Asset Health and Criticality Method

Power and Water Corporation

Executive Summary

Risk is that uncertain events or conditions associated with an asset failure that, if it occurs, will affect Power and Water's ability to successful execute its strategies to achieve its organisational objectives of operating a safe and reliable power network at the lowest cost to the customer.

The health and criticality framework provide a structured and consistent basis for understanding the risk associated with each particular asset class. It is used to support the decision-making process for investments required on existing assets and provides a means of assessing if investment is targeted towards areas of high risk.

A key attribute of the risk and value based decision-making framework is the adoption of a consistent and comparative method for assessing assets and risks.

The two main features of the framework are the attribution of the concepts of "health" and "criticality" to an asset. Asset health is a measure of the useful remaining life of an asset and a key factor in the likelihood of asset failure. Asset criticality is a measure of the potential consequence as a result of an asset failure and is a key determinant in quantifying the loss associated with the failure.

Health indices change over time as attributes that affect the probability of asset failure change, such as the physical condition or operating conditions. Criticality indices may change over time when network attributes change, such as the demand supplied or the network configuration. The probability of asset failures and the associated consequences are continually refined over time as data is collected across the asset base.

The health and criticality framework provides PWC with the ability to forecast its expenditure at levels which achieves a residual risk that meets regulatory and legislative requirements, and where these requirements do not exist, sufficient to maintain the existing risk profile.

1 Introduction

1.1 Purpose

The purpose of this document is to provide an overview of the approach and methodology that Power and Water has taken to determine the health and criticality of the assets in the system; and to outline how this information is used by Power and Water in developing targeted and prioritised expenditure forecasts.

1.2 Background

Understanding the risk of the assets within an electricity distribution network is crucial for ensuring investments are targeted at those assets bearing the greatest risks.

Power and Water recognise the need to understand the spread of risk across network assets and to identify the asset groups, and assets within each asset group that present the greatest risk. This proactive approach to asset management ensures that expenditure on replacement and maintenance activities is prudent.

Power and Water uses an asset health and criticality methodology to assess the risk across the network. The methodology is loosely based on the OFGEM Network Asset Indices Methodology[1]. The methodology has allowed for the development of asset health and criticality indices for the following assets classes that make up Power and Water's network:

- Power transformers;
- HV circuit breakers
- Underground cables
- Conductors
- Distribution substations;
- Distribution switchgear;
- Poles and Towers;
- Pole top hardware;
- Protection; and
- SCADA and communications.

1.3 NER Context for making decisions on risk

The National Electricity Rules (NER) provide guidance in terms of setting acceptable risk and expenditure trade-offs via the capital and operating expenditure objectives and criteria for standard control services. These capital and operating expenditure objectives, specified in clause 6.5.6(a) and 6.5.7(a) of the NER describe the outcomes or outputs to be achieved by the expenditure. The objectives include:

1. Meet or manage the expected demand for standard control services;
2. Comply with all applicable regulatory obligations or requirements associated with the provision of standard control services;
3. To the extent that there is no applicable regulatory obligation or requirement in relation to the quality, reliability or security of supply of standard control services; or the reliability or security of the distribution system through the supply of standard control services, to the relevant extent:

[1] https://www.ofgem.gov.uk/system/files/docs/2017/05/dno_common_network_asset_indices_methodology_v1.1.pdf

   a. Maintain the quality, reliability and security of supply of standard control services
   b. Maintain the reliability and security of the distribution system through the supply of standard control services
4. Maintain the safety of the distribution system through the supply of standard control services.

The objectives effectively require a DNSP to forecast its expenditure at levels which achieves a risk level that meets regulatory or legislative requirements, and where these requirements do not exist, sufficient to maintain the existing risk profile.

To objectively maintain the risk profile over time, Power and Water has developed an asset health and criticality framework.

1.4 Strategic Asset Management Plan and Asset Management Plans

The SAMP sets out how Power and Water will achieve the corporate objectives of operational performance, health and safety, people and culture, customers, and financial performance of the power network. The asset class AMPs describes how individual asset classes will deliver the SAMP. It explains the challenges associated with the asset class and lays out the investment programs to manage the asset class and achieve the corporate objectives.

The health and criticality methodology are central to the assessment of asset class risk and therefore, the prioritisation and allocation of investment to achieve the organisation's objectives.

1.5 Investment decision making

Risk analysis is an integral part of the decision-making process. To balance competing drivers such as network performance versus cost, contemporary asset management practice applies risk and value based decision-making frameworks. This ensures that investment decisions are made as consistently as possible, and balance the organisation's objective to deliver a safe, reliable and affordable network.

