Meeting Date: 6 August 2020

RELIABILITY INFORMATION AS OF MID-2020

SECURITY AND RELIABILITY COUNCIL

This is the 2020 annual reliability report, providing the SRC with reliability information.

Note: This paper has been prepared for the purpose of providing the SRC with reliability information. Content should not be interpreted as representing the views or policy of the Electricity Authority.

Contents

1. The purpose of this paper 2
1.1 This is an annual report to provide the SRC with reliability information 2
1.2 The list of measures in this report was discussed by the SRC in 2017 and again in 2018 2
1.3 Reliability measures are important to consumers 3
2. Limitations to the monitoring regime 4
2.2 Data quality 4
2.3 Forecasting reliability 4
3. Reliability measures 5
3.1 Measures of system events 5
Count of grid warning notices 5
Count of voltage excursion notices 5
Management of power system frequency 6
Count of times when reserves are less than required for security 10
3.2 Measures of transmission grid reliability 11
Primary and secondary transmission outage counts 11
Primary and maximum transmission outage duration in minutes 12
3.3 Measures of distribution network reliability 13
EDB network reliability 13
Increase in capacity of small distributed generation 15
4. Other available data 16
4.2 Data from the system operator 16
4.3 Data from the Commerce Commission 16
SAIDI and SAIFI measures 16
Other measures 18
5. Questions for the SRC to consider 19

1. The purpose of this paper

This is an annual report to provide the SRC with reliability information

1.1 The Security and Reliability Council (SRC) requested its secretariat prepare an annual report at the second calendar meeting of each calendar year comprising various reliability measures and associated commentary.

1.2 When these reports were first prepared, the intent was to provide the **available** security and reliability data to the SRC, excluding data already published. The instruction from the SRC was not to expend additional resources developing new data. Section 4 contains examples of publicly available data.

1.3 In general, any large and sudden changes to the metrics in this paper would signal that further investigation was required. However, these metrics are not able to signal possible future problems. Identifying future reliability issues is the role of asset owners, and for distribution, potential future reliability issues are at the centre of several Commerce Commission customised price paths.

The list of measures in this report was discussed by the SRC in 2017 and again in 2018

1.4 The SRC meeting of 28 July 2017 considered a paper "Monitoring reliability: Measures available for reporting to the SRC to monitor reliability of electricity supply[1]" ('the July 2017 paper').

1.5 The July 2017 paper included a list of measures that could be provided to the SRC, reproduced below:

a) the count of under-frequency events (UFE).

b) the count of grid warning notices.

c) the count of voltage and frequency excursion notices.

d) the count of times when reserves are less than required for security.

e) primary and secondary transmission outage counts.

f) primary and maximum transmission outage duration in minutes.

g) key metrics derived from the Authority's electricity distribution business (EDB) monitoring of disclosed data, including the average system availability index (ASAI).

h) changes in embedded generation volumes and trends.

1.6 The above measures are included in this paper, with the exception of the count of UFEs and the count of frequency excursion notices which have been replaced with improved measures of power system frequency management.

[1] https://www.ea.govt.nz/dmsdocument/22388-reliability-monitoring

1.7 The July 2017 paper also noted that the following information sources are publicly available:

a) Authority reports into automatic under-frequency load shedding (AUFLS) events: https://www.ea.govt.nz/monitoring/enquiries-reviews-and-investigations/

b) the Annual Security Assessment (ASA) and any ad hoc system operator studies: https://www.transpower.co.nz/system-operator/security-supply/security-supply-annual-assessment

c) electricity risk curves[2], which are available from the system operator and on EMI.

1.8 During the 22 June 2018 discussion[3] of this topic, members suggested various improvements to future editions of the paper:

d) Improve the breadth of metrics available that relate to distributors, such as asset condition.

e) Include more commentary, including what interpretation members should take out of the graphs, and highlight any next steps for the SRC.

f) Seek to establish baseline performance against which future results can be assessed.

g) A useful additional version of measuring average system availability index by EDB could be a scatter plot by average length of lines.

h) Either describe why the growth of small-scale distributed generation is meaningful for reliability or remove/replace it in favour of data that is meaningful (perhaps a measure of low voltage network constraints imposed on distributed generation).

1.9 The secretariat has attempted to account for this feedback and implement improvements in this paper where possible.

1.10 In 2019 this paper was not presented due to resourcing constraints at the Authority.

Reliability measures are important to consumers

1.11 Reliability is not an easy thing to monitor – the Electricity Price Review (EPR) panel looked at this and ultimately decided a review of the security/reliability monitoring systems (the G2 review) was appropriate.

1.12 An output of the G2 review is to think about how we can monitor these things long term to put everyone in a better position to understand state of system reliability to support the Government, the SRC, and consumers' needs.

[2] Previously known as 'hydro risk curves'

[3] https://www.ea.govt.nz/dmsdocument/24942-src03-minutes-of-previous-meeting

2. Limitations to the monitoring regime

2.1 There are limitations both on the quality of the data and the ability to forecast future reliability.

Data quality

2.2 Data quality problems occur in every industry and can manifest in many ways, such as:

a) Data availability – data may be lost (eg paper records destroyed in a fire), or was never collected in the first place.

b) Data consistency (eg changing what data is collected or in what format).

c) Data improvements over time - access to new data, data granularity changes, and modelling changes all have an effect.

d) Unexplained or unexpected causes behind data. For example, Network Waitaki has a large percentage of assets with an unknown age, relative to other networks. Since age is one indicator of condition, at first glance this might give the impression there is uncertainty about Network Waitaki's asset quality. However, on review of the asset condition metrics, they have no assets which are ungraded, suggesting they know the condition of all of their assets and not knowing their specific age (which may be due to the point in a)) is not critical.

2.3 These quality issues can affect the ability to view trends, provide accurate forecasts, or know any measure with absolute certainty.

Forecasting reliability

2.4 One-off events such as the Penrose substation fire, or AUFLS trips, are idiosyncratic and while they may indicate systemic issues, it is not possible to forecast such events. However, these events are often worth reviewing thoroughly to understand and learn as much as possible. It is important that lessons from these events are disseminated.

2.5 Other approaches such as looking at the age of asset classes and developing a statistical understanding of reliability may give some indication of future reliability. This ought to be an important part of managing a network.

2.6 As noted in the 28 July 2017 paper:

> "reliability metrics and trends are useful if they can be used to identify areas of interest to carry out more in-depth analysis to find root causes of issues, such as issues with risk management or maintenance practices. In this sense the measures in this paper are more akin to a temperature gauge in a car—they indicate that there may be a problem without specifically identifying the problem".

3. Reliability measures

Measures of system events

3.1 This section provides information on:

a) the count of grid warning notices.

b) the count of voltage excursion notices.

c) various measures of management of power system frequency.

