Security and Reliability Council

The system operator’s 2018 annual assessment of security of supply

19 March 2018

Note: This paper has been prepared for the purpose of the Security and Reliability Council (SRC). Content should not be interpreted as representing the views or policy of the Electricity Authority (Authority).

Contents

1	**Background**	**2**
2	**Understanding the security standards**	**2**
2.1	The security standards represent an efficient level of generation	2
2.2	The Authority expects to update the security margins and the SSAD in time for the 2019 annual assessment	3
3	**Understanding the 2018 annual assessment**	**4**
3.1	The system operator has made several improvements to the 2018 annual assessment	4
3.2	Interpreting the results	5
4	**Questions for the SRC to consider**	**8**

1 Background

1.1.1 The Security and Reliability Council (SRC) functions under the Electricity Industry Act 2010 (Act) include providing advice to the Electricity Authority (Authority) on security of supply matters.

1.1.2 The Act also mandates that Transpower is the system operator and is responsible for managing security of supply emergencies and forecasting security of supply. Short-term forecasting is achieved by the system operator's risk meter and hydro risk curves in the case of energy security, and by the New Zealand Generation Balance report in the case of capacity security. Forecasting of medium-term energy and capacity security is achieved through the system operator's annual assessment of security of supply (annual assessment).

1.1.3 The purpose of this paper is to provide the SRC with a copy of the system operator's 2018 annual assessment and ask questions that may help to establish whether the SRC has advice to offer the Authority.

2 Understanding the security standards

2.1 The security standards represent an efficient level of generation

2.1.1 The key standards set by the Authority are:

a) a winter energy margin for New Zealand (NZ-WEM) of 14-16% greater than forecast energy consumption

b) a winter energy margin for the South Island (SI-WEM) of 25.5-30% greater than forecast energy consumption

c) a winter capacity margin for the North Island (WCM) of 630-780 MW greater than forecast peak demand (in MW).

2.1.2 The margins set reflect that if under-supply occurs, there is an increase in costs to the country through loss of production and loss of load events. When over-supply occurs, there is a cost to consumers through cost recovery for the surplus generation. While the risks are asymmetric, the margins represent an efficient level of generation supply that minimises overall cost to the country.

2.1.3 The results against the margins help inform stakeholders whether an efficient level of energy or capacity generation supply exists now and in future scenarios. Results outside the efficient margins (especially results exceeding the margins) are not necessarily problematic. They are a single measure and need to be examined in a broader context before conclusions can be reliably drawn.

2.1.4 There are no legislative consequences for generators not meeting the efficient margins; the margins are intended to be informative. By contrast, measures like the customer compensation scheme and scarcity pricing are explicitly designed to provide incentives that augment spot price signals to better promote reliability.

2.1.5 The system operator is obliged to annually publish an assessment of security of supply against the NZ-WEM, SI-WEM and WCM margins.

2.1.6 The Authority provides certain assumptions that the system operator must use when preparing the annual assessment. These assumptions are published in the Security Standards Assumptions Document (SSAD). The purpose of the SSAD is to help ensure that results against the margins are calculated in a way that is consistent with the derivation of the margins. The system operator can use alternative assumptions if it provides reasons for doing so and still notes the results of using the Authority's assumptions.

2.2 The Authority expects to update the security margins and the SSAD in time for the 2019 annual assessment

2.2.1 The security margins and the SSAD were last updated in 2012. Since then, there have been significant changes that are likely to affect the inputs to the calculation of the security margins:

a) transmission investments including Pole 3 of the HVDC

b) expansion of geothermal and wind generation

c) retirement of the Otahuhu and Southdown thermal generators

d) reductions in the amounts of frequency-keeping and instantaneous reserve procured

e) improved estimates of the value of lost load.

2.2.2 To maintain consistency, the SSAD will need to be updated to reflect whatever assumptions get used in any revised security margins.

2.2.3 The Authority has committed to completing the analysis for revising the margins in its 2017-18 work programme. The project will continue into the 2018-19 year with the goal of delivering outputs in time for the system operator to complete its 2019 annual assessment using any updated information.

3 Understanding the 2018 annual assessment

3.1 The system operator has made several improvements to the 2018 annual assessment

3.1.1 The system operator has made several changes to the 2018 annual assessment to improve it in comparison to earlier annual assessments:

a) The structure and presentation of the annual assessment report has been altered to better accommodate a range of readership. The executive summary is longer and couched in terms a new reader should be able to grasp. The main body of the report should be easy reading for industry stakeholders with some familiarity of the issues. The appendices now provide a more complete set of assumptions that will be useful for modellers and analysts. The colour scheme of most charts has been inverted to draw readers' attention to the range of plausible outcomes rather than the outcome where no new generation gets built. This has been a good improvement.

b) The system operator no longer categorises the pipeline of possible generation in terms of Low/Medium/High build probabilities. Instead, such generation is categorised depending on its resource consents as either 'consented' or 'unconsented'. The probability-based assessment was problematic since the generator build likelihoods weren't adaptive to each scenario. This led to confusion or dismissal of results because stakeholders expect markets to adapt. The consent-based assessment side-steps this issue by avoiding applying a probability label. The strength of this approach is that it is very objective. However, this approach has the limitation of being unable to take a view on how markets would likely adapt to a scenario. This has been a good improvement, though there may be potential for further improvement.

c) There is no longer a 'base case' scenario—the base case approach was problematic because there were no agreed assumptions upon which generators submitted information on (and so was a hybrid of each submitter's view of the future), yet it appeared to have prominence among readers as a 'most likely', or 'industry agreed' scenario. Instead, the system operator now uses three central scenarios. This has been a small improvement

> "**Thermal Remains**: this scenario assumes we continue to rely on existing gas and coal fired thermal generation to support and compliment hydro generation during times of low inflows to hydro lakes and to assist meeting peak demand for electricity in winter over the next 10 years. We assume all existing grid connected generation remains in service throughout the 10-year assessment period. Underlying wholesale market demand for electricity grows at 1% per year."
>
> "**Thermal Retirement:** this scenario assumes we reduce our reliance on thermal generation, as part of increasing the proportion of renewable generation. In this scenario, approximately 500MW of existing thermal generation is withdrawn from service at the end of 2022. Underlying wholesale market demand for electricity grows at 1% per year."
>
> "**Low Carbon and Electrification:** this scenario assumes the energy sector plays a significant role in assisting New Zealand to achieve its climate change targets through electrification of the transport fleet and industrial process heat, as well as shifting to a greater reliance on renewable generation. In this scenario, we reduce our reliance on thermal generation from 2022 (same assumption as the Thermal Retirement scenario above), and restrict all new

generation to renewable generation only. It is assumed electrification results in wholesale electricity market demand growth of 2% per year."[1]

3.2 Interpreting the results

3.2.1 The model prescribed for the annual assessment is, by necessity, an over-simplification of a complex market that has many feedback loops. In reality, the events that would cause a scenario to actually occur would in turn influence the timing and likelihood of further generation development. For example:

a) retaining the Huntly Rankine units beyond 2022 will incentivise the deferral of other generation investment

b) retiring the Huntly Rankine units in 2022 would incentivise investment in generation

c) the higher demand growth and withdrawal of thermal generation in the 'Low carbon and electrification' scenario would incentivise investment in generation.

3.2.2 Obviously, analysing the year ahead is more accurate than analysing the tenth year out and there is a spectrum of certainty in between. The latter years of the analysis appear to not add much value, primarily due to two factors:

a) Forecasting demand has inherent uncertainties that are amplified with longer-term forecasts. The effect of demand forecasts is discussed further in paragraphs 3.2.4-3.2.6.

b) Generation investments seem to be developed with, at most, a seven- to eight-year horizon. If it takes four to five years to plan and build new large-scale generation, then firms are unlikely to invest five years before that generation might be needed. Therefore, demand growth is modelled as happening, but there is no supply pipeline being planned that far out.

3.2.3 The system operator is required to forecast at least five years in each annual assessment. The 2018 annual assessment forecasts ten years. The 2013 annual assessment forecast only eight years.

3.2.4 As an example of how pessimistic longer-term annual assessment forecasts can be, NZ-WEM forecasts for what 'committed generation' would supply in 2018 under base case conditions were approximately:

a) 8% in the 2011 annual assessment

b) 10% in the 2012 annual assessment

c) 17% in the 2013 annual assessment

d) 18% in the 2014 annual assessment

e) 23% in the 2015 annual assessment

f) 16% in the 2016 annual assessment

g) 16% in the 2017 annual assessment

h) 22% in the 2018 annual assessment (though there is no base case for this report).

[1] Page 4 of the 2018 annual assessment.

