Cost Benefit Analysis

Framework and Principles

Part of Energy Queensland

Cost Benefit Analysis

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Cost Benefit Analysis

1. COST/BENEFIT ANALYSIS OVERVIEW

1.1. Net Present Value (NPV) Analysis

NPV analysis should show the difference between the present value of cash inflows and the present value of cash outflows over a specified period. In simple terms, the costs and benefits of a project should be calculated or estimated for each year that they are incurred and discounted in a compounding manner by the "discount rate". Finance will provide the discount rate for use. Suffice to say that each cashflow into the future is discounted by this rate. Table 1 shows a simple example of an NPV and the difference when discounted cashflows is utilised.

Table 1 – Simple NPV Example with 5% discount rate

Type	Year 1 ($)	Year 2 ($)	Year 3 ($)	Year 4 ($)	Year 5 ($)
Cost	5,000.00	2,000.00	500.00	500.00	500.00
Cost with Discounting	**4,761.90**	**1,814.06**	**431.92**	**411.35**	**391.76**
Benefits	0.00	0.00	3,000.00	5,000.00	2,000.00
Benefits with Discounting	**0.00**	**0.00**	**2,591.51**	**4,113.51**	**1,567.05**
Total Cost/Benefit	**-4,761.90**	**-1,814.06**	**2,159.59**	**3,702.16**	**1,175.29**
Total without Discounting				**$1,500.00**	
Total with Discounting				**$461.08**	

As can be seen from Table 1, without discounting the cost/benefit analysis would result in a positive balance of $1,500, however accounting for a discount rate of 5% results in a greatly reduced balance of $461.08.

1.2. Counterfactual

The counterfactual is an estimate of what would have happened in the absence of the program, project, or intervention, and is the view of the future to compare the options under consideration against. While the counterfactual is sometimes referred to as the "Do-Nothing" option, it should be framed around a continuation of current practise that would happen without the proposed network intervention. Examples include:

- Continuation of the operation and maintenance of an asset or set of assets, with a replacement or repair on failure strategy. Operation and maintenance activities may continue to increase in cost as asset performance reduces.
- Continued investment in network augmentation with load growth if there is not effective dynamic load and generation connections that limit maximum and minimum demand.
- Continued investment in a program at historic rates, such as continuing to replace 10,000 poles / year.

1.3. Options Analysis

In undertaking options analysis, the costs and benefits of any intervention should be calculated with respect to the counterfactual. For instance:

- Costs to improve the network or remove assets in poor condition should be compared to the cost of undertaking the counterfactual.
- Operational or maintenance cost decreases resulting from an intervention should be the difference between the option and the counterfactual.

For clarity, an NPV of the counterfactual should be $0, both in cost and benefits. Any interventions costs and benefits are the difference between the counterfactual and the option under consideration, both in terms of cost and benefits.

Where there is a clear and specific regulatory obligation to undertake an intervention, such as the rectification of a clearance defect on a conductor, or the removal of asbestos as part of a regulatory safety obligation, then it is acceptable for an NPV to be negative. Where an intervention is compliance driven, the concept of the counterfactual is not particularly important and a simple assessment of absolute costs and benefits can be undertaken, rather than having to assess the counterfactual and have a direct comparison. Even so, it is still important to undertake analysis of different options to ensure that the least negative NPV option is chosen.

Where there is no clear and specific regulatory obligation, a positive NPV is essential for an intervention to be justified. A positive result in NPV terms is the determinant in maximising the value to customers. If all options assessed are negative, this is evidence that the counterfactual should be continued. Where several options are positive, the option with the highest value (to the extent it is deliverable) should be undertaken.

2. IDENTIFYING COSTS

For cost/benefit analysis the fundamental consideration should be the difference between the cost for the intervention and the counterfactual.

Figure 1 – Costs Calculations

Many NPVs will have a set of easily identifiable costs, such as the initial cost to complete a project, however some areas that are worth considering in constructing the costs side of an NPV are discussed below

2.1. Counterfactual Strategy

As outlined earlier, in NPV terms there are no costs for the counterfactual. However, the strategy under the counterfactual does have actual costs to the business and these need to be understood to assess the difference in costs between the counterfactual and an intervention. Some examples of these types of considerations are:

- Maintaining or increasing operating and maintenance costs associated with ageing plant and equipment under a counterfactual of running an item of plant until failure and replacing on failure.
- Capital investment involved in maintaining an existing supply arrangement, such as longer distribution feeders from an existing substation as a residential development.
- Asset strategy following a failure. Not all assets will require replacement following a failure, while some may not result in a “like-for-like” replacement.

