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Project justifications for other replacement programs

Ausgrid

Content

1 INTRODUCTION

1.1 Support systems for Ausgrid's network

The electrical assets on Ausgrid's network are supported by a range of systems, services and infrastructure to maintain the electrical assets in a safe, secure and functional state. This support infrastructure includes:

- Buildings which house switchgear, control and protection equipment and other electrical components
- Fences which provide security against unauthorised access to substations or switchyards
- Oil containment facilities which prevent uncontained leakage polluting the environment
- Fire services and equipment which detects and controls or extinguish fires within substations.

These assets are utilised to mitigate the safety, security and environmental risks posed by the electricity network and also to ensure compliance with legislative obligations.

1.2 Changes in built environment legislation

Ausgrid initially installed the vast majority of the electricity network and associated building and civil components in a period where crime rates and standards related to the safety of people, building safety and environmental contamination were less onerous than they are today. As a result of increasing legislative obligations and more stringent requirements in terms of the health and safety of the public and workers, the safe and secure construction of buildings and prevention of environmental contamination, some of the infrastructure which supports the electrical assets has to be replaced or modified to ensure compliance with the current legislative obligations. Specific programs that address these obligations include:

- Fire doors – to remove asbestos from the work environment and improve fire safety
- Fire services – to address safety risks to the public, workers, properties and Ausgrid assets
- Earthing systems – to address safety risks to the public, workers and the electricity network
- Buildings and roofs – to remove asbestos, secure the buildings from terrorism, crime and increasing environmental impact
- Substation security – to address safety risks associated with unauthorised entry to substations and switchyards by improving substation security systems and perimeter fences
- Protection systems – to address National Electricity Rules compliance risks
- Transformer bushings – to address safety risks to the public, workers and the electricity network.

1.3 Working out what we need to replace or modify

The changes in legislation and compliance requirements are well established and detailed. These changes in requirements highlight the compliance risks on the network in addition to legislation reflecting the areas of community concern. Legislation drivers are applicable for normal operations and in the event of asset failure. To address these risks, Ausgrid plans to progressively replace or modify all the legislatively required assets identified in these problematic asset classes. Replacement and upgrades are undertaken in planned programs.

1.4 Summary of programs

In total Ausgrid expects to spend $119.1 million on improvements and equipment as part of planned programs during the 2019-24 regulatory period. Depending on the asset group, Ausgrid may use a 'run to failure' approach for specific parts of the asset base but the vast majority of these programs relate to duty of care and therefore are delivered in a planned program to minimise costs associated with upgrades and replacements in advance of a failure. Management of some of these asset risks (typically those related to major substations) may also be undertaken as part of major projects - refer to Attachment 5.14 for further detail on these projects.

The following programs are discussed in further detail below:

- Substation security ($41.1 million)
- Protection systems ($4.0 million)
- Oil containment ($28.2 million)
- Perimeter fences ($5.1 million)
- Buildings and roofs ($14. 5 million)
- Fire services ($9.5 million)
- Fire doors ($6.4 million)
- Bushings ($4.9 million)
- Subtransmission earthing systems ($5.6 million).

2 SUBSTATION SECURITY

2.1 Program description

Ausgrid has a duty of care to protect the public and workers from its electrical infrastructure and to ensure security of the network supply. The proposed programs are driven by the need to meet workplace health and safety (WH&S) and duty of care obligations. Ausgrid has seven planned programs to upgrade substation security to mitigate unauthorised access to substations as detailed below:

- Distribution chamber substation security (DOC_11.03.01)
- Brick wall outdoor enclosure substations (DOC_11.03.10)
- Substation fencing upgrade – distribution substations (DOC_11.03.50)
- Mackellar chamber substation safety – distribution substations (DOC_11.03.65)
- Electronic security – zone substations (DOC_11.05.01)
- Electronic security – sub-transmission substations (DOC_11.05.05)
- Substation lock upgrade (DOC_11.03.77).

These programs are continuing from the 2014-19 regulatory period and Ausgrid expects to spend $41. million in direct costs ($, real FY19) during the 2019-24 regulatory period. Given that the expenditure in the Mackellar chamber substation safety – distribution substations program represents less than 0.5% of the total investment in this category, the focus of this section is primarily on the six other programs.

Unauthorised access with the intent to harm and disrupt is also considered as an increased possibility and is included in the program drivers. Critical Infrastructure is defined in the "National Guidelines for Protecting Critical Infrastructure from Terrorism (2011)".[1]

Ausgrid's assets designated as Critical Infrastructure are those that are critical to either:

- The viability of the network, or
- The social or economic wellbeing of NSW, or
- Australia's ability to conduct national defence and maintain national security.

The NSW Critical Infrastructure protection management framework (2005)[2] requires operators of critical infrastructure to provide adequate security for their assets.

2.2 Background

A 2003 Coronial inquiry into the cause of the death of a child found that the substation fence, gate and locks were inadequate. A review of the security measures found that there was a need to upgrade the security at substations to control unauthorised access. Ausgrid completed a comprehensive program to upgrade security at its zone substations. There however, remains a requirement to review the security of distribution substations so that the same risks are mitigated proportionally in a sustainable approach.

Ausgrid has a duty of care to the public and its workers by limiting access to hazardous electrical equipment. Substations contain hazardous electrical equipment that has the potential for an electric shock causing injury or death and arcing, explosion or fire causing

[1] https://www.nationalsecurity.gov.au/Media-and-publications/Publications/Documents/national-guidelines-protection-critical-infrastructure-from-terrorism.pdf

[2] This document is a security in confidence document that can be viewed for verification on request.

burns. There also exists safety risk to those persons directly affected by a supply interruption caused as consequence of unauthorised access.

An overview of the assets and populations covered in these programs is provided in Table 1 below.

Table 1. Substations with compromised security

Type	Affected Population	Overview
Distribution chamber substation (security program)	2,380	Chamber substations are an enclosed space housed in a purpose built standalone building or within a chamber inside a customer building. The purpose of the distribution chamber substation security program is to improve security at above ground distribution chamber substations so that unauthorised persons cannot gain access to a substation. The average age of these substations is 45 years, with 48% over the standard technical life of 45 years.
Brick wall outdoor enclosure substations	260	The outdoor enclosures do not have a roof and the equipment is open to the environment. The low voltage switchboard is enclosed within a wooden or steel cabinet for environmental protection. Brick wall fences may have three strands of barbed wire installed as a deterrent to unauthorised entry. The average age of these substations is 41 years, with 38% over the standard technical life of 45 years.
Non brick outdoor enclosure substations (fencing program)	270	These substations are secured by chain wire or weldmesh fences. Chain-wire fences are typically 2.4 metres high, topped with barbed wire and have two locked entrance gates as well as danger warning signs on the fences. The average age is 41 years, with 53% over the standard technical life of 45 years. The chain-wire fencing design has been found to be vulnerable to security breaches from unauthorised persons. Chain wire fences can be easily climbed and are typically in poor condition.
Mackellar chamber substation (safety program)	89	Many chamber substations built by the former Mackellar County Council have exposed energised conductors and do not meet safe electrical clearance distances. These substations are all over 32 years old and do not meet modern design or security standards.
Zone and subtransmission substations (Electronic security program)	235	The perimeter of these substations are generally secured with a live yard fence and/or building. Some sites do not have electronic security on buildings and, depending on the site criticality, may require the installation of motion sensors (such as cameras) to detect unauthorised entry. This program will incorporate the substation lock upgrade program where this program is implemented.
All Substation types (lock upgrade program)	15,928	Ausgrid's Abloy key and locking systems have been in place since 2002 and have patent protection until 2019. To ensure the continued security of Ausgrid's substations (excluding those mounted on poles), it is proposed to upgrade the locks to a modern equivalent system. This program excludes locks replaced under the electronic security program.

2.3 Risks – Consequence and likelihood

The key consequences that can result from a loss of this function are shown in Table 2 below.

Table 2. Consequences from loss of function for substation security

Consequences	Description
Harm to the public, communities and workers	Electric shock causing injury or death. The electric shock may be received by direct or indirect contact, tracking through or across a medium, or by arcing. The injuries are suffered due to arcing or explosion or both which occur when high fault currents are present.
	Asbestos containing materials are present in the majority of these substations and require specialised handling. Any inadvertent release of asbestos fibres has the potential to impact the public and workers.
	Fire caused by damage, vandalism or theft of equipment may cause injury (electric shock or burns) or a fatality.
	Safety issues as a result of loss of supply are detailed below.
Harm to the environment	Mineral oil spills or release of asbestos due to vandalism can lead to environmental contamination if equipment is damaged.
Damage to property	Theft and damage to substation equipment through vandalism which can lead to damage to surrounding property and other substation equipment as a result of a transformer or switchboard explosion or fire.
Loss of supply	Network interruptions to customers connected to the substation.
	Interruptions to electricity supply for an extended period can affect a single customer or communities in the form of transport systems, traffic controls, emergency services, business and communication systems, critical infrastructure and vulnerable customers including those on life support systems.

A significant proportion of the assets considered are beyond their standard technical life and a number of the security controls have reduced effectiveness as a result of degradation. These assets were constructed to out-of-date standards compounding the risks and need to be replaced or renewed so that the effectiveness of the security controls, are so far as is reasonably practicable, not able to be inadvertently or easily compromised.

2.3.1 Distribution chamber substation safety

The main source of risk to security at chamber substations relate to doors, vents and windows. The vulnerability is made worse, in some cases, by the poor condition of assets. Whilst the probability of unauthorised entry is low the safety consequences are high.

In 2010, Ausgrid commissioned an investigation into the security risk of electrical substations. The investigation found that 13% of distribution substations had an extreme level of risk.

2.3.2 Brick wall outdoor enclosure substations

The majority of these substations are located on customers' premises and may have objects located near or against them which act as climbing aids for unauthorised persons to gain access to the substations. There is substantial evidence of unauthorised access into this style of distribution substation including the presence of graffiti within substations and switchyards and also illegally stored materials. This highlights that the likelihood of an incident occurring is unacceptably high.

2.3.3 Substation fencing upgrade

Outdoor enclosure substations are considered to be the highest risk substations for unauthorised access. These substations are protected only by a fence, which is easily climbed or cut through with wire cutters. Failure modes of the fencing include:

- Rusting
- Sagging
- Fallen, damaged or missing barbed wire.