3.2.5 The system operator's sensitivity analysis illustrates just how sensitive the results are to assumptions about demand growth. Figure 1 and Figure 2 reproduce two such charts that illustrate the importance of assumptions about any demand growth.[2]

Figure 1: High demand sensitivity on the 'Thermal remains' scenario against NZ-WEM

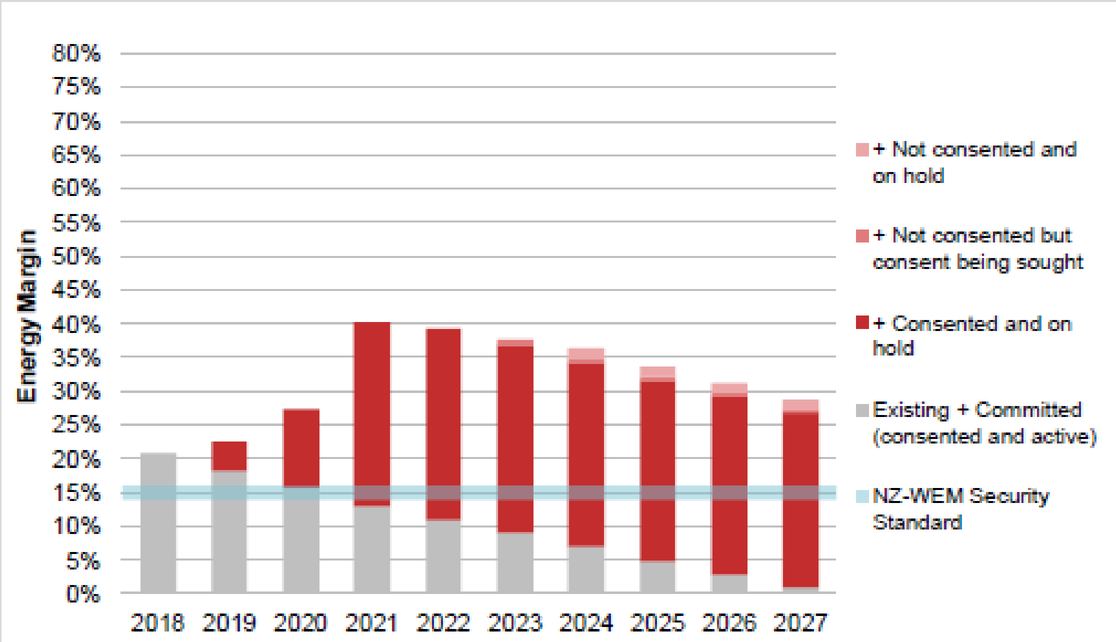
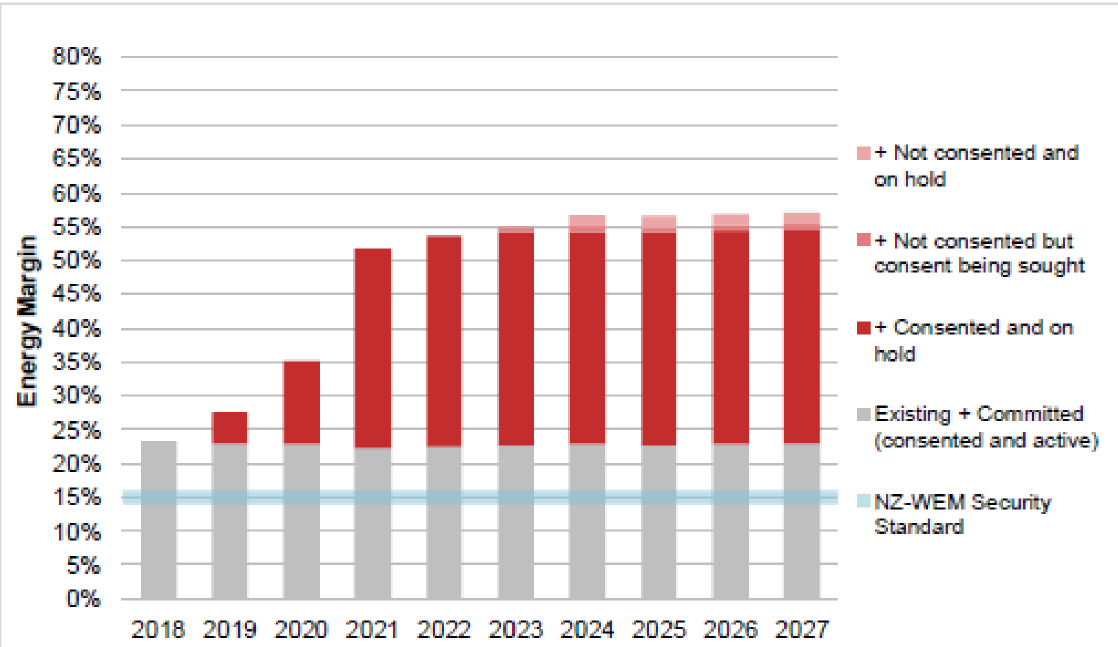


Figure 2: Low demand sensitivity on the 'Thermal remains' scenario against NZ-WEM



2 From Figures 18 (page 23) and 22 (page 24) of the 2018 annual assessment.

3.2.6 In all three of the central scenarios, the system operator assumes demand growth of at least one per cent. The system operator's demand growth assumptions are obtained from Transpower's demand forecasting team. Demand growth in New Zealand levelled off after the 2008 global financial crisis. Transpower, like many other forecasters of demand, has tended to over-estimate demand ever since, though the size of the over-estimate appears to have shrunk over time. While demand forecasting is inherently uncertain, there appears to be some scope for the system operator to consider whether its demand forecast process is as fit for purpose as possible.

3.2.7 The SSAD requires that the annual assessment make the following important assumptions about demand. These assumptions are in scope of the Authority's review of the security standards.

> "In the calculation of WEM, demand should be reduced by 2% to account for normal demand-side response. This is intended to represent the demand reduction that typically occurs in the electricity market in response to periods of high spot prices, but to exclude any demand response that arises from energy savings campaigns or the forced rationing of demand."
>
> "In the calculation of WCM, an allowance of 176 MW should be made for expected demand response and interruptible load in the North Island at peak times. No allowance need be made for South Island peak-time demand response or interruptible load."[3]

3.2.8 In preparing WCM analysis, the system operator has forecast demand based on the top 100 hours *in 2017* and then forecasted by applying the percentage growth in Transpower's peak demand forecasts to future years. It is sub-optimal to index these forecasts to one particular year. If 2017 happened to be particularly high or low for peak demand, this would propagate through all such forecasts. The system operator noted that:

> "This approach removes the need to explicitly account for transmission losses. This methodology for calculating demand is not expected have a material impact on the WCM results and is intended to make the derivation of H100 less resource intensive, less prone to errors and easier to align with supply assumptions."[4]

3.2.9 The system operator's assumptions about generation build times are also fairly important. Some key assumptions are that:

a) thermal generation is the quickest to build and hydro generation the slowest

b) geothermal and wind generation have the same build-time assumptions

c) 2020 is the earliest that consented thermal generation could be built

d) 2025 is the earliest that unconsented hydro generation could be built.[5]

3.2.10 The system operator notes that its assumptions around generation build times:

> "…do not account for transmission consent and build times, nor do they account for intra-island locational issues (such as regional voltage issues). Accounting for transmission consent and build times for some new generation projects may lead to commissioning dates for these projects being later in some circumstances."[6]

3 Paragraphs 4.5 and 4.6 of the SSAD available from https://www.ea.govt.nz/dmsdocument/14134

4 Final paragraph of section 6.1.3 of the 2018 annual assessment.

5 Page 18 of the 2018 annual assessment.

6 Second paragraph of section 3.2 of the 2018 annual assessment.

4 Questions for the SRC to consider

4.1.1 The SRC may wish to consider the following questions.

Q1.	What further information, if any, does the SRC wish to have provided to it by the secretariat?
Q2.	Do the system operator's three central scenarios seem appropriate?
Q3.	Do the system operator's assumptions around demand growth seem appropriate?
Q4.	Do the system operator's assumptions around build-time for generation (Table 1 of Page 18 of the annual assessment) seem appropriate?
Q5.	Does the ten-year horizon of the annual assessment seem appropriate?
Q6.	Does the SRC consider that, overall, the annual assessment provides an adequate representation of generation adequacy against the security margins?
Q7.	What advice, if any, does the SRC wish to provide to the Authority?

