure and the RIS estimates for each zone substation is provided in each of the appendices.

4.12 Rules threshold

The Rules[29] require the contingent project application to demonstrate that proposed capital expenditure exceeds either:

- exceeds either $30 million; or
- the *annual revenue requirement* for the relevant *Distribution Network Service Provider* for the first year of the relevant *regulatory control period*, whichever is the larger amount[30]

AusNet Services' maximum allowed revenue in the first year of the current regulatory period is $586.0 million, 5 per cent being $29.3 million. Therefore, the applicable threshold in relation to this contingent project is $30 million, being the larger amount.

29 Clause 6.6A.2(b)(iv).

30 Clause 6.6A.1(b)(2)(iii).

As shown in Table 5 of section 4.10, the total forecast capital expenditure is $104.5 million[31] (real $2016) for this contingent project, and therefore the threshold has been met.

5 Forecast incremental operating expenditure

5.1 Expenditure categories and drivers

In addition to the capital works described in chapter 4, AusNet Services will incur on-going incremental operating expenditure as a result of the installation of REFCLs, requiring additional specialist planning resources and resources to deliver the following activities:

- **Annual testing**

  Annual tests take the form of Primary Earth Fault Testing and Insulation Testing at each site. The first of these tests will be performed as part of the capital installation project for that site. However, annual testing is an on-going operating cost, and has been included in the forecast incremental operating expenditure.

- **Monitoring and forecasting capacitive balancing**

  This involves monitoring capacitive balance and initiating corrective action where balance is outside range. Forecasting capacitive balance is necessary to ensure that material changes to the network (such as conductor replacement or retirement, and changes in loads or generation) are known in sufficient time to rebalance the network.

- **Fault response**

  It is expected that the time spent on fault response and analysis will increase due to the complexities of the resonant earthing network. A small incremental operating expenditure allowance has been included to address this new activity.

- **Establish documentation**

  In order to operate and maintain the REFCL devices safely and effectively, documentation will need to be created including:

  - Operating instructions;
  - Maintenance instructions; and
  - Testing requirements.

  The cost of this activity has been included in the forecast incremental operating expenditure.

- **Annual inspections**

  Prior to each fire season it will be necessary to fully test the functionality of the REFCLs to ensure they are capable of operating in accordance with the regulations. This will involve annual insulation and compliance tests to demonstrate the correct operation of the devices.

- **Equipment maintenance**

  Following the installation of the REFCL devices, routine maintenance is required, similar to any other plant and equipment in the zone substation. A small incremental cost has been included in the forecast operating expenditure to perform this routine maintenance.

- **Line equipment purchases**

  The introduction of the REFCL devices imposes higher voltage conditions on existing installed lines infrastructure. Some of the equipment that AusNet Services uses for

[31] Excluding cost escalation adjustments and capitalised overheads

operating and maintaining the network is not rated to handle these higher voltages. Such equipment includes:

- Mid-span isolator units;
- Rigid hoppers;
- Insulated hard covers; and
- Line cut-out tools.

Many of these items will be capitalised, but insulated hard covers do not meet the unit cost requirements for capitalisation and therefore the costs of these items has been included as an incremental operating cost.

- **Alternative technologies and vendors**

  Currently, there is only one supplier of GFNs which offers the technology that is able to comply with the performance standards specified in the regulations. A sole supplier model is not desirable because it inevitably exposes AusNet Services and our customers to increased risk in terms of performance, delivery and costs.

  To mitigate this risk, it is prudent and efficient to engage other suppliers and work with them to develop an alternative, compliant product. To that end, AusNet Services proposes to commit resources to engage with alternative suppliers to explore alternatives technologies that have the potential to comply with the mandated performance requirements. The cost of these additional resources is included in the forecast incremental operating expenditure.

  The ‘do nothing’ option is not preferred because it would expose AusNet Services and customers to increased sole supplier risk, with possible adverse consequences in terms of performance, delivery and cost.

- **Update policy documents and reporting**

  To reflect the changes associated with the introduction of REFCL devices, AusNet Services will need to update key business documentation including the Asset Management Strategy and Policy documents. Monthly reporting will also be required to meet the ESV’s requirements.

Further information on each of these activities is provided in the supporting document, *Operational Requirements*.

5.2 Forecasting efficient and prudent operating expenditure

AusNet Services has adopted a ‘bottom up’ forecasting approach for each of the activities described in section 5.1. The objective of the forecasting method is to determine the efficient and prudent incremental operating expenditure associated with each activity.

AusNet Services has adopted ‘global’ assumptions in relation to the REFCL installation timetable and labour rates, which apply across each of the operating expenditure activities. It should be noted that the labour rates are consistent with the rates that were applied by the AER in the 2016-20 EDPR. AusNet Services is not seeking to amend these rates or the rate of escalation over the regulatory period.

In addition to these global assumptions, AusNet Services has developed specific assumptions regarding the resource requirements for each activity. These assumptions are explained in the supporting document, *Operational Requirements*. In each case, the resource requirements reflect AusNet Services’ estimate of the efficient and prudent level of activity.

The AER must accept AusNet Services' operating expenditure forecast if it reasonably reflects the operating expenditure criteria in the Rules[32], taking into account the expenditure factors in the context of the contingent project. The application of the expenditure factors to this contingent project was discussed in section 4.8. For the reasons outlined in the *Operational Requirements* supporting document, AusNet Services considers that the application of the forecasting methodology produces operating expenditure forecasts that comply with the Rules requirements.

5.3 Summary of forecasts

The annual incremental operating expenditure is set out in the table below.

Table 7: Forecast incremental operational costs, $000's, $2016

	2016	2017	2018	2019	2020	Total
Fault response & analysis	-	27.0	72.0	81.0	81.0	261.0
Operating, maintenance and testing instructions	-	30.0	-	-	4.5	34.5
Routine maintenance of zone substation assets	-	-	9.5	37.8	37.8	85.2
Network Balancing	-	36.4	89.3	217.1	247.8	590.7
Annual Testing	-	27.7	111.0	305.2	332.9	776.8
Live line equipment purchases	-	72.0	62.8	-	-	134.8
Training & Change Management	-	256.0	107.8	-	-	363.8
Regulation & Code Changes	-	34.0	5.5	5.5	5.5	50.4
Alternative technologies and vendors	-	123.8	247.5	123.8	-	495.0
Total	-	**606.9**	**705.3**	**770.4**	**709.6**	**2,792.1**

Source: AusNet Services, excludes cost escalation adjustments

As shown in the above table, in relation to the REFCL devices installed in Tranche 1 of the program, incremental operating expenditure of $606.9k (real $2016) is required in 2017, increasing to $709.6k (real $2016) by 2020. The largest single component of operating expenditure (approximately 47% of the total incremental operating expenditure in 2020) will be for testing, which is required by legislation.

For the reasons outlined in section 5.1, each of the operating expenditure activities is required in order to ensure that the network operates safely and reliably during REFCL implementation and the subsequent operation of REFCL equipment.

32 Clause 6.6A.2(f)(2).

6 Accelerated Depreciation of Retired Assets

AusNet Services proposes to accelerate depreciation of certain network assets that will be removed from service over the current regualtory period. The nature of the assets and asset classes is such they will be replaced ahead of the end of their expected economic and/or technical lives. The AER has recently approved AusNet Services' proposal to accelerate depreciation of certain high bushfire risk assets which have been, or are forecast to be replaced as part of our safety programs.[33]

AusNet Services' proposal to apply accelerated depreciation to the identified assets under this contingent project application accurately reflects change in the remaining economic lives of those assets. Accordingly, AusNet Services' proposal conforms to the requirement in NER clause 6.5.5(b)(1)[34].

The methodology undertaken by AusNet Services to determine the proposed accelerated depreciation is similar to our approach used in the 2016-20 EDPR proposal.

For this contingent project application AusNet Services has used the following methodology:

1. Identify assets that are to be removed in the current period (2016-20).
2. Estimate opening RAB value of relevant asset classes (as at January 2015).
3. Determine portion of asset class to be accelerated (i.e. proportion removed from asset base).
4. Roll forward the estimated 2015 opening RAB values to 2017 using a nominal RAB roll forward approach.

Step 1 – Identify assets

The assets considered in AusNet Services' accelerated depreciation proposal include:

- Surge Arrestors;
- Automatic Circuit Reclosers (ACRs); and
- Sectionalisers

The proposed surge arrestor and ACR replacements form part of the Line hardening and compatible equipment investments as outlined in sections 4.4 and 4.5, while sectionaliser replacements form part of the proposed DFA scheme updates as explained in section 4.8.2.

Step 2 – Estimate RAB value of identified asset class

AusNet Services has relied on data within its 2015 Repex Model[35] to establish each asset class's share of the total RAB value. The Repex model contains Electricity Distribution system assets including Network SCADA assets and does not contain IT or Non Network assets. The proportion obtained from the Repex model for each asset class was then separately applied to the 2015 opening RAB values[36] (excluding assets not modelled in the Repex model, such as IT assets) to derive estimated 2015 opening RAB values for each asset class.

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33 AER - Final decision, AusNet distribution determination - Attachment 5 - Regulatory depreciation - May 2016, p.5-13

34 NER clause 6.5.5(b)(1) requires that "the schedules must depreciate using a profile that reflects the nature of the assets or category of assets over the economic life of that asset or category of assets".

35 2015 Repex Model owned and maintained by the Regulatory & Network Strategy team within AusNet Services.

36 Opening RAB values obtained from the AER Final Decision Roll Forward Model, May 2016.

In the case of surge arrestors the share of total RAB value was determined using the replacement unit rate multiplied by total volume multiplied by an average remaining life factor (average remaining life / standard life). This depreciated replacement value was then divided into the total depreciated replacement value for all asset classes consistent with the approach used for the other assets identified in step 1 above. Since the Repex model does not separate out the entire surge arrestor fleet into a single benchmark asset category this alternate approach was used and is considered management's best estimate of the 2015 opening RAB value.

Step 3 – Determine proportion of identified RAB value to be depreciated

The portion of the asset class that is to be included in the accelerated depreciation proposal is calculated based on forecast replacement volumes included in this contingent project application, as a share of the total volume of assets in each asset class as at January 2015.

The total volume of assets within the identified asset classes are obtained from the 2015 Repex model. In the case of surge arrestors the total volume was taken from AusNet Services' 2016 RIN in lieu of available data within the Repex model. As noted in step 2 above surge arrestors are not captured in a single benchmark asset category within the Repex model, rather they are spread across multiple categories.

Step 4 - Roll forward the estimated 2015 opening RAB values to 2017

Since our approach described above established the opening RAB values as at January 2015 there is a requirement to roll forward the RAB values to January 2017, to align with the REFCL program delivery schedule which will see the replacement of identified assets commencing in 2017. AusNet Services has applied the AER's standard nominal RAB roll forward approach to establish the 2017 opening RAB values[37].

AusNet Services therefore proposes to accelerate depreciation over the remaining four years of the current regulatory period (2017-20). To facilitate this in the Proposed Amended PTRM model we have established a new asset class 'Accelerated Depr - Distr assets (Contingent Project 1)'.
This allows for the opening RAB transfers between 'Distribution system assets' and the new accelerated depreciation assets class. Since the opening RAB transfers do not occur until 2017 we have reflected these transfers within our Amended Year by Year tracking model[38] which is a supporting attachment to this contingent project application.

In summary, AusNet Services' proposed accelerated depreciation allowance is $2.9 million ($Nominal) as shown in Table 8 below.

Table 8: Proposed Accelerated Depreciation Allowance ($m, nominal)

	2016	2017	2018	2019	2020	Total
Accelerated Depreciation	-	0.7	0.7	0.7	0.8	2.9

37 Using forecast inflation contained in the AER Final Decision PTRM.

38 AusNet Services' Amended RAB Depreciation model. The PTRM depreciation schedule for the opening RAB has been updated accordingly.

7 Incremental revenue requirement

7.1 Introduction

This chapter presents information on the incremental revenue requirement of the contingent project described in this application. We have used the post-tax building block approach outlined in NER 6.5.4, and the AER's post-tax revenue model to calculate the incremental revenue requirement. Information that explains and substantiates the forecast incremental capital and operating expenditure has been set out in chapters 4 and 5.

The building block formula applied in each year of the regulatory control period is:

MAR = return on capital + return of capital + opex + revenue adjustments + tax

= (WACC x RAB) + D + opex + revenue adjustments + tax

where:

MAR = Maximum allowed revenue

WACC = Post tax nominal weighted average cost of capital

RAB = Regulatory Asset Base

D = Economic depreciation (nominal depreciation minus indexation of the RAB)

Opex = Operating and maintenance expenditure

Revenue adjustments = efficiency benefit sharing scheme carry-overs, forecast DMIA, 2010 S-factor scheme close out and shared asset adjustments

Tax = Cost of corporate income tax of the regulated business

The sections below set out further information on each building block component of the incremental revenue requirement. Details regarding the total incremental revenue allowance and the amended revenue determination to enable recovery of the contingent project costs are provided at the conclusion of this chapter.

7.2 Regulated asset base and depreciation

The forecast RAB in relation to the contingent project is set out in the table below. These values incorporate the capital expenditure plans set out in chapter 4, and the forecast depreciation over the period.

Table 9: Contingent Project Regulatory Asset Base ($m, nominal)

	2016	2017	2018	2019	2020
Contingent project Opening RAB	-	8.3	71.9	112.8	109.3
Contingent project capital expenditure[39]	8.3	64.5	42.9	0.1	-
CPI indexation on opening RAB	-	0.2	1.7	2.6	2.5
Contingent project depreciation	-	-1.1	-3.7	-6.2	-6.3
Contingent project Closing RAB	**8.3**	**71.9**	**112.8**	**109.3**	**105.5**

Source: AusNet Services PTRM.

The regulatory depreciation in relation to this contingent project has been calculated using the straight-line depreciation method and the standard asset lives approved by the AER in its final decision for the 2016-20 regulatory period. Full details of this calculation are provided in the updated PTRM which is submitted as part of this contingent project application.

A number of assets will be replaced or upgraded sooner than forecast in the 2016-2020 EDPR. For the purpose of this contingent project application, however, we are not proposing to accelerate the depreciation of these assets. AusNet Services reserves the right to revisit this issue in the 2021-2025 EDPR.

For completeness, Table 10 below shows the derivation of the regulatory asset base (RAB) for the 2016-20 period, sourced from the AER's Final Determination PTRM model and updated for the 2017 cost of debt in accordance with the Final Determination WACC requirements.

Table 10: AER's Final Decision Regulatory Asset Base 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020
Opening RAB	3,442.1	3,674.8	3,957.7	4,209.9	4,471.6
Capital expenditure	336.6	370.7	344.3	354.1	342.6
CPI indexation on opening RAB	80.0	85.4	91.9	97.8	103.9
Straight-line depreciation	-183.8	-173.2	-184.0	-190.2	-203.0
Closing RAB	**3,674.8**	**3,957.7**	**4,209.9**	**4,471.6**	**4,715.1**

Source: AusNet Services PTRM.

Table 11 below shows the amended RAB for the 2016-20 period, which reflects the summation of the values set out in Table 9 and Table 10.

39 Details of the forecast capital expenditure for the contingent project are set out in chapter 4.

Table 11: AusNet Services' Amended Regulatory Asset Base 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020
Amended Opening RAB	3,442.1	3,683.1	4,029.6	4,322.7	4,580.9
Amended Capital expenditure	344.9	435.2	387.2	354.2	342.6
CPI indexation on opening RAB	80.0	85.6	93.6	100.4	106.4
Amended Straight-line depreciation	-183.8	-174.3	-187.7	-196.4	-209.3
Amended Closing RAB	**3,683.1**	**4,029.6**	**4,322.7**	**4,580.9**	**4,820.6**

Source: AusNet Services PTRM.

7.3 Return on capital

The return on capital in relation to the contingent project has been calculated by applying the AER's estimated post-tax nominal vanilla WACC to the regulatory asset base, in accordance with the AER's final decision. This calculation is shown in the table below.

Table 12: Return on capital for contingent project, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020
Contingent project RAB for revenue calculation purposes	-	8.3	71.9	112.8	109.3
WACC (percent per annum)[40]	6.31	6.27	6.27	6.27	6.27
Contingent project return on capital	**-**	**0.5**	**4.5**	**7.1**	**6.9**

Source: AusNet Services PTRM.

It is noted that the AER's WACC allowance for our 2016-20 Final Determination is presently subject to appeal. Accordingly, the information presented in the table above, and in this application, may be amended to reflect the outcome of that appeal.

For completeness, Table 13 below shows the return on capital for the 2016-20 period, as set out in the AER's Final Determination, including updates to the annual WACC allowance.

Table 13: AER's Final Decision Return on capital, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020
RAB for revenue calculation purposes	3,442.1	3,674.8	3,957.7	4,209.9	4,471.6
WACC (percent per annum)[41]	6.31	6.27	6.27	6.27	6.27
Return on capital	**217.3**	**230.3**	**248.0**	**263.8**	**280.2**

Source: AusNet Services PTRM.

40 Updated annually for return on debt.

41 Updated annually for return on debt.

Table 14 below shows the amended return on capital for the 2016-20 period, which reflects the summation of the values set out in Table 12 and Table 13.

Table 14: AusNet Services' Amended return on capital, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020
Amended RAB for revenue calculation purposes	3,442.1	3,683.1	4,029.6	4,322.7	4,580.9
WACC (percent per annum)[42]	6.31	6.27	6.27	6.27	6.27
Amended return on capital	**217.3**	**230.8**	**252.5**	**270.8**	**287.0**

Source: AusNet Services PTRM.

7.4 Tax allowance

The calculation of estimated corporate income tax attributable to the contingent project has been undertaken in accordance with the provisions set out in clause 6.5.3 of the NER. The estimated tax allowance is shown in the table below.

Table 15: Estimated cost of corporate tax for contingent project, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020
Tax payable	0.0	0.2	0.4	0.7	0.8
Less value of imputation credits	0.0	-0.1	-0.2	-0.3	-0.3
Net corporate income tax allowance	**-**	**0.1**	**0.2**	**0.4**	**0.5**

Source: AusNet Services PTRM.

For completeness, Table 16 below shows the corporate tax allowance for the 2016-20 period, as set out in the AER's Final Determination.

Table 16: AER's Final Decision on corporate tax allowance, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020
Tax payable	55.4	45.1	46.0	47.2	45.8
Less value of imputation credits	-22.2	-18.0	-18.4	-18.9	-18.3
Net corporate income tax allowance	**33.2**	**27.1**	**27.6**	**28.3**	**27.5**

Source: AusNet Services PTRM.

42 Updated annually for return on debt.

Table **17** below shows the amended tax allowance for the 2016-20 period, which reflects the summation of the values set out in Table 15 and Table 16.

Table 17: AusNet Services' Amended corporate tax allowance, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020
Tax payable	55.4	45.3	46.4	47.9	46.6
Less value of imputation credits	-22.2	-18.1	-18.6	-19.2	-18.6
Amended net corporate income tax allowance	**33.2**	**27.2**	**27.9**	**28.8**	**28.0**

Source: AusNet Services PTRM.

7.5 Incremental operating expenditure

AusNet Services' operating expenditure forecasts for this contingent project are described in chapter 5 of this proposal.

The table below shows the operating expenditure allowance for the 2016-20 period set out in the AER's Final Determination. Also shown is the amended operating expenditure allowance for the 2016 period, which is the sum of the AER's Final Determination allowance and the incremental operating expenditure for the contingent project (set out in Table 7 above).

Table 18: Amended operating expenditure allowance, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020
Contingent project operating expenditure (from Table 7)	-	0.6	0.8	0.9	0.8
Opex allowance, AER Final Determination	230.3	239.4	250.7	261.3	273.0
Revised operating expenditure allowance	**230.3**	**240.0**	**251.5**	**262.3**	**273.9**

Source: AusNet Services. Totals may not add due to rounding

7.6 Incremental revenue allowance

The table below shows the building block elements that comprise the incremental revenue requirement for the contingent project over the 2016-20 period.

Table 19: Contingent project revenue requirement, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020	Total
Return on capital	-	0.5	4.5	7.1	6.9	18.9
Regulatory depreciation	-	0.9	2.0	3.6	3.8	10.3
Operating expenditure	-	0.6	0.8	0.9	0.9	3.2
Revenue adjustments	-	-	-	-	-	-
Net tax allowance	-	0.1	0.2	0.4	0.5	1.3
Annual revenue requirement (unsmoothed)	**-**	**2.2**	**7.6**	**12.0**	**12.0**	**33.7**

Source: AusNet Services PTRM

7.7 Revised revenue determination

Table 20 below shows the revenue allowance and X factors for the 2016-20 period sourced from the AER's Final Determination and updated for the annual cost of debt in accordance with the Final Determination WACC requirements. Accordingly, the 2017 X Factor has been updated to determine the smoothed revenue requirement.

Table 20: AER Final Determination revenue requirement, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020	Total
Return on capital	217.3	230.3	248.0	263.8	280.2	1,239.4
Regulatory depreciation	103.8	87.8	92.1	92.4	99.1	475.3
Operating expenditure	230.3	239.4	250.7	261.3	273.0	1,254.8
Revenue adjustments	5.3	-6.4	-3.6	16.1	0.1	11.6
Net tax allowance	33.2	27.1	27.6	28.3	27.5	143.7
Annual revenue requirement (unsmoothed)	**590.0**	**578.2**	**614.8**	**662.0**	**679.9**	**3,124.8**
Annual expected revenue (smoothed)	**586.0**	**597.9**	**616.8**	**643.7**	**678.4**	**3,122.8**
X factor[43]	8.27%	0.30%	–0.82%	–2.00%	–3.00%	n/a

43 The X factors from 2018 to 2020 will be revised to reflect the annual return on debt update. Under the CPI–X framework, the X factor measures the real rate of change in annual expected revenue from one year to the next.

Table 21 below shows our amended revenue requirement, which includes the contingent project revenue requirement.

Table 21: Amended revenue requirement, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020	Total
Return on capital	217.3	230.8	252.5	270.8	287.0	1,258.4
Regulatory depreciation	103.8	88.7	94.1	96.0	102.9	485.5
Operating expenditure	230.3	240.0	251.5	262.3	273.9	1,258.0
Revenue adjustments	5.3	-6.4	-3.6	16.1	0.1	11.6
Net tax allowance	33.2	27.2	27.9	28.8	28.0	145.0
Annual revenue requirement (unsmoothed)	**590.0**	**580.3**	**622.4**	**674.0**	**691.9**	**3,158.5**
Annual expected revenue (smoothed)	**586.0**	**597.9**	**623.5**	**657.1**	**692.5**	**3,157.0**
X factor[44]	8.27%	0.30%	-1.91%	-3.00%	-3.00%	n/a

Table 22 below shows our incremental smoothed revenue requirement for the contingent project.

Table 22: Incremental revenue requirement, 2016-20 ($m, nominal)

	2016	2017	2018	2019	2020	Total
Annual expected incremental revenue (smoothed)	-	-	6.7	13.4	14.1	34.2

44 The X factors from 2018 to 2020 will be revised to reflect the annual return on debt update. Under the CPI–X framework, the X factor measures the real rate of change in annual expected revenue from one year to the next.

8 List of supporting documents

In addition to the appendices to this contingent project application, the following 7 supporting documents are provided:

1. Network Balancing Strategy
2. Compatible Equipment - Line Voltage Regulator Strategy
3. Compatible Equipment - Automatic Circuit Recloser Strategy
4. Compatible Equipment - Line Hardening Strategy
5. REFCL Equipment Building Block Functional Description
6. Cost estimating, Unit Rates & Program Delivery
7. Operational Requirements

1 Appendix 1 – Kinglake Zone Substation REFCL Planning Report

1.1 Purpose

The purpose of this appendix is to demonstrate that the forecast capital expenditure and incremental operating expenditure to install the mandated REFCL technology at Kinglake (KLK) zone substation are prudent and efficient. In doing so, this appendix highlights the specific issues at KLK zone substation that influence the design and cost of the REFCL installation at this location.

A number of supporting documents are listed in section 1.9, which provide further information on the strategies that underpin our forecast expenditure, and detail why these strategies and cost estimates are prudent and efficient. This appendix should therefore be read in conjunction with the supporting documents listed in section 1.9.

As explained in the Chapter 1 of this contingent project application, the installation of REFCLs at selected zone substations is the only engineering solution that is capable of complying with the performance standards mandated by the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

KLK zone substation is located in the township of Kinglake approximately 40 km northeast of Melbourne. This small zone substation was established in the 1960s and supplies the township and surrounding areas. The station supplies 2,435 customers by means of two small (5 MVA) transformers and three distribution feeders. The feeders cover a 22kV route length of 184km. The 22kV network includes 11 automatic switchable sections.

The estimated total capacitance of the KLK 22kV network is 48 (A) or 72 (A) including existing automatic transfer feeders.

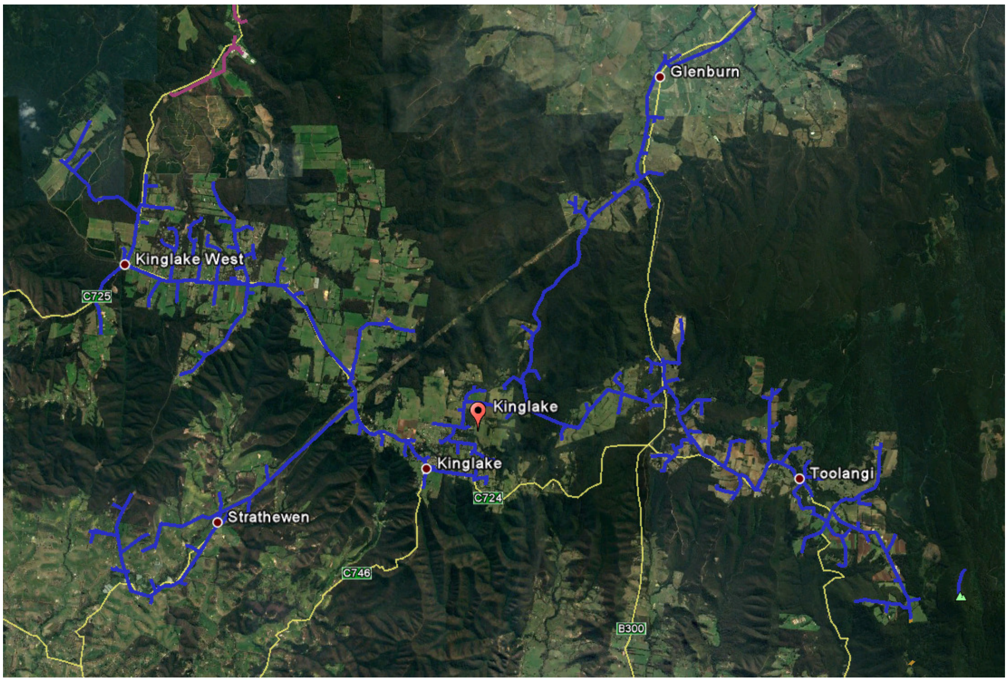

Figure 1-1: KLK 22kV feeders shown above in blue.

1.2 Key issues and challenges at KLK

The key issue impacting the installation of a REFCL at KLK is the lack of available physical space at the current site. The station is configured as a rural station located on a small block.

The site does not have sufficient space to locate the Arc Suppression Coil (ASC), additional station service transformers and new switchgear.

C-I-C

The existing 22 kV feeders are switched using Automatic Circuit Reclosers (ACRs). These ACRs, which are mounted on poles, are not fitted with sufficiently accurate measuring transformers. In addition, the configuration of the switchgear means that any testing on the transformer (which is necessary prior to REFCL commissioning) cannot be completed without disconnecting supply to all customers fed from the station.

The installation of the REFCL at KLK is complicated by the proposed replacement of some of the overhead lines under the Government's Powerline Replacement Program. Under this program, the overhead lines will be replaced with underground cables or covered conductors. These underground cables and covered conductors affect the capacitance of the network. The capacitance of the network could increase to a level which exceeds the capacity of the REFCL, leading to the need for a second REFCL unless specific measures are taken to limit the capacitive increase.

Two large codified areas are located near Kinglake. KLK 1 feeder distributes electricity into these codified areas. A short section of KLK 1 is located in the township of Kinglake however most of the feeder is located in the codified areas. Any material asset replacement work in these areas or customer connections will affect the capacitance of the network and will need to be closely monitored and controlled to avoid the need for a second REFCL.

The existing control room is small with insufficient space for the REFCL protection and controls, and the room contains asbestos panelling. Due to the asbestos panelling and its size, the control room is unsuitable for refurbishment or reuse. The options to address this issue are discussed in section 1.3.1.

1.3 Scope of work

The scope of work to install a REFCL at KLK involves:

- Zone substation works;
- Compatible works, including replacement of 6 ACRs installed on a KLK feeder;
- Network balancing; and
- Line hardening, which requires the replacement of incompatible surge arrestors installed on feeders.

Each of these activities is discussed in turn below, as follows:

- Section 1.3.1 – Zone substation works; and
- Section 1.3.2 – Line works, which addresses the remaining three workstreams.

It should be noted that there are no line voltage regulators requiring upgrade on the KLK network.

1.3.1 Zone substation works and options analysis

The proposed REFCL installation at KLK will involve a number of activities that are common to most Tranche 1 zone substations REFCL installations. These include:

- Specification, procurement and installation of a Ground Fault Neutraliser (GFN), including an ASC, Residual Current Compensation (RCC) and control system.

- Specification, procurement and installation of a neutral bus switchboard. The introduction of the GFN requires a neutral bus which enables different earthing arrangements to be automatically configured. The switchboard facilitates remote year round selection of earthing arrangements and operating modes. Provides the ability to balance bushfire risk reduction with network reliability, depending on network and weather conditions.
- Upgrade of the existing station service transformers and changeover boards. This work is required because the alternating current (AC) supply requirement dramatically increases due to the GFN installation.
- Testing and replacement of equipment incapable of operating at elevated voltages including switchgear, measuring transformers and cables.
- Replacement and extension of existing protection and control equipment with equipment capable of operating in several modes including resonant earthing and traditional earth fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of maloperation.
- Prior to commissioning the GFN, network hardening tests involve the process of lifting voltages (using the GFN) in a healthy three phase powerline network (phase by phase) to check network readiness for future states of REFCL operation. During this activity there is an increased likelihood of asset failures. We would replace any assets that fail during the testing process. These tests are necessary to ensure the GFN can operate without causing line and station equipment to fail resulting in a fire start. These tests are conducted in times of low fire risk to mitigate the likelihood of failure in the Declared Bushfire Season.
- Installation of monitoring equipment to prove compliance with regulations and enable remote engineering access to control systems.

Further information on these works is provided in the following supporting document:

- REF 10-04 REFCL Program Equipment Building Block Functional Description

The additional specific work required at KLK involves:

- C-I-C

- Work associated with converting a small rural zone substation into a station capable of operating with a REFCL. This required work includes civil foundations for new switchgear, REFCL control room, battery room, station service transformers and REFCL equipment, earthing, surfacing and fencing.
- Installation of a standard rural relocatable switchboard to provide the required REFCL fault detection and operation capability. 22 kV switching is currently provided by pole mounted ACRs which are not capable of detecting the low currents necessary for REFCL operation.
- Installing one standard control rooms to house standard zone substation protection and controls, REFCL associated protection, control, and indoor auto-change over board.
- In relation to network hardening tests on the KLK 22 kV network prior to commissioning the GFN, our expectation is that there is a reasonable likelihood that some surge arrestors, insulators, pole top transformers and/or cables may fail and require replacement.
- Development and execution of a community engagement plan for works associated with the KLK network REFCL implementation. Community engagement is required to explain

the likely customer reliability impact during the new network insulation tests. The importance of effective community engagement has been highlighted by the Woori Yallock REFCL implementation in September 2016, which led to issues being raised by customers, media, the community and the Victorian Parliament.

KLK is the only zone substation in Tranche 1 where it is necessary to acquire additional land to install the REFCL and associated equipment. C-I-C

The alternative to land acquisition would be to relocate and reconstruct the zone substation on a site large enough to accommodate 66 kV and 22 kV switchgear, transformers, station services and REFCL equipment. As explained in further detail below, the cost of acquiring a new site, and relocating and reconstructing the zone substation would be significantly more expensive than the acquisition of additional land. Specifically, the relocation and reconstruction option would require additional line and cable relocation works and the establishment of new earthing and foundations, in addition to the majority of the work required for the preferred option.

Before determining our preferred scope of work at KLK, we considered 6 planning options:

1. Purchase additional land to install REFCL and new 22 kV switchboard (our preferred option, as described above);
2. Purchase additional land to install two REFCLs and new 22 kV switchboard;
3. Rebuild substation at a new location (with new transformers and 66 kV switchgear);
4. Rebuild substation at a new location (relocating existing transformers and 66 kV switchgear);
5. Supply KLK feeders from nearest adjacent zone substations; and
6. Same as Option 1, but install outdoor switchgear instead of standardised rural relocatable switchboard.

In developing these options, AusNet Services considered non-network options and substitution possibilities between operating and capital expenditure. In relation to the zone substation works, there were no identified non-network options or substitution possibilities, other than those inherent in the above options.

A summary of our analysis in relation to each of these options is shown in Table 1.

Table 1: Options evaluated

Option	Advantages	Disadvantages
1. Purchase additional land to install REFCL and new switchboard. Utilise new technology low capacitance cable to reduce need for 2nd REFCL (preferred option).	Readily enables existing transformers, 66 kV switchgear and earthing to be utilised. Makes maximum use of standard designs for new equipment and 22 kV switchgear thereby lowering lifetime costs and minimising time to implement works at zone substation. Standard equipment can readily be transported and relocated to other sites if necessary. (Minimises stranding risk.) Minimum disruption to community as station works would be constrained to (expanded) site. Option cost is $7,199k.	Complex project as supply must be maintained while new equipment is installed. Modifying protection systems is more complex than Options 3 and 4.
2. Purchase additional land to install two REFCLs and new switchboard.	Same as Option 1, but also eliminates need to introduce new technology (low capacitance cable) or closely monitor increase in feeder capacitance due to PRF or customer works.	Same as Option 1, but greater cost than single REFCL installation at $8,787k.
3. Rebuild substation at a new location (new transformers & 66 kV switchgear).	New substation can be built without impacting customer supply. Simpler construction with less risk as limited work near live equipment.	Would require acquisition of new site and potential community concern over development of electrical infrastructure. Does not utilise existing transformers and 66 kV switchgear which has some remaining life. Greater cost than preferred Option 1 by ~$12,000k.
4. Rebuild substation at a new location (relocating existing power transformers & 66 kV switchgear).	No advantage over Option 1.	Very complex project as supply would need to be maintained during move of major plant. Would involve temporary supplies and equipment. Moving aged plant may bring forward end of life, leading to higher replacement costs. Greater cost than Option 1.

Option	Advantages	Disadvantages
5. Supply KLK feeders from nearest adjacent zone substations.	Would allow zone substation to be decommissioned reducing zone substation maintenance and asset replacement costs.	Would require installation of an additional transformer and REFCL at Woori Yallock and possibly a third transformer at Seymour. Would require significant line works to upgrade capacity of lines. Customers likely to experience lower reliability as long radial lines would be necessary to provide supply. Greater cost than Option 1.
6. Same as Option 1, but install outdoor switchgear instead of standardised rural relocatable switchboard.	Requires less land than standard switchboard. (However additional land still required for site REFCL and station supplies.) Marginally lower initial capital cost than Option 1 $6,129k.	Increased design effort and equipment procurement lead-time due to non-standard switchgear. Appears less expensive than preferred option but the introduction of non-standard switchgear introduces multiple issues and ongoing risks which are not incorporated in the capex forecast including: • Would lead to non-standard switchgear in a rural location leading to more complex, non-standard maintenance. • New Standard Maintenance Instructions (SMI) would need to be prepared • Additional spares & training would be required. • Eliminates potential to relocate and reuse switchboard in future should demand change • Any future work involving switchgear at KLK becomes more expensive

It is evident from the above table that Option 1 is the appropriate planning solution because it has:

- Lower cost than Options 2, 3, 4 and 5;
- Reduced complexity and supply risks compared to Options 4 and 5; and
- Standardised equipment, lower lead times and procurement risks compared to Option 6.

1.3.2 Line works

The scope of works outside the zone substation involves the following work on the KLK network:

- Replacement of 6 ACRs on a KLK feeder;
- Balancing 11 automatic switching zones – this involves:
  - 33 sites where phases are rotated;
  - 3 sites where the third phase of cable must be unbonded;
  - The installation of 2 single phase balancing capacitors and 7 three-phase balancing capacitors; and
  - The replacement of 11 fuse sites required to be replaced with solid links.
- Replacement of surge arresters at 159 sites distributed across the feeders.

ACRs are currently used to detect 'downstream' faults and to interrupt supply to the faulted feeder section thereby minimising the number of customers who experience a supply interruption due to a fault. The existing ACRs are not capable of:

- detecting the low fault currents that will occur with REFCL operation; and
- identifying faults and the affected section of the feeder when earthing arrangements are altered at the zone substation (i.e. when the REFCL is switched onto the network). This inability leads to a larger number of customers being affected in the event of a sustained fault on a REFCL network and spurious tripping of ACRs on unaffected healthy feeders when the REFCL operates.

ACRs will therefore be upgraded or replaced so that they can detect low fault currents along with any changes to the earthing arrangement at the zone substation, this will ensure in the event of a fault customer outage numbers are minimised and healthy feeders are not tripped with REFCL operation.

Equally important as the ACR works is the capacitive balancing of the KLK 22kV network. Network capacitance must be balanced for REFCLs to operate. AusNet Services will undertake network balancing on each 'automated switching zone' where an automated switching zone is a feeder section delineated by ACRs, sectionalisers and/or circuit breakers. Balancing switching zones involves a combination of works including, phase transpositions, adding balancing capacitors, unbonding cable installations, removing fuses and adding a third phase conductor to balance each section. A combination of this work involving the least cost for each switching zone will be undertaken.

