Report to Electricity Networks Aotearoa

Electricity Distribution Sector

Cyclone Gabrielle Review

Energia Limited

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Executive summary

Introductory comments

This report assesses the appropriateness of the electricity distribution sector's risk reduction, readiness and response to Cyclone Gabrielle. Our assessment was based on an extensive information-gathering exercise from ten EDBs impacted by the cyclone. We appreciate the efforts made by the impacted EDBs to provide us with the required information.

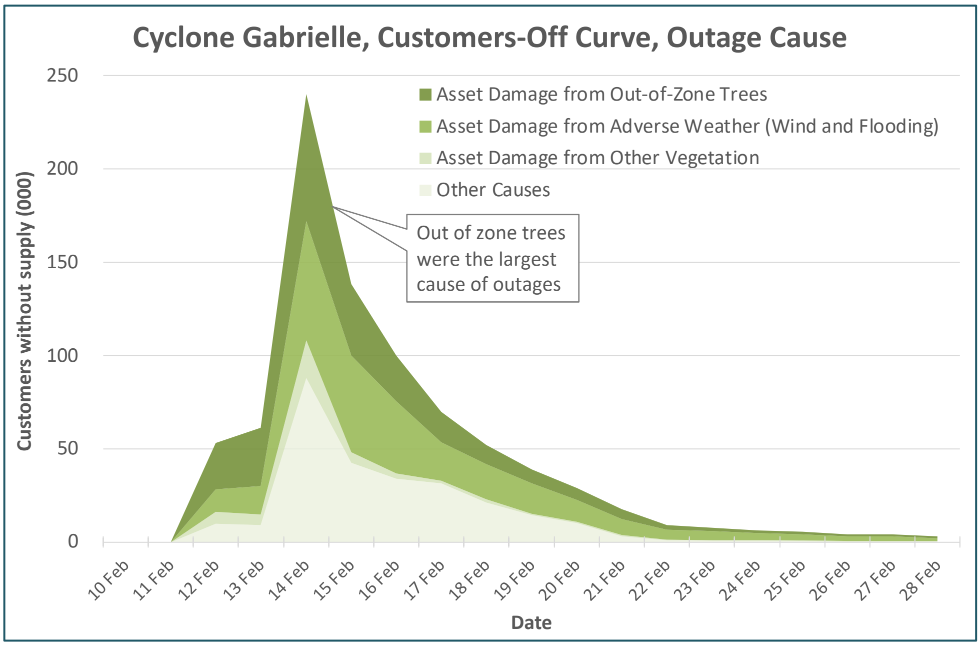
The resilience of the electricity sector is gaining importance due to an increasing number of extreme weather events and the growing reliance on electricity as we decarbonise the economy. This comprehensive review reflects the importance of resilience and the need for continuous improvement.

The impact of Cyclone Gabrielle on EDBs

Cyclone Gabrielle was a significant event. By midday on 14 February, nearly 240,000 customers (11% of connections in New Zealand) lost supply across the North Island.

Figure 1 shows the "decay curve" for customers without supply (by outage cause). The largest cause of outages for EDBs was out-of-zone tree damage to overhead lines. Out-of-zone trees grow outside the zone where EDBs can control their trimming or removal.

Figure 1: The Material Causes of Customer Outages[1]



The second largest cause of outages was adverse weather damage to assets. High winds were the most significant cause of asset damage to overhead lines, followed by flooding damage to lines and zone substations. The windspeeds experienced during Cyclone Gabrielle were very close to current design limits (for the affected regions), and we believe that it is highly likely that the windspeeds in certain locations were above the design limits for older (pre-2000) poles and that this was the primary cause of failures.

[1] Source: EDB outage data. Energia analysis. Customers off was measured at midday to provide a view of the impact on customers. Some EDBs did not provide staged restoration data, which means that some customers were restored earlier than shown in the graph. Transmission outages is the largest component of "other".

The flood damage was most significant in Hawkes Bay and Tairāwhiti and interrupted over 60,000 customers. It was the primary cause of the damage to Unison's subtransmission network and zone substations. Flooding was also the primary cause of transmission network damage.

Unison sustained flood damage at two zone substations due to the overtopping of stop banks, which had 0.5m of clearance above a 1:100-year flood level. The stopbanks were intended to mitigate the flood risk but failed. Asset damage was caused by flood water and wood slash from stop bank breaches. Unison did not anticipate the failure of the stop banks.

Networks have inherent redundancy in critical areas, and those areas stood up well during the cyclone. Outages on the subtransmission network and zone substations accounted for only 4% of outages (by count). This shows the benefit of prior investment in security and network hardening.

Risk reduction activities

Reducing risks from natural hazards (including cyclones) requires identifying hazards, determining the vulnerable assets, having appropriate design standards (including asset location), applying those standards as the network is developed and renewed, and maintaining the assets.

Our assessment indicated that hazard identification is generally robust for typical hazards (snow, tsunami, volcanic activity, wind), but work is at an earlier stage in relation to flooding, geotechnical hazards, and assessing how hazards may alter with climate change. The latter three issues have emerged more recently due to recent weather trends. Identifying assets vulnerable to hazards and preparing mitigation plans is also generally robust for typical hazards but still forming for flooding and geotechnical hazards.

Current design standards (generally to importance-level 4) are robust and, where applied, performed well during Cyclone Gabrielle. However, the standards applying to flooding (for post-disaster operations) do not appear to be as clearly defined as the structural standards.

Older design standards (pre-2000) were to a lower standard and less rigorously applied (reflecting the practices of the time). Hence assets designed to older standards are generally more vulnerable to hazards. As mentioned above, the windspeeds experienced in some locations during Cyclone Gabrielle were highly likely to have been above the design limits for pre-2000 overhead lines.

Mitigating hazards by replacing assets with the current design standard is incremental. Distribution assets are long-lived, and early replacement to current standards would not be economic in most situations (but there may be cases where upgrading critical assets is appropriate). Our assessment indicates that around 22% of overhead lines were built to modern limit-state design, and a further 10% were built under the current design standard. Some EDBs have implemented higher standards in recent years.

EDB assets are aging. However, the asset condition is being maintained appropriately, and we do not consider that asset health was a material factor in the performance of assets during Cyclone Gabrielle.

Trees are a significant hazard to lines, particularly in strong winds. Current rules constrain the ability of EDBs to manage trees that present a fall-risk to lines. This presents a material constraint to resilience. Only 16% of customer outages were caused by in-zone vegetation. Our analysis indicates that EDBs are likely doing a reasonable job of managing vegetation within the rules available to them.

Overall we consider that the work by impacted EDBs on identifying hazards, understanding vulnerabilities, and progressing their mitigation has been undertaken appropriately up to this point. However, the risks posed by hazards would appear to be increasing, likely due to climate change. In our opinion, this may necessitate an acceleration of some assessment and mitigation work to maintain or improve resilience.

Readiness activities

Weather events and emergencies are common for EDBs, which has driven a high level of preparedness across EDBs. Emergency plans were comprehensive and included contingency plans to deal with various events. All impacted EDBs had undertaken specific exercises or had recently responded to weather emergencies. They understood what was required to manage extreme weather events.

Cyclone Gabrielle's approach was well-signalled. Tracking commenced around 06 February; weather watches were issued on 10 February, warnings were issued on 11 February, and the event started on 12 February. The extent of the preparations was appropriate for a large storm event. It is a challenging judgement as to how extensively to prepare. Weather watches aren't a certainty, nor are all weather warnings accurate.

In our opinion, the impacted EDBs have appropriate emergency management plans that can respond to weather events. We also believe that all impacted EDBs took the watches and warnings seriously and prepared accordingly. Only with hindsight could we be critical of the preparation efforts.

Sector response to Cyclone Gabrielle

The overall emergency control worked well with only a few resourcing constraints. Impacted EDBs needed to manage a range of issues during the event (e.g. public telecommunication failures and the complexity of the restoration of electricity into Hawkes Bay), and we believe that they showed appropriate agility and competently managed the event as it unfolded.

Impacted EDBs expanded the number of people involved in the response. However, due to the scale of Cyclone Gabrielle (which was difficult to anticipate in advance), the ability to expand was constrained by the number of trained people within the EDBs (this being more acute in the smaller EDBs). EDBs experienced varying constraints across the restoration process (from outage notification, network control, dispatch, logistics and field work). The extent of the impact across the North Island and roading failures in affected regions severely limited the level of mutual aid that could be provided in the initial stages of the cyclone. However, despite the access challenges, mutual aid was provided as the event progressed, and this included field resources and network controllers.

Our overall comment is that EDBs did an appropriate job restoring supply and competently responded to a wide range of issues. We believe there are incremental improvements that can be made that will enhance restoration and improvement communication with customers.

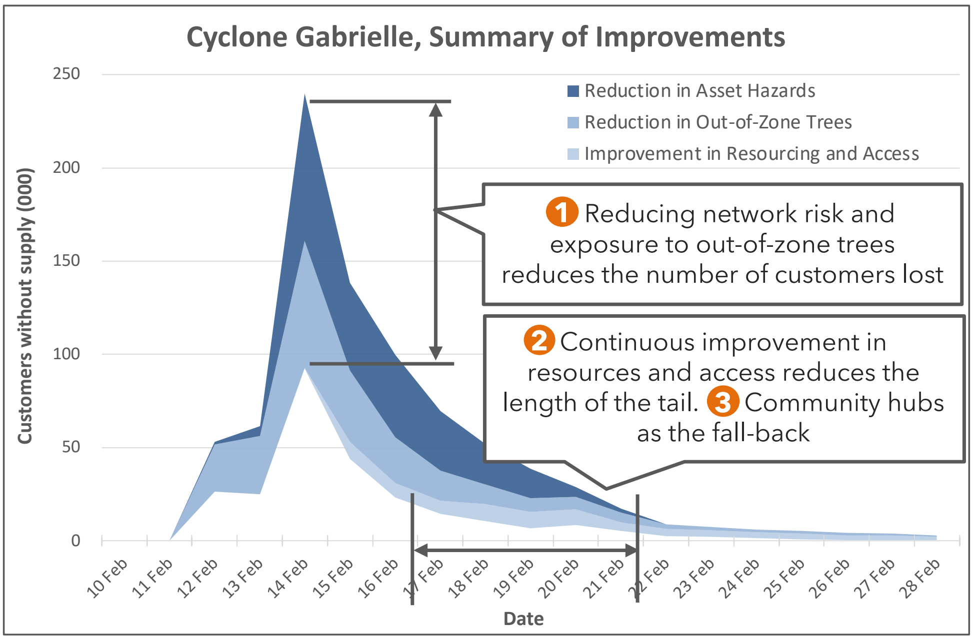
Strategy, lessons, and improvements

We believe that a combination of strategies is needed to improve resilience (to reduce the height and length of the customer-off curve). The focus should be on reducing risk, which will be the most effective strategy in reducing customer outages. Lowering the number of customers impacted (the curve's height) also reduces the workload pressure on resources, minimising resourcing constraints.

Referring to Figure 2 below, we have identified three key activities:

1. **Remove hazards.** This involves addressing the risk posed by out-of-zone trees, upgrading some specific critical assets that are vulnerable to hazards, and incrementally hardening the network as assets are renewed. This activity will take time and investment, and the investments will need to be appropriately tested for alternatives and affordability.
2. **Continuously improve resourcing and access.** Improvements to resourcing and contingency plans to deal with access will help shorten the restoration "tail".
3. **Develop secure community hubs.** Due to our topography, vulnerabilities in the roading networks, and the types of damage that can occur, there will always be some hard-to-restore customers. For these customers and communities, having community hubs with a secure standalone supply of electricity and communication will provide support while restoration or alternatives can be brought online. Community hubs will be an important safety net while hazard reduction and other improvements are made.

Figure 2: EDB resilience improvement strategy



In Sections 10.3 and 10.4 we have described the lessons learnt, strategy, benefits and actions that we consider can improve resilience. Implementing our recommendations will impact EDB's forecast opex and capex. The asset hardening recommendation will increase capex. Managing out-of-zone trees, additional planning work, and resourcing improvements will increase opex.

Non-regulated EDBs can pass these costs through (giving them due affordability consideration and benefit assessments), and regulated EDBs need to receive opex and capex allowances. We have suggested that engagement with the Commerce Commission is required to enable greater expenditure to improve resilience.

Closing comments

This executive summary attempts to distil our assessment into the most important issues. However, a significant amount of useful information is contained in the body of our report, and we encourage you to read it in full.

Content

Introduction

1. Purpose and scope of this report

This report assesses and appropriateness of the electricity distribution sector's risk reduction, readiness and response to Cyclone Gabrielle. We prepared this report for the ENA with the express intent of being submitted to government agencies, stakeholders, and EDBs.

The scope of this report is to:

- Summarise the risk reduction, readiness and response activities of EDBs impacted by Cyclone Gabrielle;
- Assessing the causes of outages and the impact on customers;
- Determine the industry-wide lessons learnt;
- Determining recommendations to make to the Cyclone Taskforce;
- Providing an opinion on the industry's performance concerning each area mentioned above

The layout of this report generally follows the scope mentioned above.