Security of Supply Annual Assessment 2018

Transpower New Zealand Limited

February 2018

Keeping the energy flowing

TRANSPOWER

Version[1]	Date	Change
1.0	2/2/2018	Draft for industry review
2.0	28/2/2018	Final version

	Position	Date
Prepared by:	Bennet Tucker Market Security Services Manager	February 2018

IMPORTANT

Contact Details

Address: Transpower New Zealand Ltd
Waikoukou
22 Boulcott Street
PO Box 1021
Wellington 6140

Telephone: +64 4 495 7000

Email: system.operator@transpower.co.nz

Website: https://www.transpower.co.nz/system-operator

[1] For previous assessments undertaken by the system operator refer to *https://www.transpower.co.nz/system-operator/security-supply/security-supply-annual-assessment*

For similar assessments by the Electricity Commission prior to 2011, refer to *http://www.ea.govt.nz/about-us/what-we-do/our-history/archive/operations-archive/security-of-supply/asa/*

Contents

1 Executive summary 4
2 Background 7
2.1 Assessment Context 7
2.2 Security of Supply Assessment 7
3 Analysis 9
3.1 Central Scenarios 9
3.2 Discussion of results 9
3.3 Winter Energy Margin results 10
3.4 North Island Winter Capacity Margin results 10
3.5 Future development 11
4 Results 12
4.1 Energy Margin Results 13
4.2 Capacity Margin Results 15
5 input assumptions 17
5.1 Generation Assumptions 17
5.2 Demand Forecast Assumptions 18
5.3 Inter-island Transmission Assumptions 18
Appendix 1: South Island Winter Energy Margin Results 19
1.1 South Island Winter Energy Margins 19
Appendix 2: Sensitivities 20
2.1 Energy Margin Sensitivities 22
2.2 Capacity Margin Sensitivities 26
Appendix 3: Methodology 29
3.1 Security of supply standards and Interpretation 29
3.2 Energy Margin Assessment 30
3.3 Capacity Margin Assessment 31
Appendix 4: Detailed Supply Assumptions 32
4.1 Existing Generation 32
4.2 New Generation 36
4.3 Other Generation Assumptions 38
Appendix 5: Transmission 40
5.1 HVDC flow south contributes to South Island WEM 40
5.2 HVDC flow north contributes to WCM 40
5.3 AC Transmission Assumptions 41
Appendix 6: Detailed Demand Forecast Assumptions 42
6.1 Demand Forecast Methodology 42
6.2 Demand Data used for the 2018 Annual Assessment 43

1 EXECUTIVE SUMMARY

This document is Transpower's annual medium to long-term security of supply assessment. It provides a 10-year view (2018 to 2027) of security of supply metrics for three key supply and demand scenario scovering energy and capacity. This assessment enables industry stakeholders to compare the risk of supply shortages both between scenarios and over time in order to inform risk management and investment decisions.

In this year's annual assessment, we have used three central scenarios to test the ability of the power system to meet security of supply standards over the next 10 years based on current, committed and consented generation projects that we are aware of. The scenarios reflect two main futures – one where participants continue to pursue operating strategies similar to those observed today, with variations based on the future of thermal generation in New Zealand (Thermal Remains and Thermal Retirement scenarios); and a second where New Zealand increases reliance on electricity, coupled with a greater dependence on renewable generation (Low Carbon and Electrification scenario).

- **Thermal Remains:** this scenario assumes existing gas and coal fired thermal generation continues to support and complement hydro generation during times of low inflows to hydro lakes and to assist meeting peak demand for electricity in winter over the next 10 years. We assume all existing grid connected thermal generation remains in service throughout the 10-year security assessment. Underlying wholesale electricity demand[2] grows at 1% per year.
- **Thermal Retirement:** this scenario assumes we reduce our reliance on thermal generation, as part of increasing the proportion of renewable generation. In this scenario, approximately 500 MW of existing thermal generation[3] is withdrawn from service at the end of 2022. Underlying wholesale electricity demand grows at 1% per year.
- **Low Carbon and Electrification:** this scenario assumes the energy sector plays a significant role in assisting New Zealand to achieve its climate change targets through electrification of the transport fleet and industrial process heat, as well as shifting to a greater reliance on renewable generation. In this scenario, we reduce our reliance on thermal generation from 2022, and restrict all new generation to renewable generation only. It is assumed electrification results in a wholesale electricity demand growth of 2% per year.

We make the assumption New Zealand remains an economically viable location to produce aluminium and the existing New Zealand Aluminium Smelter (NZAS) demand remains in all scenarios.

In the Thermal Remains and Thermal Retirement scenarios, the security of supply margins[4] are forecast to remain above or within their respective security of supply standards[5] without the need for generation investment until at least 2023. There are sufficient consented generation options available to be commissioned to enable the security of supply standards to be maintained throughout the period of assessment.

In the Low Carbon and Electrification scenario, without investment, the security of supply margins begin to fall below the security of supply standards from 2021. Investment in generation that is consented, but on hold, would be required to maintain the security of supply standards from 2021.

---

[2] Wholesale electricity demand in this context means demand for large scale generation. Demand for small scale generation (e.g. Rooftop solar) is not directly accounted for in this assessment.

[3] It is up to the market to determine the merit order of generation plant, and any commentary on this is out of the scope of this assessment. For modelling purposes, we have assumed the Huntly Rankine units are retired.

[4] The set of metrics include three margins; the New Zealand and South Island Winter Energy Margins (WEMs) and North Island Winter Capacity Margins (WCMs). The energy margins assess whether it is likely there will be an adequate level of generation and HVDC south transmission capacity to meet to meet expected electricity demand in extended dry periods. The capacity margin assesses whether it is likely there will be adequate generation and HVDC north transmission capacity to meet peak North Island demand.

[5] The Security Standards are defined by the Electricity Authority as part of its responsibility to ensure that the regulatory environment promotes an efficient level of reliability. It is important to note that falling below the standards does not equate to electricity shortage. It simply implies that investment in new generation would result in an efficient increase to reliability. It can also be interpreted as representing the likelihood of electricity shortage – the higher the margin the less likely electricity shortage will be. See Appendix 3: for more information.

The Low Carbon and Electrification scenario is broadly consistent with the climate change goal of 100% renewable electricity generation by 2035 in a normal hydrological year. All consented renewable generation would need to be commissioned by 2024 to maintain security of supply standards. The pursuit of a low carbon future would almost certainly require additional new generation options (over and above those already known) to be developed and commissioned to maintain the standards beyond this date.

These results are illustrated using the New Zealand Winter Energy Margins[6] below (Figure 1). For each scenario, the lower, light bars indicate the margin attained from existing and committed generation, allowing for the withdrawal of approximately 500 MW of thermal generation in the Thermal Retirement and Low Carbon and Electrification scenarios. The upper, dark bands indicate the amount of consented, but on hold, new generation (note - the Low Carbon and Electrification scenario future generation does not include any new thermal generation).

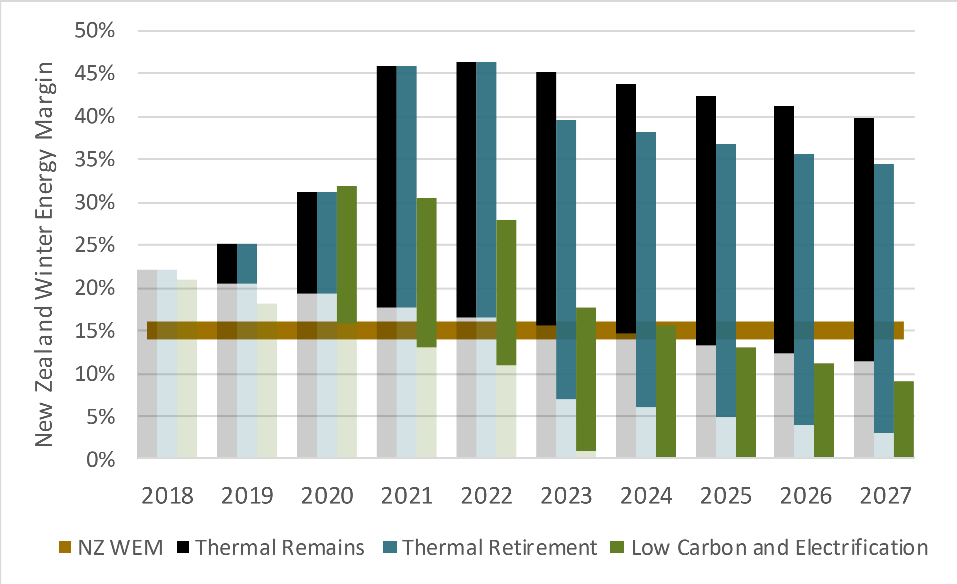


Figure 1: NZ-WEM with existing (including committed) generation and consented but on hold generation

This year we have modified the presentation of the results to categorise new generation by consent status, rather than likelihood of generation investment used in previous years. We believe this approach improves consistency. It removes the need to take a view on the likelihood of generation investment decisions, but we recognise that it makes like for like comparisons with previous year's assessments more difficult. The reduction in assumed demand growth this year has increased margins slightly compared to last year's assessment (the amount of generation is similar).