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA) involves a combination of ACR and sectionaliser operations plus the use of adjacent feeders to supply feeder sections downstream of a faulted section. This scheme is currently used to provide network reliability. DFA will only operate with REFCLs where each switching zone is capacitively balanced and ACR works are completed.

As well as network balancing works, type testing of surge arrestors has been undertaken to determine the types which cannot withstand the elevated voltages that result from REFCL operation. Failure of these types can lead to ground fire ignition and therefore their replacement is essential to prevent fire ignition during REFCL operation. A survey of the feeders has identified 159 sites with incompatible surge arrestors and these will be replaced with a standard surge arrestor with adequate ratings for REFCL operation.

In scoping the above line works, AusNet Services has considered whether there are any non-network options or substitution possibilities between operating and capital expenditure. The nature of the required works at KLK is such that there are no non-network options or opportunities to substitute operating activities for the proposed capital works.

Further detail on the need for replacement and/or upgrade of ACRs, network balancing and surge arrester replacement is available in:

- REF 20-08 Automatic Circuit Recloser Strategy
- REF 20-06 Network Balancing Strategy
- REF 20-07 Line Hardening Strategy

1.3.3 Operational costs

In addition to the capital works described above, incremental ongoing operational costs will result from REFCL installation. Operational costs not specific to this site location are contained in the Operational Expenditure Requirements - Tranche 1 (REF 70-10) document. Operational costs that are either specific to KLK or vary by zone substation include:

- A number of new or expanded devices will be installed at KLK as a result of the REFCL installation including REFCL equipment, auto-changeover board, station services and line balancing capacitor units. As these items are new they are unlikely to require material additional maintenance, however they will require routine inspection.
- Prior to each fire season it will be necessary to fully test the functionality of the REFCL to ensure that it is capable of operating to meet the Regulations. This will involve annual insulation and compliance tests to demonstrate the correct operation of the device together with ESV reporting.

Table 2: Forecast incremental operational costs

Activity	Frequency	Calendar Year Cost $		
		18	19	20
Maintain additional equipment	Annual	-	6,308	6,308
Pre fire season testing (insulation and compliance testing)	Annual	-	27,742	27,742

1.4 Key assumptions, risks and mitigation strategies

The key assumptions and risks made in forecasting the cost of REFCL installation at KLK are shown in Table 3 below.

Table 3: Key assumptions, risks and mitigation strategies

Assumption or Risk	Impact	Mitigation
C-I-C	C-I-C	C-I-C
C-I-C	C-I-C	C-I-C

Assumption or Risk	Impact	Mitigation
Work to replace powerlines under the Powerline Replacement Fund will not materially increase the capacitance of the network.	Should capacitance materially increase, a second REFCL unit would be required at KLK.	Investigate potential to use low capacitance cable for PRF and customer works on KLK feeders.
C-I-C	C-I-C	C-I-C
Customers adversely affected by outages due to failure of equipment operating at higher than design voltages.	Extended customer outages e.g. cable failures. S-factor & GSL impacts.	Assets which are not compatible with REFCL such as surge arrestors & ACRs replaced prior to testing. Critical cables tested. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the KLK network.
Customers adversely react to the number of outages required to deliver the REFCL works on the KLK network.	Repeat customer outages lead to increased customer costs and community frustration e.g. outages for line work, and station and REFCL testing works.	Where possible, the co-ordination of work outages to minimise impact on the community.
Proximity to live assets during construction.	The project involves brownfield works to be carried out in the midst of an in-service zone substation. This will result in risk associated with the close proximity of live overhead and underground assets to employees, contractors and mobile plant.	Access permit conditions will clearly specify the requirements to ensure safety whilst work is being carried out in the station. Controls will be required for site induction and earth potential rise under fault conditions.
Sole supplier delivers GFN product to required standard.	Failure to have the GFN operating by 30 April 2019 will incur a one off civil penalty of $8M, and a fine of $5,500 for each day the criteria is not met after that date.	Develop and monitor strategic spares for the GFN product. Engage and invest in the relationship with GFN supplier. Seek an alternative REFCL supplier that can meet performance criteria of the Regulations. KLK costing has no allowance for sole supplier risk.

Assumption or Risk	Impact	Mitigation
KLK network can be capacitively balanced, achieving the performance required under the Regulations.	Accurate network balance is essential if the performance criteria are to be met. To date these criteria have been achieved in one instance on a 40km network at Kilmore South. Failure to meet the performance criteria by 30 April 2019 will incur a one off civil penalty of $8M, and a fine of $5,500 for each day the criteria is not met after that date.	Extensive survey, design and modelling work is required. Works must ensure all material capacitive imbalances are accounted for on the KLK network.

1.5 Total costs for KLK Zone Substation

The total forecast costs to install a REFCL at KLK are shown in Table 4.

Table 4: Forecast costs

Item	Cost $000s 2016 direct
Capex	
Zone substation works (including land purchase), network insulation testing (elevated voltage testing) and REFCL commissioning	7,081
Replacement of 6 ACRs that are not capable of detecting low fault currents or automatically blocking conventional earth protection during REFCL operation.	379
Network balancing – Rotating phases, unbonding cable at a 3 locations, installing single and three phase capacitors and replacing fuses with solid links.	819
Replacement of 416 units at 159 surge arrestor sites that present a risk of failure (and fire ignition) during REFCL operation.	391
Total	*8,670*
Opex	
Pre fire season testing including insulation and compliance testing.	55
Equipment maintenance.	13
Total	*68*

The capital costs have been prepared using AusNet Services' standard project cost estimating approach. The capital costs associated with zone substation equipment installation, replacement of an ACR and replacement of surge arrestors are reasonably certain. i.e. they carry the same level of uncertainty as routine projects such as zone substation construction or rebuilds.

The total capex cost at KLK is higher than majority of other tranche one stations driven by an increased zone substation costs. KLK zone substation has land constraints and the existing 22KV switchgear is not capable of detecting the low current necessary for REFCL operation.

Additional land purchase is required for the installation of the REFCL and a standard rural relocatable switchboard is required to provide REFCL fault detections and operation capability. This is reflective of increased zone substation costs at this site.

Uncertainties in forecast capital costs primarily arise from performance of the REFCL, the extent of network balancing required and community reaction to the installation and testing works. An allowance of $34,477 has been included in the zone substation works for network insulation testing activities. This cost is based on 1.5 days to complete this activity, anticipating 1 fault per day of testing. Each fault has been attributed a cost of $5,467 using established contractor rates. Based on insulation testing carried out to date, it is reasonably likely that cables/joints and surge arrestors will fail at this elevated voltage testing.

Ongoing cost uncertainty arises from the need to use untested low capacitance cable to limit network capacitance to a level which can be managed by one REFCL; and, from the level of effort required to keep the network balanced to keep the REFCL in service.

1.6 Addressing reliability degradation

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA), has played an important role in delivering current levels of reliability. It involves a combination of ACRs, Remote Control Gas Switches and feeder management relay operations, together with the use of adjacent feeders, to supply feeder sections downstream of a faulted section. This scheme is specific to AusNet Services and reflects an important difference between our network and that of Powercor Australia.

However, the current DFA algorithms are all based on a conventional Resistance Earthed System network, and are incompatible with the required change to a Resonant Earthed System network as REFCLs are installed. As a consequence, without an upgrade to the algorithms (DFA2), the reliability outcomes on completion of each REFCL installation will degrade significantly.

AusNet Services' cost benefit analysis demonstrates that the costs of allowing a degradation in reliability significantly outweigh the costs of DFA2 and, therefore, the expenditure is justified in terms of economic efficiency. Furthermore, customers would be concerned if reliability degraded following the significant investment in REFCL technology, especially during periods of extreme heat.

The costs of DFA2 are not specific to each zone substation. Therefore, the costs are not included in this planning report, but are set out in the main body of the contingent project application.

1.7 Cost comparison with the Government's estimate in the RIS

To demonstrate the efficiency and prudency of our proposed expenditure, we must have regard to available benchmark information. In this instance, industry benchmarking is not available because the application of this technology for fire mitigation purposes is a world's first. In addition, the costs of installation are site-specific – which means that there is a potentially wide range of efficient and prudent installation costs across zone substations.

Despite these limitations, we note that the Regulatory Impact Statement (RIS) prepared by ACIL ALLEN for the Victorian Government in 2015 estimated costs for the REFCL installation program. The cost estimates were an important component of the RIS assessment, which considered the costs and benefits of introducing the bushfire mitigation regulations.

We note that ACIL ALLEN's cost estimates were prepared in 2015. Since then, we have developed location specific scopes of work, which have also been informed by experience gained at the REFCL installation at Woori Yallock zone substation. For these reasons, we have substantially more confidence in our cost estimates for KLK compared to the earlier ACIL

ALLEN estimates, which were developed for a different purpose and which no longer reflect the best available information.

The table below provides a detailed explanation of the differences between our forecasts and ACIL ALLEN's estimates in the RIS. For some line items, the RIS did not provide a specific estimate for each zone substation. In these cases, we have presented the volume range set out in the RIS and commented on whether our forecast falls within this range.

Table 5: Reconciliation of AusNet Services' cost forecasts at KLK with the RIS cost estimates

Item	AusNet Services forecast $ 2016 direct	RIS estimate[1] $2015 direct	Explanation
Capex			
Zone substation works	7,081k	1,800 – 4,895k[2] Including - REFCL, design, civil works, installation and commissioning; - Station lighting arrestors; -Station service transformers; -Station services low voltage transfer switch; and - Capacitor banks.	AusNet Services' zone substation works include the following additional items which were not included in the RIS estimate: neutral bus switchboard; REFCL control room; REFCL backup protection and interface control systems; REFCL testing including to prescribed requirements; and a community engagement plan. Additional costs at Kinglake zone substation include the 22kV switchgear replacement including associated works and additional land purchase.
ACRs replacement	6 unit replacements @ cost of $63.2k per unit, producing a cost of $379k	RIS only provided an estimated volume range of 0-18 for each zone substation @ cost of $70k per unit, producing a cost estimate between $0 and $1,260k per zone substation.	AusNet Services' ACR replacement unit cost is lower than the RIS estimate.

[1] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, 74 & 75. It should be noted that the RIS costs are expressed in $2015 while our costs are expressed in $2016. Strictly speaking, for comparison purposes the RIS costs are approximately 1.5 per cent higher than indicated here.

[2] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, Table 14 includes zone substation components

Item	AusNet Services forecast $ 2016 direct	RIS estimate[1] $2015 direct	Explanation
Network balancing	819k (see scope of work in 'explanation column')	RIS only provided an estimated volume range for conductor phase movements. Anticipated 0-85 for each zone substation @ cost of $4k per unit, producing a cost estimate between $0 and $340k per zone substation.	Significant increase in the scope and cost post the learnings of the WYK REFCL commissioning. This has led to an increased understanding of the least cost mix of work required to meet and maintain the prescribed sensitivity criteria in the Regulations. Field works required to meet the criteria which is world first involve: - 33 sites where conductor phase movements are required; - 3 sites where third phase conductor is required to be unbonded; - Installation of 2 single phase balancing capacitors and 7 three phase balancing capacitors; and - 11 sites where fuses are required to be removed and replaced with solid links.
Surge arrestors	416 unit replacements @ cost of $0.94k per unit, producing a cost of $391k	RIS only provided an estimated volume range of 0-8,224 units for each zone substation @ cost of $1k per unit, producing a cost estimate between $0 and $8,224k per zone substation.	AusNet Services approach is to replace the 40% of surge arrestors that sample testing has determined will not operate satisfactorily at elevated voltages. Cost forecast is lower than the average of the RIS estimate. 159 surge arrestor sites requiring replacement at $2,460 each, (equates to 416 surge arrestors units at $940 each).
Voltage regulators	-	-	
Total	8,670k	3,960[3]k	The RIS estimate is specific to this zone substation, even though only cost ranges are provided in relation to the cost build up. The KLK total cost is higher than the RIS estimate for the reasons set out above. See further discussion below this table.
Code compliance	-	-	No HV customers are served from the KLK 22kV network.
Opex			
Pre fire season testing	55k	-	Not costed in the RIS estimate. Required to ensure the KLK network is operating to the prescribed criteria of the Regulations and vulnerabilities to overvoltage on the KLK network are exposed prior to the Declared Bushfire Season.

[3] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 74, Table 20

Item	AusNet Services forecast $ 2016 direct	RIS estimate[1] $2015 direct	Explanation
Equipment maintenance	13k	107k[4]	AusNet Services' equipment maintenance cost is lower than the RIS estimate.
Total	*68k*		

The table shows that a number of items were either not included in the RIS cost estimate, or were underestimated for the reasons noted in the table above. These variances reflect the level of understanding on the part of the government and the industry at the time the RIS was prepared.

The key areas of cost difference are zone substation works and network balancing. Additional zone substations works that were not included in the RIS estimate are:

- Neutral bus switchboard – required for effective year-round protection of the network, balancing bushfire risk reduction with network reliability requires multiple operating modes with differing earthing arrangements. A neutral bus switchboard facilitates these arrangements.
- REFCL control room – necessary as there is insufficient space in the existing control room and the inverter and secondary panels are larger than anticipated.
- REFCL backup protection and interface control systems – protection and control equipment must operate in several earthing fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Testing the REFCL – As part of the project commissioning it will be necessary to fully test the functionality of the REFCL ensuring that it is capable of operating to meet the Regulations. It involves the first instance of insulation and compliance testing to demonstrate the correct operation of the device and to comply with the ESV's reporting requirements.
- KLK network community engagement plan - required due to the number of outages forecast for the community and the new network insulation tests, which in the short term are expected to have an unfavourable reliability experience for customers.
- Land purchase – existing site does not have sufficient space to locate the REFCL technology, additional station service transformers and new switchgear.
- Existing 22kV switchgear replacement – the KLK 22 kV feeders are switched using ACRs. These ACRs, which are mounted on poles, are not fitted with sufficiently accurate measuring transformers. In addition, the configuration of the switchgear means that any testing on the transformer (which is necessary prior to REFCL commissioning) cannot be completed without disconnecting supply to all customers fed from the station.
- C-I-C

[4] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 74, Table 20

Additional network balancing works not included in the RIS estimate include:

- Work required to achieve the performance criteria in each automatic switching zone - involving a combination of additional works including, adding balancing capacitors, unbonding cable installations and adding a third phase conductor to balance each section. The RIS detailed phase rotations alone as the only network balancing cost, this will not achieve the required performance criteria of the Regulations.
- Works needed to maintain balance – including replacing fuses with solid links where fuse operation will lead to out of balance, potential non-compliance with the Regulations and possible REFCL mal operation.

As evidenced by the above table, AusNet Services has examined the cause of forecast expenditure differences to those presented in the RIS for the REFCL installation at KLK. The reconciliation to the Government's cost estimates provides further assurance that AusNet Services' cost forecasts are prudent and efficient.

It is also important to emphasise that the cost forecasts presented in this contingent project application reflect a detailed scope of work for each zone substation installation in accordance with the AER's 'trigger event' definition. As such, AusNet Services' forecasts are fully substantiated having regard to the actual conditions at each zone substation whereas the RIS estimate adopted a broader estimating approach that was unavoidably less comprehensive.

1.8 Why the proposed costs are efficient

This appendix has explained that:

- The proposed scope of station works at KLK is the lowest cost technically acceptable option for addressing the specific issues at KLK;
- Our proposed replacement of ACRs and surge arrestors is consistent with our strategies in relation to these assets, which adopt a prudent and efficient replacement approach;
- Our network balancing work is consistent with our strategy in relation to these works, which is focused on achieving the required capacitive balance at the lowest cost in each automatic switchable section of the 22kV network;
- We have considered non-network options and the substitution possibilities between capital and operating expenditure;
- We have employed our standard approach to project cost estimation;
- The key assumptions underpinning our forecasts are reasonable;
- We have identified the key risks in relation to the REFCL installation at KLK and taken appropriate risk mitigation measures; and
- Our projected costs are within the Government's estimated range in the RIS, and we have explained why they exceed the Government's average estimate.
- Our projected costs are within the Government's estimated range in the RIS. More importantly, we have reviewed our cost estimates on a line-by-line basis, explaining the reasons for any differences compared to the RIS estimates and highlighting gaps in the scope of work assumed in the RIS.

In addition, it should be noted that our forecast expenditure for the REFCL installation at KLK has been subject to our standard business case review and approval processes. The project will also be subject to our project management and governance arrangements.

For these reasons, we regard the forecast expenditure at KLK as prudent and efficient, in accordance with the Rules requirements relating to contingent projects.

1.9 Supporting documents

Supporting documents to be provided as part of this submission:

- REF 10-04 REFCL Program Equipment Building Block Functional Description;
- Operational Requirements ;
- REF 20-08 Automatic Circuit Recloser Strategy;
- REF 20-06 Network Balancing Strategy; and
- REF 20-07 Line Hardening Strategy.

Appendix 2 – Barnawartha Zone Substation REFCL Planning Report

2.1 Purpose

The purpose of this appendix is to demonstrate that the forecast capital expenditure and incremental operating expenditure to install the mandated REFCL technology at Barnawartha (BWA) zone substation are prudent and efficient. In doing so, this appendix highlights the specific issues at BWA zone substation that influence the design and cost of the REFCL installation at this location.

A number of supporting documents are listed in section 2.9, which provide further information on the strategies that underpin our forecast expenditure, and detail why these strategies and cost estimates are prudent and efficient. This appendix should therefore be read in conjunction with the supporting documents listed in section 2.9.

As explained in Chapter 1 of this contingent project application, the installation of REFCLs at selected zone substations is the only engineering solution that is capable of complying with the performance standards mandated by the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

BWA zone substation is located on the south-western outskirts of the Barnawartha township approximately 299km northeast of Melbourne. This small zone substation was established in 2005 and supplies the township and surrounding areas including Rutherglen and Indigo Valley. The station supplies 1,861 customers, including two High Voltage (HV) customers by means of one medium (20/33 MVA) transformer and four distribution feeders. The BWA 22kV feeders cover a total route length of 295km. The 22kV network includes 8 automatic switchable sections.

The estimated total capacitance of the BWA 22kV network is 51 (A) or 62 (A) including existing automatic transfer feeders.

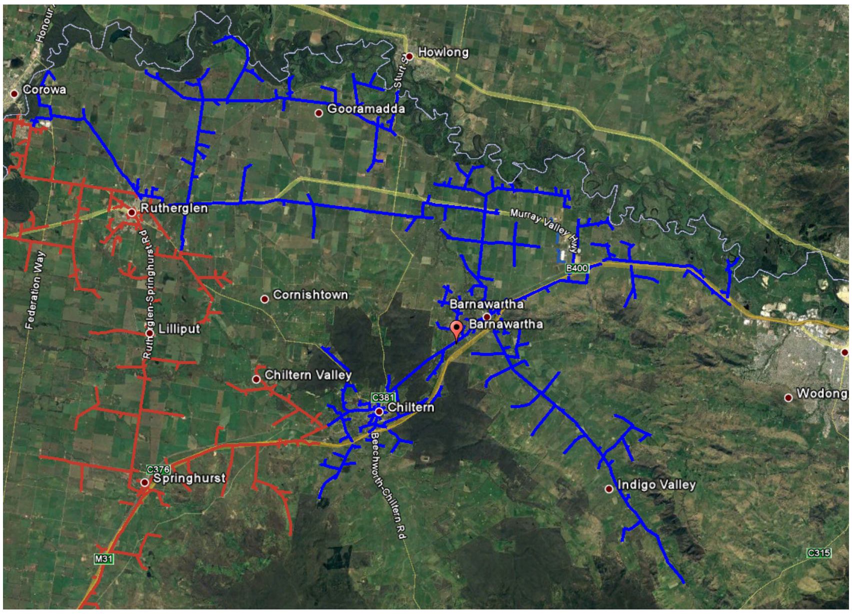

Figure 1-1: BWA 22kV feeders shown above in dark blue.

2.2 Key issues and challenges at BWA

The key issue impacting the installation of a REFCL at BWA is the lack of available physical space in the existing site control building. This control room is small with insufficient space for the REFCL protection, controls and required upgrade to battery supplies. Due to its size, the existing control room is unsuitable for reuse.

2.3 Scope of work

The scope of work to install a REFCL at BWA involves:

- Zone substation works;
- Compatible works, including replacement of an Automatic Circuit Recloser (ACR) installed on a BWA feeder;
- Network balancing;
- Line hardening, which requires the replacement of incompatible surge arrestors installed on feeders; and
- Victorian Electricity Distribution Code compliance, which requires the installation of 2 isolating transformer solutions at HV customer points of supply. As already noted, BWA serves 2 HV customers.

Each of these activities is discussed in turn below, as follows:

- Section 2.3.1 – Zone substation works; and
- Section 2.3.2 – Line works, which addresses the remaining four workstreams.

It should be noted that there are no line voltage regulators requiring upgrade on the BWA network.

2.3.1 Zone substation works and options analysis

The proposed REFCL installation at BWA will involve a number of activities that are common to most Tranche 1 zone substation REFCL installations. These include:

- Specification, procurement and installation of a Ground Fault Neutraliser (GFN), including an Arc Suppression Coil (ASC), Residual Current Compensation (RCC) and control system.
- Specification, procurement and installation of a neutral bus switchboard. The introduction of the GFN requires a neutral bus which enables different earthing arrangements to be automatically configured. The switchboard facilitates remote year round selection of earthing arrangements and operating modes. Provides the ability to balance bushfire risk reduction with network reliability, depending on network and weather conditions.
- Upgrade of the existing station service transformers and changeover boards. This work is required because the alternating current (AC) supply requirement dramatically increases due to the GFN installation. In BWA case this involves only one transformer as this is a single power transformer location.
- Testing and potential replacement of cable equipment which are at risk of failure if operated at elevated voltages.
- Replacement and extension of existing protection and control equipment with equipment capable of operating in several modes including resonant earthing and traditional earth fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.

- Prior to commissioning the GFN, network hardening tests involve the process of lifting voltages (using the GFN) in a healthy three phase powerline network (phase by phase) to check network readiness for future states of REFCL operation. During this activity there is an increased likelihood of asset failures. We would replace any assets that fail during the testing process. These tests are necessary to ensure the GFN can operate without causing line and station equipment to fail resulting in a fire start. These tests are conducted in times of low fire risk to mitigate the likelihood of failure in the Declared Bushfire Season.
- Installation of monitoring equipment to demonstrate compliance with regulations and enable remote engineering access to control systems.

Further information on these works is provided in the following supporting document:

- REF 10-04 REFCL Program Equipment Building Block Functional Description

The additional specific work required at BWA involves:

- Work associated with converting a rural zone substation into a station capable of operating with a REFCL. This required work includes civil foundations for neutral bus switchgear, battery room, station service transformer and REFCL equipment and earthing.
- Installing one standard control room to house REFCL associated protection, control, and indoor auto-changeover board.
- In relation to network hardening tests on the BWA 22 kV network prior to commissioning the GFN, our expectation is that there is a reasonable likelihood that some surge arrestors, insulators, pole top transformers and/or cables may fail and require replacement.
- Development and execution of a community engagement plan for works associated with the BWA network REFCL implementation. Community engagement is required to explain the likely customer reliability impact during the new network insulation tests. The importance of effective community engagement has been highlighted by the Woori Yallock REFCL implementation in September 2016, which led to issues being raised by customers, media, the community and the Victorian Parliament.

Before determining our preferred scope of work at BWA, we considered 3 planning options:

1. Install REFCL technology and 2 new buildings (battery and REFCL control rooms). In the battery room install Direct Current (DC) supplies with no contingency (our preferred option, as described above).
2. Same as Option 1, but extend the existing control room to cater for REFCL control room requirements.
3. Same as Option 1, but upgrade DC supplies in battery room to cater for a single contingency.

In developing these options, AusNet Services considered non-network options and substitution possibilities between operating and capital expenditure. In relation to the zone substation works, there were no identified non-network options or substitution possibilities, other than those inherent in the above options.

A summary of our analysis in relation to each of these options is shown in Table 1.

Table 1: Options evaluated

Option	Advantages	Disadvantages
1. Install REFCL and 2 new buildings (battery and REFCL control rooms). Install DC supplies in battery room with no contingency (preferred option).	New REFCL control building can be built without impacting customer supply. Makes maximum use of standard battery room design and thereby lowering lifetime costs and minimising time to implement the zone substation works. Least cost option at $3,752k.	All existing and new REFCL protection and control equipment not housed in one location. Non-standard DC supply in a rural location leading to more complex maintenance and training. This disadvantage is considered minimal as this arrangement is in line with the existing installation.
2. Same as Option 1, but extend the existing control room to cater for REFCL control room requirements.	All protection and control equipment housed in one location. By extending the existing control room building the available zone substation real estate is maximised for future augmentation works.	Complex construction as supply and protection must be maintained while control existing room is extended. Modifying existing control room is more complex than Option 1. Greater cost than Option 1 $3,786k.
3. Same as Option 1, but upgrade DC supplies in battery room to cater for a single contingency	Provides a duplicate DC supply to the BWA zone substation. Uses the standard DC supply for a rural location leading to less complex maintenance and training than Option 1.	Greater cost than Option 1 $3,841k.

It is evident from the above table that Option 1 is the appropriate planning solution because it has:

- Lower cost than Options 2 and 3;
- Reduced complexity and supply risks compared to Options 2; and
- Marginally higher supply risk than Option 3, but consistent with present day supply risk.

2.3.2 Line works

The scope of works outside the zone substation involves the following work on the BWA network:

- Replacement of 1 ACR on a BWA feeder;
- Balancing 8 automatic switching zones – this involves:
    - 22 sites where phases are rotated;
    - 1 site where the third phase of cable must be unbonded;

  - The installation of 1 single phase balancing capacitors and 9 three-phase balancing capacitors; and
  - The replacement of 8 fuse sites required to be replaced with solid links;
- Replacement of surge arresters at 180 sites distributed across the feeders; and
- Installation of 2 isolating transformer solutions at HV customer points of supply;

ACRs are currently used to detect 'downstream' faults and to interrupt supply to the faulted feeder section thereby minimising the number of customers who experience a supply interruption due to a fault. The existing ACRs are not capable of:

- detecting the low fault currents that will occur with REFCL operation; and
- identifying faults and the affected section of the feeder when earthing arrangements are altered at the zone substation (i.e. when the REFCL is switched onto the network). This inability leads to a larger number of customer being affected in the event of a sustained fault on a REFCL network and spurious tripping of ACRs on unaffected healthy feeders when the REFCL operates.

ACRs will therefore be upgraded or replaced so that they can detect low fault currents along with any changes to the earthing arrangement at the zone substation, this will ensure in the event of a fault customer outage numbers are minimised and healthy feeders are not tripped with REFCL operation.

Equally important as the ACR works is the capacitive balancing of the BWA 22kV network. Network capacitance must be balanced for REFCLs to operate. AusNet Services will undertake network balancing on each 'automated switching zone' where an automated switching zone is a feeder section delineated by ACRs, sectionalisers and/or circuit breakers. Balancing switching zones involves a combination of works including, phase transpositions, adding balancing capacitors, unbonding cable installations, removing fuses and adding a third phase conductor to balance each section. A combination of this work involving the least cost for each switching zone will be undertaken.

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA) involves a combination of ACR and sectionaliser operations plus the use of adjacent feeders to supply feeder sections downstream of a faulted section. This scheme is currently used to provide network reliability. DFA will only operate with REFCLs where each switching zone is capacitively balanced and ACR works are completed.

As well as network balancing works, type testing of surge arrestors has been undertaken to determine the types which cannot withstand the elevated voltages that result from REFCL operation. Failure of these types can lead to ground fire ignition and therefore their replacement is essential to prevent fire ignition during REFCL operation. A survey of the feeders has identified 180 sites with incompatible surge arrestors and these will be replaced with a standard surge arrestor with adequate ratings for REFCL operation.

The elevated voltages in the event of a single phase fault also raise compliance issues in relation to the Victorian Electricity Distribution Code. In particular, clause 4.2.2 of the Code sets out the maximum permissible variation in nominal voltages at the point of supply to each HV customer's electrical installation. AusNet Services must install 2 isolating transformers at BWA to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.

In scoping the above line works, AusNet Services has considered whether there are any non-network options or substitution possibilities between operating and capital expenditure. The nature of the required works at BWA is such that there are no non-network options or opportunities to substitute operating activities for the proposed capital works.

Further detail on the need for replacement and/or upgrade of ACRs, network balancing and surge arrester replacement is available in:

- REF 20-08 Automatic Circuit Recloser Strategy
- REF 20-06 Network Balancing Strategy
- REF 20-07 Line Hardening Strategy

2.3.3 Operational costs

In addition to the capital works described above, incremental ongoing operational costs will result from REFCL installation. Operational costs not specific to this site location are contained in the Operational Expenditure Requirements - Tranche 1 (REF 70-10) document. Operational costs that are either specific to BWA or vary by zone substation include:

- A number of new or expanded devices will be installed at BWA as a result of the REFCL installation including REFCL equipment, auto-changeover board, station services and line balancing capacitor units. As these items are new they are unlikely to require material additional maintenance, however they will require routine inspection.
- Prior to each fire season it will be necessary to fully test the functionality of the REFCL to ensure that it is capable of operating to meet the Regulations. This will involve annual insulation and compliance tests to demonstrate the correct operation of the device together with ESV reporting.

Table 2: Forecast incremental operational costs

Activity	Frequency	Calendar Year Cost $		
		18	19	20
Maintain additional equipment	Annual	3,154	3,154	3,154
Pre fire season testing (insulation and compliance testing)	Annual	27,742	27,742	27,742

2.4 Key assumptions, risks and mitigation strategies

The key assumptions and risks made in forecasting the cost of REFCL installation at BWA are shown in Table 3 below.

Table 3: Key assumptions, risks and mitigation strategies

Assumption or Risk	Impact	Mitigation
Customers adversely affected by outages due to failure of equipment operating at higher than design voltages.	Extended customer outages e.g. cable failures. S-factor & GSL impacts.	Assets which are not compatible with REFCL such as surge arrestors and ACRs replaced prior to testing. Critical cables tested. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the BWA network.

Assumption or Risk	Impact	Mitigation
Customers adversely react to the number of outages required to deliver the REFCL works on the BWA network.	Repeat customer outages lead to increased customer costs and community frustration e.g. outages for line work, and station and REFCL testing works.	Where possible, the co-ordination of work outages to minimise impact on the community.
High Voltage (HV) customer (s) adversely affected by outages due to failure of their equipment operating at higher than design voltages.	Extended outage or safety incident for HV customer, caused by underrated equipment failures. Loss of production and potential health and/or safety impacts. AusNet Services would need to undertake substantial work with each HV customer to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes. A change to the Distribution Code would also be required.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customer's point of supply complies with this Code provision and meets the mandated timeframe.
Operation of the REFCL would lead to voltage levels that are outside the allowable range specified in the Victorian Electricity Distribution Code (the Code).	Unless the Code is changed, operation of the REFCL would lead to non-compliance with our obligations. The Essential Services Commission has made it clear that it does not intend to amend the Victorian Distribution Code to address the voltage variation issue[1].	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.

[1] Essential Services Commission, Electricity Distribution Code Compliance and REFCLs, letter to Hannah Williams, Powercor, dated 7 February 2017.

Assumption or Risk	Impact	Mitigation
Scope of HV customer works and funding mechanism unclear.	Delays in a suitable funding mechanism and/or work completion for HV customers could delay the project resulting in additional costs and fines due to project delays and failure to have the REFCL in service ahead of the 2017/18 fire season, and April 2019 compliance date. AusNet Services would need to undertake substantial work with HV customers to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision and meets the mandated timeframe.
Proximity to live assets during construction.	The project involves brownfield works to be carried out in the midst of an in-service zone substation. This will result in risk associated with the close proximity of live overhead and underground assets to employees, contractors and mobile plant.	Access permit conditions will clearly specify the requirements to ensure safety whilst work is being carried out in the station. Controls will be required for site induction and earth potential rise under fault conditions.
Sole supplier delivers GFN product to required standard.	Failure to have the GFN operating by 30 April 2019 will incur a one off civil penalty of $6M, and a fine of $5,500 for each day the criteria is not met after that date.	Develop and monitor strategic spares for the GFN product. Engage and invest in the relationship with GFN supplier. Seek an alternative REFCL supplier that can meet performance criteria of the Regulations. BWA costing has no allowance for sole supplier risk.

Assumption or Risk	Impact	Mitigation
BWA network can be capacitively balanced, achieving the performance required under the Regulations.	Accurate network balance is essential if the performance criteria are to be met. To date these criteria have been achieved in one instance on a 40km network at Kilmore South. Failure to meet the performance criteria by 30 April 2019 will incur a one off civil penalty of $6M, and a fine of $5,500 for each day the criteria is not met after that date.	Extensive survey, design and modelling work is required. Works must ensure all material capacitive imbalances are addressed on the BWA network.

2.5 Total costs for BWA Zone Substation

The total forecast costs to install a REFCL at BWA are shown in Table 4

Table 4: Forecast costs

Item	**Cost** $000s 2016 direct
Capex	
Zone substation works, network hardening testing (elevated voltage testing) and REFCL commissioning	3,752
Replacement of 1 ACR that is not capable of detecting low fault currents or automatically blocking conventional earth protection during REFCL operation.	63
Network balancing – Rotating phases, unbonding cable at a single location, installing single and three phase capacitors and replacing fuses with solid links.	851
Replacement of 471 units at 180 surge arrestors sites that present a risk of failure (and fire ignition) during REFCL operation	443
Total	*5,109*
Code compliance - the installation of 2 isolating transformer solutions to ensure that AusNet Services maintains compliance with the maximum permissible voltage variations specified in the Victorian Distribution Code.	2,361
Opex	
Pre fire season testing including insulation and compliance testing.	83
Equipment maintenance.	9
Total	*93*

The capex costs have been prepared using AusNet Services' standard project cost estimating approach. The capital costs associated with zone substation equipment installation, replacement of an ACR and replacement of surge arrestors are reasonably certain. i.e. they carry the same level of uncertainty as routine projects such as zone substation construction or rebuilds.

The total capex cost at BWA is lower than other tranche one zone substations. This is driven by a range of factors as described above. These include:

- BWA is a relatively small network with a lower number of customers. This is reflected in the reduced costs for surge arrestors and ACR replacements when compared to other tranche one zone substations.
- BWA has a small number (8) of automatic switchable sections that must be balanced. This is reflected in reduced costs for network balancing when compared to other zone substations within tranche one.
- BWA has negligible land constraints and existing 22kV equipment is relative new and electrically capable sustaining REFCL operation.

Uncertainties in forecast capital costs primarily arise from performance of the REFCL, the extent of network balancing required and community reaction to the installation and testing works. An allowance of $45,970 has been included in the zone substation works for network insulation testing activities. This cost is based on 2 days to complete this activity, anticipating 1 fault per day of testing. Each fault has been attributed a cost of $5,467 using established contractor rates. Based on insulation testing carried out to date, it is reasonably likely that cables/joints and surge arrestors will fail at this elevated voltage testing.

2.6 Addressing reliability degradation

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA), has played an important role in delivering current levels of reliability. It involves a combination of ACRs, Remote Control Gas Switches and feeder management relay operations, together with the use of adjacent feeders, to supply feeder sections downstream of a faulted section. This scheme is specific to AusNet Services and reflects an important difference between our network and that of Powercor Australia.

However, the current DFA algorithms are all based on a conventional Resistance Earthed System network, and are incompatible with the required change to a Resonant Earthed System network as REFCLs are installed. As a consequence, without an upgrade to the algorithms (DFA2), the reliability outcomes on completion of each REFCL installation will degrade significantly.

AusNet Services' cost benefit analysis demonstrates that the costs of allowing a degradation in reliability significantly outweigh the costs of DFA2 and, therefore, the expenditure is justified in terms of economic efficiency. Furthermore, customers would be concerned if reliability degraded following the significant investment in REFCL technology, especially during periods of extreme heat.

The costs of DFA2 are not specific to each zone substation. Therefore, the costs are not included in this planning report, but are set out in the main body of the contingent project application.

2.7 Cost comparison with the Government's estimate in the RIS

To demonstrate the efficiency and prudency of our proposed expenditure, we must have regard to available benchmark information. In this instance, industry benchmarking is not available because the application of this technology for fire mitigation purposes is a world's first. In addition, the costs of installation are site-specific – which means that there is a potentially wide range of efficient and prudent installation costs across zone substations.

Despite these limitations, we note that the Regulatory Impact Statement (RIS) prepared by ACIL ALLEN for the Victorian Government in 2015 estimated costs for the REFCL installation program. The cost estimates were an important component of the RIS assessment, which considered the costs and benefits of introducing the bushfire mitigation regulations.

We note that ACIL ALLEN's cost estimates were prepared in 2015. Since then, we have developed location specific scopes of work, which have also been informed by experience gained at the REFCL installation at Woori Yallock zone substation. For these reasons, we have substantially more confidence in our cost estimates for BWA compared to the earlier ACIL ALLEN estimates, which were developed for a different purpose and which no longer reflect the best available information.

The table below provides a detailed explanation of the differences between our forecasts and ACIL ALLEN's estimates in the RIS. For some line items, the RIS did not provide a specific estimate for each zone substation. In these cases, we have presented the volume range set out in the RIS and commented on whether our forecast falls within this range.

Table 5: Reconciliation of AusNet Services' cost forecasts at BWA with the RIS cost estimates

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
Capex			
Zone substation works	3,752k	1,800 – 4,895k[3] Including - REFCL, design, civil works, installation and commissioning; - Station lighting arrestors; -Station service transformers; -Station services low voltage transfer switch; and - Capacitor banks.	AusNet Services' zone substation works include the following additional items which were not included in the RIS estimate: neutral bus switchboard; REFCL control room; REFCL backup protection and interface control systems; REFCL testing including to prescribed requirements; and a community engagement plan.
ACRs replacement	1 unit replacements @ cost of $63.2k per unit, producing a cost of $63.2k.	RIS only provided an estimated volume range of 0-18 for each zone substation @ cost of $70k per unit, producing a cost estimate between $0 and $1,260k per zone substation.	AusNet Services' ACR replacement unit cost is lower than the RIS estimate.

