Long Term Planning Into Uncertain Future: Forming Investment Plan For Emerging Network Needs

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1 Abstract

Both nationally and regionally, the push for sustainable low-carbon alternatives is increasing as we shift towards a low-carbon economy. This has led to a rapid increase in the uptake of renewable energy technologies and electrification across the country. Furthermore, the resilience risk associated with the changing climate has compelled Electricity Distribution Businesses (EDBs) to reassess the vulnerability and exposure of their networks to hazards like storm events, flooding, fire risk, and sea level rise, explore potential options for improving resilience, and prepare their network for extreme weather events.

In addition to the risks posed by climate change and decarbonisation EDBs will need to continue to replace and renew assets considering their age, condition and effects of the environment to prioritise replacement. Horizon Networks has embarked on developing risk models that produce risk-based long-term forecasts for asset replacements, the risk models have been recently enhanced to consider the significance of Low Voltage (LV) assets to better reflect their criticality on to support the electrification of the economy and maintain reliability of supply.

This paper provides an overview of the end-to-end process adopted by Horizon Networks that is transparent, data-driven, integrated, and systematic, to form the long-term Network investment plan. This process allows Horizon Networks to optimise and adapt its investments in the face of a highly unpredictable future as we progress through the energy transition and adapt to climate change. The approach also enables us to expand and improve continuously to reflect the latest understanding of risks and input assumptions.

Firstly, we discuss key risks and constraints to be considered when developing an investment plan. Key investment drivers and forecasting are then discussed, these include asset replacement and renewal, demand growth from organic and emerging decarbonisation needs, resilience and reliability, operational expenditures and reactive work such as defects and faults.

This is followed by the risk-based prioritisation approach adopted by Horizon Networks, assessing and quantifying risks through a range of categories such as Public Safety, Reliability, Environmental, Reputation, and Cost, with constraints like the expenditure limits set in the Default Price-Quality Path (DPP), spend profile and contractor resourcing levels.

Cost estimate review is then initiated for short to medium-term complex projects to provide a good level of cost certainty for the upcoming works.

To address the uncertainty in the Commerce Commission's decision for the next DPP, a scenarios analysis was subsequently performed to understand the impact on the network risk profile and business financial impacts by applying different constraints.

The conclusions and future directions are presented at the end of the paper.

2 Introduction

Horizon Networks is a member of the Horizon Energy Group (HEG) that owns, manages, and operates the electricity network that serves the Eastern Bay of Plenty Region. Our network covers more than 8,400km2 of land area with 25,280 customers. Horizon Networks and the other subsidiaries of HEG are 100% owned by Trust Horizon, a charitable trust based in Whakatane focusing on investing in projects that bring transformational change to the Eastern Bay of Plenty.

This paper provides an overview of the end-to-end long-term Network investment planning process adopted by Horizon Networks, which is transparent, data-driven, integrated, and systematic. The outputs of the planning process are integrated into our corporate strategic financial model that allows Horizon Networks to optimise its investment plan considering multiple constraints and drivers including cash flow impact to the business and enables continuous improvement over time. The overarching methodology involves identifying investment drivers, establishing modelling for each investment driver to develop the baseline investment plan, and overall investment envelope. All the key stakeholders are involved in the planning process ensuring the most optimal plan is developed that can be delivered within the defined risk tolerance levels. In addition, some projects will require business cases to be developed to provide detailed justifications and more accurate cost estimates.

Table 1: Horizon Networks' Key Statistics

Key Statistics	Quantity
Maximum Coincident System Demand	Approximately 93MW
Number of Zone Substation	10
Overhead Circuit Length	2,005km
Underground Circuit Length	619km

3 Key Considerations for Investment Planning

The electricity sector is encountering growing uncertainties as New Zealand navigates its way through an energy transition and climate change. Horizon Networks as a non-exempt EDB that is subject to the Commerce Commission's 5-year Default Price-Quality Path regulation which sets the Maximum Allowable Revenue (MAR) and defined reliability of supply requirements that Horizon Networks must adhere to.