When analysing these results, it should be noted the annual assessment results are based on a simplified model of the New Zealand electricity system. As such, the assessment makes several assumptions that should be considered when drawing conclusions. In particular:

- The timelines illustrated in the results for new renewable generation do not account for the consenting and build times for additional transmission infrastructure, nor do they account for intra-island locational issues (such as regional voltage issues). This may delay commissioning dates in situations where major transmission investment is required.
- All scenarios highlight the reliance on consented (but on hold) generation. If consented projects are not committed before consents lapse, then new consents or other sources will be required. This may delay commissioning dates in some instances.
- The impact of increased small-scale generation (for example, domestic roof-top solar PV) and new technologies is not explicitly considered in this assessment (although in some cases, such as small-scale generation, it is implicitly accounted for in the demand forecast). This may mean the assessment under-estimates the impact of these technologies.

[6] The New Zealand WEMs are broadly reflective of the results in general. The two other margins, the South Island WEM and the North Island WCM show similar results.

Due to the range of outcomes associated with the future scenarios, we will be carrying out further work in 2018 to ensure that future security of supply assessments, and the broader security of supply framework, provide support and advice to industry stakeholders during this anticipated period of change. This work, in conjunction with other Transpower initiatives, will focus on developing an understanding of the impact of new technologies, low carbon goals and any other potential disruptions to the security of New Zealand electricity supply.

2 BACKGROUND

2.1 ASSESSMENT CONTEXT

This document is Transpower's annual medium to long-term security of supply assessment. Its purpose is to inform risk management and investment decisions by generators, other market participants, and investors.

It forms part of New Zealand's electricity security of supply framework. Transpower performs other security of supply-related functions described in its *Security of Supply Forecasting and Information Policy* and the *Emergency Management Policy*.[7] These include:

- Short-term monitoring and information provision, such as the weekly reporting of hydro levels relative to the hydro risk curves.
- Implementation of emergency measures where necessary.
- Detailed assessment of grid capability to meet demand over the next three years, available in Transpower's System Security Forecast.
- Detailed assessment of the North Island winter capacity margin for the current year, available in Transpower's New Zealand Generation Balance assessment.

For more detail on the security of supply framework see *https://www.transpower.co.nz/system-operator/security-supply*.

We review the content of the Annual Security of Supply Assessment each year to provide a meaningful analysis to a wide readership, whilst respecting information provided to us in commercial confidence. We welcome your ideas on how we could improve future assessments.

Please direct all such ideas to System Operations, Transpower NZ Limited, preferably by email: *system.operator@transpower.co.nz*.

2.2 SECURITY OF SUPPLY ASSESSMENT

This assessment provides a long-term view of the balance between supply and demand in the New Zealand electricity system. The security of supply assessment forecasts two winter margins, the Winter Energy Margin (WEM) and the Winter Capacity Margin (WCM).

- The energy margins, for New Zealand and the South Island, are the sum of the respective expected winter energy supply, in gigawatt-hours (GWh), divided by the expected energy demand, in GWh. The margins are expressed as a percentage of total demand.
- The capacity margin is the sum of expected North Island generation capacity less the expected peak demand plus surplus South Island capacity able to be sent via the HVDC link to the North Island. The margin is expressed as a megawatt (MW) value.

Winter is defined as the period from April to October for the WCM, and April to September for the WEMs.

The energy margins assess whether it is likely that there will be an adequate level of generation and, in the case of the South Island, HVDC south transmission capacity, to meet expected electricity demand during the winter. The capacity margin assesses whether it is likely there will be adequate generation and HVDC north transmission capacity to meet peak North Island demand.

The security of supply standards are defined by the Electricity Authority as part of its responsibility to ensure that the regulatory environment promotes an efficient level of reliability. It is important to note that falling below the standards does not equate to electricity shortage. It simply implies that investment in new generation would result in an efficient increase to reliability. It can also be

[7] *https://www.transpower.co.nz/system-operator/security-supply/security-supply-forecasting-and-information-policy*

interpreted as representing the *likelihood* of electricity shortage – the higher the margin the less likely electricity shortage will be.

The current security of supply standards[8] specified in the Code are:

- a WEM of 14-16% for New Zealand
- a WEM of 25.5-30% for the South Island
- a WCM of 630-780 MW for the North Island.

A more detailed description of the security of supply assessment methodology may be found in Appendix 3:.

[8] The Authority reviews the security of supply standards on a regular basis to ensure they account for the risks to supply, the mix of generation and demand side technologies employed by participants, uncertainty in primary fuel availability (especially hydro inflow uncertainty), and costs.

3 ANALYSIS

We use three central scenarios[9] to represent three quite different, but plausible, futures. We assess the degree to which margins are met against each of these scenarios. Two scenarios assume no significant changes to energy policy or regulations, and explore different futures for existing thermal generation plant. A third scenario tests the impact of an increased focus on reducing carbon emissions in the industrial and transport sectors. Each scenario is based on Transpower's demand forecast. Supply and new generation options under consideration are those reported to us by generators.

3.1 CENTRAL SCENARIOS

The three scenarios are:

- **Thermal Remains:** this scenario assumes we continue to rely on existing gas and coal fired thermal generation to support and compliment hydro generation during times of low inflows to hydro lakes and to assist meeting peak demand for electricity in winter over the next 10 years. We assume all existing grid connected generation remains in service throughout the 10-year assessment period. Underlying wholesale market demand for electricity grows at 1% per year.
- **Thermal Retirement:** this scenario assumes we reduce our reliance on thermal generation, as part of increasing the proportion of renewable generation. In this scenario, approximately 500MW of existing thermal generation is withdrawn from service at the end of 2022. Underlying wholesale market demand for electricity grows at 1% per year.
- **Low Carbon and Electrification:** this scenario assumes the energy sector plays a significant role in assisting New Zealand to achieve its climate change targets through electrification of the transport fleet and industrial process heat, as well as shifting to a greater reliance on renewable generation. In this scenario, we reduce our reliance on thermal generation from 2022 (same assumption as the Thermal Retirement scenario above), and restrict all new generation to renewable generation only. It is assumed electrification results in wholesale electricity market demand growth of 2% per year.[10]

We make the assumption New Zealand remains an economically viable location to produce aluminium and the existing New Zealand Aluminium Smelter (NZAS) demand remains in all scenarios for the entire duration of the assessment.[11]

For further information on the assumptions used in this assessment see section 5 for high level information and sections Appendix 4: and Appendix 6: for detailed information.

3.2 DISCUSSION OF RESULTS

This assessment indicates that if participants continue to pursue operating strategies similar to those observed today, then there are currently sufficient consented, but on hold, new generation options to ensure efficient levels of reliability in the coming decade. However, if a low carbon future is pursued, it is likely further new generation options will also need to be found in order to maintain the security of supply standards. Regardless of the scenario, investment in new generation will be required to

---

[9] In this document, we use the term scenario to denote a standalone, plausible future. We use sensitivities to denote exploration of the impact of various factors on each of these scenarios. In previous assessments, we used a single base case in order to represent our most likely estimate of the future.

[10] If sustained over a 30-year period this would double electricity demand, consistent with some of the higher estimates from emerging work on the potential for electrification.

[11] Given our high proportion of renewable electricity, it is possible aluminum made in New Zealand may be an attractive product in international markets.

maintain the security of supply standards. When this new generation is required is dependent on the circumstances. The margin forecasts are especially sensitive to the withdrawal of thermal generation.

If no new generation is built, it is expected that all margins will fall below security of supply standards, indicating that the New Zealand electricity system could risk uneconomic levels of demand curtailment. For the Thermal Remains and Thermal Retirement scenarios investment in consented generation should be sufficient to ensure all three margins remain above or within the security of supply standards throughout the assessment period. In the Low Carbon and Electrification scenario, new generation projects[12] will be required to maintain the margins at or above the security of supply standards. The timelines illustrated in the results for new generation do not account for transmission consent and build times, nor do they account for intra-island locational issues (such as regional voltage issues). Accounting for transmission consent and build times for some new generation projects may lead to commissioning dates for these projects being later in some circumstances.[13]

This assessment does not consider consents that may lapse during the assessment (and are not immediately reconsented). It does not take account of the impact of uncertainty on generation investment decisions, nor does it explicitly consider development of transmission and connection infrastructure (as described above). If new generation investment is restricted by these factors the margins could be lower than those presented in this assessment.

3.3 WINTER ENERGY MARGIN RESULTS

In the Thermal Remains scenario, new generation is required to maintain the New Zealand WEM at, or above, the standard from 2025. For the South Island WEM no new generation is required to maintain the margin at, or above, the standard. In the Thermal Retirement scenario, new generation is required to maintain both the New Zealand and South Island energy margins from 2023. There is sufficient consented generation in both of these scenarios to maintain the security of supply standards.

In the Low Carbon and Electrification scenario, where limitations are placed on new thermal generation (all new generation is restricted to renewable only), and electrification of industrial and transport accelerates (in addition to existing thermal generation being withdrawn), significantly more generation investment would be needed to maintain the energy margins than in the other two scenarios. The NZ WEM is forecast to drop below the standard in this scenario even if all consented generation is built. This is forecast to occur in 2026.