[2] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, 74 & 75. It should be noted that the RIS costs are expressed in $2015 while our costs are expressed in $2016. Strictly speaking, for comparison purposes the RIS costs are approximately 1.5 per cent higher than indicated here.

[3] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, Table 14 includes zone substation components.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
Network balancing	851k (see scope of work in 'explanation column')	RIS only provided an estimated volume range for conductor phase movements. Anticipated 0-85 for each zone substation @ cost of $4k per unit, producing a cost estimate between $0 and $340k per zone substation.	Significant increase in the scope and cost post the learnings of the WYK REFCL commissioning. This has led to an increased understanding of the least cost mix work required to meet and maintain the prescribed sensitivity criteria in the Regulations. Field works required to meet the criteria which is world first involve: - 22 sites where conductor phase movements are required; - 1 sites where third phase conductor is required to be unbonded; - Installation of 1 single phase balancing capacitors and 9 three phase balancing capacitors; and - 8 expected sites where fuses are required to be removed and replaced with solid links.
Surge arrestors	471 unit replacements @ cost of $0.94k per unit, producing a cost of $443k.	RIS only provided an estimated volume range of 0-8,224 units for each zone substation @ cost of $1k per unit, producing a cost estimate between $0 and $8,224k per zone substation.	AusNet Services approach is to replace the 40% of surge arrestors that sample testing has determined will not operate satisfactorily at elevated voltages. Cost forecast is lower than the average of the RIS estimate. 180 surge arrestor sites requiring replacement at $2,460 each, (equates to 471 surge arrestors units at $940 each).
Voltage regulators	-	-	-
Total	*5,109k*	*3,421[4]k*	The RIS estimate is specific to this zone substation, even though only cost ranges are provided in relation to the cost build up. The BWA total cost is higher than the RIS estimate for the reasons set out above. See further discussion below this table.
Code compliance	2,361k	164k[5]	Two HV customers and two points of supply served from the BWA 22kV network.
Opex			
Pre fire season testing	83k	-	Not costed in the RIS estimate. Required to ensure the BWA network is operating to the prescribed criteria of the Regulations and vulnerabilities to overvoltage on the BWA network are exposed prior to the Declared Bushfire Season.
Equipment maintenance	9k	92k[6]	AusNet Services' equipment maintenance cost is lower than the RIS estimate.
Total	*93k*		

[4] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 74, Table 20

[5] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 74, Table 20

[6] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 74, Table 20

The table shows that a number of items were either not included in the RIS cost estimate, or were underestimated for the reasons noted in the table above. These variances reflect the level of understanding on the part of the government and the industry at the time the RIS was prepared.

The key areas of cost difference are zone substation works and network balancing. Additional zone substations works that were not included in the RIS estimate are:

- Neutral bus switchboard – required for effective year-round protection of the network, balancing bushfire risk reduction with network reliability requires multiple operating modes with differing earthing arrangements. A neutral bus switchboard facilitates these arrangements.
- REFCL control room – necessary as there is insufficient space in the existing control room and the inverter and secondary panels are larger than anticipated.
- REFCL backup protection and interface control systems – protection and control equipment must operate in several earthing fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Testing the REFCL – As part of the project commissioning it will be necessary to fully test the functionality of the REFCL ensuring that it is capable of operating to meet the Regulations. It involves the first instance of insulation and compliance testing to demonstrate the correct operation of the device and to comply with the ESV's reporting requirements.
- Community engagement plan - required due to the number of outages forecast for the community and the new network insulation tests, which in the short term are expected to have an unfavourable reliability experience for customers.

Additional network balancing works not included in the RIS estimate include:

- Work required to achieve the performance criteria in each automatic switching zone - involving a combination of additional works including, adding balancing capacitors, unbonding cable installations and adding a third phase conductor to balance each section. The RIS detailed phase rotations alone as the only network balancing cost, this will not achieve the required performance criteria of the Regulations.
- Works needed to maintain balance – including replacing fuses with solid links where fuse operation will lead to out of balance, potential non-compliance with the Regulations and possible REFCL mal operation.

As evidenced by the above table, AusNet Services has examined the cause of forecast expenditure differences to those presented in the RIS for the REFCL installation at BWA. The reconciliation to the Government's cost estimates provides further assurance that AusNet Services' cost forecasts are prudent and efficient.

It is also important to emphasise that the cost forecasts presented in this contingent project application reflect a detailed scope of work for each zone substation installation in accordance with the AER's 'trigger event' definition. As such, AusNet Services' forecasts are fully substantiated having regard to the actual conditions at each zone substation whereas the RIS estimate adopted a broader estimating approach that was unavoidably less comprehensive.

2.8 Why the proposed costs are efficient

This appendix has explained that:

- The proposed scope of station works at BWA is the lowest cost option for addressing the specific issues at BWA;

- Our proposed replacement of a ACR and surge arrestors is consistent with our strategies in relation to these assets, which adopt a prudent and efficient replacement approach;
- Our network balancing work is consistent with our strategy in relation to these works, which is focused on achieving the required capacitive balance at the lowest cost in each automatic switchable section of the 22kV network;
- We have considered non-network options and the substitution possibilities between capital and operating expenditure;
- We have employed our standard approach to project cost estimation;
- The key assumptions underpinning our forecasts are reasonable;
- We have identified the key risks in relation to the REFCL installation at BWA and taken appropriate risk mitigation measures; and
- Our projected costs are within the Government's estimated range in the RIS. More importantly, we have reviewed our cost estimates on a line-by-line basis, explaining the reasons for any differences compared to the RIS estimates and highlighting gaps in the scope of work assumed in the RIS.

In addition, it should be noted that our forecast expenditure for the REFCL installation at BWA has been subject to our standard business case review and approval processes. The project will also be subject to our project management and governance arrangements.

For these reasons, we regard the forecast expenditure at BWA as prudent and efficient, in accordance with the Rules requirements relating to contingent projects.

2.9 Supporting documents

Supporting documents to be provided as part of this submission:

- REF 10-04 REFCL Program Equipment Building Block Functional Description;
- Operational Requirements;
- REF 20-08 Automatic Circuit Recloser Strategy;
- REF 20-06 Network Balancing Strategy; and
- REF 20-07 Line Hardening Strategy.

Appendix 3 – Rubicon A Zone Substation REFCL Planning Report

3.1 Purpose

The purpose of this appendix is to demonstrate that the forecast capital expenditure and incremental operating expenditure to install the mandated REFCL technology at Rubicon A (RUBA) zone substation are prudent and efficient. In doing so, this appendix highlights the specific issues at RUBA zone substation that influence the design and cost of the REFCL installation at this location.

A number of supporting documents are listed in section 3.9, which provide further information on the strategies that underpin our forecast expenditure, and detail why these strategies and cost estimates are prudent and efficient. This appendix should therefore be read in conjunction with the supporting documents listed in section 3.9.

As explained in Chapter 1 of this contingent project application, the installation of REFCLs at selected zone substations is the only engineering solution that is capable of complying with the performance standards mandated by the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

RUBA zone substation is located in the township of Rubicon approximately 100km northeast of Melbourne. This zone substation was established in the 1930s and supplies the township and surrounding areas including Eildon, Alexandra and Marysville. The station supplies 4,883 customers, including two High Voltage (HV) customers by means of two medium (15/20 MVA) transformers and three distribution feeders. The RUBA 22kV feeders cover a total route length of 514km. The 22kV network includes 20 automatic switchable sections.

The estimated total capacitance of the RUBA 22kV network is forecast to be 69 (A) or 80 (A) including existing automatic transfer feeders.

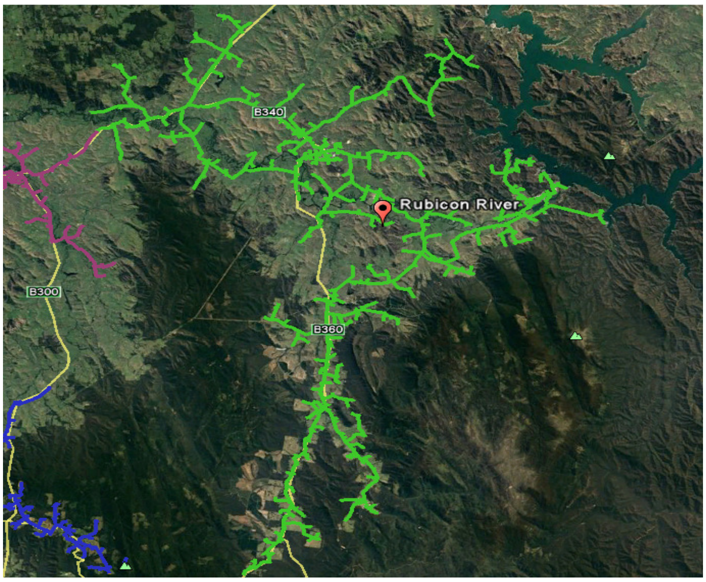

Figure 1-1: RUBA 22kV feeders shown above in green.

3.2 Key issues and challenges at RUBA

The key issues impacting the installation of a REFCL at RUBA is the lack of available physical space at the site's 22kV control room, rating of the existing station capacitor bank and the availability of physical space within the zone substation yard.

The existing 22kV control room is a relatively new modular containerised solution installed in 2014. It is however, compact with insufficient space for addition of REFCL protection and control equipment. Due to the control rooms size it is unsuitable for reuse.

The RUBA zone substation does have another building, used in the mid 1900's as the original control building for the Rubicon power station. This building can be modified to house the new REFCL protection and control equipment. The building will require the removal of asbestos and other redundant equipment before it can be utilised for this purpose.

RUBA zone substation has one 22kV capacitor bank. The capacitor bank must be modified as the existing capacitor cans are not rated for REFCL operating voltages. The consequence of not modifying the capacitor cans means REFCL operation will lead to equipment failure and possible fire at the zone substation.

The zone substation yard electrical layout at RUBA presents further space availability challenges. The 66kV bus surrounds the only useable space within the yard. This space is earmarked to be used for the new REFCL and associated new station service supplies. This installation of equipment into the yard must be constructed with the northern and western sections of the 66kV bus de-energised. This will place the RUBA zone substation on a single contingency during stages of the construction.

3.3 Scope of work

The scope of work to install a REFCL at RUBA involves:

- Zone substation works;
- Compatible works, including:
  - ➢ replacement of 6 Automatic Circuit Reclosers (ACRs) installed on a RUBA feeder; and
  - ➢ upgrade of 1 line voltage regulator on a RUBA feeder.
- Network balancing; and
- Line hardening, which requires the replacement of incompatible surge arrestors installed on feeders; and
- Victorian Electricity Distribution Code compliance, which requires the installation of 3 isolating transformer solutions at HV customer points of supply. As already noted, RUBA serves 2 HV customers, via 3 points of supply.

Each of these activities is discussed in turn below, as follows:

- Section 3.3.1 – Zone substation works; and
- Section 3.3.2 – Line works, which addresses the remaining four work streams.

3.3.1 Zone substation works and options analysis

The proposed REFCL installation at RUBA will involve a number of activities that are common to most Tranche 1 zone substation REFCL installations. These include:

- Specification, procurement and installation of a Ground Fault Neutraliser (GFN), including an Arc Suppression Coil (ASC), Residual Current Compensation (RCC) and control system.
- Specification, procurement and installation of a neutral bus switchboard. The introduction of the GFN requires a neutral bus which enables different earthing arrangements to be automatically configured. The switchboard facilitates remote year round selection of earthing arrangements and operating modes. Provides the ability to balance bushfire risk reduction with network reliability, depending on network and weather conditions.

- Upgrade of the existing station service transformers and changeover boards. This work is required because the alternating current (AC) supply requirement dramatically increases due to the GFN installation.
- Testing and potential replacement of cable equipment which are at risk of failure if operated at elevated voltages.
- Replacement and extension of existing protection and control equipment with equipment capable of operating in several modes including resonant earthing and traditional earth fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Prior to commissioning the GFN, network hardening tests involve the process of lifting voltages (using the GFN) in a healthy three phase powerline network (phase by phase) to check network readiness for future states of REFCL operation. During this activity there is an increased likelihood of asset failures. We would replace any assets that fail during the testing process. These tests are necessary to ensure the GFN can operate without causing line and station equipment to fail resulting in a fire start. These tests are conducted in times of low fire risk to mitigate the likelihood of failure in the Declared Bushfire Season.
- Installation of monitoring equipment to demonstrate compliance with regulations and enable remote engineering access to control systems.

Further information on these works is provided in the following supporting document:

- REF 10-04 REFCL Program Equipment Building Block Functional Description

The additional specific work required at RUBA involves:

- Work associated with converting the rural zone substation into a station capable of operating with a REFCL. This required work includes civil foundations for the new neutral bus switchgear, station service transformers and REFCL equipment and earthing.
- Replacement of the existing cap cans within the 22kV station capacitor bank. This work is required as the existing capacitor cans are not rated for the elevated voltages of REFCL operation.
- Modification of the historical power station control room into a building suitable for housing protection and control equipment.
- In relation to network hardening tests on the RUBA 22 kV network prior to commissioning the GFN, our expectation is that there is a reasonable likelihood that some surge arrestors, insulators, pole top transformers and/or cables may fail and require replacement.
- Development and execution of a community engagement plan for works associated with the RUBA network REFCL implementation. Community engagement is required to explain the likely customer reliability impact during the new network insulation tests. The importance of effective community engagement has been highlighted by the Woori Yallock REFCL implementation in September 2016, which led to issues being raised by customers, media, the community and the Victorian Parliament.

Before determining our preferred scope of work at RUBA, we considered 3 planning options:

1. Install REFCL technology and associated equipment. Utilise the historic power station control room for housing REFCL protection and control equipment. De-energise the overhead north and west ends of the existing 66kV bus during some stages of the installation of REFCL and associated equipment (our preferred option, as described above).

2. Same as Option 1, but install a new modular building for the REFCL protection and control equipment.
3. Same as Option 1, but re-arrange the 66kV bus to enable ease of access for operation and maintenance of the REFCL and associated equipment.

In developing these options, AusNet Services considered non-network options and substitution possibilities between operating and capital expenditure. In relation to the zone substation works, there were no identified non-network options or substitution possibilities, other than those inherent in the above options.

A summary of our analysis in relation to each of these options is shown in Table 1.

Table 1: Options evaluated

Option	Advantages	Disadvantages
1. Install REFCL technology and associated equipment. Utilise the historic power station control room for protection and control equipment. De-energise the overhead partial sections of the 66kV bus during some stages of the installation (our preferred option, as described above).	Utilises an existing building at the zone substation. Least cost option at $4,187k.	Complex REFCL and equipment installation. Future maintenance of the REFCL may require the 66kV bus to be de-energised in part.
2. Same as Option 1, but install a new modular building for the REFCL protection and control equipment.	New REFCL control building can be built without impacting customer supply. No modifications required to the existing buildings at site.	Complex REFCL and equipment installation. Future maintenance of the REFCL may require the 66kV bus to be de-energised in part. Additional adjacent land required to be purchased to allow new building. Land availability adjacent to the property is limited and acquiring it would be costly. More expensive than the Option 1, with additional land and building costs. Option costed at $4,305k without cost for land and establishment works.
3. Same as Option 1, but re-arrange the 66kV bus to enable ease of access for operation and maintenance of the REFCL and associated equipment.	Simplifies the installation of REFCL and station service transformers. 66kV supply to RUBA can remain unaffected for construction and future maintenance works.	More complex design and construction. Involving 66kV equipment. Greater cost than Option 1 $4,742k.

It is evident from the above table that Option 1 is the appropriate planning solution because it has:

- Lower cost than Options 2 and 3; and

- Reduced complexity compared to Option 2 and 3.

3.3.2 Line works

The scope of works outside the zone substation involves the following work on the RUBA network:

- Replacement of 6 Automatic Circuit Reclosers (ACRs) installed on RUBA feeders;
- Balancing 20 automatic switching zones – this involves:
    - 62 sites where phases are rotated;
    - The installation of 5 single phase balancing capacitors and 13 three-phase balancing capacitors; and
    - The replacement of 20 fuse sites required to be replaced with solid links.;
- Replacement of surge arresters at 651 sites distributed across the feeders;
- Upgrade of 1 line voltage regulator; and
- Installation of 3 isolating transformer solutions at HV customer points of supply.

ACRs are currently used to detect 'downstream' faults and to interrupt supply to the faulted feeder section thereby minimising the number of customers who experience a supply interruption due to a fault. The existing ACRs are not capable of:

- detecting the low fault currents that will occur with REFCL operation; and
- identifying faults and the affected section of the feeder when earthing arrangements are altered at the zone substation (i.e. when the REFCL is switched onto the network). This inability leads to a larger number of customers being affected in the event of a sustained fault on a REFCL network and spurious tripping of ACRs on unaffected healthy feeders when the REFCL operates.

ACRs will therefore be upgraded or replaced so that they can detect low fault currents along with any changes to the earthing arrangement at the zone substation, this will ensure in the event of a fault customer outage numbers are minimised and healthy feeders are not tripped with REFCL operation.

Equally important as the ACR works is the capacitive balancing of the RUBA 22kV network. Network capacitance must be balanced for REFCLs to operate. AusNet Services will undertake network balancing on each 'automated switching zone' where an automated switching zone is a feeder section delineated by ACRs, sectionalisers and/or circuit breakers. Balancing switching zones involves a combination of works including, phase transpositions, adding balancing capacitors, unbonding cable installations, removing fuses and adding a third phase conductor to balance each section. A combination of this work involving the least cost for each switching zone will be undertaken.

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA) involves a combination of ACR and sectionaliser operations plus the use of adjacent feeders to supply feeder sections downstream of a faulted section. This scheme is currently used to provide network reliability. DFA will only operate with REFCLs where each switching zone is capacitively balanced and ACR works are completed.

As well as network balancing works, type testing of surge arrestors has been undertaken to determine the types which cannot withstand the elevated voltages that result from REFCL operation. Failure of these types can lead to ground fire ignition and therefore their replacement is essential to prevent fire ignition during REFCL operation. A survey of the feeders has identified 651 sites with incompatible surge arrestors and these will be replaced with a standard surge arrestor with adequate ratings for REFCL operation.

Also, line voltage regulators (typically open delta configuration) have been the lowest cost option to regulate voltage on 22kV long rural feeders. Unfortunately they are not compatible with REFCL technology as they displace the system neutral voltage by regulating only two phases (line-to-line voltages), rather than regulating all three phases. As a result these regulators will need to be replaced on REFCL affected feeders.

Separately, all line voltage regulators with two phase controllers will need to be upgraded to a three phase controller ensuring voltages across all three 22kV phases remains consistent and voltage variations between the phases is avoided.

The elevated voltages in the event of a single phase fault also raise compliance issues in relation to the Victorian Electricity Distribution Code. In particular, clause 4.2.2 of the Code sets out the maximum permissible variation in nominal voltages at the point of supply to each HV customer's electrical installation. AusNet Services must install 3 isolating transformers at RUBA to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.

In scoping the above line works, AusNet Services has considered whether there are any non-network options or substitution possibilities between operating and capital expenditure. The nature of the required works at RUBA is such that there are no non-network options or opportunities to substitute operating activities for the proposed capital works.

Further detail on the need for replacement and/or upgrade of ACRs, network balancing, surge arrester replacement and replacement and/or upgrade of line voltage regulators is available in:

- REF 20-08 Automatic Circuit Recloser Strategy
- REF 20-06 Network Balancing Strategy
- REF 20-07 Line Hardening Strategy
- REF 20-09 Line Voltage Regulator Strategy

3.3.3 Operational costs

In addition to the capital works described above, incremental ongoing operational costs will result from REFCL installation. Operational costs not specific to this site location are contained in the Operation Expenditure Requirements - Tranche 1 (REF 70-10) document. Operational costs that are either specific to RUBA or vary by zone substation include:

- A number of new or expanded devices will be installed at RUBA as a result of the REFCL installation including REFCL equipment, auto-changeover board, station services and line balancing capacitor units. As these items are new they are unlikely to require material additional maintenance however they will require routine inspection.
- Prior to each fire season it will be necessary to fully test the functionality of the REFCL to ensure that it is capable of operating to meet the Regulations. This will involve annual insulation and compliance tests to demonstrate the correct operation of the device together with ESV reporting.

Table 2: Forecast incremental operational costs

Activity	Frequency	Calendar Year Cost $		
		18	19	20
Maintain additional equipment	Annual	3,154	3,154	3,154
Pre fire season testing (insulation and compliance testing)	Annual	27,742	27,742	27,742

3.4 Key assumptions, risks and mitigation strategies

The key assumptions and risks made in forecasting the cost of REFCL installation at RUBA are shown in Table below.

Table 3: Key assumptions, risks and mitigation strategies

Assumption or Risk	Impact	Mitigation
Customers adversely affected by outages due to failure of equipment operating at higher than design voltages.	Extended customer outages e.g. cable failures. S-factor & GSL impacts.	Assets which are not compatible with REFCL such as surge arrestors and ACRs replaced prior to testing. Critical cables tested. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the RUBA network.
Customers adversely react to the number of outages required to deliver the REFCL works on the RUBA network.	Repeat customer outages lead to increased customer costs and community frustration e.g. outages for line work, and station and REFCL testing works.	Where possible, the co-ordination of work outages to minimise impact on the community.
High Voltage (HV) customer (s) adversely affected by outages due to failure of their equipment operating at higher than design voltages.	Extended outage or safety incident for HV customer e.g. underrated equipment failures. Loss of production and potential health and/or safety impact. AusNet Services would need to undertake substantial work with HV customer to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes. A change to the Distribution Code would also be required.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customer's point of supply complies with this Code provision and meets the mandated timeframe.

Assumption or Risk	Impact	Mitigation
Operation of the REFCL would lead to voltage levels that are outside the allowable range specified in the Victorian Electricity Distribution Code (the Code).	Unless the Code is changed, operation of the REFCL would lead to non-compliance with our obligations. The Essential Services Commission has made it clear that it does not intend to amend the Victorian Distribution Code to address the voltage variation issue[1].	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.
Scope of HV customer works and funding mechanism unclear.	Delays in a suitable funding mechanism and/or work completion for HV customers could delay the project resulting in additional costs and fines due to project delays and failure to have the REFCL in service ahead of the 2017/18 fire season, and April 2019 compliance date. AusNet Services would need to undertake substantial work with HV customers to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision and meets the mandated timeframe.
Proximity to live assets during construction.	The project involves brownfield works to be carried out in the midst of an in-service zone substation. This will result in risk associated with the close proximity of live overhead and underground assets to employees, contractors and mobile plant.	Access permit conditions will clearly specify the requirements to ensure safety whilst work is being carried out in the station. Controls will be required for site induction and earth potential rise under fault conditions.

1 Essential Services Commission, Electricity Distribution Code Compliance and REFCLs, letter to Hannah Williams, Powercor, dated 7 February 2017.

Assumption or Risk	Impact	Mitigation
Sole supplier delivers GFN product to required standard.	Failure to have the GFN operating by 30 April 2019 will incur a one off civil penalty of $8M, and a fine of $5,500 for each day the criteria is not met after that date.	Develop and monitor strategic spares for the GFN product. Engage and invest in the relationship with GFN supplier. Seek an alternative REFCL supplier that can meet performance criteria of the Regulations. RUBA costing has no allowance for sole supplier risk.
RUBA network can be capacitively balanced, achieving the performance required under the Regulations.	Accurate network balance is essential if the performance criteria are to be met. To date these criteria have been achieved in one instance on a 20km network at Kilmore South. Failure to meet the performance criteria by 30 April 2019 will incur a one off civil penalty of $8M, and a fine of $5,500 for each day the criteria is not met after that date.	Extensive survey, design and modelling work is required. Works must ensure all material capacitive imbalances are accounted for on the RUBA network.

3.5 Total costs for RUBA Zone Substation

The total forecast costs to install a REFCL at RUBA are shown in Table 4.

Table 4: Forecast costs

Item	**Cost** $000s 2016 direct
Capex	
Zone substation works, network insulation testing (elevated voltage testing) and REFCL commissioning.	4,187
Replacement of 6 ACRs that are not capable of detecting low fault currents or automatically blocking conventional earth protection during REFCL operation.	379
Network balancing – Rotating phases, installing single and three phase capacitors and replacing fuses with solid links.	1,470
Replacement of 1,705 units at 651 surge arrestor sites that present a risk of failure (and fire ignition) during REFCL operation.	1,602
Upgrade of 1 line voltage regulator not compatible with REFCL operation.	47
Total	*7,685*

Item	Cost $000s 2016 direct
Code compliance - the installation 3 isolating transformer solutions (2 customers – three points of supply) to ensure that AusNet Services maintains compliance with the maximum permissible voltage variations specified in the Victorian Distribution Code.	3,541
Opex	
Pre fire season testing including insulation and compliance testing.	55
Equipment maintenance.	6
Total	*101*

The capex costs have been prepared using AusNet Services' standard project cost estimating approach. The capital costs associated with zone substation equipment installation, replacement of an ACR and replacement of surge arrestors are reasonably certain. i.e. they carry the same level of uncertainty as routine projects such as zone substation construction or rebuilds.

The total capex cost at RUBA is lower than the average of the other tranche one zone substations driven by a range of factors as described above. These include:

- RUBA is a relatively small network with a lower number of customers. This is reflected in the reduced costs for surge arrestors and ACR replacements when compared to other tranche one zone substations such as Seymour, Wangaratta and Wonthaggi.
- RUBA has small number (20) of automatic switchable sections that require to be balanced. This is reflective in reduced costs for network balancing when compared to Seymour, Wangaratta and Wonthaggi.

Uncertainties in forecast capital costs primarily arise from performance of the REFCL, the extent of network balancing required and community reaction to the installation and testing works. An allowance of $34,477 has been included in the zone substation works for network insulation testing activities. This cost is based on 1.5 days to complete this activity, anticipating 1 fault per day of testing. Each fault has been attributed a cost of $5,467 using established contractor rates. Based on insulation testing carried out to date, it is reasonably likely that cables/joints and surge arrestors will fail at this elevated voltage testing.

3.6 Addressing reliability degradation

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA), has played an important role in delivering current levels of reliability. It involves a combination of ACRs, Remote Control Gas Switches and feeder management relay operations, together with the use of adjacent feeders, to supply feeder sections downstream of a faulted section. This scheme is specific to AusNet Services and reflects an important difference between our network and that of Powercor Australia.

However, the current DFA algorithms are all based on a conventional Resistance Earthed System network, and are incompatible with the required change to a Resonant Earthed System network as REFCLs are installed. As a consequence, without an upgrade to the algorithms (DFA2), the reliability outcomes on completion of each REFCL installation will degrade significantly.

AusNet Services' cost benefit analysis demonstrates that the costs of allowing a degradation in reliability significantly outweigh the costs of DFA2 and, therefore, the expenditure is justified in terms of economic efficiency. Furthermore, customers would be concerned if reliability degraded following the significant investment in REFCL technology, especially during periods of extreme heat.

The costs of DFA2 are not specific to each zone substation. Therefore, the costs are not included in this planning report, but are set out in the main body of the contingent project application.

3.7 Cost comparison with the Government's estimate in the RIS

To demonstrate the efficiency and prudency of our proposed expenditure, we must have regard to available benchmark information. In this instance, industry benchmarking is not available because the application of this technology for fire mitigation purposes is a world's first. In addition, the costs of installation are site-specific – which means that there is a potentially wide range of efficient and prudent installation costs across zone substations.

Despite these limitations, we note that the Regulatory Impact Statement (RIS) prepared by ACIL ALLEN for the Victorian Government in 2015 estimated costs for the REFCL installation program. The cost estimates were an important component of the RIS assessment, which considered the costs and benefits of introducing the bushfire mitigation regulations.

We note that ACIL ALLEN's cost estimates were prepared in 2015. Since then, we have developed location specific scopes of work, which have also been informed by experience gained at the REFCL installation at Woori Yallock zone substation. For these reasons, we have substantially more confidence in our cost estimates for RUBA compared to the earlier ACIL ALLEN estimates, which were developed for a different purpose and which no longer reflect the best available information.

The table below provides a detailed explanation of the differences between our forecasts and ACIL ALLEN's estimates in the RIS. For some line items, the RIS did not provide a specific estimate for each zone substation. In these cases, we have presented the volume range set out in the RIS and commented on whether our forecast falls within this range.

Table 5: Reconciliation of AusNet Services' cost forecasts at RUBA with the RIS cost estimates

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
Capex			
Zone substation works	4,187k	1,800 – 4,895k[3] Including - REFCL, design, civil works, installation and commissioning; - Station lighting arrestors; -Station service transformers; -Station services low voltage transfer switch; and - Capacitor banks.	AusNet Services' zone substation works include the following additional items which were not included in the RIS estimate: neutral bus switchboard; REFCL backup protection and interface control systems; REFCL testing including to prescribed requirements; and a community engagement plan.

[2] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, 74 & 75. It should be noted that the RIS costs are expressed in $2015 while our costs are expressed in $2016. Strictly speaking, for comparison purposes the RIS costs are approximately 1.5 per cent higher than indicated here.

[3] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, Table 14 includes zone substation components.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
ACRs replacement	6 unit replacements @ cost of $63.2k per unit, producing a cost of $379k.	RIS only provided an estimated volume range of 0-18 for each zone substation @ cost of $70k per unit, producing a cost estimate between $0 and $1,260k per zone substation.	AusNet Services' ACR replacement unit cost is lower than the RIS estimate.
Network balancing	1,470k (see scope of work in 'explanation column')	RIS only provided an estimated volume range for conductor phase movements. Anticipated 0-85 for each zone substation @ cost of $4k per unit, producing a cost estimate between $0 and $340k per zone substation.	Significant increase in the scope and cost post the learnings of the WYK REFCL commissioning. This has led to an increased understanding of the least cost mix work required to meet and maintain the prescribed sensitivity criteria in the Regulations. Field works required to meet the criteria which is world first involve: - 62 sites where conductor phase movements are required; - Installation of 5 single phase balancing capacitors and 13 three phase balancing capacitors; and - 20 sites where fuses are required to be removed and replaced with solid links.
Surge arrestors	1,705 unit replacements @ cost of $0.94k per unit, producing a cost of $1,602k.	RIS only provided an estimated volume range of 0-8,224 units for each zone substation @ cost of $1k per unit, producing a cost estimate between $0 and $8,224k per zone substation.	AusNet Services approach is to replace the 40% of surge arrestors that sample testing has determined will not operate satisfactorily at elevated voltages. Cost forecast is lower than the average of the RIS estimate. 651 surge arrestor sites requiring replacement at $2,460 each, (equates to 1,705 surge arrestors units at $940 each).
Voltage regulators	47k	RIS only provided an estimated cost range of $0-375k for each zone substation.	Cost is higher than the RIS estimate. RUBA network requires upgrade of 1 line voltage regulator.
Total	*5,109k*	*3,421k*	Not costed in the RIS estimate. Required to ensure the RUBA network is operating to the prescribed criteria of the Regulations and vulnerabilities to overvoltage on the RUBA network are exposed prior to the Declared Bushfire Season.
Code compliance	3,541k	0 k[4]	Two HV customers and three points of supply served from the RUBA 22kV network.
Opex			
Pre fire season testing	83k	-	Not costed in the RIS estimate. Required to ensure the RUBA network is operating to the prescribed criteria of the Regulations and vulnerabilities to overvoltage on the RUBA network are exposed prior to the Declared Bushfire Season.
Equipment maintenance	9k	107k[5]	AusNet Services' equipment maintenance cost is lower than the RIS estimate.

4 Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 74, Table 20

5 Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 74, Table 20

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
Total	*93k*		

The table shows that a number of items were either not included in the RIS cost estimate, or were underestimated for the reasons noted in the table above. These variances reflect the level of understanding on the part of the government and the industry at the time the RIS was prepared.

The key areas of cost difference are zone substation works and network balancing. Additional zone substations works that were not included in the RIS estimate are:

- Neutral bus switchboard – required for effective year-round protection of the network, balancing bushfire risk reduction with network reliability requires multiple operating modes with differing earthing arrangements. A neutral bus switchboard facilitates these arrangements.
- REFCL backup protection and interface control systems – protection and control equipment must operate in several earthing fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Testing the REFCL – As part of the project commissioning it will be necessary to fully test the functionality of the REFCL ensuring that it is capable of operating to meet the Regulations. It involves the first instance of insulation and compliance testing to demonstrate the correct operation of the device and to comply with the ESV's reporting requirements.
- Community engagement plan - required due to the number of outages forecast for the community and the new network insulation tests, which in the short term are expected to have an unfavourable reliability experience for customers.

Additional network balancing works not included in the RIS estimate include:

- Work required to achieve the performance criteria in each automatic switching zone - involving a combination of additional works including, adding balancing capacitors, unbonding cable installations and adding a third phase conductor to balance each section. The RIS detailed phase rotations alone as the only network balancing cost, this will not achieve the required performance criteria of the Regulations.
- Works needed to maintain balance – including replacing fuses with solid links where fuse operation will lead to out of balance, potential non-compliance with the Regulations and possible REFCL mal operation.

As evidenced by the above table, AusNet Services has examined the cause of forecast expenditure differences to those presented in the RIS for the REFCL installation at RUBA. The reconciliation to the Government's cost estimates provides further assurance that AusNet Services' cost forecasts are prudent and efficient.

It is also important to emphasise that the cost forecasts presented in this contingent project application reflect a detailed scope of work for each zone substation installation in accordance with the AER's 'trigger event' definition. As such, AusNet Services' forecasts are fully substantiated having regard to the actual conditions at each zone substation whereas the RIS estimate adopted a broader estimating approach that was unavoidably less comprehensive.

3.8 Why the proposed costs are efficient

This appendix has explained that:

- The proposed scope of station works at RUBA is the lowest cost and risk option for addressing the specific issues at RUBA;
- Our proposed replacements and upgrades of ACRs and line voltage regulators is consistent with our strategies in relation to these assets, which adopt a prudent and efficient replacement approach;
- Our replacement of surge arrestors reflects our strategy in relation to this asset, which is based on significant sample sizing and again a prudent and efficient replacement approach;
- Our network balancing work is consistent with our strategy in relation to these works, which is focused on achieving the required capacitive balance at the lowest cost in each automatic switchable section of the 22kV network;
- We have considered non-network options and the substitution possibilities between capital and operating expenditure;
- We have employed our standard approach to project cost estimation;
- The key assumptions underpinning our forecasts are reasonable;
- We have identified the key risks in relation to the REFCL installation at RUBA and taken appropriate risk mitigation measures; and
- Our projected costs are within the Government’s estimated range in the RIS. More importantly, we have reviewed our cost estimates on a line-by-line basis, explaining the reasons for any differences compared to the RIS estimates and highlighting gaps in the scope of work assumed in the RIS.

In addition, it should be noted that our forecast expenditure for the REFCL installation at RUBA has been subject to our standard business case review and approval processes. The project will also be subject to our project management and governance arrangements.

For these reasons, we regard the forecast expenditure at RUBA as prudent and efficient, in accordance with the Rules requirements relating to contingent projects.

3.9 Supporting documents

Supporting documents to be provided as part of this submission:

- REF 10-04 REFCL Program Equipment Building Block Functional Description;
- REF 20-08 Automatic Circuit Recloser Strategy;
- REF 20-06 Network Balancing Strategy;
- REF 20-07 Line Hardening Strategy; and
- REF 20-09 Line Voltage Regulator Strategy.

Appendix 4 – Wangaratta Zone Substation REFCL Planning Report

4.1 Purpose

The purpose of this appendix is to demonstrate that the forecast capital expenditure and incremental operating expenditure to install the mandated REFCL technology at Wangaratta (WN) zone substation are prudent and efficient. In doing so, this appendix highlights the specific issues at WN zone substation that influence the design and cost of the REFCL installation at this location.

A number of supporting documents are listed in section 4.9, which provide further information on the strategies that underpin our forecast expenditure, and detail why these strategies and cost estimates are prudent and efficient. This appendix should therefore be read in conjunction with the supporting documents listed in section 4.9.

As explained in Chapter 1 of this contingent project application, the installation of REFCLs at selected zone substations is the only engineering solution that is capable of complying with the performance standards mandated by the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

WN zone substation is located in the southern end of the city of Wangaratta approximately 250km northeast of Melbourne. This zone substation was established in the 1960s and supplies the City of Wangaratta and surrounding areas including Glenrowan. The station supplies 17,430 customers, including two High Voltage (HV) customers by means of three large (20/33 MVA) transformers and seven distribution feeders. The WN 22kV feeders cover a total 22kV route length of 1,475km. The 22kV network includes 49 automatic switchable sections.

The estimated total capacitance of the WN 22kV network is forecast to be 188 (A) or 210 (A) including existing automatic transfer feeders.

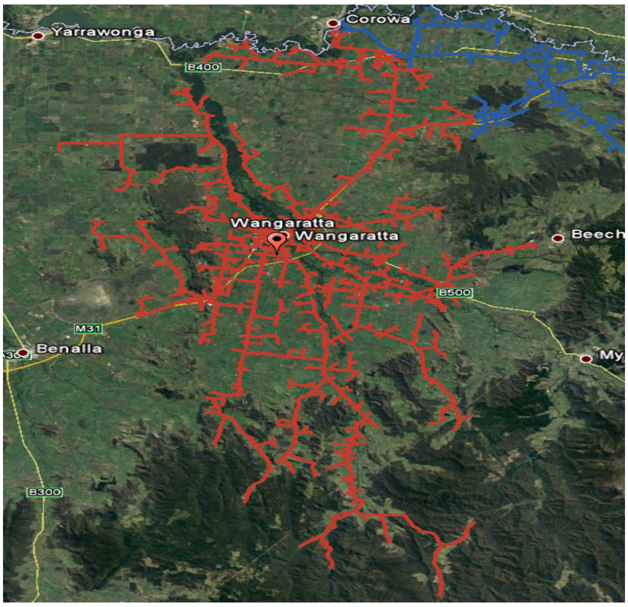

Figure 1-1: WN 22kV feeders shown above in Red.