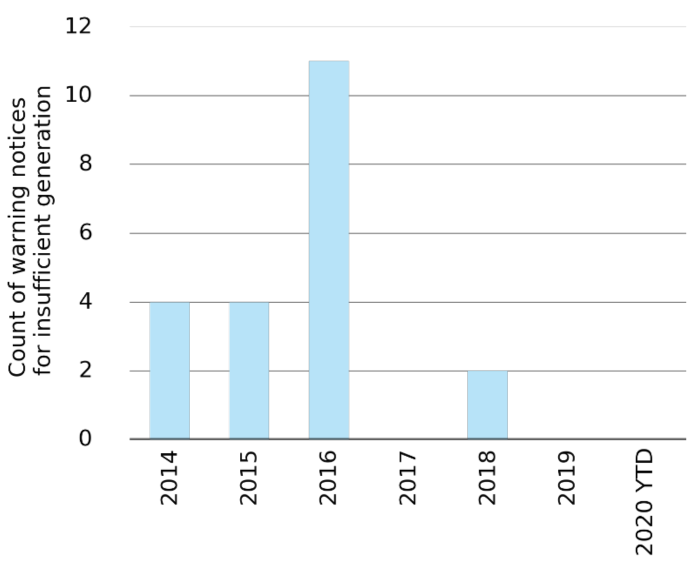
d) the count of times when reserves are less than required for security.

Count of grid warning notices

3.2 Grid warning notices are issued by the system operator when there are insufficient offers to meet forecast demand. The number of grid warning notices for insufficient generation[4] issued each year is shown in Figure 1. Trends in the numbers of grid warning notices can drive more detailed enquiries into things like maintenance scheduling and the incentives on generators to build new plant.

3.3 There were two warning notices issued so far in 2020, for insufficient reserve offers, and not for insufficient generation.

Figure 1: Number of grid warning notices for insufficient generation



3.4 No grid warning notices have been issued in 2017, 2019 or so far in 2020.

Count of voltage excursion notices

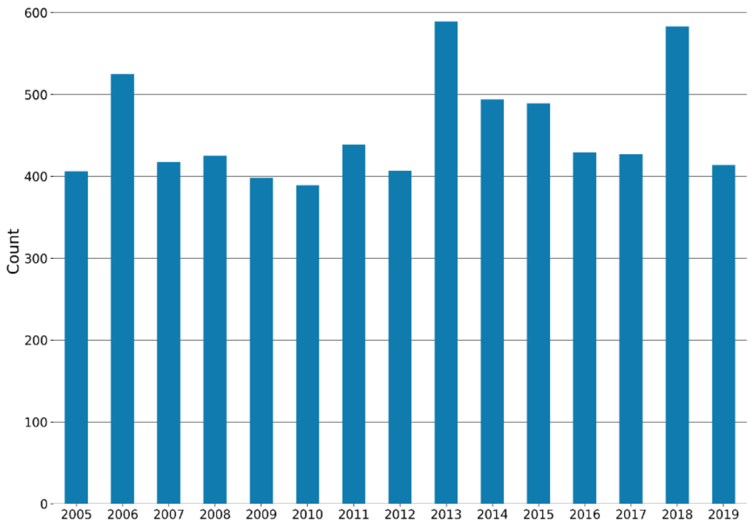
3.5 Transpower sends excursion notices[5] when voltage measures exceed stated limits. Figure 2 shows the annual counts of voltage notices. Excursion notice

[4] Source: https://www.transpower.co.nz/system-operator/operational-information/formal-notices

[5] Source: https://www.transpower.co.nz/system-operator/operational-information/excursion-notices

counts reflect the state of transmission and generation equipment. For example, an increase may indicate that assets are under pressure or getting to the end of their useful life. An upward trend would warrant further enquiries.

Figure 2: Voltage excursion notices



3.6 The number of voltage excursions in 2019 was less than most previous years.

Management of power system frequency

3.7 In New Zealand, power system frequency between 49.8 Hz and 50.2 Hz is considered the 'normal band'. However, the power system has been designed to cope with frequencies outside of the normal band (within limits).

3.8 The data in Figures 4-6 is sourced from the system operator.[6]

3.9 Figure 3 illustrates the variation of frequency outside the normal band, by island. As the dataset represents the highest or lowest frequency reached each time frequency went outside the normal band, this data says nothing about the duration or number of instances in which frequency exceeded the normal band.

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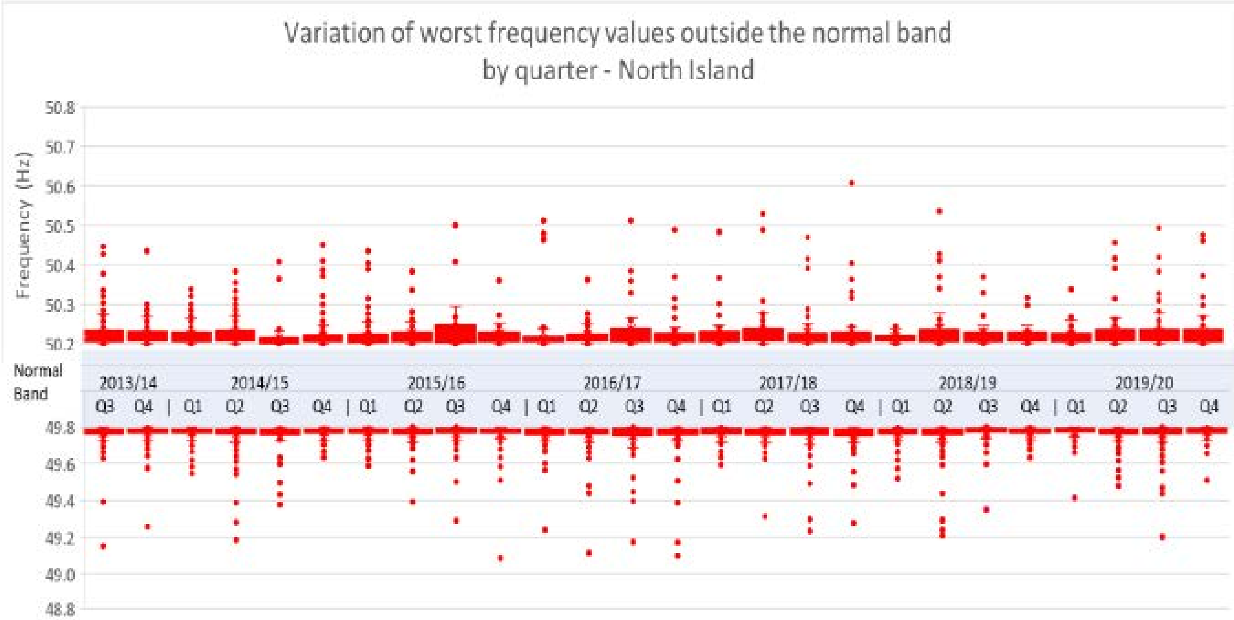
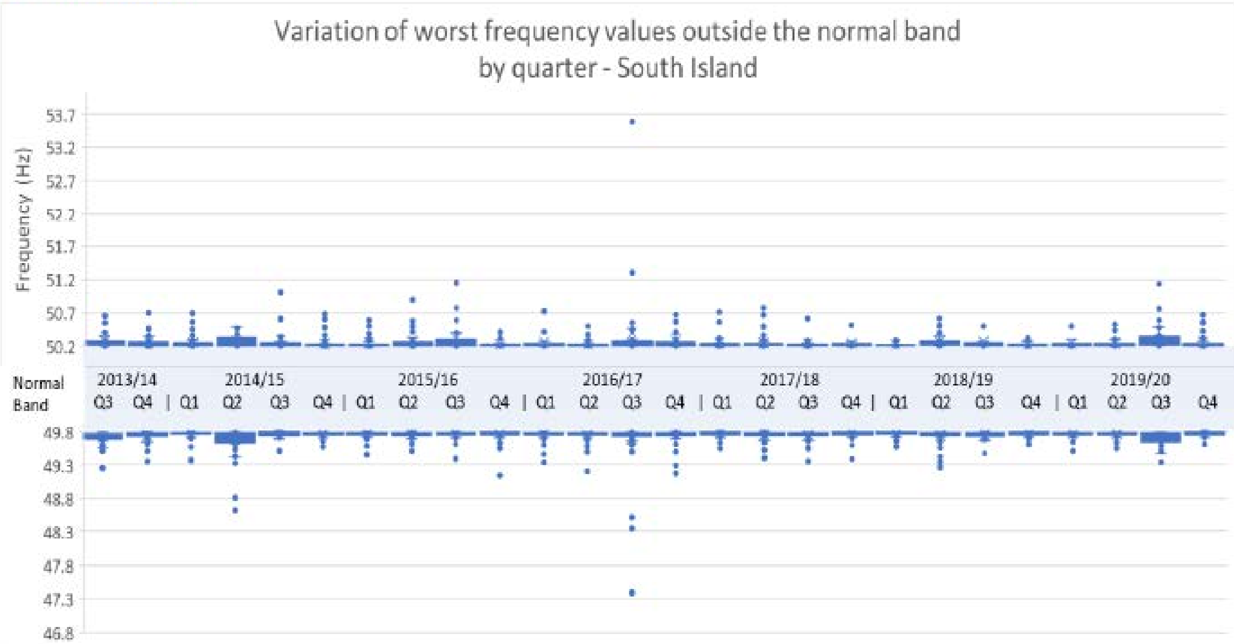
6 Available from https://www.ea.govt.nz/operations/market-operation-service-providers/system-operator/monthly-reports/

