Essential Energy

6.03.04 System Capital Risk and Value Based Investment Methodology

December 2022

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1 Introduction

1.1 Purpose

The System Capital Risk and Value Based Investment methodology (this document) details the approach and methodology used for developing Essential Energy's portfolio of standard control services (SCS) capital investments and provides a summary of the outcomes to be delivered during the 2024-29 regulatory period. This document provides detail on the approach for risk valuation and forecasting of standard control investment and should be read in conjunction with the referenced documents and investment cases.

This document specifically supports Chapters 6, 7 and 10 of Essential Energy's Regulatory Proposal for 2024-29.

The methodology provides a consistent basis for trading off the costs, risks and benefits of investment decisions. This ensures our approach delivers the value stakeholders expect while achieving our strategic and asset management objectives as detailed in our Strategic Asset Management Plan (**Attachment 10.01**). Our stakeholders include customers, shareholders, regulators, policy makers, industry groups, landowners, employees, and the public.

1.2 Scope

This document covers Essential Energy's portfolio of SCS capex for the 2024-29 regulatory period and includes the categories of repex, augex, connections and export services.

It does not cover Essential Energy's non-system assets (e.g. ICT, property and fleet) or alternative control services (ACS) (e.g. streetlighting).

1.3 Approach

The approach used to establish the system capex proposal has been built around modelling, risk valuation and challenges both internal and external. Investment options and risk tolerance have been established with the support of customers through customer engagement.

Chapter 6 of the Proposal, Network Risk Management Manual **(Attachment 6.03.02)** and Appraisal Value Framework **(Attachment 6.03.03)** explain the application of risk value at Essential Energy.

A high-level representation of the risk framework approach is shown in Figure 1.

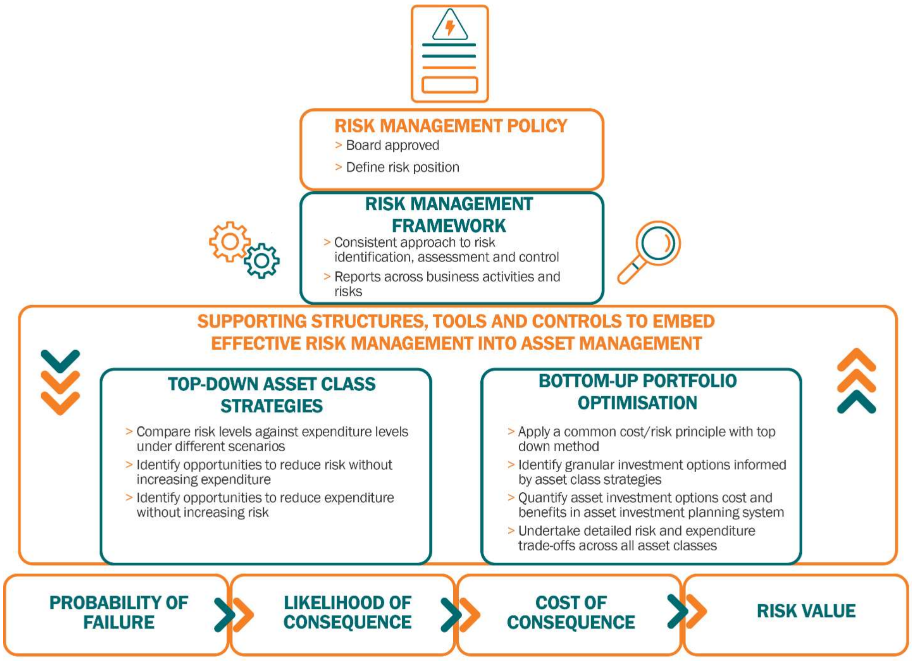

Figure 1 – Risk approach

Within this risk framework, Figure 2 depicts the high-level process (sections referenced below) used for the development of the system capital expenditure categories within our Proposal. Resilience and export services are new areas of focus for Essential Energy and our customers for the 24-29 regulatory period.

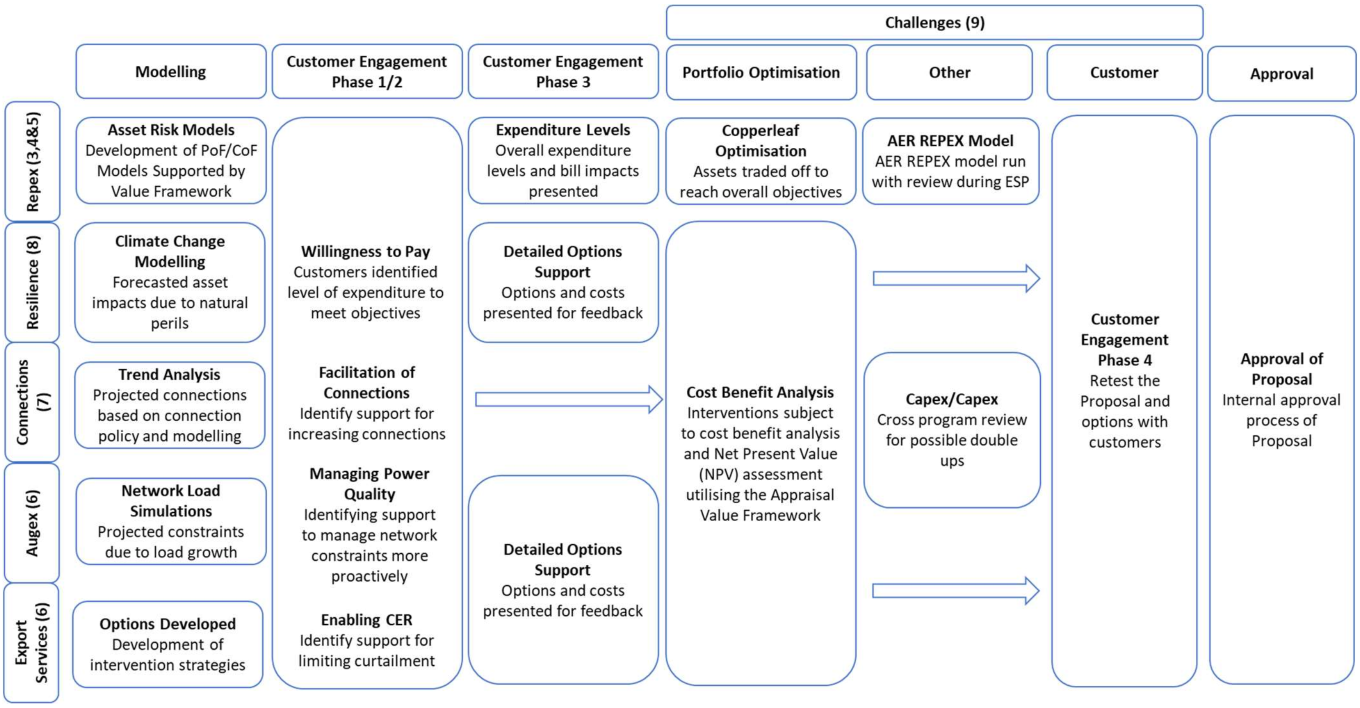

Figure 2 - Capex approach

1.4 Improvements from 2019-2024 Proposal

The approach to system capex development and evaluation for the 2024-2029 period has been improved since the last regulatory proposal as detailed in Table 1 below.

Table 1 - Key improvements

Topic	2019-2024	2024-2029
Customer Engagement	Directional Only: Customers predominately gave feedback on high level risk appetite (reliability focused) and overall expenditure levels and two discretionary spending programs: • Worst served customers • Blackspot program	Optioneering: Customers gave feedback on high level risk appetite and expenditure levels but also were involved in detailed options for investment
Asset Modelling	High level: Asset modelling utilised a combination of trend and probabilistic modelling. Granularity was limited to broader asset grouping and level of calibration predominately relied on SME elicitation	Granular and calibrated: Asset models have been embedded in the business and have undergone a formal calibration review process utilising a combination of data and SME elicitation
Portfolio Optimisation	Program Trate-off: Optimisations were completed with varying levels of program investment (i.e. Do Nothing, replace x number of assets, replace y number of assets). Required additional top-down review to validate cross-asset	Asset trade-off: Optimisations traded off investments with granular asset numbers to optimise to a number of risk and expenditure constraints

Topic	2019-2024	2024-2029
Non-Network Solutions (NNS)	Limited NNS	Broader usage of NNS: Current proposal has identified NNS inclusive of: • Microgrids • SAPs • Dynamic Operating Envelopes (DOE) • Battery Energy Storage Systems (BESS)

2 Asset investment portfolio

Table 2 - Capital expenditure forecasting approach by expenditure type

Expenditure type	Forecasting approach
Replacement expenditure ('Repex')	Predictive models or trend analysis (based on asset condition, performance and risk/cost analysis)
Augmentation expenditure ('Augex')	Bottom-up assessment (cost benefit analysis), drawing on demand forecasts as relevant
Customer connection	Trend analysis, demand forecasts, benchmarking unit costs
Export Services	Bottom-up assessment and business case development (including cost benefit analysis) incorporating demand forecasts and technology options (as relevant).

2.1 Setting the objectives

To build our system capex forecasts we have undertaken an extensive process of bottom-up build of various asset conditions and network constraints. We have used this analysis in our investment trade-off software package Copperleaf portfolio for repex based investment. Investment cases have been developed to support all aspects of the portfolio such as augex and future networks (expenditure supporting the provision of export services).

The desired outcomes or objectives of the portfolio of investments were established through a multi-phased customer engagement program covering such topics as resilience and reliability, the network of the future and pricing.

These topics were tested at each phase of the engagement, including options and their relative price impacts (refer **Attachment 4.02 How engagement informed our Proposal**).

Along with business and asset management objectives, the desired outcomes of customers were applied as constraints and targets to the overall portfolio. These objectives and their application to the portfolio are covered in the following sections.

2.2 Business and asset management objectives

As detailed in the Strategic Asset Management Plan (**Attachment 10.01**) our business has core objectives that we strive to deliver. These objectives closely complement the priorities and preferences provided by our customers.

Predominately, this relates to both bushfire prevention and safety risks as well as maintaining reliability of supply. As a business we place safety above all else and we are also obliged through legislation to run a safe and reliable network. As such, we have included a constraint on our safety performance in the portfolio to at least **maintain current levels of safety**.

Given the current changes in climate and recent weather-related events, i.e. large scale bushfires in NSW and Victoria, appetite for bushfire risk for network initiated fires has reduced. In line with this, we have established internal targets to **reduce our controllable bushfire** risk **by 20% over the next 20 years**.

2.3 Customer engagement

Through customer engagement, we were able to determine what risks and expenditure we should be constraining when developing our expenditure forecasts. This was achieved through a multi-phased approach as shown in Figure 3 below.