3.4 NORTH ISLAND WINTER CAPACITY MARGIN RESULTS

Like the WEMs, the medium to long-term outlook for the North Island WCM is sensitive to the future of existing thermal generation. If no new generation is built, the North Island WCM is forecast to remain above or within the security of supply standard until at least 2021 in the Low Carbon and Electrification scenario, 2022 in the Thermal Retirement scenario and 2025 in the Thermal Remains scenario, respectively. Investment in consented generation currently on hold would be required beyond these dates in order to maintain the security of supply standard for peak demand.

The North Island capacity margin is much more sensitive to changes in thermal generation than the energy margins. In the Low Carbon and Electrification scenario, the margin is forecast to drop below the WCM even if all consented generation options are built by 2024, and gets very close to zero by the end of the assessment period.

---

[12] Projects that are, currently, unknown or not included in this assessment, which, may include completely new developments or technology.

[13] Although outside the scope of assessing the WCM, should thermal generation be withdrawn from the Waikato region ahead of new generation or transmission in the northern Waikato or further north, the ability to meet demand in this region could become constrained. For more information please see: https://www.transpower.co.nz/waikato-and-upper-north-island-voltage-management-investigation

3.5 FUTURE DEVELOPMENT

Further work will be undertaken during 2018 to ensure that future security of supply assessments, and the broader security of supply framework, provide support and advice to industry stakeholders during this anticipated period of change. The key areas of focus in this work will be:

- Extend security of supply analysis to incorporate low carbon and electrification futures. That is, we will attempt to help answer the question "how can the electricity industry deliver a low carbon future, while ensuring security of supply?"
- Provide further clarity and advice on what might be required in the scenarios presented in this assessment. For example, we will look to assess the impact and timing of transmission and infrastructure needs on the Low Carbon and Electrification scenario.
- Develop the scenarios to include more detailed inputs, including demand and supply forecasts that explicitly account for emerging technologies (for example, solar PV, batteries, demand response) and detailed projections of significant industry changes (for example, electrification of the dairy industry).
- Assess the merits of including contingent event analysis, e.g. HVDC or gas supply disruptions, in the annual security assessment or an alternate publication.
- Continue to develop and refine the presentation of our security of supply assessment results to ensure we are meeting the needs of industry stakeholders.

This work will be progressed in the 2018 calendar year, and feedback, or suggestions, from the industry or other interested parties are welcome. Feedback or suggestions can be sent to *system.operator@transpower.co.nz*.

4 RESULTS

The charts in this section show the margins for the three key scenarios assessed. Each chart presents three key pieces of information:

- The security standard represented by a horizontal blue or orange line on the charts. This is a reference to compare the margins against. These are calculated by the Electricity Authority as the upper and lower margins that represent an efficient level of reliability.
- The margins calculated with the electricity supply from existing, and committed generation. This is represented by the grey bars on the charts. As time passes, and demand grows, the margin based on this generation decreases.
- The margins with new generation added. That is, the margins if all known new generation options are built (assuming some practical limitations on lead times). This is represented by the series of red coloured bars on the charts.

We have drawn conclusions from the results by firstly analysing what the future looks like with no new generation. Following this, we made an assessment on the ability of new generation options to meet the security standard in the future. If there is a significant volume of new generation options available that, when added to existing generation, results in a margin that exceeds the security standard, then it is likely the electricity system will be able to maintain the margin at or near the security standard.

Conversely, if the sum of known generation options, on top of existing generation, results in a margin that is below the standard then industry participants will need to investigate and develop new generation options beyond those on hold, or the margin may fall below the standard, and the New Zealand electricity system may experience inefficient levels of shortage risk.

For perspective, in the New Zealand WEM analysis, to increase the margin by 5% would require approximately 1,000 GWh of generation over the period April to September inclusive.[14] For the South Island WEM analysis, the same increase could be achieved by approximately 400 GWh of South Island generation over the period April to September inclusive.

The South Island WEM analysis results are not shown in this section as they are not materially different from the conclusions of the New Zealand WEM analysis. For full results, including South Island WEMs, and a complete set of results from the sensitivity analysis please see Appendix 1: and Appendix 2: respectively.

[14] 1,000 GWh of generation is equivalent to a 230-240 MW of geothermal generator (95-98% capacity factor) or a 560-570 MW wind farm (40% capacity factor).

4.1 ENERGY MARGIN RESULTS

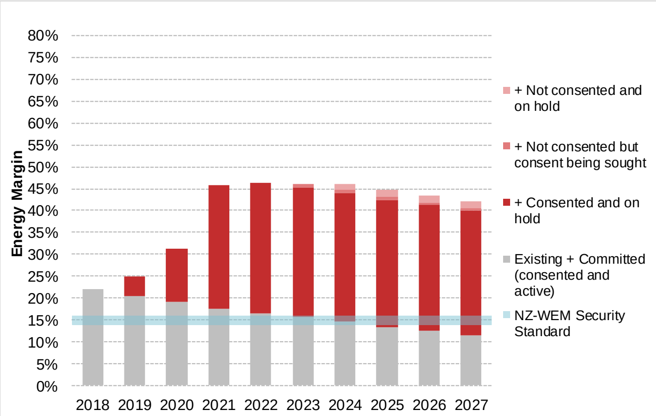


Figure 2: NZ WEM – Thermal Remains

- In the Thermal Remains scenario existing thermal generation is assumed to be available for the duration of the assessment.
- The New Zealand WEM is forecast to fall below the security of supply standard in 2025.
- Some consented generation would need to be commissioned prior to the winter of 2025 to continue to meet the New Zealand WEM security of supply standard.

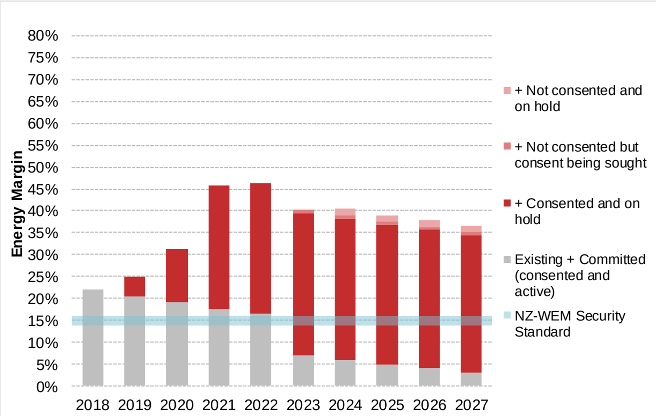


Figure 3: NZ WEM – Thermal Retirement

- In the Thermal Retirement scenario, approximately 500 MW of thermal generation is withdrawn at the end of 2022.
- New generation will be required following the withdrawal of existing thermal generation to meet the New Zealand WEM security of supply standard.

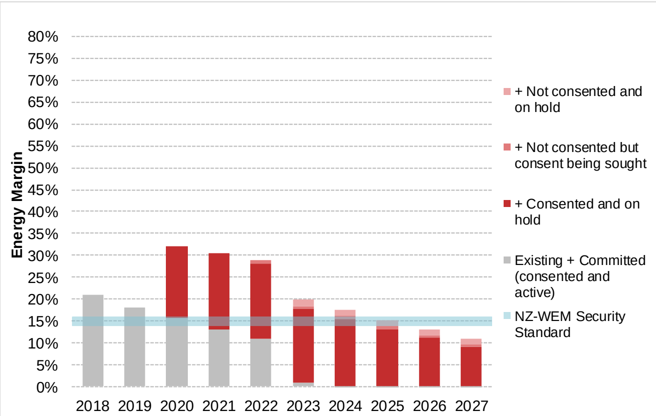


Figure 4: NZ WEM – Low Carbon and Electrification

- In the Low Carbon and Electrification scenario, demand is increased, new thermal generation is restricted, and generation investments are assumed available one year earlier than the other two scenarios.
- The New Zealand WEM is forecast to fall below the security of supply standard in 2021. Investment in new generation will be required from this point. From 2026, investment in known new generation would be insufficient to maintain the New Zealand WEM security of supply standard, and new generation options will need to be developed if the standard is to be maintained.

4.1.1 Winter Energy Margins sensitivities summary

A number of sensitivities to changes in supply and demand were assessed against the scenarios[15], including:

- **NZAS closure:** ceases production at the end of 2022
- **High demand:** an additional 1% p.a. demand growth
- **Low demand:** a 1% reduction in annual demand growth
- **Reduced generation availability:** a 5% reduction in non-thermal generation output

Observations from the sensitivity analyses, depicted in section 2.1 of Appendix 2:, are:

- In the event of low demand or the NZAS closure little or no new generation investment would be required to maintain the New Zealand or South Island WEMs during the 10 year forecast period.
- High demand or reduced generation availability scenarios would result in a decrease of the New Zealand and South Island WEMs. Investment in new generation would be required to maintain the security of supply standard.
- Reduced generation availability in conjunction with the Low Carbon and Electrification scenario will mean the New Zealand WEM may fall below the security of supply standard in 2019, and a significant amount of new generation options would need to be developed from 2023 as currently known options would be insufficient from 2024.