There have been a number of incidents of unauthorised access into Ausgrid's chain wire outdoor enclosure substations resulting in an unacceptable risk.

2.3.4 Electronic security

The main source of risk to security at all types of substations relate to doors, vents and windows including substation configurations with fenced outdoor yards. This program comprises the installation of monitoring equipment so that any unauthorised entry is detected and can be responded to. Electronic security also significantly minimises the risks associated with secondary unauthorised access that can result after an initial security breach.

2.3.5 Substation lock upgrade

A source of risk to security with all types of locking systems is the control of keys (lost keys, particularly where workers are exiting the organisation and cannot locate their keys). In addition, the patents applying to the Abloy locking system used on Ausgrid substations is coming to an end. The use of electronic locking ensures that access to substations is controlled and assessed against valid entry requirements which improve staff and contractor safety. This program increases the tracking of keys, operation of locks and ensuring that a gate or door is closed and locked when workers leave a site, in addition to enabling an immediate intruder detection of site access through a gate or door. This program is a critical component of the overall substation security.

2.4 Treatment analysis

Assessment of the planned treatment solutions considered for substation security is shown in Table 3.

Table 3. Treatment options for managing substation security

Treatment option	Treatment overview
1 Repair the security system	Undertake repairs to the security system such as the external enclosure as conditional issues are identified.
2 Refurbish the security system	Components to distribution substations such as the perimeter fencing or walls and the low voltage board housing could be practicably refurbished to achieve adequate security of the assets contained within. The HV switch, transformer and LV board are managed under separate replacement programs.
3 Replace the security system	Replace the security system (this may include replacement of the entire distribution substation).

The different treatment options are all utilised at different points in the asset's lifecycle. A repair may be completed where practical and efficient. Treatments that improve substation security depend on the specific characteristics and design of the substation. Distribution substations are assessed individually (including all the internal components) and if the electrical components are nearing end of their standard technical life, a full substation replacement may be considered.

2.5 Options

The options for addressing risks associated with managing substation security are presented in the Table 4 below.

Table 4. Program options for managing substation security

Program need options	Option overview
1 Reactive Treatment	Implement treatment such as replacement or refurbishment on a 'run to failure' basis.
2 Conditional Treatment	Implement treatment to reinforce or replace when inspections identify that security systems have deteriorated to the point of conditional failure.
3 Planned Treatment	Implement treatment such as replacement or refurbishment prior to security failing. Individual assets are identified into a priority list of assets to be treated. Assets are replaced in a systematic and efficient way, starting from those at highest risk.

Due to the varied nature of the programs, the chosen program options are presented in Table 5.

Table 5. Chosen option for substation security

Program	Option	Description
Distribution chamber substation (safety program)	Planned refurbishment	Each site is assessed individually for condition issues with the scope of work generally including installation of metal security grilles on windows, vents, replacement of doors that are in poor condition, and upgrade of door locks/hinges. Work could also include modifications to the substation layout.
Brick wall outdoor enclosure substations	Planned refurbishment	Each site is assessed individually for the scope which may include: · Installation razor tape to the top of the existing wall · Installation of a weldmesh roof top. Most substations are likely to require additional structural modifications.
Distribution Substation (fencing upgrade program)	Planned refurbishment	The refurbishment involves the upgrade of the existing chain wire fences at outdoor enclosures substations with 'intruder resistant' fencing. The type of fence required at each site will depend on the risks assessed outcomes from community consultation.
Mackellar chamber substation (safety program)	Planned refurbishment	Each site is individually assessed with the refurbishment often involving replacement of some electrical equipment to remove exposed energised conductors or the installation of permanent screening.

Program	Option	Description
Zone and subtransmission substations (Electronic security program)	Planned replacement	The types of treatment for improving substation security depend on the characteristics and construction of the substation. Each substation is treated to address the nature of security drivers based on the urban environment, crime rates, substation criticality and this is done on a case-by-case basis. Other options are not practicable such as fully enclosing all electrical equipment and having 24/7 security staff on site.
All Substation types (lock upgrade program)	Planned replacement	Due to the low effectiveness of key control, a planned replacement option allows for a modern technology to minimise these risks. The criticality of sites are assessed to determine a recommended priority.

2.6 Costing and volumes

To minimise the impact of price variations on Ausgrid's customers, a smoothed approach to the refurbishments (excluding the substation locks program) is proposed, as such Ausgrid prioritises the substations within each program. In each of these programs, Ausgrid is intending to continue with a similar volume to the current regulatory period to mitigate the risks.

The substation lock upgrades program addresses site security upgrades and is expected to occur over a period of three years due to the large number of sites to be addressed.

The remaining substation security systems programs form part of the overall investment being proposed for the replacement and modification of substation security systems. Refer to the Ausgrid Reset RIN template ‘2.2 REPEX’ for details in regard to the overall investment proposed for this asset category during 2019-24.

The rate of delivery has been set to balance risk and resource availability and results in the program being delivered over a 20 year period. Sites are prioritised based on crime rates and break-in information. In 2014, funding for this program was reduced, however due to increased theft and risk to the network, this program has been re-introduced with a realignment of priorities. New delivery contracts are in place to enable this program to be delivered at sustainable rates. Older assets can represent a higher risk and therefore individual assessments are required to assess the sites and timing of delivery within the longer term sustained program.

Within the overarching substation security program, decreases in expenditure in some programs is being balanced with increases in other programs, as requirements are reprioritised. The overall program is expected to continue for the next four regulatory periods. It is not expected that security threat levels will decrease in the future. Within the short to medium term, security protection levels are lagging currently advised threat level requirements due to the time required to design and deliver security related capital works.

The distribution substations for security upgrade are assessed on a case by case basis. An assessment of the cost to refurbish the security controls is completed to determine if it is more cost effective to replace the outdoor enclosure.

The scope for zone and subtransmission substation security upgrades are assessed individually taking into account the site criticality to ensure the most cost effective mitigations are implemented first.

The locking program is a new program of works and is scheduled to be completed within a short period to ensure all locks are updated to consistent keying, with electronic tracking and termination and that improved security outcomes can be achieved on substation perimeter access.

The summary forecast for these programs is shown in Table 6. The costs shown are direct costs only.

Table 6. Forecast for substation security refurbishment

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Distribution chamber substations					
Volumes for replacement	100	100	100	100	100
Unit cost	$21,220	$21,181	$21,158	$21,140	$21,113
Total costs ($m)	**$2.12**	**$2.12**	**$2.12**	**$2.11**	**$2.11**
Brick wall outdoor enclosure substations					
Volumes for replacement	15	15	15	15	15
Unit cost	$50,257	$50,296	$50,539	$50,866	$51,135
Total costs ($m)	**$0.75**	**$0.75**	**$0.76**	**$0.76**	**$0.77**
Substation fencing upgrade – distribution substation					
Volumes for replacement	20	20	20	20	20
Unit cost	$51,038	$50,973	$51,105	$51,314	$51,454
Total costs ($m)	**$1.02**	**$1.02**	**$1.02**	**$1.03**	**$1.03**
Mackellar chamber substation safety					
Volumes for replacement	12	12	1	0	0
Unit cost	$6,056	$6,026	$6,008	$0	$0
Total costs ($m)	**$0.07**	**$0.07**	**$0.01**	**$0**	**$0**
Electronic security – zone substations					
Volumes for replacement	5	5	5	5	5
Unit cost	$170,555	$167,785	$165,111	$164,028	$164,623
Total costs ($m)	**$0.85**	**$0.84**	**$0.83**	**$0.82**	**$0.82**
Electronic security – sub-transmission substations					
Volumes for replacement	3	3	3	3	3
Unit cost	$466,486	$458,935	$451,656	$448,701	$450,295
Total costs ($m)	**$1.40**	**$1.38**	**$1.35**	**$1.35**	**$1.35**
Substation lock upgrade					
Volumes for replacement	26,946	0	0	0	0
Unit cost	$389	$0	$0	$0	$0

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Total costs ($m)	**$10.49**	**$0**	**$0**	**$0**	**$0**

3 PROTECTION SYSTEMS

3.1 Program description

Ausgrid has four planned programs to replace or renew specific protection schemes. The programs include a subset of relay schemes which have been identified as not meeting the required level of safety for workers and the public or protection of Ausgrid's network assets. There is also a requirement that the protection schemes are compliant with the National Electricity Rules.

The planned programs are:

- Optical arc fault protection systems (DOC_11.03.38)
- Siemens 8DN8 circuitry modification – Zone (DOC_11.03.69)
- Siemens 8DN8 circuitry modification – Subtransmission (DOC_11.03.70)
- Mandatory protection links (DOC_11.05.09).

The combined value of these programs is forecast to be $4.0 million in direct costs ($, real FY19) for the 2019-24 regulatory period.

The primary objective of these programs is to continue to provide protection systems for Ausgrid's network that meet the legislative requirements now and into the future in an economically sustainable manner. There are a number of specific drivers which relate to each of the programs that are summarised in Table 7.

Table 7. Need for protection systems

Program	Need
Optical arc fault protection systems	The optical arc fault protection program is driven by the need to protect the safety of workers so far as is reasonably practicable at substations. The present summated current protection schemes are inadequate and will be replaced with the modern standard optical arc fault protection systems. The modern optical arc fault protection systems will also operate to limit the damage to other network assets in the event of an on-site fault.
Siemens 8DN8 circuitry modification	The Siemens 8DN8 low gas alarm circuitry renewal is driven by the National Electricity Rules compliance that prevents a single point of failure that would cause both primary and backup protection to fail. The present configuration does not meet this requirement as the failure of the low gas alarm sensor can inhibit the operation of the primary and back-up protection systems. Renewal of the circuitry will eliminate this failure mode.
Mandatory protection links	The program for the renewal of mandatory protection link labels and configuration documentation is driven by the need to protect the safety of workers so far as is reasonably practicable. The correct labelling and configuration documentation will also reduce the likelihood of this leading to a widespread loss of supply by incorrect operation.

3.2 Background

Protection systems are installed to provide the primary function of detecting electrical faults on the network and after detecting a fault initiating the safe operation of switchgear to protect network assets. Protection schemes at Ausgrid substations that form part of the transmission network must comply with the National Electricity Rules.