Figure 3: Distribution of frequency outside the normal band (by island)

North Island



South Island

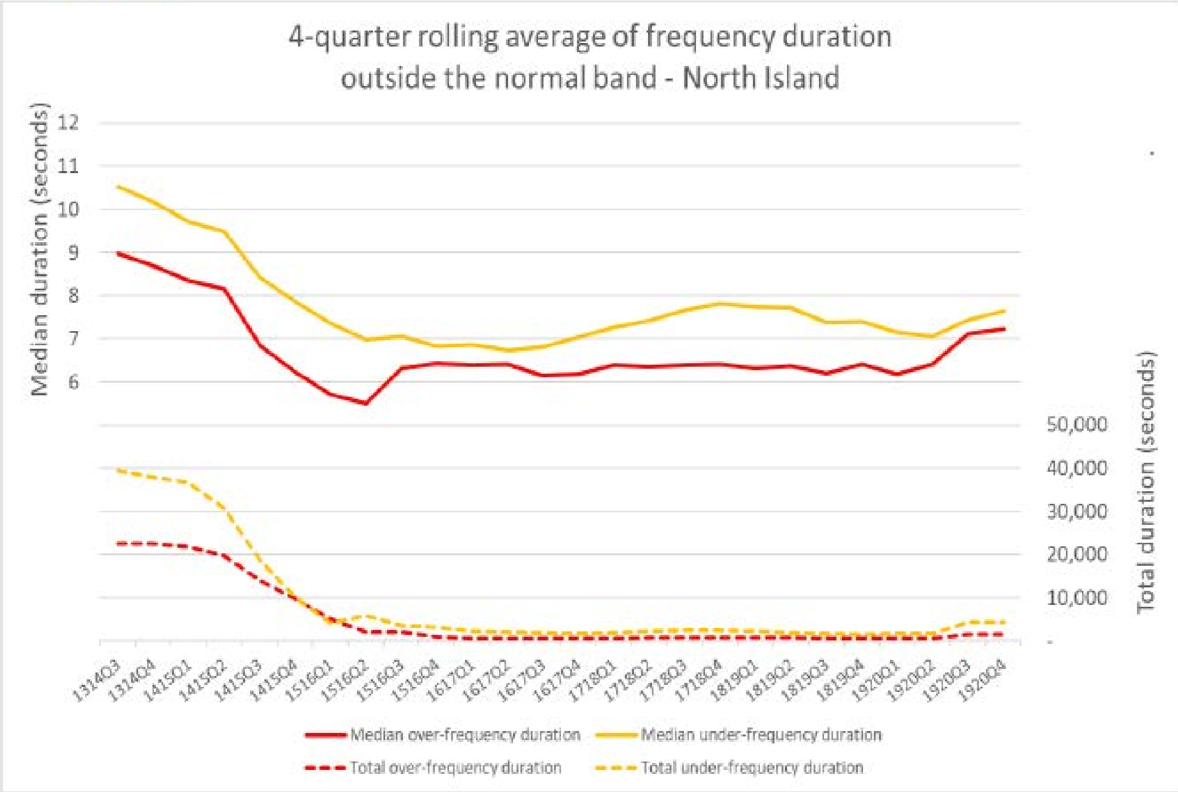


3.10 The above results show no trends of any alarm. In the South Island, Q3 of the 2019/20 year (January to April 2020) shows a broader distribution of frequency maximums and minimums. That relates to Transpower's testing of its HVDC assets throughout that quarter.

