31 January 2023

Attachment 5.2.d: Principles of CBA

Ausgrid's 2024-29 Regulatory Proposal

Empowering communities for a resilient, affordable and net-zero future.

Table of Contents

Executive Summary

This document sets out the principles of Cost Benefit Analysis (CBA) that Ausgrid applies in order to make prudent decisions on capital investments in network assets to achieve the objectives of providing an affordable, safe, reliable and secure supply that meets customer expectations. These CBA principles are applicable to all assets in Ausgrid's network and aim to provide a cohesive framework for those making decisions on the network needs and the evaluation of prudent investment.

The primary principle of cost-benefit analysis is to assess the economic efficiency of an investment being considered to address risks or otherwise deliver benefits. It involves the process of assessing and ranking options in a quantitative manner to identify the preferred option and the optimal timing of investment in projects.

Key processes incorporated within a CBA are outlined in the diagram below.

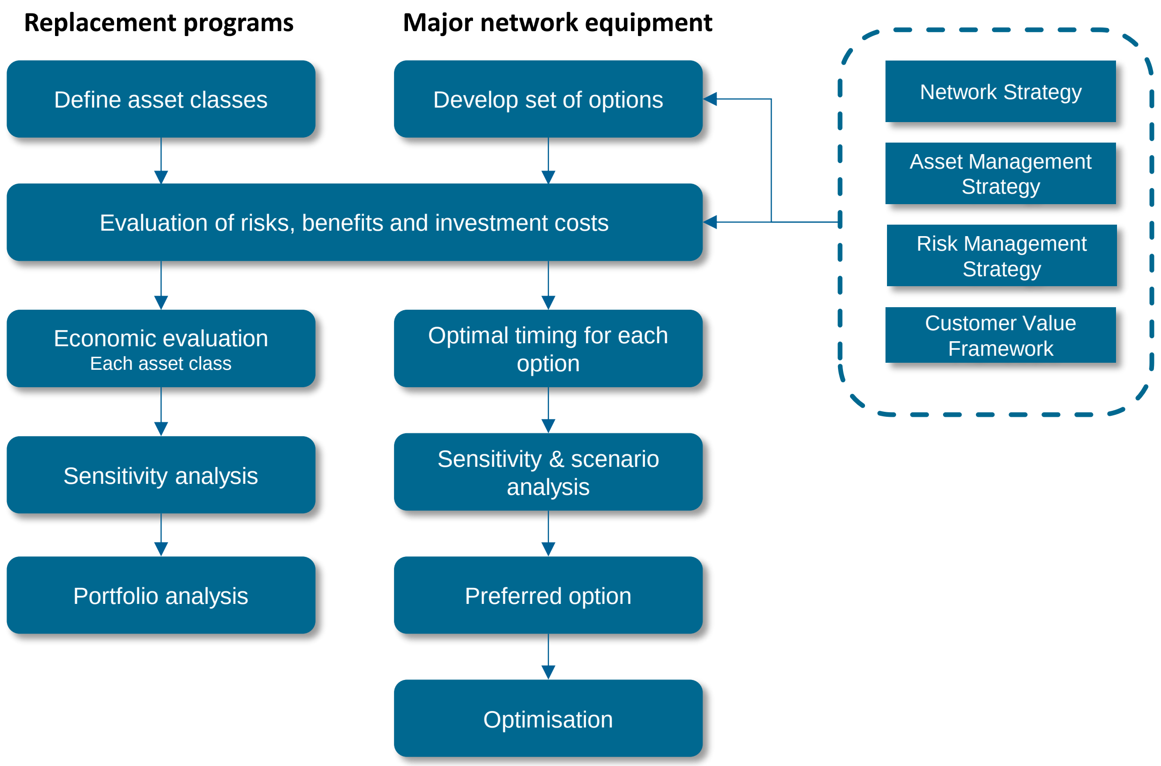

Figure 1: Key processes of a CBA

Ausgrid's CBA principles and the processes outlined above accord with good asset management and risk management practices by demonstrating prudency and efficiency for these network asset investments.

Ausgrid has developed an investment governance framework to identify economically efficient investment outcomes for all asset classes. The framework also ensures the CBA principles are applied consistently within all investment categories. Integral to this framework, Ausgrid has had a number of models in place and refined them over many years to assess the investment needs for its Major Projects and Replacement Programs.

Sensitivity analysis and scenario analysis are also applied to mitigate the risks associated with future uncertainty, helping to ensure the investment decision is sound, robust and least regret.