2.2. Capital Costs

In most instances the capital costs will simply be the initial capital cost of a project, particularly where the counterfactual strategy is simply maintaining the existing asset in place. In these circumstances, the costs will be the upfront cost of the project. However, for scenarios where the intervention is centred on a program such as a broad-based reconductoring program, it is more likely that the costs will represent the difference in volumes and unit costs between the counterfactual and the options under consideration. For instance, if the counterfactual is to replace 500km / year at $2m / year, while the intervention is to replace 700km / year at $3m / year, the cost attributable to the NPV should be the difference between these two figures (that is, $1m / year).

A factor to also consider is the extent to which the intervention defers or eliminates expenditure associated with the counterfactual. For instance, in an example where long feeders are being constructed, an intervention where a substation is located more centrally to the load should factor the reduction in costs associated with these extra feeder lengths into the costs side of the NPV.

2.3. Operating Costs

The operating costs that are attributable to the costs in an NPV are again the difference between the counterfactual and the intervention. An example cost decrease is where an asset in poor condition that requires extra maintenance is replaced with a new asset requiring less maintenance. However, it is important to consider that some interventions will increase operating costs. For instance, where a new asset is established to increase reliability or performance, the operating costs of the new asset should be included as a cost of the intervention in the cash-flows. There are also many instances where there is no material impact on operating costs from an intervention.

3. IDENTIFYING BENEFITS

There are broadly five value streams for inclusion in cost benefit analysis. These are Reliability, Financial, Export, Safety and Environmental. Figure 1 summarises these value streams.

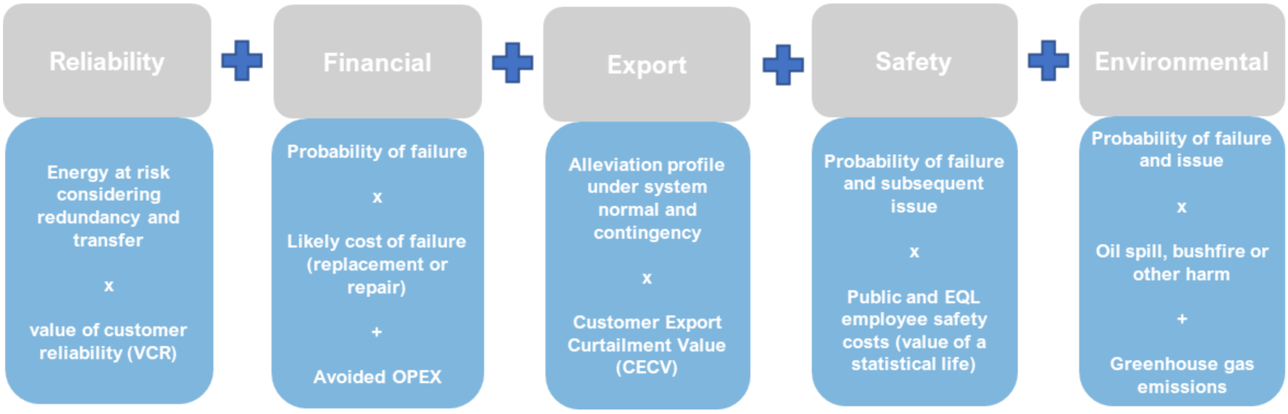

Figure 2 – Value Streams for Cost/Benefit Analysis

Each of these benefits or value streams are discussed in detail in Appendix A, but are briefly summarised below:

- **Reliability** – this is the improvement in unserved energy for customers following a network intervention and should be calculated as MWh. An example may be providing an increased level of redundancy in the network such that the failure of an item of plant prevents or reduces unserved energy supplied to customers. This is also known as Value of Customer Reliability (VCR).
- **Financial** – these benefits can generally be thought of as saving cost having undertaken an intervention. While these could be factored into the cost side of the NPV, some may have a probabilistic nature meaning they are more easily calculated in line with other benefits. An example would be the cost associated with repairing or replacing an item of plant following failure. Under the counterfactual and any intervention, the probability of failure would be multiplied by the anticipated cost to provide a cashflow into the NPV.
- **Export** – this is the curtailment of export for a customer under both system normal or contingency and is measured in MWh. The AER have calculated a Customer Export Curtailment Value (CECV) for this purpose, however EQL will also commission the calculation of other values for use in determining the value of enabling export in addition to the CECV.
- **Safety** – this is the value that can be attributed to an improvement in the safety of the network from a network intervention and broadly factors the cost of a fatality (Value of a Statistical Life (VSL)) and the cost of an injury. A typical network intervention may be the replacement of an asset that is likely to fail and could cause a safety issue, or greater network visibility enabling the safer operation of the network.
- **Environment** – this is the value of the reduction in likelihood of environmental impacts such as bushfire and oil spills. It also includes the value of reduction in greenhouse gas emissions.