Investment decisions principally revolve around three matters: "**what**" needs to be done; "**how**" does it need to be done; and, "**when**" does it need to be done.

The "**what"** requires the clear and precise identification of the need for an investment. For example, this may be associated with an identified capacity constraint or an asset in poor condition and becoming increasingly likely to fail. Correctly defining the need is crucial to identifying the most prudent and efficient solution. For example, a capacity constraint should not be identified as a need to augment, but rather a need to relieve the constraint. This allows for the appropriate and full consideration of all feasible options for meeting the need – that is, the "**how**".

Deciding on the "**how**" requires comprehensive analysis of all reasonably practicable options to meet the need. Ceteris paribus, the life-cycle cost of each option is the central determinant of the most likely option to be successful in the evaluation of all options to meet the need. That is, the option with the lowest life-cycle cost that meets the need is the most likely option to be selected.

The final matter to determine in the decision-making process is "**when**" the investment needs to be made. Both premature and belated investments introduce unintended consequences, such as a lack of available capital to mitigate higher risks, or the manifestation of undesirable performance or safety consequences. Determining the correct timing requires an understanding and consideration of how the risk changes over time.

2 Health and criticality

The health and criticality framework and methodology support the decision-making process for investments required on existing assets by identifying the need for investment, together with the timing of when the investment is most likely to be required. The options (i.e. the "how") is addressed separately from the framework to ensure that there is apposite consideration of all reasonably practicable options that could address the need.

The health and criticality methodology support the decision-making process by providing a perspective on the risk within an asset group. The addition of a value framework to the health and criticality framework allows consideration and comparison of risks between asset classes. This allows for investment decision-making to be prioritised towards those assets and issues that comprise the greatest risk on the network.

A key attribute of risk and value based decision-making framework is the adoption of a consistent and comparative method for assessing assets and risks. The health and criticality framework is used to determine "*asset indices*" that describe each asset for the purposes of risk prioritisation. Asset indices allow the performance (or risk) of assets to be monitored over time, and when required, investment programs to be developed that target and prioritise investment towards those assets that exhibit a level of risk that is increasing (or already intolerable), so that overall risk levels can be maintained.

The "*DNO Common Network Asset Indices Methodology*" developed by the UK Distribution Network Operators (UK DNO) and approved by the UK Regulator, Ofgem, is one such methodology that defines the framework, principles and approach to assessing assets and determining asset risk. One aspect of the UK DNO methodology is that whilst it is comprehensive, it is also exceptionally data intensive, and time consuming to develop, implement and maintain.

As significant value can be gained in the decision-making process from the insights gained through a robust health and criticality framework, Power and Water appropriated many the key features of the UK methodology whilst seeking to balance the benefits with the time, cost and data availability required to define all possible asset characteristics. Power and Water's methodology is used to monitor asset risk over time so that decisions can be made about what needs to be done, and when the actions are required, such that risk levels can be maintained.

The two critical features embraced by both the UK DNO and Power and Water frameworks are the attribution of concepts of "*health*" and "*criticality*" to an asset.

2.1 Asset Health

Asset health is a measure of the useful remaining life of an asset. The poorer the health of an asset, the nearer it is to the end of its life, and thus, the more likely it is to fail.

To account for the deterioration of assets over time (i.e. time-based degradation that is exhibited by all physical electricity network infrastructure), the age of the asset forms the basis of asset health. The asset health attribute is modified by applying factors that correct for observed and monitored conditions. For example, factors such as the results from recent condition based inspections, location and duty are considered to determine an asset's conditional age. The conditional age is then compared to the assets expected life (generally derived from a combination of historical and industry data) to determine the asset's remaining life.

A three-point health index scale is used to categorise assets in terms of their expected remaining life. The criteria for determining each of the three categories is customised to suit each asset class based on its expected life. A typical set of criteria are:

- H1 indicates assets with more than 30%, of expected life remaining. These assets present a very low probability of failure given they are assessed as being in a good condition.
- H2 indicates assets with between 10% and 30% of expected life remaining. These assets present a low probability of failure given they are assessed as being in a reasonable state of deterioration.
- H3 indicates assets with 10% or less of expected life remaining. These assets present a reasonable probability of failure given their condition is assessed as poor or very poor.

The criteria applied must allow appropriate time for planning mitigation action. For example, for protection relays which are stock items, the response time for a simple replacement can be short. However, for a high value asset such as a power transformer, further planning studies may be required and new assets have long lead times when ordered.