4.2 Key issues and challenges at WN

The key issues impacting the installation of REFCL technology at WN is the expected capacitance of the network, the condition of the existing 22kV switchgear, required modifications to the existing 22kV capacitor banks and the lack of physical space in the existing site control room.

As stated above, the forecast capacitance of the WN network is 210 (A) including transfers. The performance criteria of the Regulations state fault current must be limited to 0.5 (A) or less. Testing at Woori Yallock has confirmed that the maximum capacitance a REFCL can serve must be limited to 150 (A). This will allow the REFCL to be able to detect fault current down to the required limit of 0.5 (A) once the necessary balancing works have been performed. Two standard REFCLs are required to be installed and operated at WN to meet this component of the performance criteria.

The existing 22kV bus and feeders are switched using bulk (9 of) and minimum oil (3 of) circuit breakers no longer supported by the manufacturer. Three of the bulk oil circuit breakers are in poor condition. All 22kV switchgear at WN was planned (prior to REFCL implementation) to be replaced with 2 indoor switchgear rooms in 2022. This replacement plan must now be revisited with the required introduction of REFCLs onto the WN network.

Three bulk oil 22kV circuit breakers although appropriately rated for REFCL voltages are over 40 years old and approaching end of life due to condition. The elevated voltages of insulation testing and REFCL operation is expected to further accelerate end of life and possible failure. A decision to replace the three circuit breakers has been made, reducing associated risks (health and safety and adjacent plant damage) caused by explosive failure of any of the three circuit breakers. The options to address this issue are discussed in section 4.3.1.

WN zone substation has two 22kV capacitor banks. The capacitor banks must be modified to be compatible with REFCL operation. The consequence of not modifying the capacitor banks means REFCL operation will lead to equipment failure from dangerous voltages placing customer supply and safety at risk.

The need to modify capacitor banks in ‘earthed star’ configuration was noted in the REFCL trial report, explaining that the earth connection must be removed from the star point and protection systems modified accordingly[1].

The existing site control room does not have the physical space for the required installation of REFCL technology at WN. This control room has insufficient space for the REFCLs Residual Current Compensation (RCC) units (2 of) and associated control systems. Due to its space capacity, the existing control room is unsuitable for reuse. Two separate buildings will be created to house the REFCL equipment.

4.3 Scope of work

The scope of work to install two REFCLs at WN involves:

- Zone substation works;
- Compatible works, including upgrade of 1 Automatic Circuit Recloser (ACR) and replacement of ACRs installed on WN feeders;
- Network balancing;
- Line hardening, which requires the replacement of incompatible surge arrestors installed on feeders; and
- Victorian Electricity Distribution Code compliance, which requires the installation of 2 isolating transformer solutions at HV customer points of supply. As already noted, WN serves two HV customers.

1 REFCL Trial: Ignition Tests, Marxsen Consulting Pty Ltd, Monday 4 August 2014, page 94.

Each of these activities is discussed in turn below, as follows:

- Section 4.3.1 – Zone substation works; and
- Section 4.3.2 – Line works, which addresses the remaining four work streams.

It should be noted that there are no line voltage regulators requiring upgrade on the WN network.

4.3.1 Zone substation works and options analysis

The proposed REFCL installation at WN will involve a number of activities that are common to most Tranche 1 zone substation REFCL installations. These include:

- Specification, procurement and installation of a Ground Fault Neutraliser (GFN), including an Arc Suppression Coil (ASC), Residual Current Compensation (RCC) and control system. In WNs case two GFNs are required.
- Specification, procurement and installation of a neutral bus switchboard. The introduction of the GFN requires a neutral bus which enables different earthing arrangements to be automatically configured. The switchboard facilitates remote year round selection of earthing arrangements and operating modes. Provides the ability to balance bushfire risk reduction with network reliability, depending on network and weather conditions. In WNs case two neutral bus switchboards are required.
- Upgrade of the existing station service transformers and changeover boards. This work is required because the alternating current (AC) supply requirement dramatically increases due to the GFN installation.
- Testing and potential replacement of cable equipment which are at risk of failure if operated at elevated voltages.
- Replacement and extension of existing protection and control equipment with equipment capable of operating in several modes including resonant earthing and traditional earth fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Prior to commissioning the GFN, network hardening tests involve the process of lifting voltages (using the GFN) in a healthy three phase powerline network (phase by phase) to check network readiness for future states of REFCL operation. During this activity there is an increased likelihood of asset failures. We would replace any assets that fail during the testing process. These tests are necessary to ensure the GFN can operate without causing line and station equipment to fail resulting in a fire start. These tests are conducted in times of low fire risk to mitigate the likelihood of failure in the Declared Bushfire Season.
- Installation of monitoring equipment to demonstrate compliance with regulations and enable remote engineering access to control systems.

Further information on these works is provided in the following supporting document:

- REF 10-04 REFCL Program Equipment Building Block Functional Description

The additional specific work required at WN involves:

- Work associated with converting the zone substation into a station capable of operating with multiple REFCLs. This required work includes civil foundations for neutral bus switchgear, REFCL control rooms, station service transformer and REFCL equipment and earthing.

- Modification to the earthing arrangements of the two existing capacitor banks to enable operation of the resonant earthing required during REFCL operation.
- Replacement of three outdoor 22kV bulk oil circuit breakers. Switchgear has an increased risk of accelerated end of life failure from REFCL operation.
- Installing two REFCL control rooms to house REFCL associated protection, control, and indoor auto-change over board.
- In relation to network hardening tests on the WN 22 kV network prior to commissioning the GFN, our expectation is that there is a reasonable likelihood that some surge arrestors, insulators, pole top transformers and/or cables may fail and require replacement.
- Development and execution of a community engagement plan for works associated with the WN network REFCL implementation. Community engagement is required to explain the likely customer reliability impact during the new network insulation tests. The importance of effective community engagement has been highlighted by the Woori Yallock REFCL implementation in September 2016, which led to issues being raised by customers, media, the community and the Victorian Parliament.

WN is one of three zone substations in Tranche 1 where it is necessary to implement a multiple REFCL site philosophy meaning additional neutral bus switchgear and a more complex protection and control philosophy.

There are limited alternative options that avoid the need to install another REFCL. Installing another REFCL is directly related to the total capacitive size of the network with constraints placed on the total capacitance so that detection sensitivity can be met. There are ways of reducing the total capacitive size of the network such as installing line reactors however this is counter to the key performance objective of the program which is to detect extremely high impedance faults. The only way to reduce the capacitive size of the network at WN would be to permanently transfer parts of the WN network to adjacent feeders or build a new zone substation along an existing 66kV line and supply the nearby 22kV feeder network.

The existing 22kV feeders are switched using bulk (9 of) and minimum oil (3 of) circuit breakers no longer supported by the manufacturer. Three of the bulk oil circuit breakers are in poor condition. All 22kV switchgear at WN was originally planned (prior to REFCL implementation) to be replaced with 2 indoor switchgear rooms in 2022.

Three of the bulk oil 22kV circuit breakers although appropriately rated for REFCL are over 40 years old and approaching end of life due to their condition. The elevated voltages of insulation testing and REFCL operation is expected to further accelerate end of life. A decision to replace the three circuit breakers has been made, reducing associated risks (health and safety and adjacent plant damage) caused by explosive failure of any of the three circuit breakers.

Before determining our preferred scope of work at WN, we considered 3 planning options:

1. Install REFCL technology and associated equipment. Replace 3 22kV bulk oil circuit breakers and modify 2 capacitor banks. Test remaining 22kV circuit breakers for any likely failure points and increase maintenance on circuit breakers in the interim to mitigate risk posed by REFCL operation (our preferred option, as described above).
2. Same as Option 1, but replace all 12 22kV circuit breakers with 2 new 22kV indoor switchboards.
3. Same as Options 1, but do not replace any 22kV circuit breakers.

In developing these options, AusNet Services considered non-network options and substitution possibilities between operating and capital expenditure. In relation to the zone substation works, there were no identified non-network options or substitution possibilities, other than those inherent in the above options.

A summary of our analysis in relation to each of these options is shown in Table 1.

Table 1: Options evaluated

Option	Advantages	Disadvantages
1. Install REFCL and associated equipment. Replace 3 22kV bulk oil circuit breakers. Increase maintenance on remaining 22kV circuit breakers (preferred option).	New REFCL control building can be built without impacting customer supply. Makes maximum use of standard REFCL control room design and thereby lowering lifetime costs and minimising time to implement the zone substation works. Balance risk and cost approach, $8,042k.	All existing and new REFCL protection and control equipment not housed in one location. Failure of remaining 22kV switchgear due to a combination of condition and REFCL operation not fully mitigated. Increased monitoring of remaining switchgear required. Higher cost than Option 3.
2. Same as Option 1, but replace all 12 22kV outdoor circuit breakers with 2 new 22kV indoor switchboards.	Eliminates 22kV switchgear accelerated end of life failure risk due to REFCL operation.	Increased construction time and delivery risk. Greater cost $11,201k.
3. Same as Option 1, but do not replace any 22kV circuit breakers.	Lower cost than the preferred option, $7,714k.	Increased monitoring of remaining bulk oil circuit breakers. Failure of 22kV switchgear due to a combination of condition and REFCL operation not mitigated. Risks (health and safety and adjacent plant damage) caused by explosive failure of any of the three circuit breakers not mitigated. For the above reasons this option was not considered feasible.

It is evident from the above table that Option 1 is the appropriate planning solution because it has:

- Lower cost and delivery risk than Options 2;
- Lower risk when compared to Option 3 of plant failure causing:
  - health and safety to employees and or contractors; and
  - adjacent plant damage.

As noted in the table, while Option 3 has lower costs than the preferred optrion, the safety risks are such that Option 3 is not considered feasible.

4.3.2 Line works

The scope of works outside the zone substation involves the following work on the WN network:

- Upgrade of 1 and replacement of 19 ACRs installed on WN feeders
- Balancing 49 automatic switching zones – this involves:
    - 155 sites where phases are rotated;
    - 8 sites where third phase conductor is required to be installed;
    - The installation of 14 single phase balancing capacitors and 31 three-phase balancing capacitors; and
    - The replacement of 49 fuse sites required to be replaced with solid links;
- Replacement of surge arresters at 1,032 sites distributed across the feeders; and
- Installation of 2 isolating transformer solutions at HV customer points of supply.

ACRs are currently used to detect 'downstream' faults and to interrupt supply to the faulted feeder section thereby minimising the number of customers who experience a supply interruption due to a fault. The existing ACRs are not capable of:

- detecting the low fault currents that will occur with REFCL operation; and
- identifying faults and the affected section of the feeder when earthing arrangements are altered at the zone substation (i.e. when the REFCL is switched onto the network). This inability leads to a larger number of customers being affected in the event of a sustained fault on a REFCL network, and spurious tripping of ACRs on unaffected healthy feeders when the REFCL operates.

ACRs will therefore be upgraded or replaced so that they can detect low fault currents along with any changes to the earthing arrangement at the zone substation. This will ensure that in the event of a fault, customer outage numbers are minimised and healthy feeders are not tripped with REFCL operation.

Equally important as the ACR works is the capacitive balancing of the WN 22kV network. Network capacitance must be balanced for REFCLs to operate. AusNet Services will undertake network balancing on each 'automated switching zone' where an automated switching zone is a feeder section delineated by ACRs, sectionalisers and/or circuit breakers. Balancing switching zones involves a combination of works including phase transpositions, adding balancing capacitors, unbonding cable installations, removing fuses and adding a third phase conductor to balance each section. A combination of this work involving the least cost for each switching zone will be undertaken.

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA), involves a combination of ACR and sectionaliser operations plus the use of adjacent feeders to supply feeder sections downstream of a faulted section. This scheme is currently used to provide network reliability. Existing DFA will only operate with REFCLs where each switching zone is capacitively balanced and ACR works are completed.

As well as network balancing works, type testing of surge arrestors has been undertaken to determine the types which cannot withstand the elevated voltages that result from REFCL operation. Failure of these types can lead to ground fire ignition and therefore their replacement is essential to prevent fire ignition during REFCL operation. A survey of the feeders has identified 1,032 sites with incompatible surge arrestors and these will be replaced with a standard surge arrestor with adequate ratings for REFCL operation.

The elevated voltages in the event of a single phase fault also raise compliance issues in relation to the Victorian Electricity Distribution Code. In particular, clause 4.2.2 of the Code sets out the maximum permissible variation in nominal voltages at the point of supply to each HV customer's electrical installation. AusNet Services must install 2 isolating transformers at WN to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.

In scoping the above line works, AusNet Services has considered whether there are any non-network options or substitution possibilities between operating and capital expenditure. The nature of the required works at WN is such that there are no non-network options or opportunities to substitute operating activities for the proposed capital works.

Further detail on the need for replacement and/or upgrade of ACRs, network balancing and surge arrester replacement is available in:

- REF 20-08 Automatic Circuit Recloser Strategy
- REF 20-06 Network Balancing Strategy
- REF 20-07 Line Hardening Strategy

4.3.3 Operational costs

In addition to the capital works described above, incremental ongoing operational costs will result from REFCL installation. Operational costs not specific to this site location are contained in the Operational Expenditure Requirements - Tranche 1 (REF 70-10) document. Operational costs that are either specific to WN or vary by zone substation include:

- A number of new or expanded devices will be installed at WN as a result of the REFCL installation including REFCL equipment, auto-changeover board, station services and line balancing capacitor units. As these items are new they are unlikely to require material additional maintenance, however they will require routine inspection.
- Prior to each fire season it will be necessary to fully test the functionality of the REFCL to ensure that it is capable of operating to meet the Regulations. This will involve annual insulation and compliance tests to demonstrate the correct operation of the device, together with ESV reporting.

Table 2: Forecast incremental operational costs

Activity	Frequency	Calendar Year Cost $		
		18	19	20
Maintain additional equipment	Annual	-	6,308	6,308
Pre fire season testing (insulation and compliance testing)	Annual	-	55,484	55,484

4.4 Key assumptions, risks and mitigation strategies

The key assumptions and risks made in forecasting the cost of REFCL installation at WN are shown in Table 3 below.

Table 3: Key assumptions, risks and mitigation strategies

Assumption or Risk	Impact	Mitigation
Customers adversely affected by outages due to failure of equipment operating at higher than design voltages.	Extended customer outages e.g. cable failures. S-factor & GSL impacts.	Assets which are not compatible with REFCLs, such as surge arrestors and ACRs replaced prior to testing. Critical cables tested. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the WN network.
Customers adversely react to the number of outages required to deliver the REFCL works on the WN network.	Repeat customer outages lead to increased customer costs and community frustration e.g. outages for line work, and station and REFCL testing works.	Where possible, the co-ordination of work outages to minimise impact on the community.
High Voltage (HV) customer(s) adversely affected by outages due to failure of their equipment operating at higher than design voltages.	Extended outage or safety incident for HV customer, caused by underrated equipment failures. Loss of production and potential health and/or safety impacts. AusNet Services would need to undertake substantial work with each HV customer to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes. A change to the Distribution Code would also be required.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customer's point of supply complies with this Code provision and meets the mandated timeframe.
Operation of the REFCL would lead to voltage levels that are outside the allowable range specified in the Victorian Electricity Distribution Code (the Code).	Unless the Code is changed, operation of the REFCL would lead to non-compliance with our obligations. The Essential Services Commission has made it clear that it does not intend to amend the Victorian Distribution Code to address the voltage variation issue[2].	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customer's point of supply complies with this Code provision.

2 Essential Services Commission, Electricity Distribution Code Compliance and REFCLs, letter to Hannah Williams, Powercor, dated 7 February 2017.

Assumption or Risk	Impact	Mitigation
Scope of HV customer works and funding mechanism unclear.	Delays in a suitable funding mechanism and/or work completion for HV customers could delay the project, resulting in additional costs and fines due to project delays and failure to have the REFCL in service ahead of the 2017/18 fire season, and April 2019 compliance date. AusNet Services would need to undertake substantial work with HV customers to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customer's point of supply complies with this Code provision and meets the mandated timeframe.
Present 22kV switchgear condition together with the elevated voltages of REFCL operation poses an increased risk of asset failure.	The existing 22kV feeders are switched using a combination of bulk and minimum oil circuit breaker switchgear no longer supported by the manufacturer. The present condition of 3 circuit breakers suggests these assets are at risk of failure under the elevated voltages of REFCL operation. The equipment is approaching end of life and was due to be replaced in 2022.	Bring forward the replacement of 3 poor condition 22kV circuit breakers that will now have an accelerated end of life due to the introduction of REFCL technology.
Proximity to live assets during construction.	The project involves brownfield works to be carried out in the midst of an in-service zone substation. This will result in risk associated with the close proximity of live overhead and underground assets to employees, contractors and mobile plant.	Access permit conditions will clearly specify the requirements to ensure safety whilst work is being carried out in the station. Controls will be required for site induction and earth potential rise under fault conditions.

Assumption or Risk	Impact	Mitigation
Sole supplier delivers GFN product to required standard.	Failure to have the GFN operating by 30 April 2019 will incur a one off civil penalty of $10M, and a fine of $5,500 for each day the criteria is not met after that date.	Develop and monitor strategic spares for the GFN product. Engage and invest in the relationship with GFN supplier. Seek an alternative REFCL supplier that can meet performance criteria of the Regulations. WN costing has no allowance for sole supplier risk.
WN network can be capacitively balanced, achieving the performance required under the Regulations.	Accurate network balance is essential if the performance criteria are to be met. To date these criteria have been achieved in one instance on a 40km network at Kilmore South. Failure to meet the performance criteria by 30 April 2019 will incur a one off civil penalty of $10M, and a fine of $5,500 for each day the criteria is not met after that date.	Extensive survey, design and modelling work is required. Works must ensure all material capacitive imbalances are addressed on the WN network.

4.5 Total costs for WN Zone Substation

The total forecast costs to install a REFCL at WN are shown in Table 4.

Table 4: Forecast costs

Item	**Cost** $000s 2016 direct
Capex	
Zone substation works, network hardening testing (elevated voltage testing) and REFCL commissioning	8,042
Replacement of 19 ACRs and upgrade of 1 ACR that are not capable of detecting low fault currents or automatically blocking conventional earth protection during REFCL operation.	1,202
Network balancing – Rotating phases, additional third phase at 8 locations, installing single and three phase capacitors and replacing fuses with solid links.	3,750
Replacement of 2,703 units at 1,032 surge arrestors sites that present a risk of failure (and fire ignition) during REFCL operation	2,539
Total	*15,573*
Code compliance - the installation of 2 isolating transformer solutions to ensure that AusNet Services maintains compliance with the maximum permissible voltage variations specified in the Victorian Distribution Code.	2,361

Item	Cost $000s 2016 direct
Opex	
Pre fire season testing including insulation and compliance testing.	111
Equipment maintenance.	13
Total	*124*

The capex costs have been prepared using AusNet Services' standard project cost estimating approach. The capital costs associated with zone substation equipment installation, replacement of an ACR and replacement of surge arrestors are reasonably certain. i.e. they carry the same level of uncertainty as routine projects such as zone substation construction or rebuilds.

The total capex cost at WN is higher than other tranche one zone substations. This is driven by a range of factors as described above. These include:

- WN is a large network with a large number of customers. This is reflected in the increased costs for surge arrestor and ACRs when compared to other tranche one zone substations.
- WN has a large number (49) of automatic switchable sections that must be balanced. WN also has the second largest amount of 22kV single phase network (376km) within tranche one requiring balancing. This is reflected in increased costs for network balancing when compared to zone substations in tranche one.
- WN zone substation requires the replacement of 3 bulk oil outdoor 22kV circuit breakers which are at increased risk of failure from REFCL operation. This replacement cost coupled with the need for two REFCLs and associated equipment at WN is a significant driver of increased zone substation costs at this site.

Uncertainties in forecast capital costs primarily arise from performance of the REFCL, the extent of network balancing required and community reaction to the installation and testing works. An allowance of $80,447 has been included in the zone substation works for network insulation testing activities. This cost is based on 3.5 days to complete this activity, anticipating 1 fault per day of testing. Each fault has been attributed a cost of $5,467 using established contractor rates. Based on insulation testing carried out to date, it is reasonably likely that cables/joints and surge arrestors will fail at this elevated voltage testing.

4.6 Addressing reliability degradation

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA), has played an important role in delivering current levels of reliability. It involves a combination of ACRs, Remote Control Gas Switches and feeder management relay operations, together with the use of adjacent feeders, to supply feeder sections downstream of a faulted section. This scheme is specific to AusNet Services and reflects an important difference between our network and that of Powercor Australia.

However, the current DFA algorithms are all based on a conventional Resistance Earthed System network, and are incompatible with the required change to a Resonant Earthed System network as REFCLs are installed. As a consequence, without an upgrade to the algorithms (DFA2), the reliability outcomes on completion of each REFCL installation will degrade significantly.

AusNet Services' cost benefit analysis demonstrates that the costs of allowing a degradation in reliability significantly outweigh the costs of DFA2 and, therefore, the expenditure is justified in terms of economic efficiency. Furthermore, customers would be concerned if reliability degraded following the significant investment in REFCL technology, especially during periods of extreme heat.

The costs of DFA2 are not specific to each zone substation. Therefore, the costs are not included in this planning report, but are set out in the main body of the contingent project application.

4.7 Cost comparison with the Government's estimate in the RIS

To demonstrate the efficiency and prudency of our proposed expenditure, we must have regard to available benchmark information. In this instance, industry benchmarking is not available because the application of this technology for fire mitigation purposes is a world first. In addition, the costs of installation are site-specific – which means that there is a potentially wide range of efficient and prudent installation costs across zone substations.

Despite these limitations, we note that the Regulatory Impact Statement (RIS) prepared by ACIL ALLEN for the Victorian Government in 2015 estimated costs for the REFCL installation program. The cost estimates were an important component of the RIS assessment, which considered the costs and benefits of introducing the bushfire mitigation regulations.

We note that ACIL ALLEN's cost estimates were prepared in 2015. Since then, we have developed location specific scopes of work, which have also been informed by experience gained at the REFCL installation at Woori Yallock zone substation. For these reasons, we have substantially more confidence in our cost estimates for WN compared to the earlier ACIL ALLEN estimates, which were developed for a different purpose and which no longer reflect the best available information.

The table below provides a detailed explanation of the differences between our forecasts and ACIL ALLEN's estimates in the RIS. For some line items, the RIS did not provide a specific estimate for each zone substation. In these cases, we have presented the volume range set out in the RIS and commented on whether our forecast falls within this range.

Table 5: Reconciliation of AusNet Services' cost forecasts at WN with the RIS cost estimates

Item	AusNet Services forecast $ 2016 direct	RIS estimate[3] $2015 direct	Explanation
Capex			

[3] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, 74 & 75. It should be noted that the RIS costs are expressed in $2015 while our costs are expressed in $2016. Strictly speaking, for comparison purposes the RIS costs are approximately 1.5 per cent higher than indicated here.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[3] $2015 direct	Explanation
Zone substation works	8,042k	1,800 – 4,895k[4] Including - REFCL, design, civil works, installation and commissioning; - Station lighting arrestors; -Station service transformers; -Station services low voltage transfer switch; and - Capacitor banks.	AusNet Services' zone substation works include the following additional items which were not included in the RIS estimate: neutral bus switchboard (2 of); REFCL control rooms; REFCL backup protection and interface control systems; REFCL testing including to prescribed requirements; community engagement plan and 22kV circuit breaker replacements (3 of) due to condition coupled with REFCL operation.
ACRs replacement	19 unit replacements @ cost of $63.2k per unit, producing a cost of $1,202k. 1 unit upgrade @ cost of $39.8k per unit, producing a cost of $39.8k.	RIS only provided an estimated volume range of 0-18 for each zone substation @ cost of $70k per unit, producing a cost estimate between $0 and $1,260k per zone substation.	AusNet Services' ACR replacement/upgrade unit cost is lower than the RIS estimate.
Network balancing	2,361k (see scope of work in 'explanation column')	RIS only provided an estimated volume range for conductor phase movements. Anticipated 0-85 for each zone substation @ cost of $4k per unit, producing a cost estimate between $0 and $340k per zone substation.	Significant increase in the scope and cost post the learnings of the WYK REFCL commissioning. This has led to an increased understanding of the least cost mix work required to meet and maintain the prescribed sensitivity criteria in the Regulations. Field works required to meet the criteria which is world first involve: - 155 sites where conductor phase movements are required; - 8 sites where third phase conductor is required to be installed; - Installation of 14 single phase balancing capacitors and 31 three phase balancing capacitors; and - 49 expected sites where fuses are required to be removed and replaced with solid links.
Surge arrestors	2,703 unit replacements @ cost of $0.94k per unit, producing a cost of $2,539k.	RIS only provided an estimated volume range of 0-8,224 units for each zone substation @ cost of $1k per unit, producing a cost estimate between $0 and $8,224k per zone substation.	AusNet Services approach is to replace the 40% of surge arrestors that sample testing has determined will not operate satisfactorily at elevated voltages. Cost forecast is lower than the average of the RIS estimate. 1,064 surge arrestor sites requiring replacement at $2,460 each, (equates to 2,703 surge arrestors units at $940 each).

[4] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, Table 14 includes zone substation components.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[3] $2015 direct	Explanation
Voltage regulators	-	-	-
Total	*15,573k*	*9,672[5]k*	The RIS estimate is specific to this zone substation, even though only cost ranges are provided in relation to the cost build up. The WN total cost is higher than the RIS estimate for the reasons set out above. See further discussion below this table.
Code compliance & deferral of third REFCL installation.	2,361k	88.9k[6]	Two HV customers and two points of supply served from the WN 22kV network.
Opex			
Pre fire season testing	110k	-	Not costed in the RIS estimate. Required to ensure the WN network is operating to the prescribed criteria of the Regulations and vulnerabilities to overvoltage on the WN network are exposed prior to the Declared Bushfire Season.
Equipment maintenance	13k	102k[7]	AusNet Services' equipment maintenance cost is lower than the RIS estimate.
Total	*123k*		

The table shows that a number of items were either not included in the RIS cost estimate, or were underestimated for the reasons noted in the table above. These variances reflect the level of understanding on the part of the government and the industry at the time the RIS was prepared.

The key areas of cost difference are zone substation works and network balancing. Additional zone substations works that were not included in the RIS estimate are:

- Neutral bus switchboard – required for effective year-round protection of the network, balancing bushfire risk reduction with network reliability requires multiple operating modes with differing earthing arrangements. A neutral bus switchboard facilitates these arrangements.
- REFCL control room – necessary as there is insufficient space in the existing control room and the inverter and secondary panels are larger than anticipated. At WN two will be installed.
- REFCL backup protection and interface control systems – protection and control equipment must operate in several earthing fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Testing the REFCL – As part of the project commissioning it will be necessary to fully test the functionality of the REFCL ensuring that it is capable of operating to meet the

[5] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 75, Table 20

[6] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 75, Table 20

[7] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 75, Table 20

Regulations. It involves the first instance of insulation and compliance testing to demonstrate the correct operation of the device and to comply with the ESV's reporting requirements.

- Community engagement plan - required due to the number of outages forecast for the community and the new network insulation tests, which in the short term are expected to have an unfavourable reliability experience for customers.
- 22kV switchgear replacement - Three bulk oil 22kV circuit breakers although appropriately rated for REFCL voltages are over 40 years old and approaching end of life due to condition. The elevated voltages of insulation testing and REFCL operation is expected to further accelerate end of life and possible failure. A decision to replace the three circuit breakers has been made, reducing associated risks (health and safety and adjacent plant damage) caused by explosive failure of any of the three circuit breakers.

Additional network balancing works not included in the RIS estimate include:

- Work required to achieve the performance criteria in each automatic switching zone - involving a combination of additional works including, adding balancing capacitors, unbonding cable installations and adding a third phase conductor to balance each section. The RIS detailed phase rotations alone as the only network balancing cost, this will not achieve the required performance criteria of the Regulations.
- Works needed to maintain balance – including replacing fuses with solid links where fuse operation will lead to out of balance, potential non-compliance with the Regulations and possible REFCL mal operation.

As evidenced by the above table, AusNet Services has examined the cause of forecast expenditure differences to those presented in the RIS for the REFCL installation at WN. The reconciliation to the Government's cost estimates provides further assurance that AusNet Services' cost forecasts are prudent and efficient.

It is also important to emphasise that the cost forecasts presented in this contingent project application reflect a detailed scope of work for each zone substation installation in accordance with the AER's 'trigger event' definition. As such, AusNet Services' forecasts are fully substantiated having regard to the actual conditions at each zone substation whereas the RIS estimate adopted a broader estimating approach that was unavoidably less comprehensive.

4.8 Why the proposed costs are efficient

This appendix has explained that:

- The proposed scope of station works at WN is the lowest cost and risk appropriate option for addressing the specific issues at WN;
- Our proposed replacement of ACRs and surge arrestors is consistent with our strategies in relation to these assets, which adopt a prudent and efficient replacement approach;
- Our network balancing work is consistent with our strategy in relation to these works, which is focused on achieving the required capacitive balance at the lowest cost in each automatic switchable section of the 22kV network;
- We have considered non-network options and the substitution possibilities between capital and operating expenditure.
- We have employed our standard approach to project cost estimation;
- The key assumptions underpinning our forecasts are reasonable;
- We have identified the key risks in relation to the REFCL installation at WN and taken appropriate risk mitigation measures; and

- Our projected costs are within the Government's estimated range in the RIS. More importantly, we have reviewed our cost estimates on a line-by-line basis, explaining the reasons for any differences compared to the RIS estimates and highlighting gaps in the scope of work assumed in the RIS.

In addition, it should be noted that our forecast expenditure for the REFCL installation at WN has been subject to our standard business case review and approval processes. The project will also be subject to our project management and governance arrangements.

For these reasons, we regard the forecast expenditure at WN as prudent and efficient, in accordance with the Rules requirements relating to contingent projects.

4.9 Supporting documents

Supporting documents to be provided as part of this submission:

- REF 10-04 REFCL Program Equipment Building Block Functional Description;
- Operational Requirements;
- REF 20-08 Automatic Circuit Recloser Strategy;
- REF 20-06 Network Balancing Strategy; and
- REF 20-07 Line Hardening Strategy.

Appendix 5 – Wonthaggi Zone Substation REFCL Planning Report

5.1 Purpose

The purpose of this appendix is to demonstrate that the forecast capital expenditure and incremental operating expenditure to install the mandated REFCL technology at Wonthaggi (WGI) zone substation are prudent and efficient. In doing so, this appendix highlights the specific issues at WGI zone substation that influence the design and cost of the REFCL installation at this location.

A number of supporting documents are listed in section 5.9, which provide further information on the strategies that underpin our forecast expenditure, and detail why these strategies and cost estimates are prudent and efficient. This appendix should therefore be read in conjunction with the supporting documents listed in section 5.9.

As explained in Chapter 1 of this contingent project application, the installation of REFCLs at selected zone substations is the only engineering solution that is capable of complying with the performance standards mandated by the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

WGI zone substation is located in the seaside town of Wonthaggi approximately 132km southeast of Melbourne. This zone substation was established in the 1960s and supplies the town of Wonthaggi and surrounding areas including Inverloch and San Remo. The station supplies 23,263 customers, including one High Voltage (HV) customer by means of three medium (10/13.5 MVA) transformers and eight distribution feeders. The WGI 22kV feeders cover a large total 22kV route length of 1,023km. The 22kV network includes 52 automatic switchable sections.

WGI zone substation has three non-REFCL tranche 1 22kV transfers feeder used for automatic switching of customers in the event of a fault between WGI to Lang Lang, Phillip Island or Leongatha zone substations.

The estimated total capacitance of the WGI 22kV network is forecast to be 113 (A) or 124 (A) including existing automatic transfer feeders.

Figure 1-1: WGI 22kV feeders shown above in blue.

5.2 Key issues and challenges at WGI

The key issue impacting the installation of a REFCL at WGI is the required co-ordination with the WGI re-build project, modification of the existing 22kV capacitor banks and the lack of physical space in the existing site control room.

The rebuild project was approved internally in January 2015 and is currently at the design stage. The scope of the re-build project includes:

- Re-configuring the 66kV by installing two new bus-tie circuit breakers and 22kV buses via the installation of two new indoor switchboards to reduce the potential for large supply outages affecting more than 16,000 customers;
- Replacing seven 22kV bulk oil circuit breaker and eleven 22kV oil filled current transformers at failure risk and associated secondary equipment via the installation of two new indoor substations;
- Replacing the existing number 1 and number 3 capacitor banks;
- Upgrade site security fencing and control room security to current standards;
- Refurbish existing control room and battery room to remove asbestos cement sheeting on external walls; and
- Upgrade switchyard lighting, surfaces, drainage, cable ducts to current standards.

The existing 22kV bulk oil circuit breakers are in poor condition and are not expected to withstand the elevated voltages and durations of REFCL insulation testing and operation. The 22kV circuit breaker replacements must be completed prior to the installation of REFCL technology at WGI. However, these assets are being replaced as part of the rebuild program, and therefore are not included in the REFCL project.

The two 22kV capacitor banks being replaced under the re-build project must be modified to be compatible with REFCL operation. The consequence of not modifying the capacitor banks means REFCL operation will lead to equipment failure from dangerous voltages placing customer supply and safety at risk.

The need to modify capacitor banks in 'earthed star' configuration was noted in the REFCL trial report, explaining that the earth connection must be removed from the star point and protection systems modified accordingly[1]. Only the incremental cost for the modification of the capacitor banks ($18,200 per unit) has been included within the REFCL project.

The existing site control room does not have the physical space for the required installation of REFCL technology at WGI. This control room is small with insufficient space for the REFCLs Residual Current Compensation (RCC) unit and associated control system. Due to its size, the existing control room is unsuitable for reuse. As explained in section 5.3.1, the lowest cost option is to construct a separate building to house the REFCL equipment.

5.3 Scope of work

The scope of work to install a REFCL at WGI involves:

- Zone substation works, including modifying the station capacitor banks;
- Compatible works, including:
  - Replacement or upgrade of 14 Automatic Circuit Reclosers (ACRs) installed on WGI, Phillip Island and Lang Lang feeders f; and

[1] REFCL Trial: Ignition Tests, Marxsen Consulting Pty Ltd, Monday 4 August 2014, page 94.

  - Replacement or upgrade of 2 line voltage regulators on WGI feeders; and
- Network balancing;
- Line hardening, which requires the replacement of incompatible surge arrestors installed on feeders; and
- Victorian Electricity Distribution Code compliance, which requires the installation of 1 isolating transformer solutions at a HV customer point of supply. As already noted, WGI serves one HV customer.

Each of these activities is discussed in turn below, as follows:

- Section 5.3.1 – Zone substation works; and
- Section 5.3.2 – Line works, which addresses the remaining four workstreams.

5.3.1 Zone substation works and options analysis

The proposed REFCL installation at WGI will involve a number of activities that are common to most Tranche 1 zone substations REFCL installations. These include:

- Specification, procurement and installation of a Ground Fault Neutraliser (GFN), including an Arc Suppression Coil (ASC), Residual Current Compensation (RCC) and control system.
- Specification, procurement and installation of a neutral bus switchboard. The introduction of the GFN requires a neutral bus which enables different earthing arrangements to be automatically configured. The switchboard facilitates remote year round selection of earthing arrangements and operating modes. Provides the ability to balance bushfire risk reduction with network reliability, depending on network and weather conditions.
- Upgrade of the existing station service transformers and changeover boards. This work is required because the alternating current (AC) supply requirement dramatically increases due to the GFN installation.
- Replacement and extension of existing protection and control equipment with equipment capable of operating in several modes including resonant earthing and traditional earth fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Prior to commissioning the GFN, network hardening tests involve the process of lifting voltages (using the GFN) in a healthy three phase powerline network (phase by phase) to check network readiness for future states of REFCL operation. During this activity there is an increased likelihood of asset failures. We would replace any assets that fail during the testing process. These tests are necessary to ensure the GFN can operate without causing line and station equipment to fail resulting in a fire start. These tests are conducted in times of low fire risk to mitigate the likelihood of failure in the Declared Bushfire Season.
- Installation of monitoring equipment to demonstrate compliance with regulations and enable remote engineering access to control systems.

Further information on these works is provided in the following supporting document:

- REF 10-04 REFCL Program Equipment Building Block Functional Description

The additional specific work required at WGI involves:

- Work associated with converting the zone substation into a station capable of operating with a REFCL. This required work includes civil foundations for the neutral bus switchgear, REFCL equipment and earthing.
- Installing one standard control room to house REFCL associated protection, control, and indoor auto-changeover board.
- In relation to network hardening tests on the WGI 22 kV network prior to commissioning the GFN, our expectation is that there is a reasonable likelihood that some surge arrestors, insulators, pole top transformers and/or cables may fail and require replacement.
- Development and execution of a community engagement plan for works associated with the WGI network REFCL implementation. Community engagement is required to explain the likely customer reliability impact during the new network insulation tests. The importance of effective community engagement has been highlighted by the Woori Yallock REFCL implementation in September 2016, which led to issues being raised by customers, media, the community and the Victorian Parliament.

Before determining our preferred scope of work at WGI, we considered 3 planning options:

1. Install REFCL technology and 1 new building (REFCL control room). At the same time as completing the WGI zone substation rebuild works, which includes the replacement of the existing 22kV switchgear (our preferred option, as described above).
2. Same as Option 1, but extend the refurbished control room to cater for REFCL control room requirements.
3. Same as Option 1, but complete the rebuild works first and then the REFCL works.

In developing these options, AusNet Services considered non-network options and substitution possibilities between operating and capital expenditure. In relation to the zone substation works, there were no identified non-network options or substitution possibilities, other than those inherent in the above options.