3.1. Calculating Risk

To determine the benefits from an intervention, project, or program, quantifying the risks for the counterfactual and any interventions is required. In quantifying risk, it is important to consider three key elements, outlined in the sequence shown in Figure 3.

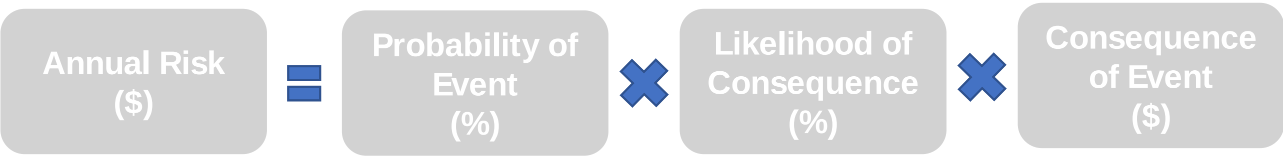

Figure 3 – Annual Risk Calculation

- **Probability of Event** – this is the likelihood that the cause of any outcome that is foreseen to be treated will happen. An example is the probability of failure of a transformer or other type of plant.
- **Likelihood of Consequence** – this is the likelihood that following the event occurring, the consequence eventuates. This might include the likelihood of a death or serious injury following a transformer failure.
- **Consequence of Event** – this is the cost of the outcome. In the above example, this would be the cost of a serious injury or death.
- **Annual risk –** this is the monetised value of the risk that remains should either the counterfactual be continued or the residual risk following the implementation of any of the options. Multiplying the three factors above will yield the annual risk of the scenario under analysis, whether that is the counterfactual or an intervention option.

3.1.1. Probability of Event

Calculating the *probability of event* when undertaking cost/benefit analysis is not something that can be prescriptive, but rather needs to be assessed individually and specifically to the benefit being calculated as part of the analysis. The probability will ideally be based off condition data or historic failure rates. However, they can be based on industry practise or engineering judgement where data or history is limited. Some examples of *probability of event* used in cost/benefit analysis include:

- **Common Network Asset Indices Method (CNAIM)** - to establish a probability of failure for an asset based on its condition.
- **Historic outage rates** – for distribution and sub-transmission feeders, utilising an average per km outage rate for reliability based on a network wide analysis, or a historic view of outages on a particular asset, group of assets or feeder.
- **Industry practise** – where condition information or historic outage data is unavailable, national, and international industry practise should be used if available. For example, cable populations are relatively young throughout Australia, however the United Kingdom has utilised cables for a longer period to allow failure trends to be assessed.
- **Qualitative assessment**– where limited information is available, engineering judgement or a qualitative assessment of probability can be used. This should be a last resort and coupled with sensitivity analysis to establish the range of outputs that could exist.

- **Sensitivity analysis** – this should be incorporated where there is uncertainty over the probability used. The range of sensitivity should reflect the level of uncertainty.

3.1.2. Likelihood of Consequence

Like the *probability of event, c*alculating the *likelihood of consequence* when undertaking cost/benefit analysis cannot be prescriptive, but should be assessed with respect to the exact benefit being calculated. To the extent possible, the likelihood should be based off measured data. However, where this doesn't exist, a qualitative assessment of the risk can be undertaken. Some examples of *probability of event* used in cost/benefit analysis include:

- **Plant ratings, Load Duration Curve and Load Transfers** - in assessing reliability, plant ratings should be used to determine the amount of time or likelihood that the load following an event will be above the rating, with respect to the load curve and transfers available.
- **Historic injury and fatality data –** historic analysis of the conversion from an asset failure to an injury or fatality. This may include near misses and an assessment of the condition that might have arisen that would have caused an injury or fatality.
- **Qualitative assessment**– where limited information is available, engineering judgement or a qualitative risk assessment of the likelihood can be used. This is likely for a specific site analysis, such as for a substation, where historic data is not available because of the scarcity of plant failure at that location.
- **Sensitivity analysis** – this should be incorporated where there is uncertainty over the probability used. The range of sensitivity should reflect the level of uncertainty.

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3.1.3. Consequence of Event

The consequence of event is the monetary value of the outcome. Unlike the probability of event and likelihood of consequence, EQL has determined specified values for some of the five value streams. Further to the specified values, EQL has further specified *disproportionality factors (DP)* to apply to the safety measure, which represent the elevated expectation of the community and other stakeholders that EQL operate a safe network. The DP values that EQL has chosen are consistent with the *AERs Industry Practice Application Note*. Table 2 summarises the EQL values.