[15] Not all scenarios were tested against all sensitivities, for example, the Low Carbon and Electrification scenario was not tested against low demand as this scenario assumes high demand.

4.2 CAPACITY MARGIN RESULTS

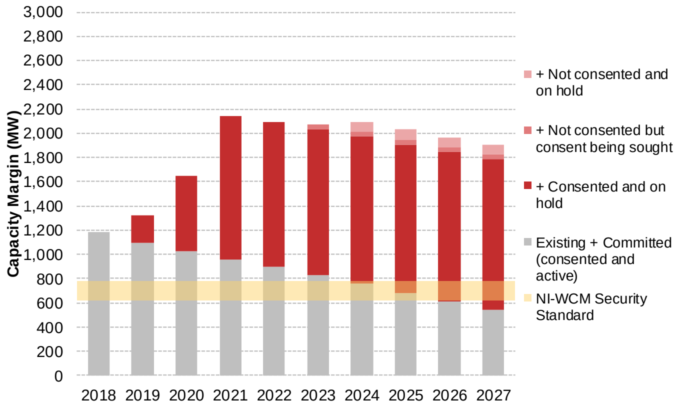


Figure 6: NI WCM – Thermal Remains

- In the Thermal Remains scenario existing thermal generation is assumed to be available for the duration of the assessment.
- The North Island WCM is forecast to fall below the security of supply standard in 2026.
- New generation would need to be commissioned prior to the winter of 2026 to continue to meet the North Island WCM security of supply standard.

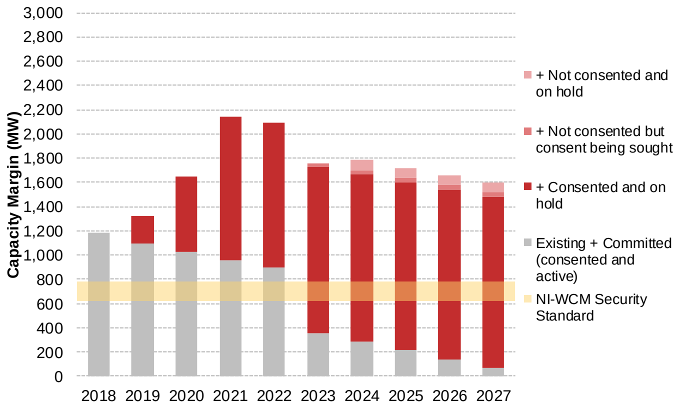


Figure 7: NI WCM – Thermal Retirement

- In the Thermal Retirement scenario, approximately 500 MW of thermal generation is withdrawn at the end of 2022.
- New generation will be required following the retirement of existing thermal capacity to maintain the North Island WCM security of supply standard.

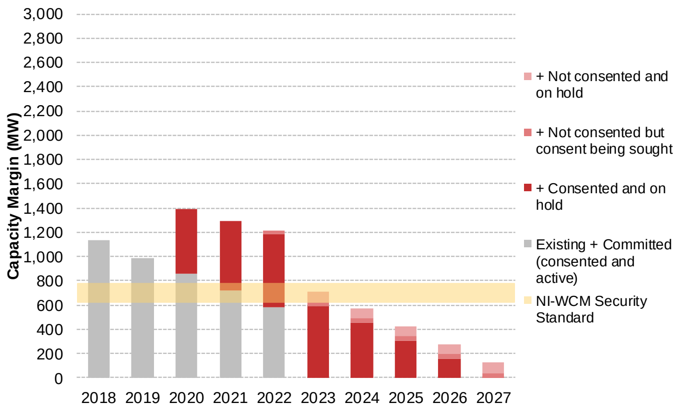


Figure 8: NI WCM – Low Carbon and Electrification

- In the Low Carbon and Electrification scenario, demand is increased. New thermal generation is restricted, and generation investments are assumed available one year earlier than the other two scenarios.
- The North Island WCM is forecast to fall below the security of supply standard in 2022, investment in new generation will be required from this point. From 2024, investment in currently known new generation would be insufficient to maintain the North Island WCM security of supply standard. New generation options would need to be developed if the standard is to be maintained.

4.2.1 North Island Winter Capacity Margin sensitivities summary

A number of sensitivities to changes in supply and demand were assessed against the central scenarios, including:

- **NZAS closure:** NZAS ceases production at the end of 2022
- **High demand:** an additional 1% p.a. demand growth
- **Low demand:** a 1% reduction in annual demand growth
- **Reduced generation availability:** a 5% reduction in non-thermal generation output
- **Limited north HVDC transfer:** north transfer is limited to 500MW.

Observations from the sensitivity analyses, depicted in section 2.2 of Appendix 2: are:

- As in the assessment of the WEMs, little or no new generation investment would be required to maintain the North Island WCM if demand is lower than expected. However, unlike the WEMs, in the NZAS closure sensitivities, investment will be required from 2023 to maintain the security of supply standards in the Thermal Retirement and Low Carbon and Electrification scenarios.
- High demand or reduced generation availability would result in a significant decrease of the North Island WCM in the Thermal Remains and Thermal Retirement scenarios. Investment in consented generation would be required earlier and the amount of generation required increases compared to the standard scenarios.
- Reduced generation availability in conjunction with the Low Carbon and Electrification scenario will mean the North Island WCM may fall below the North Island WCM security of supply standard in 2020, and a significant amount of new generation options would need to be developed from 2023 as currently known options would be insufficient from this point. With only currently known generation options, the margin may fall below zero in 2026.
- The North Island WCM is highly sensitive to north HVDC transfer capability. The loss of a monopole would lower the WCM in all scenarios.

5 INPUT ASSUMPTIONS

A set of standardised assumptions are used to determine the margins.[16] The main input assumptions used in this assessment were the levels of:

- electricity generation (existing and proposed new projects)
- electricity demand (including demand response)
- inter-island transmission capability.

5.1 GENERATION ASSUMPTIONS

Generation companies are surveyed confidentially about their existing and proposed new generation.

The expected energy supply in GWh used to determine the winter energy margins is the sum of:

- controlled hydro generation based on an average hydrological year.[17]
- thermal generation capacity de-rated to allow for any outages, multiplied by the number of winter hours.
- other major sources of generation (uncontrolled hydro, geothermal, wind, co-generation) based on reported capacity and utilisation, multiplied by the number of winter hours.

The expected generation capacity in MW used to determine the winter capacity margin is the sum of:

- expected thermal and controlled hydro generation capacity, de-rated to allow for any outages.
- expected winter peak contributions for all other generation (i.e. uncontrolled hydro, geothermal, wind, co-generation) based on historical winter peak contributions (in MW).

All existing generation is expected to remain operationally available throughout the assessment period unless otherwise stated, with the exception of generation with a publicly notified retirement date. Genesis Energy has previously announced the potential retirement of the Huntly Rankine units at the end of 2022 (pending market conditions at the time). This possibility is anticipated in the Thermal Retirement and Low Carbon and Electrification scenarios.

We assume thermal fuel availability, or operational limitations, will not constrain electricity generation, with the exception of the Whirinaki diesel generator. Whirinaki's energy contribution is limited to 30 GWh per year for the calculation of the WEMs due to fuel delivery logistics.

Proposed new generation options have been aggregated to preserve confidentiality. New generation development options under consideration by investors may or may not proceed for a variety of reasons. New generation projects have been allocated to four categories:

- Consented and proceeding (i.e. Commited)
- Consented and on hold/awaiting market conditions to change
- Not consented, but consent is likely to be sought within the next 2 years
- Not consented and on hold, long term project not currently being progressed.

The dates at which new generation becomes available is based on the type of generation, and its consent status. Table 1 shows the earliest potential commissioning dates for different types of generation and the consent status.[18]

---

[16] The assumptions and methodology are based on the Electricity Authority's Security Standards Assumptions Document (SSAD) http://www.ea.govt.nz/dmsdocument/14134 .

[17] This is the average of inflows into controlled hydro lakes in years 1931 to 2017.

[18] These commissioning dates are one year earlier in the Low Carbon and Electrification scenario.

Table 1: Earliest new generation commissioning dates based on consent status and generation type

		Committed	Consented and on hold	Not consented, but consent likely to be sought	Not consented and on hold
Thermal	Estimated build date	2020	2022	2023	
Geothermal	Estimated build date	2021	2023	2024	
Wind	Estimated build date	2021	2023	2024	
Hydro	Estimated build date	2022	2024	2025	

We have not considered the lapsing of consents in this assessment, and assume that all currently consented projects will be reconsented should that be required.