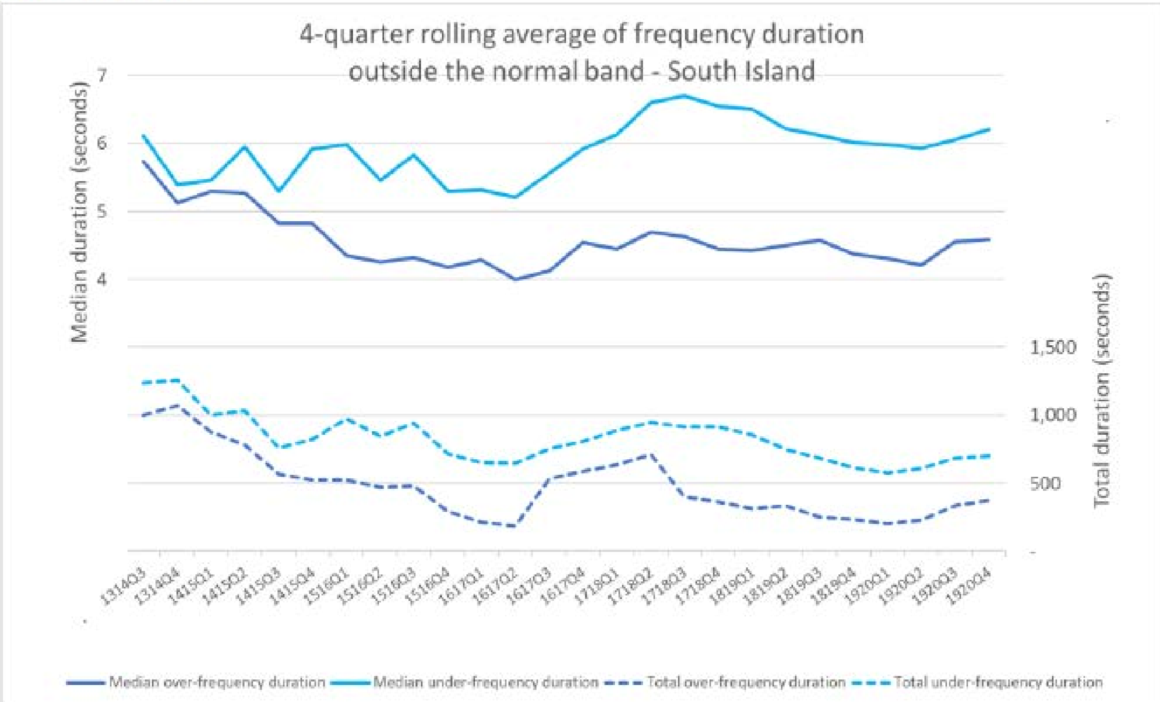
3.11 Figure 4 illustrates the duration of times that frequency exceeded the normal band. Each chart includes measures of median and aggregate duration. Median duration is essentially unaffected by outliers, so provides a better measure of typical performance. Aggregate duration provides a better measure of overall performance.

Figure 4: Duration of frequency outside the normal band (by island)

North Island



South Island



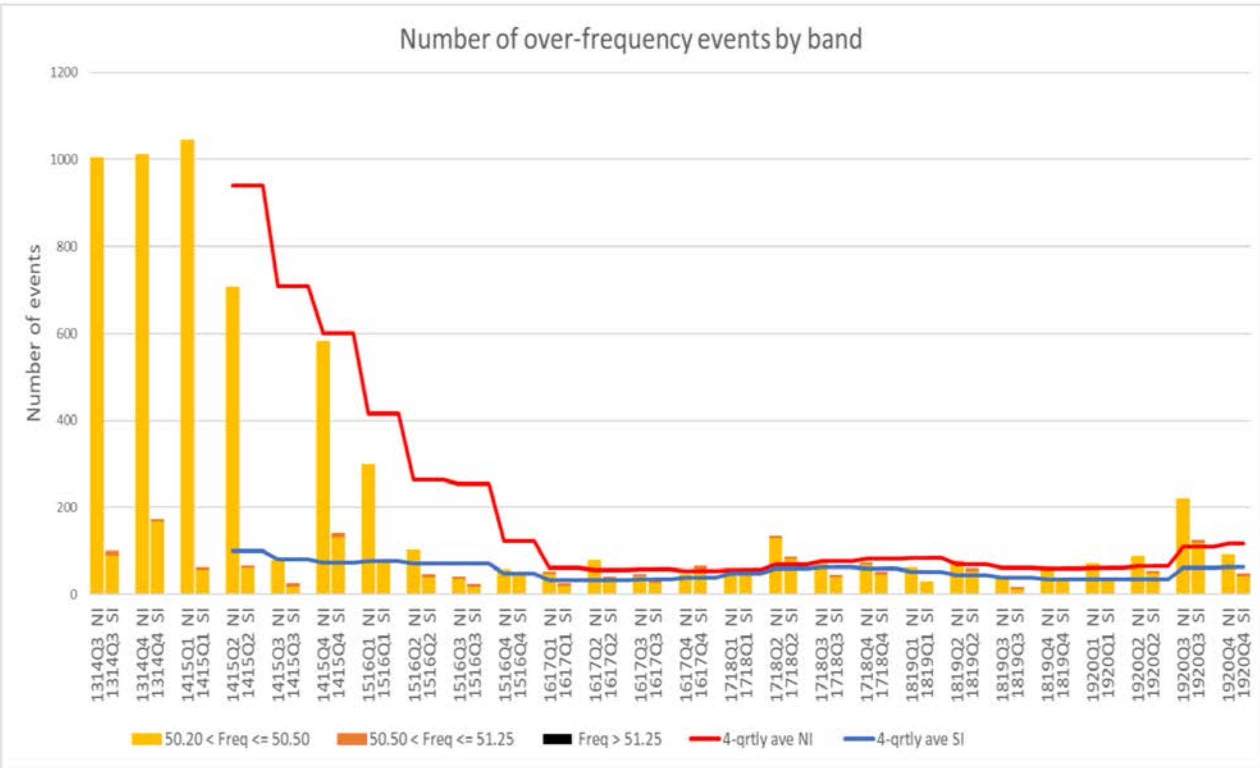
3.12 These charts illustrate the superior performance of frequency in the South Island across all measures of duration. This is largely a consequence of the South Island generation fleet (which is almost exclusively hydro) having better reliability and frequency response than the North Island fleet.

3.13 Transpower's HVDC testing in Q3 of 2019/20 is also evident in these charts. This seems unlikely to be the start of an upward trend in duration of frequency outside the normal band.

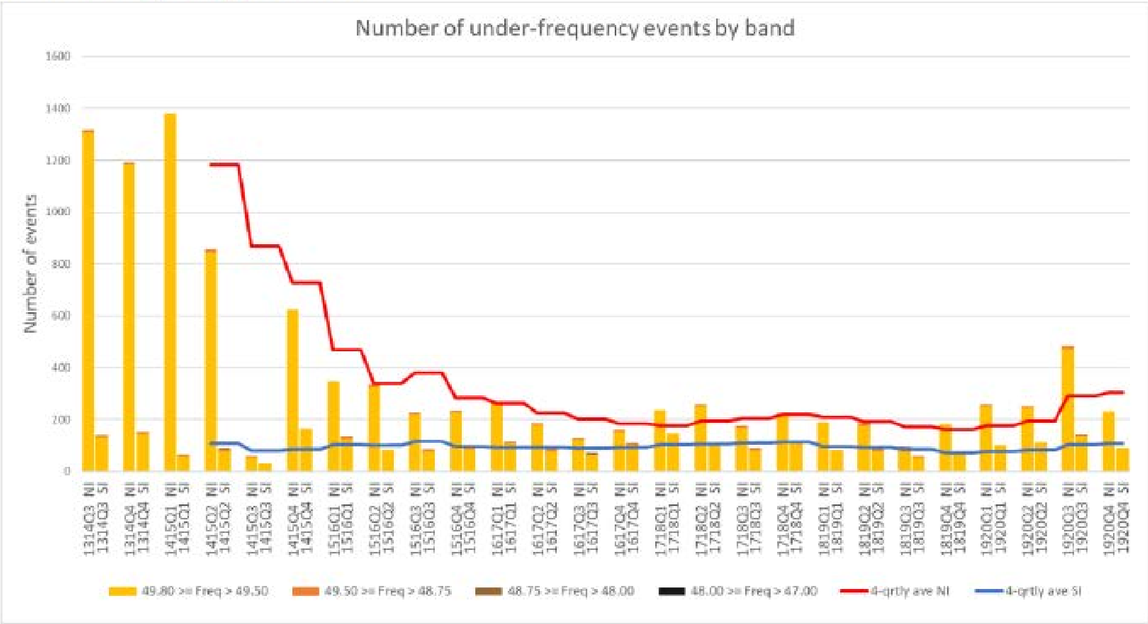
3.14 Figure 5 illustrates the number of instances in which frequency exceeded the normal band. The quarterly averages (the line chart) are solely an indicator of the number of instances and say nothing about the magnitude of the frequency outside of the normal band. However, the count of instances (the bar chart) is banded (and coloured) to give an indication of severity.