Table 8. Asset overview for protection systems

Program	Background
Optical arc fault protection systems	Ausgrid has approximately 600 distribution substations with low voltage switchboards supplied by multiple transformers with summated overcurrent protection.
Siemens 8DN8 circuitry modification	Ausgrid has used Siemens 8DN8 for 15 years with approximately 250 panels installed.
Mandatory protection links	The mandatory protection links are provided to facilitate the safe and reliable operation of the network by allowing workers to disconnect, configure and test protection schemes. These mandatory protection links are required at all zone and sub-transmission substations.

3.3 Risks – Consequence and likelihood

The key consequences that can result in a loss of these functions are shown in Table 9 below.

Table 9. Consequences from loss of function for protection systems

Consequences	Description
Harm to the public, communities and workers	Delay in the clearing of a fault has the potential to increase the risk to workers due to flashover of equipment. Ausgrid workers have been injured due to delayed fault clearing following failures on low voltage switchboards
	Safety issues as a result of loss of supply are detailed below.
Damage to property	Damage to surrounding property and other substation equipment as a result of a delayed protection operation.
	Inability of circuit breaker(s) to safely operate due to insufficient SF6 gas pressure damaging the circuit breaker and other network equipment.
Loss of supply	Wider network interruptions to customers connected to the substation.
	Interruptions to electricity supply for an extended period can affect a single customer or whole communities in the form of transport systems, traffic controls, emergency services, business and communication systems, critical infrastructure and vulnerable customers including those on life support systems.
Compliance	Non-compliance with the National Electricity Rules will result in financial and reputational consequences.

The programs for optical arc fault protection systems and mandatory protection links both manage the likelihood of a fault or maloperation leading to safety risks and loss of supply.

The risk associated with the single point of failure with Siemens 8DN8 low gas alarm circuitry is not primarily associated with an increase in the risk of failure but is required for compliance with National Electricity Rules.

3.4 Treatment analysis

Assessment of the planned treatment solutions considered for protection systems is shown in Table 10.

Table 10. Treatment options for protection systems

Treatment option	Treatment overview
1 Repair the protection system	Undertake repairs to the protection system and mandatory protection links labels as conditional issues are identified.
2 Refurbish the protection system	Modification of the existing trip circuits, improvement to processes and labelling.
3 Replace the protection system	Replacement of the existing protection system with a modern equivalent.

The optical arc fault equipment will replace the previously installed summated overcurrent protection system. The Siemens 8DN8 circuitry modification (modified to comply) and mandatory protection links labelling and configuration documentation will be refurbished to extend the life of the switchgear and overcome the design issue.

3.5 Options

The mitigation of the duty of care risks associated with these assets and the options are considered in Table 11 below.

Table 11. Program options for managing protection systems

Program need options	Option overview
1 Reactive Treatment	The existing systems would be retained. Treatment such as replacement / retrofitting would be implemented when the assets fail.
2 Conditional Treatment	Inspect and testing of assets on a routine basis to identify problems with the condition. Assets are treated when an asset condition problem identified.
3 Planned Treatment	Implement planned treatment of all affected protection systems. Individual assets are built into a priority list of assets to be treated.

3.6 Costing and volumes

The protection systems programs form part of the overall investment being proposed for the replacement and modification of protection systems. Refer to the Ausgrid Reset RIN template '2.2 REPEX' for details in regard to the overall investment proposed for this asset category during 2019-24.

Ausgrid is proposing to undertake the Siemens 8DN8 circuitry modification over a period of 15 years from program initiation. As such this program is intended to continue in the 2019-24 regulatory period and beyond. These works are assessed on a site by site basis with any sites that have other pending works are bundled together to ensure a cost effective outcome.

Ausgrid is only proposing to retrofit optical arc fault protection at a total of 25 substations over the 2019-24 period due to the impact of other capital works reducing the needs further.

The summary forecast for these programs is shown in 0. The costs shown are direct costs only.

Table 12. Forecast for protection systems

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Optical arc fault protection systems					
Volumes for replacement	5	5	5	5	5
Unit cost	$107,442	$106,739	$106,330	$106,022	$105,533
Total costs ($m)	**$0.54**	**$0.53**	**$0.53**	**$0.53**	**$0.53**
Siemens 8DN8 circuitry modification – zone substations					
Volumes for replacement	13	8	0	19	5
Unit cost	$13,969	$13,842	$0	$13,712	$13,623
Total costs ($m)	**$0.18**	**$0.11**	**$0**	**$0.26**	**$0.07**
Siemens 8DN8 circuitry modification – sub-transmission substations					
Volumes for replacement	0	6	12	0	0
Unit cost	$0	$13,842	$13,768	$0	$0
Total costs ($m)	**$0**	**$0.08**	**$0.17**	**$0**	**$0**
Mandatory protection links					
Volumes for replacement	3	3	3	3	3
Unit cost	$29,261	$29,089	$28,988	$28,912	$28,792
Total costs ($m)	**$0.09**	**$0.09**	**$0.09**	**$0.09**	**$0.09**

4 OIL CONTAINMENT

4.1 Program description

Ausgrid has a planned program to upgrade and install oil containment in zone substations. The program is aimed at minimising the risk of oil from Ausgrid's equipment escaping into the environment such as waterways. This program is required to meet requirements of NSW environmental legislation. The remaining program is:

- Oil containment – zone substations (DOC_11.04.01).

A related program to upgrade oil containment in sub-transmission substations is expected to be completed in 2018/19. During the 2019-24 regulatory period, Ausgrid is planning to modernise or install missing oil containment systems at 50 zone substations at a cost of $28.2 million in direct costs $, (real FY19).

4.2 Background

Ausgrid has approximately 190 zone substations that are generally equipped with large oil-filled power transformers. The transformers typically contain between 10,000-50,000 litres of oil. Transformers contain oil for electrical insulation and cooling purposes. Leakage of oil from these transformers has the potential to breach environmental legislation.

The NSW *Protection of the Environment Operation Act 1997* (POEO Act) makes it an offence to pollute any waters or the environment. Ausgrid initiated prioritised programs to minimise the possibility of oil being discharged into the environment from sub-transmission and zone substations as far as reasonably practicable.

The oil containment systems comprise several components including: transformer bunding; oil pipelines and inspection pits, oil containment tanks, oil separation units, isolation valves, and oil spray shields. Transformer bunding is a retaining wall designed to contain oil within the walls and capture the oil into tanks.

4.3 Risks – Consequence and likelihood

The key consequences that can result in a loss of this function are shown in Table 13 below.

Table 13. Consequences from loss of function for oil containment

Consequences	Description
Harm to the environment	Mineral oil spills can lead to environmental damage.
Compliance	Non-compliant oil in water discharge levels and not meeting obligations under POEO Act will result in financial and reputational consequences.

Environmental incidents could result in financial penalties for a breach of the POEO Act of up to $1 million. Non-compliant oil discharges from the oil containment tank and leaking pipes over time are likely to result in a large, onsite and offsite (including waterways) environmental event. Based on past remediation work, the cost of site remediation works can easily exceed $1 million.

4.4 Treatment analysis

Assessment of the planned treatment solutions considered for oil containment systems is shown in Table 14.

Table 14. Treatment options for managing oil containment

Treatment option	Treatment overview
1 Repair the oil containment system	Undertake repairs to the oil containment system as conditional issues are identified. This is an operational task.
2 Refurbish the oil containment system	If the site has an existing oil containment system, the pipes and tanks can be relined.
3 Replace the oil containment system	This option involves upgrading oil containment systems at each substation to parallel plate oil separation units or the enhanced gravity oil water separator system. The upgrade would include relining the oil pipes to fix any cracks in the pipes. Where necessary, transformer bunding made from brick will be replaced with a concrete bunding to remove risk of oil leakage.

The different treatment options are all utilised at different points in the asset's lifecycle. A repair may be completed where practical and efficient. A repair or refurbishment treatment does not remove the inherent non-compliance of some older designs, so will not meet Ausgrid's environmental obligations unless the replacement/upgrade is completed.

4.5 Options

An assessment of oil containment system remediation options has been undertaken to mitigate the risks associated with environmental damage and compliance. The serious risks make a 'run to failure' approach unacceptable. The remaining options are summarised in Table 15 below.

Table 15. Program options for managing oil containment

Program need options	Option overview
1 Reactive Treatment	Implement treatment such as replacement when the oil containment systems fail.
2 Conditional Treatment	Implement treatments to repair or replace oil containment systems when inspections / testing identify they have deteriorated to the point of conditional failure based on a set of criteria.
3 Planned Treatment	Implement planned treatment prior to oil containment systems failing. This involves identifying the individual sites and treating based on a priority list.

The risk of non-compliance to the POEO Act due to environmental damage supports a planned treatment approach. Once all systems are upgraded to compliance level, a conditional treatment approach is considered appropriate where issues are rectified as they are raised. Many sites do not have oil containment systems installed and these sites will continue to be prioritised for system installations in line with upgrade works.

4.6 Costing and volumes

The ongoing delivery timing has been based upon the non-compliant condition of the oil containment systems and the application of a risk prioritisation process. Ausgrid has adopted a risk-based approach for the oil containment programs at substation sites. The program is based on risk models which prioritise work at sites with the highest environmental risk. These risks include volume of oil in each transformer, transformer age, proximity to sensitive environments, bund capacity and type (tray, brick, concrete), in addition to determining if oil containment assets are present on the site. This approach ensures that the program is focused on most effectively reducing environmental risk while the works are delivered. Ausgrid is intending to complete the works at 10 sites annually due to the limitations with network outages to complete the required work.

The oil containment program forms part of the overall investment being proposed for the replacement and modification of oil containment systems. Refer to the Ausgrid Reset RIN template '2.2 REPEX' for details in regard to the overall investment proposed for this asset category during 2019-24.

The decision about which system to install at each site is determined on a case-by-case basis and has historically included different scopes such as pipe lining. The type of oil containment upgrade depends on a number of factors including the lowest cost option and the technical feasibility of installing the two types of systems at each location. These works are undertaken using external contracted services which ensures Ausgrid is able to choose the most cost effective service provider.