There are several risks and constraints Horizon Networks needs to consider and balance when developing the investment plan, these are:-

1. Capital and operational expenditure (CAPEX and OPEX) allowances
2. Reliability requirements (SAIDI/SAIFI)
3. Resourcing
4. Asset risk

5. Network growth
6. Impact of climate change
7. Supply chain costs escalations – materials, labour and traffic management
8. Business financial constraints
9. Shareholder expectations

Additionally, Horizon Networks need to manage uncertainties in government policies, consumer behaviours, electrification activities, and increasing frequency and magnitude of storm events.

4 Investment Drivers and Planning Methodology

This section describes the key areas in our spend forecasting for Network CAPEX and OPEX and the methodologies adopted for developing the baseline plan.

4.1 System Growth and Decarbonisation

The core objective of system growth planning is to ensure the following are maintained:-

- **Capacity** – Operation of the network not exceeding the thermal and fault current ratings; and
- **Security** – Maintain current network security levels.

Historically, Horizon Networks has used linear regression modelling to forecast future demand on the network based on historical growth rates and known committed step changes from third-party developers and industrial customers. This method was effective as the growth was relatively consistent with adequate capacity available across the network. However, we recognised solely relying on historical information to forecast growth is no longer adequate as the fundamental operating environment has changed with increased electrification, storage solutions and grid-connected solar PV beginning to connect to the network. We have strengthened our forecasting models to incorporate impacts from electrification activities as we transition to a low-carbon economy. Our growth planning model is illustrated in Figure 1.

In 2023, we conducted an extensive study to explore the potential pathways decarbonisation incorporates in the region and the impact on the network [1]. A bottom-up approach was taken to estimate the total aggregated demand from various decarbonisation activities including Electrical Vehicle (EV) charging, the electrification of domestic and process heat, penetration of Distributed Energy Resources (DERs), and hydrogen electrolysis plants. Additionally, we disaggregated the national-level forecasts presented in the BCG's *Future Is Electric* and Transpower's *Whakamana I Te Mauri Hiko* reports in considering plausible decarbonisation pathways for the region. This forms the basis of our substations and feeders' demand forecast[1].

Pre-Contingency and Post-Contingency modelling was performed in DIgSILENT PowerFactory. The outputs allow us to understand the network constraints. High-level option analysis to relieve the network constraints was performed before integrating into the long-term investment plan.

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[1] Further details of this analysis are explained in Horizon's EEA 2024 Conference Paper titled "Strategic Load Forecasting and Network Planning: Integrating Decarbonisation Energy Transition Trajectories" [1]

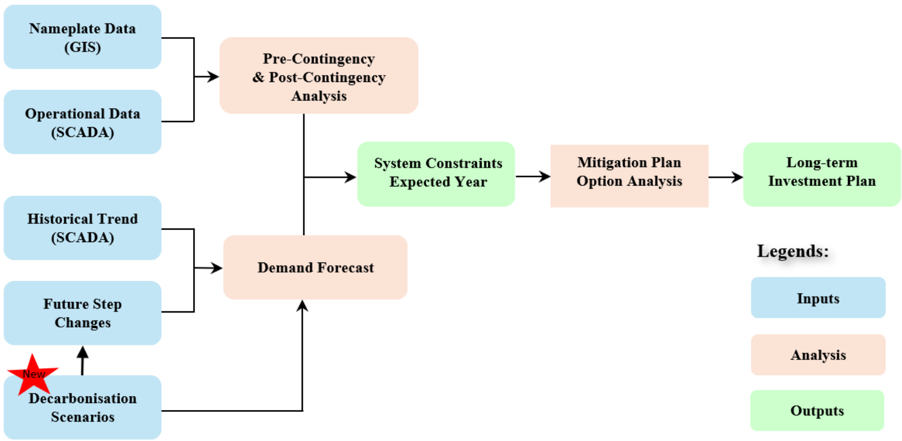

Figure 1: System Growth Planning Methodology

4.2 Risk-based Replacement and Renewal

Over the last few years, Horizon Networks has embarked on a programme to collect network asset data including asset condition. This initiative enables us to develop Asset Risk Models that provide visibility to current risk and future risk predictions. These models were developed using a combination of the UK's Distribution Network Operator (DNO) common network asset indices methodology [2], and New Zealand's EEA's Health [3] and Criticality Guides [4]. The Asset Risk Models utilise Asset Health Indices (H1-H5) and Asset Criticality Levels (C1-C5) categorising assets into five risk categories R1 to R5, with R1 representing the highest risk and R5 the lowest, as shown in Figure 2. For assets where there are no condition data, the risk is calculated using age as a proxy for health.