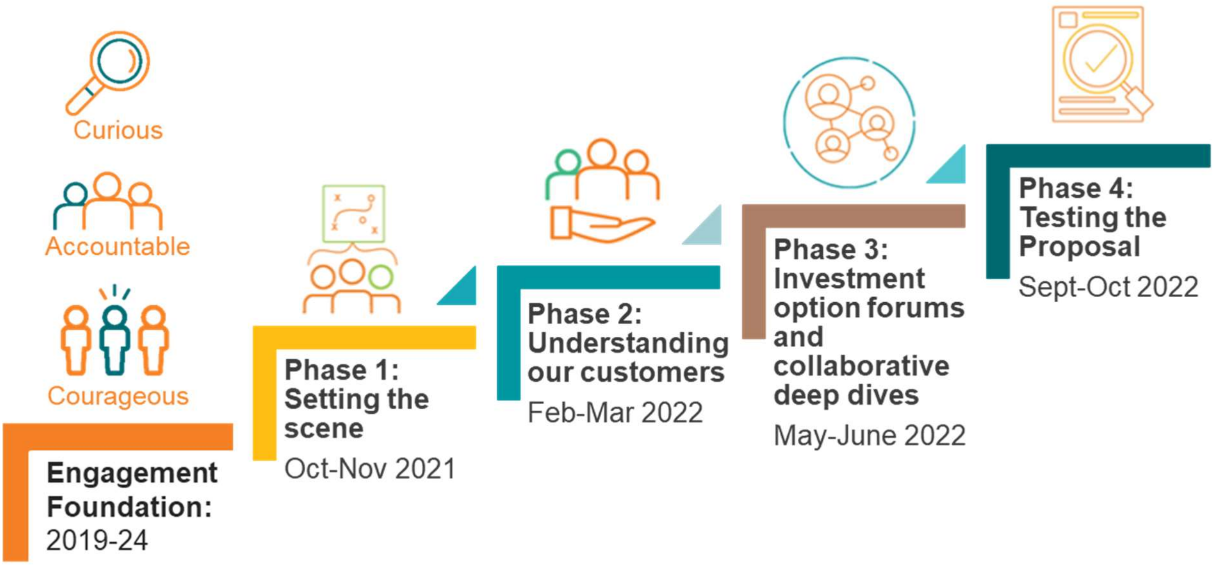

Figure 3 - Phases of customer engagement

Through phases 1 and 2 of customer engagement, customers identified that:

- They are content with our level of reliability and there was no support for either increasing or decreasing expenditure levels. There was support for improving the reliability for those customers that experienced the worst reliability.
- Network resilience was seen as important, and they are willing to see bill increases and higher expenditure to deal with this.
- Safety risk and bushfire risk (i.e. network assets starting bushfires) are important but are slightly less so than network reliability.

More information on customer engagement can be found at **Attachment 4.02 - How engagement informed our Proposal**.

2.4 Core objectives

The objectives were translated into the following high-level objectives or constraints for the portfolio:

- Maintain network reliability risk
- Maintain network safety risk
- Improve network bushfire risk
- Minimise capex increases to resilience expenditure

3 Repex portfolio build

The aim is to develop a portfolio that delivers value (considering risk mitigation, benefits and costs) across the portfolio of system investments while working within affordability constraints.

The portfolio has been optimised via an iterative process considering:

- The 'bottom-up build' of investments
- The top-down 'risk vs expenditure' challenge
- Constraints placed on the portfolio

3.1 Bottom-up build

The bottom-up build of investments for the portfolio was established across multiple asset classes utilising risk profiles of the assets within Essential Energy's network. These probabilistic risk profiles represent both the Essential Energy and societal fiscal risk value that each asset possesses.

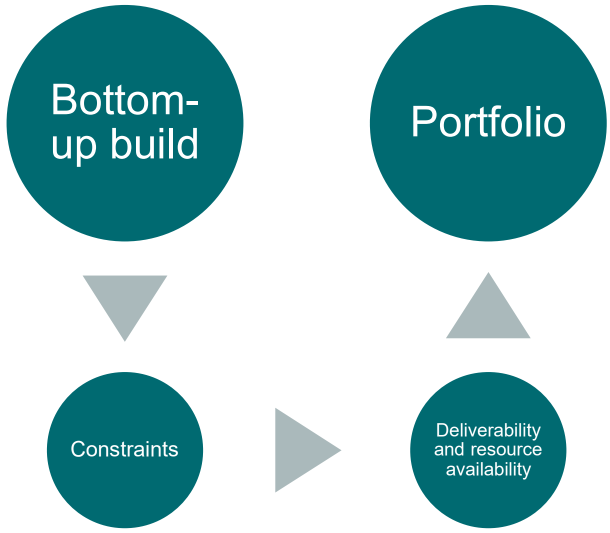

Figure 4 – Repex optimisation approach

As part of building asset investments for the portfolio, each asset within the asset class is subjected to an equivalent annualised cost (EAC) calculation to evaluate if the replacement of the asset shows positive risk value by FY34 (a net present valuation (NPV) is completed during optimisation). This smaller subset of EAC positive assets was included in the portfolio for optimisation with aggregation occurring by grouping assets with similar risk attribution into individual investments (refer repex investment cases for asset grouping details).

Table 3 summarises the quantum of investment options that were loaded into Copperleaf for optimisation.

Table 3 – Quantum of repex investments

Number of investments	4,221
Number of assets EAC positive	1,253,645
Total investment cost	$2,284,435,081

Where applicable, assets with alternative replacement types were also included as options within the investments to allow optimisation within the asset class for optimal investment types.

3.2 Portfolio constraints

As well as objectives covered in 2.4 above, consideration was also given to the following when establishing constraints in Copperleaf configuration:

- Resource levels (deliverability); and
- Legislative requirements (National Electricity Rules).

3.3 Baseline risk

The baseline risk used for analysis is the 2022 network risk profile which was projected forward. To project the baseline risk, the calibrated probability of failure (PoF) and consequence of failure (CoF) asset risk models were utilised (refer to section 4).

In these models, CoF remains a static value with the only variation over time being the PoF component. In Figure 5 the total network baseline risk profile shows a steadily increasing risk across all risk categories. Figure 6 provides the breakdown of risk over the 2024-29 period as a percentage of total risk over the period. As can be seen in Figure 6 network risk i.e. reliability has the high proportion of risk on the network.

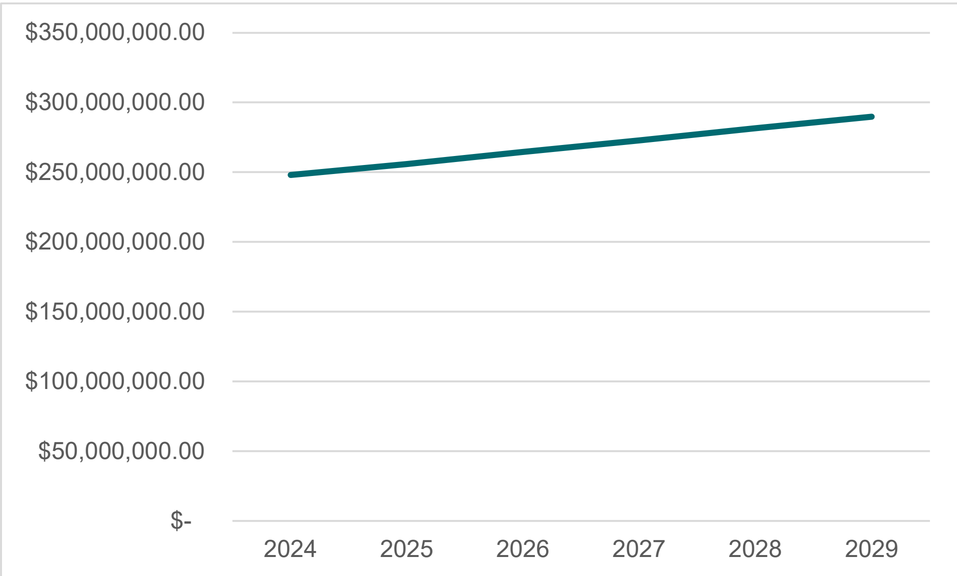

Figure 5 - Total baseline risk (all categories)

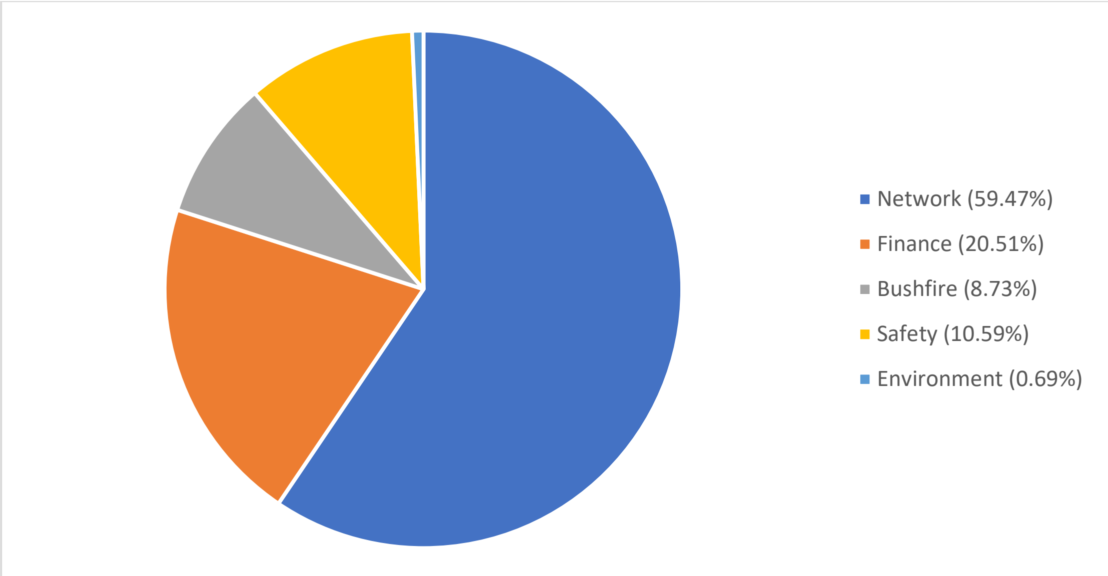

Figure 6 - Risk breakdown 2024-29 by category

4 Repex risk outcomes

In development of the Proposal, Essential Energy completed a number of optimisations to establish the most efficient investments to meet the objectives outlined in section 2.4. This involved varying the level of constraints in Copperleaf and review and resolve the impact on competing priorities. As an example, bushfire risk could be set with a lower target however this pushed lower or even negative value investments into the portfolio to meet the target. This would also compete with the other constraints and potentially lead to insufficient performance in other areas.

The resulting risk profiles of the final proposed investment scenario can be found in Figure 7, Figure 8 and Figure 9. Permitting optimisation to trade-off between asset classes allows the portfolio to meet objectives by selecting investments (assets) that most efficiently deliver on these outcomes. The subsequent outcome risk profiles are in line with customer expectations.