Figure 5: Count of instances of frequency outside the normal band (by island)

Over-frequency events



Under-frequency events



3.15 As with Figure 3 and Figure 4, Transpower's testing of the HVDC shows up in the penultimate quarter. Aside from that, there are no concerning results in Figure 5.

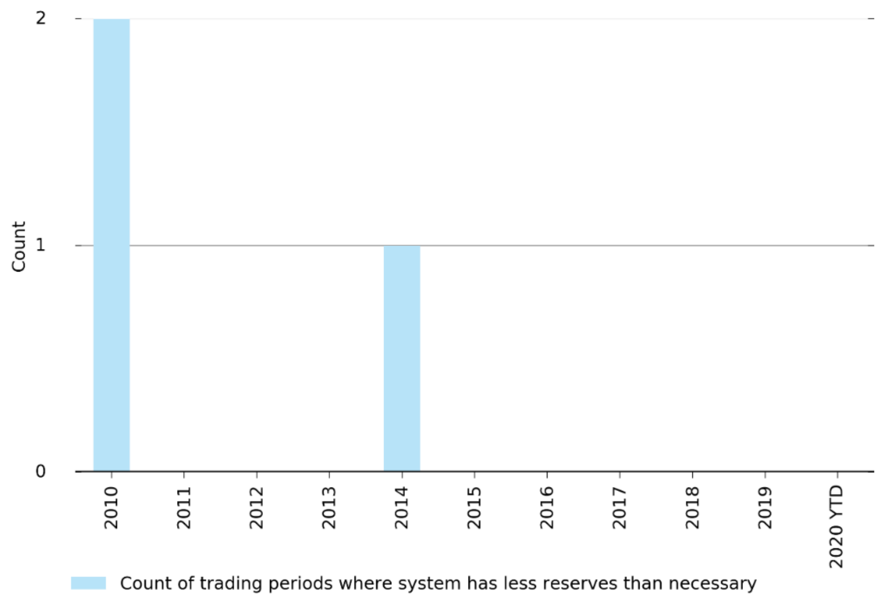
3.16 Compared to the North Island, the South Island has fewer instances of both under- and over-frequency outside the normal band. The difference between the islands is much larger with instances of under-frequency. This is also a consequence of the relative number, reliability and responsiveness of the generation fleets in each island.

Count of times when reserves are less than required for security

3.17 Figure 6 shows the annual number of occasions on which insufficient reserve was dispatched. Reserves are required to cover the largest risk in the system, usually a large generator or the HVDC. The system operator may not have enough reserve to cover the largest risk, after an event or due to inaccuracies in forecasting of supply and demand.

3.18 A trend of an increasing number of occasions of insufficient reserve being dispatched would warrant further investigation. The more such occasions, the higher the risk of an asset failure triggering the AUFLS system (thereby disconnecting load) rather than triggering reserves (which has no involuntary load loss).

Figure 6: Number of occasions on which insufficient reserve was dispatched



3.19 No such events have occurred since 2014.

Measures of transmission grid reliability

3.20 This section provides information on:

a) primary and secondary transmission outage counts.

b) primary and maximum transmission outage duration in minutes.

Primary and secondary transmission outage counts

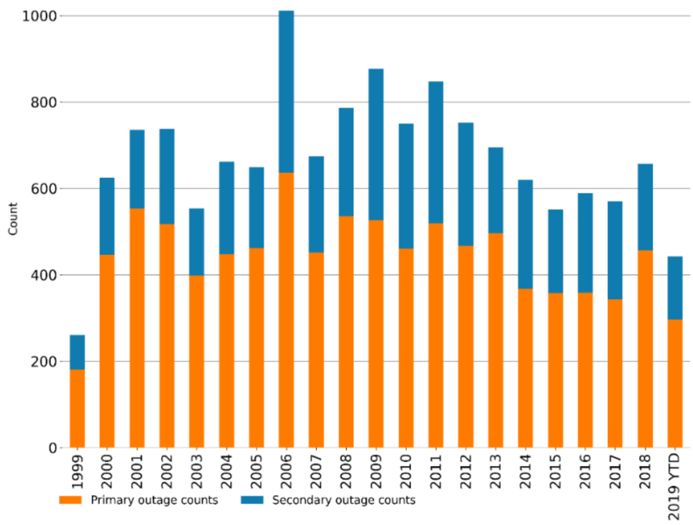
3.21 The information in this section specifically refers to forced outages, defined as those for which the equipment was tripped or manually taken out of service within 24 hours of the fault occurring or being discovered.

3.22 ‘Primary outage’ refers to the first piece of equipment to go out; a ‘secondary outage’ is a different piece of equipment that went out as a result of the primary outage.

3.23 A number of outages within a relatively short space of time, sharing a cause, are generally recorded as a single incident. If a second fault occurs or is discovered when attempting to return equipment to service, it is counted as a second outage.

3.24 Annual counts of primary and secondary outages are shown in Figure 7.

Figure 7: Transmission forced outages

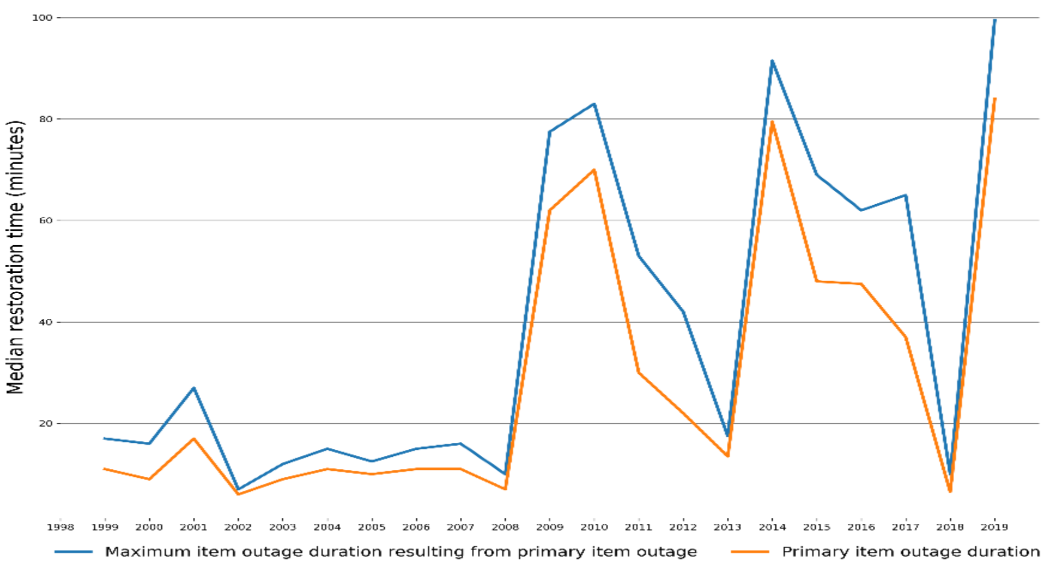


3.25 There has been a generally decreasing trend in the number of forced outages since 2011. The number of forced outages in 2017 was the second lowest in a decade.