The historical volume fluctuations associated with this program are the result of numerous drivers affecting delivery against forecast units. The initial drivers and strategy for oil containment compliance remain unchanged. Approaching the sale of Ausgrid, approvals associated with the commitment to large capital programs resulted in delays in board approval for expenditure which resulted in a significant drop in delivery. The program will begin to reduce at the end of the next two regulatory periods when the majority of large expenditure with the installation of new systems is completed.

The summary forecast for this program is shown in Table 16. The costs shown are direct costs only.

Table 16. Forecast for oil containment

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Oil containment systems – zone substations					
Volumes for replacement	10	10	10	10	10
Unit cost	$578,244	$568,512	$558,942	$555,156	$557,657
Total costs ($m)	**$5.78**	**$5.69**	**$5.59**	**$5.55**	**$5.58**

5 PERIMETER FENCING

5.1 Program description

Ausgrid has two perimeter fencing programs aimed at installing or upgrading the perimeter fencing at major substations:

- Perimeter fencing – Zone substations (DOC_11.03.02)
- Perimeter fencing – Subtransmission substations (DOC_11.03.02-1).

Ausgrid proposes to spend a total of $5.1 million in direct costs ($, real FY19) on replacing and refurbishing perimeter fencing at substations in the 2019-24 regulatory period.

5.2 Background

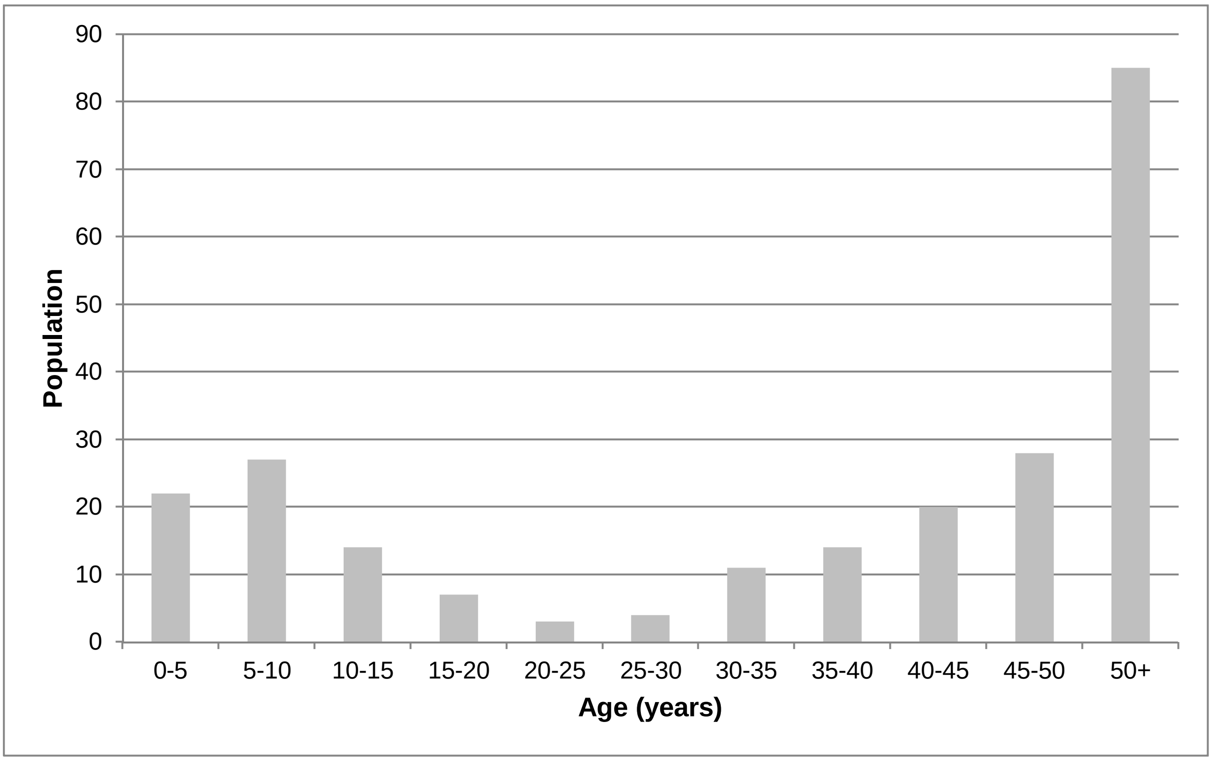
Perimeter fencing is designed to stop unauthorised access onto land surrounding substations. Ausgrid is required to prevent, as far as is reasonably practicable, unauthorised access to its substations to meet its common law duty of care obligations.

Perimeter fences are required at substations where buffer land forms a boundary around the substation building and/or the outdoor switchyard. Ausgrid has experienced a number of trespassing incidents at substations. The type of trespassing involved illegal dumping of bulk waste including contaminated materials such as asbestos, theft and damage to Ausgrid assets at the sites. These buffers of land provide asset protection in bush fire location areas and screening in residential areas which require maintenance.

Ausgrid plans to replace/install perimeter fencing at 25 zone substation sites and 15 subtransmission sites during the 2019-24 regulatory period.

An overview of the population of major substations covered by these programs is provided in Figure 1. The perimeter fences at these sites are in original condition and therefore the age of the substation is a good indication of the age of the fence.

Figure 1. Age profile of major substations (as at 30 June 2017)



5.3 Risks – Consequence and likelihood

The key consequences that can result in a loss of this function are shown in Table 17 below.

Table 17. Consequences from loss of function perimeter fencing

Consequences	Description
Harm to the public, communities and workers	Serious harm to intruders from contact with energised equipment.
	Injury to the public due to the poor condition of fences.
	Potential hazards on land outside of the outdoor switch yards such as open pits, drains, retaining walls, uneven surfaces and stored machinery / equipment.
	Safety issues as a result of loss of supply are detailed below.
Damage to and theft of property	Theft of copper has occurred at a number of Ausgrid's substations. Additional fencing assists in providing further layers of security.
Illegal dumping	Bulk contaminated waste material has been found on Ausgrid's property next to substations. These materials have to be removed to the waste management centre at Ausgrid's expense.
Loss of supply	Unauthorised access can have implications for the security of the network and may result in supply interruptions due to unauthorised operation of equipment.
	Interruptions to electricity supply can affect a single customer or whole communities in the form of transport systems, traffic controls, emergency services, business and communication systems, critical infrastructure and vulnerable customers including those on life support systems.

The major fencing failure modes experienced at substations incudes:

- Corrosion and weather damage of fencing structures
- Vandalism and break-ins resulting in damaged fencing
- Fencing that can be easily climbed
- Lack of boundary fencing.

Further consequences of inadequate fencing include public liability claims. In 2011, a public liability claim was made against Ausgrid by the parent of a child who was injured while playing on the land surrounding a substation owned by Ausgrid.

5.4 Treatment analysis

Assessment of the treatment solutions considered for perimeter fencing is shown in Table 18.

Table 18. Treatment options for perimeter fencing

Treatment option	Treatment overview
1 Repair the perimeter fence	Undertake repairs to the perimeter fence as conditional issues are identified.
2 Refurbish the perimeter fence	If the site has an existing perimeter fence, the strands can be tightened and posts replaced.
3 Replace the perimeter fence	This option involves installing perimeter fencing.

The different treatment options are all utilised at different points in the asset's lifecycle. A repair may be completed where practical and efficient. A repair or refurbishment treatment does not remove the inherent non-compliance of the some older designs, so will not meet Ausgrid's security requirements unless the replacement/upgrade is completed.

5.5 Options

The options to mitigate the risk of unauthorised access to Ausgrid's land and substations are identified and assessed in Table 19 below.

Table 19. Program options for managing perimeter fencing

Program need options	Option overview
1 Reactive Treatment	This option involves undertaking no proactive treatment to mitigate the risks of trespassing on Ausgrid owned land.
2 Conditional Treatment	This option involves undertaking treatment to mitigate the risks of trespassing on Ausgrid's land based on assessing the condition of the fencing on a routine basis.
3 Planned Treatment	Replacing or installing the fences in a planned program. This involves identifying the individual substations and placing them on a risk-based priority list.

The planned installation (replacement) of perimeter fences is the preferred solution to mitigate the risks for sites with no perimeter fence installed or sites with very poor condition fences. For those that have existing perimeter fencing, the preferred option is to conditionally repair/refurbish these fences.

5.6 Costing and volumes

The perimeter fencing programs form part of the overall investment being proposed for the replacement and modification of substation fencing. Refer to the Ausgrid Reset RIN template '2.2 REPEX' for details in regard to the overall investment proposed for this asset category during 2019-24.

These works are delivered by contracted services so that pricing received is competitive. The most appropriate least-cost solution associated with the risks and site location (i.e. urban, industrial or rural) is determined on a case-by-case basis. The unit rates are shown in Table 20 below. Ausgrid has adopted a risk-based approach for upgrading fencing at substation sites. The most at risk sites have been identified and planned for upgrading based on a priority list. This is balanced against what is reasonably practicable, deliverable and sustainable. Zone substation fences are typically installations of new fences and sub-transmission substation fences are generally refurbishments.

The program will continue into the future as a sustainable program with volumes based on the asset replacement lifecycle after the initial installation of fences is completed. Fence life is type/material/location dependent and the condition includes consideration of the structural integrity and the potential for harm to the public from the fence if it is in poor condition. Replacement life is cycled on an average 35 years and as a result drives volumes for sustainable delivery of approximately eight units per year. Minor variations and the shortfall are expected to be addressed through performance improvements in fence construction, improved materials and innovations that are expected into the future. Litigation, illegal dumping and public liability re-invigorated this program to address known extreme risk sites and is scheduled to be delivered sustainably into the future periods based on the realised risks.

The summary forecast for these programs is shown in Table 20. The costs shown are direct costs only.