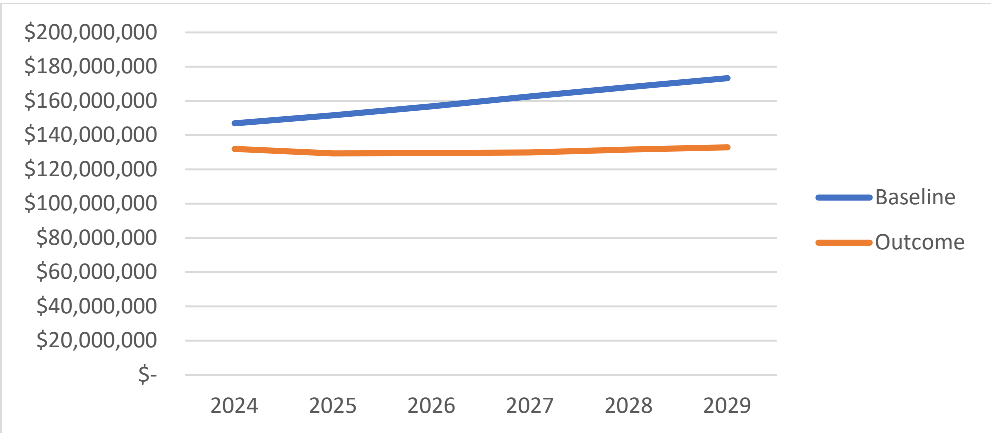

Figure 7 - Network (reliability) risk profile

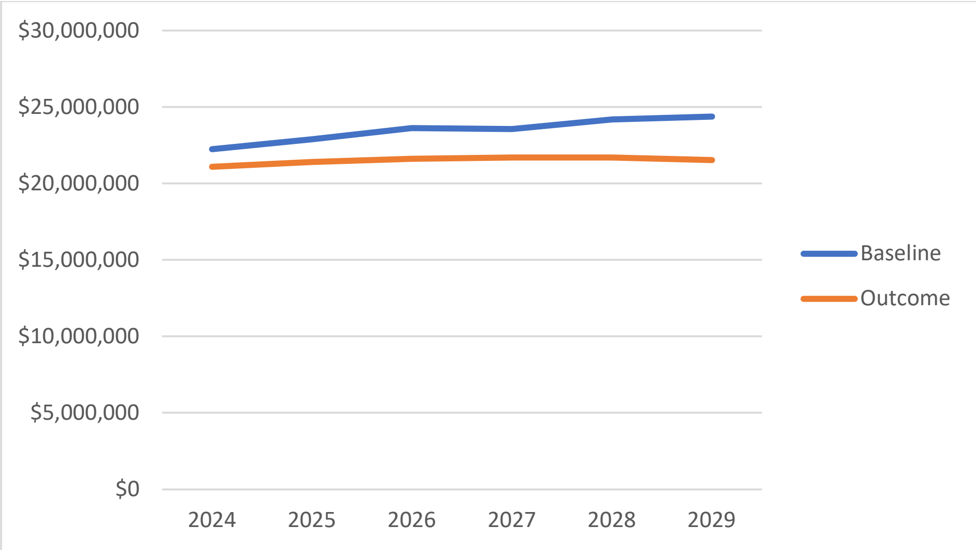

Figure 8 - Bushfire Risk Profile

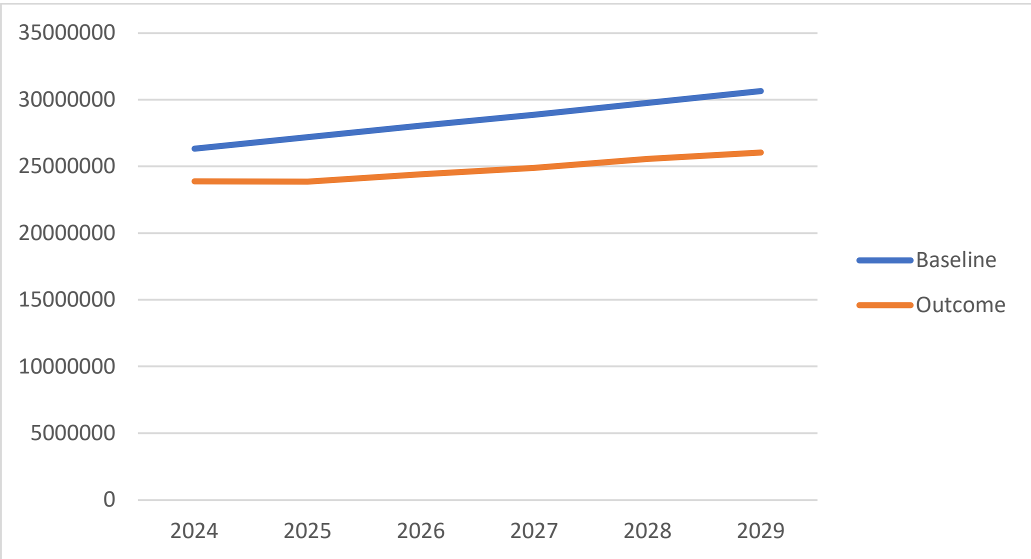

Figure 9 - Safety risk profile

As expected, based on our network configuration, the overhead network accounts for over 80% of the total residual risk over the period as shown in Figure 10.

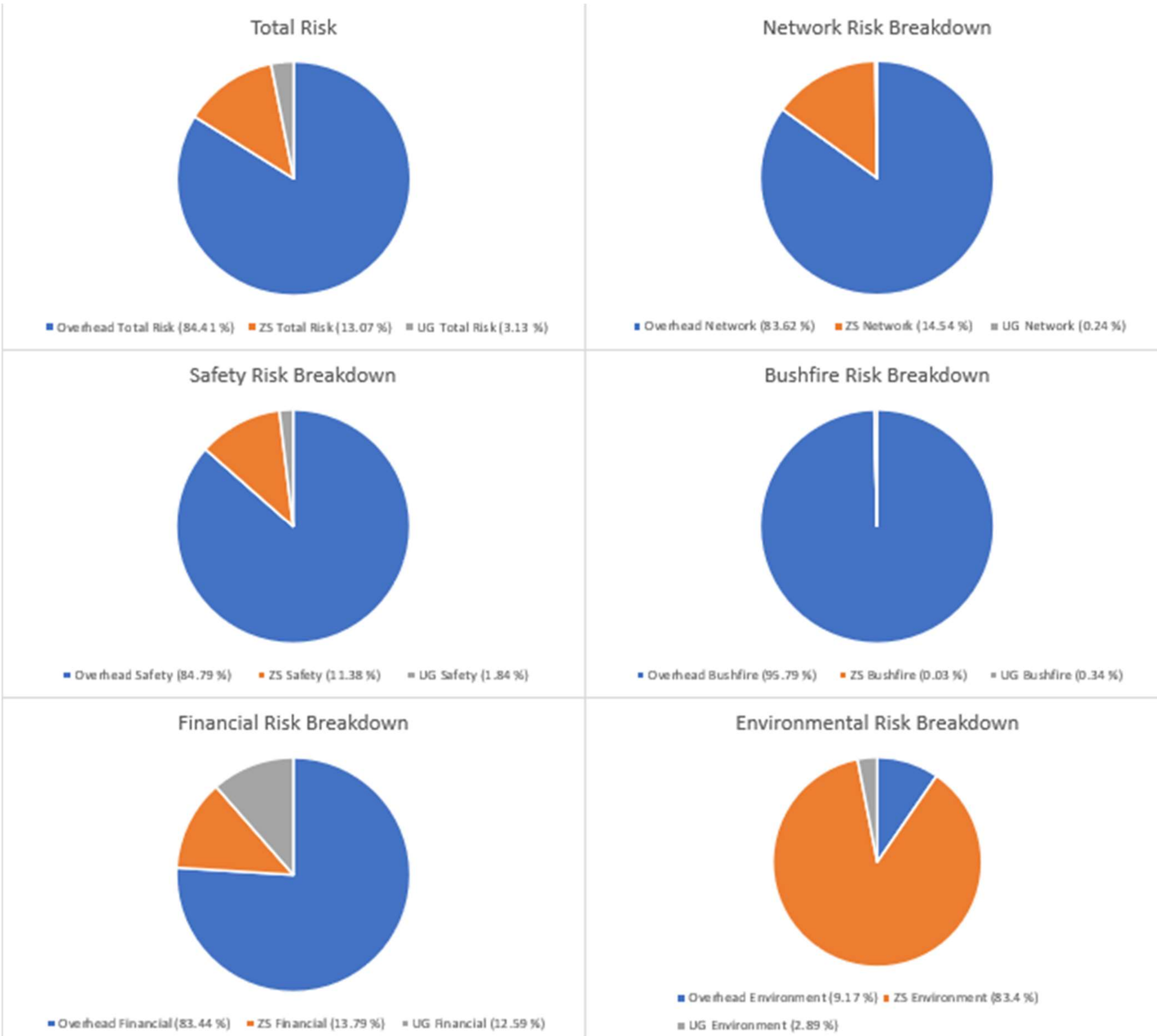

Figure 10 – Residual risk breakdowns (summated risk 2024-29)

4.1 Overhead network risk

As per Figure 11, overhead conductor makes up the largest proportion of baseline risk on the network, however over the period has a risk growth rate of 5.24%. Poles is currently experiencing the largest uplift in total baseline risk growth increasing $6.72M (15.73%) over the period. This growth in risk has been reduced through the optimisation process inclusive of resilience as shown in Figure 12.

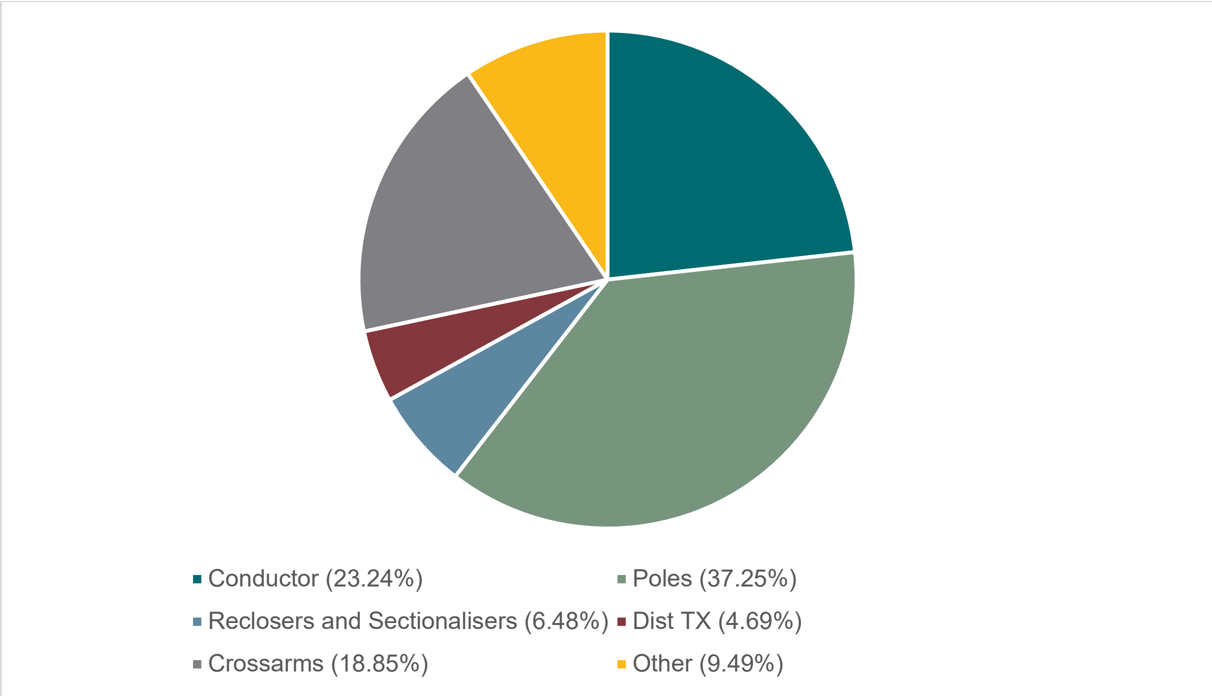

Figure 11 – Baseline overhead risk by overhead asset class (summated 2024-29)

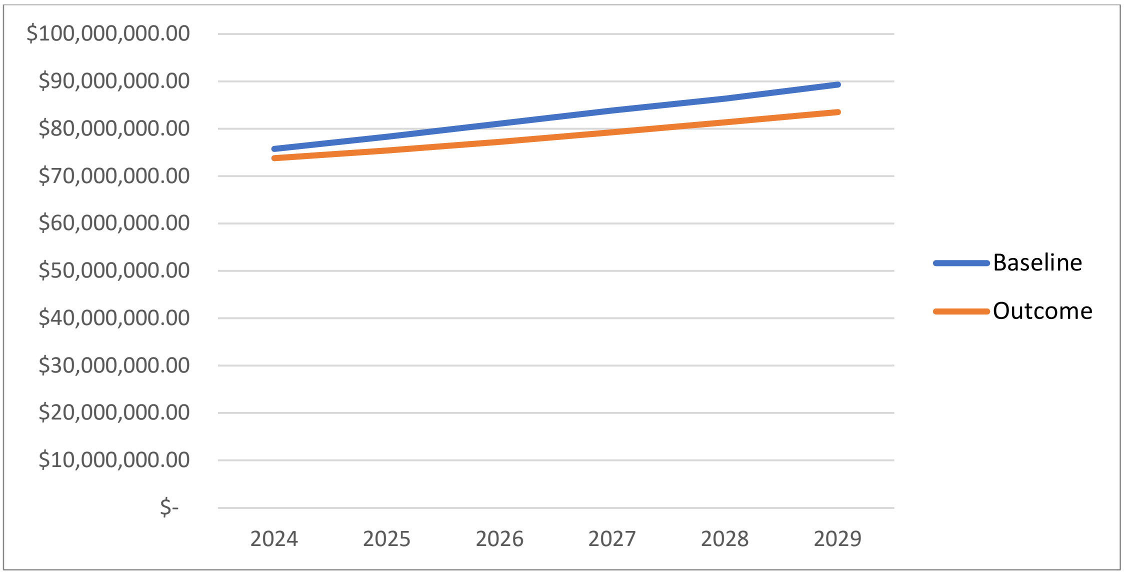

Figure 12 - Poles optimised risk profile

4.2 Underground network risk

There is minimal investment being undertaken to proactively reduce network risk for the underground (UG) network. Essential Energy currently replaces or repairs UG cable on failure however this only results in a small reduction in risk as annual cable replacement equates to <0.1% of total underground network length. We are establishing a cable testing program (piloted in FY23). Historically, Essential Energy has conditionally assessed UG distribution cables via various testing methods during commissioning and during fault and emergency restoration. The tests include sheath insulation resistance, tan delta (TD), withstand (MWT) and megger tests. In

FY23, a program has been budgeted and aims to test 150 in-service, HV, XLPE cables on the network. This was a recommendation of the Underground Cables Strategy completed in 2021.