Table 2 – Summary of Consequence Values

Value Stream	Compulsory Inputs	DP	Optional Values
VCR	Rates published by the AER - link.	NA	**Projects** – individually calculated by connected customer to the asset, substation or feeder **Programs** – network wide average for programs across multiple assets (e.g pole replacement program).
Financial	Direct costs	NA	Emergency replacement upon failure - 30% factor
Export	CECV rates published by the AER - link	NA	Avoided generation capacity, environmental, and customer. See Appendix A.
Safety	Fatality (VSL) published by the Office of Best Practise Regulation - link Injury – 25% of VSL	6 for public 3 for staff	NA
Environment	Bushfire - $10m	NA	NA
	Oil spill	6 outside site 3 within site	Varies according to volume of oil and the nature of the environment where the spill occurs. See Appendix A.

3.2. Calculating Benefits

The annual risk is required to be calculated for the counterfactual and each intervention being proposed. The benefit for each option that becomes part of the NPV is the difference between the risk under the counterfactual and the risk under each option. The simple equation is shown in Figure 4 below.

Figure 4 – Benefits Calculation

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4. INVESTMENT ANALYSIS

Having established the key inputs into a cost/benefit analysis, there are some key concepts to understand in establishing a financial model to inform which intervention to choose. The below lists the simple considerations in undertaking a cost/benefit analysis. Further information on some of the more complex concepts in NPV analysis can be found in Appendix B.

4.1. Evaluation Period and Discount Rate

In developing an NPV, it is generally always possible to achieve a positive cost/benefit analysis simply by extending the number of years of benefits so that the positive cashflows of the NPV outweigh the costs. The length of time benefits and costs are accrued should be considered in the context of the project.

For example, where a 60-year asset is being established, and where decisions today could have impacts well into the future, it is appropriate to extend the period under consideration to 60 years. While this may seem like a long period to consider, it is important to understand that the level of discounting is significant in the outer years, so this will have relatively less impact on the overall outcome than for costs and benefits in the early years. On the other hand, where an investment has most of its costs and benefits in a shorter period, it is reasonable to shorten this period. For instance, with some ICT equipment having a life cycle of more like 7 years, it is reasonable to choose this period to evaluate.

4.2. Discount rate and nominal cashflows

The pre-tax, real discount rate should be used for cost/benefit analysis. To enable this, all cashflows are required to be real. That is, cashflows into the future are not escalated (such as by inflation) and should simply be calculated as if occurring in today's dollars.

The use of this WACC and real cashflows will ensure consistency across all Ergon Network and Energex business cases. It also means that any changes to escalators or other inputs into the financial model can be easily and consistently incorporated through a simple change to the WACC, rather than having to adjust all cashflows.

4.3. Optimal Timing

To counteract the impact that benefits well into the future on an NPV, the analysis should be overlayed with an optimum timing assessment. This is a simplified approach to NPVs, where any capital costs are "annualised" to have a direct comparison to the year-on-year benefits to ensure that the time of investment is optimised such that the immediate benefits are more than the annualised cost from the first year of the project. Figure 5 below shows a stylised version of this analysis.

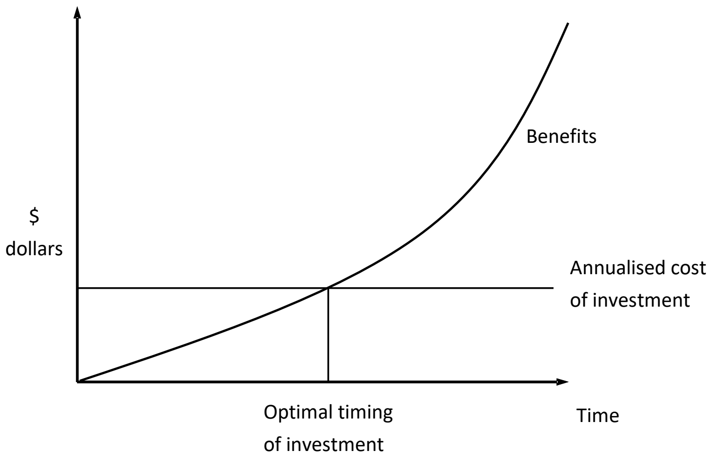

Figure 5 – Optimum Timing for Investments

Annualising the costs as shown in Figure 5 is the initial capital cost multiplied by the WACC. The point at which this value becomes less than the annual benefits is the optimal timing for the investment. Where this analysis is more complex, the simplest way to assess the optimal timing is to adjust the time of the project or program as well as the associated benefits to determine the year for investment that results in the most positive NPV.