The CBA principles and process for asset investment planning have been in use for many years. This has provided a strong and consistent basis for deferring capital investments which otherwise would have been undertaken earlier under the previous deterministic approach. This has resulted in the delivery of greater customer benefits, which are more aligned to the value placed on affordability by customers.

1 Introduction

1.1 Purpose

This document sets out the principles of Cost Benefit Analysis (**CBA**) that Ausgrid applies in order to make prudent decisions on capital investments in network assets to achieve the objectives of providing an affordable, safe, reliable and secure supply that meets customer expectations. These principles are applicable to all assets in Ausgrid's network under the Capital investment governance framework. The guiding principles aim to provide a cohesive framework for those making decisions on how best to address network needs and the evaluation of prudent investment within the context of limited resources.

1.2 What is Cost Benefit Analysis?

Cost Benefit Analysis is a systematic methodology used to assess whether to proceed with investment options. Ausgrid uses CBA when assessing capital investments being considered to address network risks or otherwise deliver customer benefits. In its broadest sense, it is the process of assessing and ranking options in a quantitative manner enabling the identification of the most efficient option taking account both the relative benefits and costs.

1.3 Customer and stakeholder needs

Customer needs are at the forefront of our objectives underpinning our approach to CBA, which seeks to maximise the benefit to the community by making investments that account future cost impacts on our customers. Ausgrid actively engages with customers to understand their needs, this includes facilitating the foreseeable transition to support a low carbon economy and Net Zero ambitions. Ausgrid's investment requirements are carefully considered to efficiently maintain a safe, reliable and secure network while recognising the challenges faced due to the ongoing energy transformation.

Ausgrid's stakeholders have similar expectations. The Australian Energy Regulator (**AER**) Regulatory Test and Chapter 5 of the NER mandate a probabilistic planning approach to network investment decisions which underpins the requirement for cost benefit analysis of assessing investments.

The AER Industry practice application note for asset replacement planning[1] (the ARP note) sets out regulatory expectations for asset risk (benefit) modelling. The ARP note incorporates the principles and approaches in accordance with good asset management and risk management practices, support sound asset retirement planning, and are generally consistent with previous AER decisions.

Consistent with this ARP note Ausgrid has refined its asset management and risk assessment processes to ensure the use of effective technical and economic practices. The intention is to strike an appropriate balance between outlining the relevant principles to enable a consistent understanding and use of effective technical and economic practices,

[1] https://www.aer.gov.au/system/files/D19-2978%20-%20AER%20-Industry%20practice%20application%20note%20Asset%20replacement%20planning%20-%2025%20January%202019.pdf

and specific methods and practice. The National Electricity Objective (**NEO**) also mandates the requirement as below.

*"*to promote efficient investment in, and efficient operation use of, electricity services for the long-term interests of consumers of electricity with respect to: price, quality, safety and reliability and security of supply of electricity.*"*

In addition to meeting the current regulatory requirements noted above, Ausgrid is continuing to explore and quantify how customers value reliability and other services provided by Ausgrid more broadly, with a view to further refining the alignment between Ausgrid's investments and customers' wants and needs.

1.4 Investment governance framework

The objective of Ausgrid's Investment Governance Framework (**IGF**) is to provide clear guidance and accountability for the development, determination and authorisation of regulated network investments. In addition to this role, it serves to inform the AER and other stakeholders of the processes by which Ausgrid makes and tests investment decisions, to assist them to assess the prudence and efficiency of investments put forward under this process.

Ausgrid applies a modern planning approach to proposed investments, consistent with the AER's requirements, which is aimed at:

- providing a basis for comparing investment options to determine the most preferable investment option, whilst maximising the net economic benefit; and
- determining if the project is a sound investment and to determine the most beneficial economic timing of the investment.

Ausgrid has been using the quantification of customer benefits and probabilistic planning approach presented in this document for over five years. This has provided a strong and consistent basis for deferring capital investments which otherwise would have been undertaken earlier under the previous deterministic approach – resulting in delivery of greater customer benefits, which are more aligned to the value placed on affordability by customers.

1.5 Application

The objective of Ausgrid's CBA approach is to apply consistent principles when assessing potential investments for assets ranging from major equipment such as power transformers, switchgear and sub-transmission cables to smaller network elements such as poles, towers, conductors, pole top structures etc. (where asset populations are large and there may be a large number of similar assets to be replaced). The guiding principles of this CBA approach are applied to a number of asset investment streams. They are:

1. Major Projects
2. Replacement Programs
3. High Voltage and Low Voltage Augmentation Programs
4. Reliability Program

5. Resilience Program
6. DER Integration Strategy[2]

Ausgrid has developed specific documents which describe the application of these principles in the CBA modelling approach to the areas noted above. The details of these documents are given in Section 3.1.