Primary and maximum transmission outage duration in minutes

3.26 Trends in the typical duration of transmission forced outages are shown in Figure 8. The orange line indicates the annual median of the duration of primary outages (in minutes). The blue line indicates the annual median of the *maximum* duration of all outages (primary or secondary) relating to a single primary outage – arguably a better measure of how long it takes to return the grid to normal operation.

Figure 8: Median transmission outage duration



Measures of distribution network reliability

3.27 This section provides information on:

a) EDB network reliability.

b) the increase in capacity of small distributed generation.

EDB network reliability

3.28 EDB network reliability is expressed in terms of the average system availability index (ASAI), which is the percentage of customer-hours that were supplied. This measure takes into account both the frequency and the duration of outages. A high value means that the network was usually supplying power to customers.

3.29 Figure 9 compares ASAI (in the year to 31 March 2019) between EDBs, with the highest level of reliability on the right-hand side. Figure 10 compares ASAI between years, for all EDBs combined.

Figure 9: ASAI by EDB 2019

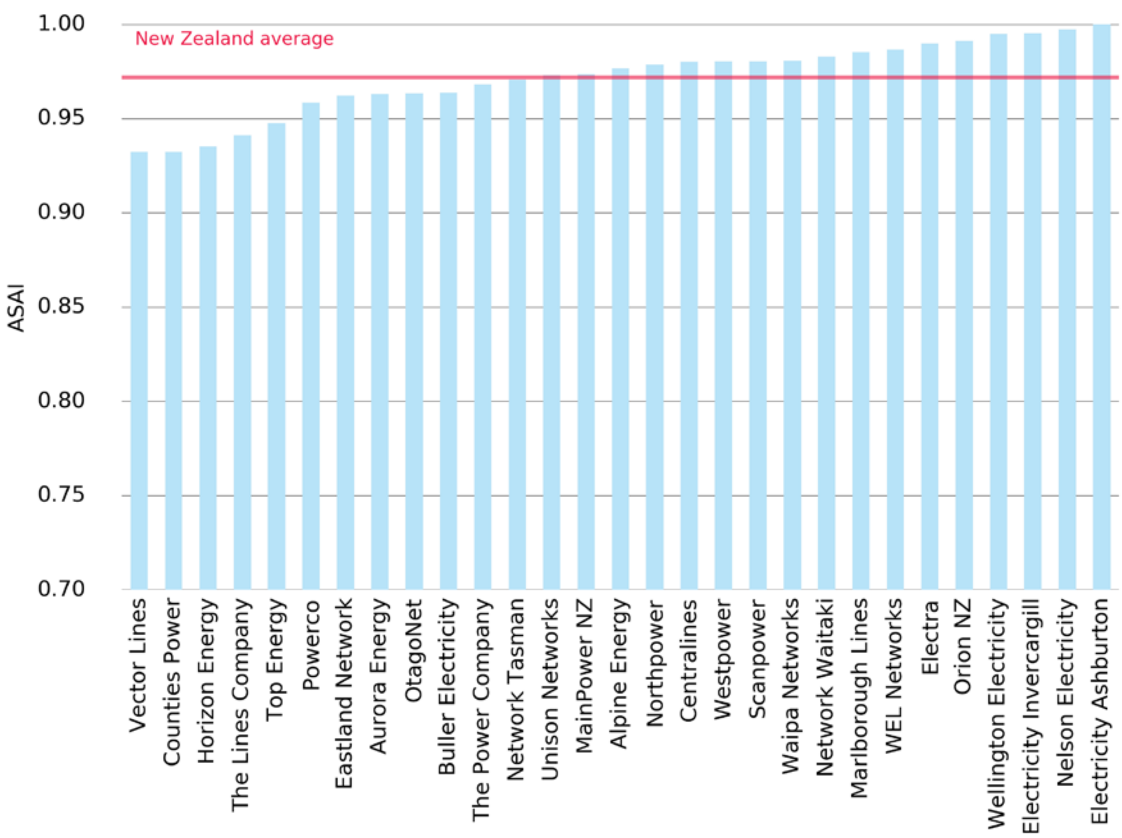
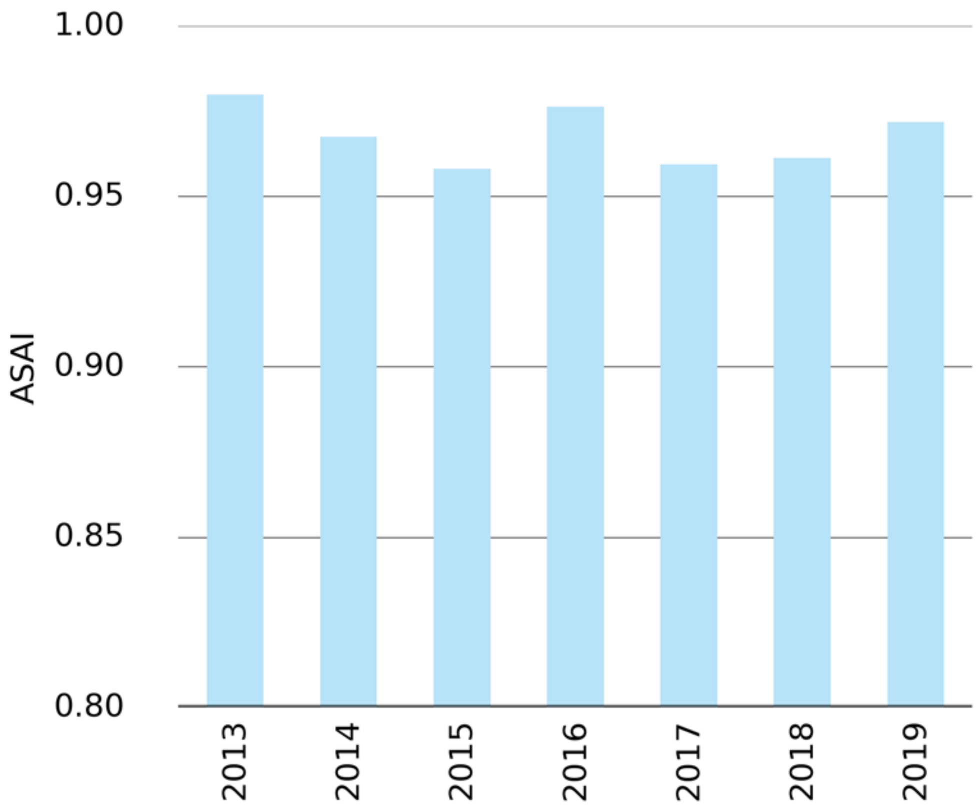