A summary of our analysis in relation to each of these options is shown in Table 1.

Table 1: Options evaluated

Option	Advantages	Disadvantages
1. Install REFCL and 1 new building (REFCL control room). At the same time complete WGI zone substation rebuild works (preferred option).	New REFCL control building can be built without impacting customer supply. REFCL project work can be constructed together with the rebuild project works. This will create construction efficiency. Least cost option at $3,630k.	All existing and new REFCL protection and control equipment not housed in one location. This will impose some increased transit between the two locations for commissioning and testing of REFCL technology. This is not seen as a material issue. Re-build project design having to be re-worked to cater for the REFCL technology installation. Increased scope of work at WGI increases the delivery risk of the REFCL related works. The REFCL is required to be installed and operating to prescribed criteria ahead of the April 2019 deadline. Any delay to the deadline will result in a large civil penalty being incurred.

Option	Advantages	Disadvantages
2. Same as Option 1, but extend the refurbished control room to cater for REFCL control room requirements.	All protection and control equipment housed in one location. Zone substation future construction space maximised. REFCL project work can be constructed together with the rebuild project works. This will create construction efficiency.	Complex construction as supply and protection must be maintained while the existing control room is extended. Modifying control room is more complex than Option 1. Greater cost than Option 1 $3,681k.
3. Same as Option 1, but complete the rebuild works first and then the REFCL works.	Simplified design and construction at WGI zone substation. Rebuild works can be completed first at WGI due to yard space availability.	Longer construction window at the WGI zone substation. REFCL operation will increase the short term likelihood on an end of life explosive failure of the 22KV bulk oil circuit breakers. The health and safety and adjacent plant risks are amplified if the circuit breakers are not replaced by completing the re-build project prior to REFCL operation. Larger risk of the WGI REFCL works not being completed. The REFCL is required to be installed and operating to prescribed criteria ahead of the April 2019 deadline. Any delay to the deadline will result in a large civil penalty. Greater cost than Option 1 $3,818k.

It is evident from the above table that Option 1 is the appropriate planning solution because it has:

- Lower cost than Options 2 and 3;
- Reduced complexity and supply risks compared to Options 2; and
- Lower risk of financial penalty than Option 3.

5.3.2 Line works

The scope of works outside the zone substation involves the following work on the WGI network and 3 transfer feeders:

- Replacement of 13 ACRs and upgrade of 1 ACR;
- Balancing 52 automatic switching zones – this involves:
    - 84 sites where phases are rotated;
    - 1 site where the third phase of cable must be unbonded;

  - The installation of 8 single phase balancing capacitors and 30 three-phase balancing capacitors; and
  - The replacement of 52 fuse sites required to be replaced with solid links.
- Replacement of 1,912 surge arrester units at 730 sites distributed across the feeders;
- Replacement of 1 line voltage regulator and upgrade of 1 line voltage regulator; and
- Installation of 1 isolating transformer solution at a HV customer point of supply;

ACRs are currently used to detect ‘downstream’ faults and to interrupt supply to the faulted feeder section thereby minimising the number of customers who experience a supply interruption due to a fault. The existing ACRs are not capable of:

- detecting the low fault currents that will occur with REFCL operation; and
- identifying faults and the affected section of the feeder when earthing arrangements are altered at the zone substation (i.e. when the REFCL is switched onto the network). This inability leads to larger number of customers being affected in the event of a sustained fault on a REFCL network and spurious tripping of ACRs on unaffected healthy feeders when the REFCL operates.

ACRs will therefore be upgraded or replaced so that they can detect low fault currents along with any changes to the earthing arrangement at the zone substation, this will ensure in the event of a fault customer outage numbers are minimised and healthy feeders are not tripped with REFCL operation.

Equally important as the ACR works is the capacitive balancing of the WGI 22kV network. Network capacitance must be balanced for REFCLs to operate. AusNet Services will undertake network balancing on each ‘automated switching zone’ where an automated switching zone is a feeder section delineated by ACRs, sectionalisers and/or circuit breakers. Balancing switching zones involves a combination of works including, phase transpositions, adding balancing capacitors, unbonding cable installations, removing fuses and adding a third phase conductor to balance each section. A combination of this work involving the least cost for each switching zone will be undertaken.

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA) involves a combination of ACR and sectionaliser operations plus the use of adjacent feeders to supply feeder sections downstream of a faulted section. This scheme is currently used to provide network reliability. DFA will only operate with REFCLs where each switching zone is capacitively balanced and ACR works are completed.

As well as network balancing works, type testing of surge arrestors has been undertaken to determine the types which cannot withstand the elevated voltages that result from REFCL operation. Failure of these types can lead to ground fire ignition and therefore their replacement is essential to prevent fire ignition during REFCL operation. A survey of the feeders has identified 730 sites with incompatible surge arrestors and these will be replaced with a standard surge arrestor with adequate ratings for REFCL operation.

Also, line voltage regulators (typically open delta configuration) have been the lowest cost option to regulate voltage on 22kV long rural feeders. Unfortunately, they are not compatible with REFCL technology as they displace the system neutral voltage by regulating only two phases (line-to-line voltages), rather than regulating all three phases. As a result these regulators will need to be replaced on REFCL affected feeders.

Separately, all line voltage regulators with two phase controllers will need to be upgraded to a three phase controller ensuring voltages across all three 22kV phases remains consistent and voltage variations between the phases is avoided.

The elevated voltages in the event of a single phase fault also raise compliance issues in relation to the Victorian Electricity Distribution Code. In particular, clause 4.2.2 of the Code sets out the maximum permissible variation in nominal voltages at the point of supply to each HV customer's electrical installation. AusNet Services must install 1 isolating transformers at WGI to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.

In scoping the above line works, AusNet Services has considered whether there are any non-network options or substitution possibilities between operating and capital expenditure. The nature of the required works at WGI is such that there are no non-network options or opportunities to substitute operating activities for the proposed capital works.

Further detail on the need for replacement and/or upgrade of ACRs, network balancing and surge arrester replacement is available in:

- REF 20-08 Automatic Circuit Recloser Strategy
- REF 20-06 Network Balancing Strategy
- REF 20-07 Line Hardening Strategy

5.3.3 Operational costs

In addition to the capital works described above, incremental ongoing operational costs will result from REFCL installation. Operational costs not specific to this site location are contained in the Operational Expenditure Requirements - Tranche 1 (REF 70-10) document. Operational costs that are either specific to WGI or vary by zone substation include:

- A number of new or expanded devices will be installed at WGI as a result of the REFCL installation including REFCL equipment, auto-changeover board, station services and line balancing capacitor units. As these items are new they are unlikely to require material additional maintenance, however they will require routine inspection.
- Prior to each fire season it will be necessary to fully test the functionality of the REFCL to ensure that it is capable of operating to meet the Regulations. This will involve annual insulation and compliance tests to demonstrate the correct operation of the device together with ESV reporting.

Table 2: Forecast incremental operational costs

Activity	Frequency	Calendar Year Cost $		
		18	19	20
Maintain additional equipment	Annual	-	3,154	3,154
Pre fire season testing (insulation and compliance testing)	Annual	-	27,742	27,742

5.4 Key assumptions, risks and mitigation strategies

The key assumptions and risks made in forecasting the cost of REFCL installation at WGI are shown in Table 3 below.

Table 3: Key assumptions, risks and mitigation strategies

Assumption or Risk	Impact	Mitigation

Assumption or Risk	Impact	Mitigation
Customers adversely affected by outages due to failure of equipment operating at higher than design voltages.	Extended customer outages e.g. cable failures. S-factor & GSL impacts.	Assets which are not compatible with REFCL such as surge arrestors, line voltage regulators and ACRs replaced prior to testing. Critical cables tested. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the WGI network.
Customers adversely react to the number of outages required to deliver the REFCL works on the WGI network.	Repeat customer outages lead to increased customer costs and community frustration e.g. outages for line work, and station and REFCL testing works.	Where possible, the co-ordination of work outages to minimise impact on the community.
Safe REFCL operation requires the replacement of a number of existing 22kV bulk oil circuit breakers which are in poor condition and approaching their end of life.	REFCL operation will increase the short term likelihood of an end of life explosive failure of the 22KV bulk oil circuit breakers. The health, safety and adjacent plant risks are amplified if the circuit breakers are not replaced.	Ensure the 22kV circuit breakers (covered under the WGI re-build scope of works) are replaced ahead of REFCL works and operation.
High Voltage (HV) customer adversely affected by outages due to failure of their equipment operating at higher than design voltages.	Extended outage or safety incident for HV customer, caused by underrated equipment failures. Loss of production and potential health and/or safety impacts. AusNet Services would need to undertake substantial work with each HV customer to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes. A change to the Distribution Code would also be required.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customer's point of supply complies with this Code provision and meets the mandated timeframe.

Assumption or Risk	Impact	Mitigation
Operation of the REFCL would lead to voltage levels that are outside the allowable range specified in the Victorian Electricity Distribution Code (the Code).	Unless the Code is changed, operation of the REFCL would lead to non-compliance with our obligations. The Essential Services Commission has made it clear that it does not intend to amend the Victorian Distribution Code to address the voltage variation issue[2].	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.
Scope of HV customer works and funding mechanism unclear.	Delays in a suitable funding mechanism and/or work completion for HV customers could delay the project resulting in additional costs and fines due to project delays and failure to have the REFCL in service ahead of the 2018/19 fire season, and April 2019 compliance date. AusNet Services would need to undertake substantial work with HV customers to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision and meets the mandated timeframe.
Proximity to live assets during construction.	The project involves brownfield works to be carried out in the midst of an in-service zone substation. This will result in risk associated with the close proximity of live overhead and underground assets to employees, contractors and mobile plant.	Access permit conditions will clearly specify the requirements to ensure safety whilst work is being carried out in the station. Controls will be required for site induction and earth potential rise under fault conditions.

2 Essential Services Commission, Electricity Distribution Code Compliance and REFCLs, letter to Hannah Williams, Powercor, dated 7 February 2017.

Assumption or Risk	Impact	Mitigation
Sole supplier delivers GFN product to required standard.	Failure to have the GFN operating by 30 April 2019 will incur a one off civil penalty of $2M, and a fine of $5,500 for each day the criteria is not met after that date.	Develop and monitor strategic spares for the GFN product. Engage and invest in the relationship with GFN supplier. Seek an alternative REFCL supplier that can meet performance criteria of the Regulations. WGI costing has no allowance for sole supplier risk.
WGI network can be capacitively balanced, achieving the performance required under the Regulations.	Accurate network balance is essential if the performance criteria is to be met. To date this criteria has been achieved in one instance on a 40km network at Kilmore South. Failure to meet the performance criteria by 30 April 2019 will incur a one off civil penalty of $2M, and a fine of $5,500 for each day the criteria is not met after that date.	Extensive survey, design and modelling work is required. Works must ensure all material capacitive imbalances are addressed on the WGI network.

5.5 Total costs for WGI Zone Substation

The total forecast costs to install a REFCL at WGI are shown in Table 4.

Table 4: Forecast costs

Item	**Cost** $000s 2016 direct
Capex	
Zone substation works, network insulation testing (elevated voltage testing) and REFCL commissioning.	3,630
Replacement of 13 ACRs and upgrade of 1 ACR that are not capable of detecting low fault currents or automatically blocking conventional earth protection during REFCL operation.	862
Network balancing – Rotating phases, unbonding cable at a single location, installing single and three phase capacitors and replacing fuses with solid links.	3,031
Replacement of 1,912 units at 730 surge arrestors sites that present a risk of failure (and fire ignition) during REFCL operation	1,796
Replacement of 1 line voltage regulator and upgrade of 1 line voltage regulator not compatible with REFCL operation.	387
Total	*9,705*
Code compliance - the installation of 1 isolating transformer solution to ensure that AusNet Services maintains compliance with the maximum permissible voltage variations specified in the	1,180

Item	Cost $000s 2016 direct
Victorian Distribution Code.	
Opex	
Pre fire season testing including insulation and compliance testing.	55
Equipment maintenance.	6
Total	*62*

The capex costs have been prepared using AusNet Services' standard project cost estimating approach. The capital costs associated with zone substation equipment installation, replacement of an ACR and replacement of surge arrestors are reasonably certain. i.e. they carry the same level of uncertainty as routine projects such as zone substation construction or rebuilds.

The total capex cost at WGI is higher than majority of other tranche one zone substations driven by a range of factors as described above. These include:

- WGI is a large network with a large number of customers. This is demonstrated in the increased costs for surge arrestors and ACR replacements when compared to all other tranche one zone substations with the exception of Seymour and Wangaratta
- WGI has a large number (52) of automatic switchable sections that require to be balanced. This is reflected in increased costs for network balancing when compared to all other tranche one zone substations with the exception of Seymour and Wangaratta.
- WGI has minimal land constraints and existing poor condition 22kV bulk oil switchgear is being replaced with new indoor switchgear as part of the re-build project. This work is not costed as part of the REFCL program. The re-build works also include the battery upgrades and the majority of the capacitor bank costs. As a result, the zone substation costs at WGI are lower than other tranche one zone substations, with the exception of Myrtleford and Kilmore South.

Uncertainties in forecast capital costs primarily arise from performance of the REFCL, the extent of network balancing required and community reaction to the installation and testing works. An allowance of $114,925 has been included in the zone substation works for network insulation testing activities. This cost is based on 5 days to complete this activity, anticipating 1 fault per day of testing. Each fault has been attributed a cost of $5,467 using established contractor rates. Based on insulation testing carried out to date, it is reasonably likely that cables/joints and surge arrestors will fail at this elevated voltage testing.

5.6 Addressing reliability degradation

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA), has played an important role in delivering current levels of reliability. It involves a combination of ACRs, Remote Control Gas Switches and feeder management relay operations, together with the use of adjacent feeders, to supply feeder sections downstream of a faulted section. This scheme is specific to AusNet Services and reflects an important difference between our network and that of Powercor Australia.

However, the current DFA algorithms are all based on a conventional Resistance Earthed System network, and are incompatible with the required change to a Resonant Earthed System network as REFCLs are installed. As a consequence, without an upgrade to the algorithms

(DFA2), the reliability outcomes on completion of each REFCL installation will degrade significantly.

AusNet Services' cost benefit analysis demonstrates that the costs of allowing a degradation in reliability significantly outweigh the costs of DFA2 and, therefore, the expenditure is justified in terms of economic efficiency. Furthermore, customers would be concerned if reliability degraded following the significant investment in REFCL technology, especially during periods of extreme heat.

The costs of DFA2 are not specific to each zone substation. Therefore, the costs are not included in this planning report, but are set out in the main body of the contingent project application.

5.7 Cost comparison with the Government's estimate in the RIS

To demonstrate the efficiency and prudency of our proposed expenditure, we must have regard to available benchmark information. In this instance, industry benchmarking is not available because the application of this technology for fire mitigation purposes is a world's first. In addition, the costs of installation are site-specific – which means that there is a potentially wide range of efficient and prudent installation costs across zone substations.

Despite these limitations, we note that the Regulatory Impact Statement (RIS) prepared by ACIL ALLEN for the Victorian Government in 2015 estimated costs for the REFCL installation program. The cost estimates were an important component of the RIS assessment, which considered the costs and benefits of introducing the bushfire mitigation regulations.

We note that ACIL ALLEN's cost estimates were prepared in 2015. Since then, we have developed location specific scopes of work, which have also been informed by experience gained at the REFCL installation at Woori Yallock zone substation. For these reasons, we have substantially more confidence in our cost estimates for WGI compared to the earlier ACIL ALLEN estimates, which were developed for a different purpose and which no longer reflect the best available information.

The table below provides a detailed explanation of the differences between our forecasts and ACIL ALLEN's estimates in the RIS. For some line items, the RIS did not provide a specific estimate for each zone substation. In these cases, we have presented the volume range set out in the RIS and commented on whether our forecast falls within this range.

Table 5: Reconciliation of AusNet Services' cost forecasts at WGI with the RIS cost estimates

Item	**AusNet Services forecast** $ 2016 direct	**RIS estimate**[3] $2015 direct	**Explanation**
Capex			

[3] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, 74 & 75. It should be noted that the RIS costs are expressed in $2015 while our costs are expressed in $2016. Strictly speaking, for comparison purposes the RIS costs are approximately 1.5 per cent higher than indicated here.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[3] $2015 direct	Explanation
Zone substation works	3,630k	1,800 – 4,895k[4] Including - REFCL, design, civil works, installation and commissioning; - Station lighting arrestors; -Station service transformers; -Station services low voltage transfer switch; and - Capacitor banks.	AusNet Services' zone substation works include the following additional items which were not included in the RIS estimate: neutral bus switchboard; REFCL control room; REFCL backup protection and interface control systems; REFCL testing including to prescribed requirements; and a community engagement plan.
ACRs replacement/upgrade	13 unit replacements @ cost of $63.2k per unit, producing a cost of $822k. 1 unit upgrade @ cost of $39.8k per unit, producing a cost of $39.8k.	RIS only provided an estimated volume range of 0-18 for each zone substation @ cost of $70k per unit, producing a cost estimate between $0 and $1,260k per zone substation.	AusNet Services' ACR replacement/upgrade unit cost is lower than the RIS estimate.
Network balancing	3,031k (see scope of work in 'explanation column')	RIS only provided an estimated volume range for conductor phase movements. Anticipated 0-85 for each zone substation @ cost of $4k per unit, producing a cost estimate between $0 and $340k per zone substation.	Significant increase in the scope and cost post the learnings of the WYK REFCL commissioning. This has led to an increased understanding of the least cost mix of work required to meet and maintain the prescribed sensitivity criteria in the Regulations. Field works required to meet the criteria which is world first involve: - 84 sites where conductor phase movements are required. - 1 site where third phase conductor is required to be unbonded. - Installation of 8 single phase balancing capacitors and 30 phase balancing capacitors; and - 52 sites where fuses are required to be removed and replaced with solid links.
Surge arrestors	1,912 unit replacements @ cost of $0.94k per unit, producing a cost of $1,796k.	RIS only provided an estimated volume range of 0-8,224 units for each zone substation @ cost of $1k per unit, producing a cost estimate between $0 and $8,224k per zone substation.	AusNet Services approach is to replace 40% of surge arrestors that sample testing has determined will not operate satisfactorily at elevated voltages. Cost forecast is lower than the average of the RIS estimate. 730 surge arrestor sites requiring replacement at $2,460 each, (equates to 1,912 surge arrestors units at $940 each).
Voltage regulators	387k	RIS only provided an estimated cost range of $0-375k for each zone substation.	Cost is higher than the RIS estimate. WGI network requires replacement of 1 line voltage regulator and upgrade of 1 line voltage regulator.

[4] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, Table 14 includes zone substation components.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[3] $2015 direct	Explanation
Total	*9,705k*	*5,744k*	The RIS estimate is specific to this zone substation, even though only cost ranges are provided in relation to the cost build up. The WGI total cost is higher than the RIS estimate for the reasons set out above. See further discussion below this table.
Code compliance	1,180k	152k[5]	One HV customer with one point of supply served from the WGI 22kV network.
Opex			
Pre fire season testing	55k	-	Not costed in the RIS estimate. Required to ensure the WGI network is operating to the prescribed criteria of the Regulations and vulnerabilities to overvoltage on the WGI network are exposed prior to the Declared Bushfire Season.
Equipment maintenance	6k	83k[6]	AusNet Services' equipment maintenance cost is lower than the RIS estimate.
Total	*62k*		

The table shows that a number of items were either not included in the RIS cost estimate, or were underestimated for the reasons noted in the table above. These variances reflect the level of understanding on the part of the government and the industry at the time the RIS was prepared.

The key areas of cost difference are zone substation works and network balancing. Additional zone substations works that were not included in the RIS estimate are:

- Neutral bus switchboard – required for effective year-round protection of the network, balancing bushfire risk reduction with network reliability requires multiple operating modes with differing earthing arrangements. A neutral bus switchboard facilitates these arrangements.
- REFCL control room – necessary as there is insufficient space in the existing control room and the inverter and secondary panels are larger than anticipated.
- REFCL backup protection and interface control systems – protection and control equipment must operate in several earthing fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Testing the REFCL – As part of the project commissioning it will be necessary to fully test the functionality of the REFCL ensuring that it is capable of operating to meet the Regulations. It involves the first instance of insulation and compliance testing to demonstrate the correct operation of the device and to comply with the ESV's reporting requirements.

[5] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 75, Table 20

[6] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 75, Table 20

- Community engagement plan - required due to the number of outages forecast for the community and the new network insulation tests, which in the short term are expected to have an unfavourable reliability experience for customers.

Additional network balancing works not included in the RIS estimate include:

- Work required to achieve the performance criteria in each automatic switching zone - involving a combination of additional works including, adding balancing capacitors, unbonding cable installations and adding a third phase conductor to balance each section. The RIS detailed phase rotations alone as the only network balancing cost, this will not achieve the required performance criteria of the Regulations.
- Works needed to maintain balance – including replacing fuses with solid links where fuse operation will lead to out of balance, potential non-compliance with the Regulations and possible REFCL mal operation.

As evidenced by the above table, AusNet Services has examined the cause of forecast expenditure differences to those presented in the RIS for the REFCL installation at WGI. The reconciliation to the Government's cost estimates provides further assurance that AusNet Services' cost forecasts are prudent and efficient.

It is also important to emphasise that the cost forecasts presented in this contingent project application reflect a detailed scope of work for each zone substation installation in accordance with the AER's 'trigger event' definition. As such, AusNet Services' forecasts are fully substantiated having regard to the actual conditions at each zone substation whereas the RIS estimate adopted a broader estimating approach that was unavoidably less comprehensive.

5.8 Why the proposed costs are efficient

This appendix has explained that:

- The proposed scope of station works at WGI is the lowest cost and risk option for addressing the specific issues at WGI;
- Our proposed replacements and upgrades of ACRs and line voltage regulators is consistent with our strategies in relation to these assets, which adopt a prudent and efficient replacement approach;
- Our replacement of surge arrestors reflects our strategy in relation to this asset, which is based on significant sample sizing and again a prudent and efficient replacement approach;
- Our network balancing work is consistent with our strategy in relation to these works, which is focused on achieving the required capacitive balance at the lowest cost in each automatic switchable section of the 22kV network;
- We have considered non-network options and the substitution possibilities between capital and operating expenditure.
- We have employed our standard approach to project cost estimation;
- The key assumptions underpinning our forecasts are reasonable;
- We have identified the key risks in relation to the REFCL installation at WGI and taken appropriate risk mitigation measures; and
- Our projected costs are within the Government's estimated range in the RIS. More importantly, we have reviewed our cost estimates on a line-by-line basis, explaining the reasons for any differences compared to the RIS estimates and highlighting gaps in the scope of work assumed in the RIS.

In addition, it should be noted that our forecast expenditure for the REFCL installation at WGI has been subject to our standard business case review and approval processes. The project will also be subject to our project management and governance arrangements.

For these reasons, we regard the forecast expenditure at WGI as prudent and efficient, in accordance with the Rules requirements relating to contingent projects.

5.9 Supporting documents

Supporting documents to be provided as part of this submission:

- REF 10-04 REFCL Program Equipment Building Block Functional Description;
- Operational Requirements;
- REF 70-11 REFCL Operating Mode Policy;
- REF 30-04 REFCL Arc Suppression Coil Sizing;
- REF 20-08 Automatic Circuit Recloser Strategy;
- REF 20-06 Network Balancing Strategy; and
- REF 20-07 Line Hardening Strategy.

Appendix 6 – Seymour Zone Substation REFCL Planning Report

6.1 Purpose

The purpose of this appendix is to demonstrate that the forecast capital expenditure and incremental operating expenditure to install the mandated REFCL technology at Seymour (SMR) zone substation are prudent and efficient. In doing so, this appendix highlights the specific issues at SMR zone substation that influence the design and cost of the REFCL installation at this location.

A number of supporting documents are listed in section 6.10, which provide further information on the strategies that underpin our forecast expenditure, and detail why these strategies and cost estimates are prudent and efficient. This appendix should therefore be read in conjunction with the supporting documents listed in section 6.10.

As explained in Chapter 1 of this contingent project application, the installation of REFCLs at selected zone substations is the only engineering solution that is capable of complying with the performance standards mandated by the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

SMR zone substation is located in the town of Seymour approximately 100km north of Melbourne. This zone substation was established in the 1950s and supplies the town and surrounding areas including the substantial Puckapunyal military army base, which is a HV customer connected via two 22kV points of supply. The station supplies 10,395 customers by means of two transformers and six distribution feeders. The SMR 22kV feeders cover a total route length of 1,006km. The 22kV network includes 29 automatic switchable sections.

The estimated total capacitance of the SMR 22kV network is 151 (A) or 156 (A) including existing automatic transfer feeders. The capacitance will increase to 276 (A) with the planned Puckapunyal network undergrounding.

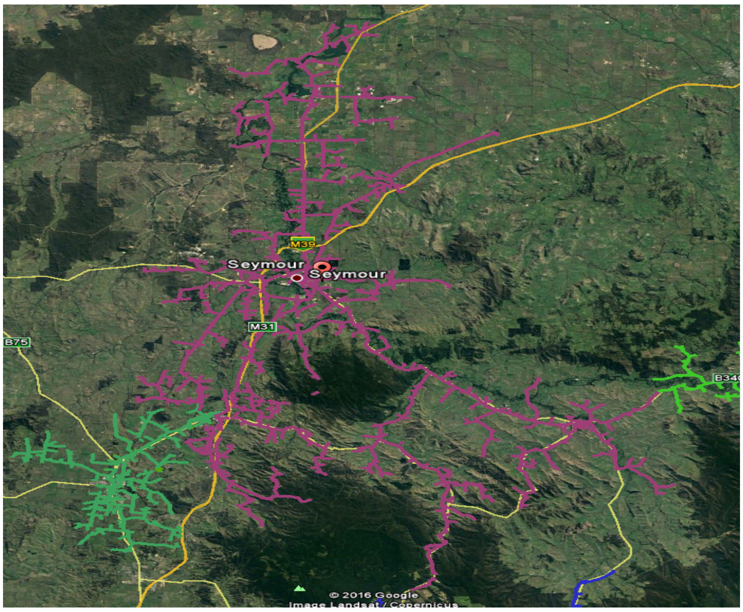

Figure 1-1: SMR 22kV feeders shown above in Purple.

6.2 Key issues and challenges at SMR

The key issues impacting the installation of a REFCL at SMR is the capacitance of the network, planned replacement of the existing power transformers and 66 kV switchgear, condition of existing physical infrastructure, lack of available physical space at the site and required modifications to the existing 22kV capacitor banks.

The SMR 22kV network feeders include 24km of underground cable and 3km of Aerial Bundled Cable which results in high capacitance (156 (A)). The Regulations state fault current must be limited to 0.5 (A) or less. WYK testing has confirmed for each REFCL the capacitance they serve must be limited to 150 (A) at a maximum driving the need for two REFCLS to serve an equal amount of capacitance and no more than 150 (A) at a maximum.

Further, the Australian Army base at Puckapunyal has an extensive 36 km embedded network[1] and the Army has commenced a project to underground this network. Undergrounding this network will add 120 (A) of capacitance resulting from the use of cable and would bring forward the installation of a third REFCL at SMR. SMR currently requires two transformers to supply the load and to provide supply security. The installation of a third REFCL would require the installation of a third transformer. As the Puckapunyal army network will be undergrounded, there is no fire risk presented by this network. Therefore, to defer the installation of a third REFCL and power transformer, two isolating transformers will be installed on each of the feeders (SMR1 and SMR4) supplying the army base. The installation of isolating transformers also achieves compliance with the Victorian Electricity Distribution Code obligations regarding voltage variations at HV customers' points of supply.

Current plans are in place to replace the existing aged equipment at SMR including the three power transformers, 66 kV switchgear, control building and associated protection works. The project to replace this equipment, which was identified in AusNet Services' 2016-20 EDPR program, was timed to commence in 2019 with construction in 2020. As substantial works are required at the site to install REFCLs, the planned asset replacement project will be brought forward and will run concurrently with the installation of REFCLs. All works remunerated through the 2016-20 EDPR are excluded from this contingent project application.

Outdoor 22 kV switchgear is currently installed at SMR. Replacement of the switchgear was not included in the scope of the 2020 replacement project. In addition, insufficient space exists at the site to install the required two REFCLs and achieve acceptable access to the site for ongoing operation and maintenance. Therefore, it will be necessary to replace the outdoor switchgear with indoor compact switchgear to make enough space available to install the REFCLs and associated equipment.

SMR zone substation has two 22kV capacitor banks. The capacitor banks must be modified to be compatible with REFCL operation. The consequence of not modifying the capacitor banks means REFCL operation will lead to equipment failure from dangerous voltages placing customer supply and safety at risk.

The need to modify capacitor banks in 'earthed star' configuration was noted in the REFCL trial report, explaining that the earth connection must be removed from the star point and protection systems modified accordingly[2].

6.3 Scope of work

The scope of work to install two REFCLs at SMR involves:

- Zone substation works;
- Compatible works, including:
    - Replacement of 8 ACRs installed on a SMR feeder; and

1 This network also supplies a small number of AusNet Services' customers from a single substation fed from an underground cable.

2 REFCL Trial: Ignition Tests, Marxsen Consulting Pty Ltd, Monday 4 August 2014, page 94.

- Replacement or upgrade of 3 line voltage regulators on SMR feeders.

- Network balancing;
- Line hardening, which requires the replacement of surge arrestors installed on feeders; and
- Victorian Electricity Distribution Code compliance, which requires the installation of isolating transformers on the two feeders supplying Puckapunyal Army Base (22kV HV customer).

Each of these activities is discussed in turn below, as follows:

- Section 6.3.1 – Zone substation works; and
- Section 6.3.2 – Line works, which addresses the remaining four workstreams.

6.3.1 Zone substation works and options analysis

The proposed REFCL installation at SMR will involve a number of activities that are common to most Tranche 1 zone substation REFCL installations. These include:

- Specification, procurement and installation of a Ground Fault Neutraliser (GFN), including an Arc Suppression Coil (ASC), Residual Current Compensation (RCC) and control system. In SMR's case, two GFNs are required.
- Specification, procurement and installation of two neutral bus switchboards. The introduction of the GFN requires a neutral bus which enables different earthing arrangements to be automatically configured. The switchboard facilitates remote year round selection of earthing arrangements and operating modes. Provides the ability to balance bushfire risk reduction with network reliability, depending on network and weather conditions.
- Upgrade of the existing station service transformers and changeover boards. This work is required because the alternating current (AC) supply requirement dramatically increases due to the GFN installation.
- Testing and potential replacement of cable equipment, which are at risk of failure if operated at elevated voltages.
- Replacement and extension of existing protection and control equipment with equipment capable of operating in several modes, including resonant earthing and traditional earth fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Prior to commissioning the GFN, network hardening tests involve the process of lifting voltages (using the GFN) in a healthy three phase powerline network (phase by phase) to check network readiness for future states of REFCL operation. During this activity there is an increased likelihood of asset failures. We would replace any assets that fail during the testing process. These tests are necessary to ensure the GFN can operate without causing line and station equipment to fail resulting in a fire start. These tests are conducted in times of low fire risk to mitigate the likelihood of failure in the Declared Bushfire Season.
- Installation of monitoring equipment to demonstrate compliance with regulations and enable remote engineering access to control systems.

Further information on these works is provided in the following supporting document:

- REF 10-04 REFCL Program Equipment Building Block Functional Description

The additional specific work required at SMR involves:

- Work associated with converting the zone substation into a station capable of operating with multiple REFCLs. This required work includes civil foundations for neutral bus switchgear, station service transformer and REFCL equipment and earthing.
- Replacement of the three existing 66/22 kV power transformers with two new transformers, replacement of the 66 kV switchgear. This component of work is the first stage of the planned staged replacement of assets at SMR due to commence in 2019. The cost of this work is not included in this contingent project application as shown in the section 6.9. (Further information on the staged replacement of assets at SMR is available in AMS 20-258 Planning Report Project 74396063 – Seymour zone substation rebuild[3].)
- Modification to the earthing arrangements of the two existing capacitor banks to enable operation of the resonant earthing required during REFCL operation, including the relocation of capacitor bank No.1.
- Construction of a combined 22 kV switchroom and control room using tilt slab construction to house all 22 kV switchgear and control systems. Replacement of the existing 22 kV switchgear (not included in the re-build) is necessary to make sufficient space available on site to install REFCL equipment. The existing control room cannot be economically reused or extended as it is constructed of asbestos panelling and is in poor condition.
- Replacement of cables internal to the zone substation site and feeder exit cables to serve the new 22kV switchroom.
- Installing a REFCL control room to house REFCL associated protection, control, and indoor auto-change over board.
- In relation to network hardening tests on the SMR 22 kV network prior to commissioning the GFN, our expectation is that there is a reasonable likelihood that some surge arrestors, insulators, pole top transformers and/or cables may fail and require replacement.
- Development and execution of a community engagement plan for works associated with the SMR network REFCL implementation. Community engagement is required to explain the likely customer reliability impact during the new network insulation tests. The importance of effective community engagement has been highlighted by the Woori Yallock REFCL implementation in September 2016, which led to issues being raised by customers, media, the community and the Victorian Parliament.

Before determining our preferred scope of work at SMR, we considered 4 planning options:

1. Install REFCL equipment (two units), construct tilt slab 22 kV switchroom/control room, and replace existing power transformers and 66 kV switchgear as an integrated project (our preferred option, as described above);
2. Install REFCL equipment and two 22 kV switchboards and delay replacement of power transformers and 66 kV switchgear until 2020;
3. Install REFCL equipment and replace 22 kV switchgear using Air Insulated Switchgear (AIS), and replace existing power transformers and 66 kV switchgear as an integrated project;
4. Install REFCL equipment, two standard modular 22 kV switchboards and replace existing power transformers and 66 kV switchgear as an integrated project.

[3] AMS 20-258 was submitted to the AER as a document supporting AusNet Services' 2016-20 EDPR submission.

In developing these options, AusNet Services considered non-network options and substitution possibilities between operating and capital expenditure. In relation to the zone substation works, there were no identified non-network options or substitution possibilities, other than those inherent in the above options.

In addition, the option of extending the existing site was not formally evaluated as the existing site is constrained on all four sides; by roads on two sides and abutting residential properties on the other two sides.

The option of redeveloping the station on an alternative site was also not formally evaluated as it is more expensive that the preferred option.

A summary of our analysis in relation to each of these options is shown in Table 1.

Table 1: Options evaluated

Option	Advantages	Disadvantages
1. Install REFCL equipment (two units), construct tilt slab 22 kV switchroom /control room and replace power transformers and 66 kV switchgear as an integrated project (preferred option).	Can be undertaken on the current site. Tilt slab building is more compact than separate control rooms and switchrooms. Reduced timeframe for construction as new switchroom can be installed before old switchgear is retired. Better access during and after construction (safer and more secure). Less civil works (benching) required to provide flat land for plant installation. Improves supply security (compared to Option 2) as major works are only undertaken on the site once. Least cost option at $9,691k.	Additional design effort required for tilt slab building. Small increase in NPCost (over Option 2) as power transformers and 66 kV switchgear is replaced earlier than originally planned. Tilt slab building is not relocatable; cannot be reused at other sites if switchgear or protection systems are no longer required.
2. Install REFCL equipment (two units) and two 22 kV switchboards. Defer replacement of power transformers and 66 kV switchgear.	Minimises on-site work required to deliver operating REFCL. Extends useful life of existing assets by one year.	Installation of REFCLs on site prior to removal of 3 existing transformers (and replacement with 2 transformers) does not release sufficient land to enable construction to occur. i.e. this option is not feasible. Option is more expensive $10,036k.

Option	Advantages	Disadvantages
3. Install REFCL equipment and replace 22 kV switchgear using Air Insulated Switchgear (AIS), and replace existing power transformers and 66 kV switchgear as an integrated project.	Marginally cheaper than preferred option.	Control room and additional items barely fit on site. Cabling may not be possible. Adequate access for ongoing maintenance and construction cannot be provided. Additional site work (benching & retaining walls) required to create flat land for plant. Eliminates future option to install indoor switchgear (which is the industry standard). For the above reasons this option was not considered feasible.
4. Install REFCL equipment, two standard modular 22 kV switchboards and replace existing power transformers and 66 kV switchgear as an integrated project.	Standard pre-fabricated switchboards utilise standard design and are constructed and pre-commissioned before delivery to site.	At least $360k more expensive than Option 1 (preferred option). (Could be more as the need for additional walls/benching has not be fully assessed.) Second switchroom requires part of existing 22 kV yard to be retired leading to staged construction, longer elapsed time, and increased reliability risk. Access to buildings after construction is limited and may require development of a permanent second access way to the site (increasing cost and reducing site security).

It is evident from the above table that Option 3 is not feasible, while Option 1 is the appropriate planning solution because it has:

- Lower cost than Options 2 and 4;
- Can be delivered on the existing site compared to Option 2 and 3;
- Can be delivered in the required timeframe compared to Option 4; and
- Provides reasonable access for ongoing operations and maintenance compared to Options 2, 3 and 4.

6.3.2 Line works

The scope of works outside the zone substation involves the following work on the SMR network:

- Replacement of 8 Automatic Circuit Reclosers (ACRs);
- Balancing 29 automatic switching zones – this involves:
    - 87 sites where phases are rotated;

  - 1 site where third phase conductor is required to be installed;
  - 3 sites where the third phase of cable must be unbonded;
  - The installation of 18 single phase balancing capacitors and 28 three-phase balancing capacitors; and
  - The replacement of 29 fuse sites required to be replaced with solid links;
- Replacement of surge arresters at 835 sites distributed across the feeders;
- Upgrade of 3 line voltage regulators on SMR feeders; and
- Installation of 2 isolating transformer solutions at the Puckapunyal Army base points of supply.