[2] In conjunction with the requirements of the AER's *DER integration guidance note*, June 2022

2 Guiding Principles

2.1 Introduction

Ausgrid applies common guiding principles for CBA across its range of potential investments. These principles are crucial to supporting prudent and timely investment decisions that focus on enhancing customer and community outcomes via efficient investments. Figure 2 below illustrates Ausgrid's overall approach to the establishment of its investment portfolio on the network under the investment governance framework.

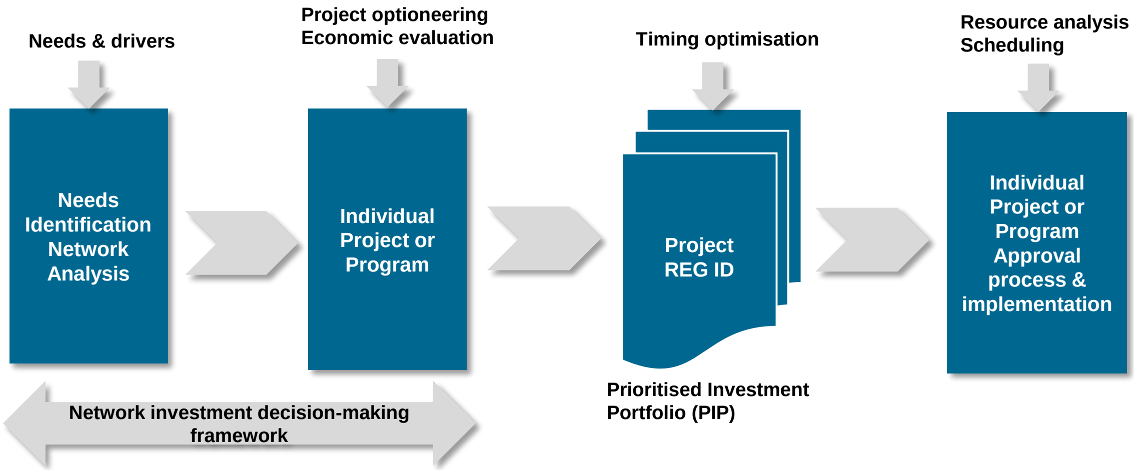

Figure 2: Investment governance framework

2.2 Investment decision-making framework

Figure 3 provides an illustration of the broader decision-making framework for investment in Ausgrid's network.

Investment options identified during the initial assessment are evaluated using cost benefit analysis with a view to maximizing overall benefits. This report focuses on the basic principles to be applied via CBA across all network investment decision-making and the development of a Prioritised Investment Portfolio (**PIP**).

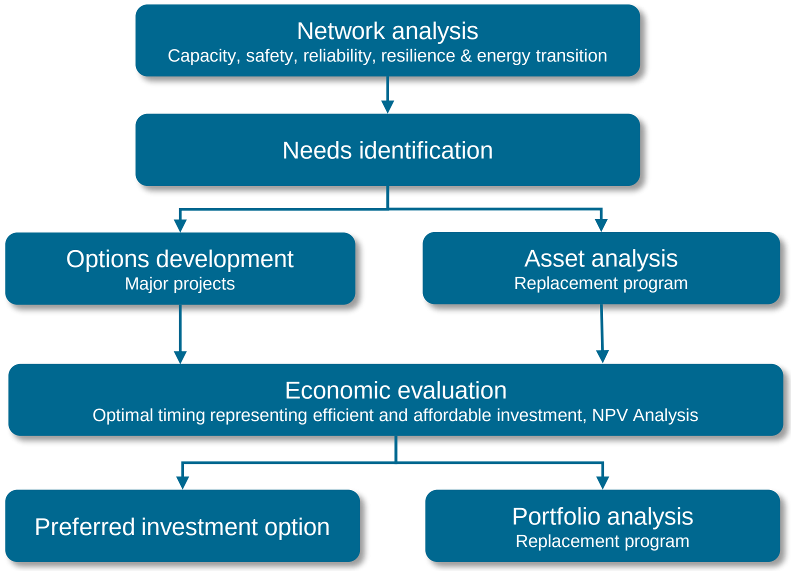

Figure 3: Network investment decision-making framework

2.3 Pathway to development of PIP

The objective of the PIP is to capture future investment requirements for all the assets in Ausgrid's network in a single portfolio which can be scrutinised, prioritised and tested. A high-level pathway for the development of PIP is shown in the Figure 4.