Figure 10: ASAI by year, for all EDBs combined



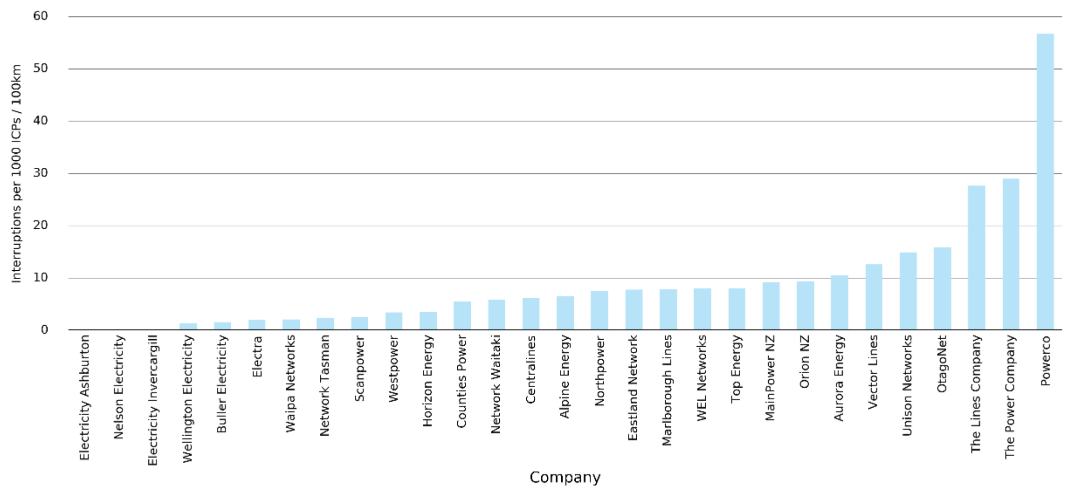
3.30 ASAI in 2019 was near the median of the preceding five years.

3.31 These results should be taken with the context of the length of the lines an EDB manages. Figure 11 shows the number of interruptions per 1000 ICPs, per 100 km of line for 2019. Including the number of ICPs and line length helps to partially account and normalise for the vastly different EDBs compared here.

3.32 Some of the networks with the lowest number of interruptions are heavily undergrounded (Nelson Electricity, Electricity Invercargill).

3.33 Powerco stands out as having the highest number of interruptions per 1000 ICPs per 100 km of line. However, their SAIFI results for the same period are only slightly above the industry average and the twelfth worst amongst EDBs. The secretariat is investigating and is aiming to be able to offer a verbal explanation by the time of the SRC meeting.

Figure 11: Number of interruptions per 1000 ICPs per 100 km of line

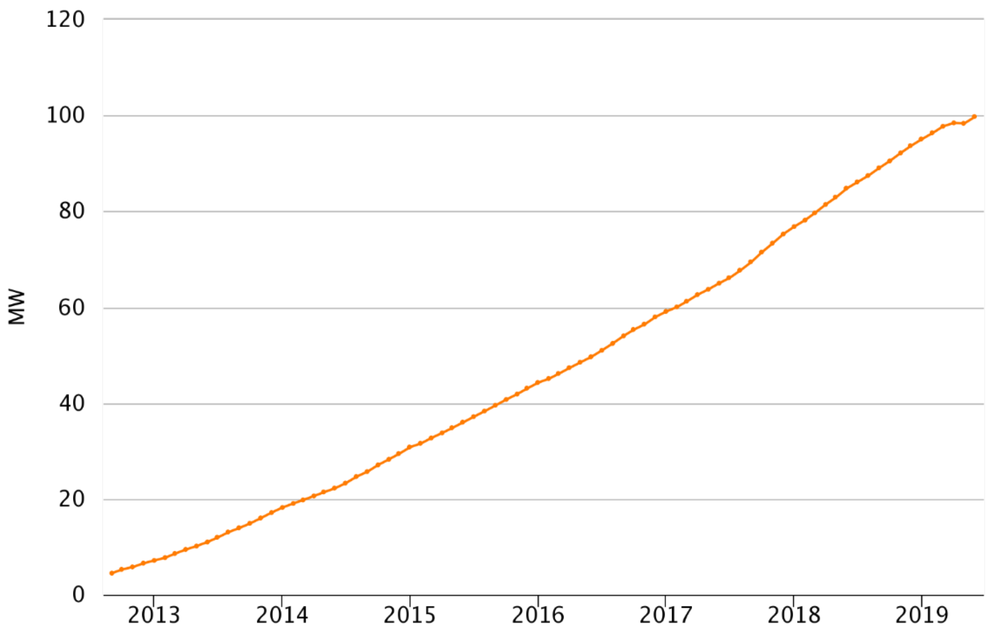


Increase in capacity of small distributed generation

3.34 Distributed generation can have positive or negative impacts on reliability. A more distributed system is less vulnerable to single points of failure, but issues with voltage at the end of lines may also cause a deterioration in power quality and level of service.

3.35 Figure 12 shows the trend in total distributed generation capacity at residential ICPs, nationwide. It covers installations under 10 kW capacity only.

Figure 12: Distributed generation under 10kW capacity at residential ICPs



3.36 Such distributed generation capacity has been increasing roughly linearly over the last few years with no discernible impact on reliability.

4. Other available data

4.1 Reliability data is improving steadily with the installation of more sophisticated equipment and processes, and digital access to records.

Data from the system operator

4.2 The system operator is working to improve their monitoring. As part of their Strategic Objective Work Plan for 2019/20, the system operator has:

a) developed a Dispatch Accuracy dashboard for energy dispatch.[7] It is a means of monitoring overall performance of the system operator's load forecasting, scheduling and real time adjustments to dispatch. It relates to reliability in the sense that more accurate dispatch means that the frequency keeper has to respond less to generation fluctuations.

b) committed to improved monitoring of the accurate dispatch of reserves. The system operator is required to dispatch the minimum amount of instantaneous reserves needed to maintain frequency within prescribed limits for certain events.

Data from the Commerce Commission

4.3 The Commerce Commission has a large set of metrics publicly available[8] on EDBs, including System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) maps and asset conditions. We have reproduced a selection of graphs below.

SAIDI and SAIFI measures

4.4 SAIDI and SAIFI are two of the measures the Commerce Commission monitors for ensuring customers are receiving a reliable standard of service.

4.5 SAIDI is calculated by adding all customer interruption durations and dividing it by the total number of customers served, to give, on average, the number of minutes a customer was without power over the course of the year. Figure 13 gives the 2019 SAIDI by EDB.