As the management of asset condition information improves for each asset class it is expected that a more robust condition based age will enable further refinement of asset health indexes. The SAMP provides more information on strategic initiatives and projects that will enable this to be achieved and how this aligns with the organisations objectives.

2.2 Asset Criticality

The failure of an asset results in a consequence. For example, this could range from a localised loss of supply, to a wide scale outage, or a near miss incident to the fatality of a network worker or member of the public. The severity of the consequence is dependent on the criticality of the asset. For example, assets supplying critical infrastructure (hospitals, water treatment plants, data centres) are more critical than asset supplying residential dwellings. Likewise, from a safety risk perspective, assets in high density areas (e.g. CBD, shopping centres) are considered more critical than those in less dense areas (e.g. rural).

At this point in time the criticality assessment for most asset classes is largely based on reliability and system security factors. Health, Safety, Environment and Financial risk domains are applied in cases where criticality has been assessed for an asset sub-class or asset type issue. However at an asset portfolio level the application of risk domains other than reliability and system security require further development.

2.3 Health and Criticality matrix

The outcomes of the asset categorisation are presented in a health and criticality matrix providing a risk profile of the asset at a particular point in time. Asset risk is assessed in 5 tiers from very low risk to extreme risk to provide for discrimination between risks.

The asset health and criticality is a function of time and is expected to change as assets continue to age, condition deteriorate and assets are replaced. The risk profile is therefore expected to change over time and based on the level of investment.

The criticality of assets generally doesn't change, or changes infrequently, as it is based on the network and customers rather than the individual asset. Asset condition changes more quickly and can be observed to change over a number of years for most assets.

The change in risk and risk management is demonstrated in the movement in the number of assets from the left to the right of the matrix as assets deteriorate in condition and from top to bottom as their criticality increases.

Table 1: Health and Criticality matrix template

	H1	H2	H3
C1	Very low	Low	Moderate
C2	Low	Moderate	High
C3	Moderate	High	Extreme

Risk legend				
Very low	Low	Moderate	High	Extreme

3 Asset class parameters

This section outlines the approach taken for each asset class to determine the health and criticality parameters.

The health and criticality indices rely heavily on available asset data and evolve as the quality of data improves, such as the asset condition and operating environment. The indices will continue to evolve over time as the asset composition changes with age, investments, and network development. These changes are captured during routine inspections and targeted methodical inspections aimed at recording and updating asset data related to age, condition, and operating environment. The probability of asset failures and the associated risks are therefore continually refined as routine data, and targeted data is collected across the asset base.

3.1 Power transformers

3.1.1Health

The health index has been determined based on the Degree of Polymerization (DP) values of the transformer. The health index can be modified based on the results of condition assessments which assess:

- Dissolved gas analysis and oil quality;
- Corrosion of the transformer tank;
- The extent of oil leaks;
- Suitability of the transformer bunding;
- Condition of the tap changer;
- Condition of the transformer bushings; and
- Electrical tests.

3.1.2 Criticality

Criticality is dependent on the following attributes which are assessed at the level of a zone substation:

- The type of customer they serve, typically segregated into:
  - CBD, Urban and Rural for reliability metrics, and
  - Residential, Industrial and Commercial for the value of lost load (VoLL) or Value of Customer Reliability (VCR)
- The redundancy of the substation, that is the number of transformers and their capacities compared to the demand;
- Other mitigation factors that can be implemented in the case of transformer failure, such as transferring load to other substations; and
- Amount of time required to replace the transformer. Large transformers have a longer lead time, and the ability to undertake the installation and commissioning works is limited to the dry season.

3.2 HV Circuit breakers

3.2.1 Health

Power and Water undertakes an asset fleet health assessment at portfolio level, to understand the risk posed to the network and to help identify where effort should be focused to effectively manage risk at the lowest cost to customers.

The asset health assessment is based on modelling the condition of circuit breakers using a combination of weighted attributes. Each attribute is allocated a score depending on defined performance criteria and it is then weighted to reflect its relative impact on health compared to the other attributes, refer to Table 2.