A cyclone is just one major event the distribution sector must respond to. There are other forms of "natural" major events (e.g. earthquakes, volcanic eruptions, tsunamis) as well as different types of major events (e.g. cyber-attacks). Every type of major event has similarities and differences. Whilst the report primarily assesses reduction, readiness and response to a cyclone, we also make more general comments where appropriate.

2. The extent of our investigations

To prepare this report's summaries, assessments, and opinions, we undertook an extensive information-gathering exercise from impacted EDBs. We obtained the following information:

- Historical risk reduction activities, including the network vulnerabilities considered;
- Network security of supply standards and their implementation on the network;
- Network design standards;
- Asset condition;
- Comprehensive outage data from the event, including primary and secondary causes and customer impacts;
- Timeline of the preparation and response to Cyclone Gabrielle, including a description of the activities undertaken[2] and any constraints encountered and responses to those constraints;
- Lessons learnt during Cyclone Gabrielle.

[2] This covered: the control structure and incident management, network operations centre, field operations, communication with customers and stakeholders.

The impacted EDBs were: Top Energy, Northpower, Vector, Counties Power, WEL Networks, Waipa Network, the Lines Company, Powerco, Firstlight Network[3], and Unison Networks. We thank the companies for the effort to supply the information and for their prompt response to any subsequent questions.

3. Structure of our assessment

There are various models for assessing resilience capability. They all have similarities and include the 4Rs (which covers reduction, readiness, response, and recovery), the EEA Resilience Guideline (which used the 4Rs), ISO 22301 (which covers, amongst the usual ISO requirements, impact analysis and risk assessment, business continuity plans, recovery, exercises, improvement), and the Australian critical asset resilience standard (which covers anticipate, withstand, recover and evolve).

Our comments on the models are that the more "modern" standards focus more on learning as the speed of evolution is important when considering threats wider than just natural hazards (e.g. cyber, terrorism, pandemics, global conflicts, etc.). The absence of learning is a gap with the 4Rs as it has its foundation in natural hazards (but learning is inherent in its application).

We have used the 4Rs as the primary areas for our assessment, mainly as there is a high level of familiarity with these definitions of capabilities, and our review relates to a natural hazard event.

3 At the time of Cyclone Gabrielle the company was Eastland Network. Eastland Network became part of the Firstgas Group on 01 April 2023 and we have refered to the company as Firstlight Network throughout the report.

Background information

4. The electricity sector and resilience

4.1 Overview of the electricity industry

The electricity industry is a complex and highly interconnected system of generators, grid and network companies, energy retailers, customers and a system operator. Each party works together to ensure electricity is delivered safely and securely to customers.

From generators, electricity is carried at high voltage through large transmission lines (owned and operated by Transpower) to large regional or city substations (known as GXPs). From here, EDBs distribute the electricity using their subtransmission networks to suburban and rural zone substations. From here, the electricity is further distributed down roads and streets on distribution feeders and then through the low-voltage network to homes and businesses. Some large industrial customers take supply directly from the transmission network, subtransmission network, or distribution feeder.

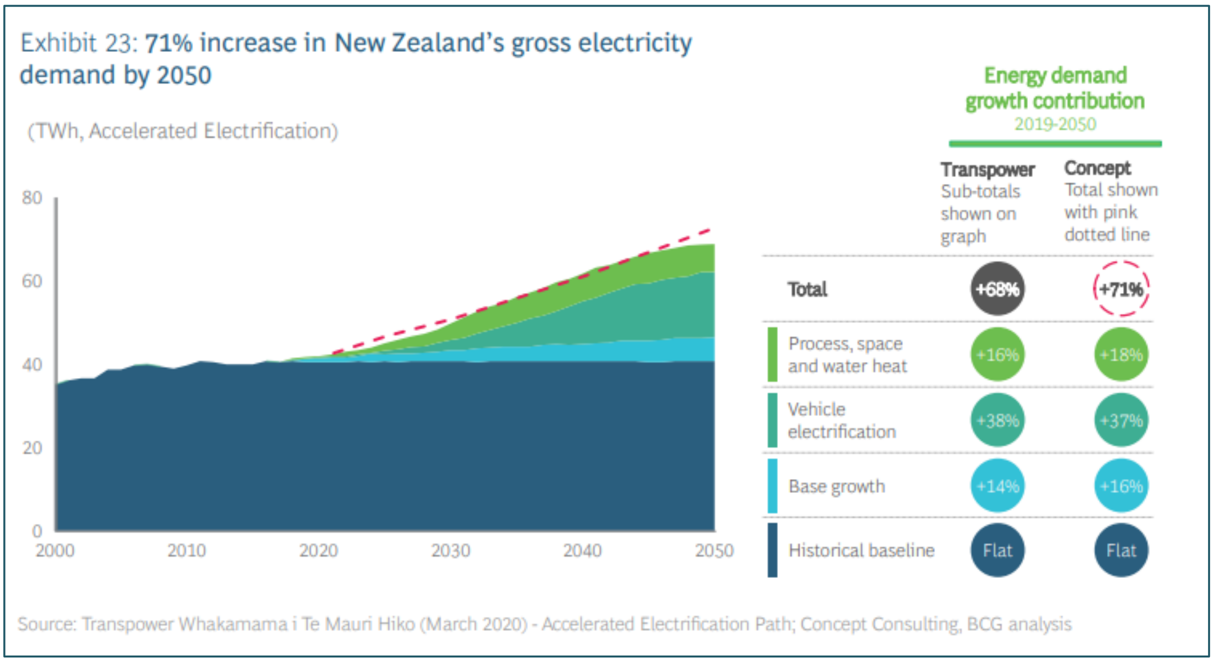
The wholesale electricity market balances the generation and consumption of electricity across the physical grid and networks. The role of the system operator in the wholesale electricity market is to manage the security of the power system in real-time and coordinate the supply of, and demand for, electricity in a manner that avoids fluctuations in frequency or supply interruptions. A key role of the system operator is to respond to transmission and generator outages and implement contingency plans to restore or maintain supply. The system operator coordinates all parties—generators, Transpower, EDBs, energy retailers, and large customers.

4.2 Importance of resilience in an electric future

New Zealand's policy direction involves the increasing use of electricity to decarbonise transport, industrial process heat, and commercial and domestic heating (refer to Figure 3). This will increase the reliance on electricity and reduce fuel diversity. As a result, in the future, a loss of supply will have more significant community and economic consequences and impact more sectors.

Therefore, the electricity sector's resilience must be commensurate with its increasing dominance and linkage of electricity supply to economic activity.

Figure 3: Increasing use of electricity in New Zealand



4.3 Definition of resilience

In the modern context, resilience means:[4]

- The capacity of the network to absorb a shock; recover from disruptions; adapt to changing conditions; and retain essentially the same function as it had before;
- Having the capacity to adapt to those shocks and rapidly recover, even if that means providing services in a new way.

In practice for the sector, resilience tends to mean:

- Minimising the potential number of customers interrupted during a major event (generally by way of risk reduction);
- Minimising the duration of the interruptions that occur during a major event (generally by way of readiness and response);
- Communicating with customers and stakeholders so that they can be informed in their decision-making and so that restoration can be effectively coordinated and targeted;
- Recovering to the pre-event state.

The differences between the modern and practical meanings are subtle and relate to "new ways" of providing services during and after major events.

4.4 Definition of security of supply

Security of supply means "the ability of the electricity supply to meet demand over time". It has slightly different practical meanings at a wholesale electricity market level and a distribution network level.

Concerning the wholesale market, it's about the availability of enough generation each day to meet peak electricity demand and enough fuel to generate electricity over the longer term. Security of supply assessments encompasses both generators and the transmission grid.

[4] DPMC, "Strengthening the resilience of Aotearoa New Zealand's critical infrastructure system", June 2023.

Concerning distribution networks, security of supply means the ability of the network to withstand and recover from an outage of an item of equipment. In this context, security of supply is a function of:

- The physical capabilities of the assets (e.g. mechanical strength, ground conditions, asset health, and location);
- The level of redundancy inherent in the network design (e.g. "N-1" means supply is not impacted with the loss of one component; "N-1 Switched" means supply can be restored by reconfiguring the network, and only a small faulted area is without supply for repair time; "N" means supply is lost until the asset is repaired).[5]

Electricity system security is "layered". That is, the more customers being supplied, or energy being conveyed, the higher the level of security. Typically this is:

- At a GXP, N-1 security is provided (with only a very few exceptions), often with other potential switching options;
- At zone substations, typically N-1 security is provided for urban and large rural zone substations, and N-1 switched or N at smaller zone substations;
- At distribution feeders, this can be N-1 for critical customers (e.g. hospitals) and large CBDs, and N-1 Switched for other CBDs, commercial areas, suburban areas, and parts of the rural area. N security occurs at a street level and in remote rural areas.

[5] In the case of transmission grids, security is also assessed using N-G-1, where G is the largest generator connected.

Cyclone Gabrielle and its Impact on EDBs

5. Overview of Cyclone Gabrielle

Cyclone Gabrielle followed a period of significant rainfall (and flooding) between 24 January and 08 February. During that period, the Northland, Auckland, and Coromandel regions incurred over 300mm of rain (around 8-10x normal rainfall). Other regional also incurred significantly higher rainfall over that period.[6] Flooding also occurred in Northland, Auckland, Waikato, Bay of Plenty and Tairāwhiti. Severe flash flooding occurred across Auckland on 27 January.

Forecasters signalled the emergence of Cyclone Gabrielle from around 06 February, with weather warnings being issued on 10 February (for the event commencing on Sunday 12th).[7] Metservice issued Red and Orange Heavy Rain and Strong Wind Warnings on 11 February, one day before the event. Metservice gave further Red Heavy Rain and Strong Wind Warnings during the event. Table 1 below indicates the event timeline.

Concerning the impact of Cyclone Gabrielle, "Gabrielle is one of the worst storms to hit Aotearoa New Zealand in living history. Like Cyclone Bola in 1988, Giselle that caused the Wahine disaster in 1968 and the unnamed cyclone of 1936, Gabrielle caused shocking impacts to the North Island." Between the 12th and 14th of February, parts of Aotearoa New Zealand recorded rainfall amounts of 300-400mm, wind gusts of 130-140km/h and waves were recorded as high as 11 metres along some of our coasts. It is no wonder that the North Island experienced the devastating impacts that have been seen from Cyclone Gabrielle."[8]

Concerning the extensive flooding in Hawkes Bay, rainfall reached 450mm during the storm (about a quarter of the usual annual rainfall). This resulted in significant river flooding of the Esk, Tūtaekurī and Ngaruroro rivers. Floodwater overtopped stopbanks, partly caused by debris buildup at structures such as bridges. Overtopping caused erosion of stopbanks, leading to thirty breaches of them, covering five kilometres. The stopbank had half a metre clearance on a one-in-100-year flood when designed.[9]

Figure 4 and Table 2 below indicate the extent of the wind and rainfall during Cyclone Gabrielle.

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7 Metservice stated the warning were issued on 09 February, however, we could only find warnings issued on 10 February. Gisborne District Council also noted warnings being issued on 10 February.

8 https://blog.metservice.com/TropicalCycloneGabrielleSummary. Quote from Head of Weather Communications Lisa Murray.

9 https://niwa.co.nz/publications/water-and-atmosphere/water-atmosphere-29-june-2023/in-the-wake-of-gabrielle. Various other news articles.