Our risk management strategy is to maintain the maximum asset risk with the fleet at R3 or better at the end of the 10-year planning period, this approach helps us to smooth expenditure and minimise significant variability in overall fleet risk over the long term, well beyond the planning window. Figure 3 illustrates the forecasted risk level given the planned capital investment.

Recently, the Asset Risk Model has been enhanced to include the consideration of the criticality of Low Voltage (LV) assets to better reflect their importance on public safety and electrification of domestic and small commercial loads.

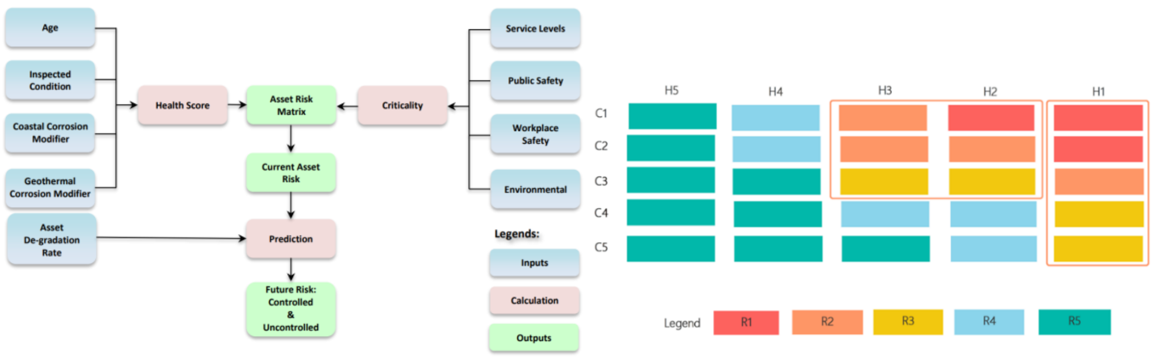

Figure 2: Horizon Networks' Asset Risk Model Overview (Left) and The Asset Risk Matrix (Right)

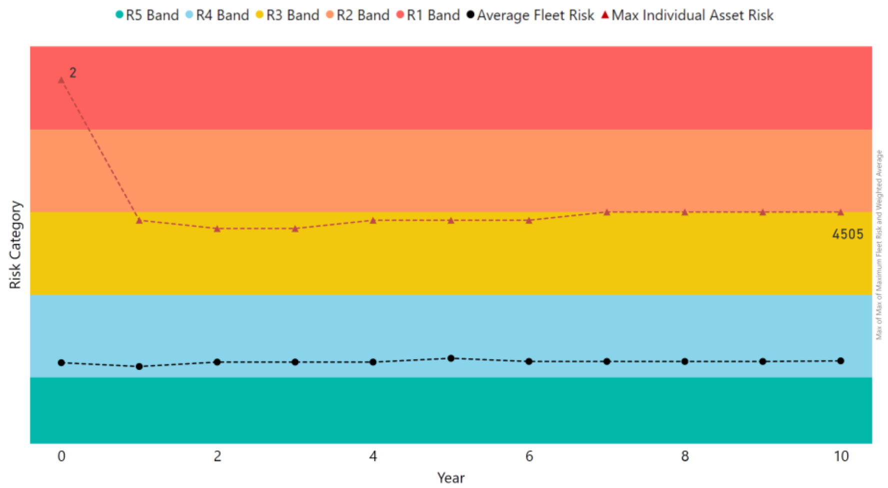

Figure 3: Example Fleet Average and Maximum Risk (Structure, ABS and Transformer)

4.3 Reliability Planning

The Commerce Commission sets quality standards through SAIDI and SAIFI performances, which drives our reliability improvement programmes.