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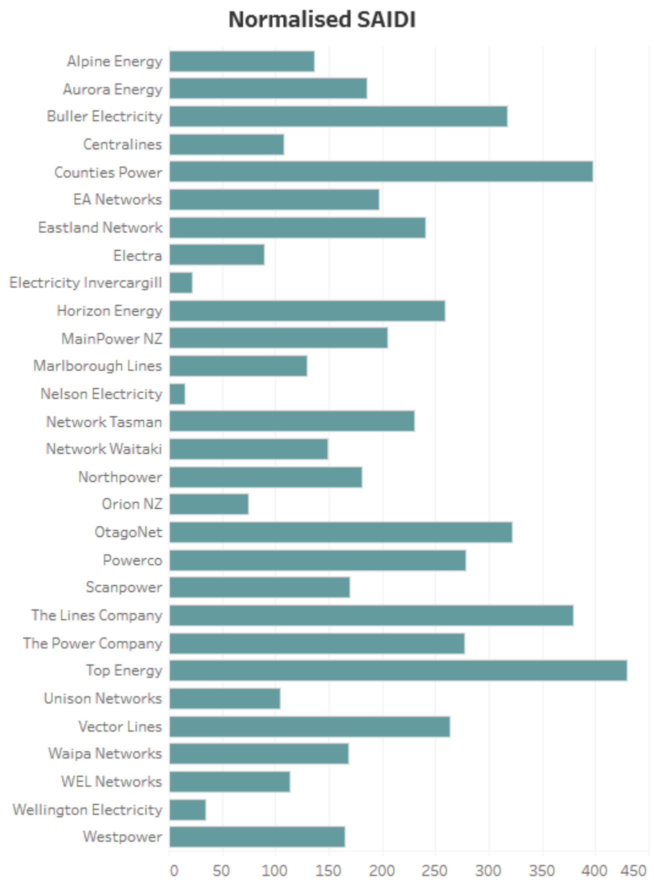
7 Available from https://www.ea.govt.nz/operations/market-operation-service-providers/system-operator/monthly-reports/2020/

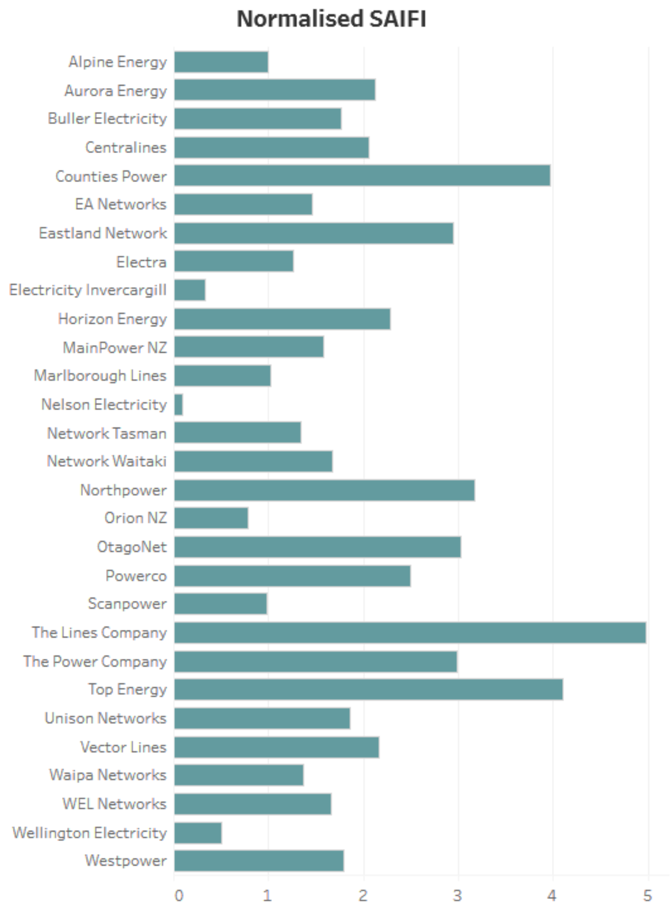
8 https://public.tableau.com/profile/commerce.commission.regulation#!/vizhome/Performanceaccessibilitytool-NewZealandelectricitydistributors-Dataandmetrics/Homepage

Figure 13: 2019 SAIDI by EDB



4.6 SAIFI is calculated by taking the total number of customer interruptions divided by the total number of customers served, to tell us, on average, how many times the power went out for each customer over the course of the year. Figure 14 gives the 2019 SAIFI by EDB.

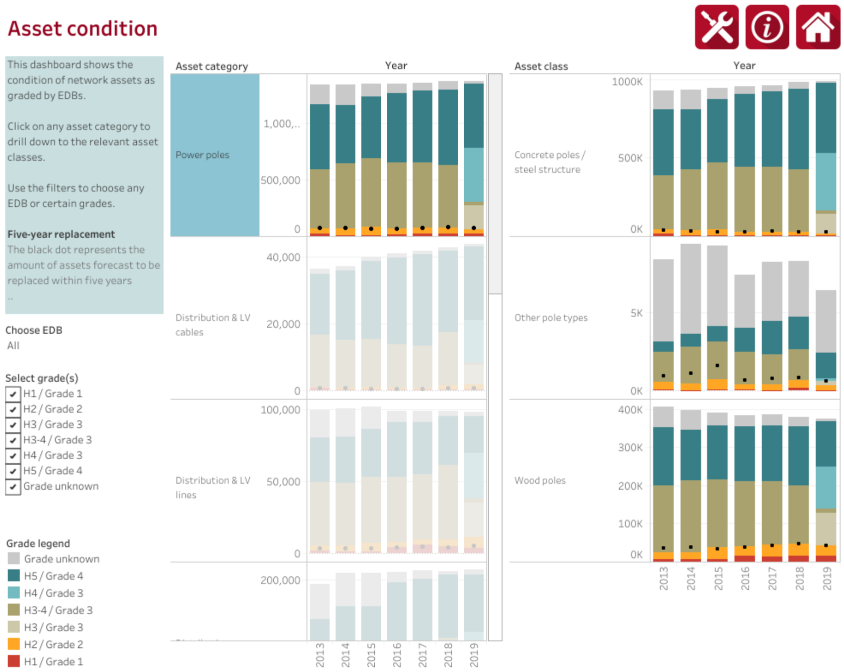
Figure 14: 2019 SAIFI by EDB



4.7 The Commerce Commission sets a target 'threshold' for SAIDI that 17 EDBs are incentivised to achieve ('price-quality regulation'). There are a further 12 EDBs not subject to price-quality regulation. All 29 EDBs are subject to information disclosure obligations to ensure SAIDI, SAIFI and other reliability measures can be scrutinised by stakeholders.

Other reliability measures

4.8 The Commerce Commission holds additional detailed data which can give an overview of the system. A sample of this data which highlights asset condition of power poles, is included below to give the SRC an idea of what is available for further analysis.



5. Questions for the SRC to consider

5.1 The SRC is asked to consider and provide advice on the following questions:

Q1. Does the SRC want to receive different data in the 2021 version of this report?

Q2. Having considered this report, what advice, if any, does the SRC wish to provide to the Authority?