Figure 4: Cyclone Gabrielle Impacts

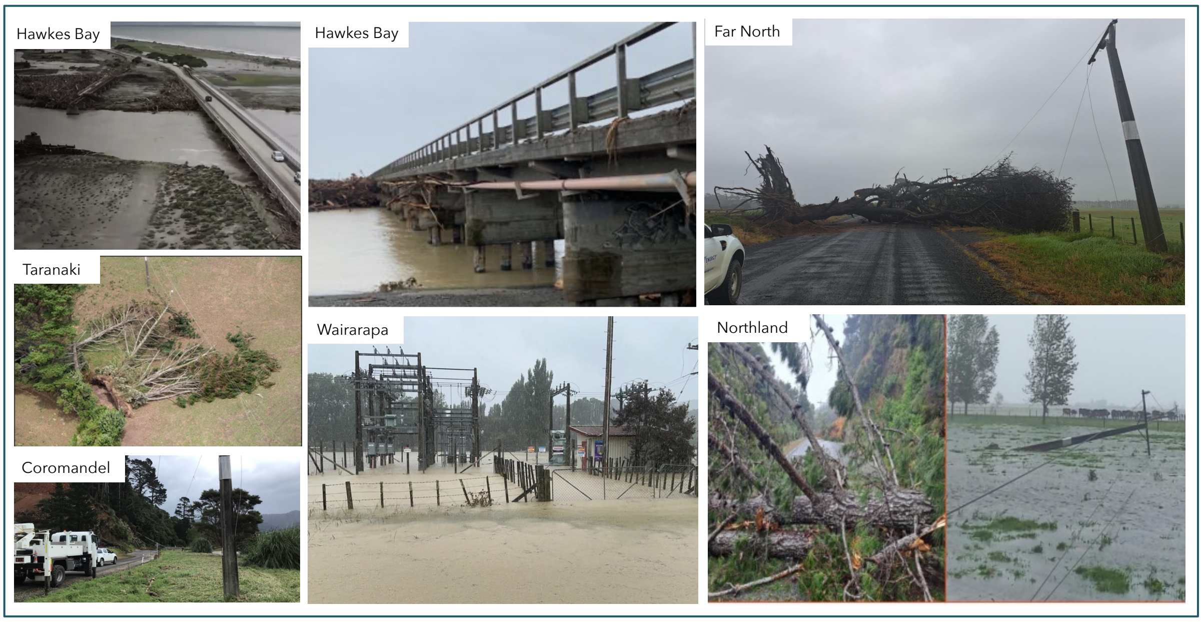


Table 1: Cyclone Gabrielle timeline[10]

Date	Notice/Impact
06 February (Monday)	• First indications that modelling is suggesting that the weather system is likely to impact the Northern and Eastern regions of the North Island
09 February (Thursday)	• Further indications that the weather system could bring severe weather in the Northern and Eastern regions of the North Island. Forecasters noted "it was not possible to forecast the exact intensity of the severe weather". Indications were that the weather system could hit the North Island on Sunday (12th), with the worst effects on Monday (13th) and Tuesday (14th)
10 February (Friday)	• Metservice issued Heavy Rain Watches for Sunday 12th to Tuesday 14th for Northland, Auckland and Coromandel; and for Sunday 12th to Wednesday 15th for Tairāwhiti and Hawkes Bay. • Metservice issued Strong Wind Watches for Sunday 12th through to Tuesday 14th for Northland, Auckland and Coromandel.
11 February (Saturday)	• Metservice issued Red Heavy Rain Warnings for Coromandel and East Cape. • Metservice issued Orange Heavy Rain Warnings for Northland, Auckland, Hawkes Bay and the remainder of Tairāwhiti. • Metservice issued Orange Strong Wind Warnings for all of Northland, Auckland, Bay of Plenty, Waikato, Central Plateau, and Tairāwhiti. • These were for the period from Sunday 12th to Wednesday 15th
12 February to 14 February	Throughout the intensive three-day event: • MetService issued (or upgraded to) Red Heavy Rain Warnings for Northland, Auckland, Coromandel, Gisborne, and Hawkes Bay. • MetService issued (or upgraded to) Red Strong Wind Warnings for Northland, Auckland, Coromandel, and Taranaki.

[10] Metservice twitter feed, NIWA Weather twitter feed, Metservice Cyclone Gabrielle Blog, RNZ new articles, weatherwatch.co.nz

Table 2: Severe Weather[11]

Conditions	Description
Rain	• 183.8mm was recorded at Whangarei from 9 am 12 February – 9 am 13 February. • Over 200 mm was recorded around the Auckland region. • 185.3mm was recorded at Gisborne Airport until power and communications ceased at 2 am Tuesday. • Napier Airport recorded 175.8mm from 9 am 13 February – 9 am 14 February. • Coastal inundation and flooding were amplified due to storm surges associated with the cyclone – either by directly inundating the coastal area or reducing the efficiency of the rivers draining into the sea.
Wind	• As the system moved south and east, many areas were impacted by gale-force constant wind and extreme gusts. • 141 km/h wind gusts were recorded at Cape Reinga on 12 February. • 132km/h wind gusts were recorded at Whangaparāoa on 13 February. • 115 km/h wind gusts were recorded on the Auckland Harbour Bridge. • 126 to 151 km/h wind gusts were recorded at weather stations around Tairāwhiti on 13 February. • Note: many weather stations in the affected regions lost power and communications, which impacted measurements.

6. The impact of Cyclone Gabrielle on the EDBs and their customers

6.1 Introduction

Cyclone Gabrielle was a significant event. By midday on 14 February, nearly 240,000 customers (11% of connections in New Zealand) lost supply across the North Island.

We undertook a review of the impacts using outage data from the impacted EDBs, including:

- The primary causes of customer interruptions;
- What influenced the duration of the outages;
- How different elements of the network performed;
- The use of generators.

We also estimated the value of the lost load during the cyclone.

Our observations concerning these matters are discussed in the following sections.

6.2 The primary causes of customer outages

Figure 5 shows the "decay curve" for customers without supply (by outage cause). The largest cause of outages was out-of-zone tree damage to overhead lines. Out-of-zone trees grow outside of the zone where EDBs can control their trimming or removal (refer to Section 7.8 for additional details). Out-of-zone tree outages interrupted supply to 68,000 customers at the cyclone's peak.

[11] Metservice Cyclone Gabrielle Blog.

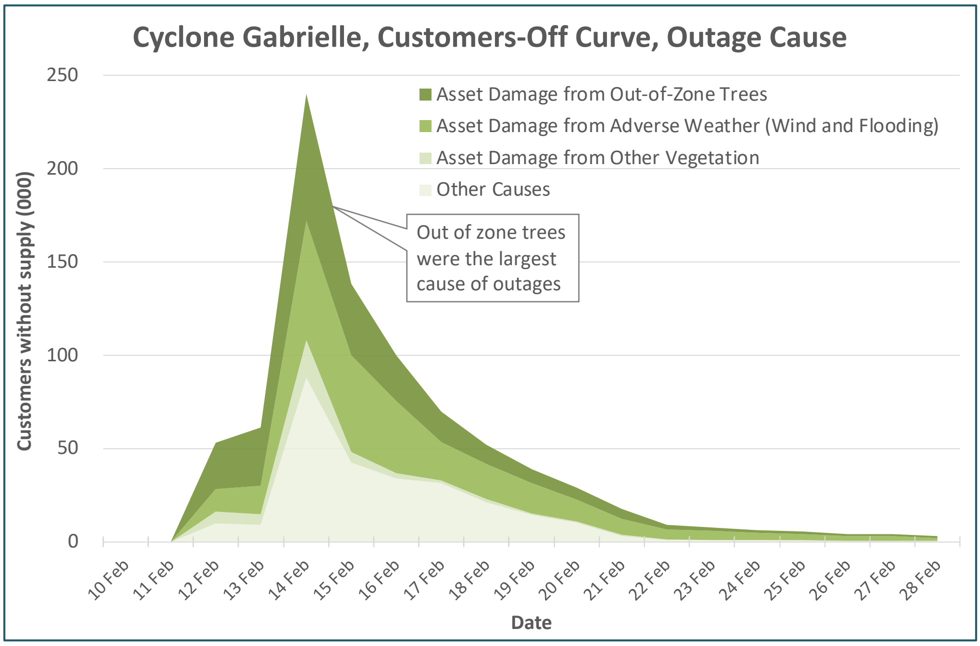
The second largest cause of outages was adverse weather damage to assets. The adverse weather causes included flood damage; wind damage; landslips; and failure of ground conditions.[12]

High winds were the most significant cause of asset damage, followed by flooding. The flood damage was most significant in Hawkes Bay and Tairāwhiti, which interrupted over 60,000 customers. It was the primary cause of the damage to Unison's subtransmission network and zone substations. Flooding was also the primary cause of transmission network damage.

We also noted the failure of ground conditions occurred in several locations. The failures were caused by a reduction in the ground resistance moment (caused by extensive rainfall significantly increasing ground moisture levels) and high wind speeds resulting in pole movement in the ground, bringing down the line.

Land slips also caused damage to assets but accounted for far fewer outages (impacting around 3,000 customers).

Figure 5: The Material Causes of Customer Outages[13]



6.3 What influenced the duration of the outages

Figure 6 and Figure 7 show the percentage of customers restored by 6:00 pm daily. 90% of customers were restored by the end of day six. The areas where the outage duration was the longest (where large customer numbers were involved) were Hawkes Bay (due to the extent of the flood damage) and the Far North (due to the extent of the out-of-zone trees and wind damage).

The storm conditions persisted from the 12th to the 14th of February. Those EDBs impacted on the 12th were delayed in undertaking aerial surveys of the damage. Hence much of the work over that period was "make-safe" and network switching to restore supply via alternative circuits.

[12] We conbined adverse weather and adverse environment cause codes due to some inconsistency in their application in the source data.

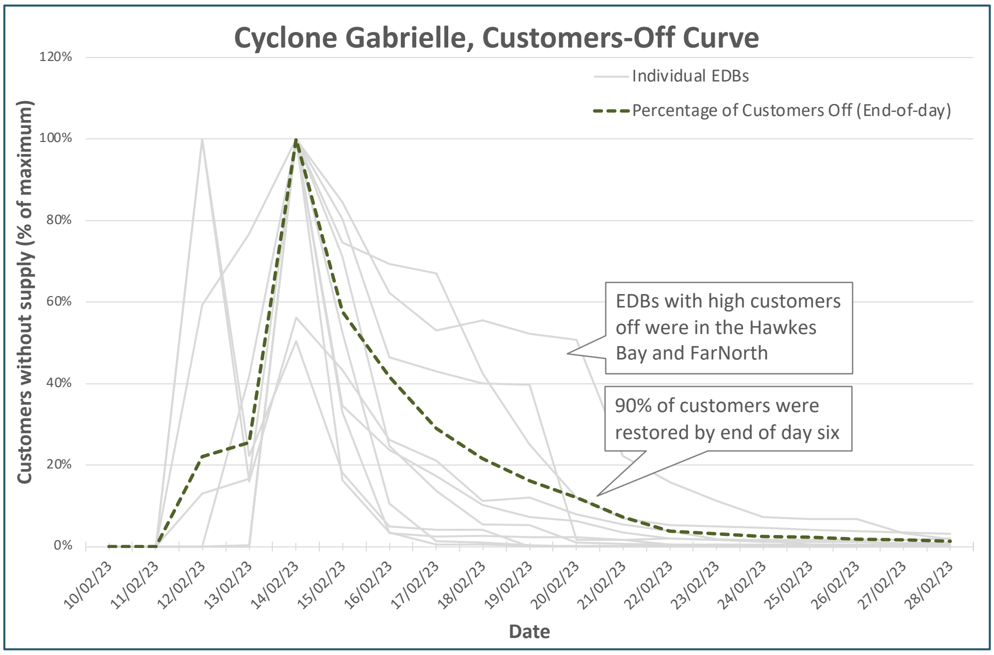
[13] Source: EDB outage data. Energia analysis. Customers off was measured at midday to provide a view of the impact on customers. Some EDBs did not provide staged restoration data, which means that customers were restored earlier than shown in the graph. Transmission outages is the largest component of other.

Vector's network had been impacted by the late January flood event, and when Cyclone Gabrille hit, it had not been fully returned to a normal state. This increased its vulnerability to the extreme cyclone weather.

Figure 7 shows the restoration by cause. Adverse weather damage (mainly wind) took the longest to repair due to the significant number of damaged locations. The restoration was exacerbated by field resourcing and access constraints (discussed further in Sections 8.3 and 9.5).

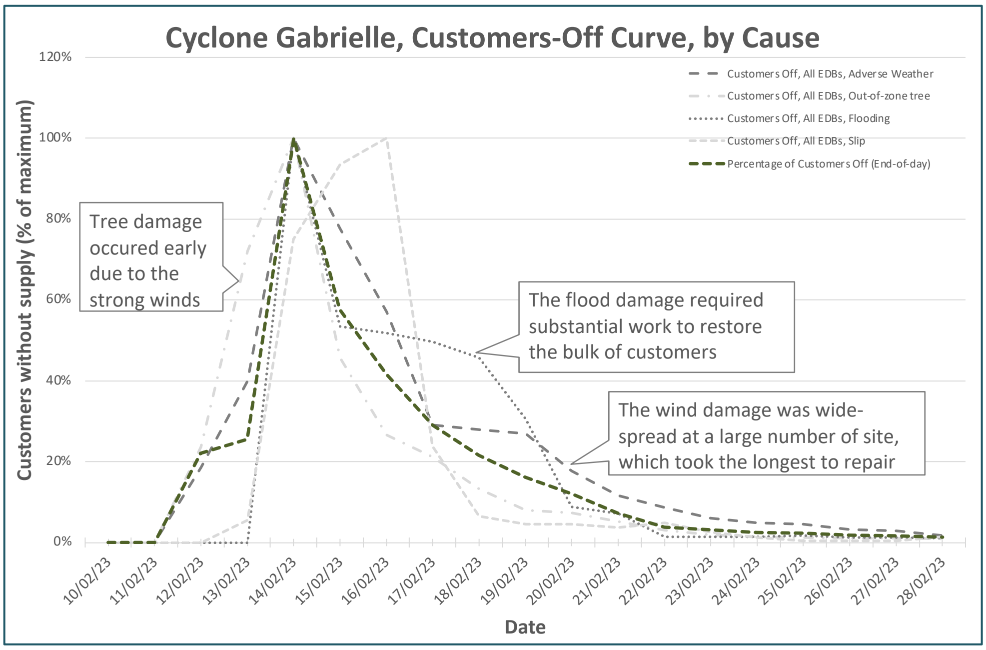
There will always be a "tail" in the restoration of supply, whether caused by road access constraints, landslips that destroy line routes (and a new line route needs to be designed), extensive flooding making access difficult, or some other reason. Resources to effect repairs aren't infinite, so prioritisation also needs to be made, which can impact the size and length of the tail. Customers in the "tail" need to be supported while EDBs make repairs or arrange alternative supplies.