Table 2 Asset health weighting criteria

Attribute	Weighting
Age (years)	20%
History of functional test failures for the asset and type	50%
Number of defects over the past 5 years	5%
Defect rectification cost over the past 5 years	10%
Insulation type	10%
Operating mechanism type	5%

3.2.2 Criticality

The criticality of a circuit breaker is an assessment of its importance to the continued operation, reliability, stability and security of the power network. Criticality is dependent on the following key attributes which are assessed at the level of a zone substation:

- The type of customer they serve, typically broken down into:
    - CBD, Urban and Rural for reliability metrics, and
    - Residential, Industrial and Commercial for the value of lost load (VoLL) or Value of Customer Reliability (VCR)
- Redundancy in the network, ie, the ability to re-establish supply from another feeder
- Amount of time required to replace the circuit breaker
- The voltage level of the circuit breaker

3.3 Underground cables

3.3.1 Health

The underlying failure mode for cables is the degradation of insulation material over time. The degradation is accelerated by aspects such as soil type, design, damage (termites, incorrect installation methods), and thermal loading.

Where available; failure data, inspection findings, and test results have been used to inform the cable asset health. Asset age, or age based remaining life has been used as a proxy for asset health where additional condition data was not available.

The health segregation adopted the three-point health index scale described in section 2.1 to categorise assets in terms of their expected remaining life where conditional factors were not evident to suggest a different segregation. Assets with more than 15 years remaining life were allocated a good health score, H1. Assets with a remaining life between 5 and 15 years were allocated an average health score, H2. Assets with less than 5 years remaining life were allocated a poor health score, H3.

3.3.2 Criticality

The cable network contributes to both the reliability and safety risk of the power network.

Criticality ratings have been assigned at feeder level based on the impact of contingencies on the security of supply and system loading conditions. The main criteria are an assessment of contingencies resulting from a radially supplied network, system overload conditions, and system critical supply feeders.

Where appropriate and based on inspection and test data, criticality level adjustments have been made to reflect the contribution to public and worker safety risk.

For transmission cables criticality ratings have been assigned at feeder level based on the impact of contingencies on the security of supply and system loading conditions. A workshop involving key Power and Water planning and asset management personnel as well as external expertise were undertaken to assess the relative criticality of transmission feeders. The main criteria included an assessment of contingencies resulting in radialisation of the network, system overload conditions, and system critical supply feeders.

Criticality allocations for distribution cables were made based on reliability risk as demonstrated through customer density and relative redundancy, and relative performance as approximated through the feeder categorisation. Assets on short rural feeders (medium density but low interconnectivity and redundancy, and poor reliability performance) have been allocated to the highest criticality rating (C3), urban assets (high density and medium redundancy) to C2 and CBD (high redundancy) and long rural (low density, low redundancy) assets to the lowest criticality rating.

3.4 Conductors

3.4.1 Health

The underlying failure mode for conductors is failure to meet safe ground clearance standards, and mechanical fatigue resulting from annealing or corrosion. The deterioration in conductor health is accelerated by factors such as location, design, third-party impacts, vegetation impacts, and damage during severe weather events.

AS/NZS 2312 - Guide to the Protection of Structural Steel Against Atmospheric Corrosion by the Use of Protective Coatings and a study on corrosion rates developed by Wattyl Industrial Coatings in 2004 (*GUIDE TO AS/NZS 2312:2002*) were used to rate the health of conductors.

The coastal areas of Darwin are subject to a higher corrosion environment than inland areas. The tropical coastal areas of Darwin are also prone to continuous windy conditions, and cyclone activities with high wind speeds. These condition factors were used to assess the underlying conductor health. Where additional condition data were available these were used to adjust the health allocations.

The health segregation adopted the three-point health index scale described in section 2.1 to categorise assets in terms of their expected remaining life where conditional factors were not evident to suggest a different segregation. Assets outside the Darwin region and assets within Darwin region with more than 15 years remaining life were allocated a good health score, H1. Assets in Darwin and with a remaining life between 5 and 15 years were allocated an average health score, H2. Assets in the Darwin region with less than 5 years remaining life were allocated a poor health score, H3.

3.4.2 Criticality

The criticality of transmission conductor assets within the network has been based on the expected contribution to the system reliability risk resulting from asset failure. Where appropriate, the criticality has been modified to reflect any contribution to public and worker safety risk.

For transmission conductor criticality ratings have been assigned at feeder level based on the impact of contingencies on the security of supply and system loading conditions. A workshop involving key Power and Water planning and asset management personnel as well as external expertise were undertaken to assess the relative criticality of transmission feeders. The main criteria included an assessment of contingencies resulting in radialisation of the network, system overload conditions, and system critical supply feeders.