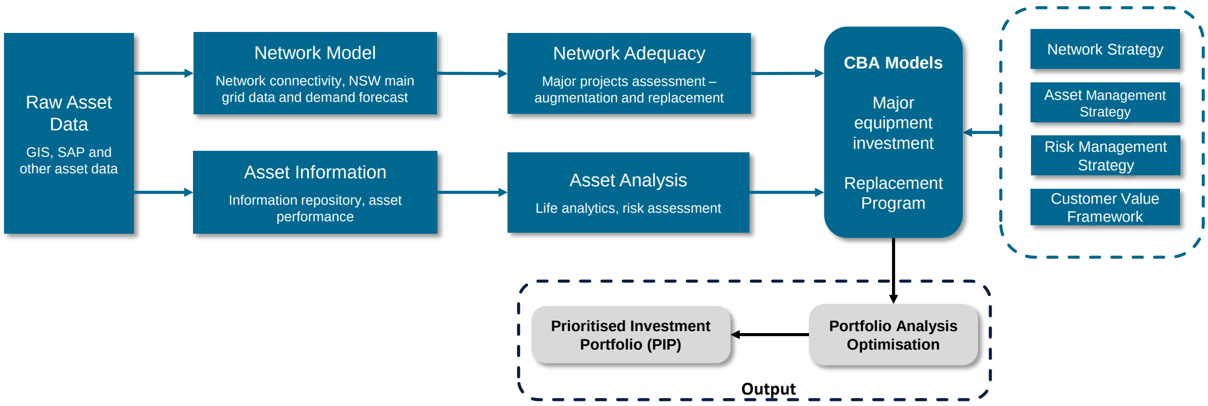

Figure 4: Pathway to the development of PIP

The process begins with the identification of the performance and condition of all assets – specifically whether they perform as required by the network. By applying various techniques, the future performance of those assets is forecast using metrics which include probability of failure. The capability to avoid or otherwise mitigate outages via meshed networks, to reactively restore supply by switching around failed assets and the repair and recovery times in the event of an outage are all considered, allowing the level of the risks posed to the customer to be evaluated.

Where an investment may be required in major network elements such as sub-transmission substations or feeders, or zone substations, Ausgrid employs a holistic approach which focusses on determining whether an alternative network configuration will maximise the net benefit to customers compared to the existing configuration. Ausgrid considers strategies such as decommissioning the asset or alternate configurations, as well as replacement or augmentation with the goal of addressing the issue identified in a way which results in the best utilisation and most efficient use of the network.

Equipment with large populations of similar and lower value assets (e.g., poles or LV services) are assessed under the Replacement Program which will determine the requirements for planned asset replacement or refurbishment. Depending on the circumstance, a detailed analysis is undertaken to examine whether the impacted asset can be retired without requiring an upfront investment.

Using appropriate CBA models, the most economically feasible solution is determined taking into account other Ausgrid's policies and procedure documents such as Network Strategy, Asset Management Framework, Risk Management Strategy and Customer Value Framework. The outcomes are further refined using portfolio analysis and optimisation techniques to have an efficient expenditure forecast which results in the development of PIP.

2.4 Key processes of a CBA

Key processes for undertaking a CBA, using best practice methods are outlined in the diagram below.