Table 20. Forecast for perimeter fencing

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Perimeter fencing – zone substations					
Volumes for replacement	5	5	5	5	5
Unit cost	$152,554	$152,002	$151,680	$151,438	$151,053
Total costs ($m)	**$0.76**	**$0.76**	**$0.76**	**$0.76**	**$0.76**
Perimeter fencing – sub-transmission substations					
Volumes for replacement	3	3	3	3	3
Unit cost	$85,499	$84,735	$84,037	$83,733	$83,803
Total costs ($m)	**$0.26**	**$0.25**	**$0.25**	**$0.25**	**$0.25**

6 BUILDINGS AND ROOFS

6.1 Program description

Ausgrid has a total of four programs to restore or replace buildings, roofs and pit lids for zone and sub-transmission substations as detailed below:

- Substation roof – zone substations (REP_02.02.42)
- Substation roof – sub-transmission substations (REP_03.04.06)
- Building refurbishment/replacement works – zone substations (REP_02.04.05)
- Pit lids – zone substations (REP_02.02.43).

Restoration of buildings and roofs is conducted in planned and condition based programs. Ausgrid proposes to spend a total of $14.5 million in direct costs ($, real FY19) on these programs in the 2019-24 regulatory period. Pit lid expenditure represents less than 2% of the total investment in this category.

6.2 Background

Substation buildings and roofs have the primary function to protect sensitive electrical equipment from being damaged by the environment. Substation buildings and roofs on Ausgrid's network have varying designs and are made of various building materials including asbestos. The designs of substation buildings reflect different building standards over the years. Some of Ausgrid's substation buildings are heritage listed and therefore any building works must be consistent with the original design of the building.

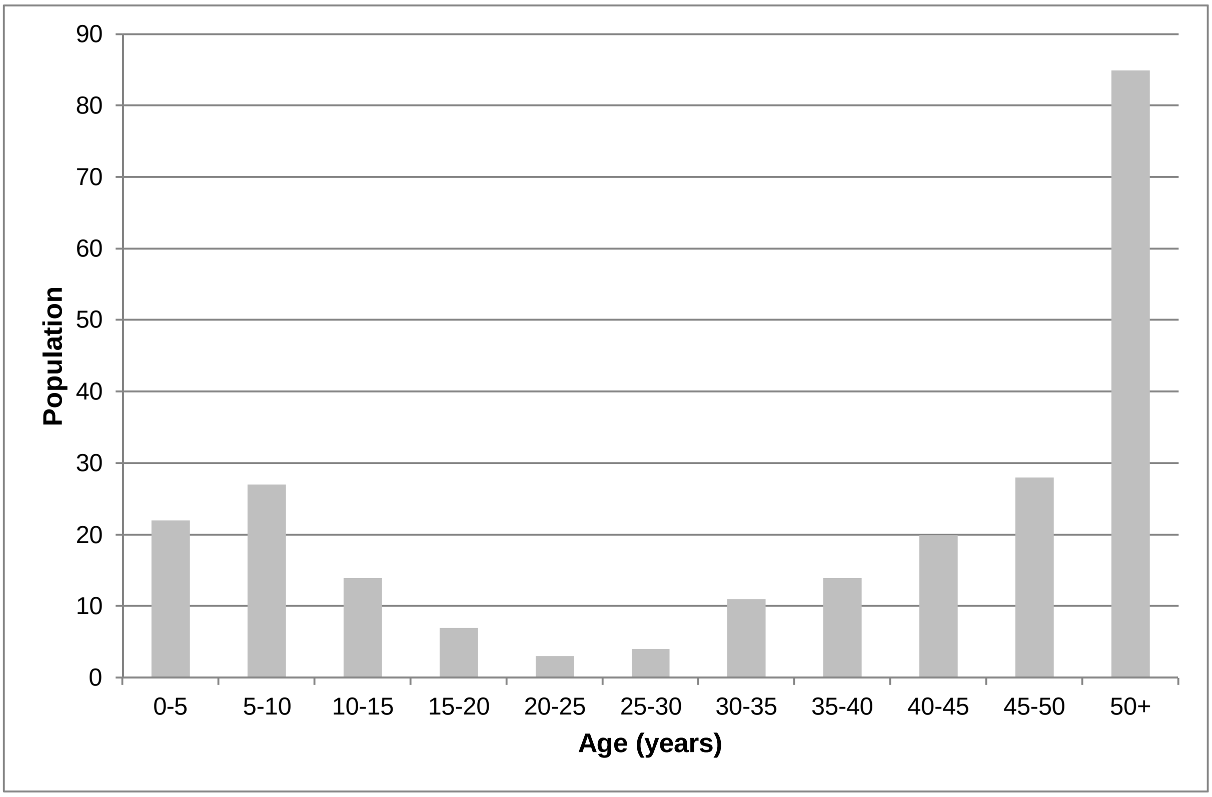
The network equipment installed in buildings is not designed to be operated in an unprotected environment and is dependent on buildings and roofs to provide adequate environmental protection to be operated and maintained. The elements that provide environmental protection (i.e. roof, gutters, storm water systems) degrade with time (e.g. due to corrosion and deterioration of window seals) and require their protective function to be restored or replaced where appropriate.

The pit lids provide mechanical protection for underground electrical cables and equipment. Their function must also provide for the safe traffic of people yet facilitate easy entry into the underground space to conduct maintenance or reconfigure the network when required. The pit lids are typically constructed from cast iron, steel or concrete.

The mechanical protection that pit lids provide also degrades over time due to environmental damage and usage wear. The ability of these assets to provide safe traffic also degrades due to them becoming dislodged and from use over time. Protective galvanized coatings wear with traffic and the galvanization is consumed as it protects the item over the items life. Other civil structures associated with the substation building such as stairs and access ways degrade due to subsidence, corrosion and wear.

An overview of the population of major substations covered by these programs is provided in 0 below. The buildings and roofs at these sites are in original condition and therefore the age of the substation is a good indication of the age of the buildings and roofs.

Figure 2. Age profile of major substations (as at 30 June 2017)



6.3 Risks – Consequence and likelihood

The key consequences that can result from a loss of this function are shown in Table 21 below.

Table 21. Consequences from loss of function for buildings and roofs

Consequences	Description
Harm to the public, communities and workers	Deterioration of buildings and roofs can be hazardous to workers and the public. This can include the risk of failed building and roofing elements falling on workers or public. Failed pit lids, stairs and access ways often result in uneven surfaces to walk and stand on presenting a safety risk to workers in substations.
	Safety issues as a result of loss of supply are detailed below.
Damage to property	Failure of a building or roof will result in loss of the environmental protection for the substation building. In particular, the risk of rain entering substations has the potential to cause significant damage to sensitive electrical equipment.
	The risk of failed building and roofing elements falling onto electrical equipment and causing damage.
Loss of supply	Failure of building and roofs will increase the likelihood of damaged electrical equipment in substations leading to interruptions to electrical supply.
	Interruptions to electricity supply can affect a single customer or whole communities in the form of transport systems, traffic controls, emergency services, business and communication systems, critical infrastructure and vulnerable customers including those on life support systems.

6.4 Treatment analysis

The treatment solutions considered for substation building, roof and pit lids are shown in Table 22.

Table 22. Treatment options for managing buildings and roofs

Treatment option	Treatment overview
1 Repair the building/roof/pit lid	Undertake repairs to the building/roof as conditional issues are identified.
2 Restore the building/roof/pit lid	Replacement of components such as roof sheeting, tiles and guttering/ downpipes can be undertaken in situ. The building walls can be strengthened as required.
3 Replace the building/roof/pit lid	This option involves installing a new building or roof.

The different treatment options are all utilised at different points in the asset's lifecycle. A repair may be completed where practical and efficient.

6.5 Options

The options to mitigate the risks of Ausgrid's substation roofs, buildings and pit lids are identified and assessed in Table 23 below.

Table 23. Program options for managing buildings and roofs

Program need options	Option overview
1 Reactive Treatment	This option involves undertaking no proactive treatment to mitigate the risks of degraded substation buildings.
2 Conditional Treatment	Implement treatment to reinforce or replace when inspections identify that buildings have deteriorated to the point of conditional failure.
3 Planned Treatment	Implement treatment such as replacement or restoration.

Ausgrid's preferred solution is to conditionally treat the buildings, roofs and pit lids within substations. However, there are buildings with outstanding condition issues which have been prioritised, making an initial planned program more appropriate than conditional. The buildings, roofs and pit lids are treated using a combination of restoration and replacement.

6.6 Costing and volumes

The building and roof programs form part of the overall investment being proposed for the replacement and modification of substation buildings and roofs. Refer to the Ausgrid Reset RIN template '2.2 REPEX' for details in regard to the overall investment proposed for this asset category during 2019-24.

These works are undertaken using external contracted services which ensures Ausgrid is able to choose the most cost effective service provider. Each site is considered on a case by case basis with restoration and replacement options considered. Ausgrid has adopted a risk-based approach for upgrading roofs at substation sites. The most at risk sites have been identified and planned for upgrading based on a priority list. This is balanced against what is reasonably practicable, deliverable and sustainable.

Roof replacement works have been significantly influenced by the initial large volumes of poor condition roofs that existed across the network (some of asbestos construction). This large volume of poor condition roofs has been progressively addressed and is forecast to continue at the current predicted lower levels to ensure that the program becomes sustainable in the longer term and avoids large step changes into the future. Dependent on the roof construction and materials utilised in the construction, the location and environment, the roof life should be in the range of 20 to 50 years.

Newer technologies allow for increased low cost condition monitoring of roof conditions that enable this program to progressively determine more accurate conditional and functional failure points for roofs into the future. Using degradation prediction techniques, the future regulatory periods will see a refining of failure prediction resulting in a near run to failure method of delivery for roofs. Presently the forecasts represent known upcoming replacements based on assessed remaining life.

The summary forecast for these programs is shown in Table 24. The costs shown are direct costs only.

Table 24. Forecast for buildings and roofs

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Substation roof – zone substations					
Volumes for replacement	3	3	3	3	3
Unit cost	$471,582	$464,289	$457,428	$454,553	$455,687
Total costs ($m)	**$1.41**	**$1.39**	**$1.37**	**$1.36**	**$1.37**
Substation roof – sub-transmission substations					
Volumes for replacement	1	1	1	1	1
Unit cost	$597,705	$588,143	$578,982	$575,233	$577,117
Total costs ($m)	**$0.60**	**$0.59**	**$0.58**	**$0.58**	**$0.58**
Building restoration/replacement – zone substations					
Volumes for replacement	1	1	1	1	1
Unit cost	$914,715	$902,221	$889,739	$884,903	$888,582
Total costs ($m)	**$0.91**	**$0.90**	**$0.89**	**$0.88**	**$0.89**
Pit Lids – zone substations					
Volumes for replacement	1	1	1	1	1
Unit cost	$31,323	$31,220	$31,158	$31,112	$31,038
Total costs ($m)	**$0.03**	**$0.03**	**$0.03**	**$0.03**	**$0.03**

7 FIRE SYSTEMS

7.1 Program description

Ausgrid has three fire risk mitigation programs that target installing or upgrading fire systems at major substations. The three programs are:

- Smoke detection installation – zone substations (DOC_11.03.25)
- Fire hydrants – zone substations (DOC_11.03.26)
- Fire hydrants – subtransmission substations (DOC_11.03.33).