Our reliability improvement programmes aim to improve the performance of both unplanned and planned interruptions by analysing historical fault performance to understand unplanned faults in relation to the subnetwork and leveraging insights from our field and operations teams. We develop a visualisation tool to assist planning engineers with planned project optimisation through analysing opportunities for bundling projects to minimise customer impacts.

Our significant outages review meetings and continual improvement forums offer additional channels to provide suggestions for improving reliability. The reliability improvement solutions are then further assessed using our project prioritisation framework (see Section 5), taking into account the potential SAIDI benefits across the solution's lifetime, before it is scheduled in our long-term investment plan.

4.4 Resilience Planning

Our network is primarily coastal with extensions into inland plains and mountainous areas, and is exposed to several weather and climate change hazards. In most prevailing issues that we face are:

- Coastal inundation and increased flooding affecting ground-mount assets.
- Higher-intensity storms with increased rainfall and wind gusts causing increased damage to overhead network from vegetation.
- Increased rainfall leading to land instability that affects access and damage infrastructure.
- Increased lightning activities directly damaging network equipment.

It is challenging to establish an accurate quantitative risk assessment for climate change risks to electricity networks and to do so will require significant support from climate scientists. Horizon Networks is taking a pragmatic approach that is achieved by iterating through the cycle of assess, adapt/mitigate, monitor, and report (Figure 4) to continuously update and refine our risk management and investment planning.

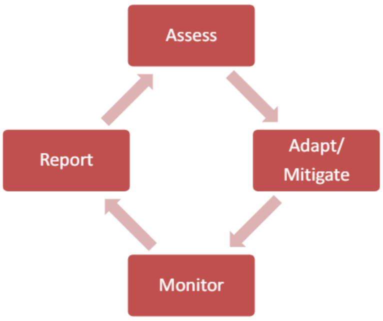

Figure 4: Climate Change Risk Management Cycle

A risk management framework was established based on *AS 5334-2013 Climate change adaptation for settlements and infrastructure — A risk based approach* [5] to assist with assessing the climate change risk. Based on the asset type and location, the vulnerability of each network asset was assessed against the relevant climate hazards (e.g. coastal inundation, erosion, flooding etc) to establish the likelihood of damage. Asset-level qualitative risk was calculated by combining the likelihood and criticality. The framework is illustrated in Figure 5 and Figure 6.

Figure 5: Risk Calculation Methodology

Risk			Criticality				
			Very low	Low	Moderate	High	Very high
			1	2	3	4	5
Combined likelihood	Very unlikely	VU	1VU	2VU	3VU	4VU	5VU
	Unlikely	UL	1UL	2UL	3UL	4UL	5UL
	Likely	L	1L	2L	3L	4L	5L
	Very likely	VL	1VL	2VL	3VL	4VL	5VL

Figure 6: Climate Change Risk Matrix

Through our partnership with NIWA, Whakatane District Council (WDC), and Bay of Plenty Regional Council (BOPRC), we obtained relevant modelling data that allowed us to understand the extent of flooding that could result from coastal inundation and fluvial flooding for a given return period in our network area. An example of the output from the collaboration with BOPRC is shown in Figure 7. Overlaying the model with our network data enabled us to establish the assets that would be at risk of flood damage and this informed our remediation plan.

The modelling work is still progressing as we are currently seeking additional regional flood depth datasets (Ohope and Ohiwa Harbour areas) that will provide us with greater insights. Due to the complexity and interconnectedness of infrastructures, we are continuously working with local and regional councils to gain the latest insight into the information that may affect our electricity network. Those include the work planned by the councils that may mitigate flooding risk to the network before we make investment decisions.