4.4. Sensitivity Analysis

As part of ensuring that any intervention is robust to any uncertainties, various inputs to the analysis should be tested to assess whether the NPV becomes negative, or an alternative intervention becomes preferred. Some judgement will be required to determine those inputs that are most likely sensitive to change, however at a minimum the following should be tested:

- **WACC –** this should be at least tested +- 1% of the regulated rate at the time of assessment.
- **Benefits –** +- 25% of the overall benefits. If certain benefits are more uncertain or subject to significant change then these should be tested beyond these.
- **Costs** - +- 25% of the overall costs. Again, if certain costs are more uncertain then these should be tested beyond this threshold.

Judgement will also be required in how to assess the results of these various NPVs. Where significant changes in timing or options occur across the sensitivities, consideration should be given on the likelihood of the variations of the inputs being tested. The Network NPV tool allows Monte Carlo analysis to be conducted that can produce up to 10,000 simulations across numerous inputs that will help in coming to a judgement on the impacts of these sensitivities.

4.5. Option Value

Where different versions of the future cause differing cost or benefits, these should be tested to ensure an intervention that is less sensitive to different future outcomes is selected. An example of this is for an augmentation project that is dependent on load growth and three load forecasts have been created, three NPVs can be conducted under each forecast. These should then be weighted according to the likelihood of each forecast occurring, and then the overall NPV should be a weighted average of these NPVs.

APPENDIX A - CONSEQUENCE OF EVENT VALUES

Value of Customer Reliability (VCR)

The VCR seeks to reflect the value different types of customers place on reliable electricity under different conditions. As such, VCRs are useful inputs in regulatory and network investment decision-making to factor in competing tensions of reliability and affordability. Importantly, VCR is not a single number but a collection of values across residential and business customer types and geographical location which need to be selectively applied depending on the context in which they are being used.

Electricity outages incur costs for customers, both directly through financial losses resulting from lost productivity and business revenues, and in the form of intangible or indirect costs such as a reduction in the convenience, comfort, safety and amenity provided by electricity.

How different customers value electricity supply depends on a number of factors, including what they use their energy for, where they are located and what level of reliability they are used to. Residential customers in regional, hot climatic zones would require electricity to run air conditioners for large portions of the year, but they may also be used to experiencing lengthy outages. The value these customers place on electricity reliability is likely to be vastly different to a small business customer or a large-scale manufacturing processor, or even residential customers in the CBD. The value customers place on electricity reliability therefore depends on the value they place on the services they receive and where they live, and because these factors differ, so too does the value of reliability across these different customer segments and climatic zones.

The two main inputs required to calculate the lost energy are - Load at Risk and Contingency Response.

Load at Risk

In considering energy at risk, it is important not to solely consider the peak load, but rather the entire range of conditions that will result in load at risk.

- **Site Specific Projects** – a load duration curve should be utilised to determine the amount of time that the load is above the N-1 rating of a substation or feeder.
- **System Wide Programs** – system wide average load by asset category is a reasonable approximation of the load at risk for a program of work.

Contingency Response

In most circumstances, the initial load at risk is not the load at risk that remains throughout the event. For instance, following an outage of a transformer, the 2-hour rating of the remaining transformer will reduce to the emergency cyclic rating, which can also be supplemented through load transfers to adjacent substations and deployment of mobile plant to restore most load prior to the repair or replacement of the transformer. Again, broadly there are likely to be two approaches:

- **Site Specific Projects** – 4, 5 or 6 state Markov modelling is the most appropriate method to ensure an accurate representation of the lost energy where there are several restoration steps to restore load. For example, where the system being modelled is a substation, emergency ratings, load transfers and mobile plant should be factored into the restoration of any outage.

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- **System Wide Programs** – where specific information isn't known about the actual outage, it is reasonable to use a system-wide outage duration to determine the energy at risk. For example, for a pole replacement program an average load by distribution feeder, as well as the average restoration time following an outage can be used to determine the average benefits of replacing poles as part of an overall program.

Export

The AER's *DER integration expenditure guidance note* outlines DNSP best-practise in valuing export enablement. Figure 2 below outlines their identified value streams specifically for VaDER.