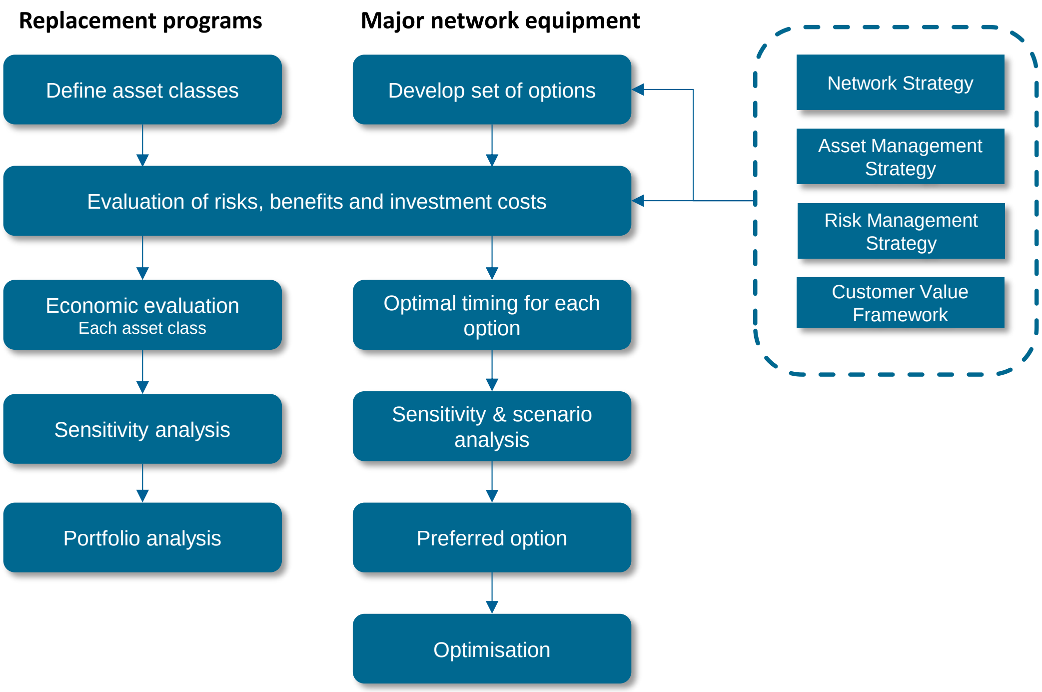

Figure 5: Key processes of a CBA

The following sections describe and outline the principles adopted by Ausgrid for key processes given in the diagram above.

2.5 Option analysis

Option analysis is performed to identify alternative network solutions capable of resolving the identified network constraint or condition issues. This is a key component of the decision-making framework for major projects, as it leads to the identification of solutions that maximise the market benefit. Potential network and non-network options are considered, and stakeholder consultations are undertaken where required. The approach used for options analysis typically depends on the investment driver, size, and complexity of the potential solutions.

The general options that Ausgrid considers include demand management, decommissioning assets, like-for-like replacement, opportunities for better network arrangement, holistic solutions for multiple issues and potential for staging of investments. In some cases, a detailed feasibility study is carried out to gain better understanding of the feasibility of the option prior to economic analysis. The initial stage considers multiple options, but only a few of the more feasible options are included in the economic analysis. The baseline option that is used for comparison is a '**do nothing**' option. This is generally undertaken for network investments related to major equipment and is discussed in more depth in the **Attachment 5.4.e - CBA Approach for Major Projects**.

Equipment classes under the Replacement Program are generally considered on an individual asset basis (for example protection relay for a transformer). Assets can also be combined into larger 'build block' packages (for example the transformer and secondary assets), so the most beneficial option can be determined - whether replacing individual assets at different times or replacing them together. These investments are based on careful examination of assets' condition and capacity.

2.6 Risks and benefits quantification

A key element of Ausgrid's cost benefit analysis is the quantification of the consequences to customers, staff and/or the community of not acting. These are expressed in the form of a number of risks,

Risks can be quantified using probability distribution functions developed from historic asset performance, load data and network configuration. In the analysis, reduction of risk is considered a benefit to the market (including both Ausgrid and its customers), and the risk is generally computed as:

$$Risk = Probability \times Consequence$$

Probability of the event occurrence is derived from the probability distribution curve related to the asset, The consequence of the event occurrence is calculated in terms of the financial or economic impact, measured in dollars.

Ausgrid uses the following broad benefits categories in the cost benefit analysis. These fundamentally relate to the reduction of negative impacts to customers and the community:

- Expected Unserved Energy (**EUE**) – using the Value of Customer Reliability (**VCR**) determined and published by the AER;
- Safety risk reduction – using the Value of a Statistical Life (**VoSL**) determined and published by the Australian Office of Best Practice Regulation;
- Environmental risk reduction – quantified based on cost of polluted water and likelihood of fines;
- Financial risk reduction – using Ausgrid's database of repair and maintenance costs including adjusting for the cost premium associated with reactive repair; and
- Fire risk reduction – using analysis commissioned by Ausgrid examining catastrophic fire event data from NSW and Victoria.

- Other risks due to emerging issues such as supply quality risks, DER curtailment etc.

Attachment 5.2.c - Customer Value Framework sets out these metrics in more detail.

Different risks may be applicable to different types of equipment or parts of the network to a greater or lesser degree and therefore have differing levels of impact in corresponding CBA assessments.

The following figure illustrates the key input data Ausgrid uses in the process of quantification of risks and benefits for the cost benefit assessment.