Criticality allocations for distribution conductors were made based on customer density, relative redundancy, and relative performance as approximated through the feeder categorisation. Assets on short rural feeders (medium density but low interconnectivity and redundancy, and poor reliability performance) have been allocated to the highest criticality rating (C3), urban assets (high density and medium redundancy) to C2 and CBD (high redundancy) and long rural (low density, low redundancy) assets to the lowest criticality rating.

3.5 Distribution substations

3.5.1 Health

The underlying failure mode for distribution substations is structural degradation resulting from corrosion. The deterioration in asset health is accelerated by factors such as location, design, third-party impacts, and damage during severe weather events.

AS/NZS 2312 - Guide to the Protection of Structural Steel Against Atmospheric Corrosion by the Use of Protective Coatings and a study on corrosion rates developed by Wattyl Industrial Coatings in 2004 (*GUIDE TO AS/NZS 2312:2002*) were used to provide guidance on the disparate corrosion related issues observed across the Power and Water network. The coastal area of Darwin is identified as an area subject to higher corrosion rates, whereas the inland areas of the power network are subject to relatively lower expected corrosion rates.

The health segregation adopted the three-point health index scale described in section 2.1 to categorise assets in terms of their expected remaining life where conditional factors were not evident to suggest a different segregation. Assets outside the Darwin region, and asset within Darwin region with more than 15 years remaining life were allocated a good health score, H1. Assets in Darwin and with a remaining life between 5 and 15 years were allocated an average health score, H2. Assets in the Darwin region with less than 5 years remaining life were allocated a poor health score, H3.

3.5.2 Criticality

Criticality allocations were made based on the likely impact of a failure on customer numbers. Substations with a rating of up to 100kW were allocated to C1, substations rated between 100kW and 500kW were allocated to C2, and substations rated above 500kW were allocated to C3.

3.6 Distribution switchgear

3.6.1 Health

The underlying failure mode for distribution switchgear is the degradation of electrical contacts and switching mechanisms over time. The degradation is accelerated by factors such as the frequency of operation under normal and fault conditions.

The degradation factors are typically related to changes over time, with age providing the best indicator for potential targeted inspections. Asset age or remaining life has been used as a proxy for asset health where additional condition data was not available.

The health segregation adopted the three-point health index scale described in section 2.1 to categorise assets in terms of their expected remaining life where conditional factors were not evident to suggest a different segregation. Assets with more than 15 years remaining life were allocated a good health score, H1. Assets with a remaining life between 5 and 15 years were allocated an average health score, H2. Assets with less than 5 years remaining life were allocated a poor health score, H3.

3.6.2 Criticality

Distribution switchgear criticality across the asset class was allocated in the first instance based on customer density, relative redundancy, and relative performance as approximated through the feeder categorisation. Assets on short rural feeders (medium density but low interconnectivity and redundancy, and poor reliability performance) have been allocated to the highest criticality rating (C3), urban assets (high density and medium redundancy) to C2 and CBD (high redundancy) and long rural (low density, low redundancy) assets to the lowest criticality rating.

Where appropriate and based on inspection and system data, criticality level adjustments have been made to reflect the contribution to public and worker safety risk.

3.7 Poles and towers

3.7.1 Health

The underlying failure mode for poles and towers is mechanical fatigue resulting from corrosion. The deterioration in asset health is accelerated by factors such as location, design, third-party impacts, and damage during severe weather events.

AS/NZS 2312 - Guide to the Protection of Structural Steel Against Atmospheric Corrosion by the Use of Protective Coatings and a study on corrosion rates developed by Wattyl Industrial Coatings in 2004 (*GUIDE TO AS/NZS 2312:2002*) were used to provide guidance on the disparate corrosion related issues observed across the Power and Water network. The coastal area of Darwin is identified as an area subject to higher corrosion rates, whereas the inland areas of the power network are subject to relatively lower expected corrosion rates.

Studies undertaken by Power and Water found the high salinity soil conditions in the Alice Springs area to be a particularly aggressive corrosive environment.

The health segregation adopted the three-point health index scale described in section 2.1 to categorise assets in terms of their expected remaining life where conditional factors were not evident to suggest a different segregation. Assets outside the Darwin region and assets within Darwin region with more than 15 years remaining life were allocated a good health score, H1. Assets in Darwin and with a remaining life between 5 and 15 years were allocated an average health score, H2. Assets in the Darwin region with less than 5 years remaining life were allocated a poor health score, H3.

Alice Springs poles were segregated using the same approach, however applying a shorter asset life based on the age of the assets that have failed unassisted in the last three years.