ACRs are currently used to detect 'downstream' faults and to interrupt supply to the faulted feeder section, thereby minimising the number of customers who experience a supply interruption due to a fault. The existing ACRs are not capable of:

- detecting the low fault currents that will occur with REFCL operation; and
- identifying faults and the affected section of the feeder when earthing arrangements are altered at the zone substation (i.e. when the REFCL is switched onto the network). This inability leads to a larger number of customers being affected in the event of a sustained fault on a REFCL network and spurious tripping of ACRs on unaffected healthy feeders when the REFCL operates.

ACRs will therefore be upgraded or replaced so that they can detect low fault currents along with any changes to the earthing arrangement at the zone substation, this will ensure in the event of a fault customer outage numbers are minimised and healthy feeders are not tripped with REFCL operation.

Equally important as the ACR works is the capacitive balancing of the SMR 22kV network. Network capacitance must be balanced for REFCLs to operate. AusNet Services will undertake network balancing on each 'automated switching zone' where an automated switching zone is a feeder section delineated by ACRs, sectionalisers and/or circuit breakers. Balancing switching zones involves a combination of works including, phase transpositions, adding balancing capacitors, unbonding cable installations, removing fuses and adding a third phase conductor to balance each section. A combination of this work involving the least cost for each switching zone will be undertaken.

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA) involves a combination of ACR and sectionaliser operations plus the use of adjacent feeders to supply feeder sections downstream of a faulted section. This scheme is currently used to provide network reliability. DFA will only operate with REFCLs where each switching zone is capacitively balanced and ACR works are completed.

As well as network balancing works, type testing of surge arrestors has been undertaken to determine the types which cannot withstand the elevated voltages that result from REFCL operation. Failure of these types can lead to ground fire ignition and therefore their replacement is essential to prevent fire ignition during REFCL operation. A survey of the feeders has identified 835 sites with incompatible surge arrestors and these will be replaced with a standard surge arrestor with adequate ratings for REFCL operation.

Finally, line voltage regulators (typically open delta configuration) have been the lowest cost option to regulate voltage on 22kV long rural feeders. Unfortunately they are not compatible with REFCL technology as they displace the system neutral voltage by regulating only two phases (line-to-line voltages), rather than regulating all three phases. As a result these regulators will need to be replaced on REFCL affected feeders.

Separately, all line voltage regulators with two phase controllers will need to be upgraded to a three phase controller ensuring voltages across all three 22kV phases remains consistent and voltage variations between the phases is avoided.

The elevated voltages in the event of a single phase fault also raise compliance issues in relation to the Victorian Electricity Distribution Code. In particular, clause 4.2.2 of the Code sets out the maximum permissible variation in nominal voltages at the point of supply to each HV customer's electrical installation. AusNet Services must install 2 isolating transformers at SMR to ensure that the voltage variation at each Punckapunyal army base points of supply comply with this Code provision.

Isolating the Puckapunyal army base underground network will also eliminate the future need for the installation of a third REFCL and power transformer to be installed at SMR. The installation of the two isolating transformers located at the army base' points of supply, separates the forecast capacitance of the installation (120(A)). This option is significantly cheaper than installing a third transformer and third REFCL at SMR.

In scoping the above line works, AusNet Services has considered whether there are any non-network options or substitution possibilities between operating and capital expenditure. The nature of the required works at SMR is such that there are no non-network options or opportunities to substitute operating activities for the proposed capital works.

Further detail on the need for replacement and/or upgrade of ACRs, network balancing, surge arrester replacement and replacement/upgrade of line voltage regulators is available in:

- REF 20-08 Automatic Circuit Recloser Strategy
- REF 20-06 Network Balancing Strategy
- REF 20-07 Line Hardening Strategy
- REF 20-09 Line Voltage Regulator Strategy

6.3.3 Operational costs

In addition to the capital works described above, incremental ongoing operational costs will result from REFCL installation. Operational costs not specific to this site location are contained in the Operational Expenditure Requirements - Tranche 1 (REF 70-10) document. Operational costs that are either specific to SMR or vary by zone substation include:

- A number of new or expanded devices will be installed at SMR as a result of the REFCL installation including REFCL equipment, auto-changeover board, station services and line balancing capacitor units. As these items are new they are unlikely to require material additional maintenance, however they will require routine inspection.
- Prior to each fire season it will be necessary to fully test the functionality of the REFCL to ensure that it is capable of operating to meet the Regulations. This will involve annual insulation and compliance tests to demonstrate the correct operation of the device together with ESV reporting.

Table 2: Forecast incremental operational costs

Activity	Frequency	Calendar Year Cost $		
		18	19	20
Maintain additional equipment	Annual	-	6,308	6,308
Pre fire season testing (insulation and	Annual	-	55,484	55,484

compliance testing)				

6.4 Key assumptions, risks and mitigation strategies

The key assumptions and risks made in forecasting the cost of REFCL installation at SMR are shown in Table 3 below.

Table 3: Key assumptions, risks and mitigation strategies

Assumption or Risk	Impact	Mitigation
Customers adversely affected by outages due to failure of equipment operating at higher than design voltages.	Extended customer outages e.g. cable failures. S-factor & GSL impacts.	Assets which are not compatible with REFCL such as surge arrestors and ACRs replaced prior to testing. Critical cables tested. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the SMR network.
Customers adversely react to the number of outages required to deliver the REFCL works on the SMR network.	Repeat customer outages lead to customer and community frustration e.g. outages for line, station and REFCL testing works.	Where possible, the co-ordination of work outages to minimise impact on the community.
High Voltage (HV) customer (s) adversely affected by outages due to failure of their equipment operating at higher than design voltages.	Extended outage or safety incident for HV customer, caused by underrated equipment failures. Loss of production and potential health and/or safety impacts. AusNet Services would need to undertake substantial work with each HV customer to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes. A change to the Distribution Code would also be required.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision and meets the mandated timeframe. At SMR, the isolation transformer installations also defer the future need for the third GFN and power transformer due to the capacitance of the planned Puckapunyal army base undergrounding.

Assumption or Risk	Impact	Mitigation
Operation of the REFCL would lead to voltage levels that are outside the allowable range specified in the Victorian Electricity Distribution Code (the Code).	Unless the Code is changed, operation of the REFCL would lead to non-compliance with our obligations. The Essential Services Commission has made it clear that it does not intend to amend the Victorian Distribution Code to address the voltage variation issue[4].	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.
Scope of HV customer works and funding mechanism unclear.	Delays in a suitable funding mechanism and/or work completion for HV customers could delay the project resulting in additional costs and fines due to project delays and failure to have the REFCL in service ahead of the 2017/18 fire season, and April 2019 compliance date. AusNet Services would need to undertake substantial work with HV customers to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision and meets the mandated timeframe. At SMR, the isolation transformer installations also defer the need for the third GFN and power transformer due to the capacitance of the planned Puckapunyal Army Base undergrounding.
The planned replacement of power transformers and 66 kV switchgear will be brought forward to be undertaken concurrently with the REFCL installation.	Larger project with more complexity. Improved supply security as major works at station only undertaken once.	Project development plans in place.
The Puckapunyal army base will make land available for the isolating transformers.	The REFCLs at SMR will have insufficient capacity unless the Army network is isolated.	Early approach to the Army to make suitable land available for the isolating transformers.
Resource is available to undertake additional design required for combined 22 kV switchroom and control room.	Design delay could lead to commissioning delays.	Utilise existing panel of design service providers (DSPs) to provide additional resources.

4 Essential Services Commission, Electricity Distribution Code Compliance and REFCLs, letter to Hannah Williams, Powercor, dated 7 February 2017.

Assumption or Risk	Impact	Mitigation
The Puckapunyal army base will proceed with undergrounding its network.	Fire risk at Puckapunyal not mitigated if the network is isolated and HV remains bare overhead wire.	Army appears fully funded and committed to project. Maintain regular communications with Army to ensure project is progressing.
Proximity to live assets during construction.	The project involves brownfield works to be carried out in the midst of an in-service zone substation. This will result in risk associated with the close proximity of live overhead and underground assets to employees, contractors and mobile plant.	Access permit conditions will clearly specify the requirements to ensure safety whilst work is being carried out in the station. Controls will be required for site induction and earth potential rise under fault conditions.
Sole supplier delivers GFN product to required standard.	Failure to have the GFN operating by 30 April 2019 will incur a one off civil penalty of $10M, and a fine of $5,500 for each day the criteria is not met after that date.	Develop and monitor strategic spares for the GFN product. Engage and invest in the relationship with GFN supplier. Seek an alternative REFCL supplier that can meet performance criteria of the Regulations. SMR costing has no allowance for sole supplier risk.
SMR network can be capacitively balanced, achieving the world first performance criteria of the Regulations.	Accurate network balance is essential if the performance criteria are to be met. To date these criteria have been achieved in one instance on a 40km network at Kilmore South. Failure to meet the performance criteria by 30 April 2019 will incur a one off civil penalty of $10M, and a fine of $5,500 for each day the criteria is not met after that date.	Extensive survey, design and modelling work is required. Works must ensure all material capacitive imbalances are accounted for on the SMR network.

6.5 Project scope and cost allocation

This contingent project application includes the costs of works necessary for REFCL operation. The installation of REFCLs and associated equipment is to be undertaken in conjunction with a planned replacement of some SMR assets. The split of costs between the two projects is shown in the table below. The costs associated with the activities in the 'REFCL' column are included in this contingent project application and the costs associated with the activities in the 'Rebuild' column are excluded.

Table 4: Cost allocation split

REFCL	Rebuild

REFCL	Rebuild
Relocate and modification of No.1 cap bank	Control room (building and panels, excluding REFCL related components)
22kV switchroom (building and two switchboards, any associated earth works)	66kV/22kV Transformers
Control panels and percentage of control building (REFCL components only)	66kV yard works
Ground fault neutralisers	Neutral Earthing Resistor (NER)
Neutral bus switchboards	Battery room (building and components)
Station service transformers	Environmental water treatment system
415V A/C changeover boards	Amenities room
22kV cables and feeder exit works	Cable trenches
Cap bank No.2 Modifications	

6.6 Total costs for SMR Zone Substation

The total forecast costs to install a REFCL at SMR are shown in Table 5.

Table 5: Forecast costs

Item	**Cost** $000s 2016 direct
Capex	
Zone substation works, network hardening testing (elevated voltage testing) and REFCL commissioning	9,691
Replacement of 8 ACRs that is not capable of detecting low fault currents or automatically blocking conventional earth protection during REFCL operation.	506
Network balancing – Rotating phases, additional third phase at a 1 location, unbonding cable at 3 locations, installing single and three phase capacitors and replacing fuses with solid links.	3,412
Replacement of 2,187 units at 835 surge arrestors sites that present a risk of failure (and fire ignition) during REFCL operation	2,054
Upgrade of 3 line voltage regulator not compatible with REFCL operation.	141
Total	*15,804*
Code compliance and future deferral of third GFN - the installation of 2 isolating transformer solutions to ensure that AusNet Services maintains compliance with the maximum permissible voltage variations specified in the Victorian Distribution Code. The 2 isolating transformers also isolate the downstream capacitance of the Puckapunyal army base deferring the need for a third GFN and power transformer installation at	2,361

Item	Cost $000s 2016 direct
Seymour Zone Substation.	
Opex	
Pre fire season testing including insulation and compliance testing.	111
Equipment maintenance.	13
Total	*124*

The capex costs have been prepared using AusNet Services' standard project cost estimating approach. The capital costs associated with zone substation equipment installation, replacement of an ACR and replacement of surge arrestors are reasonably certain. i.e. they carry the same level of uncertainty as routine projects such as zone substation construction or rebuilds.

The total capex cost at SMR is higher than other tranche one zone substations driven by a range of factors as described above. These include:

- SMR is a large network with a large number of customers. This is reflected in the increased costs for surge arrestor and ACRs when compared to other tranche one zone substations.
- SMR has a large number (29) of automatic switchable sections that require to be balanced. SMR also has the largest amount of 22kV single phase network (459km) within tranche one requiring balancing. This is reflected in increased costs for network balancing when compared to zone substations in tranche one.
- SMR zone substation has insufficient space at the site to install the required two REFCLs and achieve acceptable access to the site for ongoing operation and maintenance. Therefore it will be necessary to replace the outdoor switchgear with indoor compact switchgear to make enough space available to install the REFCLs. This coupled with the need for two REFCLs at SMR is reflective of increased zone substation costs at this site.

Uncertainties in forecast capital costs primarily arise from performance of the REFCL, the extent of network balancing required and community reaction to the installation and testing works. An allowance of $68,955 has been included in the zone substation works for network insulation testing activities. This cost is based on 3 days to complete this activity, anticipating 1 fault per day of testing. Each fault has been attributed a cost of $5,467 using established contractor rates. Based on insulation testing carried out to date, it is reasonably likely that cables/joints and surge arrestors will fail at this elevated voltage testing.

6.7 Addressing reliability degradation

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA), has played an important role in delivering current levels of reliability. It involves a combination of ACRs, Remote Control Gas Switches and feeder management relay operations, together with the use of adjacent feeders, to supply feeder sections downstream of a faulted section. This scheme is specific to AusNet Services and reflects an important difference between our network and that of Powercor Australia.

However, the current DFA algorithms are all based on a conventional Resistance Earthed System network, and are incompatible with the required change to a Resonant Earthed System network as REFCLs are installed. As a consequence, without an upgrade to the algorithms

(DFA2), the reliability outcomes on completion of each REFCL installation will degrade significantly.

AusNet Services' cost benefit analysis demonstrates that the costs of allowing a degradation in reliability significantly outweigh the costs of DFA2 and, therefore, the expenditure is justified in terms of economic efficiency. Furthermore, customers would be concerned if reliability degraded following the significant investment in REFCL technology, especially during periods of extreme heat.

The costs of DFA2 are not specific to each zone substation. Therefore, the costs are not included in this planning report, but are set out in the main body of the contingent project application.

6.8 Cost comparison with the Government's estimate in the RIS

To demonstrate the efficiency and prudency of our proposed expenditure, we must have regard to available benchmark information. In this instance, industry benchmarking is not available because the application of this technology for fire mitigation purposes is a world's first. In addition, the costs of installation are site-specific – which means that there is a potentially wide range of efficient and prudent installation costs across zone substations.

Despite these limitations, we note that the Regulatory Impact Statement (RIS) prepared by ACIL ALLEN for the Victorian Government in 2015 estimated costs for the REFCL installation program. The cost estimates were an important component of the RIS assessment, which considered the costs and benefits of introducing the bushfire mitigation regulations.

We note that ACIL ALLEN's cost estimates were prepared in 2015. Since then, we have developed location specific scopes of work, which have also been informed by experience gained at the REFCL installation at Woori Yallock zone substation. For these reasons, we have substantially more confidence in our cost estimates for SMR compared to the earlier ACIL ALLEN estimates, which were developed for a different purpose and which no longer reflect the best available information.

The table below provides a detailed explanation of the differences between our forecasts and ACIL ALLEN's estimates in the RIS. For some line items, the RIS did not provide a specific estimate for each zone substation. In these cases, we have presented the volume range set out in the RIS and commented on whether our forecast falls within this range.

Table 6: Reconciliation of AusNet Services' cost forecasts at SMR with the RIS cost estimates

Item	AusNet Services forecast $ 2016 direct	RIS estimate[5] $2015 direct	Explanation
Capex			

[5] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, 74 & 75. It should be noted that the RIS costs are expressed in $2015 while our costs are expressed in $2016. Strictly speaking, for comparison purposes the RIS costs are approximately 1.5 per cent higher than indicated here.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[5] $2015 direct	Explanation
Zone substation works	9,691k	1,800 – 4,895k[6] Including - REFCL, design, civil works, installation and commissioning; - Station lighting arrestors; -Station service transformers; -Station services low voltage transfer switch; and - Capacitor banks.	AusNet Services' zone substation works include the following additional items which were not included in the RIS estimate: neutral bus switchboard (2 of); REFCL control room; REFCL backup protection and interface control systems; REFCL testing including to prescribed requirements; community engagement plan and 22kV switchgear replacement allowing space available at the site.
ACRs replacement	8 unit replacements @ cost of $63.2k per unit, producing a cost of $506k.	RIS only provided an estimated volume range of 0-18 for each zone substation @ cost of $70k per unit, producing a cost estimate between $0 and $1,260k per zone substation.	AusNet Services' ACR replacement unit cost is lower than the RIS estimate.
Network balancing	3,412k (see scope of work in 'explanation column')	RIS only provided an estimated volume range for conductor phase movements. Anticipated 0-85 for each zone substation @ cost of $4k per unit, producing a cost estimate between $0 and $340k per zone substation.	Significant increase in the scope and cost post the learnings of the WYK REFCL commissioning. This has led to an increased understanding of the least cost mix work required to meet and maintain the prescribed sensitivity criteria in the Regulations. Field works required to meet the criteria which is world first involve: - 87 sites where conductor phase movements are required; - 1 site where third phase conductor is required to be installed; - 3 sites where third phase conductor is required to be unbonded; - Installation of 18 single phase balancing capacitors and 28 three phase balancing capacitors; and - 29 expected sites where fuses are required to be removed and replaced with solid links.
Surge arrestors	2,187 unit replacements @ cost of $0.94k per unit, producing a cost of $2,054k.	RIS only provided an estimated volume range of 0-8,224 units for each zone substation @ cost of $1k per unit, producing a cost estimate between $0 and $8,224k per zone substation.	AusNet Services approach is to replace the 40% of surge arrestors that sample testing has determined will not operate satisfactorily at elevated voltages. Cost forecast is lower than the average of the RIS estimate. 835 surge arrestor sites requiring replacement at $2,460 each, (equates to 2,187 surge arrestors units at $940 each).

[6] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, Table 14 includes zone substation components.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[5] $2015 direct	Explanation
Voltage regulators	141k	RIS only provided an estimated cost range of $0-375k for each zone substation.	Cost is within the range of the RIS estimate. SMR network requires upgrade of 1 line voltage regulator.
Total	*15,804k*	*9,177[7]k*	The RIS estimate is specific to this zone substation, even though only cost ranges are provided in relation to the cost build up. The SMR total cost is higher than the RIS estimate for the reasons set out above. See further discussion below this table.
Code compliance & deferral of third REFCL installation.	2,361k	192k[8]	One HV customer with two points of supply served from the SMR 22kV network.
Opex			
Pre fire season testing	111k	-	Not costed in the RIS estimate. Required to ensure the SMR network is operating to the prescribed criteria of the Regulations and vulnerabilities to overvoltage on the SMR network are exposed prior to the Declared Bushfire Season.
Equipment maintenance	13k	113k[9]	AusNet Services' equipment maintenance cost is lower than the RIS estimate.
Total	*124k*		

The table shows that a number of line items were either not costed in the RIS or underestimated for the reasons already noted in the table above. These variances arise due to the level of understanding by both government and industry at the time the RIS was prepared.

The key areas of cost difference are zone substation works and network balancing. Additional zone substations works that were not included in the RIS estimate are:

- Neutral bus switchboard – required for effective year-round protection of the network, balancing bushfire risk reduction with network reliability requires multiple operating modes with differing earthing arrangements. A neutral bus switchboard facilitates these arrangements.
- REFCL control room – necessary as there is insufficient space in the existing control room and the inverter and secondary panels are larger than anticipated.
- REFCL backup protection and interface control systems – protection and control equipment must operate in several earthing fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Testing the REFCL – As part of the project commissioning it will be necessary to fully test the functionality of the REFCL ensuring that it is capable of operating to meet the Regulations. It involves the first instance of insulation and compliance testing to

[7] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 75, Table 20

[8] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 75, Table 20

[9] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 75, Table 20

demonstrate the correct operation of the device and to comply with the ESV's reporting requirements.

- Community engagement plan - required due to the number of outages forecast for the community and the new network insulation tests, which in the short term are expected to have an unfavourable reliability experience for customers.
- 22kV switchgear replacement - Outdoor 22 kV switchgear is currently installed at SMR. Insufficient space exists at the site to install the required two REFCLs and achieve acceptable access to the site for ongoing operation and maintenance. Therefore it will be necessary to replace the outdoor switchgear with indoor compact switchgear to make enough space available to install the REFCLs.

Additional network balancing works not included in the RIS estimate include:

- Work required to achieve the performance criteria in each automatic switching zone - involving a combination of additional works including, adding balancing capacitors, unbonding cable installations and adding a third phase conductor to balance each section. The RIS detailed phase rotations alone as the only network balancing cost, this will not achieve the required performance criteria of the Regulations.
- Works needed to maintain balance – including replacing fuses with solid links where fuse operation will lead to out of balance, potential non-compliance with the Regulations and possible REFCL mal operation.

As evidenced by the above table, AusNet Services has examined the cause of forecast expenditure differences to those presented in the RIS for the REFCL installation at SMR. The reconciliation to the Government's cost estimates provides further assurance that AusNet Services' cost forecasts are prudent and efficient.

It is also important to emphasise that the cost forecasts presented in this contingent project application reflect a detailed scope of work for each zone substation installation in accordance with the AER's 'trigger event' definition. As such, AusNet Services' forecasts are fully substantiated having regard to the actual conditions at each zone substation whereas the RIS estimate adopted a broader estimating approach that was unavoidably less comprehensive.

6.9 Why the proposed costs are efficient

This appendix has explained that:

- The proposed scope of station works at SMR is the lowest cost option for addressing the specific issues at SMR;
- The installation of isolating transformers at the Puckapunyal Army Base is more efficient than the option of installing a third power transformer and REFCL at SMR;
- Our proposed replacements and upgrades of ACRs and line voltage regulators is consistent with our strategy in relation to these assets, which adopts a prudent and efficient replacement approach;
- Our replacement of surge arrestors reflects our strategy in relation to this asset, which is based on significant sample sizing and again a prudent and efficient replacement approach;
- Our network balancing work is consistent with our strategy in relation to these works, which is focused on achieving the required capacitive balance at the lowest cost in each automatic switchable section of the 22kV network;
- We have considered non-network options and the substitution possibilities between capital and operating expenditure.
- We have employed our standard approach to project cost estimation;

- The key assumptions underpinning our forecasts are reasonable;
- We have identified the key risks in relation to the REFCL installation at SMR and taken appropriate risk mitigation measures; and
- Our projected costs are within the Government's estimated range in the RIS. More importantly, we have reviewed our cost estimates on a line-by-line basis, explaining the reasons for any differences compared to the RIS estimates and highlighting gaps in the scope of work assumed in the RIS.

In addition, it should be noted that our forecast expenditure for the REFCL installation at SMR has been subject to our standard business case review and approval processes. The project will also be subject to our project management and governance arrangements.

For these reasons, we regard the forecast expenditure at SMR as prudent and efficient, in accordance with the Rules requirements relating to contingent projects.

6.10 Supporting documents

Supporting documents to be provided as part of this submission:

- REF 10-04 REFCL Program Equipment Building Block Functional Description;
- Operational Requirements;
- REF 20-08 Automatic Circuit Recloser Strategy;
- REF 20-06 Network Balancing Strategy;
- REF 20-07 Line Hardening Strategy; and
- REF 20-09 Line Voltage Regulator Strategy.

Appendix 7 – Woori Yallock Zone Substation REFCL Planning Report

7.1 Purpose

The purpose of this appendix is to demonstrate that the forecast capital expenditure and incremental operating expenditure to install the mandated REFCL technology at Woori Yallock (WYK) zone substation are prudent and efficient. In doing so, this appendix highlights the specific issues at WYK zone substation that influence the design and cost of the additional REFCL installation at this location.

A number of supporting documents are listed in section 7.9, which provide further information on the strategies that underpin our forecast expenditure, and detail why these strategies and cost estimates are prudent and efficient. This appendix should therefore be read in conjunction with the supporting documents listed in section 7.9.

As explained in Chapter 1 of this contingent project application, the installation of REFCLs at selected zone substations is the only engineering solution that is capable of complying with the performance standards mandated by the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

WYK zone substation is located in the township of Woori Yallock approximately 60 km east of Melbourne. This zone substation was established in the 1980s and supplies the township and surrounding areas including Warburton and Healesville. The station supplies 17,535 customers, including one High Voltage (HV) customer by means of two large (20/33 MVA) transformers and four distribution feeders. The feeders cover a total 22kV route length of 659km. The 22kV network includes 47 automatic switchable sections.

WYK zone substation has one non-REFCL tranche 1 22kV transfer feeder used for automatic switching of customers in the event of a fault between WYK to Lilydale zone substation. Line works are required on this transfer feeder.

The existing total capacitance of the WYK 22kV network is 181 (A) or 224 (A) including existing automatic transfer feeders.

WYK zone substation has one REFCL installed currently with a capacity of 200 (A), the existing installation is not in line to the prescribed performance requirements.

Figure 1-1: WYK 22kV overhead feeders shown above in orange.

7.2 Key issues and challenges at WYK

The key challenges at WYK relate to the completion of further essential works to ensure the prescribed requirements of the Regulations are met, community impact from further works, 22kV switchgear condition and existing battery room size.

As stated above, the WYK network capacitance is presently 181 (A) not including transfers. A forecast series of underground and overhead cable works on the WYK and Kinglake 22kV transfer feeder will see the capacitance grow over the next three year period. This cabling work is associated with the Government's Powerline Replacement Fund and AusNet Services' 56M programs of work. Subsequent to this additional cable, the WYK total network forecast is 300(A), to be met within the next 3 years. The cable works will need to be closely monitored to ensure conductors selected and installed result in the least amount of capacitance added to the network.

The extra capacitance has driven the need for a second REFCL installation at WYK. This need is further complicated by the required sensitivity of the Regulations. The Regulations state fault current must be limited to 0.5 (A) or less. WYK testing to date has confirmed for each REFCL the capacitance they serve must be limited to 150 (A) at a maximum. This will also lead to feeder re-configuration at the zone substation such that the two REFCLS serve an equal amount of capacitance and no more than 150 (A) at a maximum.

Constraints to the available physical space at the zone substation is not currently a key issue for a two REFCL site, however as the network grows in capacitance it will become the principal issue as the addition of the second REFCL has occupied most of the free space.

Historically the WYK network is AusNet Services' worst performing zone substation in terms of reliability, due to its geographical location, radial lines and susceptibility to faults cause by nature or wildlife. This coupled with ongoing feeder conductor changes, REFCL stress testing and annual maintenance and vegetation programs has resulted in many outages for customers in the area. This history has driven the need for additional community engagement for the upcoming REFCL works. This is reflected in additional customer engagement costs for this project.

The existing 22kV feeders are switched using a minimum oil circuit breaker switchboard no longer supported by the manufacturer. Although on load and off load tests have been conducted on this switchboard (as part of the first REFCL installation), the present switchboard condition together with the elevated voltages of REFCL operation pose a risk of failure as the equipment was not originally designed for this mode of operation or duty. As a result, increased maintenance is required to best mitigate the risk of failure in the absence of replacing the switchboard with newer technology.

The existing control room has sufficient space for REFCL protection and control equipment although the existing battery supplies will need to be replaced to cater for the added equipment introduced by the second REFCL. The existing battery room cannot cater for the battery upgrades; as such a modular battery room will be installed.

7.3 Scope of work

The scope of work to install a REFCL at WYK involves:

- Zone substation works;
- Compatible works, including replacement of 4 Automatic Circuit Reclosers (ACRs) and upgrade of 10 ACRs installed on a WYK and Lilydale feeders;
- Network balancing;
- Line hardening, which requires the replacement of incompatible surge arrestors installed on feeders. This also includes works on the Lilydale transfer feeder; and

- Victorian Electricity Distribution Code compliance, which requires the installation of 1 isolating transformer solution at a HV customer point of supply. As already noted, WYK serves one HV customer.

Each of these activities is discussed in turn below, as follows:

- Section 7.3.1 – Zone substation works; and
- Section 7.3.2 – Line works, which addresses the remaining four workstreams.

It should be noted that there are no line voltage regulators requiring upgrade on the WYK network.

7.3.1 Zone substation works and options analysis

The proposed REFCL installation at WYK will involve a number of activities that are common to most Tranche 1 zone substations REFCL installations. These include:

- Specification, procurement and installation of a Ground Fault Neutraliser (GFN), including an Arc Suppression Coil (ASC), Residual Current Compensation (RCC) and control system. In WYK's case this is the second GFN unit.
- Specification, procurement and installation of two neutral bus switchboards. The introduction of the GFN requires a neutral bus which enables different earthing arrangements to be automatically configured. The switchboard facilitates remote year round selection of earthing arrangements and operating modes. Provides the ability to balance bushfire risk reduction with network reliability, depending on network and weather conditions.
- Upgrade the existing station service transformers and changeover boards. This work is required because the alternating current (AC) supply requirement dramatically increases due to the GFN installation.
- Testing and potential replacement of cable equipment which are at risk of failure if operated at elevated voltages.
- Replacement and extension of existing protection and control equipment with equipment capable of operating in several modes including resonant earthing and traditional earth fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Prior to commissioning the GFN, network hardening tests involve the process of lifting voltages (using the GFN) in a healthy three phase powerline network (phase by phase) to check network readiness for future states of REFCL operation. During this activity there is an increased likelihood of asset failures. We would replace any assets that fail during the testing process. These tests are necessary to ensure the GFN can operate without causing line and station equipment to fail resulting in a fire start. These tests are conducted in times of low fire risk to mitigate the likelihood of failure in the Declared Bushfire Season. Noting WYK's transfer feeders to Kinglake and Lilydale are planned to undertake insulation testing for the first time in 2017.
- Installation of monitoring equipment to demonstrate compliance with regulations and enable remote engineering access to control systems.

Further information on these works is provided in the following supporting document:

- REF 10-04 REFCL Program Equipment Building Block Functional Description

The additional specific work required at WYK involves:

- Work associated with converting the zone substation into a station capable of operating with more than one REFCL. This required work includes civil foundations for the new neutral bus switchgear, battery room, station service transformers and additional REFCL equipment and earthing.
- Installing one standard battery room to house new batteries that supply standard zone substation protection and controls, including additional REFCL associated protection and control equipment.
- Development and execution of a community engagement plan for works associated with the WYK network REFCL implementation. Community engagement is required to explain the likely customer reliability impact during the next stage of network insulation tests. The importance of effective community engagement has been highlighted by the Woori Yallock REFCL implementation in September 2016, which led to issues being raised by customers, media, the community and the Victorian Parliament.
- In relation to network hardening tests on the WYK 22 kV network prior to commissioning the GFN, our expectation is that there is a reasonable likelihood that some surge arrestors, insulators, pole top transformers and/or cables may fail and require replacement. This will be more likely to occur on the Lilydale transfer feeder which is yet to have insulation testing undertaken, as no surge arrestor replacement has occurred on that feeder.

WYK is one of three zone substations in Tranche 1 where it is necessary to implement a multiple REFCL site philosophy meaning additional neutral bus switchgear and a more complex protection and control philosophy.

Alternative options are limited which avoid installing another REFCL. Installing another REFCL is directly related to the total capacitive size of the network with constraints placed on the total capacitance so that detection sensitivity can be met. There are ways of reducing the total capacitive size of the network such as installing line reactors however this is counter to the key performance objective of the program which is to detect extremely high impedance faults. The only way you can reduce the capacitive size of the network at WYK would be to permanently transfer parts of the WYK network to adjacent feeders or build a new zone substation along an existing 66kV line and supply the nearby 22kV feeder network.

As explained in further detail below, the cost of acquiring a new zone substation or supplying parts of the WYK network from adjacent zone substations would be significantly more expensive than the installation of a second REFCL. Specifically, the relocation of a WYK feeder may then transfer the problem (capacitive network size) to another zone substation and the new zone substation would require additional line and cable relocation works with the establishment of new earthing and foundations, in addition to the majority of the work required for the preferred option.

Before determining our preferred scope of work at WYK, we considered 3 planning options:

1. Install second REFCL and utilise new technology low capacitance cable for new underground cable projects (our preferred option, as described above);
2. New zone substation between WYK and Kinglake. (1 GFN, 1 Bus, 1 66kV breaker, etc.) Rebuild substation at a new location (relocating existing transformers and 66 kV switchgear); and
3. Transfer WYK23 to KLK1. Supply KLK feeders from nearest adjacent zone substations.

In developing these options, AusNet Services considered non-network options and substitution possibilities between operating and capital expenditure. In relation to the zone substation works, there were no identified non-network options or substitution possibilities, other than those inherent in the above options.

A summary of our analysis in relation to each of these options is shown in Table 1.

Table 1: Options evaluated

Option	Advantages	Disadvantages
1. Install second REFCL and utilise new technology low capacitance cable (preferred option).	Readily enables existing zone substation infrastructure. Least cost option at $3,851k.	Complex project as supply must be maintained while new equipment is installed. Modifying protection systems is more complex than Options 2 and 3.
2. New zone substation between WYK & Kinglake. (1 GFN, 1 Bus, 1 66kV breaker, etc.)	New substation can be built without impacting customer supply. Simpler construction with less risk as limited work near live equipment. Eliminates need to introduce new technology (low capacitance cable) or closely monitor increase in feeder capacitance due to PRF or customer works. Makes maximum use of standard designs for new equipment and 22kV switchgear thereby lowering lifetime costs and minimising time to implement works at zone substation. Minimum disruption to community as station works would be constrained to (expanded) site. Standard equipment can readily be transported and relocated to other sites if necessary. (Minimises stranding risk.)	Would require acquisition of new site and potential community concern over development of electrical infrastructure. Does not utilise existing transformers and 66kV switchgear, which has some remaining life. Greater cost than preferred Option 1 ~$16,000k.
3. Transfer WYK23 to KLK1. Supply KLK feeders from nearest adjacent zone substations	Would result in a single REFCL zone. Minimum disruption to community as station works would be constrained to (expanded) site.	Would require installation of a second REFCL at Kinglake. Would require significant line works to upgrade capacity of lines. Customers expected to experience lower reliability as long radial lines would be necessary to provide supply. Greater cost than Option 1.

It is evident from the above table that Option 1 is the appropriate planning solution because it has:

- Lower cost than Options 2 and 3; and
- Reduced supply risks compared to Options 3.

7.3.2 Line works

The scope of works outside the zone substation involves the following work on the WYK network and 1 transfer feeder:

- Replacement of 4 ACRs and upgrade of 10 ACRs;
- Balancing 47 automatic switching zones – this involves:
  - 36 sites where phases are rotated;
  - 6 sites where third phase conductor is required to be installed;
  - The installation of 12 three-phase balancing capacitors; and
  - The replacement of 47 fuse sites required to be replaced with solid links; and
- Replacement of surge arresters at 623 sites distributed across the feeders; and
- Installation of 1 isolating transformer solution at a HV customer point of supply;

ACRs are currently used to detect ‘downstream’ faults and to interrupt supply to the faulted feeder section thereby minimising the number of customers who experience a supply interruption due to a fault. The existing ACRs are not capable of:

- detecting the low fault currents that will occur with REFCL operation; and
- identifying faults and the affected section of the feeder when earthing arrangements are altered at the zone substation (i.e. when the REFCL is switched onto the network). This inability leads to a larger number of customers being affected in the event of a sustained fault on a REFCL network and spurious tripping of ACRs on unaffected healthy feeders when the REFCL operates.

ACRs will therefore be upgraded or replaced so that they can detect low fault currents along with any changes to the earthing arrangement at the zone substation, this will ensure in the event of a fault customer outage numbers are minimised and healthy feeders are not tripped with REFCL operation.

Equally important as the ACR works is the capacitive balancing of the WYK 22kV network. Network capacitance must be balanced for REFCLs to operate. AusNet Services will undertake network balancing on each ‘automated switching zone’ where an automated switching zone is a feeder section delineated by ACRs, sectionalisers and/or circuit breakers. Balancing switching zones involves a combination of works including, phase transpositions, adding balancing capacitors, unbonding cable installations, removing fuses and adding a third phase conductor to balance each section. A combination of this work involving the least cost for each switching zone will be undertaken.

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA) involves a combination of ACR and sectionaliser operations plus the use of adjacent feeders to supply feeder sections downstream of a faulted section. This scheme is currently used to provide network reliability. DFA will only operate with REFCLs where each switching zone is capacitively balanced and ACR works are completed.

As well as network balancing works, type testing of surge arrestors has been undertaken to determine the types which cannot withstand the elevated voltages that result from REFCL operation. Failure of these types can lead to ground fire ignition and therefore their replacement is essential to prevent fire ignition during REFCL operation. A survey of the feeders has identified 623 sites with incompatible surge arrestors and these will be replaced with a standard surge arrestor with adequate ratings for REFCL operation.

Of the 623 sites and in accordance with the line hardening strategy, 344 sites must be replaced on the Woori Yallock network, which were not replaced as part of the original Woori Yallock REFCL project. The 344 sites relate to 3 surge arrestor types which have been exposed as having thermal runaway at operating voltages under 24kV. If not replaced these sites run the risk of failure in the near term. The replacement of these surge arrestors are therefore included in Tranche 1 works. The remainder of the surge arrestor sites are on the Lilydale transfer feeder LDL23 used for automatic switching of customers in the event of a fault between WYK to Lilydale zone substation.

The elevated voltages in the event of a single phase fault also raise compliance issues in relation to the Victorian Electricity Distribution Code. In particular, clause 4.2.2 of the Code sets out the maximum permissible variation in nominal voltages at the point of supply to each HV customer's electrical installation. AusNet Services must install one isolating transformer at WYK to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.

In scoping the above line works, AusNet Services has considered whether there are any non-network options or substitution possibilities between operating and capital expenditure. The nature of the required works at WYK is such that there are no non-network options or opportunities to substitute operating activities for the proposed capital works.

Further detail on the need for replacement and/or upgrade of ACRs, network balancing and surge arrester replacement is available in:

- REF 20-08 Automatic Circuit Recloser Strategy
- REF 20-06 Network Balancing Strategy
- REF 20-07 Line Hardening Strategy

7.3.3 Operational costs

In addition to the capital works described above, incremental ongoing operational costs will result from REFCL installation. Operational costs not specific to this site location are contained in the Operational Expenditure Requirements - Tranche 1 (REF 70-10) document. Operational costs that are either specific to WYK or vary by zone substation include:

- A number of new or expanded devices will be installed at WYK as a result of the REFCL installation including REFCL equipment, auto-changeover board, station services and line balancing capacitor units. As these items are new they are unlikely to require material additional maintenance however they will require routine inspection.
- Prior to each fire season it will be necessary to fully test the functionality of the REFCL to ensure that it is capable of operating to meet the Regulations. This will involve annual insulation and compliance tests to demonstrate the correct operation of the device together with ESV reporting.