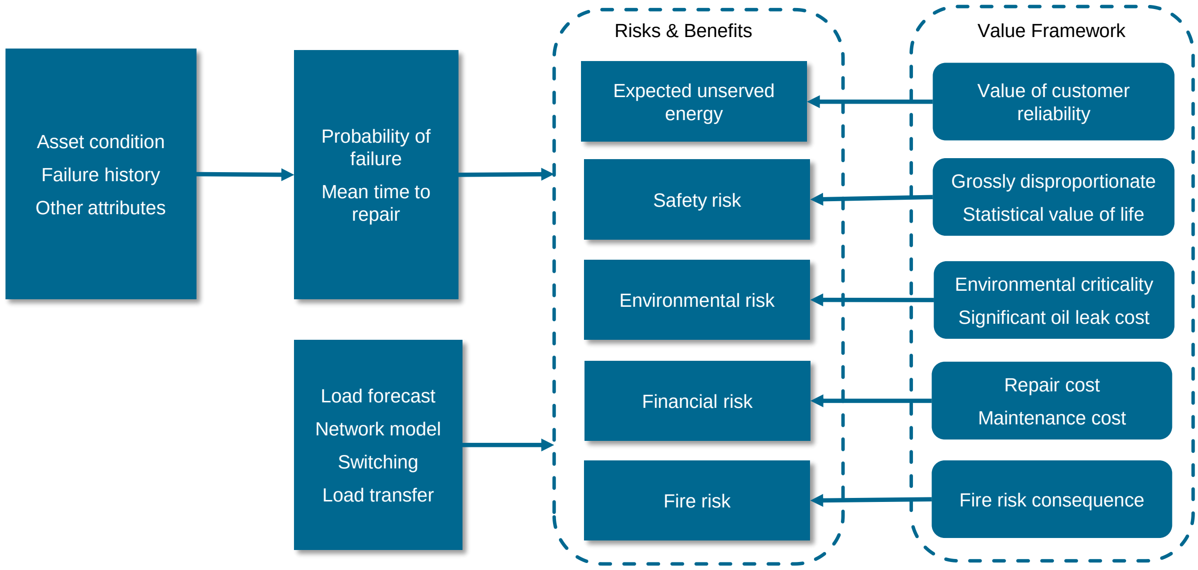

Figure 6: Cost benefit analysis – key input data

One of the key components of this assessment is the determination of Probability of Failure, a parameter that is used in all types of benefits quantifications. Future asset failures are assessed as time dependant based on the historical failure and condition data, as well as the variation due to geographical location. Various models are applied as appropriate, including Weibull[3] and Crow-AMSAA[4] models. Ausgrid's Value Framework[5] defines the value dimensions and metrics to monetise the risks and benefits that are then used to optimise an investment decision. A summary of value framework input data used in the cost benefit analysis is provided in Section 3.2.

Where assets are run to failure additional costs can be incurred to reactively replace the asset, compared to a planned replacement. This includes overtime costs and productivity costs due to diverting resources from other tasks and having less time to efficiently plan the work. A careful consideration is given to this reactive cost premium when making decisions about proactive versus reactive replacement and when considering asset/work packaging for efficient delivery under the Replacement Program.

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[3] Abernethy, R. 1996, *The New Weibull Handbook Second Edition*.

[4] Gill, Y. 2011, '*Development of an electrical cable replacement simulation model to aid with the management of aging underground electric cables*.', IEEE Electrical Insulation Magazine, vol. 27, January-February, no. 1, pp. 31-37.

[5] *Customer Value Framework, September 2021 (Version 0.6)*

2.7 Investment costs estimation

Investment cost estimation is a key element of cost benefit analysis. Ausgrid's cost estimation approach is based on unit rates and building block costs of assets. Estimates and unit rates are developed and updated within an established governance process for review and acceptance of these unit rates before use. The project cost estimates also reflect the cash flow over the construction period of the proposed project related to the investment where it spans multiple years.

Ausgrid has established a two-step process to determine its network investments. The first step is to identify the timing for a network investment, and the second step is to undertake an economic analysis to confirm that a net economic benefit result is produced.

In the first step, to ascertain the initial timing of the network investment, costs and benefits are compared on an annualised basis, and both are expressed in constant or un-escalated dollars. In the second step, a full economic analysis is carried out to consider that some investments require several years to be completed, and the benefits are only realised once the investment is finalised/ commissioned. As a result, investment and benefits cashflows are discounted using a discount rate equivalent to the Weighted Average Cost of Capital (**WACC**), which represents the opportunity cost of Ausgrid's capital. We report our investments in real dollars to the AER.

For the purposes of assessing project timing, the annual deferral benefit is based on the annualised cost of a capital investment with a multi-year life.

2.8 Timing for investment

The timing of investment is chosen by comparing the proposed project cash flows and monetised benefits. When the annual benefits of a particular investment outweigh the annual savings from deferring capital expenditure, *and* those benefits are forecast to continue or grow into the future, the investment is considered to be 'economically justified' at that time.