Each of these programs is continuing from the current regulatory period. Ausgrid proposes to spend a total of $9.5 million in direct costs ($, real FY19) on installing and upgrading fire systems at substations in the 2019-24 regulatory period.

7.2 Background

Substations pose a significant fire hazard due to the presence of large quantities of flammable insulating oil in some equipment and the potential for a failure to ignite materials within the substation. Ausgrid has had a program of retrofitting vacuum circuit breakers into switchboards to reduce the indoor oil volume and hence the risk of fire.

Smoke detection systems are present in approximately 60% (as at 30 June 2017) of all zone and sub-transmission (major) substations. Smoke detectors alert emergency services and Ausgrid to a fire in a substation.

Fire hydrant systems are used exclusively by NSW Fire & Rescue and the Rural Fire Service when attending a fire. There are approximately 117 major substations that have fire hydrants installed on site. In some of these locations, the water pressure and flow rates have reduced (due to changes to the Sydney Water/Hunter Water networks) to an extent that some fire hydrants are no longer sufficient to meet their design performance levels. The fire hydrant pipe work at older substations has also deteriorated and spare parts are no longer commercially available.

Ausgrid has a duty of care to reduce the risk of fire in its substations as far as is reasonably practicable. Fire systems are designed to mitigate the consequence of the fire risk at major substations. Deterioration in condition has the potential to cause the fire systems to fail to meet statutory requirements and the water pressure required for fire-fighting purposes.

7.3 Risks – Consequence and likelihood

The key consequences that can result in the failure of fire systems are shown in Table 25 below.

Table 25. Consequences from loss of function for fire systems

Consequences	Description
Harm to the public, communities and workers	Major fires and explosions can result in serious injury to workers in the substation at the time of the fire.
	Fires may result in injury to members of the public (including emergency services workers) and public liability claims against Ausgrid.
	Safety issues as a result of loss of supply are detailed below.

Consequences	Description
Damage to property	Fires initiated by substation equipment can lead to damage to surrounding property and other substation equipment.
	Fires initiated by substation equipment can escape the substation and impact third party property.
Loss of supply	Interruption to the electricity supply to customers connected to the substation.
	Interruptions to electricity supply can affect a single customer or whole communities in the form of transport systems, traffic controls, emergency services, business and communication systems, critical infrastructure and vulnerable customers including those on life support systems.

Ausgrid is exposed to unacceptable risk without fire detection systems. It is considered reasonably practicable to install fire systems to manage the risk of a substation fire to workers, the public, Ausgrid and third party property.

Site specific factors can also increase the likelihood of hydrant failure and may include:

- Mine subsidence
- Acid sulphate soils
- Reactive soils
- In ground moisture.

The most common failure modes include:

- Corrosion
- Loss of pressure.

7.4 Treatment analysis

Assessment of the planned treatment solutions considered to mitigate the risk of failure of fire systems at Ausgrid's major substations are identified and assessed in Table 26 below.

Table 26. Treatment options for managing fire systems

Treatment option	Treatment overview
1 Repair the fire systems	Undertake repairs to the fire systems.
2 Refurbish the fire systems	Replacement of components such as smoke detectors, valves and joints that make up the fire systems.
3 Replace the fire systems	Replace the fire systems.

7.5 Options

The options to mitigate the risk of failure of fire systems at Ausgrid's major substations are considered in 0 below.

Table 27. Program options for managing fire systems

Program need options	Option overview
1 Reactive Treatment	Implement treatment such as replacement or refurbishment on a 'run to failure' basis.
2 Conditional Treatment	Implement treatment to reinforce or replace when inspections identify that fire systems have deteriorated to the point of conditional failure.
3 Planned Treatment	Replacing or installing fire systems in a planned program. This involves identifying the individual substations that require upgrading and placing them on a risk-based priority list.

The conditional refurbishment (or replacement, if required) of fire hydrants is Ausgrid's preferred solution. Upon conditional failure, the site is reviewed for compliance to ensure the upgrade is suitable for equipment layouts within site.

The planned installation of smoke detectors at substations that do not have smoke detectors is Ausgrid's most prudent option to expediently mitigate the consequence of a fire. A planned program allows for progressive installation using a risk-based approach.

7.6 Costing and volumes

Each site is assessed on a case by case basis to determine the most cost effective option between refurbishment or replacement of fire systems. The design process considers different types of fire systems and chooses the most cost effective option that provides site coverage.

The fire systems programs form part of the overall investment being proposed for the replacement and modification of fire systems. Refer to the Ausgrid Reset RIN template '2.2 REPEX' for details in regard to the overall investment proposed for this asset category during 2019-24.

Ausgrid has adopted a risk-based approach for installing fire systems at zone substations using a priority list for the planned program. The replacement rate achieves the reasonably practicable management of risk through a deliverable and sustainable program.

Based on Ausgrid's testing criteria, an average of one fire hydrant conditionally fails a year across each of the populations of zone and sub-transmission substations. Therefore a forecast replacement plan of one a year in zone substations and one in sub-transmission substations for hydrants.

Smoke detection and other fire management systems remain a priority for installation at all substation sites. All sub-transmission sites will contain fire detection equipment by the end of this regulatory period leaving only zone substations to be addressed.. The risks and priority for the program has remained and with recent regulatory and Building Code of Australia (BCA) tightening in the fire detection space, a restart on the program delivery has been undertaken and is scheduled to be delivered at a sustainable rate into the next and future regulatory periods. Fire detection equipment components have a range of certifiable serviceable life. The forecast program in the next 10 years will see all sites being installed with detection equipment and a step decrease to a lower installation rate of high cost items. Low cost high volume sub components for detection equipment will require replacement to remain certified but the total cost associated with the program will be a decrease once the initial installations are complete.

The summary forecast for these programs is shown in Table 28. The costs shown are direct costs only.

Table 28.   Forecast for fire systems

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Smoke detection installation – zone substations					
Volumes for replacement	15	15	15	15	15
Unit cost	$105,745	$104,253	$102,919	$102,322	$102,390
Total costs ($m)	**$1.59**	**$1.56**	**$1.54**	**$1.53**	**$1.54**
Fire hydrants – zone substations					
Volumes for replacement	1	1	1	1	1
Unit cost	$126,373	$124,493	$122,764	$122,018	$122,217
Total costs ($m)	**$0.13**	**$0.12**	**$0.12**	**$0.12**	**$0.12**
Fire hydrants – sub-transmission substations					
Volumes for replacement	1	1	1	1	1
Unit cost	$224,140	$220,749	$217,598	$216,256	$216,690
Total costs ($m)	**$0.22**	**$0.22**	**$0.22**	**$0.22**	**$0.22**

8 FIRE DOORS

8.1 Program description

Ausgrid has three programs to mitigate the risks of asbestos being released from fire doors that are assessed as being in poor condition. The three programs are:

- Asbestos fire doors – distribution substations (DOC_11.03.52)
- Asbestos fire doors – sub-transmission substations (DOC_11.03.53)
- Asbestos fire doors – zone substations (DOC_11.03.54).

Ausgrid proposes to replace 500 fire doors in a planned program at a forecast cost of $6.4 million in direct costs ($, real FY19) in the 2019-24 regulatory period.

8.2 Background

The entrance and (some) internal doors of Ausgrid's substations are required to be fire rated to mitigate the risk of a fire spreading beyond defined areas. Ausgrid has approximately 8,700 fire doors (constructed from different materials) in substations as at 30 June 2017.

Prior to 1989, fire doors containing asbestos were installed at Ausgrid's substations. At the time, asbestos was widely used in fire doors due to its superior fire resistant properties. Asbestos fire doors must be in good condition so that the asbestos material is not disturbed and to limit the release of asbestos fibres into the environment. Doors that are in poor condition present a risk to workers at substations due to the potential for the release of asbestos contained in the doors.

The NSW Work Health & Safety Regulations 2012 (Section 420) requires Ausgrid to ensure that exposure of a person at the workplace to airborne asbestos is eliminated as far as is reasonably practicable. The program to replace asbestos fire doors that are in poor condition forms part of Ausgrid's strategy to meet its WH&S obligations in addition to ensuring fire doors are functional for fire protection.

8.3 Risks – Consequence and likelihood

The key consequences that can result from a loss of this function are shown in Table 29 below.

Table 29. Consequences from loss of function for fire doors

Consequences	Description
Harm to the public, communities and workers	Asbestos fibres could be disturbed due to the opening and closing of doors that are in poor condition. Disturbed asbestos fibres can be released into the environment and present a safety risk to workers and the public. Inhaling asbestos fibres has the potential to cause serious respiratory disease, such as asbestosis and/or mesothelioma.
Damage to property	The release of asbestos from a fire door reduces the fire doors ability to contain fire within the fire compartment which puts Ausgrid and third party property at risk.

The most common failure modes for fire doors are:

- Swelling due to moisture ingress into the door

- Abrasion of doors from doors sagging on hinges, scraping floor or wall resulting in loosening of asbestos.

The probability of door failure is higher for those in basement substations which are subjected to combined heat and moisture.

8.4 Treatment analysis

Assessment of the treatment solutions considered for fire doors is shown in Table 30.

Table 30. Treatment options for managing fire doors

Treatment option	Treatment overview
1 Repair/Refurbish the fire doors	Undertake repairs to the fire doors. This is not considered practical as patching a fire door will lead to the door being a non-compliant fire door that cannot be certified.
2 Modify the fire doors	Modify the door using encasement. This is not considered practical as encasing a fire door will lead to the door being a non-compliant fire door that cannot be certified in addition to not fitting within the frame.
3 Replace the fire doors	Replace the fire doors. This is the only feasible treatment solution.