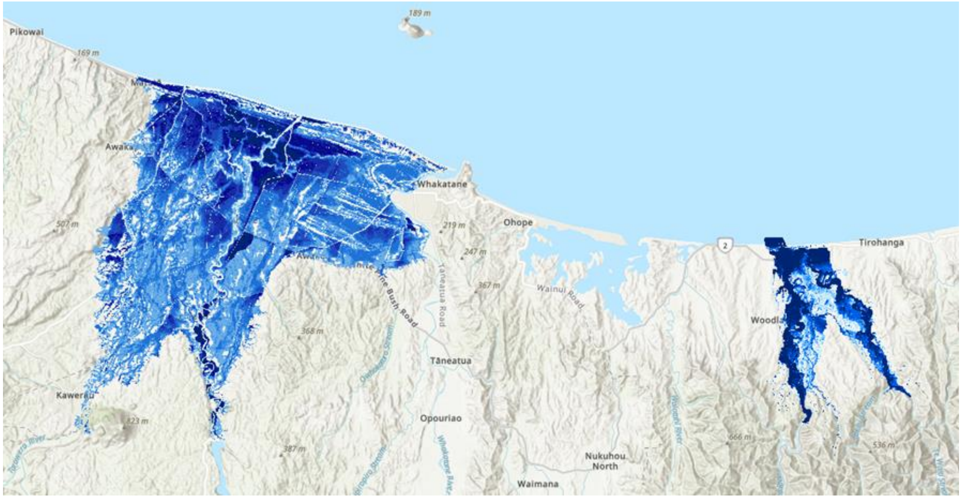

Figure 7: Example 2130 BOPRC Flood Depth Model for Raingitaiki Plains and Opotiki

4.5 Routine Maintenance, Defects, and Faults

Our preventative maintenance framework defines the approach for inspection, monitoring, and servicing activities for network assets. Depending on the asset type and maintenance activity, the timing of maintenance is determined by risk, set frequency, or usage as recommended by the manufacturer. We continually reassess the maintenance routine based on the historical performance of the fleet or industry best practices. Our Asset Management System, Ellipse, automatically schedules preventative maintenance based on established criteria, which forms the basis of our maintenance budget forecast.

Defects and faults are reactive by nature. Therefore, we allocate capital and operational expenditure based on historical expenditure performances. Figure 8 shows an example of the dashboards that we used to analyse historical performances, enabling us to identify abnormal spending and conduct a detailed analysis of the cost per voltage level and equipment type. We have a separate process for prioritising defect remediation.

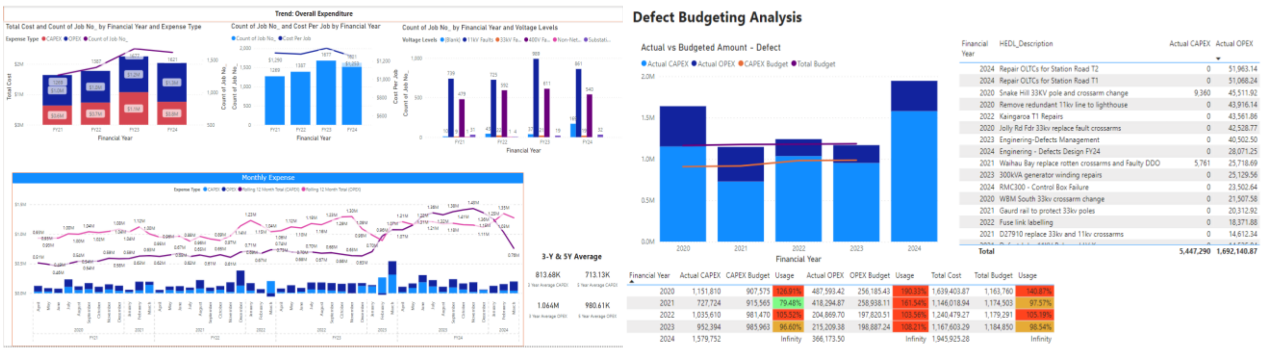

Figure 8: Dashboard Tracking Spend Performances on Faults (Left) and Defects (Right)

5 Risk-based Project Prioritisation and Scenarios Testing

5.1 Prioritisation Principles and Tools

The forecast established in Section 4 serves as the baseline forecast for capital projects. The baseline plan is then further optimised by taking into account the risks and constraints discussed in Section 3. Key considerations when levelling the investment plan are:

- CAPEX and OPEX allowance under the Commerce Commission's Default Price-Quality Path (DPP)
- Timing of the growth projects to avoid inefficient investments due to investing too early, or poor power quality if the investment is made too late
- Resource availability from our contractor
- Synergies amongst projects to improve overall delivery efficiency and minimise customer impact
- Stakeholder expectations such as public safety risk management programmes, reliability improvements, and shareholder returns.