The goal of the pilot program is to assess the viability of the testing procedures to conditionally assess the HV XLPE cables. By conditionally assessing the older HV XLPE cables, the testing may show value in proactively replacing the asset before they functionally fail in-service.

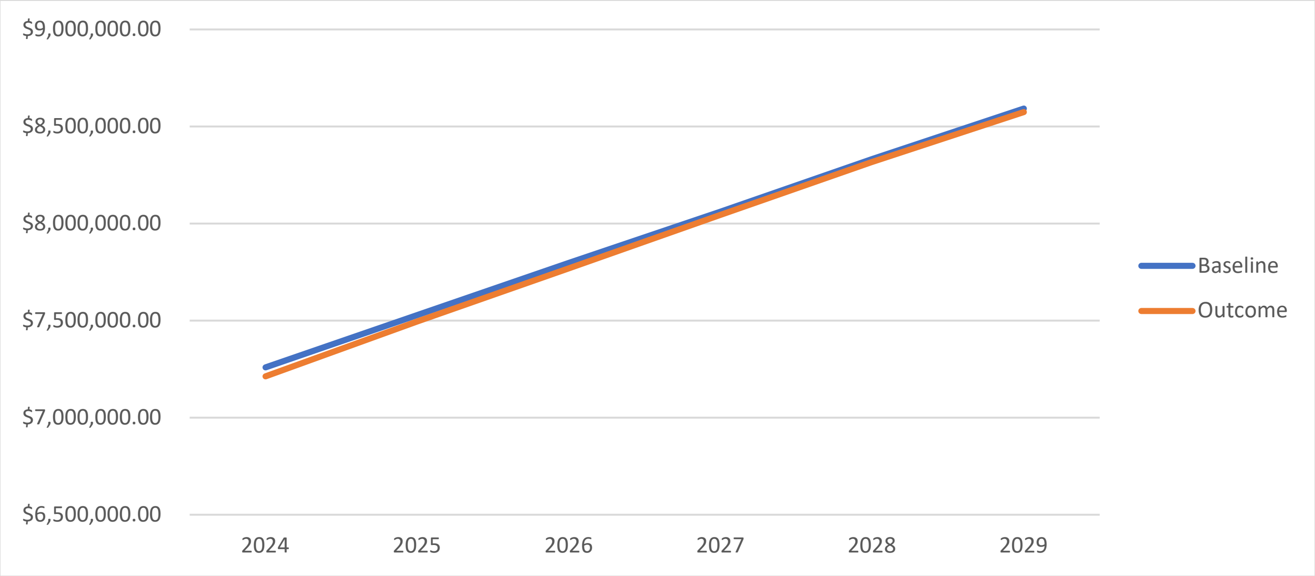

Figure 13 - Underground total risk value

4.3 Zone substation network risk

As per Figure 14, zone substation (ZS) outdoor busbars, isolators and disconnectors contributes the largest proportion of risk within the ZS system and over the period has a risk growth rate of 12%. This growth in risk has been reduced through the optimisation process as shown in Figure 15.

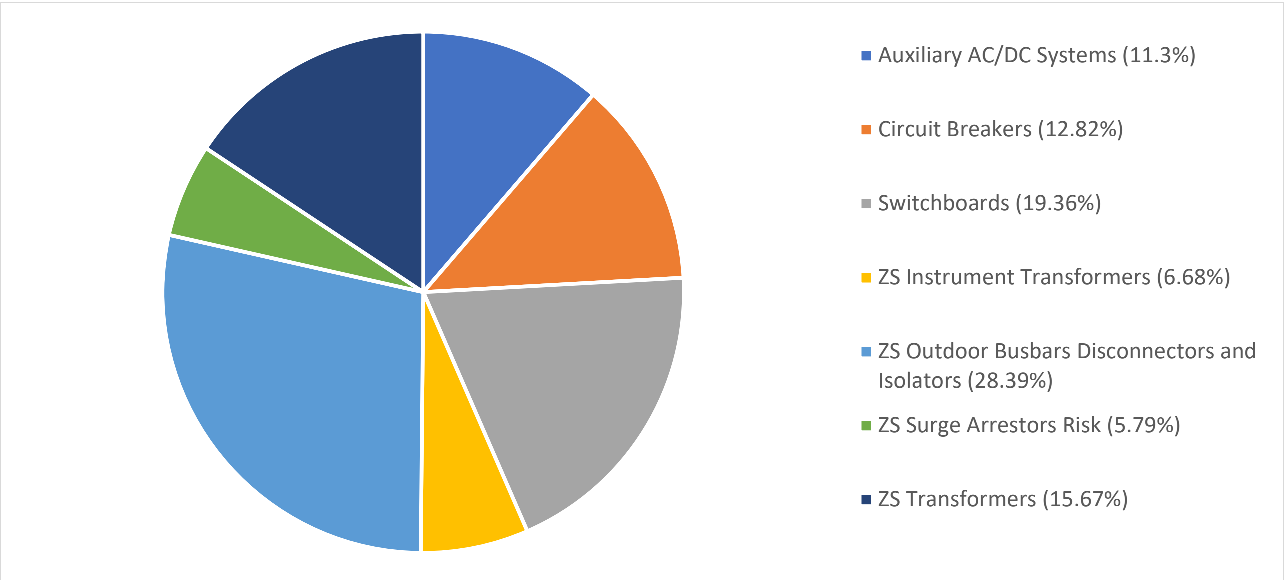

Figure 14 – Baseline risk by ZS asset class (summated 2024-29)

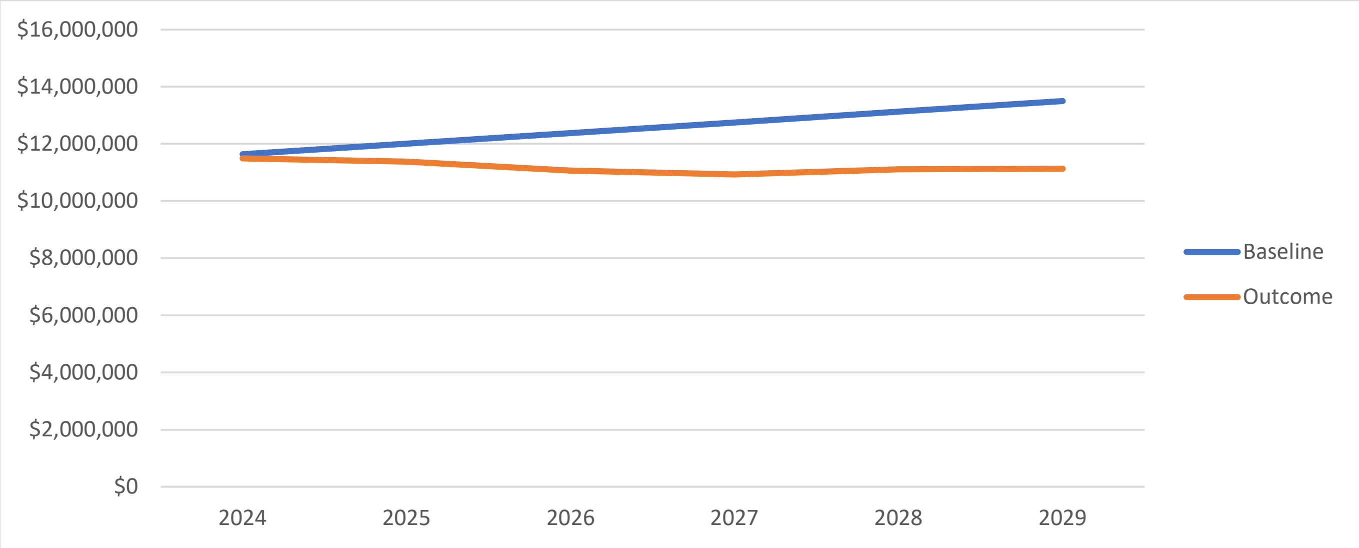

Figure 15 - Outdoor busbars disconnectors and isolators optimised risk profile

5 Repex modelling

The basis of Essential Energy's repex modelling follows the AER's *Industry practice application note; Asset replacement planning (2018)*. It is predominately aged-based analysis utilising probabilistic forecasts based on historic failure and intervention rates. EAC and NPV are then used to optimise the portfolio against the customer and business derived constraints (or objectives).

The repex forecast has been established using a probabilistic, risk-based approach to reflect the expectations of customers and other stakeholders. Reference document Business Rules for PoF, CoF and asset risk models (**Attachment 6.03.05)** has guided the development of the models described below.

The bottom up build of asset risk profiles has been calibrated such that assets are appropriately represented in the risks that they pose based on current and future states (refer Section 4.1.3)**.**

Figure 16 illustrates the overall process of the repex bottom-up build from the development of asset risk models to optimisation in Copperleaf.