Figure 6: Customer restoration by EDB[14]



[14] Source: EDB outage data. Energia analysis. Customers off was measured at 6:00pm as customer restoration most often occurred towards the end of the day. Some EDBs did not provide staged restoration data, which means that some customers were restored earlier than shown in the graph (the worst performance in the graph related to non-staged restoration).

Figure 7: Customer restoration by cause[15]



There were over 2,200 outages during the two weeks from the start of the cyclone, many with significant damage. The number of outages was a 650% increase over an average two-week period, or around a quarter of the outages in 2022. The high number of outages created a very high demand for control room resources, field resources, and materials. This demand led to resource constraints that would have impacted restoration times (we discuss the efforts to mitigate the constraints in Section 9.5).

6.4 How different elements of the network performed

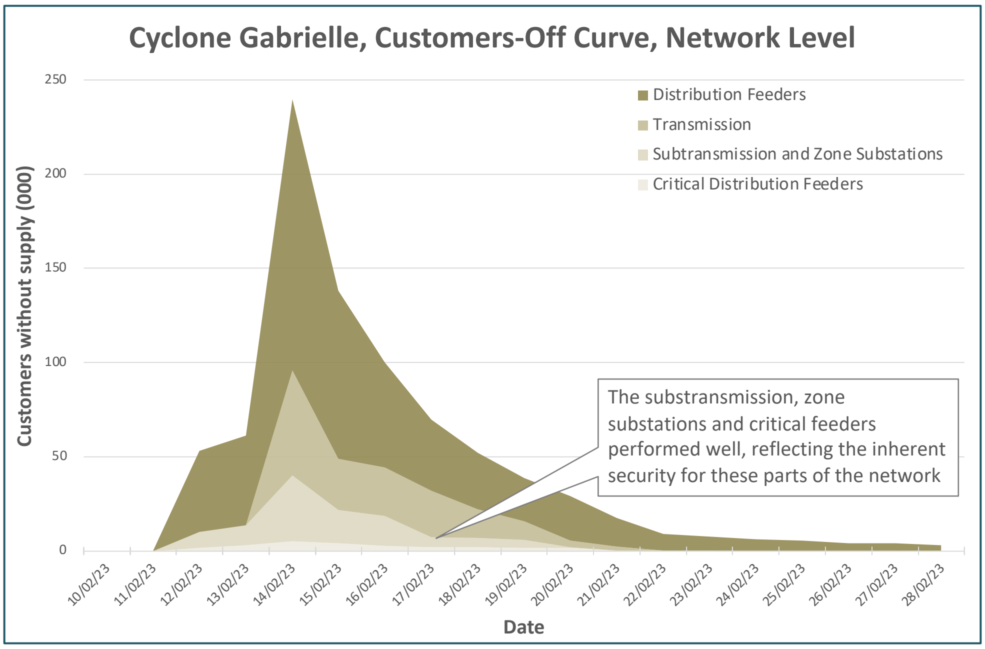
Networks have inherent redundancy in critical areas (refer to Section 4.4 for details), and those areas stood up well during the cyclone. Outages on the subtransmission network and zone substations accounted for only 4% of outages (by count). The fault rate (outages per km) on subtransmission was 1.6 outages per 100km, which was less than half of the outage rate on the distribution network. This shows the benefit of prior investment in security and network hardening.

EDBs relatively quickly restored outages on the subtransmission networks (excluding Unison flood damage). Outages were fixed within three days from the peak (or around 4.5 days from the start of the cyclone). We consider that this reflected subtransmission (appropriately) being given a higher priority for restoration and more supply alternatives being available due to the higher security at that level.

The outages on critical feeders were very low (by customers impacted), again showing the benefit of prior investment in security and network hardening.

[15] Source: EDB outage data. Energia analysis. Customers off was measured at 6:00pm as customer restoration most often occurred towards the end of the day. Some EDBs did not provide staged restoration data, which means that customers were restored earlier than shown in the graph (the worst performance in the graph related to non-staged restoration).

Figure 8: Network performance[16]



6.5 Use of generators

EDBs used portable generators during the event. Unison supported around 1,400 customers with generators at the peak of their restoration effort. Firstlight, Vector, WEL Networks, The Lines Company, Northpower, and Waipa Networks also deployed generators. Generator use was not extensive but did support some customers where restoration was forecast to take a long time.[17]

Firstlight's use of fixed generators

The impact on the Firstlight network was significant in terms of damage. However, it was not as significant in terms of customers impacted. Besides the transmission outage on 14 February, Gisborne was largely unaffected, and in rural areas, Firstlight's diesel generators operated throughout the event, which reduced the impact materially. By 6:00 pm on 15 February, only 12% of Firstlight's customers were without supply, decreasing to 8% on the 16th and 6% on the 17th. The extent of the damage (caused by out-of-zone trees) and access restrictions (due to the roading network's failure) made restoring supply to the last 5% difficult and time-consuming.

In the rural areas, Firstlight has five fixed diesel generators located at Te Araora, Ruatoria, Tolaga Bay, Puha and Mahia. These generators are part of their approach to providing security of supply at rural substations, where N-1 subtransmission or zone substation transformer security would not be economic. The generators carried two days of fuel on-site and were refuelled before the event. All the generators operated during the event and kept the local townships and much of the rural areas supplied with electricity. Firstlight sent a

[16] Source: EDB outage data. Energia analysis. Customers off was measured at midday to provide a view of the impact on customers. Some EDBs did not provide staged restoration data, which means that some customers were restored earlier than shown in the graph. Note: We received critical feeder lists from EDBs that were impacted with the most customers-off (excluding Unison). The exclusion of Unison would have overstated the performance of critical distributions feeders to some degree, however, much of their outages were subtransmission or zone substation related, hence the outages were attributed to that part of the network (and not at a feeder level).

[17] The outage information we were supplied was already "net" of generation, so it was difficult to quantify the contribution from portable or fixed generation.

portable generator to Te Puia to supply the township and hospital. Another generator was sent into Tauwhereparae to supply isolated customers.

Fuel supply was a logistic challenge due to the roading network, and alternative routes were required. The Mahia generator was stopped one evening due to delays in sourcing fuel.

Top Energy and Vector also have fixed generators in place to support network security and resilience (but we didn't capture data on the extent that these were needed and used during the event).

In our opinion, large (e.g. >300 kWe) portable generators are useful to support areas where network repair times are long. The cost and resources required to install large generators are worthwhile as an alternative to long-duration outages for many customers. The supply of many small generators is often impracticable as this is a resource-intensive process (where those resources may be better assigned to core network restoration efforts).

6.6 Value of lost load

The value of lost load is the cost to customers associated with an interruption of electricity supply. We estimated that the value of lost load during Cyclone Gabrielle was $474 million over two weeks. We calculated this by applying an adjusted SAIDI incentive rate to the SAIDI associated with Cyclone Gabrielle for each impacted EDB.[18] The value excludes the transmission outages, which calculated by the same methodology was $137 million.

This initial estimate is useful for understanding the costs that can be avoided when investigating and justifying projects to improve resilience.

[18] All regulated EDBs have an SAIDI incentive rate that is used to determine the incentive or penality for SAIDI being below or above the target SAIDI. The SAIDI incentive rate is informed by a national average VOLL of $25,000 per MW determined by PwC for Transpower (refer to the Commerce Commission's DPP3 reasons paper, footnote 725). The incentive rate is different for each EDB as the economic impact of one SAIDI minute is different for each EDB due to the size and mix of the EDB's customer base. The incentive rate used by the Commerce Commission was adjusted to account for other incentives included in the regulatory regime (refer to Commerce Commission DDP3 reasons paper, paragraph M26). We added-back these adustments to determine an unadjusted SAIDI incentive rate. For non-regulated impacted EDBs we calculated an incentive rate based on an average per ICP incentive rate.

How EDBs prepared

7. Risk reduction and readiness activities

7.1 Introduction

Reducing risks from natural hazards (including cyclones) is multifaceted. It requires identifying hazards, determining the vulnerable assets, having appropriate design standards (including asset location), applying those standards as the network is developed and renewed, and maintaining the assets so that condition does not impact performance.

We undertook a comprehensive review of the factors associated with reducing risk, which included assessing impacted EDBs' work on:

- The identification of hazards and mitigation of vulnerabilities and the extent they understood any residual vulnerabilities (including changes in hazards due to climate change);
- The implementation of more resilience asset designs;
- Network security and the extent that the network met its security standards (at a zone substation and feeder level);
- Communication network security and network control room backup;
- Asset condition;
- Managing vegetation.

We discuss each of these factors below.

7.2 The identification of hazards and mitigation of HILP vulnerabilities

Concerning the existing assets, impacted EDBs have identified the typical natural hazards (e.g. seismic, tsunami, snow, volcanic activity, strong winds, rain-induced flooding, river flooding, sea inundation, and wildfire). Most impacted EDBs have work commencing or underway on how climate change will affect these hazards. Impacted EDBs generally know where these hazards exist across the network (as some are location-specific).

Impacted EDBs have undertaken reviews against the seismic standards and understand the current ratings of zone substations and other major structures. Reviews against the other hazards varied across impacted EDBs, with some having completed studies across all natural hazards, while others had only assessed the hazards most material to their networks.

Impacted EDBs' consideration of flood hazards is a more recent activity. Quantifying this hazard is not straightforward, as the applicable return period appears to vary[19], and determining the flood level (for a particular return period) to apply in specific locations is not always clear due to the nature of stormwater systems and the impact of the built environment on stormwater flows.

[19] We found that return periods used in assessments differed between 1:100 years to 1:500 years.

Impacted EDBs' awareness of the importance of geotechnical hazards (weakened ground conditions resulting from heavy rainfall and flooding) is only very recent, and little work has commenced (concerning existing assets).

Concerning identifying assets vulnerable to earthquakes, we observed that impacted EDBs had identified these and had plans to address them (noting that the specificity of the plans varied across AMPs). Mitigation plans for seismic vulnerabilities typically involved upgrading existing structures to close to NBS[20] and replacing higher-risk distribution assets (like large pole-mounted transformers or regulators).

Concerning identifying assets vulnerable to non-seismic hazards, we observed that impacted EDBs had generally identified specific vulnerability for key assets (substations and subtransmission) for hazards that are material to their networks (e.g. snow, tsunami, volcanic activity, coastal inundation, wind). Asset vulnerabilities at a distribution level were often identified generally (e.g. by asset type) rather than by a specific asset. Mitigation plans for these vulnerabilities were generally incremental, except for the most high-risk subtransmission or zone substation assets. By incremental, we mean that impacted EDBs plan to upgrade the assets to current standards as part of asset renewal programmes or other network "hardening" programmes.

Concerning flood and geotechnical hazards, there could be unknown vulnerabilities for some impacted EDBs as mitigation plans are mostly not yet formed. Those impacted EDBs where flooding was a more recent issue showed a greater level of maturity in understanding flood hazards and associated network vulnerabilities. The "state of play" for these hazards reflected the risk that these hazards present and where the impacted EDB was in its resilience programme. Our observations were that for all other hazards, there was a good understanding of asset vulnerabilities and mitigation plans were being formed or were in place.

Our observation concerning the flooding in Unison

Unison sustained flood damage at two zone substations due to the overtopping of stop banks, which had 0.5m of clearance above a 1:100-year flood level. The stopbanks were intended to mitigate the flood risk but failed.

Unison also sustained damage to subtransmission and distribution lines that crossed river flats. The damage was caused by flood water and wood slash from stop bank breaches.

Unison had installed poles within the stop banks. Whilst the vulnerability of these poles to flood waters was known (and considered low risk), Unison did not anticipate the damage to these poles from wood slash.

7.3 Implementation of current design standards

Concerning design standards, there are two factors we assessed:

- The adequacy of the standards (and specifically in relation to Cyclone Gabrielle);
- The implementation of those standards.

Firstly concerning adequacy, current design standards respond to natural hazards. Current structural design standards use a "limit state" technique that addresses earthquakes, wind, and snow (and ice in the case of line design).[21] The design limits specifically consider the post-disaster function. For buildings, the return period for

[20] The standard varies from 67% of NBS, 75% of NBS, upto 90% NBS (IL4).

[21] AS/NZS 1170 structural design series (there are multiple standards within the series).

the structural design depends on the building's importance level. Facilities with special post-disaster operations are assigned IL4. Utility buildings not designated as post-disaster are given IL3. For a 50-year design life, the return period[22] for seismic and wind events are 1:2500 years for IL4 and 1:1000 years for IL3.