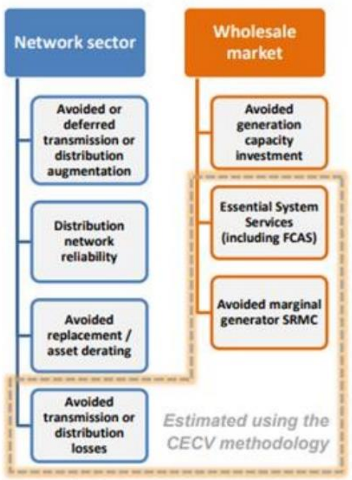

Figure 6 – Value Streams for Export

The AER have specifically calculated a Customer Export Curtailment Value (CECV) which seeks to value Frequency Control Ancillary Services (FCAS), avoided generator output and transmission and distribution losses. The AER's value for CECV can be found here. Of the four broad value streams:

- **Network Sector:** apart from that factored into the CECV, these are better placed to be captured in other value streams, or captured as deferred costs in an NPV
- **Avoided generation capacity investment:** this is the capacity of generation that wouldn't have to be established assuming no cap on DER export. Effectively, this is a market benefit to all consumers of allowing export at the expense of the next lowest cost generation source at the time of export.
- **Environment** – Queensland does not currently have a carbon price, however with the addition of environmental considerations as part of the National Electricity Objectives EQL will look to include carbon emissions avoidance as part of the VaDER.
- **Customer** – this value stream includes both the avoidance of investment by consumers in DER, as well as their "Willingness to Pay" for EQL to enable DER. EQL will engage with customers to understand whether there is an interest in valuing DER above the market based value, via a "Willingness to Pay" type study.

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Safety

While the cost of an event is a subjective matter, the Australian Government has provided a Guidance Note. The current value of a statistical life (VSL) is $5.3m (which is updated annually in October) however organisations typically apply a disproportionality figure to this. When considering the risk to members of the public, Ergon Energy and Energex utilise a Disproportionality Factor of 6 for risk to public safety and a Disproportionality Rate of 3 for a risk to employee safety.

In assessing the costs associated with serious injury, EQL utilise a simple approach of applying a proportion to the VSL (currently 10%), rather than adjusting the value of a statistical life year for each injury type and then applying this rate for an unknown number of years.

It is also recognised that different assets will pose a threat of injury or death differently as well as whether this risk is confined to employees or if members of the public are also exposed to such risk. A decision tree analysis will be required to assess whether an asset failure is likely to result in an injury or death and whether this would impact employees and/or members of the public.

Environmental

The two most common types of environmental benefits that can be attributable to investment are bushfire and oil spill damage. Carbon emissions have been discussed as part of Export, but to the extent allowable under the regulatory framework can be captured here. Other environmental benefits can be included, however where possible demonstration of how the consequence cost has been calculated will be required.

Bushfire

The cost of environmental and financial impacts of bushfire damage has been determined using literature research from recent catastrophic fires in Australia. While it is difficult to derive a precise figure, the most widely accepted economic assessment of the impacts of disasters in Australia is the Bureau of Transport Economics' 2001 report, Economic Costs of Natural Disasters in Australia which was updated in 2018. This report suggests Queensland's total costs of disasters is $1.01 billion annually. While bushfires are the third most costly event across Australia, they contribute significantly less to Queensland's disaster costs compared to cyclones, floods and severe storms, and is likely to be less than 1% of total annual disaster costs. Moderating for the occurrence of less severe bushfires in Queensland, Ergon Energy and Energex have determined an environmental cost resulting from a bushfire to be approximately $10m.

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Oil Spills

The estimated consequence of the extent of potential contamination (litres released/spilled) links to the corresponding clean-up costs and potential fines imposed as a breach of the Environmental Protection Act 1994 for water contamination. These values are summarised in below. Ergon Energy and Energex have employed the higher end of the scale from each of these tables. A disproportionality factor has also been applied to account for the reputational risk resulting from such an environmental disaster. Where there is a risk of contamination extending beyond the network asset boundary, a disproportionality factor of 6 is applied, and in all other cases a factor of 3 is applied.

Table 3 – Environmental Consequence Scale

Consequence Scale	Quantity released / spilled	Extent of Contamination	Clean up costs
6	>20,000 L	Widespread area of contamination beyond network property / worksite boundary	$5m
5	>10,000 <20,000 L	Off-site Beyond network property / worksite and enters water course	<$5m >$500,000
4	>5,000 <10,000 L	Off-site beyond network property / worksite but prevented from entering water course	<$500,000 >$50,000
3	>1,000 <5,000 L	Not beyond network property / worksite alignment border but threatens to cross boundary	<$50,000 >$5,000
2	>200 <1,000 L	Not beyond network property / worksite alignment border	<$5,000 >$500
1	<200 L	Very localised - close to activity zone or within spill containment structure / building	<$500

Financial

Financial cost will be any penalties or restorations costs that would be associated with the counterfactual but change because of the intervention. An example of this is where an asset is being run to failure under the counterfactual, but it would be replaced in the intervention. The cost of replacement under an emergency would likely remain similar following an intervention, however the probability of failure would reduce because the asset is new under the intervention. There are many other cost savings that can be attributed to an intervention which should be supported with evidence for their calculation.