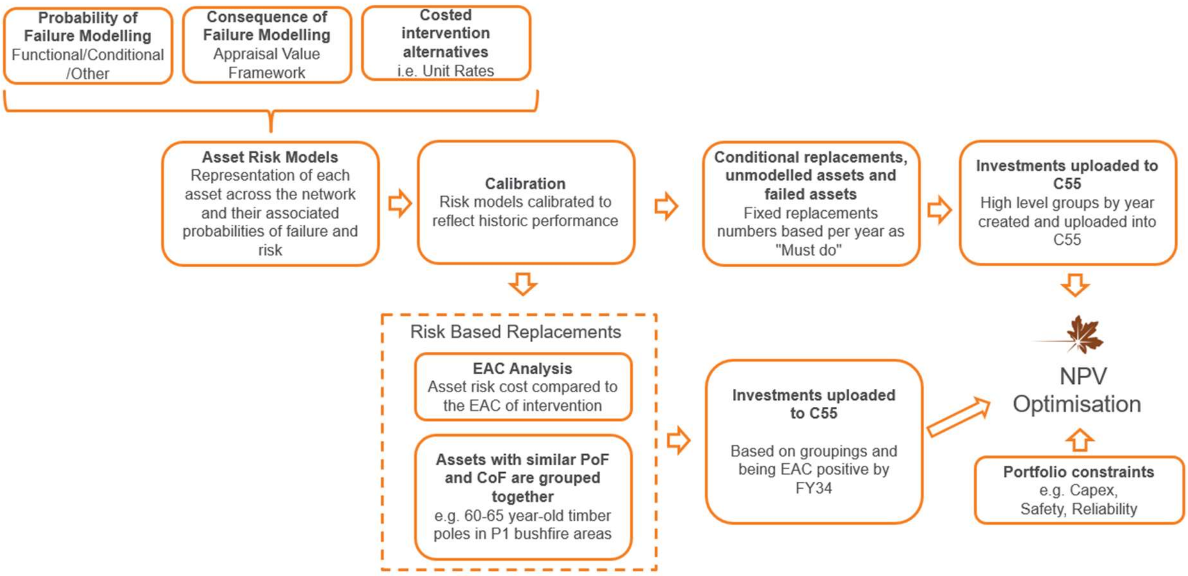

Figure 16 - Repex optimisation approach

5.1 Probability of failure models

Probability of failure (PoF) models have been developed for the majority of our assets classes and cover the predominate risks of our network (refer **6.03.05 Business Rules for PoF, CoF and asset risk models**). PoF models were developed by subject matter experts (SMEs) utilising historic asset performance and are considered accurate for population level analysis. These models are an age-based probabilistic method predominately utilising Weibull functions. Dependant on the type of asset being modelled and methods of intervention, failure functions are a combination of *functional* failure or *conditional* failure. Details of the PoF for each asset class are provided in the respective investment cases (**Attachments 10.02.01 to 10.02.23**).

Conditional failure – probabilistic forecasts reflect asset interventions whereby we intervene based on inspection and inspection policies. These conditional rates of replacement are a reflection on the health of the fleet of assets and inspection rate of finding defects.

Functional failure – probabilities are predictions of the number of assets that will fail that inspection programs either do not identify or do not directly result in replacements. These functional failures are used to forecast the risk profile of the business when combined with a consequence of failure (CoF).

Certain asset classes also have specific failure functions where particular types of interventions are used, e.g. pole staking. Also depending on the asset, the parameters calculated for the Weibull distributions have varying delineators which included aspects such as:

- Material type
- Geographic location

A top-down calibration for PoF models was intrinsic to model development as they utilised actual replacement data from recent years and are consistent with current replacement rates.

The Weibull parameters developed predominately use a conditional distribution function which considers the probability of survival of the asset as part of the calculation of PoF. Overhead conductors are an exception as it utilises a hazard rate function to forecast PoF. Typically, a conductor failure is repaired immediately after a fault, and consideration is only given later for replacement of the asset.

5.2 Consequences of failure models

It is important to understand the consequence of asset failure to equate the level of risk posed by that asset in the event that it functionally fails. Essential Energy's Appraisal Value Framework (**Attachment 6.03.03**) has seven categories of consequence:

- Network (reliability)
- Safety
- Bushfire
- Financial
- Reputational (zero for repex)
- Environment (non-bushfire)
- Compliance (zero for repex)

In development of CoF models, Essential Energy utilised various means and data sources to calculate likelihoods of each consequence and their severity, these included:

- Totalsafe data
- Reliability database
- Failure database
- SME knowledge
- Fire starts register

Based on the above datasets and information, consequence trees were developed to understand the cascading probabilities of events occurring (likelihood of consequence). Similar to PoF, CoF models also have differentiators within asset classes that are used to build up these event trees. These differentiators include aspects such as:

- Numbers of customers served by the asset (network impact)
- The type of land the asset is located on (safety impact)
- The type of asset and it's failure modes e.g. explosive

A top-down challenge of these models was undertaken as some parameters utilised SME derived values and therefore had the potential to overstate or understate certain risk levels, particularly when combined with PoF modelling. The calibrated CoF was then combined with PoF to give a risk value applied to each asset modelled.

5.3 Calibration approach

A critical part of the model development process is calibration, refer Network Risk Calibration Approach **(Attachment 6.03.06)**. This provides confidence that the aggregate model outputs provide a credible and realistic representation of total network risk (resulting from modelled assets/failures), which then supports their use in decision making.

There are two components to model calibration:

- PoF model calibration
- Overall risk model calibration

PoF models are calibrated during their development, wherein the volume of functional failures predicted by individual models are calibrated to historical failure data. The approach to calibration of the risk models then seeks to align the overall model outputs with averaged, monetised performance data from recent years. This assumes that recent performance is a reasonable representation of the risk exposure over the reference period.

Risk models are calibrated at the level of asset class and value measure. For example, bushfire performance/risk for poles, reliability performance/risk for overhead conductors, etc. Top-down calibration targets are derived from data where possible, or from structured SME elicitation where data is not available or is not of sufficient quality. Datasets used for calibration are as large as possible, while maintaining data quality and relevance to current day asset management practices.

Risk models are 'tuned' as much as possible to align with calibration targets, using reasonable adjustments to defined variables. Remaining gaps to the calibration targets are then addressed using scaling factors, which effectively overcome:

- unmodelled factors
- modelling simplifications
- data issues, and
- system effects, such as interdependencies between failure modes, that cannot be accurately addressed through a suite of independent models.

Models are also subject to validation, either through:

- Risk maps (to sense-check geo-spatial risk distribution predicted by models), or
- Spot checks (to sense-check risk calculations for a sample of assets).

5.4 Assets without risk models

A small number of asset classes with lower expenditure levels have not had risk models developed, predominately due to lack of a PoF model. As the PoF models are derived from asset failures these smaller asset classes generally do not have a large enough dataset to calculate failure characteristics. Where feasible industry PoF models such as the Office of Gas and Electricity Markets (OFGEM) from Great Britain have been utilised and scaled to current performance, however, this was limited to assets such as underground cables.

The approach for other assets such as ZS buildings and property has been a mixture of linear extrapolation of expenditure and age-based trigger replacements. The method utilised to ascertain each of these forecasts can be found within the relevant investment case.

6 Augex and export services modelling

The Essential Energy augex program consists of several investments relating to management of network performance within defined standard limits. A summary of the key augex programs and the desired outcomes are provided in the table below. Further details on each of these programs can be found in their respective investment cases (**Attachments 10.03.01 to 10.03.16 and 10.05**).

Table 4 – Augex/export services outcomes

Augex Program	Program Outcomes
Thermal constraint management	Maintain level of monetised risk relating to thermal constraints
Reliability compliance management	Maintain level of compliance to IPART Reliability Standards over regulatory period
Power quality	Management of power quality complaints relating to demand
Distribution fault level protection	Provide back-up protection as per Protection Guidelines CEOP8002.02 (Reference 10.01.05.17)
Major and minor growth	Maintain voltage levels within acceptable range following load growth
Metering services	Compliant master-subtractive metering services
Export services	Management of power quality complaints related to CER and limiting curtailment of CER exports

6.1 Network modelling and hosting capacity

To support our identification of network constraints as they relate to augex we undertook a modelling process to stress test our network models with projections of load and generation growth occurring each year until 2037 (refer Hosting Capacity Study **Attachment 7.01.01**). This modelling considered a number of global influencing factors as shown in Figure 17 below including various technology uptake forecasts.

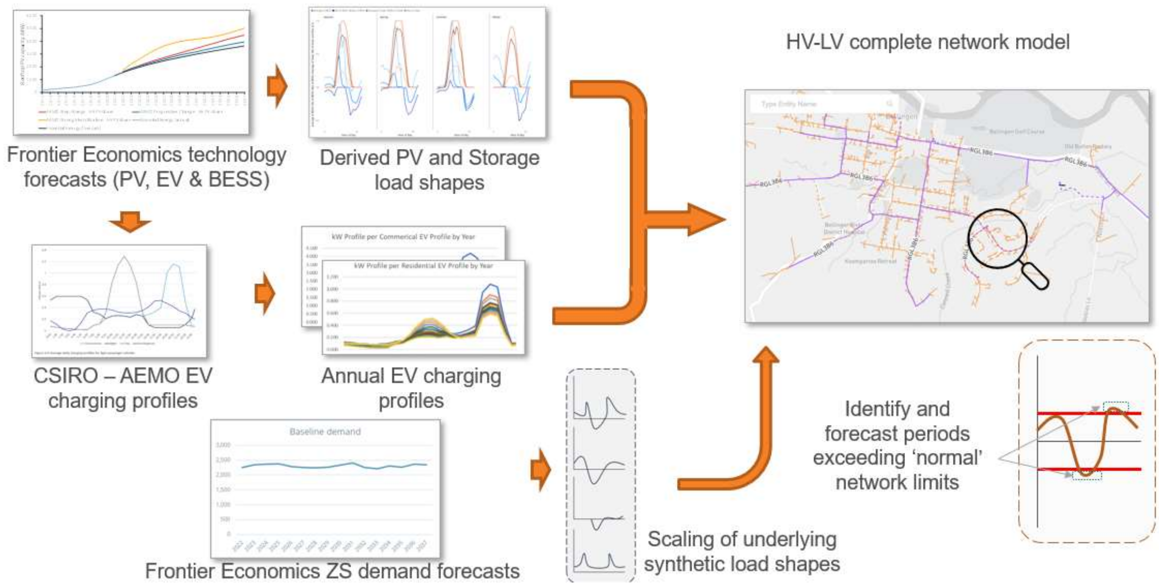

Figure 17 - Hosting capacity model

Through this modelling we looked at voltage and thermal constraints that would occur on the network and how to best alleviate these issues. We performed cost benefit analysis on varying remedial options including:

- Traditional augex (reconductoring, transformer upgrades, additional transformers)
- Voltage management schemes
- Tariffs
- Equipment selection (on-load tap-changing transformers)
- New solutions (batteries)

Details relating to the cost benefit analysis for voltage constraints are detailed in Future Network Business Case Overview (FNBC) (**Attachment 10.05)**.

In conjunction with the FNBC, analysis was completed of thermal constraints on the network using a common network model to ensure we did not double count on these interventions. The relationship between the network modelling approach and development of forecasts for traditional load driven augex and voltage/CER driven augex is provided in the Figure 18.

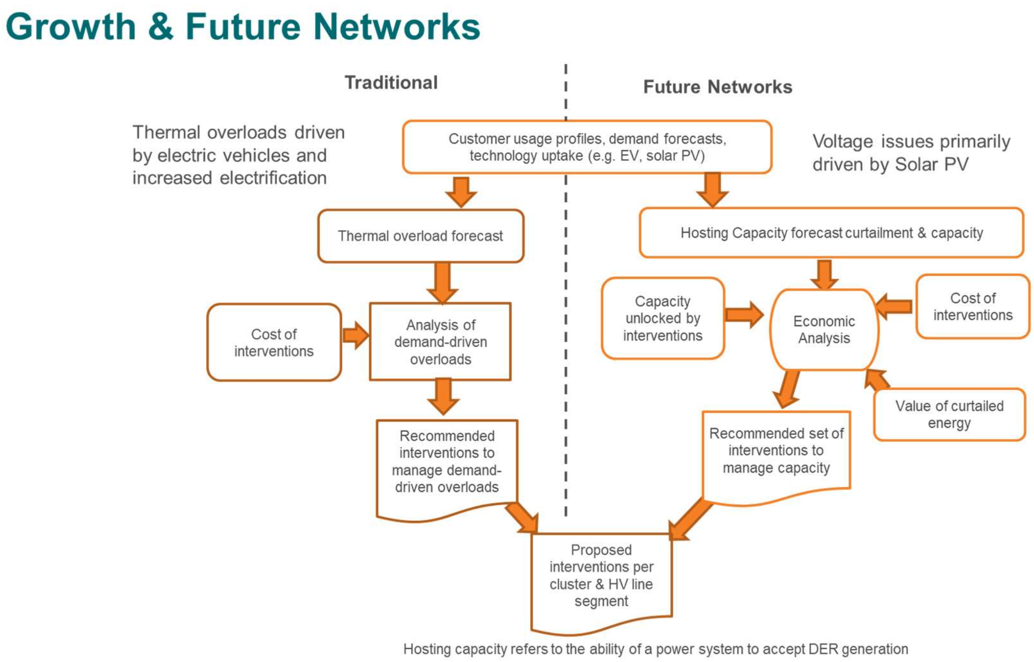

Figure 18 - Differentiation between FNBC and traditional augex

Using the outputs of the model shown above we selected a representative subset of 97 feeders based on length, customer numbers and geographical location to forecast and value our thermally constrained portions of the network. This subset of feeders was selected due to the size of the datasets required to create hourly forecasts for each network component and thus too intensive for the purposes of population-based forecasting.