3.7.2 Criticality

The criticality of the pole and tower assets within the network has in the first instance been based on the expected contribution to the system reliability risk resulting from asset failure. Where appropriate and based on inspection and test data, criticality level adjustments have been made to reflect the contribution to public and worker safety risk.

Criticality ratings are assigned at the feeder level based on the expected reliability impact as result of a failure.

For transmission poles and towers criticality ratings have been assigned at feeder level based on the impact of contingencies on the security of supply and system loading conditions. A workshop involving key Power and Water planning and asset management personnel as well as external expertise were undertaken to assess the relative criticality of transmission feeders. The main criteria included an assessment of contingencies resulting in radialisation of the network, system overload conditions, and system critical supply feeders.

Distribution pole criticality across the asset class was allocated in the first instance based on customer density, relative redundancy, and relative performance as approximated through the feeder categorisation. Assets on short rural feeders (medium density but low interconnectivity and redundancy, and poor reliability performance) have been allocated to the highest criticality rating (C3), urban assets (high density and medium redundancy) to C2 and CBD (high redundancy) and long rural (low density, low redundancy) assets to the lowest criticality rating.

3.8 Pole-top hardware

3.8.1 Health

The underlying failure mode for pole-tops is mechanical fatigue resulting from corrosion. The deterioration in asset health is accelerated by factors such as location, design, third-party impacts, and damage during severe weather events.

AS/NZS 2312 - Guide to the Protection of Structural Steel Against Atmospheric Corrosion by the Use of Protective Coatings and a study on corrosion rates developed by Wattyl Industrial Coatings in 2004 (*GUIDE TO AS/NZS 2312:2002*) were used to provide guidance on the disparate corrosion related issues observed across the Power and Water network.

Routine inspections on pole-tops in the Darwin region are finding an increasing number of advanced corrosion issues. Inspection criteria are currently being adapted to more accurately capture pole-top condition data to allow for trending analysis and appropriate selection of health.

The health segregation adopted the three-point health index scale described in section 2.1 to categorise assets in terms of their expected remaining life where conditional factors were not evident to suggest a different segregation. Assets outside the Darwin region, and assets within Darwin region with more than 15 years remaining life were allocated a good health score, H1. Assets in Darwin and with a remaining life between 5 and 15 years were allocated an average health score, H2. Assets in the Darwin region with less than 5 years remaining life were allocated a poor health score, H3.

3.8.2 Criticality

The pole-top assets contribute to both the reliability and safety risk of the power network.

Similar to poles and towers the criticality ratings have been assigned at feeder level based on the expected reliability impact as result of a failure. Where appropriate, and based on inspection and test data, criticality level adjustments have been made to reflect the contribution to public and worker safety risk.

For transmission poletops criticality ratings have been assigned at feeder level based on the impact of contingencies on the security of supply and system loading conditions. A workshop involving key Power and Water planning and asset management personnel as well as external expertise were undertaken to assess the relative criticality of transmission feeders. The main criteria included an assessment of contingencies resulting in radialisation of the network, system overload conditions, and system critical supply feeders.

Criticality allocations for distribution pole-top assets were made based on customer density, relative redundancy, and relative performance as approximated through the feeder categorisation. Assets on short rural feeders (medium density but low interconnectivity and redundancy, and poor reliability performance) have been allocated to the highest criticality rating (C3), urban assets (high density and medium redundancy) to C2 and CBD (high redundancy) and long rural (low density, low redundancy) assets to the lowest criticality rating.

3.9 Protection

3.9.1 Health

Power and Water considers the results of the age and condition assessments identified above to develop an Asset Health Score. The Health Score identifies the assets that are considered to have the highest risk of failure.

3.9.2 Criticality

The criticality of protection relays is taken to be the same as the network element with which it is associated. In other words, the criticality of a protection relay for a transformer circuit breaker is taken to be the same as the transformer. The criticality of protection relays at 66kV substations older than ten years has been increased to the highest level as the 66kV Bus protection is not duplicated.

The criticality of a relay reflects its importance to the continued operation, reliability, stability and security of the power network.

3.10 SCADA and Communications

3.10.1 Health

The remaining life of assets is used to develop an Asset Health Score. The Health Score identified the assets that are considered to have the highest risk of failure, categorising them in three categories based on whether they have more than 10% of their life remaining, are within the last 10% of their life, or exceeding their expected life.

3.10.2 Criticality

Power and Water's SCADA engineers have categorised assets as critical if they pose a high risk to the network should they fail, and non-critical if they will not have a major impact on the network if they fail. Based on these categorisation criteria, any asset that has redundancy is considered non-critical.