8.5 Options

The options to mitigate the risk of asbestos fire doors failure are identified and assessed in Table 31 below.

Table 31. Program options for managing fire doors

Program need options	Option overview
1 Reactive Treatment	Doors would be treated on a reactive basis as identified by users of the doors as failing to meet their function.
2 Conditional Treatment	This option involves undertaking treatment to mitigate the risks of asbestos fire doors on a conditional basis. There is a requirement for asbestos fire doors to be inspected on a regular basis.
3 Planned Treatment	This option involves replacing all asbestos fire doors that are found to be in a degraded condition. Replacement is conducted on a risk-based priority basis.

There are a large number of identified asbestos fire doors that are at risk of failure making planned replacement the only prudent option. This eliminates known risks and minimises the risk of releasing asbestos fibres from doors. This is the most effective option to meet Ausgrid's duty of care obligations to its workers and the public. This planned approach makes allowance for any doors that are reactively identified with funding drawn in conjunction with Part K (Reactive replacement programs).

8.6 Costing and volumes

The forecast rate of replacement is based on following a risk-based priority list by addressing the highest risk first and treating all the poor condition asbestos fire doors located at a substation as a group to ensure good value. The replacement rate achieves the reasonably practicable management of risk through a deliverable and sustainable program.

The fire door programs form part of the overall investment being proposed for the replacement and modification of fire doors in substations. Refer to the Ausgrid Reset RIN template '2.2 REPEX' for details in regard to the overall investment proposed for this asset category during 2019-24.

The specialised nature of these works (asbestos removal) is undertaken with contracted services which enables Ausgrid to select the most cost effective service provider on a competitive basis. Fire doors have historically been replaced during substation decommissioning's or as part of operational work and have not had a dedicated program.

Decreases in available funding for programs in the last determination process resulted in this program being given a lower priority when compared to other programs. Due to this funding delay, door conditions have continued to deteriorate resulting in an increased priority to deliver this program. The sustainable volumes are scheduled to address known condition issues with the fire doors while also removing the asbestos risk from the network. New contracts have been established to deliver this program moving forward to ensure fire door compliance. This program is expected to be continued to be delivered for the next 50 years to address the poor condition of doors.

The summary forecast for this program is shown in Table 32. The costs shown are direct costs only.

Table 32. Forecast for fire doors

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Asbestos fire doors					
Volumes for replacement	100	100	100	100	100
Unit cost	$12,873	$12,758	$12,653	$12,608	$12,618
Total costs ($m)	**$1.29**	**$1.28**	**$1.27**	**$1.26**	**$1.26**

9 BUSHINGS

9.1 Program description

Ausgrid has two planned programs to replace 132kV/66kV associated with transformers and wall/floor penetrations. The purpose of these programs is to mitigate risks associated with deteriorating bushing condition which can lead to network reliability and safety concerns.

The two key programs are:

- 132kV/66kV bushings – zone substations (REP_02.03.05)
- 132kV/66kV bushings – sub-transmission substations (REP_03.03.10).

The planned programs continue from the current regulatory period. The plan is to replace a total of 93 bushings at a total cost of $4.9 million in direct costs ($, real FY19) during the 2019-24 regulatory period.

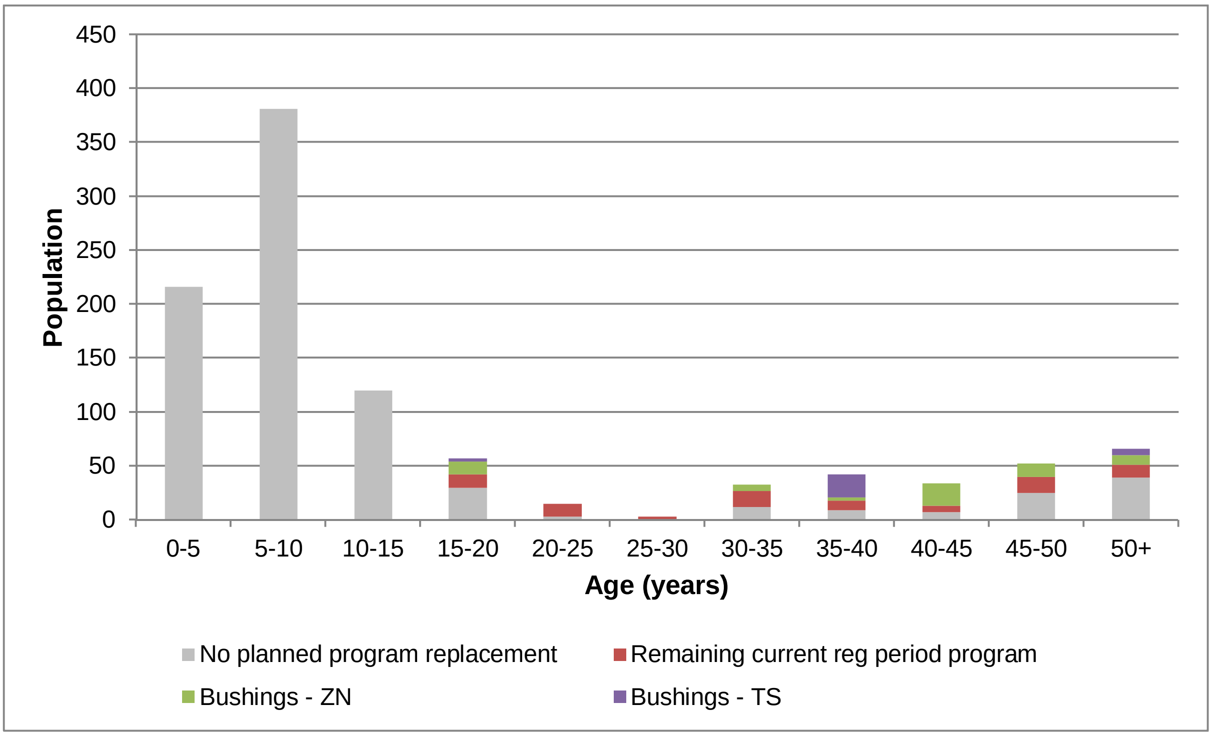
The age profile highlighting the identified programs for replacement against the total population of bushings on the network is shown in Figure 3.

9.2 Background

A bushing provides insulation to allow an electrical conductor to pass through a barrier such as a transformer tank or wall. Bushings are generally constructed of porcelain and at higher voltages such as 132kV and 66kV are impregnated with oil or resin. Ausgrid has approximately 1,000 bushings used at 132kV and 66kV for transformers or walls/floors.

The age profile of all 132kV and 66kV bushings on Ausgrid's network is shown in Figure 3 .

Figure 3. Age profile of 132kV and 66kV bushings (as at 30 June 2017)



Ausgrid has experienced catastrophic failures of capacitively graded 132kV and 66kV oil impregnated paper bushings have. Ausgrid has been replacing these with resin impregnated paper bushings and all new transformers come with this type fitted. In Ausgrid's experience, the serviceable life of these types of bushings should be approximately 25 years.

The primary function of a bushing is to insulate the transformer tank or wall from the voltage associated with the primary electrical conductor. This ensures the tank or wall is safe for worker contact.

Following the catastrophic failure of several oil impregnated paper bushings on Ausgrid's network, investigations were carried out into the condition of these assets. The investigations found that there was a degradation of the insulation material resulting in water ingress in the bushing. The seriousness of bushing failures instigated a proactive replacement program of this type of oil impregnated paper bushings.

The bushing replacement programs form part of Ausgrid's strategy to meet its obligations to manage the risks of these assets failing so far as is reasonably practicable.

9.3 Risks – Consequence and likelihood

The key consequences that can result from a loss of this function are shown in Table 33 below.

Table 33. Consequences from loss of function for bushings

Consequences	Description
Harm to the public, communities and workers	Explosive failure of transformer bushings can result in flying debris and major fires in substations, potentially harming workers at the substation and nearby members of the public.
	Fire caused by a loss of insulation, further propagated by the presence of highly flammable oil within the transformer tank.
	Safety issues as a result of loss of supply are detailed below.
Damage to property	Explosion of the bushing can result in damage to adjacent substation equipment.
Damage to the environment.	Mineral oil spills can lead to environmental issues.
Loss of supply	Network interruption to customers connected to the substation.
	Interruptions to electricity supply for an extended period can affect a single customer or whole communities in the form of transport systems, traffic controls, emergency services, business and communication systems, critical infrastructure and vulnerable customers including those on life support systems.
	Failures associated with these transformer bushings may result in large numbers of supply interruptions and penalties or intervention by our regulator.

The key failure mode for bushings is moisture ingress due to surface protection breakdown.

9.4 Treatment analysis

Assessment of the treatment solutions considered for bushings is shown in Table 34.

Table 34. Treatment options for managing bushings

Treatment option	Treatment overview
1 Repair the bushing	Undertake repairs to the bushing as conditional issues are identified.
2 Refurbish the bushing	Bushing removal, off site replacement of bushing seals and oil, reinstallation and testing.
3 Replace the bushing	Replacement of the bushing with a modern equivalent.

The different treatment options are all utilised at different points in the asset's lifecycle. A repair may be completed where practical and efficient, particularly where insulation has been compromised. A repair or refurbishment treatment does not remove the inherent risk of the oil and costs a similar order of magnitude and is therefore not the preferred option.

The oil impregnated paper bushings are replaced with bushings utilising resin impregnated paper technology which does not have the same failure modes. Ausgrid is also investigating alternative insulators such as using polymer casing rather than porcelain.

9.5 Options

The options to mitigate the risk of bushing failure are identified and assessed in Table 35 below.

Table 35. Program options for managing bushings

Program need options	Option overview
1 Reactive Treatment	Implement treatment such as replacement when the bushings fail.
2 Conditional Treatment	Implement treatments to repair or replace bushings when inspections or testing identify they have deteriorated to the point of conditional failure based on a set of criteria.
3 Planned Treatment	Implement planned treatment prior to bushing assets failure. This involves identifying the individual bushings and treating based on a priority list.

Reactive treatment of these 132kV and 66kV oil impregnated paper bushings would result in unacceptable risk and safety and reliability consequences. Functional failure while in service increases vulnerability of the network to security and reliability issues due to failed assets remaining out of service for long periods.