Further details on the thermally constrained network expenditure can be found in Augex Capacity and Thermal Investment Case (**Attachment 10.03.05**). The risk value outcome of managing thermal constraints is shown in Figure 19, with the “average’ risk value outcome for 24-29 in line with historic levels.

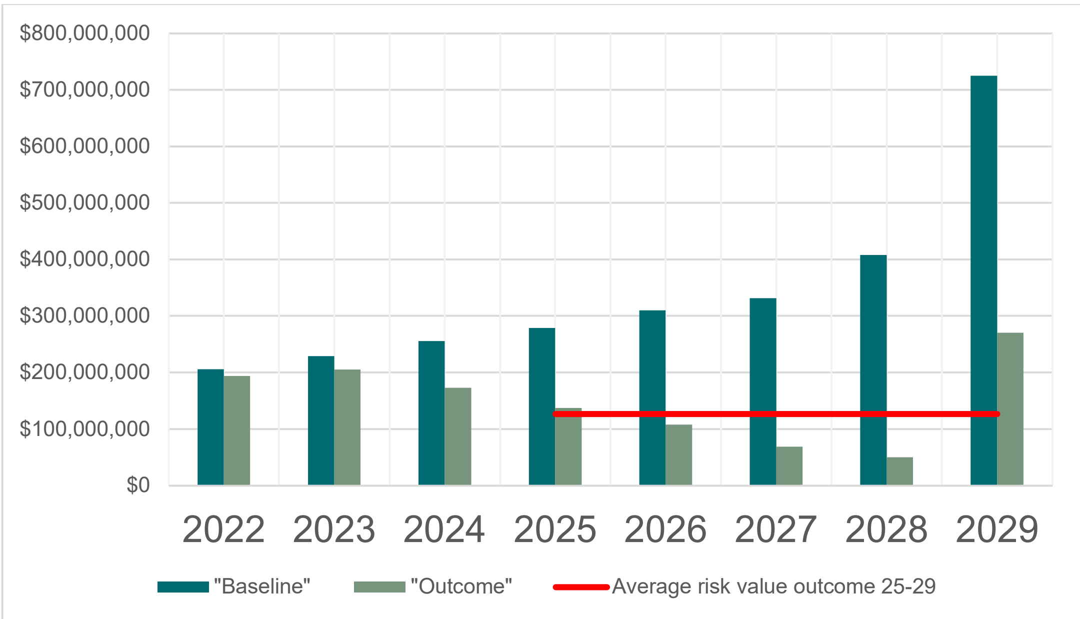

Figure 19 – Thermal constraint risk value outcome

The network interventions for each constraint type utilised the same Appraisal Value Framework (**Attachment 6.03.03**) as utilised for repex decision making to ensure a consistent approach. The FNBC utilised the Value Framework in addition to the proposed customer export curtailment value (CECV) benefits which are not currently covered in Essential Energy's Value Framework. Essential Energy is currently in the process of including CECV in the Value Framework.

6.2 Reliability program

We engaged with customers on their perception of network reliability, and customers indicated that overall, they were satisfied with current levels of reliability. This is reflected in our SAMP (**Attachment 10.01**) with asset management objectives to maintain SAIDI, SAIFI and CAIDI for each feeder type. While on average our network performance was considered reliable, there is an understanding that some sections of the network have much poorer reliability.

The licence conditions set by the NSW government requires us to maintain network reliability according to individual feeder standards. The government is proposing draft changes, which we expect would decrease the level of investment required to meet the standards. The Proposal for 2024-29 regulatory period assumes that these changes to the license conditions are formalised prior to the start of the regulatory period. Based on the updated licence conditions, we expect to identify 64 poor performing feeders per annum.

The approach we use to identify and track the worst-performing feeder segments was developed by the Energy Networks Association following the AEMC's 2014 Review of Distribution Reliability Measures. We produce quarterly feeder segment performance reports and analyse the affected equipment and parts of the networks and the causes. Causal analysis differentiates between feeder segments with an underlying issue, those with poor performance caused by non-recurrent events such as the environment, and those that only require operational actions to restore performance. Feeder segments that are being addressed under the Individual Feeder Standards are excluded from consideration.

The Augex Reliability Investment Case (**Attachment 10.03.02)** addresses both programs:

- **Poor performing feeders (PPFs**) - under our licence obligations, we are required to investigate operational, non-network and network capital solutions to certain feeders which breach the Individual Feeder Standards. As feeders can have thousands of customers over long distances, there can still be dramatic differences in reliability between the average and the worst served.
- **Worst performing segments** - this program was established to improve reliability for segments where reliability performance was sustained at 1.5x the network average SAIDI or SAIFI for that feeder category for three consecutive years.

7 Network connections

We have a steadily growing number of customers on our network. To forecast the impact of connections we have broken down our investment into major and minor investment. Updates to the application to the Connection Policy CEOP2513.06 (**Attachment 10.04**) will allow Essential Energy to fund augmentation of the shared network where it is efficient to do so, such as multiple connection proposals in the same vicinity.

We also have an increasing number of connections that fall under the classification, NER Chapter 5A - generator < 5 MW each year.

The approach has been a trend-based forecast based on past connections applications, as well as a step increase for funding projects where it is efficient for Essential Energy to enable multiple customers to connect to the network (refer **Attachment 10.04.02 - Connections Investment Case**).

The Frontier Economics provided customer number, energy consumption and demand forecasts (**Attachment 11.01**) shows the growth in invoiced energy consumption for the next fifteen years in Figure 20. While not proportional to new connections, we foresee that new or upgraded connections will be required to facilitate changing energy use, such as electric vehicle charging stations.

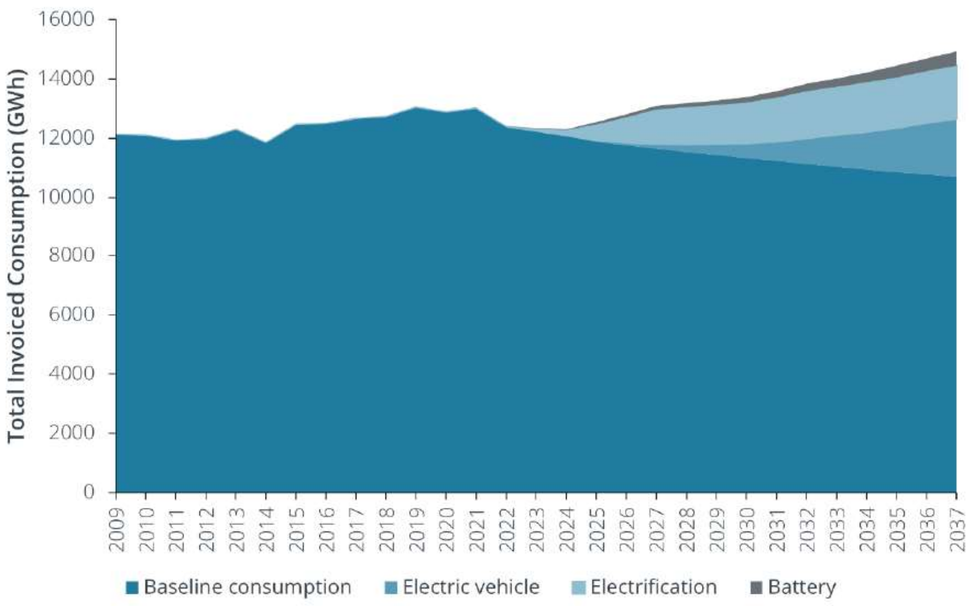

Figure 20 – Invoiced consumption - underlying demand and new technologies

8 Resilience

Essential Energy's network is predominately an overhead network with 80% of our 183,099km of lines located in designated bushfire zones. Due to the varying environments that Essential Energy's network spans, there is an innate susceptibility to natural perils and environmental impacts on the network. In response to this trend, Essential Energy has prepared a **Resilience Plan** (**Attachment 6.02**) to guide investments decision making. Over this current regulatory period, Essential Energy's network and customers have experienced significant impacts of weather events. This has resulted in network damage and widespread outages and although reported reliability SAIDI levels have remained stable over recent history the customer lived experienced has shown an increasing number of major event days (MEDs) as discussed further in the Resilience Plan.

To better understand the impact and probability of these events into the future, Essential Energy engaged KPMG to analyse climactic models and apply these to the network footprint (**Attachment 6.01 - Climate Impact Assessment**). This analysis forecast the impact of the following natural perils:

- Bushfire
- Flood
- Windstorm

This yielded both direct (asset failures) and indirect impacts (customer outage) to Essential Energy and its customer base. These were modelled at specific years i.e. 2022 (base), 2050, 2070 and 2090 over a variety of climate scenarios being; RCP4.5 and RCP8.5. For resilience-based programs the direct impacts were utilised.

8.1 Climate impact assessment

As discussed above several scenarios were modelled for the impact of climate change on Essential Energy's assets. Essential Energy has elected to conservatively utilise RCP4.5 as the basis of modelling derived from the climate impact study. The direct impact (asset failures) was broken down into specific asset failure categories (i.e. poles, conductor) to provide granularity in assessing individual asset class impacts.

At this stage, climate impact modelling has only been utilised in the analysis of PoF in specific business cases addressing resilience and has not been utilised in 'underlying' repex. These business cases include:

- Composite poles transition (**Attachment 10.02.24**)

- Risk based pole replacement (**Attachment 10.06.01**)
- Undergrounding High Risk Locations (**Attachment 10.06.02**)
- Microgrids – qualitative only (**Attachment 10.6.05** to **10.06.10**)

Using risk-based pole replacements as an example of the application of climate change modelling, PoF were modified to represent the increasing risk of asset failure. To achieve this, historic failures attributed to the perils modelled were removed from analysis for the pole functional failure PoF Weibull parameter calculations. Then an increasing/decreasing linear risk of failure was reintroduced in addition to the aged based PoF of the asset. This increasing risk was completed to a depot level of granularity as shown in Figure 21.