Overhead line design has a different standard that uses the limit state design principles and accounts for hazard response.[23] The standard covers earthquake, wind, snow and ice loadings. However, the importance level is replaced with security levels (1, 2, or 3). Level 3 is for lines that serve a post-disaster function and have high economic and safety consequences if they fail. Level 2 is for lines with low economic and safety risks and where alternative supply can be provided. Return periods for wind loadings are somewhat lower, with Level 3 being 1:200 years and Level 2 being 1:100 years (for a 50-year design life).

Flooding, tsunami, volcanic activity, and coastal inundation are outside the structural design codes and are considered during site selection and the civil design of foundations and stormwater. Our observation is that there appears to be more discretion on how the design should respond to these hazards and more reliance on local council guidance on design parameters (i.e. as far as we could determine, there is no "standard" flood level return period applicable for an IL4 building).

Concerning the application of the standards, we observed that impacted EDBs are building to an appropriate standard for post-disaster operations, generally assigning IL4 for control room facilities (or backup control room facilities) and zone substations. Some impacted EDBs assign IL3 (utility structures not designated as post-disaster) for minor zone substations.

Concerning line designs, impacted EDBs apply the current line design standard for new work (with most using the Catan line design software). Impacted EDBs assigned Level 3 (post-disaster function) for subtransmission lines and predominantly for distribution lines. Level 2 was assigned to some rural and remote rural instances.[24]

Figure 9 below estimates the percentage of overhead lines built to modern design standards. Based on the data we received and our knowledge of design practices at the time, we estimate that around 30% of the impacted EDB's lines were designed using modern design standards, with 12% being designed to the current standard.[25]

Our observations regarding Counties Energy line design

In 2020 Counties Energy adopted a more resilient design standard that uses 33kV insulators and wider crossarms on its 22kV distribution network. This standard reduces the probability of wind-blown vegetation, wildlife and conductor clashing in high winds. Counties Energy have now constructed 9% of their overhead fleet to this standard.

Concerning zone substations, modern performance-based building standards were introduced in the early 1990s, and the current structural design codes were introduced in the early 2000s. The standards have been

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22 Referred to as annual probability of exceedance in the standards.

23 AS/NZS 7000:2016.

24 Our assessment of how the line design standard is applied was not exhaustive.

25 Generally for new line routes a full line design under the current standard is undertaken. When a line is being renewed, the design often applies a standard design to the existing line route and pole positions, with full line design being applied when there are unique or difficult features on the routes. The standard design meets the current design standards.

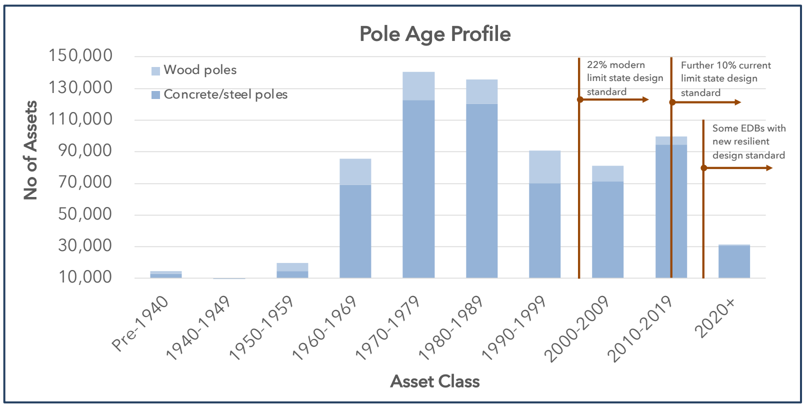
progressively revised since. Based on the age profile of zone substations,[26] we estimate that around 35% of impacted EDB zone substations were designed using the current structural design codes. Many earlier substations have since been upgraded, so the exact number of zone substations that meet modern design standards will be much higher (and we observed some impacted EDBs have brought all their zone substations up to 90% of IL4).

An observation is that the wind action structural standard[27] includes a modifier for climate change, but currently, the applied factor is 1.0 (i.e. no uplift in design windspeed). In today's climate, for a 2021 standard, this seems odd.

Design limits for flood resilience appeared to vary (due to what we believe is a lack of standards). For IL4, we observed impacted EDBs using 1:100 year, 0.5m above 1:200, and 1:500 year return periods as the design criteria. It is difficult to assess the robustness of these flood resilience standards other than to note that they appear to be lower than seismic and wind parameters for IL3 or IL4 buildings (which are 1:1000 to 1:2500, but noting the risk to life differences between the hazards).

We couldn't observe how impacted EDBs were implementing non-structural and non-flooding hazard mitigation in site selection or civil design other than to note that these are mentioned in some AMPs as risk considerations.

Figure 9: Pole age profile and estimate of modern design standard[28]



Our observations of design standards vs Cyclone Gabrielle conditions

The following paragraphs provide a brief assessment of the adequacy of the design standards in relation to Cyclone Gabrielle wind conditions.

The design return period for an IL4 building (for a 50-year design life) for wind is 1:2500. For IL3, this is 1:1000. The base windspeed applicable to a 1:2500 return period ranges between 170 km/h and 200 km/h (depending on location), and for IL3 this is 165 km/h to 195 km/h.

The design return period for a Level 3 overhead powerline (for a 50-year design life) for wind is 1:200 and 1:100 for Level 2. For Level 3, based on the current wind standard,[29] the base windspeed is 155 km/h for

[26] 2022 IDs, Sch. 9b, Zone substation 66kV and below and 110kV.

[27] AS/NZS 1170.2–2021.

[28] 2022 IDs, Schedule 9b for wood poles and concrete poles and steel structure asset classes.

[29] AS/NZS 1170.2 (wind action).

the central and upper North Island and up to 183 km/h for Wellington. Level 2 base windspeeds would be around 5 km/h lower.

Several wind speed modifiers are applied to derive the design wind speed for the site. These can increase the design windspeed by upwards of 50%. However, some of these factors (e.g. lee zones) are not applicable in Northland, Auckland, parts of the Coromandel, Tairāwhiti and Hawkes Bay, meaning the design windspeed increase may only be between 0% and 15%.

During Cyclone Gabrielle, weather stations recorded wind gusts upwards of 140 km/h to 150 km/h. Higher wind speeds may have occurred due to local topographical influences (similar to the design windspeed modifiers).

The recorded maximum gusts were comfortably below the base wind speeds for building design but much closer to base windspeeds applicable in overhead line design.[30] Topographic factors influence the actual windspeed, so the true windspeed in some locations was very likely higher.

Whilst we didn't collect quantitative data on unassisted failures of new poles (post-2000), none of the rural impacted EDBs received reports or anecdotes of unassisted new pole failures. This suggests that the current design standards were sufficient.

7.4 Historical asset design standards

The design limits used in historical design standards were lower (or, more specifically, the design limits in current standards have been raised materially). Knowledge of hazards and their return periods has also matured significantly over recent decades.

Concerning line design, the limit state design approach was included in the pole design standard from 2000, albeit without any differentiation for post-hazard performance.[31] The base windspeeds codified in that document were similar to the current standard. We did not go back and check older standards, but based on our knowledge of prior practices, older standards and their application were less robust before the 1990s and 2000s. Hence, older structures will be more vulnerable to the hazards mentioned above.

As noted in the call-out box above, the windspeeds experienced during Cyclone Gabrielle were very close to current design limits. Hence we believe that it is highly likely that the windspeeds in certain locations were above the design limits for older (pre-2000) poles.

7.5 Network security and the extent that the network met its security standards

Resilience and network security are not the same. However, network security, with its inherent redundancy, can form a component of resilience (refer to Section 4.4 for further details). Higher network security levels aren't the only means to provide resilience but are a good foundation to build on. How EDBs apply network security in future network architecture may change as DERs and other new technologies (that can provide alternatives to lines and cables) become more widespread.

The level of security afforded an area of the network differs due to the size of the load and the number of customers supplied. EDBs have their own security standards, and these are typically outlined in their AMPs.

[30] We only assessed wind gusts from NIWA weather stations in Tairāwhiti region, Northland and in the Far North.

[31] AS/NZS 4676:2000.

We observed that around 60% of customers on the impacted EDB networks were supplied from zone substations with N-1 security (there were many more supplied by N-1 Switched zone substations), and around 85% of customers were currently supplied by zone substations that met their stated security standards. We observed that where the substation didn't meet the security criteria, upgrade or contingency plans were in place.

Regarding distribution feeder security, around 80% of all customers on impacted EDB networks were supplied from feeders with N-1 Switched security. 100% of customers will generally not receive N-1 switches security due to the radial nature of electricity network architecture where the customers towards the end of feeders are on dead-end spurs with no alternative supply.[32]

7.6 Communication network security and network control room backup

Another important aspect of security is that of the SCADA communication system and backup control rooms. Based on the data provided by the impacted EDBs, 84% of zone substations have communication path redundancy, and all have backup or standby control rooms in different locations. Zone substations without communication backup are typically located in remote rural areas with limited communication options.

7.7 Maintaining assets in an appropriate condition

The condition of an asset can impact its ability to withstand the forces of nature. Rotting wood poles and wood crossarms reduces the number of wood fibres that can resist external forces. Degradation of concrete can lead to rusting of steel reinforcing, thereby decreasing the pole strength that can resist external forces.

EDBs undertake condition assessments, and each year they disclose the health of their asset fleets as part of their AMPs. Health is measured on a scale between H1 and H5, with H1 meaning "end of serviceable life, immediate intervention required", H2 meaning "material deterioration but asset condition still within serviceable life parameters, intervention likely within three years", through to H5 being "as new condition".[33] Figure 10 illustrates how the health scale works. EDBs use a mix of condition information and aged-based assessments to determine asset health, so there will always be some uncertainty in the ratings assigned; with that said, EDBs have been assessing and forecasting asset health for a decade, so the practices and data are now mature.

EDBs have policies for the replacement of H1 and H2 assets, which often vary based on the criticality of the assets (e.g. for critical assets, the replacement may occur as soon as the asset deteriorates to H2, and for other assets, this could be when the asset reaches H1).

We assessed the condition of distribution and subtransmission lines of impacted EDBs, and the results are shown in Figure 11 below. Other than wood poles, the number of assets with H1 health is around 0.5% of the population. Wood poles are an old asset fleet, and for all impacted EDBs, wood poles are subject to extensive replacement programmes. We consider that the level of H1 wood poles (at less than 3%) is consistent with where these assets are in their lifecycle and the renewal strategies of the EDBs. Poles within the fleet continually deteriorate to H1 health and are continually being replaced as they reach H1 health. Hence, at any time, there will be a small population of H1 health poles.

[32] We didn't receive a full dataset for this assessment.

[33] EEA, "Asset Health Indicator Guidelines", 2019, Table 5.

To give the wood pole fleet context, they represent 13% of the total pole fleet. H1 health poles make up less than 0.6% of the entire pole fleet.

Figure 10: Asset health measurement

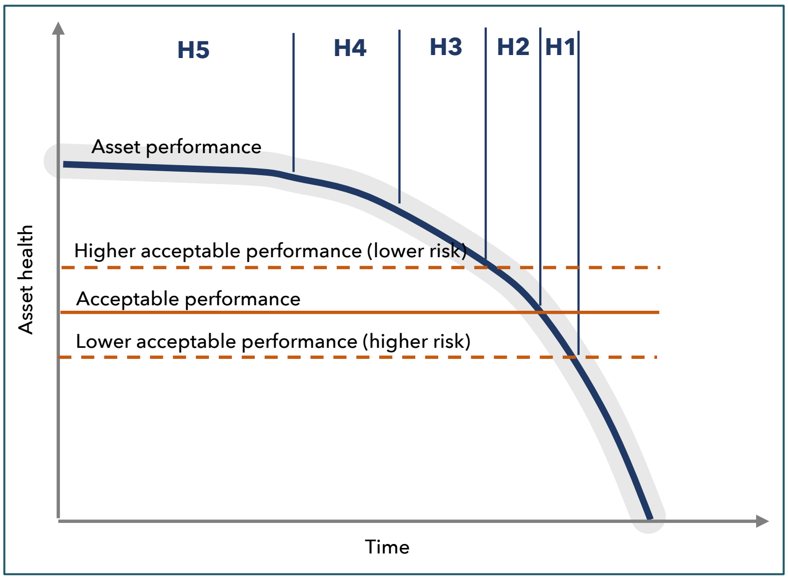
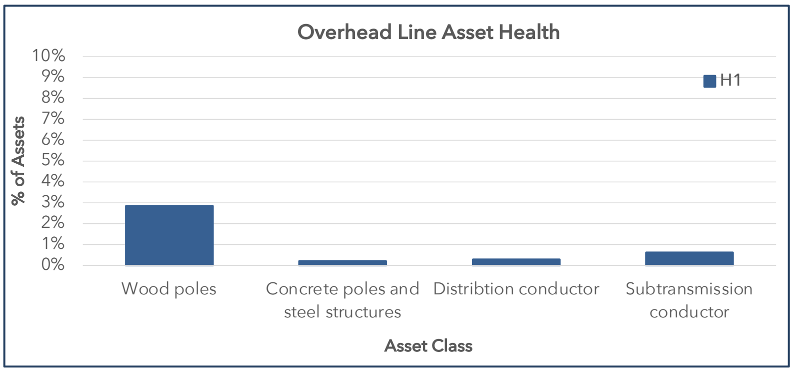


Figure 11: Asset health measurement



7.8 Vegetation management

Management of vegetation near lines is a significant undertaking for EDBs. Impacted EDBs spent $149m on vegetation management over the past five years[34] (105% of budgeted spend). This was a 70% increase over the prior 5-year period and now represents 21% of the total maintenance budget (up from 16% in the preceding five years).