The Commerce Commission's DPP regime sets the 5-year allowances for both OPEX and CAPEX for the regulatory period. Often, we found that the assumptions used by the Commerce Commission for setting these allowances, such as labour and material inflations, don't reflect the real costs that EDBs face.

To address this, Horizon Networks has developed a prioritisation tool based on 'cost-to-benefit' calculations. This tool enables planning engineers to effectively prioritise projects while maintaining acceptable risk tolerance levels. The benefit is quantified as overall network risk reduction calculated through a set of predefined options that the planning engineers can choose. The risk assessment tool evaluates the following risk categories, before and after the intervention to calculate the risk reduction.

- **Reliability Risk** – SAIDI reduction by implementing the project in a planned manner
- **Safety Risk** – Reduction in public safety risk by improvement of asset design or location
- **Environmental Risk** – Reduction in environmental risk through improvement of asset design
- **Reputational Risk** – Reduction in potential reputational impact if the asset fails or inappropriate timing of the solution
- **Cost Risk** – Cost savings by implementing the project in a planned manner.

Risks are calculated through a predefined 4-level severity for each of the risk categories and 6 exposure levels for the probability. An example of the picklist available for the planning engineers is shown in Table 2.

Table 2: Example of Available Picklist in Risk-Based Prioritisation Tool

Safety – Consequence	Environment – Consequence	Exposure
None (No Impact)	None (No Impact)	Extremely Rare (1%)
Low (Injury)	Low (Cleaning)	Rare (10%)
Medium (Hospitalisation)	Medium (Rehab)	Occasional (30%)
High (Loss of Organ/Death)	High (Rehab & Penalties)	Frequent (50%)
		Likely (70%)

	Almost certain (100%)

Figure 9 illustrates our prioritisation model which outputs a risk reduction-to-cost ratio to assist in prioritising capital projects. Initially developed in Excel, the model was later transferred to PowerBI to enhance computing efficiency and analytics capabilities.

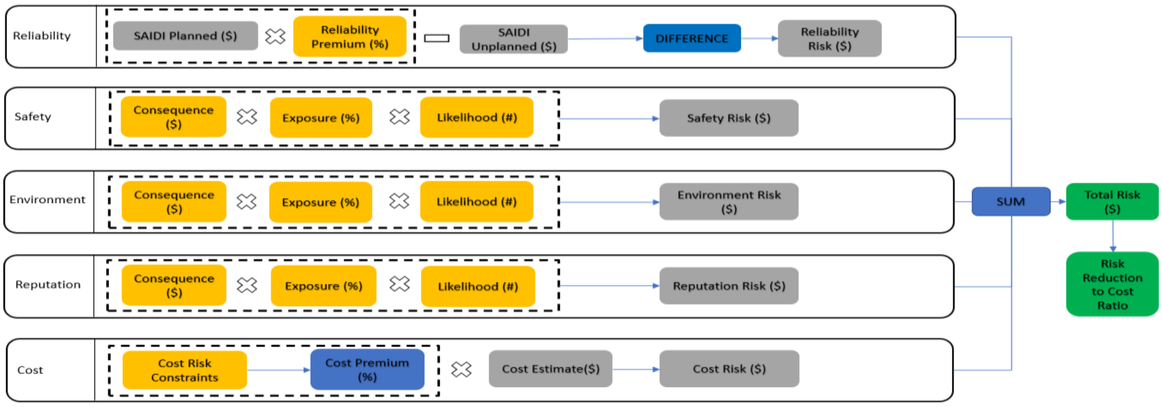

Figure 9: Risk-Based Prioritisation Framework

The risk-based prioritisation tool ranks projects by risk reduction-to-cost ratio which is then further reviewed and adjusted to consider other constraints such as resourcing, budget, stakeholder expectations (such as co-funding commitments), and project bundling to achieve delivery efficiencies. The final output is shown in Figure 10. The blue line represents the Risk Reduction to Cost Ratio, while the blue bars indicate project costs. The x-axis displays the project ranking and timing (Year). The Risk Ratio Threshold is used to assess whether a project's benefit outweighs the cost.