See section Appendix 4: for further details on about existing and new generation supply assumptions.

5.2 Demand Forecast Assumptions

The expected energy demand (GWh) is based on the growth forecast determined in Transpower's 2017 long-term energy demand forecast. This forecasts demand for electricity at Grid Exit Points (GXPs). It includes local distribution losses, but does not include transmission losses. It also does not include demand served by generation connected to the local distribution network (referred to as embedded generation).

This base forecast is then adjusted to include transmission losses and embedded generation to attain a wholesale demand forecast.[19]

The expected peak capacity demand (MW) is based on the highest 100 hours of demand in 2017, inclusive of both transmission losses and embedded generation, and increased by the forecast growth-rate in the Transpower's 2017 long-term peak demand forecast.

See Appendix 6: for more detailed assumptions about the electricity demand forecast used in the in this assessment.

5.3 Inter-Island Transmission Assumptions

North Island energy supply can meet some of the South Island's energy demand in the assessment of the South Island WEMs. It is assumed the North Island will be able to supply the South Island with up to 2,102 GWh (480 MW average transfer) of energy during the winter period, depending on the surplus energy available in the North Island[20].

Similarly, South Island capacity can meet some North Island demand in the assessment of the North Island WCMs. The contribution of the South Island is a function of the surplus capacity available in the South Island and has been derived using simulation analysis.

See Appendix 5: for detailed assumptions about inter-island transmission.

[19] Wholesale electricity demand in this context means demand for large scale generation. Demand for small scale generation (e.g. Rooftop solar) is not directly accounted for in this assessment.

[20] Energy surplus in the North Island is calculated by subtracting North Island demand from available North Island supply.

Appendix 1: South Island Winter Energy Margin Results

1.1 South Island Winter Energy Margins

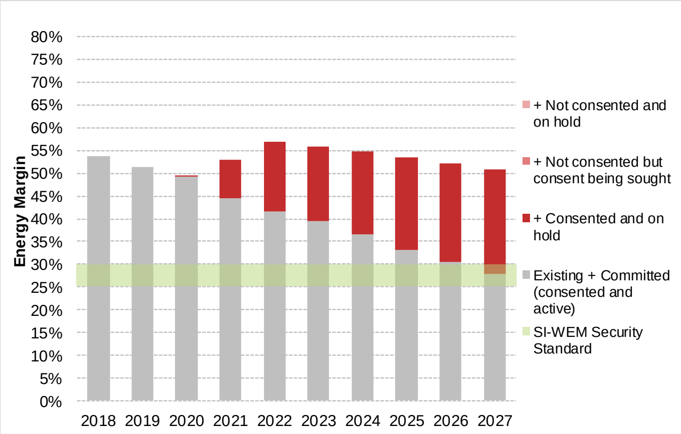


Figure 9: SI WEM – Thermal Remains

- In the Thermal Remains scenario existing thermal generation is assumed to be available for the duration of the assessment.
- The South Island WEM is forecast to remain at or above the security of supply standard for the duration of the assessment.

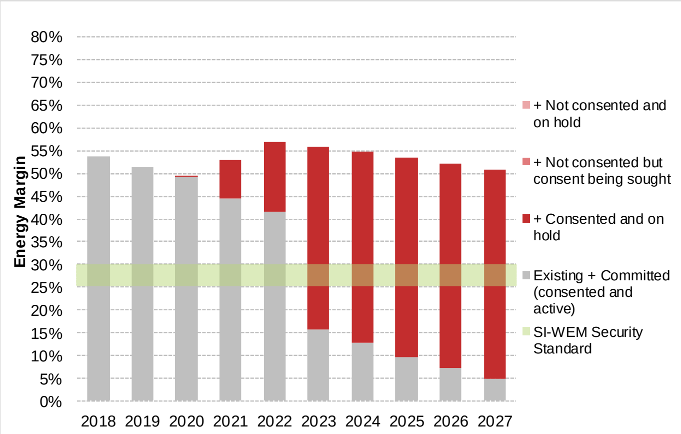


Figure 10: SI WEM – Thermal retirement

- In the Thermal Retirement scenario, approximately 500 MW of thermal generation is withdrawn at the end of 2022.
- New generation will be required following the retirement of existing thermal generation to meet the New Zealand WEM security of supply standard.

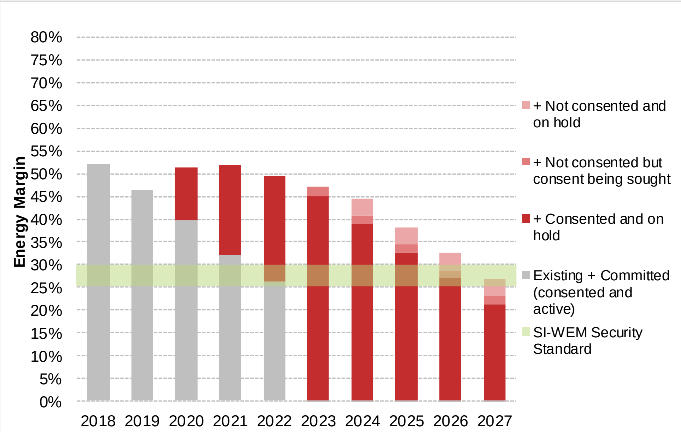


Figure 11: SI WEM – Low Carbon and Electrification

- In the Low Carbon and Electrification scenario, demand is increased, new thermal generation is restricted, and generation investments are assumed one year earlier than the other two scenarios.
- The South Island WEM is forecast to fall below the security of supply standard in 2023. Investment in new generation will be required from this point.

Appendix 2: SENSITIVITIES

The assessed energy and capacity margins central scenarios are sensitive to the assumed availability of generation (existing and new), demand (including NZAS demand), and HVDC capability. In this section we consider a range of sensitivities to assess the implications of different assumptions, and apply them to the central scenarios described in section 3.1.

Table 2 describes the change to assumptions for each of the following sensitivities:

- NZAS closure, NZAS ceases production at the end of 2022
- High demand, an additional 1% p.a. demand growth
- Low demand, a 1% reduction in annual demand growth
- Reduced generation availability, a 5% reduction in non-thermal generation output
- Limited north HVDC transfer, north transfer is limited to 500 MW (WCM only)

Some of these sensitivities have more than one set of results. For example, the High Demand sensitivity is applied to the Thermal Remains and Thermal Retirement scenarios, but not the Low Carbon and Electrification scenario (as it already uses high demand).

Table 2: Sensitivities

Sensitivity	Affects Energy	Affects Capacity	Rationale	Assumptions
NZAS closure	Yes	Yes	This sensitivity explores the situation where the NZAS aluminium smelter starts reducing its output from 2021 and closes at the end of 2022.	NZAS reduces load in stages beginning in 2021 until it reaches 0 GWh of demand in 2023. Assumed to consume 569 MW in 2020, 381 MW in 2021 and 191 MW in 2022. Applied to all three scenarios.
High demand	Yes	Yes	This sensitivity explores the situation where demand growth is higher than anticipated.	+1% demand growth p.a. on base-case for scenarios. This is equivalent to an average growth rate of approximately 2% per year. Applied to Thermal Remains and Thermal Retirement scenarios (Low Carbon and Electrification scenario already assumes high demand).
Low demand	Yes	Yes	This sensitivity explores the situation where demand growth is lower than anticipated.	-1% demand growth per year on base-case for central scenarios. This is equivalent to flat demand (i.e. an average growth rate of approximately 0% per year) Applied to Thermal Remains and Thermal Retirement scenarios.
Reduced generation availability	Yes	Yes	This sensitivity explores the impact of a reduction in electricity supply. This sensitivity is designed to indirectly account for internal and external influences that may reduce the output of electricity generation. External influences include effects such as reduction in geothermal field pressure, systemic changes to inflow patterns, etc. Internal influences include effects such as statistical errors in historical generation data and forecast errors for new generation.	In the calculation of energy margins, all non-thermal generation energy contribution is reduced by 5%. In the calculation of capacity margins, all non-thermal generation capacity factors are reduced by 5%. Applied to all three scenarios.
Limited north HVDC transfer (Also, a proxy for the loss of gas supply to thermal generation)	No	Yes	This sensitivity explores the impact of a reduction in north HVDC transfer on the North Island WCM. It reflects the impact of a monopole outage (reduced HVDC capability). A monopole outage, from a WCM perspective, is roughly equivalent to the loss of 500MW of NI thermal generation. This sensitivity is not applied to the WEMs as it does not represent a credible scenario – it is extremely unlikely that the HVDC will be restricted for an extended period of time. However, it does show the impact of reducing or removing HVDC capability (or that equivalent in North Island generation) in during peak periods.	Inter-island transfer is limited to 500 MW in the North Island WCM. Applied to all three scenarios