Figure 7 below shows the typical cost-benefit analysis for major equipment investment. As can be seen, the crossover point where the annual benefit exceeds the annualised deferral benefit is taken as the trigger for the investment to be completed, that is known as the network 'need' date. Initiation of the investment can be up to four to five years ahead of the trigger year to account for lead times due to investment size and complexity.

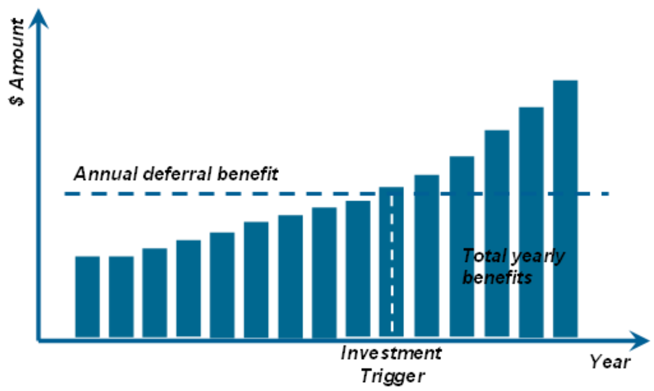

Figure 7: Optimal investment trigger year

For assets assessed under the Replacement Program, the annual deferral benefit is compared with the customer benefit and Benefit to Cost Ratio (**BCR**) is calculated for each asset, and if BCR is greater than 1, it is deemed that market benefits exceed the cost of investment. All the individual assets with BCR greater than 1 are identified for further economic evaluation.

2.9 Economic analysis

Once the timing for investment is ascertained, the next step is a full economic analysis which provides a more complete assessment of the economic viability of the investment over its life cycle. This is also used to inform the selection of the preferred option when multiple feasible solutions are identified for an investment.

Ausgrid uses following measures to determine the economic viability of the investment.

1. Net Present Value (**NPV**): This is the sum of discounted benefits minus discounted costs. The investment is efficient if the NPV is positive (greater than zero).
2. Value Investment Ratio (**VIR**): This is the ratio between the net present value and net present investment costs. The investment is efficient if the VIR is positive (greater than zero).
3. Benefit Cost Ratio (**BCR**). This is the ratio between customer benefit and investment cost. The investment is efficient if BCR is greater than 1.

The concept of time value of costs and benefits is used by applying discounting for future costs and benefits back to today's values. The discounting rate adopted for this draft regulatory proposal is a real pre-tax WACC, also referred as discount rate. The WACC applicable at the time the CBA is performed, is calculated consistently with the AER's Rate of Return Instrument (**RoRI**).

Standard CBA analysis is carried out over the normal lifetime of the assets resulting from a proposed investment to understand whole of life outcomes.

However, where the effective payback period, or number of years to reach a positive NPV, is substantially less than the life of the proposed asset, a terminal value may be used in the Net Present Value calculation to simplify representation of the later years. For example, where a substation upgrade with a single upfront investment has a positive NPV after considering 10 years of benefits a terminal value may be applied at say 20 years, despite the assets having a 45-year effective life.

Where conditions are expected to change over the lifetimes of the asset in ways which can be modelled and are material to the outcome, or where investments with different effective lives are being compared, the terminal value would not be applied and the CBA would be carried out over a longer period.

In the Replacement Program, in addition to the annual deferral benefit calculation applied to the individual assets, NPV analysis is undertaken for each asset sub-class. This NPV is performed over a 30-year forecast period considering the long-term benefit of the investment against the long-term cost.

2.10 Sensitivity and scenario analysis

Recognising potential uncertainty in forecast data, Ausgrid tests the investment decisions by applying various analysis techniques. Sensitivity analysis is undertaken by increasing or decreasing key CBA input parameters. Only variables subject to the highest degree of uncertainty and impact are subjected to sensitivity analysis.

Another approach Ausgrid uses is scenario analysis, which mainly applies to larger major project investment needs that are likely to show greater variability given future uncertainties. These investments are analysed using a number of scenario forecasts[6] to help identify the 'least regret' investment option. This is discussed in more depth in **Attachment 5.4.e – CBA Approach for Major Projects**.

2.11 Portfolio analysis/optimisation

The cost benefit analysis for a proposed network investment is carried out during the annual review process of the PIP. The sensitivity analysis is also aimed at the identification of the effect of deferral or advancing the baseline need date. Once the suite of projects is developed, Ausgrid undertakes the portfolio analysis which focuses on understanding the overall effectiveness and deliverability of the portfolio which may require adjustments to content or smoothing the planned delivery dates. Essentially, the project delivery timing will be optimised in accordance with other priority considerations while managing the potential increased risk to customers. Ausgrid takes account of the following outcomes in these assessments.