Table 2: Forecast incremental operational costs

Activity	Frequency	Calendar Year Cost $		
		18	19	20
Maintain additional equipment	Annual	3,154	3,154	3,154
Pre fire season testing (insulation and compliance testing)	Annual	55,484	55,484	55,484

7.4 Key assumptions, risks and mitigation strategies

The key assumptions and risks made in forecasting the cost of REFCL installation at WYK are shown in Table 3 below.

Table 3: Key assumptions, risks and mitigation strategies

Assumption or Risk	Impact	Mitigation
Customers adversely affected by outages due to failure of equipment operating at higher than design voltages.	Extended customer outages e.g. cable failures. S-factor & GSL impacts. Outages more likely on Kinglake and Lilydale transfer feeders which haven't yet been exposed to insulation testing and REFCL operation.	Assets which are not compatible with REFCL such as surge arrestors and ACRs replaced prior to testing. Critical cables tested. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the extended WYK network.
Customers adversely react to the further outages required to deliver the REFCL works to the prescribed standard on the WYK network.	Repeat customer outages lead to customer and community frustration e.g. outages for line, station and REFCL testing works. Local member intervention, unfavourable media attention and hostile chamber of commerce.	Where possible, the co-ordination of work outages to minimise impact on the community. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the extended WYK network.
Work to replace powerlines under the Powerline Replacement Fund (PRF) will not materially increase the capacitance of the network.	Should capacitance materially increase, a third REFCL unit would be required at WYK.	Investigate potential to use low capacitance cable for PRF and customer works on WYK and transfer feeders.
The community reacts adversely to the development of additional electricity infrastructure.	Adverse reaction to the project could lead to delays and additional costs resulting from a high level of community involvement.	Specific community consultation plan for WYK project to be developed and executed.

Assumption or Risk	Impact	Mitigation
Present switchboard condition together with the elevated voltages of REFCL operation pose a risk of failure.	The existing 22kV feeders are switched using a minimum oil circuit breaker switchboard no longer supported by the manufacturer. Although on load and off load tests have been conducted on this switchboard (as part of the first REFCL installation), the present switchboard condition together with the elevated voltages of REFCL operation pose a risk of failure as the equipment was not originally designed for this mode of operation or duty.	As a result increased maintenance is required to best mitigate the risk of failure in the absence of replacing the switchboard with newer technology.
High Voltage (HV) customer adversely affected by outages due to failure of their equipment operating at higher than design voltages.	Extended outage or safety incident for HV customer, caused by underrated equipment failures. Loss of production and potential health and/or safety impacts. AusNet Services would need to undertake substantial work with each HV customer to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes. A change to the Distribution Code would also be required.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customer's point of supply complies with this Code provision and meets the mandated timeframe.
Operation of the REFCL would lead to voltage levels that are outside the allowable range specified in the Victorian Electricity Distribution Code (the Code).	Unless the Code is changed, operation of the REFCL would lead to non-compliance with our obligations. The Essential Services Commission has made it clear that it does not intend to amend the Victorian Distribution Code to address the voltage variation issue[1].	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.

1 Essential Services Commission, Electricity Distribution Code Compliance and REFCLs, letter to Hannah Williams, Powercor, dated 7 February 2017.

Assumption or Risk	Impact	Mitigation
Scope of HV customer works and funding mechanism unclear.	Delays in a suitable funding mechanism and/or work completion for HV customers could delay the project resulting in additional costs and fines due to project delays and failure to have the REFCL in service ahead of the 2017/18 fire season, and April 2019 compliance date. AusNet Services would need to undertake substantial work with HV customers to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision and meets the mandated timeframe.
Proximity to live assets during construction.	The project involves brownfield works to be carried out in the midst of an in-service zone substation. This will result in risk associated with the close proximity of live overhead and underground assets to employees, contractors and mobile plant.	Access permit conditions will clearly specify the requirements to ensure safety whilst work is being carried out in the station. Controls will be required for site induction and earth potential rise under fault conditions.
Sole supplier delivers GFN product to required standard.	Failure to have the GFN operating by 30 April 2019 will incur a one off civil penalty of $10M, and a fine of $5,500 for each day the criteria is not met after that date.	Develop and monitor strategic spares for the GFN product. Engage and invest in the relationship with GFN supplier. Seek an alternative REFCL supplier that can meet performance criteria of the Regulations. WYK costing has no allowance for sole supplier risk.
WYK network can be capacitively balanced, achieving the performance required under the Regulations.	Accurate network balance is essential if the performance criteria are to be met. To date these criteria have been achieved in one instance on a 40km network at Kilmore South. Failure to meet the performance criteria by 30 April 2019 will incur a one off civil penalty of $10M, and a fine of $5,500 for each day the criteria is not met after that date.	Extensive survey, design and modelling work is required. Works must ensure all material capacitive imbalances are accounted for on the WYK network.

7.5 Total costs for WYK Zone Substation

The total forecast costs to install a REFCL at WYK are shown in Table 4.

Table 4: Forecast costs

Item	**Cost** $000s 2017 direct
Capex	
Zone substation works, network hardening testing (elevated voltage testing) and REFCL commissioning	3,851
Replacement of 4 ACRs and upgrade of 10 ACR that are not capable of detecting low fault currents or automatically blocking conventional earth protection during REFCL operation.	651
Network balancing – Rotating phases, additional third phase at a small number of locations, installing three phase capacitors and replacing fuses with solid links.	994
Replacement of 1,613 units at 623 surge arrestor sites that present a risk of failure (and fire ignition) during REFCL operation	1,533
Total	*7,029*
Code compliance - the installation of 1 isolating transformer solution to ensure that AusNet Services maintains compliance with the maximum permissible voltage variations specified in the Victorian Distribution Code.	1,180
Opex	
Pre fire season testing including insulation and compliance testing.	167
Equipment maintenance.	9
Total	176

The capex costs have been prepared using AusNet Services' standard project cost estimating approach. The capital costs associated with zone substation equipment installation, replacement of an ACR and replacement of surge arrestors are reasonably certain. i.e. they carry the same level of uncertainty as routine projects such as zone substation construction or rebuilds.

The total capex cost at WYK is driven by a range of factors as described above. These include:

- WYK is a large network with a large number of customers. A number of surge arrestors and ACRs require replacement or upgrade on the WYK network and Lilydale transfer feeder, aligning with strategies for these assets. This is reflected in the increased costs for surge arrestors and ACRs when compared to other tranche one zone substations such as Kinglake and Barnawartha.
- WYK has a large number (47) of automatic switchable sections that require to be balanced. Though the WYK network has been subject to previous capacitive balancing works, further effort remains to ensure when switching is undertaken under normal fault response or operation, the performance criteria is met is each automatic switchable section. The remaining work required to balance the large number of automatic switchable sections is reflected in increased costs for network balancing when

compared to zone substations such as Kinglake and Barnawartha. Balancing costs also include the works required to be undertaken to the Lilydale transfer feeder.

Uncertainties in forecast capital costs primarily arise from performance of the REFCL, the extent of network balancing required and community reaction to the installation and testing works. An allowance of $22,985 has been included in the zone substation works for network insulation testing activities. This cost is based on 1 day to complete this activity, anticipating 1 fault. Each fault has been attributed a cost of $5,467 using established contractor rates. Based on insulation testing carried out to date, it is reasonably likely that cables/joints and surge arrestors will fail at this elevated voltage testing.

Ongoing cost uncertainty arises from the need to use untested low capacitance cable to limit network capacitance to a level which can be managed by two REFCLs; and, from the level of effort required to keep the network balanced to keep the REFCL in service.

7.6 Addressing reliability degradation

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA), has played an important role in delivering current levels of reliability. It involves a combination of ACRs, Remote Control Gas Switches and feeder management relay operations, together with the use of adjacent feeders, to supply feeder sections downstream of a faulted section. This scheme is specific to AusNet Services and reflects an important difference between our network and that of Powercor Australia.

However, the current DFA algorithms are all based on a conventional Resistance Earthed System network, and are incompatible with the required change to a Resonant Earthed System network as REFCLs are installed. As a consequence, without an upgrade to the algorithms (DFA2), the reliability outcomes on completion of each REFCL installation will degrade significantly.

AusNet Services' cost benefit analysis demonstrates that the costs of allowing a degradation in reliability significantly outweigh the costs of DFA2 and, therefore, the expenditure is justified in terms of economic efficiency. Furthermore, customers would be concerned if reliability degraded following the significant investment in REFCL technology, especially during periods of extreme heat.

The costs of DFA2 are not specific to each zone substation. Therefore, the costs are not included in this planning report, but are set out in the main body of the contingent project application.

7.7 Cost comparison with the Government's estimate in the RIS

To demonstrate the efficiency and prudency of our proposed expenditure, we must have regard to available benchmark information. In this instance, industry benchmarking is not available because the application of this technology for fire mitigation purposes is a world's first. In addition, the costs of installation are site-specific – which means that there is a potentially wide range of efficient and prudent installation costs across zone substations.

Despite these limitations, we note that the Regulatory Impact Statement (RIS) prepared by ACIL ALLEN for the Victorian Government in 2015 estimated costs for the REFCL installation program. The cost estimates were an important component of the RIS assessment, which considered the costs and benefits of introducing the bushfire mitigation regulations.

We note that ACIL ALLEN's cost estimates were prepared in 2015. Since then, we have developed location specific scopes of work, which have also been informed by experience gained at the REFCL installation at Woori Yallock zone substation. For these reasons, we have substantially more confidence in our cost estimates for WYK compared to the earlier ACIL ALLEN estimates, which were developed for a different purpose and which no longer reflect the best available information.

The table below provides a detailed explanation of the differences between our forecasts and ACIL ALLEN's estimates in the RIS. For some line items, the RIS did not provide a specific estimate for each zone substation. In these cases, we have presented the volume range set out in the RIS and commented on whether our forecast falls within this range.

Table 5: Reconciliation of AusNet Services' cost forecasts at WYK with the RIS cost estimates

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
Capex			
Zone substation works	3,851k	1,800 – 4,895k[3] Including - REFCL, design, civil works, installation and commissioning; - Station lighting arrestors; -Station service transformers; -Station services low voltage transfer switch; and - Capacitor banks.	AusNet Services' zone substation works include the following additional items which were not included in the RIS estimate: neutral bus switchboard; REFCL backup protection and interface control systems; REFCL testing including to prescribed requirements; and a community engagement plan.
ACRs replacement/upgrade	4 unit replacements @ cost of $63.2k per unit, producing a cost of $253k. 10 unit upgrades @ cost of $39.8k per unit, producing a cost of $398k.	RIS only provided an estimated volume range of 0-18 for each zone substation @ cost of $70k per unit, producing a cost estimate between $0 and $1,260k per zone substation.	AusNet Services' ACR replacement/upgrade unit cost is lower than the RIS estimate.
Network balancing	994k (see scope of work in 'explanation column')	RIS only provided an estimated volume range for conductor phase movements. Anticipated 0-85 for each zone substation @ cost of $4k per unit, producing a cost estimate between $0 and $340k per zone substation.	Significant increase in the scope and cost post the learnings of the first WYK REFCL commissioning. This has led to an increased understanding of the least cost mix work required to meet and maintain the prescribed sensitivity criteria in the Regulations. Field works required to meet the criteria which is world first involve: - 36 sites where conductor phase movements are required; - 6 sites where third phase conductor is required to be installed; - Installation of 12 three phase balancing capacitors; and - 47 sites where fuses are required to be removed and replaced with solid links.

[2] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69.

[3] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, Table 14 includes zone substation components.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
Surge arrestors	1,613 unit replacements @ cost of $0.94k per unit, producing a cost of $1,533k.	RIS only provided an estimated volume range of 0-8,224 units for each zone substation @ cost of $1k per unit, producing a cost estimate between $0 and $8,224k per zone substation.	AusNet Services approach is to replace the 40% of surge arrestors that sample testing has determined will not operate satisfactorily at elevated voltages. Cost forecast is lower than the average of the RIS estimate. 623 surge arrestor sites requiring replacement at $2,460 each, (equates to 1,613 surge arrestors units at $940 each).
Voltage regulators	-	-	-
Total	*7,029k*	RIS did not provide an estimate.	Additional work and costs are required for the WYK network to be made compliant to the prescribed performance criteria of the Regulations. The RIS did not provide an estimate for further works required at WYK.
Code compliance	1,180k	RIS did not provide an estimate.	One HV customer supply served from the WYK 22kV network.
Opex			
Pre fire season testing	167k	RIS did not provide an estimate.	Not costed in the RIS estimate. Required to ensure the WYK network is operating to the prescribed criteria of the Regulations and vulnerabilities to overvoltage on the WYK network are exposed prior to the Declared Bushfire Season.
Equipment maintenance	9k	RIS did not provide an estimate.	Not costed in the RIS estimate.
Total	*176k*		

The table shows that a number of items were either not included in the RIS cost estimate, or were underestimated for the reasons noted in the table above. These variances reflect the level of understanding on the part of the government and the industry at the time the RIS was prepared.

The key areas of cost difference are zone substation works and network balancing. Additional zone substations works that were not included in the RIS estimate are:

- Neutral bus switchboard – required for effective year-round protection of the network, balancing bushfire risk reduction with network reliability requires multiple operating modes with differing earthing arrangements. A neutral bus switchboard facilitates these arrangements.
- REFCL backup protection and interface control systems – protection and control equipment must operate in several earthing fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Testing the REFCL – As part of the project commissioning it will be necessary to fully test the functionality of the REFCL ensuring that it is capable of operating to meet the Regulations. It involves the first instance of insulation and compliance testing to demonstrate the correct operation of the device and to comply with the ESV's reporting requirements.

- Community engagement plan - required due to the number of outages forecast for the community and the new network insulation tests, which in the short term are expected to have an unfavourable reliability experience for customers.

Additional network balancing works not included in the RIS estimate include:

- Work required to achieve the performance criteria in each automatic switching zone - involving a combination of additional works including, adding balancing capacitors, unbonding cable installations and adding a third phase conductor to balance each section. The RIS detailed phase rotations alone as the only network balancing cost, this will not achieve the required performance criteria of the Regulations.
- Works needed to maintain balance – including replacing fuses with solid links where fuse operation will lead to out of balance, potential non-compliance with the Regulations and possible REFCL mal operation.

As evidenced by the above table, AusNet Services has examined the cause of forecast expenditure differences to those presented in the RIS for the REFCL installation at WYK. The reconciliation to the Government's cost estimates provides further assurance that AusNet Services' cost forecasts are prudent and efficient.

It is also important to emphasise that the cost forecasts presented in this contingent project application reflect a detailed scope of work for each zone substation installation in accordance with the AER's 'trigger event' definition. As such, AusNet Services' forecasts are fully substantiated having regard to the actual conditions at each zone substation whereas the RIS estimate adopted a broader estimating approach that was unavoidably less comprehensive.

7.8 Why the proposed costs are efficient

This appendix has explained that:

- The proposed scope of station works at WYK is the lowest cost and risk option for addressing the specific issues at WYK;
- Our proposed replacement of ACRs and surge arrestors is consistent with our strategies in relation to these assets, which adopt a prudent and efficient replacement approach;
- Our network balancing work is consistent with our strategy in relation to these works, which is focused on achieving the required capacitive balance at the lowest cost in each automatic switchable section of the 22kV network;
- We have considered non-network options and the substitution possibilities between capital and operating expenditure;
- We have employed our standard approach to project cost estimation;
- The key assumptions underpinning our forecasts are reasonable;
- We have identified the key risks in relation to the REFCL installation at WYK and taken appropriate risk mitigation measures; and
- Our projected costs are within the Government's estimated range in the RIS. More importantly, we have reviewed our cost estimates on a line-by-line basis, explaining the reasons for any differences compared to the RIS estimates and highlighting gaps in the scope of work assumed in the RIS.

In addition, it should be noted that our forecast expenditure for the REFCL installation at WYK has been subject to our standard business case review and approval processes. The project will also be subject to our project management and governance arrangements.

For these reasons, we regard the forecast expenditure at WYK as prudent and efficient, in accordance with the Rules requirements relating to contingent projects.

7.9 Supporting documents

Supporting documents to be provided as part of this submission:

- REF 10-04 REFCL Program Equipment Building Block Functional Description;
- Operational Requirements;
- REF 20-08 Automatic Circuit Recloser Strategy;
- REF 20-06 Network Balancing Strategy; and
- REF 20-07 Line Hardening Strategy.

Appendix 8 – Kilmore South Zone Substation REFCL Planning Report

8.1 Purpose

The purpose of this appendix is to demonstrate that the forecast capital expenditure and incremental operating expenditure to install the mandated REFCL technology at Kilmore South (KMS) zone substation are prudent and efficient. In doing so, this appendix highlights the specific issues at KMS zone substation that influence the design and cost of the REFCL installation at this location.

A number of supporting documents are listed in section 8.9, which provide further information on the strategies that underpin our forecast expenditure, and detail why these strategies and cost estimates are prudent and efficient. This appendix should therefore be read in conjunction with the supporting documents listed in section 8.9.

As explained in Chapter 1 of this contingent project application, the installation of REFCLs at selected zone substations is the only engineering solution that is capable of complying with the performance standards mandated by the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

KMS zone substation is located in the town of Kilmore approximately 75km north of Melbourne. This zone substation was established in the 1980s and supplies the town of Kilmore and surrounding areas including Broadford, Wandong and Strath Creek. The station supplies 8,495 customers, including one High Voltage (HV) customer by means of two medium (15/20 and 10/13.5 MVA) transformers on different vector groups and two distribution feeders. The feeders cover a large total 22kV route length of 439km. The 22kV network includes 22 automatic switchable sections.

KMS zone substation has one non-REFCL tranche 1 22kV transfer feeder used for automatic switching of customers, in the event of a fault, to Kalkallo zone substation. Line works are required on this transfer feeder.

The estimated total capacitance of the KMS 22kV network is 63 (A) or 87 (A) including existing automatic transfer feeders.

KMS zone substation has one REFCL installed with a capacity of 80 (A), the existing installation was commissioned in May 2015 however is not in line with the prescribed performance requirements and has since been taken out of service.

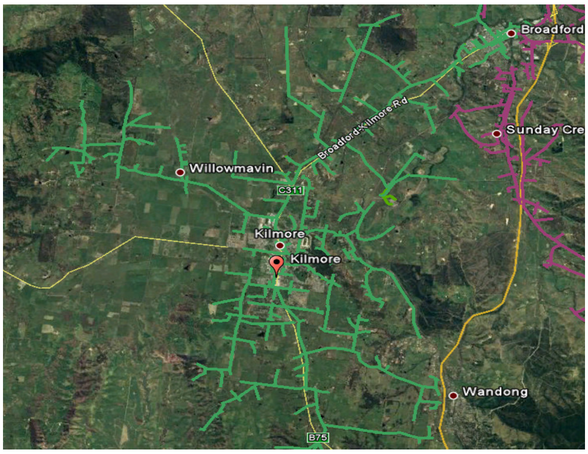

Figure 1-1: KMS 22kV feeders shown above in green.

8.2 Key issues and challenges at KMS

The key challenges at KMS relate to the completion of further essential works to ensure the prescribed requirements of the Regulations are met, required upgrades to the existing GFN, required re-configuration of the station 22kV yard and rating of the existing station capacitor bank.

The objectives of the existing GFN installation was to provide a specific site to conduct arc-ignition tests using staged faults on a real network, as a request from the Department of Economic Development (the former Department of Economic Development, Jobs, Transport and Resources).

The GFN installation was one of three REFCL configurations tested as part of the REFCL Technologies Test Program. This test program at KMS looked into obtaining reliable information on the ability of REFCL technologies of interest to meet the performance standard, as well as to generate understanding of the implementation issues associated with each technology. The other key objective was to confirm and refine the draft performance standard to improve its suitability for inclusion in an appropriate regulatory mechanism. As such, the GFN installation was designed and installed with uncertain knowledge of the future requirements any REFCL would need to adhere to, guaranteeing that further works at the site would be required once the performance criteria had been set. The upgrades to the existing GFN will require bringing the device up to the bushfire standard which includes both software and hardware changes.

The Test Program was completed on the KMS21 feeder, which is one of two feeders distributing supply from KMS zone substation. The test network was limited to approximately 40kms of HV conductor and due to the nature of the installation and schedule, only the minimum amount of work was completed in terms of the four works streams we have since identified i.e. zone substations, network hardening, network balancing and compatible equipment. No activities under these work streams outside the test area were addressed and considering the whole of the KMS network is approximately eleven times the size of the Test Program network and the feeders distributing the area are fed from two power transformers on different vector groups, many activities are required to bring the site up to the standard that will comply with the performance criteria. Activities such as network balancing and hardening on most of the KMS21 and KMS1 feeders, feeder and switchgear reconfiguration within the zone substation, hardening of non-tested or rated assets within the zone substation and decommissioning of the other REFCL technologies trialled all need to be completed.

As mentioned above, the existing REFCL installation has an ASC rating of 80A, which consequently constraints the ability to complete feeder transfers between adjacent zone substations.

8.3 Scope of work

The scope of work to install a REFCL at KMS involves:

- Zone substation works;
- Compatible works, including:
  - Upgrade of 4 Automatic Circuit Reclosers (ACRs); and
  - Replacement or upgrade of 2 line voltage regulators; and
- Network balancing;
- Line hardening, which requires the replacement of incompatible surge arrestors installed on feeders; and
- Victorian Electricity Distribution Code compliance, which requires the installation of 1 isolating transformer solution at a HV customer point of supply. As already noted, KMS serves 1 HV customer.

Each of these activities is discussed in turn below, as follows:

- Section 8.3.1 – Zone substation works; and
- Section 8.3.2 – Line works, which addresses the remaining four workstreams.

8.3.1 Zone substation works and options analysis

The proposed REFCL installation at KMS will involve a number of activities that are common to most Tranche 1 zone substation REFCL installations. These include:

- Specification, procurement and installation of a neutral bus switchboard. The introduction of the GFN requires a neutral bus which enables different earthing arrangements to be automatically configured. The switchboard facilitates remote year round selection of earthing arrangements and operating modes. It provides the ability to balance bushfire risk reduction with network reliability, depending on network and weather conditions.
- Testing and potential replacement of cable equipment which is at risk of failure if operated at elevated voltages.
- Replacement and extension of existing protection and control equipment with equipment capable of operating in several modes including resonant earthing and traditional earth fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of maloperation.
- Prior to commissioning the GFN, network hardening tests involve the process of lifting voltages (using the GFN) in a healthy three phase powerline network (phase by phase) to check network readiness for future states of REFCL operation. During this activity there is an increased likelihood of asset failures. We would replace any assets that fail during the testing process. These tests are necessary to ensure the GFN can operate without causing line and station equipment to fail resulting in a fire start. These tests are conducted in times of low fire risk to mitigate the likelihood of failure in the Declared Bushfire Season.
- Installation of monitoring equipment to demonstrate compliance with regulations and enable remote engineering access to control systems.

Further information on these works is provided in the following supporting document:

- REF 10-04 REFCL Program Equipment Building Block Functional Description

The additional specific work required at KMS involves:

- Work associated with converting a rural zone substation into a station capable of operating with a REFCL. This required work includes civil foundations for neutral bus switchgear, 22kV transformer circuit breaker and earthing.
- In relation to network hardening tests on the KMS 22 kV network prior to commissioning the GFN, our expectation is that there is a reasonable likelihood that some surge arrestors, insulators, pole top transformers and/or cables may fail and require replacement.
- Replacement of the existing 22kV station capacitor bank. This work is required as the existing capacitor is not rated for the elevated voltages of REFCL operation.
- Development and execution of a community engagement plan for works associated with the KMS network REFCL implementation. Community engagement is required to explain the likely customer reliability impact during the new network insulation tests. The importance of effective community engagement has been highlighted by the Woori

Yallock REFCL implementation in September 2016, which led to issues being raised by customers, media, the community and the Victorian Parliament.

Before determining our preferred scope of work at KMS, we considered 3 planning options:

1. Upgrade the existing GFN's software and hardware to meet the required standard of the regulations. Re-configure the 22kV equipment enabling the REFCL to service the whole of the 22kV network, includes moving KMS21 feeder onto the current 22kV switchboard. (our preferred option, as described above).
2. Same as Option 1, but rather than upgrading the existing GFN. Replace GFN with the new GFN which includes the bushfire performance specifications.
3. Same as Option 1, but in addition, install a new GFN for the second power transformer vector group

In developing these options, AusNet Services considered non-network options and substitution possibilities between operating and capital expenditure. In relation to the zone substation works, there were no identified non-network options or substitution possibilities, other than those inherent in the above options.

A summary of our analysis in relation to each of these options is shown in Table 1.

Table 1: Options evaluated

Option	Advantages	Disadvantages
1. Upgrade existing GFN and re-configure 22kV switchyard (preferred option).	Makes maximum use of existing REFCL installation and switchboard and thereby lowering lifetime costs and minimising time to implement the zone substation works. Least cost option at $2,958k.	Feeder transfers will be constrained due to existing ASC size. Non-standard ASC size remains in asset base. Non-standard DC supply in a rural location leading to more complex maintenance and training. This disadvantage is considered minimal as this arrangement is in line with the existing installation.
2. Same as Option 1, but replace existing GFN with new bushfire compliant standard rather than upgrade existing REFCL.	New REFCL control building can be built without impacting customer supply. Modular REFCL protection and control standard design can be rolled out.	Adds to sole supplier delivery risk. More real estate used potentially limiting ability to trial new REFCL technology. Greater cost than Option 1 at $4,084k.
3. Same as Option 1, but also install an additional REFCL in order to have a REFCL per vector group transformer at the zone substation.	New REFCL control building can be built without impacting customer supply. Station switching configuration risk minimised.	Adds to sole supplier delivery risk. More real estate used potentially limiting ability to trial new REFCL technology. Greater cost than Option 1 $5,042k.

It is evident from the above table that Option 1 is the appropriate planning solution because it has:

- Lower cost than Options 2 and 3; and
- Reduced complexity and supply risks compared to Options 2 and 3;

8.3.2 Line works

The scope of works outside the zone substation involves the following work on the KMS network:

- Upgrade of 4 ACRs;
- Balancing 22 automatic switching zones – this involves:
    - 53 sites where phases are rotated;
    - 2 sites where third phase conductor is required to be installed;
    - The installation of 3 single phase balancing capacitors and 17 three-phase balancing capacitors; and
    - The replacement of 22 fuse sites required to be replaced with solid links;
- Replacement of surge arresters at 312 sites distributed across the feeders;
- Replacement of 1 line voltage regulator and upgrade of 1 line voltage regulator; and
- Installation of 1 isolating transformer solution at 1 HV customer point of supply;

ACRs are currently used to detect ‘downstream’ faults and to interrupt supply to the faulted feeder section thereby minimising the number of customers who experience a supply interruption due to a fault. The existing ACRs are not capable of:

- detecting the low fault currents that will occur with REFCL operation; and
- identifying faults and the affected section of the feeder when earthing arrangements are altered at the zone substation (i.e. when the REFCL is switched onto the network). This inability leads to a larger number of customers being affected in the event of a sustained fault on a REFCL network and spurious tripping of ACRs on unaffected healthy feeders when the REFCL operates.

ACRs will therefore be upgraded or replaced so that they can detect low fault currents along with any changes to the earthing arrangement at the zone substation, this will ensure in the event of a fault, customer outage numbers are minimised and healthy feeders are not tripped with REFCL operation.

Equally important as the ACR works is the capacitive balancing of the KMS 22kV network. Network capacitance must be balanced for REFCLs to operate. AusNet Services will undertake network balancing on each ‘automated switching zone’ where an automated switching zone is a feeder section delineated by ACRs, sectionalisers and/or circuit breakers. Balancing switching zones involves a combination of works including, phase transpositions, adding balancing capacitors, unbonding cable installations, removing fuses and adding a third phase conductor to balance each section. A combination of this work involving the least cost for each switching zone will be undertaken.

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA) involves a combination of ACR and sectionaliser operations plus the use of adjacent feeders to supply feeder sections downstream of a faulted section. This scheme is currently used to provide network reliability. DFA will only operate with REFCLs where each switching zone is capacitively balanced and ACR works are completed.

As well as network balancing works, type testing of surge arrestors has been undertaken to determine the types which cannot withstand the elevated voltages that result from REFCL operation. Failure of these types can lead to ground fire ignition and therefore their replacement is essential to prevent fire ignition during REFCL operation. A survey of the feeders has identified 312 sites with incompatible surge arrestors and these will be replaced with a standard surge arrestor with adequate ratings for REFCL operation.

Also, line voltage regulators (typically open delta configuration) have been the lowest cost option to regulate voltage on 22kV long rural feeders. Unfortunately they are not compatible with REFCL technology as they displace the system neutral voltage by regulating only two phases (line-to-line voltages), rather than regulating all three phases. As a result, these regulators will need to be replaced on REFCL affected feeders.

Separately, all line voltage regulators with two phase controllers will need to be upgraded to a three phase controller ensuring voltages across all three 22kV phases remains consistent and voltage variations between the phases is avoided.

The elevated voltages in the event of a single phase fault also raise compliance issues in relation to the Victorian Electricity Distribution Code. In particular, clause 4.2.2 of the Code sets out the maximum permissible variation in nominal voltages at the point of supply to each HV customer's electrical installation. AusNet Services must install one isolating transformer to ensure that the voltage variation at the HV customers' point of supply complies with this Code provision.

In scoping the above line works, AusNet Services has considered whether there are any non-network options or substitution possibilities between operating and capital expenditure. The nature of the required works at KMS is such that there are no non-network options or opportunities to substitute operating activities for the proposed capital works.

Further detail on the need for replacement and/or upgrade of ACRs, network balancing and surge arrester replacement is available in:

- REF 20-08 Automatic Circuit Recloser Strategy
- REF 20-06 Network Balancing Strategy
- REF 20-07 Line Hardening Strategy

8.3.3 Operational costs

In addition to the capital works described above, incremental ongoing operational costs will result from REFCL installation. Operational costs not specific to this site location are contained in the Operational Expenditure Requirements - Tranche 1 (REF 70-10) document. Operational costs that are either specific to KMS or vary by zone substation include:

- A number of new or expanded devices will be installed at KMS as a result of the REFCL installation including REFCL equipment, auto-changeover board, station services and line balancing capacitor units. As these items are new they are unlikely to require material additional maintenance, however they will require routine inspection.
- Prior to each fire season it will be necessary to fully test the functionality of the REFCL to ensure that it is capable of operating to meet the Regulations. This will involve annual insulation and compliance tests to demonstrate the correct operation of the device together with ESV reporting.

Table 2: Forecast incremental operational costs

Activity	Frequency	Calendar Year Cost $		
		18	19	20
Maintain additional equipment	Annual	-	3,154	3,154
Pre fire season testing (insulation and compliance testing)	Annual	-	27,742	27,742

8.4 Key assumptions, risks and mitigation strategies

The key assumptions and risks made in forecasting the cost of REFCL installation at KMS are shown in Table 3Table 3 below.

Table 3: Key assumptions, risks and mitigation strategies

Assumption or Risk	Impact	Mitigation
Customers adversely affected by outages due to failure of equipment operating at higher than design voltages.	Extended customer outages e.g. cable failures. S-factor & GSL impacts.	Assets which are not compatible with REFCL such as surge arrestors and ACRs replaced prior to testing. Critical cables tested. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the KMS network.
Customers adversely react to the number of outages required to deliver the REFCL works on the KMS network.	Repeat customer outages lead to increased customer costs and community frustration e.g. outages for line work, and station and REFCL testing works.	Where possible, the co-ordination of work outages to minimise impact on the community. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the KMS network.
High Voltage (HV) customer(s) adversely affected by outages due to failure of their equipment operating at higher than design voltages.	Extended outage or safety incident for HV customer, caused by underrated equipment failures. Loss of production and potential health and/or safety impacts. AusNet Services would need to undertake substantial work with each HV customer to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes. A change to the Distribution Code would also be required.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customer's point of supply complies with this Code provision and meets the mandated timeframe.

Assumption or Risk	Impact	Mitigation
Operation of the REFCL would lead to voltage levels that are outside the allowable range specified in the Victorian Electricity Distribution Code (the Code).	Unless the Code is changed, operation of the REFCL would lead to non-compliance with our obligations. The Essential Services Commission has made it clear that it does not intend to amend the Victorian Distribution Code to address the voltage variation issue[1].	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision.
Scope of HV customer works and funding mechanism unclear.	Delays in a suitable funding mechanism and/or work completion for HV customers could delay the project resulting in additional costs and fines due to project delays and failure to have the REFCL in service ahead of the 2017/18 fire season, and April 2019 compliance date. AusNet Services would need to undertake substantial work with HV customers to agree the scope and execution of HV customer works, which is likely to be a highly complex and time consuming process. It is not feasible to engage our HV customers on these matters and comply with the mandated timeframes.	AusNet Services must install isolating transformers to ensure that the voltage variation at each HV customers' point of supply complies with this Code provision and meets the mandated timeframe.
Proximity to live assets during construction.	The project involves brownfield works to be carried out in the midst of an in-service zone substation. This will result in risk associated with the close proximity of live overhead and underground assets to employees, contractors and mobile plant.	Access permit conditions will clearly specify the requirements to ensure safety whilst work is being carried out in the station. Controls will be required for site induction and earth potential rise under fault conditions.

[1] Essential Services Commission, Electricity Distribution Code Compliance and REFCLs, letter to Hannah Williams, Powercor, dated 7 February 2017.

Assumption or Risk	Impact	Mitigation
Sole supplier delivers GFN product to required standard.	Failure to have the GFN operating by 30 April 2019 will incur a one off civil penalty of $6M, and a fine of $5,500 for each day the criteria is not met after that date.	Develop and monitor strategic spares for the GFN product. Engage and invest in the relationship with GFN supplier. Seek an alternative REFCL supplier that can meet performance criteria of the Regulations. KMS costing has no allowance for sole supplier risk.
KMS network can be capacitively balanced, achieving the performance required under the Regulations.	Accurate network balance is essential if the performance criteria are to be met. To date these criteria have been achieved in one instance on a 40km network at Kilmore South. Failure to meet the performance criteria by 30 April 2019 will incur a one off civil penalty of $6M, and a fine of $5,500 for each day the criteria is not met after that date.	Extensive survey, design and modelling work is required. Works must ensure all material capacitive imbalances are addressed on the KMS network.

8.5 Total costs for KMS Zone Substation

The total forecast costs to install a REFCL at KMS are shown in Table 4.

Table 4: Forecast costs

Item	Cost $000s 2016 direct
Capex	
Zone substation works, network hardening testing (elevated voltage testing) and REFCL commissioning	2,958
Upgrade of 4 ACRs that is not capable of detecting low fault currents or automatically blocking conventional earth protection during REFCL operation.	159
Network balancing – Rotating phases, installing a small number of sites where three phase conductor is required, installing single and three phase capacitors and replacing fuses with solid links.	1,574
Replacement of 817 units at 312 surge arrestors sites that present a risk of failure (and fire ignition) during REFCL operation	768
Replacement of 1 line voltage regulator and upgrade of 1 line voltage regulator not compatible with REFCL operation.	387
Total	*5,845*

Item	Cost $000s 2016 direct
Code compliance - the installation of 1 isolating transformer solution to ensure that AusNet Services maintains compliance with the maximum permissible voltage variations specified in the Victorian Distribution Code.	1,180
Opex	
Pre fire season testing including insulation and compliance testing.	55
Equipment maintenance.	6
Total	*62*

The capex costs have been prepared using AusNet Services' standard project cost estimating approach. The capital costs associated with zone substation equipment installation, replacement of an ACR and replacement of surge arrestors are reasonably certain. i.e. they carry the same level of uncertainty as routine projects such as zone substation construction or rebuilds.

The total capex cost at KMS is lower than other tranche one zone substations. This is driven by a range of factors as described above. These include:

- KMS is a relatively small network with a lower number of customers. This is reflected in the reduced costs for surge arrestors and ACR replacements when compared to other tranche one zone substations.
- KMS has a small number (22) of automatic switchable sections that must be balanced. This is reflected in reduced costs for network balancing when compared to other zone substations within tranche one.
- KMS preferred zone substation option utilises the existing REFCL installed at the site. This is reflected in the reduced costs for zone substation works when compared to other tranche one zone substations.

Uncertainties in forecast capital costs primarily arise from performance of the REFCL, the extent of network balancing required and community reaction to the installation and testing works. An allowance of $34,477 has been included in the zone substation works for network insulation testing activities. This cost is based on 1.5 days to complete this activity, anticipating 1 fault per day of testing. Each fault has been attributed a cost of $5,467 using established contractor rates. Based on insulation testing carried out to date, it is reasonably likely that cables/joints and surge arrestors will fail at this elevated voltage testing.

8.6 Addressing reliability degradation

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA), has played an important role in delivering current levels of reliability. It involves a combination of ACRs, Remote Control Gas Switches and feeder management relay operations, together with the use of adjacent feeders, to supply feeder sections downstream of a faulted section. This scheme is specific to AusNet Services and reflects an important difference between our network and that of Powercor Australia.

However, the current DFA algorithms are all based on a conventional Resistance Earthed System network, and are incompatible with the required change to a Resonant Earthed System network as REFCLs are installed. As a consequence, without an upgrade to the algorithms (DFA2), the reliability outcomes on completion of each REFCL installation will degrade significantly.

AusNet Services' cost benefit analysis demonstrates that the costs of allowing a degradation in reliability significantly outweigh the costs of DFA2 and, therefore, the expenditure is justified in terms of economic efficiency. Furthermore, customers would be concerned if reliability degraded following the significant investment in REFCL technology, especially during periods of extreme heat.