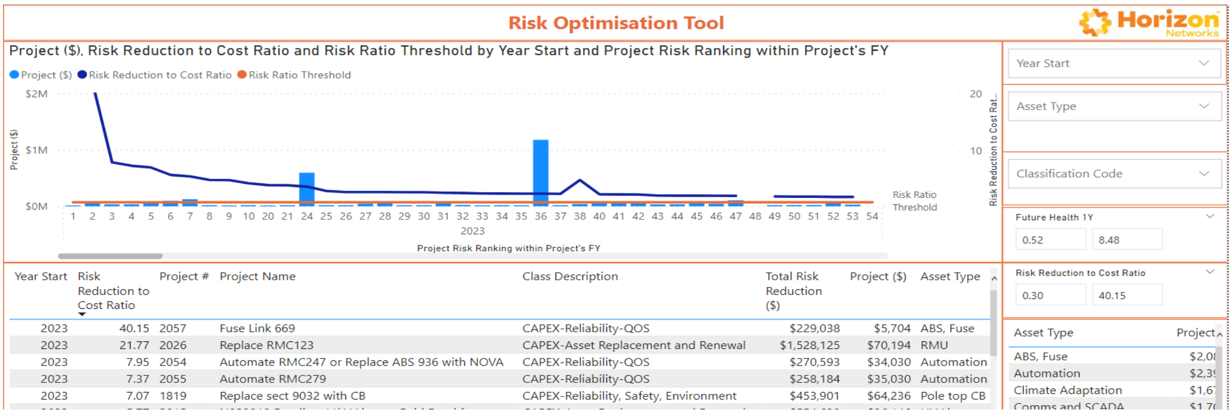

Figure 10: Drill Down View of Project Risk Optimisation Tool

The cost estimate review is initiated each year to adjust our investment plan to reflect the latest cost to deliver the work. The scope and cost of short-term (1-2 years) and/or complex projects are reviewed by the Design and Engineering team in our wholly-owned contracting business to provide reasonable cost estimates for the upcoming works. Labour costs are adjusted and agreed upon with our service provider. The material costs are adjusted based on the latest price received from our suppliers. For long-term programmes, the replacement cost is updated based on the latest Customer Price Index (CPI). This is applied when setting up the 10-year replacement programme for high-volume assets such as poles, pole hardware, distribution transformers, and overhead switches.

5.2 Investment Scenario Testing

Horizon Networks is entering the fourth regulatory period (DPP4), which spans from 1st April 2025 to 31st March 2030. During the development of our 2024 AMP, there was significant uncertainty regarding the Commerce Commission's allowance levels. To address this uncertainty and understand potential impacts, we conducted scenario testing by applying various investment constraints and Maximum Allowable Revenue (MAR) assumptions. A total of seven different scenarios were tested to understand the change in network risk profile through reprioritisation and financial impact on the business such as cash flow and profitability. The scenarios include adjusting the investment levels by a combination of deferring/cancelling key business initiatives and applying overall target spend based on a percentage of a reference forecast.

To understand the changes in the network risk profile, a set of guiding principles was developed to assist the review and prioritisation of projects with health & safety and maintaining network reliability being the highest priority. Prioritisation starts from removing or reducing the budget for lower priority projects and moves up until the target budget reduction is met. Our asset risk models were updated to reflect the constraint budget to allow for before and after comparisons. Figure 11 and Figure 12 illustrates the change in risk profiles for the pole hardware and transformer fleets before and after the constraints were applied. As shown in the figures, the risks for both fleets are steadily increasing with reduced budgets and will become unmanageable.