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APPENDIX B – FINANCIAL MODELLING

Methodology

- An excel based financial model is generally required for performing the NPV analysis. The financial model is constructed based on the discounted cash flow methodology which involves estimating cash inflows and outflows for a project/program over a specified investment evaluation period and "discounting" the net cashflows in a compounding manner by a "discount rate".
- Ergon Network and Energex have an NPV tool that is widely used for network investment cases and can be utilised for non-network investment cases.

Discount Rate

- The discount rate is also called a cost of capital or commonly referred to as Weighted Average Cost of Capital ("WACC").
- The WACC is determined by AER through the 5-year determination process. However, an update will be required annually to reflect the latest cost of debt. It also should be noted that AER only makes determination on the so called "Nominal Vanilla WACC". However, for NPV analysis, it is "Nominal Pre-Tax WACC" or "Nominal Post-Tax WACC" that is commonly used. In Ergon Network and Energex, Finance updates the WACC, undertakes the conversion and provides the "Nominal Pre-Tax and Nominal Post-Tax WACC" to the business.
- It also should be noted that an appropriate discount rate should be matched with appropriate cashflows consistently. For instance, pre-tax nominal cashflows should be matched with pre-tax nominal WACC whilst post-tax nominal cashflows should be matched with post-tax nominal WACC.

Cashflows

- Estimation of cashflows is critical to the accurate evaluation of any project, therefore it is essential that all the relevant cash flows are included in the evaluation.
- All the cashflows should be on an incremental basis (i.e. difference in costs/benefits between the counterfactual and an intervention)
- Cashflows should represent the whole-of-life cost for the project. Therefore, where future capital or operating expenditure is required during the life of the project they must be included.
- If nominal WACC is used, the cashflows should be evaluated on a nominal basis (i.e. future year cashflows must be inflated to reflect estimated increases due to price inflation over time). Wherever possible escalation of each major category of cost should be separately estimated.

Non – Cashflow Items

- Non-cash items such as depreciation, should not be included and accrued expenses or revenues should only be included at the time and to the extent that actual cashflows in relation to these items will occur.
- Financing costs such as interest expense (except the capitalised interest during the construction period) should not be included as these costs are assumed in the WACC rate

Terminal Value

- Assets that have a residual or salvage value at the end of a project or evaluation period should be included in the evaluation as a positive cashflow into the NPV. That is, in the end year of the evaluation period, the value of the asset should be incorporated as a benefit or negative cost.

APPENDIX C – WORKED EXAMPLE

Situation

A network supplies around 1,000 customers at an average load of 3MW. It has been identified that the supply arrangement has an increasing likelihood of outage over time, with the failure mode also resulting in a safety risk. Once the outage occurs, the existing assets must be repaired to restore supply as there is no alternative network that can restore customer loads.

Counterfactual Analysis

The following inputs have been included in the modelling to determine the counterfactual risk cost:

- **Probability of Event** – starting at 1% / year and increasing by 1% / year linearly over the modelled period.
- **Likelihood of Consequence (Safety)** – following the failure of the asset, we have assessed that the likelihood of causing a fatality is fixed at 1%.
- **Value of a Statistical Life** - $5.1m as per the Office of Best Practice Regulation.
- **Disproportionality Factor** – use of 6 as the event is for members of the public.
- **Likelihood of Consequence (VCR)** – every asset failure will result in the loss of supply to customers. Following an outage, it has been assumed that it will take 3 hours to restore supply.
- **VCR Rate** - $23,000 / MWh

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Table 4 – Counterfactual Risk Analysis