Management of vegetation near lines is controlled by the Electricity (Hazards from Trees) Regulations 2003. EDBs may notify tree owners to cut or trim trees that encroach the growth limit zone near lines. If tree owners fail to act, or elect not to, then EDBs can cut or trim the tree. The growth limit zones are 1.5m for distribution lines and 2.5m to 3.0m for subtransmission lines (depending on voltage).

For the most part, EDBs have learnt to work within the regulations, and in-zone vegetation only accounted for 16% of the total customers-off due to vegetation causes.

34 FY2018 to FY2022.

The tree regs currently only deal with part of the problem. As discussed in Section 6.2, outages from out-of-zone trees (trees outside of the growth limit zone) were a material issue, and EDBs have no right to cut or trim trees that present a fall risk outside the growth limit zone. This gap in the tree regulations inhibits the proper management of hazards to the lines and impacts resilience. The ENA (on behalf of EDBs) submitted on the current review of the tree regs recently.[35] This document contains more details on the issues being experienced.

Vegetation is a material cause of outages during a normal year and, over the past five years accounted for 23% of customer interruptions (as measured by SAIDI).

We do not have the data to assess whether the vegetation management spending has been effective and appropriate. However, given the relatively low contribution from in-zone vegetation to the customers interrupted, the increased spending on vegetation management, and the reliability incentives and penalties that apply[36], we consider that EDBs are most likely doing a reasonable job at managing vegetation within the rules available to them.

8. Readiness activities

8.1 Introduction

Weather events and emergencies are common for EDBs, which has driven a high level of preparedness across EDBs. The brevity of this Section probably downplays the extent that impacted EDBs were ready for this event.

In this Section, we assess how ready EDBs were for Cyclone Gabrielle. This covers their overall planning, exercises, mutual aid arrangements, and specific readiness as the cyclone approached New Zealand.

We obtained information from impacted EDBs on their emergency management documentation, the exercises they had recently undertaken, and how they prepared in the week leading up to 12 February. Impacted EDBs provided a comprehensive event timeline, describing any constraints they encountered and how they were overcome. The event timeline covered the control structure, network control centre and network communications, intelligence, resourcing to affect repairs, and communication with customers and stakeholders.[37]

8.2 Emergency management plans

All impacted EDBs have well-documented plans for dealing with emergencies on the network. Whilst every EDB's plans are slightly different, we observed the following common documentation:

- An emergency response plan;
- Specific storm major event management plans;
- Contingency plans for various incidents (e.g. the loss of the control room);

[35] https://www.ena.org.nz/submissions/previously-published-ena-submissions/2023-submissions/document/1301

[36] The majority of EDBs (17 of 29) are subject to to price-quality regulation that includes incentives for good reliability and penalites for poor reliability.

[37] We received detailed timeliness from impacted EDBs. We received other narrative information from Vector that a good overview of their response.

- Various supporting processes and procedures to support CEDM interactions, customer communication, staff wellness management, planning and preparation, use of generators, logistics, field operations, restoration prioritisation guidance, etc.;
- Participant rolling outage plans (a requirement under the electricity code).

The documentation was generally controlled and, therefore, part of formal review processes.

The depth of documentation varied between EDBs, with the larger impacted EDBs having a more comprehensive suite of documents. Our view was that these differences reflected what was "fit for purpose", given the scale of the business and the number of people typically involved in emergency management.

Some EDBs (mainly the larger EDBs) have adopted the CIMS. The CIMS is the standard structure in New Zealand for the command, control and coordination of emergency response (as used by NEMA and all emergency agencies). In theory, this should make it easier to communicate and coordinate with CDEM, NEMA and other agencies.

We believe the impacted EDBs have appropriate emergency management plans that can respond to weather events.

8.3 Mutual aid arrangement

In our review of documentation and preparedness, we did not see much formality in mutual aid arrangements (however, this may have been more to do with our information request than the absence of formality). Mutual aid has been used often in past regional events, and our understanding is that most arrangements are made on an ad-hoc, event-specific basis. Hence, before Cyclone Gabrielle, it was reasonable to continue to rely on prior ad-hoc arrangements.

8.4 Exercises

All impacted EDBs had undertaken specific exercises or had recently responded to weather emergencies. The previous events (which all add to the learning of the organisations) included:

- Cyclone Hale;
- Cyclone Dovi;
- Tsunami threats/warnings on the East Coast;
- National grid emergency in June 2022;
- Auckland flooding in January 2023;
- Various medium/moderate storm events over the past 24 months (which seemed to be experienced by most of the impacted EDBs to varying degrees);

Exercises have covered a much wider array of events than cyclones. We also noted many specific exercises, including simulated earthquakes, volcanic eruptions, Transpower grid emergencies, simulated control room emergencies, and generation shortfalls in Hawkes Bay.

We believe EDBs were well-practised in emergency management and generally had experience in various events, including many weather events.

8.5 Specific readiness activities for Cyclone Gabrielle

Cyclone Gabrielle's approach was well-signalled. Tracking commenced around 06 February; weather watches were issued on 10 February, warnings were issued on 11 February, and the event started on 12 February (with the most significant impacts on 13-14 February).

Our observation was that all impacted EDBs prepared very well for the event, including:

- Monitoring the weather forecasts to understand the likelihood of the event affecting them;
- Ensuring the control room and network communications were operating (and some repairs were made pre-event);
- Preparing emergency management structures, assigning resources, organising backup, and organising rosters (this activity appeared more in-depth for larger EDBs, or where major storms were a more regular occurrence). This work included various arrangements to deal with the large volume of work orders expected with the event. Five of the nine impacted EDBs used the CIMS structure;
- Testing backup systems (e.g. control room power supplies and fixed generators);
- Initiating the emergency management structure before the event;
- Organising a supply of portable generators and checking stores. Those EDBs that had previously experienced access issues relocated materials to regional depots (as a contingency);
- Cancelling planned work for field crews;
- Preparing the field resources (readied the vehicles with on-truck materials) and ensuring support personnel were in place. Those EDBs that had previously experienced access issues relocated resources to regional depots (as a contingency);
- Only a couple of the EDBs sought to arrange external field resource support;
- Some also confirmed stakeholder communication contacts and arrangements, and most commenced with general per-event public communication.

The extent of the preparations appeared to be appropriate for a large storm event. Our review of the watches and warnings did not suggest it would be of the intensity it was. It is a challenging judgement as to how extensively to prepare. Weather watches aren't a certainty, nor are all weather warnings accurate. We believe that all impacted EDBs took the watches and warnings seriously and prepared accordingly. In our opinion, it is only with hindsight could we be critical of the preparation efforts. And in saying this (as noted below), there were constraints in increasing resources and portable generators further.

We observed some EDBs seeking to arrange external resources from neighbouring EDBs or large contractors. However, given the extent of the forecast impact, the availability was limited, given commitments elsewhere. With hindsight, resources could have been moved from the South Island. However, this would have been a costly exercise given that (at the time the call needed to be made) EDBs were following weather watches only.

We also observed that several EDBs experienced constraints in booking generators as these had already been committed to other regions. However, this indicates a potential shortage of large portable generators.

In our opinion, the preparation by EDBs was excellent and appropriate. Given the information available to them, we believe the judgement exercised by EDBs was reasonable at the time.

How EDBs responded

9. Sector response to Cyclone Gabrielle

9.1 Introduction

In this Section, we assess how EDBs responded during Cyclone Gabrielle. This covers their control structure, network control centre and network communications, intelligence, resourcing to affect repairs and communication with customers and stakeholders. We have focused more on constraints and solutions rather than listing work activities.

As mentioned in Section 8.1, we obtained a comprehensive event timeline from impacted EDBs. This included describing the key activities, constraints, and how these were overcome.

9.2 Control structure

In terms of the overall control structure (i.e. the overall management, not the operational roles within the structure), we think these worked well with only a few resourcing constraints. We observed that the emergency controller needed to manage stakeholder interactions (discussed in Section 9.7) and that various workarounds (including resource constraints) required implementation. In our view, these are just "normal" things that the emergency organisation needs to adapt to—there will always be failures and issues to deal with in an emergency. Our review of the reports provided by impacted EDBs suggested that appropriate agility was exercised, that issues were competently managed, and that the response efforts were not unnecessarily disrupted.[38]

9.3 Network control centre and network communications

The network control centre was a pressure point for all impacted EDBs, and for some, there were constraints with network controllers and dispatchers that would have affected restoration times.

All the impacted EDBs have processes to expand the number of people involved with network control and dispatch of jobs. Generally, this is achieved by separating duties (by role, region, or sub-region) and assigning responsibilities down the line. Our sense from the reports we received was that the escalation process is largely routine. However, due to the scale of Cyclone Gabrielle, the ability to expand was constrained by the number of trained people within the EDBs (this being more acute in the smaller EDBs). This constraint is also related to various support roles. Resourcing is an area where improvements are possible.

The failure of the public telecommunication networks (cell towers running out of battery backup) impacted communication with field staff (both voice and data). Radio communication was used as the fallback.

[38] Examples of issues includes: (a) The loss of the public telecommunication in Gisborne meant that Firstlight lost access to its cloud based GIS, and needed to revert to older manual recorded for a time; (b) The lack of communication from CDEM on restoration priorities, so these were determined by the EDB; (c) Various logistical challenges due to the road network failures; (d) The disruption in communications between Napier and Hastings and the need to re-route via other comms paths; (e) Deploying generators to communication repeater sites; (f) Setting up credit facilities at petrol stations when eft-pos failed due to public telecommunications outages; (g) The inability for CDEM to provide a clear status of the roading network, so access discovery was undertaken by EDB staff; (h) managing resourcing and fatigue issues;…the list could go on, and on…

Our observations regarding Northpower and Orion

Due to commonality in SCADA/OMS systems and processes, Orion sent two network controllers to Northpower to relieve some of the constraints in the control room. These network controllers went through a half-day induction and then were supported by Northpower engineer staff to assist with gaps in local knowledge. This enabled Northpower to upscale the control room from two to four desks (during the day shift).

Across EDBs, two SCADA/OMS/ADMS systems are becoming common–the GE PowerOn and OSI Monarch. Provided EDBs implement similar processes, terminology, and symbology, network controllers should become transferable between EDBs in an emergency within these two platform groups. However, network controller resource escalation will have a natural limit due to the resource pool size and the host company's limited engineering buddy support.

9.4 Intelligence

EDBs maintained communication to their zone substations (except for Unison[39]) and remote devices (other then when cellular network failed). As mentioned in Section 7.6, EDBs generally have redundancy for core network communications.

Several EDBs have access to data from their own smart meters. This data provided important intelligence on the faults occurring (e.g. part power). If OMS systems allow, access to smart meter data could assist in understanding the extent of LV outages, particularly for medically dependent customers.

The failure of the public telecommunication networks was a serious issue (either through damage to backhaul fibre cables or cell towers running out of battery backup). In the case of Firstlight, the failure prevented the public from being able to report lines down and other electrical hazards. In the case of Vector, this impacted communication to some remote devices.

Gaining intelligence was also impacted by the weather, restricted access to helicopters in some areas (as these were prioritised to search and rescue), and roading failures.

The scale of the event also caused some system performance issues. Some EDBs had not completed implementing their OMS modules, which caused system constraints.[40] Completing these implementations is an obvious action.

Like the network control centre, intelligence gathering was a pressure point for the EDBs that sustained serious damage. We believe EDBs managed this area competently, implemented manual workarounds, and managed resource constraints appropriately. Our comment on the resource constraints made in Section 9.3 also applies here. However, we didn't observe anything suggesting that constraints in this area materially impacted restoration times.

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[39] Unison experienced disruption in communications between Napier and Hastings due to multiple bridge failures. Communicartion was re-routed via other comms paths.

[40] Our observation was that the fully implemented outage management systems generally worked well. However, those with the system partially implemented did not fair as well.

Our observation concerning WEL Networks smart meter data

WEL has developed conductor-down algorithms with data from the WEL Smart Meters. This proactively notified WEL when these faults occur during storm events.

WEL also use their smart meters to detect network faults such as broken neutrals. During major weather events, WEL analyses all HV circuits livened to assess whether there are further LV faults in the area. These LV faults could damage customers' property or present a safety hazard to the public and staff. WEL has a dedicated team overseeing LV fault safety and restoration during storm events.

9.5 Resourcing to affect repairs

Repairing the damage and restoring supply was a pressure point for all seriously impacted EDBs. Our observation was that more resources would have assisted in restoring supply quicker for those businesses. As the event progressed and the scale of the damage had been determined, additional resources were brought in. However, the commitment of resources elsewhere and the roading access issues limited the numbers available.