The preferred option is to undertake replacement in a planned manner for the programs of work to mitigate the risks of these assets failing in service.

9.6 Costing and volumes

The bushing programs form part of the overall investment being proposed for the replacement of transformer bushings. Refer to the Ausgrid Reset RIN template '2.2 REPEX' for details in regard to the overall investment proposed for this asset category during 2019-24.

Ausgrid has adopted a risk-based approach for identifying the assets that need to be replaced. All of the 132kV and 66kV oil impregnated paper bushings have been identified for replacement based on risk. The assessment took into account the operating voltage, latest test results and the age. Once the outstanding replacements are completed, Ausgrid will adopt a replacement at approximately 25 years which is included in these forecasts shown in Table 36. The bushing replacement forms a mid-life refurbishment for the power transformer, effectively extending its life.

The summary forecast for these programs is shown in Table 36. The costs shown are direct costs only.

Table 36. Forecast for bushings

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
132kV/66kV bushings – zone substations					
Volumes for replacement	7	7	7	7	7
Unit cost	$94,590	$94,116	$93,840	$93,632	$93,303
Total costs ($m)	**$0.66**	**$0.66**	**$0.66**	**$0.66**	**$0.65**
132kV/66kV bushings – sub-transmission substations					
Volumes for replacement	3	3	3	3	3
Unit cost	$108,315	$107,621	$107,124	$106,831	$106,566
Total costs ($m)	**$0.32**	**$0.32**	**$0.32**	**$0.32**	**$0.32**

10 SUBTRANSMISSION EARTHING SYSTEMS

10.1 Program description

The replacement programs for sub-transmission feeder earthing systems address known condition issues and issues associated with their design. These condition issues cause safety risks to the public, customers and workers if:

- Excessive earth potential rise occurs under normal conditions or during faults, or
- Feeder protection systems do not operate correctly.

Ausgrid has two programs targeted at refurbishing and replacing sub-transmission feeder earthing systems. These programs are:

- Replace subtransmission overhead earth wire (REP_05.02.29)
- Refurbish earthing - transmission feeders (REP_05.02.03).

The program to replace overhead sub-transmission feeder earth wires is forecast to cost $5.4 million in direct costs ($, real FY2019) replacing 101km of overhead earth wire and the refurbishment program is forecast to cost $0.2 million in direct costs ($, real FY2019) for 20 feeders during the 2019-24 regulatory period. Both of these programs continue from the 2014-19 regulatory period.

10.2 Background

The earthing system on sub-transmission feeders is a safety critical component that must be appropriately designed and maintained in suitable condition for as long as the sub-transmission feeder it protects remains in service. These earthing systems include earth electrodes, earth conductors, earth grids, link boxes and surge arrestors. Earthing systems protect assets from being damaged by electrical faults and voltage surges as well as protect the public, customers and workers from electric shock and electrocution.

Ausgrid has approximately 560 overhead and underground sub-transmission feeders operating at 33kV, 66kV or 132kV. Their total length is approximately 4,100km. Each feeder is protected by an earthing system. Earthing systems for underground feeders are typically more complex than the earthing systems for overhead feeders.

The primary function of earthing systems is to:

- Control feeder earth potential rise (EPR) under normal or fault conditions
- Ensure correct operation of protection systems to maintain system stability
- For underground feeders, achieve the designed cable capacity.

10.3 Risks – Consequence and likelihood

The key consequences that can result from a loss of function of a sub-transmission earthing system are shown in Table 37 below.

Table 37. Consequences from loss of function for Subtransmission earthing systems

Consequences	Description
Harm to the public, communities and workers	Excessive earth potential rise or ineffective operation of protection systems may cause injury (physical injury, electric shock or burns) or a fatality (electrocution).
	Fires (including bushfires) caused by excessive earth potential rise or ineffective operation of protection systems may result in injury (physical injury, electric shock or burns) or a fatality.
	Safety issues as a result of loss of supply are detailed below.
Damage to property	Contact between live electrical equipment which has failed due to excessive earth potential rise or ineffective protection system operation and buildings, infrastructure or vehicles / watercraft may cause arcing, fires or physical damage.
	Buildings, property or critical infrastructure may be damaged by fires caused by vegetation contact with live electrical equipment which has failed due to excessive earth potential rise or ineffective operation of protection systems.
	Excessive earth potential rise may damage appliances or equipment installed within customer premises. Ausgrid may be held liable for their replacement.
Damage to the environment.	The natural environment may be damaged by fires caused by failed electrical conductors or equipment or fluid leakage from damaged cables.
Loss of supply	Ineffective operation of protection systems may result in wide-spread supply interruptions and penalties or intervention by our regulator.
	Ineffective or incorrectly designed earth systems for underground cables may result in reduced supply capacity which causes interruptions and penalties or intervention by our regulator.
	Interruptions to electricity supply can affect a single customer or whole communities in the form of transport systems, traffic controls, emergency services, business and communication systems, critical infrastructure and vulnerable customers including those on life support systems.

Failure modes associated with earthing systems are deteriorating in nature and therefore present an increased likelihood over time. In the period from 2013/14 to 2016/17, there were over 900 sub-transmission feeder earthing system condition issues identified by inspections and condition assessments. The predominant failure modes for earthing systems include:

- Increased resistance to earth due to corrosion of the electrodes, bonds, conductor connections and links
- Ineffective earth voltage / current control or balancing in underground cables due to incorrect installation, incorrect original design or increased network fault levels
- Damage to cable serving or sheath due to ineffective control of earth currents
- Third party damage or theft of earthing system components.

The consequence of earthing system failure can increase due to:

- Being in areas with high pedestrian / vehicle activity or in close proximity to schools
- Buildings / developments or pools being near sub-transmission feeders
- Being in close proximity to other underground utilities (gas, fuel, telecommunications)
- Being connected to feeders which supply critical customers or infrastructure

- Being in areas prone to bushfire.

Ausgrid's asset management practices for earthing systems provide an understanding of their condition and therefore the likelihood of failure. Detecting failures before they occur and applying treatments maintains earthing systems in a serviceable condition, limiting the likelihood of failure and mitigating the potential consequences described above.

10.4 Treatment analysis

Assessment of the treatment solutions considered for these earthing systems is shown in Table 38.

Table 38. Treatment options for managing Subtransmission earthing systems

Treatment option	Treatment overview
1 Repair the earthing system	Undertake repairs to the earthing system as condition issues are identified.
2 Refurbish the earthing system	Replace conditionally failed components of the earthing system with modern equivalent components.
3 Replace the earthing system	Replacement of all earthing system components with their modern equivalent.

The different treatment options are all utilised at different points in the asset's lifecycle. A repair may be completed where practical and efficient. Replacement of the entire earthing systems has not been warranted to date. Repairs will still be undertaken where minor components (for example, bonding leads) are assessed as conditionally failed.

10.5 Options

The options considered for the treatment of earthing electrodes are summarised in Table 39 below. These options are based on the need to undertake work on these assets when their condition is assessed to be unsafe if left as-is.

Table 39. Program options for managing Subtransmission earthing systems

Program need options	Option overview
1 Reactive Treatment	Replace the earthing system when it fails.
2 Conditional Treatment	Implement treatment to repair, refurbish or replace assets when inspections or condition assessments identify that they have deteriorated to the point of conditional failure based on a set of criteria.
3 Planned Treatment	Implement treatment such as replacement or refurbishment of the earthing system at the standard technical life of 45 years.

Ausgrid's preferred approach for managing sub-transmission earthing systems is to undertake condition-based replacement of components with their modern equivalent as it provides a balance between the risks and costs so far as is reasonably practicable.

With this approach, each feeder is assessed against condition criteria during overhead line or underground cable maintenance inspections or under engineering condition assessments. When a feeder has been fully inspected or condition-assessed, all earthing system issues are 'packaged up' so components are replaced on a 'per feeder' basis – this approach is considered a ‘refurbishment’ of the feeder earthing system because the earthing system is not fully replaced.

10.6 Costing and volumes

Earthing system component replacement requirements are determined by condition assessment at the time of asset inspection or by a program of engineering condition assessments. The forecasts for the replacement programs have been based on historical identification of conditional failures, asset population and condition information, as well as known feeder earthing condition or design issues. These subtransmission earthing system programs have been aligned to the ‘Other’ category in the Category Analysis RIN template as a specific category for these assets is not included in the template. Benchmarking of unit costs is difficult and they are only directly comparable with other distributors if they are undertaking similar programs.

Replacement of earthing system components is primarily undertaken by internal resources, although external resources have been utilised on occasion. Internal benchmarking of Ausgrid costs is continually undertaken to drive efficiency and reduce costs.

These programs form part of the overall investment being proposed for the replacement and modification of subtransmission earthing systems. Refer to the Ausgrid Reset RIN template ‘2.2 REPEX’ for details in regard to the overall investment proposed for this asset category during 2019-24.

Overhead Earth Wire replacement is predominantly planned for 132kV feeders and the forecast equates to replacement of approximately 1.8% of the population annually and excludes any works covered by Area Plan projects on sub-transmission feeders.

The forecast for earthing system refurbishment will predominantly be targeting 132kV underground cable circuits, particularly where the original earthing equipment is suspected of having insufficient fault rating due to changes in the transmission and subtransmission networks, which have resulted in increased fault rating levels after the cables were initially installed. The forecast for this program equates to less than 1% of sub-transmission feeders being refurbished annually. However, refurbishments may also be undertaken with Area Plan projects and will be funded by those projects.

The summary forecast for these programs is shown in Table 40. The costs shown are direct costs only.

Table 40. Forecast for Subtransmission earthing systems

Direct Costs (real $FY19)	FY20	FY21	FY22	FY23	FY24
Replacement of overhead earth wire – transmission feeders					
Volumes for replacement	20	20	21.2	20	20
Unit cost	53,953	53,611	53,436	53,319	53,108
Total costs ($m)	**1.08**	**1.07**	**1.13**	**1.07**	**1.06**
Refurbish earthing - transmission feeders					
Volumes for replacement	4	4	4	4	4
Unit cost	11,237	11,173	11,140	11,117	11,077
Total costs ($m)	**0.04**	**0.04**	**0.04**	**0.04**	**0.04**