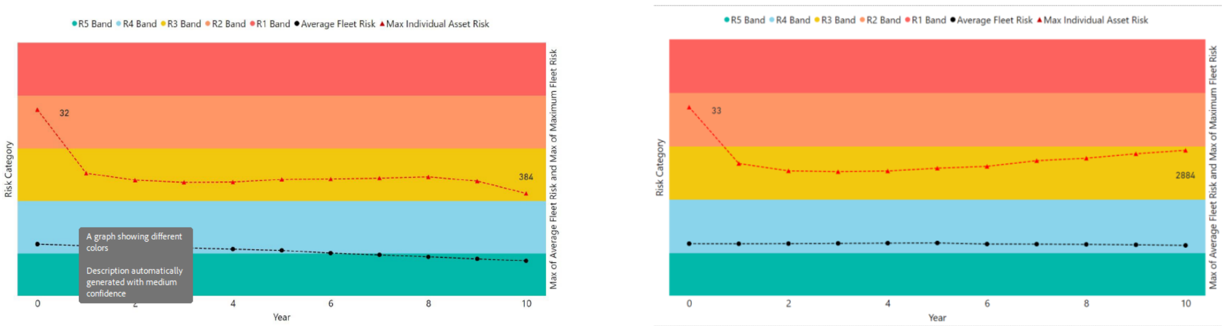

Figure 11: Pole Hardware risk profiles as per AMP2024 budget (left) and with budget reduction by circa 30% (right)

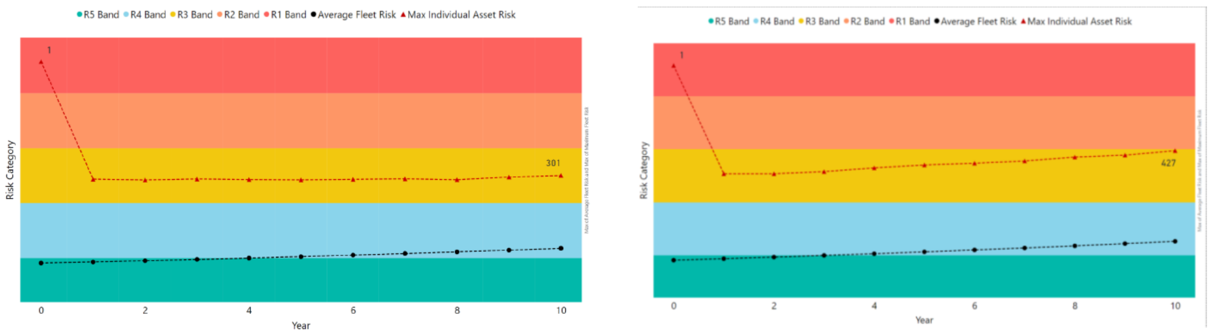

Figure 12: Transformer risk profiles as per AMP2024 budget (left) and with budget reduction by circa 40% (right)

Scenario testing enabled us to strategies and re-prioritise projects if required informed by a clear understanding of risk to both the network as well as the business.

6 Conclusions and Future Directions

Electricity Distribution Businesses have to continuously deal with changing government policies, evolving technologies, shifting consumer behaviours, increased costs, capped revenue, significant climatic events and the uncertain economic outlook that will have an impact on the level of capital that businesses will be able to access to fund the required investments to build the grids of the future. Any significant disruptive event such as another pandemic may exacerbate supply chain issues and cost increases that EDBs might not be able to recover under the current regulatory settings. Such uncertainty could change an EDB's investment profile across the regulatory period.

We have set up our planning process and tools to provide better visibility to network risks, a systematic approach that is dynamic and can be readily flexed to reflect the changes in the business's internal and external environment. Through the work that we have done we have confidence that the modelling produces consistent outputs, and enables our planning engineers to adjust and reprioritise work based on new constraints and input assumptions. Our processes and tools are continually improving to allow in-depth analysis to be performed.

We have adopted technologies and tools that are inexpensive, effective, flexible, and enable automation. These tools allow us to undertake analyses across multiple systems providing a comprehensive insight into historical performance from several angles. We are looking at further enhancing our analytical and planning capabilities through improving data architecture and data quality, visualization of risks including climate change risks, and integrating maintenance planning with capital works planning.

7 References

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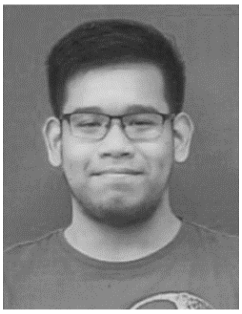
8 Author Biographies



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