Field resource escalation has its limit. In this case, due to the number of companies impacted (restricting availability, see Section 8.3) and roading damage (restricting access into affected regions). There is also a natural logistics and management limitation within EDBs, and also a limitation due to familiarisation and differing standards. External contractors typically require support for switching and permitting (to control safe access to the network) and access to materials used by the EDBs. This utilises staff that would otherwise be undertaking restoration work or supporting EDB field resources (and partner contractors). Hence, staff can be assigned to external contractors (which may be on a 1:3 to 1:4 ratio), but this has limitations to avoid hollowing out the existing teams.

Greater standardisation of materials and practices will assist. However, our history with the sector suggests this will be a difficult nut to crack (and you'll still be left with logistics and road access constraints).

In our opinion, resource escalation was actioned reasonably within the constraints of this event. There are definite opportunities for improvement, but these will be incremental, not step-change.

Unison and Transpower restoration efforts in the Hawkes Bay

Our discussions with Unison and hearing comments in various forums from Transpower indicated how closely the Unison and Transpower teams worked to restore supply. They worked as one team to develop innovative solutions for how electricity could be routed through Transpower's grid and Unison's network. This extended to how protection schemes were reconfigured. We understand that coordination and support from Genesis was also needed and was very much forthcoming.

Transpower has completed its review, which comments on the grid contingency plans developed before the event and their work with Unison and Genesis.

9.6 Communication with customers and stakeholders

We reviewed how EDBs communicated with customers, and in our opinion, this was comprehensive and utilise multiple channels (web, exchange phone messages, social media, radio, print in some cases, media stand-ups and releases, directly to CDEM to disseminate) and implemented workarounds where necessary. Communications covered preparation, safety messages, general updates, and specific updates (when restoration times became clearer). We noted that EDBs generally received positive feedback on their communications. Other than the two points made below, we don't have anything to add, as this is an area of strength for EDBs.

The failure of the public telecommunication networks (either through damage to backhaul fibre cables or cell towers running out of backup) reduced the quality of customer communications. In the case of Firstlight, they reverted to hand-delivering messages to local radio stations and CDEM to disburse to emergency centres.

The Florida Power and Light difference[41]

Florida Power and Light has approximately six million customers and is Florida's largest electricity provider.

A key part of the FPL framework, which is unavailable in NZ, happens once an emergency is declared. FPL can access the customer contact information from retailers and send email/SMS/voicemail to customers who have not previously opted into communications with FPL. This enables FPL to communicate directly with all its customers. FPL follow a hierarchy of messaging that starts with broad messaging giving an overview of the situation, and becomes more granular as the restoration progresses over several days or weeks.

The customer information is securely destroyed after the event.

For more information on how FPL responds to extreme events, please use this link: https://www.fpl.com/storm.html

EDBs generally have the same approach to messaging but do not have the same access to customer information from the retailers, so they need to rely on less targeted channels such as websites, social media, and mainstream media (as well as encouraging customers to opt-in to notifications where the EDB provides this). Gaining access to customer data during events, particularly where EDBs OMS systems can utilise this, would allow targeted communication. This would be very useful in communicating outage restoration times to specific customers.

9.7 Communication with CDEM

EDBs participate in local CDEM operations. CDEM provides information, receives information, and coordinates restoration priorities. Our review of information from impacted EDBs highlights three issues that could warrant improvement:

- In some cases, there was an incompatibility between the GIS systems used by CDEM and EDBs. This limited the ability to extract information on critical sites;
- In some areas, CDEM was not able to provide information on critical sites that could be used to prioritise restoration or the installation of portable generators;
- In some areas, CDEM did not have a handle on the state of the roading network, and the information didn't appear to be improving.

EDBs implemented workarounds for these issues. The work done by EDBs may not have optimally prioritised generator use, and EDBs needed to dedicate resources to assess access (which prevented them from doing other work associated with restoring supply).

[41] Thanks to Vector for sharing this case-study with us.

9.8 Overall comments

Our overall comment concerning restoration is that EDBs did an appropriate job restoring supply and competently responded to a wide range of issues. We believe there are incremental improvements that can be made that will enhance restoration and improvement communication with customers.

Our write-up above noted a range of resource constraints and natural limitations to resource escalation. When we considered resourcing (from outage notification through to restoration in the field), it was difficult to pinpoint what areas impacted productivity and what was the "binding" constraint—was it control decision-making, network controllers, dispatchers, intelligence or field resources? The pinch point likely changed as the event progressed. Our overall view is that if constraints can be eased across the supply chain, productivity will likely improve, EDBs could increase field resourcing, and achieve the best restoration results from the available resources.

What are the learnings and improvements?

10. Strategy, lessons, and improvements

10.1 Introduction

EDBs provided us with their lessons learnt. We reviewed this information and have extracted what we believe is relevant to the sector. We have also prepared our view of lessons learnt and areas for improvement.

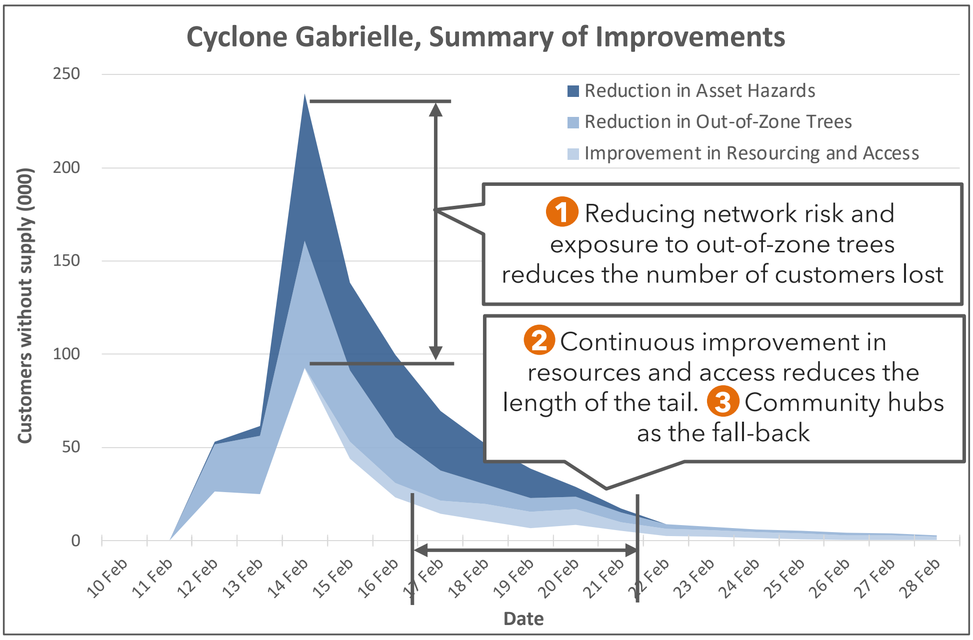
We start this Section with our view of the most important issues or strategies for improving resilience. We then drill down into specific issues and recommendations.

10.2 Strategies to make a material improvement to resilience

We believe that a combination of strategies is needed to improve resilience—to reduce the height and length of the customer-off curve. Referring to Figure 12 below, we have identified three key activities:

1. **Remove hazards.** This involves addressing the risk posed by out-of-zone trees, upgrading some specific critical assets that are vulnerable to hazards, and incrementally hardening the network as assets are renewed. This activity will take time and investment, and the investments will need to be appropriately tested for alternatives and affordability.
2. **Continuously improve resourcing and access.** Improvements to resourcing and contingency plans to deal with access will help shorten the restoration "tail".
3. **Develop secure community hubs.** Due to our topography, vulnerabilities in the roading networks, and the types of damage that can occur, there will always be some hard-to-restore customers. For these customers and communities, having community hubs with a secure standalone supply of electricity and communication will provide support while restoration or alternatives can be brought online.

Figure 12: EDB resilience improvement strategy



We believe the focus should be reducing risk as this will be the most effective in reducing customer outages. These are generally hard controls and will therefore be effective over the long term. Reducing the number of customers without supply (the curve's height) also reduces the workload pressure on resources, lowering resourcing constraints. The risk reduction investments could take a decade to make a difference (depending on the speed of investment). Hence community hubs will be an important safety net while hazard reduction and other improvements are made.

10.3 Primary learnings and improvement actions

Table 3 contains the learnings and improvements that support the strategies mentioned above. This is our general view based on the learnings from EDBs and the analysis in this report. These are suggestions, and the adoption by the sector and EDBs is at their discretion and will differ due to EDB's specific circumstances.

We suggest preparing several contingency plans. We see these are a way to codify learnings for later use.

Table 3: Primary learnings and improvements

Learnings	Strategy	Action
Out-of-zone trees were the largest cause of customer outages and could not be mitigated prior due to the narrow focus of the current tree regs	Risk reduction	**1. Mitigation of out-zone tree risk** (a) The ENA should work with MBIE on the review of the Electricity Hazards from Trees Regulations to widen the corridor where vegetation can be controlled and to make the control regime more effective. (b) The ENA should work with the Commerce Commission on a process to allow additional vegetation management opex required to fund the extra costs of widening the line corridor. This may require a pass-through cost mechanism (or other method) depending on the timing of the tree reg amendments.
There appear to be differences in standards for post-disaster performance concerning flooding and wind action (for line design)	Risk reduction	**2. Align standards for post-disaster performance across hazards and asset types** (a) EDBs (most likely via a working group) should define the standard for post-disaster flooding resilience. We suggest this should result in the same level of risk as the IL4 standard for other hazards.[42] (b) Concerning overhead lines, EDBs should define an appropriate wind standard for post-disaster performance.[43] [44] We suggest this should result in the same level of risk as the IL4 standard. [45]
The vulnerability of subtransmission and zone substations to hazards was a material cause of customer outages	Risk reduction	**3. Harden subtransmission and zone substation assets** (a) EDBs should assess the vulnerability of all key routes and sites for new hazards (e.g. flooding, geotechnical, concentration of assets along single routes, river crossings) and determine the possible

[42] We note that the IL4 standard is seeking to deliver performance that prevents the lost of life. Flooding may not pose the same threat to life as earthquakes, however, the same post-disaster performance outcome is required regardless of whether the hazard is an earthquake, wind, snow, or flooding.

[43] Security Level 3 under AS/NZS 7000.

[44] This could be addressed by changing the return period or by applying a climate multiplier to windspeed under AS/NZS 1170.2 (wind action) when it is applies to overhead lines.

[45] Refer footnote 42.

Learnings	Strategy	Action
		network projects to mitigate the risks (asset upgrades, hazard protection, or relocation). (b) EDBs should complete the other hazard and vulnerabilities assessment (where these are still progressing). (c) EDBs should assess network resilience projects against other alternatives[46] (to deliver a similar post-disaster performance). This may lead to the installation of permanent alternatives to network upgrades. (d) EDBs should progressively harden the subtransmission network and zone substation to modern standards. (e) EDBs (most likely via a working group) should work with the Commission Commission to allow additional resilience spend. This may require an industry-based explanation of the resilience vs. affordability trade-off and how the expenditure supports electrification. (f) EDBs (most likely via a working group) should work with the Commerce Commission and the Electricity Authority to enable EDB investment in resilience alternatives (including implementing appropriate market controls).
Transmission outages were a material cause of customer outages	Risk reduction	**4. Assess transmission vulnerabilities and coordination contingencies and solutions with Transpower** (a) EDBs should obtain information from Transpower on vulnerabilities that could impact grid supply and any contingency plans that Transpower has developed. (b) EDBs should work with Transpower to prepare any further contingency plans and EDBs solutions for any material risks.
Adverse weather damage to the distribution networks was a material cause of customer outages	Risk reduction	**5. Progressively harden the distribution network** (a) EDBs should progressively harden the distribution network to modern standards as assets are renewed. (b) EDBs should assess the incremental cost of hardening vs. alternatives[47] (to deliver a similar post-disaster performance). (c) The ENA could investigate the merits of a service line ownership review if this area impacts safety or resilience. (d) Same as 3 (e) above.
The length of the outages in some areas caused communication sites to lose power (or were at risk of losing power)	Risk reduction	**6. Progressively harden the SCADA (and voice) communication network** (a) EDBs should assess the vulnerability of all key network communication sites (e.g. flooding, geotechnical, concentration of assets along single routes, river crossings) and evaluate the adequacy of communication battery backup for a long-duration event.

[46] This may be local standby generation, enhanced spares, specific contingency plans, etc…

[47] This may be local standby generation, enhanced spares, specific contingency plans, or the provision of resilience at the customer premise.