- Fulfilment of obligations such as environmental act requirement, regulatory requirements etc.
- Smoothing the project/portfolio delivery plan.
- Dependency on other projects.
- Unexpected change/deterioration of condition of equipment which requires immediate replacement.
- Demand management analysis outcomes.

[6] Ausgrid develops four scenario forecasts to be in line with AEMO's scenario forecasts (Slow Change, Progressive Change, Step Change and Strong Electrification).

3 An overview of models and key input data

3.1 Models

Ausgrid has developed a number of analytical models to perform the cost benefit analysis for various categories of network elements in the Ausgrid network.

1. Replacement model
   This model enables the selection of the optimal prudent set of investments to support Ausgrid's Replacement Program requirements. The model is generally focused on the development of 'Health Index' and 'Risk Index' using current and historical information, then conducting the investment evaluation through the cost benefit analysis.

   For more details, refer to **Attachment 5.4.d – CBA Approach for Replacement Programs**.

2. Planning model
   This model enables the selection of the optimal prudent set of investments to be delivered as Ausgrid's major projects including sub-transmission cables and substation switchgear. The model uses a state-space approach to consider all practical system states and different load levels of the network.

   For more details, refer to **Attachment 5.4.e – CBA Approach for Major Projects**.

3.2 Key input data

Attachment 5.2.c - **Customer Value Framework** details how risk dimensions have been monetised to support quantitative risk assessment. Each value dimension contains several Value metrics which are considered when dollar values are assigned.

An outline of the key types of input parameters for each value dimension used in the CBA models are listed below.

Supply:

*Value of Customer Reliability (**VCR**):*
VCR is a measure of customer willingness to pay for the reliability of the network they receive. Ausgrid uses AER published values at regional level, adjusting to the current CPI.

Weibull parameters:
The Weibull distribution is a continuous probability distribution widely used in the industry to estimate reliability metrics including failure rate function. Ausgrid uses Weibull distribution to represent discrete assets within Ausgrid network.

Crow-AMSAA parameters:
A power law model, commonly known as the Crow-AMSAA model, is used to describe the failures for linear assets such as a population of cables of a particular type (XLPE, HSL, Gas or Oil-filled) based on historic performance condition and age correlation. The model assumes a cable segment that has failed can be repaired multiple times over its lifetime.

Repair time:
The mean time to repair (**MTTR**) is the average time taken to repair an asset and return the network to service. The MTTR is found from the average repair times for each failure mode for a given asset.

Switching time:

The duration in hours required to restore the supply via the actions taken by system operations.

Safety:

*Value of Statistical Life (**VoSL**):*
A value of a statistical life is an estimate of the value society places on reducing the risk of dying. The values selected are based on the VOSL developed by the Office of Best Practice Regulation in 2020[7].

*Grossly Disproportionate Factor (**GDF**):*
Ausgrid applies a grossly disproportionate factor to any safety benefit gained from investment. A reasonable range is applied depending on the nature of the risk and exposure. The application of a GDF allows Ausgrid to assess whether an investment can address a safety risk without its cost being grossly disproportionate to the consequences of the risk.

Environment:

Significant Oil Leak Cost:
This is defined as the monetised worth of a detectable oil leak per year and any fines imposed under the Protection of the Environment Operations Act.

Remediation Cost:
This is the direct cost incurred by Ausgrid to remediate environmental damage which may include oil leak clean-up costs.

Fire:

Fire Safety Consequence:
This is to represent the costs to society of injuries and fatalities caused by fire. Network initiated bushfires are one of the highest priority risks that the electricity network poses to the safety of the public, property and environment.

Direct Financial Costs:

Asset Repairs:
This is to represent the cost of repairing assets after failure.

Reactive Replacement Premium:
This is to represent the additional costs incurred to replace an asset reactively after a failure relative to a planned replacement, including overtime costs and productivity costs due to diverting resources from other tasks.

[7] Best Practice Regulation Guidance Note – Value of statistical life
https://obpr.pmc.gov.au/sites/default/files/2021-06/value-of-statistical-life-guidance-note-2.pdf

3.3 Related documents

Attachment #	Document
5.1	Proposed capex
5.2	Network Strategy
5.2.c	Customer Value Framework
5.4.d	CBA Approach for Replacement Programs
5.4.e	CBA Approach for Major Projects