The costs of DFA2 are not specific to each zone substation. Therefore, the costs are not included in this planning report, but are set out in the main body of the contingent project application.

8.7 Cost comparison with the Government's estimate in the RIS

To demonstrate the efficiency and prudency of our proposed expenditure, we must have regard to available benchmark information. In this instance, industry benchmarking is not available because the application of this technology for fire mitigation purposes is a world's first. In addition, the costs of installation are site-specific – which means that there is a potentially wide range of efficient and prudent installation costs across zone substations.

Despite these limitations, we note that the Regulatory Impact Statement (RIS) prepared by ACIL ALLEN for the Victorian Government in 2015 estimated costs for the REFCL installation program. The cost estimates were an important component of the RIS assessment, which considered the costs and benefits of introducing the bushfire mitigation regulations.

We note that ACIL ALLEN's cost estimates were prepared in 2015. Since then, we have developed location specific scopes of work, which have also been informed by experience gained at the REFCL installation at Woori Yallock zone substation. For these reasons, we have substantially more confidence in our cost estimates for KMS compared to the earlier ACIL ALLEN estimates, which were developed for a different purpose and which no longer reflect the best available information.

The table below provides a detailed explanation of the differences between our forecasts and ACIL ALLEN's estimates in the RIS. For some line items, the RIS did not provide a specific estimate for each zone substation. In these cases, we have presented the volume range set out in the RIS and commented on whether our forecast falls within this range.

Table 5: Reconciliation of AusNet Services' cost forecasts at KMS with the RIS cost estimates

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
Capex			
Zone substation works	2,957k	1,800 – 4,895k[3] Including - REFCL, design, civil works, installation and commissioning; - Station lighting arrestors; -Station service	AusNet Services' zone substation works include the following additional items which were not included in the RIS estimate: neutral bus switchboard; REFCL backup protection and interface control systems; REFCL testing including to prescribed requirements; community engagement plan and 22kV station yard re-

[2] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69. It should be noted that the RIS costs are expressed in $2015 while our costs are expressed in $2016. Strictly speaking, for comparison purposes the RIS costs are approximately 1.5 per cent higher than indicated here.

[3] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, Table 14 includes zone substation components.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
		transformers; -Station services low voltage transfer switch; and - Capacitor banks.	configuration.
ACRs upgrade	4 unit upgrades @ cost of $39.8k per unit, producing a cost of $159k.	RIS only provided an estimated volume range of 0-18 for each zone substation @ cost of $70k per unit, producing a cost estimate between $0 and $1,260k per zone substation.	AusNet Services' ACR replacement/upgrade unit cost is lower than the RIS estimate.
Network balancing	1,574k (see scope of work in 'explanation column')	RIS only provided an estimated volume range for conductor phase movements. Anticipated 0-85 for each zone substation @ cost of $4k per unit, producing a cost estimate between $0 and $340k per zone substation.	Significant increase in the scope and cost post the learnings of the WYK REFCL commissioning. This has led to an increased understanding of the least cost mix work required to meet and maintain the prescribed sensitivity criteria in the Regulations. Field works required to meet the criteria which is world first involve: - 53 sites where conductor phase movements are required; - 2 sites where third phase conductor is required to be installed; - Installation of 3 single phase balancing capacitors and 17 three phase balancing capacitors; and - 22 expected sites where fuses are required to be removed and replaced with solid links.
Surge arrestors	817 unit replacements @ cost of $0.94k per unit, producing a cost of $768k.	RIS only provided an estimated volume range of 0-8,224 units for each zone substation @ cost of $1k per unit, producing a cost estimate between $0 and $8,224k per zone substation.	AusNet Services approach is to replace the 40% of surge arrestors that sample testing has determined will not operate satisfactorily at elevated voltages. Cost forecast is lower than the average of the RIS estimate. 312 surge arrestor sites requiring replacement at $2,460 each, (equates to 817 surge arrestors units at $940 each).
Voltage regulators	387k	RIS only provided an estimated cost range of $0-375k for each zone substation.	Cost is higher than the RIS estimate. KMS network requires replacement of 1 line voltage regulator and upgrade of 1 line voltage regulator.
Total	*5,845k*	-	Additional work and costs are required for the KMS network to be made compliant to the prescribed performance criteria of the Regulations. The RIS did not provide an estimate for further works required at KMS.
Code compliance	1,180k	RIS did not provide an estimate.	One HV customer supply served from the KMS 22kV network.
Opex			
Pre fire season testing	55k	RIS did not provide an estimate.	Not costed in the RIS estimate. Required to ensure the KMS network is operating to the prescribed criteria of the Regulations and vulnerabilities to overvoltage on the KMS network are exposed prior to the Declared Bushfire Season.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
Equipment maintenance	6k	RIS did not provide an estimate.	Not costed in the RIS estimate.
Total	*62k*		

The table shows that a number of items were either not included in the RIS cost estimate, or were underestimated for the reasons noted in the table above. These variances reflect the level of understanding on the part of the government and the industry at the time the RIS was prepared.

The key areas of cost difference are zone substation works and network balancing. Additional zone substations works that were not included in the RIS estimate are:

- Neutral bus switchboard – required for effective year-round protection of the network, balancing bushfire risk reduction with network reliability requires multiple operating modes with differing earthing arrangements. A neutral bus switchboard facilitates these arrangements.
- REFCL backup protection and interface control systems – protection and control equipment must operate in several earthing fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Testing the REFCL – As part of the project commissioning it will be necessary to fully test the functionality of the REFCL ensuring that it is capable of operating to meet the Regulations. It involves the first instance of insulation and compliance testing to demonstrate the correct operation of the device and to comply with the ESV's reporting requirements.
- Community engagement plan - required due to the number of outages forecast for the community and the new network insulation tests, which in the short term are expected to have an unfavourable reliability experience for customers.

Additional network balancing works not included in the RIS estimate include:

- Work required to achieve the performance criteria in each automatic switching zone - involving a combination of additional works including, adding balancing capacitors, unbonding cable installations and adding a third phase conductor to balance each section. The RIS detailed phase rotations alone as the only network balancing cost, this will not achieve the required performance criteria of the Regulations.
- Works needed to maintain balance – including replacing fuses with solid links where fuse operation will lead to out of balance, potential non-compliance with the Regulations and possible REFCL maloperation.

As evidenced by the above table, AusNet Services has examined the cause of forecast expenditure differences to those presented in the RIS for the REFCL installation at KMS. The reconciliation to the Government's cost estimates provides further assurance that AusNet Services' cost forecasts are prudent and efficient.

It is also important to emphasise that the cost forecasts presented in this contingent project application reflect a detailed scope of work for each zone substation installation in accordance with the AER's 'trigger event' definition. As such, AusNet Services' forecasts are fully substantiated having regard to the actual conditions at each zone substation whereas the RIS estimate adopted a broader estimating approach that was unavoidably less comprehensive.

8.8 Why the proposed costs are efficient

This appendix has explained that:

- The proposed scope of station works at KMS is the lowest cost option for addressing the specific issues at KMS;
- Our proposed replacement of a ACR and surge arrestors is consistent with our strategies in relation to these assets, which adopt a prudent and efficient replacement approach;
- Our network balancing work is consistent with our strategy in relation to these works, which is focused on achieving the required capacitive balance at the lowest cost in each automatic switchable section of the 22kV network;
- We have considered non-network options and the substitution possibilities between capital and operating expenditure;
- We have employed our standard approach to project cost estimation;
- The key assumptions underpinning our forecasts are reasonable;
- We have identified the key risks in relation to the REFCL installation at KMS and taken appropriate risk mitigation measures; and
- Our projected costs are within the Government's estimated range in the RIS. More importantly, we have reviewed our cost estimates on a line-by-line basis, explaining the reasons for any differences compared to the RIS estimates and highlighting gaps in the scope of work assumed in the RIS.

In addition, it should be noted that our forecast expenditure for the REFCL installation at KMS has been subject to our standard business case review and approval processes. The project will also be subject to our project management and governance arrangements.

For these reasons, we regard the forecast expenditure at KMS as prudent and efficient, in accordance with the Rules requirements relating to contingent projects.

8.9 Supporting documents

Supporting documents to be provided as part of this submission:

- REF 10-04 REFCL Program Equipment Building Block Functional Description;
- Operational Expenditure Requirements;
- REF 20-08 Automatic Circuit Recloser Strategy;
- REF 20-06 Network Balancing Strategy; and
- REF 20-07 Line Hardening Strategy.

Appendix 9 – Myrtleford Zone Substation REFCL Planning Report

9.1 Purpose

The purpose of this appendix is to demonstrate that the forecast capital expenditure and incremental operating expenditure to install the mandated REFCL technology at Myrtleford (MYT) zone substation are prudent and efficient. In doing so, this appendix highlights the specific issues at MYT zone substation that influence the design and cost of the REFCL installation at this location.

A number of supporting documents are listed in section 9.9, which provide further information on the strategies that underpin our forecast expenditure, and detail why these strategies and cost estimates are prudent and efficient. This appendix should therefore be read in conjunction with the supporting documents listed in section 9.9.

As explained in Chapter 1 of this contingent project application, the installation of REFCLs at selected zone substations is the only engineering solution that is capable of complying with the performance standards mandated by the Electricity Safety (Bushfire Mitigation) Amendment Regulations 2016.

MYT zone substation is located on the western outskirts of the Myrtleford township approximately 220km northeast of Melbourne. This small zone substation was established in 1973 and supplies the township of Myrtleford and surrounding areas including Beechworth, Moyhu and Ovens. The station supplies 7,434 customers by means of two small (10 MVA) transformers and four distribution feeders. The transformers are 1940's vintage having been recycled from Wodonga zone substation. The MYT 22kV feeders cover a total route length of 529km. The 22kV network includes 20 automatic switchable sections.

MYT zone substation has one non-REFCL tranche 1 22kV transfer feeder used for automatic switching of customers in the event of a fault between MYT to Bright zone substation.

The estimated total capacitance of the MYT 22kV network is forecast to be 56 (A) or 72 (A) including existing automatic transfer feeders.

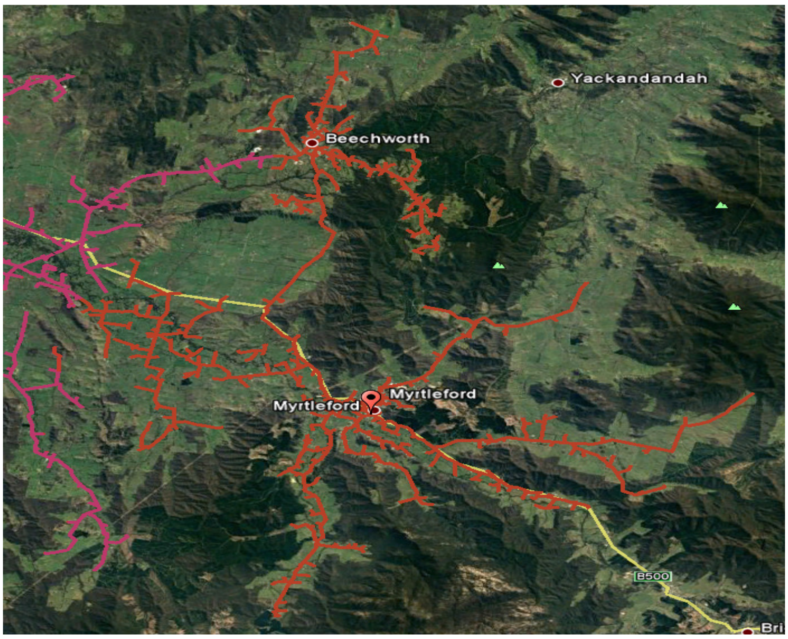

Figure 1-1: MYT 22kV feeders shown above in red.

9.2 Key issues and challenges at MYT

The key issue impacting the installation of a REFCL at MYT is the required co-ordination with the MYT re-build project, modification of the existing 22kV capacitor bank and the lack of physical space in the existing site control room.

The rebuild project includes the integrated replacement of deteriorated assets. The scope of the rebuild project includes:

- Replacing the existing 66 kV line circuit breaker "A" and replacing all current transformers and voltage transformers on all three lines. Installation of a circuit breaker in a new location to minimise outage durations. Installing a new 66 kV bus tie circuit breaker;
- Installing a new indoor 22 kV switchboard with nine circuit breakers configured as two 22 kV buses with one transformer incomer and three 22 kV feeders with a 22 kV bus tie. Demolishing and removal of existing outdoor 22 kV bulk oil circuit breakers;
- Refurbishing existing control room and battery room to remove asbestos cement sheeting on external walls;
- Associated protection and control works for new equipment;
- Upgrade site security fencing and control room security to current standards; and
- Upgrade switchyard lighting, surfaces, drainage, cable ducts to current standards.

The existing 22kV bulk oil circuit breakers are in poor condition and are not expected to withstand the elevated voltages and durations of REFCL insulation testing and operation. The 22kV circuit breaker replacements must be completed prior to the installation of REFCL technology at MYT. However, these assets are being replaced as part of the rebuild program, and therefore are not included in the REFCL project.

MYT zone substation has one 22kV capacitor bank not being replaced as part of the re-build project. The capacitor bank must be modified to be compatible with REFCL operation. The consequence of not modifying the capacitor bank means REFCL operation will lead to equipment failure from dangerous voltages placing customer supply and safety at risk.

The need to modify capacitor banks in 'earthed star' configuration was noted in the REFCL trial report, explaining that the earth connection must be removed from the star point and protection systems modified accordingly[1].

The existing site control room does not have the physical space for the required installation of REFCL technology at MYT. This control room is small with insufficient space for the REFCLs Residual Current Compensation (RCC) unit and associated control system. Due to its size, the existing control room is unsuitable for reuse. As explained in section 9.3.1, the lowest cost option is to construct a separate building to house the REFCL equipment.

9.3 Scope of work

The scope of work to install a REFCL at MYT involves:

- Zone substation works, including
  - ➢ modification to the station capacitor bank; and
  - ➢ construction of a new building to house the REFCL equipment.

1 REFCL Trial: Ignition Tests, Marxsen Consulting Pty Ltd, Monday 4 August 2014, page 94.

- Compatible works, including replacement of 6 Automatic Circuit Reclosers (ACRs) installed on a MYT feeder;
- Network balancing; and
- Line hardening, which requires the replacement of incompatible surge arrestors installed on feeders.

Each of these activities is discussed in turn below, as follows:

- Section 9.3.1 – Zone substation works; and
- Section 9.3.2 – Line works, which addresses the remaining three workstreams.

It should be noted that there are no line voltage regulators requiring upgrade on the MYT network.

9.3.1 Zone substation works and options analysis

The proposed REFCL installation at MYT will involve a number of activities that are common to most Tranche 1 zone substations REFCL installations. These include:

- Specification, procurement and installation of a Ground Fault Neutraliser (GFN), including an Arc Suppression Coil (ASC), Residual Current Compensation (RCC) and control system.
- Specification, procurement and installation of a neutral bus switchboard. The introduction of the GFN requires a neutral bus which enables different earthing arrangements to be automatically configured. The switchboard facilitates remote year round selection of earthing arrangements and operating modes. Provides the ability to balance bushfire risk reduction with network reliability, depending on network and weather conditions.
- Upgrade of the existing station service transformers and changeover boards. This work is required because the alternating current (AC) supply requirement dramatically increases due to the GFN installation.
- Replacement and extension of existing protection and control equipment with equipment capable of operating in several modes including resonant earthing and traditional earth fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Prior to commissioning the GFN, network hardening tests involve the process of lifting voltages (using the GFN) in a healthy three phase powerline network (phase by phase) to check network readiness for future states of REFCL operation. During this activity there is an increased likelihood of asset failures. We would replace any assets that fail during the testing process. These tests are necessary to ensure the GFN can operate without causing line and station equipment to fail resulting in a fire start. These tests are conducted in times of low fire risk to mitigate the likelihood of failure in the Declared Bushfire Season.
- Installation of monitoring equipment to demonstrate compliance with regulations and enable remote engineering access to control systems.

Further information on these works is provided in the following supporting document:

- REF 10-04 REFCL Program Equipment Building Block Functional Description

The additional specific work required at MYT involves:

- Work associated with converting a rural zone substation into a station capable of operating with a REFCL. This required work includes civil foundations for neutral bus switchgear, station service transformers and REFCL equipment and earthing.
- Installing one standard control room to house REFCL associated protection, control, and indoor auto-changeover board.
- In relation to network insulation tests on the MYT 22 kV network prior to commissioning the GFN, our expectation is that there is a reasonable likelihood that some surge arrestors, insulators, pole top transformers and/or cables may fail and require replacement.
- Development and execution of a community engagement plan for works associated with the MYT network REFCL implementation. Community engagement is required to explain the likely customer reliability impact during the new network insulation tests. The importance of effective community engagement has been highlighted by the Woori Yallock REFCL implementation in September 2016, which led to issues being raised by customers, media, the community and the Victorian Parliament.

Before determining our preferred scope of work at MYT, we considered 3 planning options:

1. Install REFCL technology and one new building (REFCL control room). At the same time as completing the MYT zone substation rebuild works, which includes the replacement of the existing 22kV switchgear (our preferred option, as described above).
2. Same as Option 1, but extend the refurbished control room to cater for REFCL control room requirements.
3. Same as Option 1, but complete the rebuild works first and then the REFCL works.

In developing these options, AusNet Services considered non-network options and substitution possibilities between operating and capital expenditure. In relation to the zone substation works, there were no identified non-network options or substitution possibilities, other than those inherent in the above options.

A summary of our analysis in relation to each of these options is shown in Table 1.

Table 1: Options evaluated

Option	Advantages	Disadvantages
1. Install REFCL and 1 new building (REFCL control room). At the same time complete MYT zone substation rebuild works (preferred option).	New REFCL control building can be built without impacting customer supply. REFCL project work can be constructed together with the rebuild project works. This will create construction efficiency. Least cost option at $3,435k.	All existing and new REFCL protection and control equipment not housed in one location. This will impose some increased transit between the two locations for REFCL commissioning and testing activities. This is not seen as a material issue. Re-build project design having to be brought forward to cater for the REFCL technology installation. Increased scope of work at MYT increases the delivery risk of the REFCL related works. The REFCL is required to be installed and operating to prescribed criteria ahead of the April 2019 deadline. Any delay to the deadline will result in a large civil penalty being incurred.

Option	Advantages	Disadvantages
2. Same as Option 1, but extend the refurbished control room to cater for REFCL control room requirements.	All protection and control equipment housed in one location. Zone substation future construction space maximised.	Complex construction as supply and protection must be maintained while the existing control room is extended. Modifying existing control room is more complex than Option 1. Greater cost than Option 1, $3,459k.
3. Same as Option 1, but complete the rebuild works first and then the REFCL works.	Simplified design and construction at MYT zone substation.	Longer construction window at the MYT zone substation. REFCL operation will increase the short term likelihood on an end of life explosive failure of the 22KV bulk oil circuit breakers. The health, safety and adjacent plant risks are amplified if the circuit breakers are not replaced by completing the re-build project prior to REFCL operation. Larger risk of the MYT REFCL works not being completed. The REFCL is required to be installed and operating to prescribed criteria ahead of the April 2019 deadline. Any delay to the deadline will result in a large civil penalty. Greater cost than Option 1, $5,315k.

It is evident from the above table that Option 1 is the appropriate planning solution because it has:

- Lower cost than Options 2 and 3;
- Reduced complexity and supply risks compared to Options 2; and
- Lower risk of financial penalty than Option 3.

9.3.2 Line works

The scope of works outside the zone substation involves the following work on the MYT network and 1 transfer feeder:

- Replacement of 6 ACRs on MYT feeders;
- Balancing 20 automatic switching zones – this involves:
  - 35 sites where phases are rotated;
  - 2 sites where third phase conductor is required to be installed;
  - The installation of 5 single phase balancing capacitors and 9 three-phase balancing capacitors; and
  - The replacement of 20 fuse sites required to be replaced with solid links.
- Replacement of surge arresters at 391 sites distributed across the feeders.

ACRs are currently used to detect ‘downstream’ faults and to interrupt supply to the faulted feeder section thereby minimising the number of customers who experience a supply interruption due to a fault. The existing ACRs are not capable of:

- detecting the low fault currents that will occur with REFCL operation; and
- identifying faults and the affected section of the feeder when earthing arrangements are altered at the zone substation (i.e. when the REFCL is switched onto the network). This inability leads to a larger number of customers being affected in the event of a sustained fault on a REFCL network and spurious tripping of ACRs on unaffected healthy feeders when the REFCL operates.

ACRs will therefore be upgraded or replaced so that they can detect low fault currents along with any changes to the earthing arrangement at the zone substation, this will ensure in the event of a fault customer outage numbers are minimised and healthy feeders are not tripped with REFCL operation.

Equally important as the ACR works is the capacitive balancing of the MYT 22kV network. Network capacitance must be balanced for REFCLs to operate. AusNet Services will undertake network balancing on each ‘automated switching zone’ where an automated switching zone is a feeder section delineated by ACRs, sectionalisers and/or circuit breakers. Balancing switching zones involves a combination of works including, phase transpositions, adding balancing capacitors, unbonding cable installations, removing fuses and adding a third phase conductor to balance each section. A combination of this work involving the least cost for each switching zone will be undertaken.

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA) involves a combination of ACR and sectionaliser operations plus the use of adjacent feeders to supply feeder sections downstream of a faulted section. This scheme is currently used to provide network reliability. DFA will only operate with REFCLs where each switching zone is capacitively balanced and ACR works are completed.

As well as network balancing works, type testing of surge arrestors has been undertaken to determine the types which cannot withstand the elevated voltages that result from REFCL operation. Failure of these types can lead to ground fire ignition and therefore their replacement is essential to prevent fire ignition during REFCL operation. A survey of the feeders has identified 391 sites with incompatible surge arrestors and these will be replaced with a standard surge arrestor with adequate ratings for REFCL operation.

In scoping the above line works, AusNet Services has considered whether there are any non-network options or substitution possibilities between operating and capital expenditure. The nature of the required works at MYT is such that there are no non-network options or opportunities to substitute operating activities for the proposed capital works.

Further detail on the need for replacement and/or upgrade of ACRs, network balancing and surge arrester replacement is available in:

- REF 20-08 Automatic Circuit Recloser Strategy
- REF 20-06 Network Balancing Strategy
- REF 20-07 Line Hardening Strategy

9.3.3 Operational costs

In addition to the capital works described above, incremental ongoing operational costs will result from REFCL installation. Operational costs not specific to this site location are contained in the Operational Expenditure Requirements - Tranche 1 (REF 70-10) document. Operational costs that are either specific to MYT or vary by zone substation include:

- A number of new or expanded devices will be installed at MYT as a result of the REFCL installation including REFCL equipment, auto-changeover board, station services and line balancing capacitors. As these items are new they are unlikely to require material additional maintenance, however they will require routine inspection.
- Prior to each fire season it will be necessary to fully test the functionality of the REFCL to ensure that it is capable of operating to meet the Regulations. This will involve annual insulation and compliance tests to demonstrate the correct operation of the device together with ESV reporting.

Table 2: Forecast incremental operational costs

Activity	Frequency	Calendar Year Cost $		
		18	19	20
Maintain additional equipment	Annual	-	3,154	3,154
Pre fire season testing (insulation and compliance testing)	Annual	-	27,742	27,742

9.4 Key assumptions, risks and mitigation strategies

The key assumptions and risks made in forecasting the cost of REFCL installation at MYT are shown in Table 3 below.

Table 3: Key assumptions, risks and mitigation strategies

Assumption or Risk	Impact	Mitigation
Customers adversely affected by outages due to failure of equipment operating at higher than design voltages.	Extended customer outages e.g. cable failures. S-factor & GSL impacts.	Assets which are not compatible with REFCL such as surge arrestors and ACRs replaced prior to testing. Critical cables tested. Community engagement undertaken prior to insulation testing and REFCL operation occurring on the MYT network.
Customers adversely react to the number of outages required to deliver the REFCL works on the MYT network.	Repeat customer outages lead to increased customer costs and community frustration e.g. outages for line work, and station and REFCL testing works.	Where possible, the co-ordination of work outages to minimise impact on the community. Specific community consultation plan for MYT project to be developed and executed.
Safe REFCL operation requires the replacement of a number of existing 22kV bulk oil circuit breakers which are in poor condition and approaching their end of life.	REFCL operation will increase the short term likelihood of an end of life explosive failure of the 22KV bulk oil circuit breakers. The health and safety and adjacent plant risks are amplified if the circuit breakers are not replaced.	Ensure the 22kV circuit breakers (covered under the MYT re-build scope of works) are replaced ahead of REFCL works and operation.

Assumption or Risk	Impact	Mitigation
Proximity to live assets during construction.	The project involves brownfield works to be carried out in the midst of an in-service zone substation. This will result in risk associated with the close proximity of live overhead and underground assets to employees, contractors and mobile plant.	Access permit conditions will clearly specify the requirements to ensure safety whilst work is being carried out in the station. Controls will be required for site induction and earth potential rise under fault conditions.
Sole supplier delivers GFN product to required standard.	Failure to have the GFN operating by 30 April 2019 will incur a one off civil penalty of $6M, and a fine of $5,500 for each day the criteria is not met after that date.	Develop and monitor strategic spares for the GFN product. Engage and invest in the relationship with GFN supplier. Seek an alternative REFCL supplier that can meet performance criteria of the Regulations. MYT costing has no allowance for sole supplier risk.
MYT network can be capacitively balanced, achieving the performance required under the Regulations.	Accurate network balance is essential if the performance criteria are to be met. To date these criteria have been achieved in one instance on a 40km network at Kilmore South. Failure to meet the performance criteria by 30 April 2019 will incur a one off civil penalty of $6M, and a fine of $5,500 for each day the criteria is not met after that date.	Extensive survey, design and modelling work is required. Works must ensure all material capacitive imbalances are accounted for on the MYT network.

9.5 Total costs for MYT Zone Substation

The total forecast costs to install a REFCL at MYT are shown in Table 4.

Table 4: Forecast costs

Item	Cost $000s 2016 direct
Capex	
Zone substation works, network insulation testing (elevated voltage testing) and REFCL commissioning.	3,435
Replacement of 6 ACRs that are not capable of detecting low fault currents or automatically blocking conventional earth protection during REFCL operation.	379

Item	Cost $000s 2016 direct
Network balancing – Rotating phases, installing a small number of sites where three phase conductor is required, installing single and three phase capacitors and replacing fuses with solid links.	1,202
Replacement of 1,024 units at 391 surge arrestors sites that present a risk of failure (and fire ignition) during REFCL operation	962
Total	*5,978*
Opex	
Pre fire season testing including insulation and compliance testing.	55
Equipment maintenance	6
Total	*62*

The capex costs have been prepared using AusNet Services' standard project cost estimating approach. The capital costs associated with zone substation equipment installation, replacement of an ACR and replacement of surge arrestors are reasonably certain. i.e. they carry the same level of uncertainty as routine projects such as zone substation construction or rebuilds.

The total capex cost at MYT is lower than other tranche one zone substations driven by a range of factors as described above. These include:

- MYT is a relatively small network with a lower number of customers. This is reflected in the reduced costs for surge arrestors and ACR replacements when compared to other tranche one zone substations such as Seymour and Wangaratta.
- MYT has a small number (20) of automatic switchable sections that require to be balanced. This is reflected in reduced costing for network balancing when compared to Rubicon A, Kilmore South, Wonthaggi, Seymour and Wangaratta.
- MYT zone substation has minimal land constraints and existing poor condition 22kV bulk oil switchgear is being replaced with new indoor switchgear as part of the re-build project. This work is not costed as part of the REFCL program. The re-build works also includes the necessary battery upgrades. As a result, the zone substation costs at MYT are lower than other zone substations, with the exception Kilmore South.

Uncertainties in forecast capital costs primarily arise from performance of the REFCL, the extent of network balancing required and community reaction to the installation and testing works. An allowance of $57,462 has been included in the zone substation works for network insulation testing activities. This cost is based on 2.5 days to complete this activity, anticipating 1 fault per day of testing. Each fault has been attributed a cost of $5,467 using established contractor rates. Based on insulation testing carried out to date, it is reasonably likely that cables/joints and surge arrestors will fail at this elevated voltage testing.

9.6 Addressing reliability degradation

Our existing 22kV feeder fault treatment scheme, Distribution Feeder Automation (DFA), has played an important role in delivering current levels of reliability. It involves a combination of ACRs, Remote Control Gas Switches and feeder management relay operations, together with the use of adjacent feeders, to supply feeder sections downstream of a faulted section. This scheme is specific to AusNet Services and reflects an important difference between our network and that of Powercor Australia.

However, the current DFA algorithms are all based on a conventional Resistance Earthed System network, and are incompatible with the required change to a Resonant Earthed System network as REFCLs are installed. As a consequence, without an upgrade to the algorithms (DFA2), the reliability outcomes on completion of each REFCL installation will degrade significantly.

AusNet Services' cost benefit analysis demonstrates that the costs of allowing a degradation in reliability significantly outweigh the costs of DFA2 and, therefore, the expenditure is justified in terms of economic efficiency. Furthermore, customers would be concerned if reliability degraded following the significant investment in REFCL technology, especially during periods of extreme heat.

The costs of DFA2 are not specific to each zone substation. Therefore, the costs are not included in this planning report, but are set out in the main body of the contingent project application.

9.7 Cost comparison with the Government's estimate in the RIS

To demonstrate the efficiency and prudency of our proposed expenditure, we must have regard to available benchmark information. In this instance, industry benchmarking is not available because the application of this technology for fire mitigation purposes is a world's first. In addition, the costs of installation are site-specific – which means that there is a potentially wide range of efficient and prudent installation costs across zone substations.

Despite these limitations, we note that the Regulatory Impact Statement (RIS) prepared by ACIL ALLEN for the Victorian Government in 2015 estimated costs for the REFCL installation program. The cost estimates were an important component of the RIS assessment, which considered the costs and benefits of introducing the bushfire mitigation regulations.

We note that ACIL ALLEN's cost estimates were prepared in 2015. Since then, we have developed location specific scopes of work, which have also been informed by experience gained at the REFCL installation at Woori Yallock zone substation. For these reasons, we have substantially more confidence in our cost estimates for MYT compared to the earlier ACIL ALLEN estimates, which were developed for a different purpose and which no longer reflect the best available information.

The table below provides a detailed explanation of the differences between our forecasts and ACIL ALLEN's estimates in the RIS. For some line items, the RIS did not provide a specific estimate for each zone substation. In these cases, we have presented the volume range set out in the RIS and commented on whether our forecast falls within this range.

Table 5: Reconciliation of AusNet Services' cost forecasts at MYT with the RIS cost estimates

Item	**AusNet Services forecast** $ 2016 direct	**RIS estimate**[2] $2015 direct	**Explanation**
Capex			

[2] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, 74 & 75. It should be noted that the RIS costs are expressed in $2015 while our costs are expressed in $2016. Strictly speaking, for comparison purposes the RIS costs are approximately 1.5 per cent higher than indicated here.

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
Zone substation works	3,435k	1,800 – 4,895k[3] Including - REFCL, design, civil works, installation and commissioning; - Station lighting arrestors; and -Station service transformers. -Station services low voltage transfer switch; and - Capacitor banks.	AusNet Services' zone substation works include the following additional items which were not included in the RIS estimate: neutral bus switchboard; REFCL control room; REFCL backup protection and interface control systems; REFCL testing including to prescribed requirements; and a community engagement plan.
ACRs replacement/upgrade	6 unit replacements @ cost of $63.2k per unit, producing a cost of $379k	RIS only provided an estimated volume range of 0-18 for each zone substation @ cost of $70k per unit, producing a cost estimate between $0 and $1,260k per zone substation.	AusNet Services' cost is lower than the RIS estimate.
Network balancing	1,202k (see scope of work in 'explanation column')	RIS only provided an estimated volume range for conductor phase movements. Anticipated 0-85 for each zone substation @ cost of $4k per unit, producing a cost estimate between $0 and $340k per zone substation.	Significant increase in the scope and cost post the learnings of the WYK REFCL commissioning. This has led to an increased understanding of the least cost mix of work required to meet and maintain the prescribed sensitivity criteria in the Regulations. Field works required to meet the criteria which is world first involve: - 35 sites where conductor phase movements are required; - 2 sites where third phase conductor is required to be installed; - Installation of 5 single phase balancing capacitors and 9 three phase balancing capacitors; and - 20 sites where fuses are required to be removed and replaced with solid links.
Surge arrestors	1,024 unit replacements @ cost of $0.94k per unit, producing a cost of $962k	RIS only provided an estimated volume range of 0-8,224 units for each zone substation @ cost of $1k per unit, producing a cost estimate between $0 and $8,224k per zone substation.	AusNet Services approach is to replace the 40% of surge arrestors that sample testing has determined will not operate satisfactorily at elevated voltages. Cost forecast is lower than the average of the RIS estimate. 391 surge arrestor sites requiring replacement at $2,460 each, (equates to 1,024 surge arrestors units at $940 each).
Voltage regulators	-	-	
Total	5,978k	4,527[4]k	The RIS estimate is specific to this zone substation, even though only cost ranges are provided in relation to the cost build up. The MYT total cost is higher than the RIS estimate for the reasons set out above. See further discussion below this table.

[3] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 69, Table 14 includes zone substation components

[4] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 74, Table 20

Item	AusNet Services forecast $ 2016 direct	RIS estimate[2] $2015 direct	Explanation
Code compliance	-	-	No HV customers are served from the MYT 22kV network.
Opex			
Pre fire season testing	55k	-	Not costed in the RIS estimate. Required to ensure the MYT network is operating to the prescribed criteria of the Regulations and vulnerabilities to overvoltage on the network are exposed prior to the Declared Bushfire Season.
Equipment maintenance	6k	97k[5]	AusNet Services' equipment maintenance cost is lower than the RIS estimate.
Total	*62k*		

The table shows that a number of items were either not included in the RIS cost estimate, or were underestimated for the reasons noted in the table above. These variances reflect the level of understanding on the part of the government and the industry at the time the RIS was prepared.

The key areas of cost difference are zone substation works and network balancing. Additional zone substations works that were not included in the RIS estimate are:

- Neutral bus switchboard – required for effective year-round protection of the network, balancing bushfire risk reduction with network reliability requires multiple operating modes with differing earthing arrangements. A neutral bus switchboard facilitates these arrangements.
- REFCL control room – necessary as there is insufficient space in the existing control room and the inverter and secondary panels are larger than anticipated.
- REFCL backup protection and interface control systems – protection and control equipment must operate in several earthing fault modes. Additional control systems are required to provide the interface between the GFN and AusNet Services' equipment. New protection devices are also needed to provide an adequate backup for the GFN for the instances of mal operation.
- Testing the REFCL – As part of the project commissioning it will be necessary to fully test the functionality of the REFCL ensuring that it is capable of operating to meet the Regulations. It involves the first instance of insulation and compliance testing to demonstrate the correct operation of the device and to comply with the ESV's reporting requirements.
- Community engagement plan - required due to the number of outages forecast for the community and the new network insulation tests, which in the short term are expected to have an unfavourable reliability experience for customers.

Additional network balancing works not included in the RIS estimate include:

- Work required to achieve the performance criteria in each automatic switching zone - involving a combination of additional works including, adding balancing capacitors, unbonding cable installations and adding a third phase conductor to balance each

[5] Regulatory Impact Statement, Bushfire Mitigation Regulations Amendment, ACIL ALLEN Consulting, page 74, Table 20

section. The RIS detailed phase rotations alone as the only network balancing cost, this will not achieve the required performance criteria of the Regulations.

- Works needed to maintain balance – including replacing fuses with solid links where fuse operation will lead to out of balance, potential non-compliance with the Regulations and possible REFCL mal operation.

As evidenced by the above table, AusNet Services has examined the cause of forecast expenditure differences to those presented in the RIS for the REFCL installation at MYT. The reconciliation to the Government's cost estimates provides further assurance that AusNet Services' cost forecasts are prudent and efficient.

It is also important to emphasise that the cost forecasts presented in this contingent project application reflect a detailed scope of work for each zone substation installation in accordance with the AER's 'trigger event' definition. As such, AusNet Services' forecasts are fully substantiated having regard to the actual conditions at each zone substation whereas the RIS estimate adopted a broader estimating approach that was unavoidably less comprehensive.

9.8 Why the proposed costs are efficient

This appendix has explained that:

- The proposed scope of station works at MYT is the lowest cost and risk option for addressing the specific issues at MYT;
- Our proposed replacement of ACRs and surge arrestors is consistent with our strategies in relation to these assets, which adopt a prudent and efficient replacement approach;
- Our network balancing work is consistent with our strategy in relation to these works, which is focused on achieving the required capacitive balance at the lowest cost in each automatic switchable section of the 22kV network;
- We have considered non-network options and the substitution possibilities between capital and operating expenditure.
- We have employed our standard approach to project cost estimation;
- The key assumptions underpinning our forecasts are reasonable;
- We have identified the key risks in relation to the REFCL installation at MYT and taken appropriate risk mitigation measures; and
- Our projected costs are within the Government's estimated range in the RIS. More importantly, we have reviewed our cost estimates on a line-by-line basis, explaining the reasons for any differences compared to the RIS estimates and highlighting gaps in the scope of work assumed in the RIS.

In addition, it should be noted that our forecast expenditure for the REFCL installation at MYT has been subject to our standard business case review and approval processes. The project will also be subject to our project management and governance arrangements.

For these reasons, we regard the forecast expenditure at MYT as prudent and efficient, in accordance with the Rules requirements relating to contingent projects.

9.9 Supporting documents

Supporting documents to be provided as part of this submission:

- REF 10-04 REFCL Program Equipment Building Block Functional Description;
- Operational Requirements;
- REF 20-08 Automatic Circuit Recloser Strategy;
- REF 20-06 Network Balancing Strategy; and
- REF 20-07 Line Hardening Strategy.