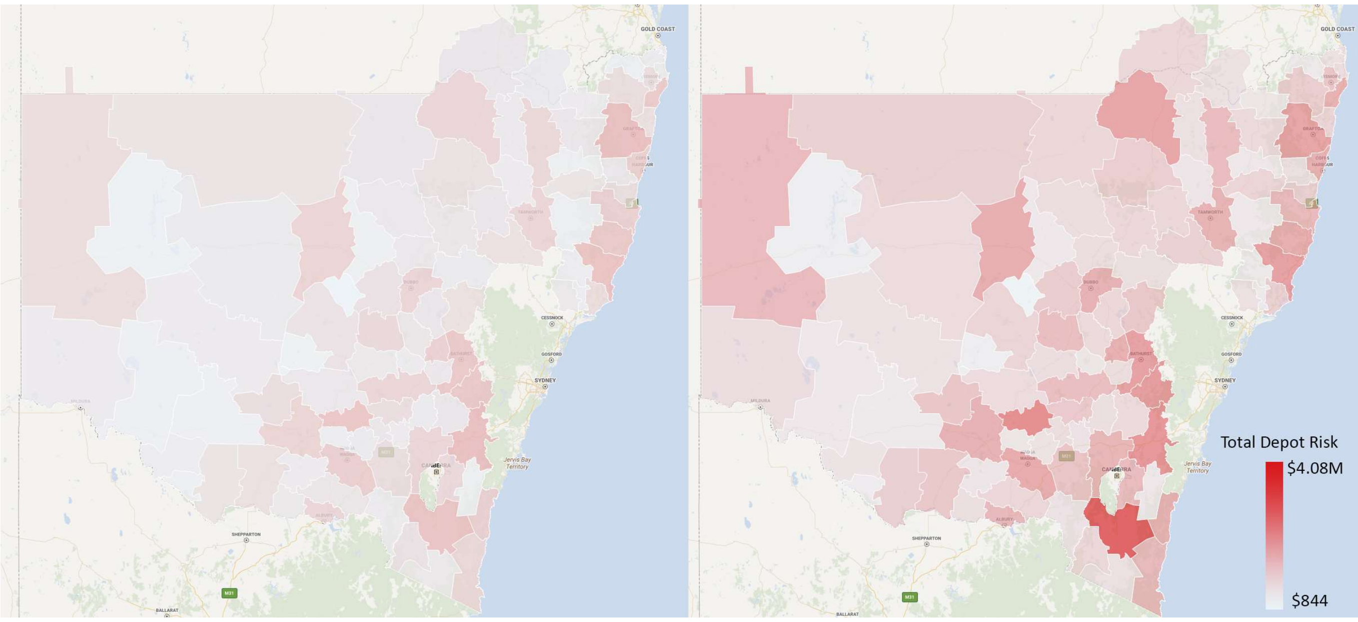

Figure 21 - Comparing risk at 2022 (left) and 2050 (right) Inclusive of climate change impact

9 Challenging the Proposal

9.1 Prioritising assets – EAC positive

The initial step of prioritising assets to be optimised is the first point of challenge in the Repex portfolio. In the bottom-up build, Essential Energy established risk profiles for all major assets of which only a smaller subset of assets were considered for optimisation within the portfolio. To achieve this prioritised list of assets, Essential Energy utilised an EAC hurdle calculation whereby the risk of the existing asset is compared with the annualised replacement cost of a new asset, a representation of which is shown in Figure 22.

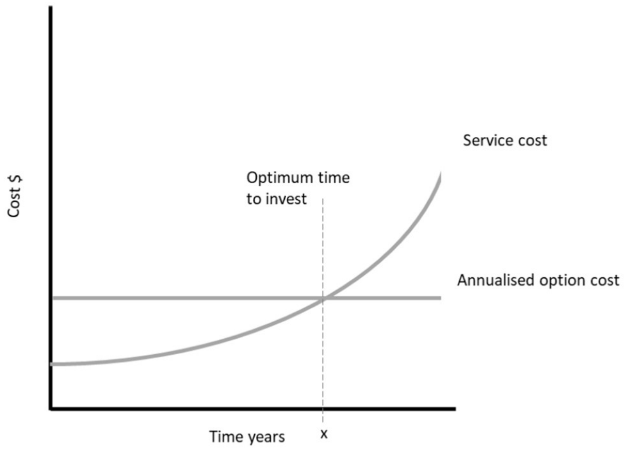

Figure 22 - EAC representation[1]

[1] Source: "Industry practice application note; Asset replacement planning" – AER 2018

The maximum hurdle timeframe was elected as FY34 which allows for increased flexibility in optimisation and to have an interim understanding of potential profiles into the following regulatory period. This generally yielded a high number of front-end assets that are “EAC positive” assets followed by a consistent annual level of assets (refer two graphs below).

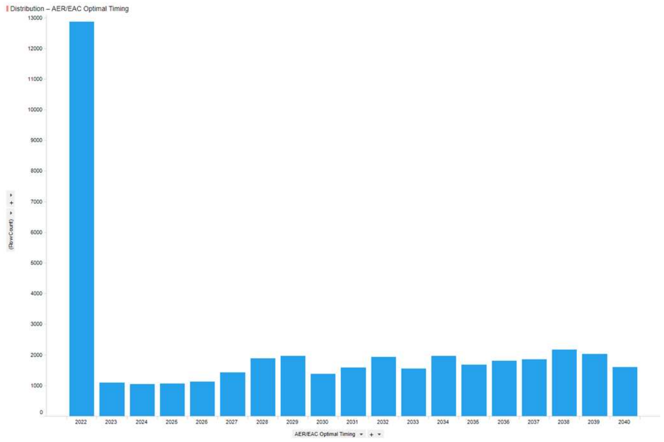

Figure 23 - Poles EAC hurdle by year

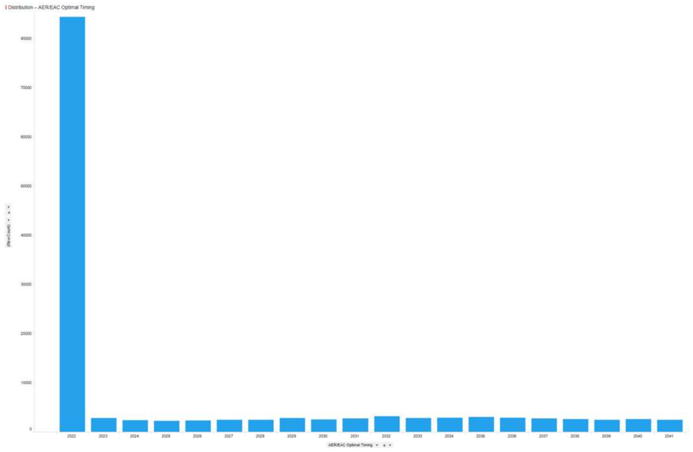

Figure 24 - Pole top equipment EAC hurdle by year

These assets were then aggregated into investments and optimised within the portfolio utilising NPV calculations.

9.2 Sensitivity analysis

As previously discussed within this document, we preformed several portfolio optimisation scenarios in the process of defining the final proposed investment portfolio. These scenarios included variations of risk-based constraints such as reliability risk outcomes, bushfire risk outcomes and safety risk outcomes.

Several capital constraint scenarios were also performed to derive a “value curve” for the portfolio as shown below in Figure 25.

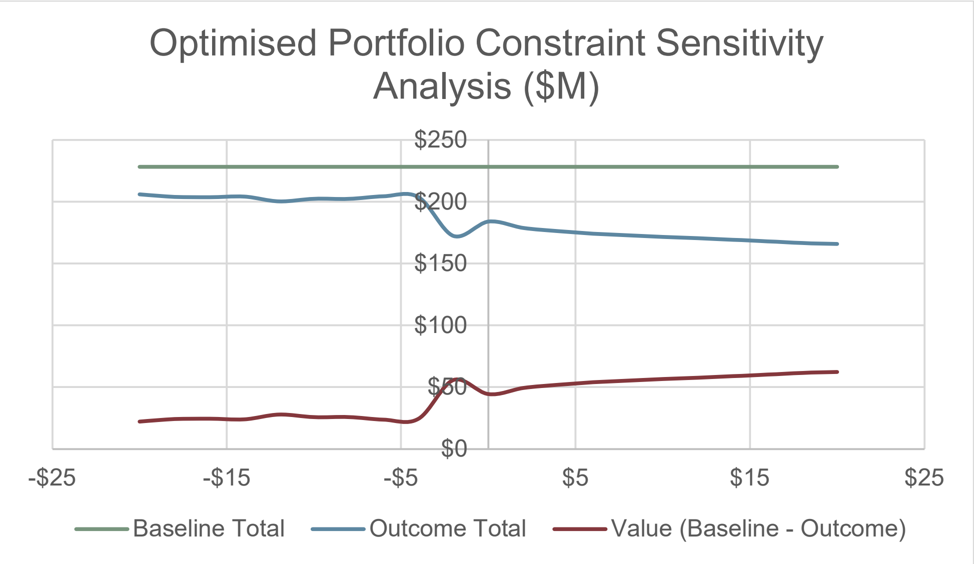

Figure 25 – Capital constraint sensitivity analysis

As shown in Figure 25 the value delivered by the portfolio shows a step change when varying the constraint, in particular between the $0 to -$5M region. At this point it can be seen that the total value delivered by the portfolio drops significantly at approximately -$2M, with value relatively stable with capital constraints varied greater than $0, i.e. increasing up to $25M above the final portfolio amount.

Value continues to increase as the capital constraint allows more expenditure, however the objectives defined with our customers can be achieved at the final portfolio total cost. This sensitivity test provides assurance that the final portfolio sufficiently balances meeting the objectives of the portfolio whilst delivering optimal value through the investments.

9.3 AER repex model

The AER's repex model has been developed to understand the capital required for non-demand-driven replacement of an asset with its modern-equivalent, where the timing of the need can be directly or implicitly linked to the age of the asset. This model utilises three years of Regulatory Information Notice (RIN) data that DNSPs such as Essential Energy provide annually. The repex model allows comparison across DNSP's through various modelling scenarios inclusive of:

- Historic
- Lives
- Cost
- Combined

At an individual asset level, Essential Energy uses asset condition assessments to inform its investment decisions. In practice, condition data is often available only for near-term investments (less than three years). Therefore, at a population level for extended forecasting where condition is not available, age is used as a proxy for condition and health.

Essential Energy has adopted a value-based decision-making framework. This means maintaining previous replacement rates and replacement age, such as the repex model, may not necessarily be the optimal decision for meeting objectives and delivering value to customers.

In summarising, Essential Energy's proposed expenditure by asset class utilising value-based decision making is directly compared to the repex model. To achieve this, many of the repex model categories have been split into the asset systems of underground, overhead and zone substations. Not all assets are assessable utilising the repex model (i.e. pole top equipment), this is due to:

- Data availability across DNSPs
- Suitability an age-based assessment
- Inconsistent reporting for asset classes across DNSPs

Despite the repex model not representing all asset classes, we have included the additional assets in the Historical Scenario in Figure 26 as this is the only scenario where non-standard assets may be included.

As requested by the AER through early signal pathways, Essential Energy removed expenditure related to the 2019/20 bushfires and recent flooding events. Also, as requested Essential Energy reduced the window of utilised RIN data from five years to three years for model calibration.

Essential Energy has scrutinised the proposed expenditure and has proposed a level of replacement expenditure which is broadly in line with this recommendation. The graphs below compare the three-year total expenditure contained in the Proposal to the bottom-up build, as well as various outcomes of the repex model. Note we have also shown our proposal with and without resilience repex spend below.