Learnings	Strategy	Action
		(b) EDBs should determine possible network projects or contingency plans to mitigate risks and implement them based on criticality.
Constraints on resourcing impacted restoration efforts	Continuously improve resourcing and access	**7. Adopt CIMS and increase training to expand the resource pool** (a) We suggest that EDBs should use the CIMS structure for emergency response. This will assist with options for external resource support, allows access to training courses, and builds transferable staff skills. (b) EDBs should strengthen role descriptions, expand training, and prepare a competency register for CIMS roles and other roles where constraints occur. This could include LV dispatchers, control room support roles, and field resource support roles. (c) EDBs should include an activity in their emergency response plan to prepare a multi-day staffing roster ahead of a large event. The roster will need to comply with the EDB's fatigue policy. (d) There could be merit in sharing learnings from best-practice CIMS operators.
		8. Develop internal processes to enhance field resource mutual aid arrangements (a) EDBs should prepare plans to induct external field resources efficiently. We see these as EDB-specific (but an industry or regional working group may assist in establishing a template). The induction must cover safety, buddy system, local knowledge, communication protocols, logistics, and rapid onboarding. (b) EDBs should assess overall stock holdings in light of a Cyclone Gabrielle-size event occurring again.
		9. Develop network controller mutual aid arrangements (a) EDBs should establish an industry working group to assess commonalities in SCADA/OMS/ADMS operations (i.e. processes, terminology, and symbology) of the two main systems (GE and OSI) and, if possible, establish a standard that will allow sharing of network controllers. This should include a register of available resources. (b) EDBs should prepare plans to rapidly onboard network controllers for mutual aid. This needs to cover the safety, buddy system, and key processes.
Failure of the roading network impacted restoration efforts	Continuously improve resourcing and access	**10. Communication and contingency for roading vulnerabilities** (a) EDBs should work with regional CDEM to understand roading vulnerabilities and post-disaster protocols for determining roading issues. (b) Based on the roading vulnerabilities, EDBs should develop appropriate contingency plans (which may include pre-event relocation of materials and resources). (c) EDBs should develop a contingency plan for when access to helicopters is restricted (due to other CDEM priorities).

Learnings	Strategy	Action
		(d) EDBs should develop a contingency plan to access fuel supplies in the event of road closures or telecommunications failures that impact the ability to pay.
System constraints and performance issues likely impacted restoration efforts	Continuously improve resourcing and access	**9. Review the ability of systems to perform in an emergency** (a) This is an action specific to each EDB. In some instances, this will involve EDBs completing planned SCADA/OMS/ADMS upgrades or reviewing the SCADA/OMS/ADMS performance during Cyclone Gabrielle and making improvements as needed. (b) EDBs should prepare contingency plans for cloud-based systems when internet access is lost.
There will always be some hard-to-restore customers	Developing secure community hubs	**11.Develop secure community hubs** (a) The ENA should advocate for government support for establishing community hubs with robust standalone electricity and telecommunications, including ongoing maintenance and testing.

10.4 Other learnings are improvement actions

Table 4 contains other learnings and improvements that we believe are important. These are suggestions, and the adoption by the sector and EDBs is at their discretion and will differ due to EDB's specific circumstances.

Table 4: Other learnings and improvements

Learnings	Benefit	Action
EDBs did not have access to customer data for direct communication	Improve customer communication	**12.Customer data** (a) The ENA should assess the merits and ability of the sector to obtain and use customer data (for the period of the event) to directly communicate with customers concerning the event and restoration times.
Lack of information on critical sites and priorities for restoration impacted restoration efforts	Improve restoration	**13.Critical site information** (a) EDBs should work with regional CDEM to establish a critical site list and protocols for determining restoration priorities. (b) EDBs shall work with regional CDEM to assess the GIS compatibility and determine a solution to the issues experienced during Cyclone Gabrielle.
Some EDBs had access to smart meter data, which improved knowledge of LV faults	Improve network intelligence and enhance safety	**14.Smart meter data** (a) EDBs (via an industry working group) should assess the merits and ability of the industry to use smart meter data to improve information on LV outages and outages that impact medically dependent customers.
Failure of public telecommunication impacted the use of systems and customer communication	Improve customer communication	**15.Customer communications** (a) EDBs should develop contingency plans for the loss of the public telecommunication network (this should include the reporting of faults). (b) There is merit in sharing learnings from best-practice communicators.
EDBs practised excellent customer communication		

10.5 Commentary on areas we didn't prioritise

We didn't include any specific recommendation concerning formalising mutual aid arrangements and standardisation. In our view, the ad-hoc arrangements work sufficiently well, and any mutual aid arrangements will likely be only on a "reasonable endeavours" basis (meaning formal documentation carry no real weight). We also consider that greater standardisation for practices, designs and materials would be great. However, our experience is that this will consume a lot of time and resources and be extremely hard to achieve. Our suggestions relate to improving onboarding and support for external contractors.

10.6 Implementation approach

We have not specified any timelines or prioritisation with our recommendation. To do this needs greater sector input to determine. Most of our suggestions are EDB-specific, and it is for the individual EDB to assess the relevance of the recommendations and priority to them.

Concerning working group or ENA recommendations, the relevance and priority of these recommendations are best reviewed by a wider group. From here, an implementation plan can be developed.

10.7 Impact on expenditure

Implementation of the recommendations will impact EDB's forecast opex and capex. The asset hardening recommendation will increase capex. The management of out-of-zone trees, hazard assessments, vulnerability assessments, standards review, training, contingency planning, inventory holdings and remote depots will increase opex.

Non-regulated EDBs can pass these costs through (giving them due affordability consideration and benefit assessments), and regulated EDBs need to receive opex and capex allowances. We have suggested (above) that engagement with the Commerce Commission is required, and it may be difficult to achieve this as part of the DPP4 reset. Hence early engagement is recommended.

There is a "double duty" benefit of resilience and electrification expenditure. EDBs should be more fully explained to the Commerce Commission.

Our last comment is that it will always be difficult to determine whether the recent increase in cyclone and ex-cyclone activity is the start of a trend or just a one-off. Recognising this uncertainty, it does feel like some cost increases are warranted, given the economic costs involved in large-scale outages and the need to improve resilience given the forecast increase in electrification load.

11. Recommendation to the Cyclone Taskforce

Recommendations to the Cyclone Taskforce were made when this report was in draft. We have included these below.

What could Government help with to improve outcomes for customers?

- Regulatory support (funding allowances for regulated businesses) for optimal resilience investments across (balanced against affordability)
- Reducing the consenting hurdle for route diversity and for hardening of networks
- Better control over lines corridor to improve resilience – deal with trees
- Little direct financial support is needed, however funding of Community hubs could enhance support for vulnerable and hard-to-restore communities
- Fine-tuning NEMA response and support expectation of lifeline utilities
- Supporting the improvement of the quality of coordination at the regional/local CDEM
- Triaging of support for vulnerable customers

Other matters

12. Key terms and acronyms

The following key terms and acronyms are used in this report.

ADMS	Advanced Distribution Management System, which is a system that allows the real-time monitoring, optimisation, and control of a network.
AMP	Asset Management Plan
Capex	Capital expenditure
CDEM	Civil Defence and Emergency Management
CIMS	Coordinated Incident Management System
DER	Distributed Energy Resources are small-scale power generation or storage technologies used to provide an alternative to, or an enhancement of, traditional electricity networks.
Distribution	Refer to the network of feeders.
DPP	Default Price Path is the default price-quality control applied to most EDBs that involve capping the total revenue the companies can earn from their consumers and requiring them to maintain their average quality to certain levels.
EDB	Electricity Distribution Business
ENA	Electricity Networks Aotearoa
Feeder	High voltage lines and cables (typically 11kV or 22kV) that distribute electricity from a zone substation around suburbs and rural areas
GIS	Geo-Spatial Information System is a computer system that analyses and displays geographically referenced information.
GXP	Grid Exit Point, which is the point of connection to the transmission grid
HILP	High Impact Low Probability event
IL	Importance Level of a building under the national building standard and AS/NZS 1170
kV	Kilo volts
N	A measure of network security. Refer to Section 4.4
N-1	A measure of network security. Refer to Section 4.4
N-1 Switched	A measure of network security. Refer to Section 4.4
NIWA	National Institute of Water and Atmospheric Research
OMS	Outage Management System is a computer system used by operators of distribution systems to assist in restoring power.
Opex	Operational Expenditure
RMA	Resource Management Act
SAIDI	System Average Interruption Duration Index. This is the average time of supply interruptions that a customer experiences in the period under consideration.
SCADA	Supervisory Control and Data Acquisition is a remote monitoring and control system that enables us to operate our network safely and reliably.

Subtransmission	Lines and cables that connect zone substations to GXPs, and between zone substations. These are typically at 33kV or higher voltages
VOLL	Value of Lost Load. Refer to Section 6.6.

13. About us, our independence, reliance and disclaimer

13.1 About Energia and the consultant used

Energia

Energia is an energy sector advisory firm with expertise in electricity distribution strategy, asset management, and valuation.

Richard Krogh–primary consultant

Richard Krogh has over 20 years of experience in executive, management and engineering roles in the electricity and gas supply industries, leading to a thorough understanding and expertise in all aspects of electricity distribution asset management, valuation, strategy, regulation, and related industry matters. He is a former Chief Executive of Powerco and acted as the establishment Chief Executive of Firstgas, and has held various governances roles in electricity distribution, gas distribution and transmission, and ports, including TopEnergy, Ngawha Generation, Firstgas, The Lines Company, and Port Taranaki. Richard has also held various executive roles in asset management and operations.

Richard Krogh holds an honours degree in electrical engineering with post-graduate studies in finance. He is a chartered member of Engineering New Zealand.

13.2 Statement of independence and probity

We confirm that Energia Limited and its consultants:

- Are independent of ENA and the EDBs cited in this report and do not have any material connection or involvement with them other than in the context of providing professional advice on various matters from time to time;
- Are in a position to give an objective and unbiased opinion;
- Are competent to undertake this review;
- Discussed various matters with EDBs and the ENA and considered the views of those parties. However, any use of these discussions did not unduly influence our assessment and opinion;
- Do not have any actual or potential conflicts of interest in respect of this work;
- Adhere to the Code of Ethical Conduct published by Engineering New Zealand.

We also confirm that:

- There were no restrictions on the scope of our services in respect of the preparation of the valuation and this report;
- The source data used in the report was appropriate for the purpose;
- The assumptions, criteria and methods used in our assessment were reasonable and appropriate for the report;
- We have exercised professional diligence and judgement in assessing the information provided to us by others;
- The judgements exercised in our assessment and opinion were appropriate for the report.

13.3 Reliance on information

In preparing this report, we have relied on publicly available information, information provided by EDBs, and information provided by others, and have assessed the creditability of this information.

We have prepared this report on the basis that all material data and information that may affect our conclusions have been made available to us. We accept no responsibility if full disclosure was not made to us. We take no responsibility for any consequential error or defect in our conclusions resulting from any error, omission or inaccuracy in the data or information supplied directly or indirectly.

13.4 Disclaimer

This report has been prepared solely for the ENA for the stated purpose and is supplied confidentially. Energia Limited, its officers, agents, subcontractors and their staff owe no duty of care and accept no liability to any other party, nor do they make any representation or warranty as to the accuracy or completeness of the information or opinions set out in the report to any person other than to the ENA including any errors or omissions howsoever caused. We accept no liability from any party if the report is used for any purpose other than its stated purpose.

14. How we judged the performance of the sector

What is an appropriate evaluation standard for 2023?

We considered two aspects in deciding on our evaluation standard used in forming our opinion:

- The first is the length of time that businesses should have been aware of the need to improve resilience capabilities;
- The second is the speed at which change can be practically and economically implemented.

Concerning the first point, managing resilience is not a new concept for the electricity distribution sector. The foundation of the 4Rs date back nearly 20 years (as if it followed the passage of the Civil Defence Emergency Management Act in 2002). The need to consider resilience in a wider context has been strengthening, given the increasing prevalence of cyber threats over the past 7-10 years. Climate change risks have also been gaining greater focus for at least five years. Given the significant increase in insurance costs over the past five years, managing threats has also gained greater importance in the Board room.

Concerning the second point, electricity distribution assets have long lives (upwards of 50-70 years in some cases), and replacing assets before they were due would generally be uneconomic. Notwithstanding EDBs requiring authority status under the RMA[48], their ability to construct assets in the road reserve[49] and their existing use rights on private land[50], designing and consenting large projects is a difficult and time-consuming process. It can take 5-10 years from concept through to completion for large projects with material impacts on the surrounding area. Another aspect to consider is new technology and arrangements to operate the network (e.g. microgrids and remote area power supplied). This area is developing with improving economics, and hence the level of implementation of new technology will necessarily only be commencing.

[48] A requiring authority allows an entity to take private land for public works projects.

[49] Electricity Act, Section 24.

[50] Electricity Act, Sections 22 and 23.

Therefore, on the one hand, EDBs should be well down the road to improving resilience. They should know what to do and be well underway in pursuing those goals. However, on the other hand, upgrading and constructing new assets is time-consuming.

With these factors in mind, we consider that an acceptable standard means:[51]

- Concerning processes (e.g. risk assessments, readiness plans, response plans, etc.), EDBs should be "systematically and consistently achieving the relevant requirements with only minor inconsistencies";
- Concerning the physical assets, where implementation takes longer, EDBs are progressing actions with creditable plans and resources.

[51] We adapted these standards fom the EEA Resilience Gude, p35.