Year	PoE	Safety Risk				Value of Customer Reliability Risk			
		LoC	VSL	DP	Safety ($)	VCR	MW	Time	VCR ($)
2025	1%	1%	$5,100,000	6	$3,060	$23,000	3	3	$690
2026	2%	1%	$5,100,000	6	$6,120	$23,000	3	3	$1,380
2027	3%	1%	$5,100,000	6	$9,180	$23,000	3	3	$2,070
2028	4%	1%	$5,100,000	6	$12,240	$23,000	3	3	$2,760
2029	5%	1%	$5,100,000	6	$15,300	$23,000	3	3	$3,450
2030	6%	1%	$5,100,000	6	$18,360	$23,000	3	3	$4,140
2031	7%	1%	$5,100,000	6	$21,420	$23,000	3	3	$4,830
2032	8%	1%	$5,100,000	6	$24,480	$23,000	3	3	$5,520
2033	9%	1%	$5,100,000	6	$27,540	$23,000	3	3	$6,210
2034	10%	1%	$5,100,000	6	$30,600	$23,000	3	3	$6,900
2035	11%	1%	$5,100,000	6	$33,660	$23,000	3	3	$7,590
2036	12%	1%	$5,100,000	6	$36,720	$23,000	3	3	$8,280
2037	13%	1%	$5,100,000	6	$39,780	$23,000	3	3	$8,970
2038	14%	1%	$5,100,000	6	$42,840	$23,000	3	3	$9,660
2039	15%	1%	$5,100,000	6	$45,900	$23,000	3	3	$10,350
2040	16%	1%	$5,100,000	6	$48,960	$23,000	3	3	$11,040
2041	17%	1%	$5,100,000	6	$52,020	$23,000	3	3	$11,730
2042	18%	1%	$5,100,000	6	$55,080	$23,000	3	3	$12,420
2043	19%	1%	$5,100,000	6	$58,140	$23,000	3	3	$13,110

Cost Benefit Analysis

Options

Two options have been identified:

1. **Replace existing assets** – this involves upgrading the existing assets to reduce the probability of failure. Following this intervention, a failure of the asset will still result in an outage to customers and a safety risk. This option has been assessed as costing $350k.
2. **Establish new assets** – this involves duplicating the existing assets, which means accepting the existing safety risk but removes any customer outage following a failure of the asset. This option has been assessed as costing $50k.

The following assumptions have been included in modelling the NPV outcome of the proposed solutions. For Option 1:

- **Probability of Event** – reduces to 0.1% and remains static across the modelled period.
- **Likelihood of Consequence (Safety)** – remains the same rate as the Counterfactual at 1%.
- **Value of a Statistical Life** - $5.1m as per the Office of Best Practice Regulation.
- **Disproportionality Factor** – use of 6 as the event is for members of the public.
- **Likelihood of Consequence (VCR)** – this option means that each outage of the asset will result in an outage to customers.
- **VCR Rate** - $23,000 / MWh

For Option 2:

- **Probability of Event** –with the existing asset remaining in place, the probability starts at 1% / year and increasing by 1% / year linearly over the modelled period.
- **Likelihood of Consequence (Safety)** – following the failure of the asset, we have assessed that the likelihood of causing a fatality is fixed at 1%.
- **Value of a Statistical Life** - $5.1m as per the Office of Best Practice Regulation.
- **Disproportionality Factor** – use of 6 as the event is for members of the public.
- **Likelihood of Consequence (VCR)** – By duplicating supply, no load is lost following an asset failure.
- **VCR Rate** - $23,000 / MWh

Cost Benefit Analysis

Benefits

The risk for each option is then calculated in the same way as shown in Table 4, however with the reduced Probability of Event or Likelihood of Consequence (VCR) figures outlined above. Following this analysis, the difference in risk between the intervention and the counterfactual is calculated to determine the benefits of each option. These results are collated in Table 5.

Table 5 – Benefits Analysis

	Option 1		Option 2	
Year	**Safety Benefit**	**VCR Benefit**	**Safety Benefit**	**VCR Benefit**
2025	$1,530	$345	$0	$690
2026	$4,590	$1,035	$0	$1,380
2027	$7,650	$1,725	$0	$2,070
2028	$10,710	$2,415	$0	$2,760
2029	$13,770	$3,105	$0	$3,450
2030	$16,830	$3,795	$0	$4,140
2031	$19,890	$4,485	$0	$4,830
2032	$22,950	$5,175	$0	$5,520
2033	$26,010	$5,865	$0	$6,210
2034	$29,070	$6,555	$0	$6,900
2035	$32,130	$7,245	$0	$7,590
2036	$35,190	$7,935	$0	$8,280
2037	$38,250	$8,625	$0	$8,970
2038	$41,310	$9,315	$0	$9,660
2039	$44,370	$10,005	$0	$10,350
2040	$47,430	$10,695	$0	$11,040
2041	$50,490	$11,385	$0	$11,730
2042	$53,550	$12,075	$0	$12,420
2043	$56,610	$12,765	$0	$13,110

Cost Benefit Analysis

Using the cashflows from Table 5, and a WACC of 5%, the NPV for Option 1 and 2 are shown in Table 6.

Table 6 – NPV Summary of Options

Option	PV of Cost	PV of Benefits	NPV
Option 1	$350k	$365k	$15k
Option 2	$50k	$71k	$21k

As can be seen in Table 6, while Option 1 has more benefits associated with it, Option 2 is the highest NPV as the cost is lower, and the risk reduction relative to the cost is higher.