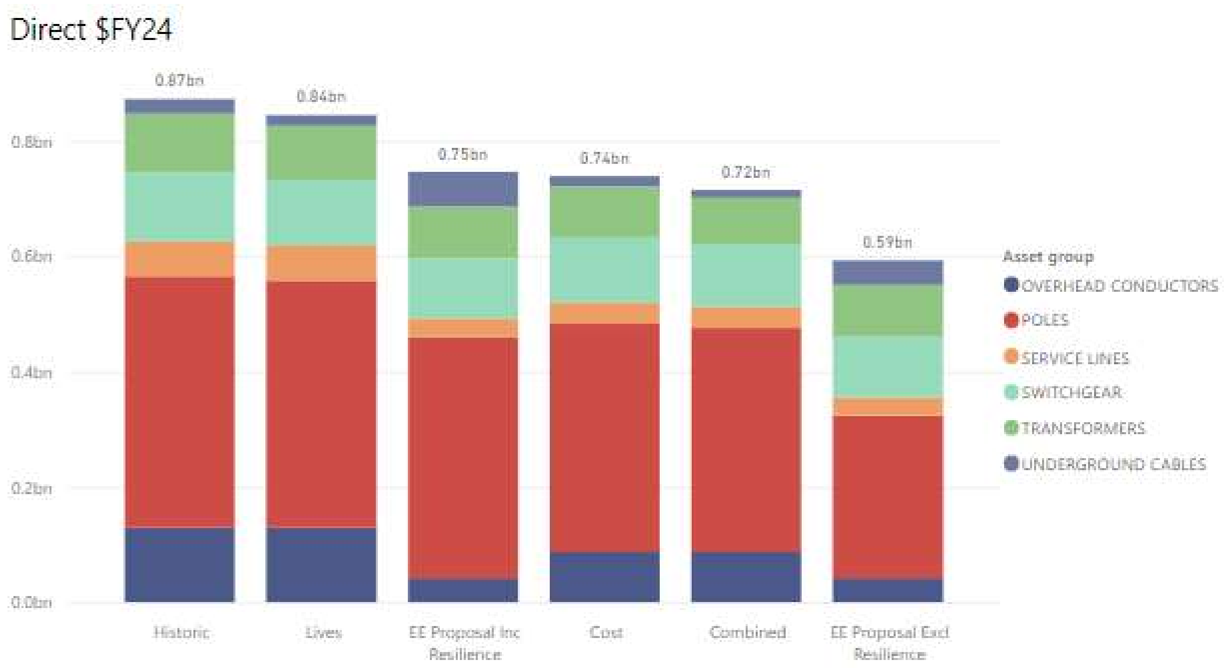

Figure 27 - Standard repex model categories by asset group

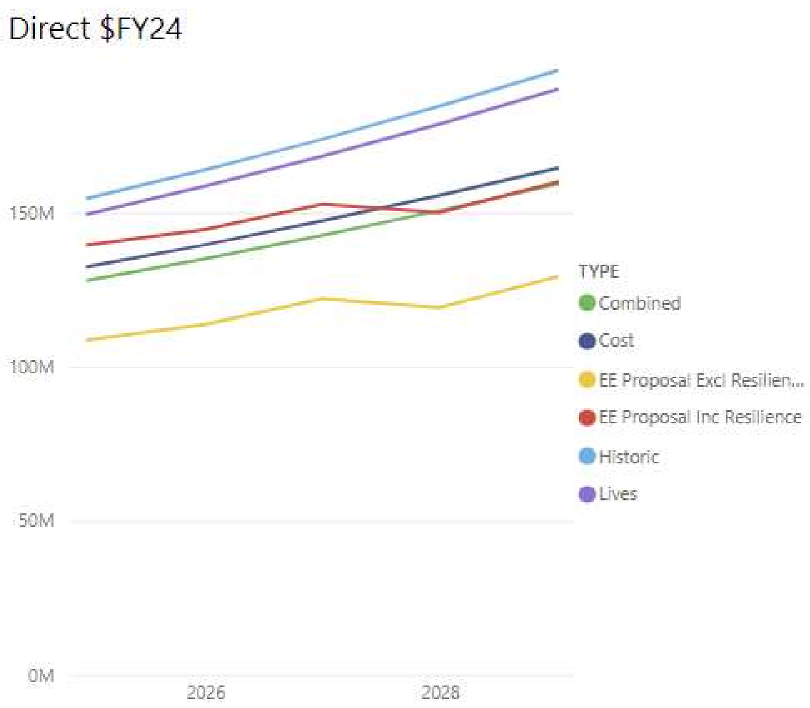

Figure 28 - Standard repex model categories

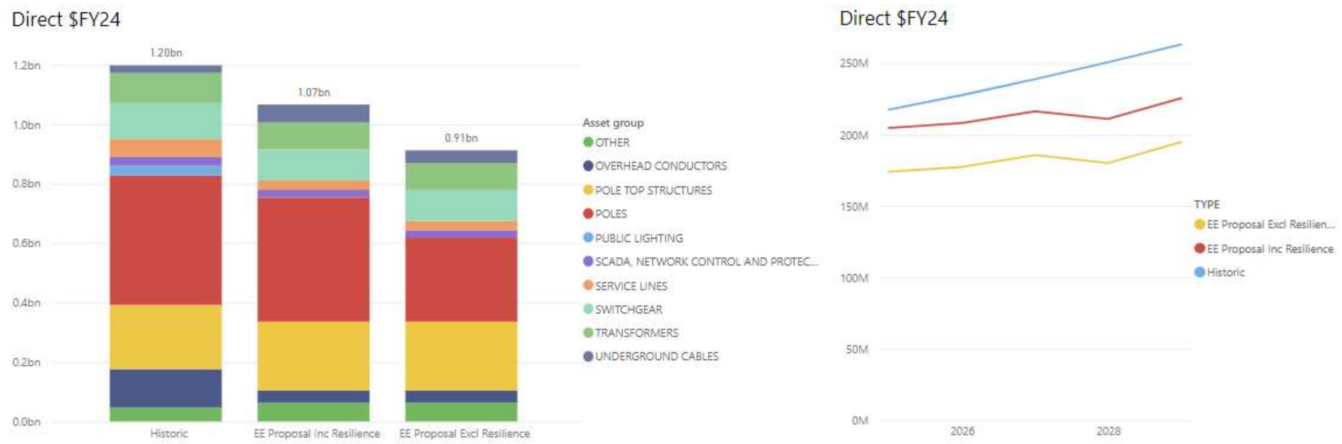

Figure 29 - Non-standard repex model categories

9.4 Customer challenge

As shown in Figure 2, customers have been engaged in reviewing the capex options on multiple occasions throughout the development of this Proposal. **Attachment 4.02 – How engagement informed our Proposal** also offers insight into the customer feedback and challenges.

9.5 Capex/capex challenge

The relationships between several capex programs have been considered in the development of the investment portfolio to ensure the trade-off between programs have been captured and are not double counted.

The repex portfolio described earlier in this document includes capex/capex trade-offs by way of the optimisation process which ensures only the investments required to meet the defined portfolio objectives are selected for inclusion in the final portfolio.

The augex portfolio considers the relationship between the FNBC and related investments including:

- Power quality is demand driven only, reactive CER related voltage management addressed by interventions included within the FNBC
- Thermal constraint management.

In the development of property investments such as substation buildings and property (**Attachment 10.02.23**), ensuring the non-system property elements are not double counted.

For details of these trade-offs refer the respective investment cases.

References

Doc No.	Document Name	Relevance
1	4.02 How engagement informed our Proposal	Reference material, justification
2	6.01 Climate impact assessment	Reference material, justification
3	6.02 Resilience plan	Reference material
4	6.03.01 Corporate risk management procedure	Reference material
5	6.03.02 Network risk management manual	Reference material
6	6.03.03 Appraisal value framework	Risk valuation
7	6.03.05 Business rules for PoF, CoF and asset risk models	Reference material
8	6.03.06 Network risk calibration approach	Reference material
9	6.03.03.03 to 6.03.03.15 CoF methodologies by asset class	Reference material
10	6.03.03.16 to 6.03.03.28 PoF methodologies by asset class	Reference material
11	6.03.03.01, 6.03.03.02, 6.03.03.29 to 6.03.03.39 Risk model summaries by asset class	Reference material
12	6.04.01 Bushfire prevention strategy	Reference material
13	10.01.05.17 Distribution protection guidelines	Reference material
14	10.05 Future network business case overview	Reference material

Appendix A – Standard control system expenditure

All figures are provided in **direct Real $FY24**.

1. Repex

Investment Name	FY25	FY26	FY27	FY28	FY29	Total
Auxiliary AC/DC Systems	$2,847,859	$441,082	$770,546	$170,085	$1,180,326	$5,409,898
Circuit Breakers	$2,908,892	$5,011,423	$4,524,824	$4,137,685	$4,964,366	$11,558,569
Distribution Power Transformers	$8,706,262	$11,662,345	$14,752,204	$11,241,215	$16,398,494	$62,760,520
Electrical Network Telecommunication System	$3,301,535	$3,301,535	$3,301,535	$3,301,535	$3,301,535	$16,507,676
HV Ring Main Units	$7,467,205	$7,938,053	$7,938,053	$8,068,529	$8,291,473	$39,703,314
Instrument Transformers	$2,875,782	$3,811,070	$3,407,211	$1,358,155	$5,271,087	$16,723,305
Load Control	$4,464,447	$4,464,447	$4,464,447	$4,464,447	$4,464,447	$22,322,235
Overhead Conductors	$8,528,818	$8,549,012	$8,818,286	$8,590,267	$8,574,686	$43,061,069
Overhead Customer Service Connections	$6,255,455	$6,348,497	$6,436,726	$6,519,341	$6,595,539	$32,155,557
Overhead Links, Switches and Fuses	$4,102,955	$4,267,073	$4,252,153	$4,273,918	$4,324,661	$21,220,760
Pole Top Equipment	$46,487,760	$46,323,776	$46,484,262	$46,330,297	$46,165,210	$231,791,306
Poles	$77,291,104	$78,223,918	$84,376,386	$87,817,027	$90,542,473	$418,250,907
Protection & Control Systems	$3,177,017	$3,229,726	$3,101,392	$3,229,726	$3,219,031	$15,956,893
Reactive Plant	$716,529	$1,465,141	$716,529		$1,208,474	$4,106,671
SAPS	$5,069,134	$8,311,656	$9,727,111	$14,001,271	$15,095,356	$52,204,528
Substation Buildings and Property	$2,101,870	$2,115,484	$2,129,099	$2,142,713	$2,156,328	$10,645,494
Surge Arrestors	$113,455	$113,455	$115,553	$117,651	$113,455	$573,569
Switchboards	$3,916,738	$2,797,670	$1,678,602	$1,119,068	$1,678,602	$11,190,679
Underground Cables	$9,860,399	$10,119,697	$10,378,994	$10,638,292	$10,897,589	$51,894,972
Underground Pits, Pillars & Cubicles	$1,769,729	$1,769,729	$1,769,729	$1,769,729	$1,769,729	$8,848,647
Voltage Regulators and Voltage Regulating Relays	$579,869	$598,214	$534,272	$608,972	$585,431	$2,906,757
ZS Outdoor Busbar, Isolators and Disconnectors	$2,166,329	$2,622,349	$2,583,415	$1,019,984	$1,847,162	$10,239,238
ZS Transformers	$6,378,174	$5,462,728	$5,621,006	$5,419,951	$5,663,784	$28,545,643

2. Augex

Investment Name	FY25	FY26	FY27	FY28	FY29	Total
Growth Major Works	$3,386,610	$3,641,880	$3,386,610	$3,840,430	$4,294,240	$18,549,770
Growth Minor Works	$12,580,040	$12,580,040	$10,742,080	$14,109,110	$14,109,110	$64,120,380
Other Augex (incl Reliability)	$4,193,620	$4,193,620	$4,193,620	$4,193,620	$4,193,620	$20,968,100
Resilience	$7,897,890	$6,763,350	$9,361,290	$5,776,770	$8,045,860	$37,845,160
Master Subtractive Metering	$1,259,550	$1,259,550	$1,259,550	$1,259,550	$1,259,550	$6,297,750

3. Connections

Investment Name	FY25	FY26	FY27	FY28	FY29	Total
Connections	$13,387,600	$13,387,600	$13,387,600	$13,387,600	$13,387,600	$66,938,000

4. Export services

Investment Name	FY25	FY26	FY27	FY28	FY29	Total
Export Services – Future Networks	$10,855,700	$10,855,700	$10,855,700	$10,855,700	$10,855,700	$54,278,500