2.1 ENERGY MARGIN SENSITIVITIES

2.1.1 NZAS closure

New Zealand Winter Energy Margin

South Island Winter Energy Margin

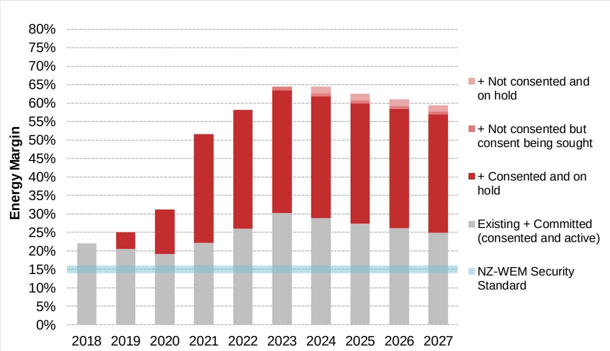


Figure 5: NZ WEM – Thermal Remains and NZAS closure

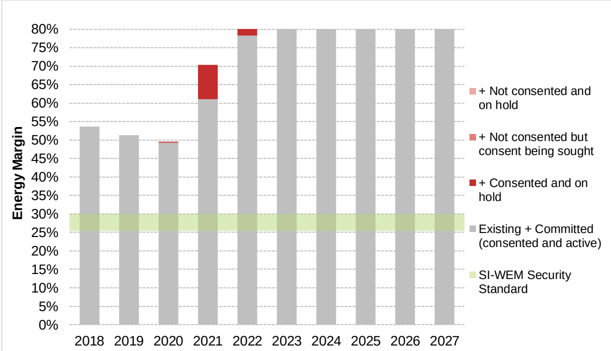


Figure 6: SI WEM – Thermal Remains and NZAS closure

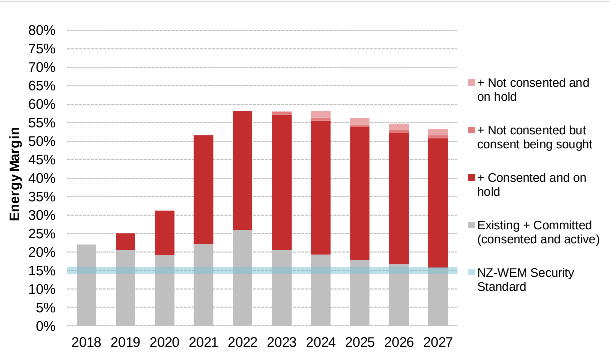


Figure 7: NZ WEM – Thermal Retirement and NZAS closure

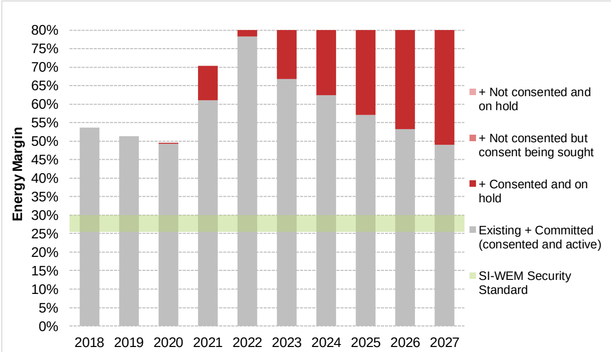


Figure 8: SI WEM – Thermal Retirement and NZAS closure

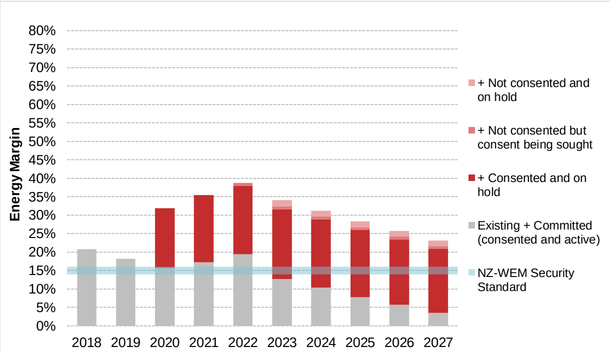


Figure 16: NZ WEM – Low Carbon and Electrification and NZAS closure

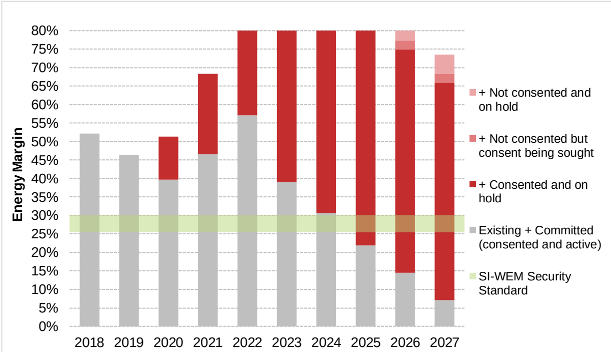


Figure 17: SI WEM – Low Carbon and Electrification and NZAS closure

2.1.2 High demand

New Zealand Winter Energy Margin

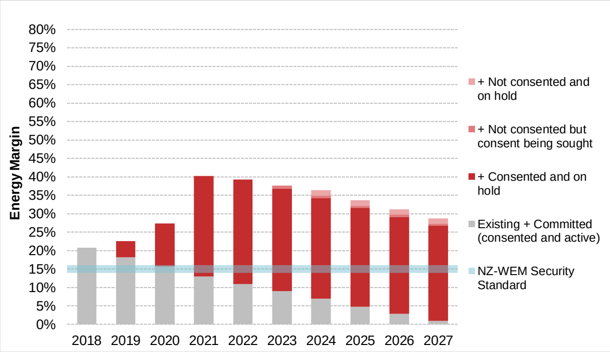


Figure 18: NZ WEM – Thermal Remains and High demand

South Island Winter Energy Margin

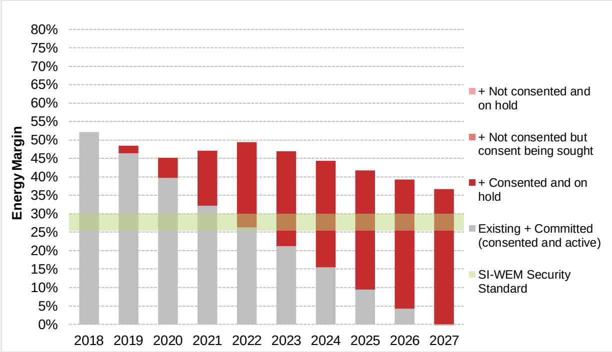


Figure 19: SI WEM – Thermal Remains and High demand

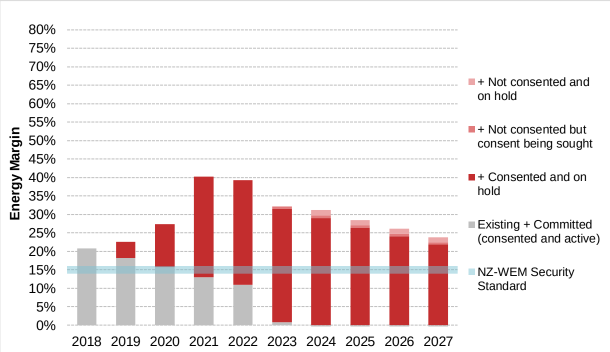


Figure 20: NZ WEM – Thermal Retirement and High demand

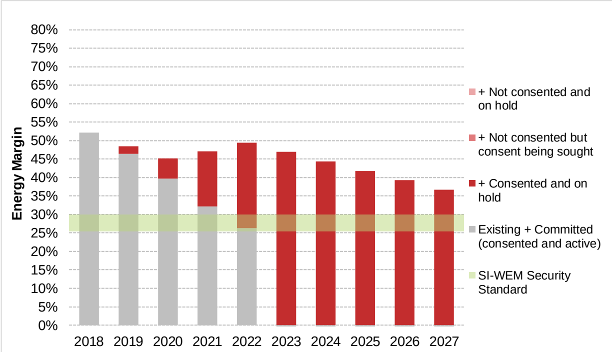


Figure 21: SI WEM – Thermal Retirement and High demand

2.1.3 Low demand

New Zealand Winter Energy Margin

South Island Winter Energy Margin

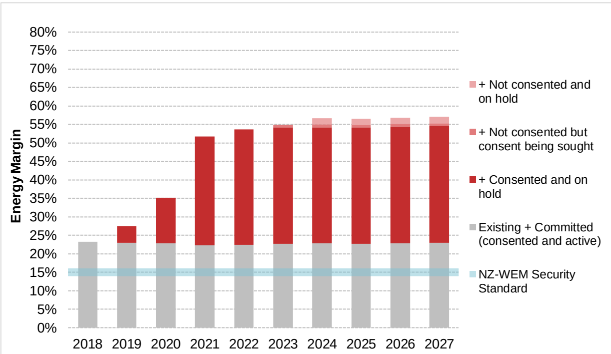


Figure 22: NZ WEM – Thermal Remains and Low demand

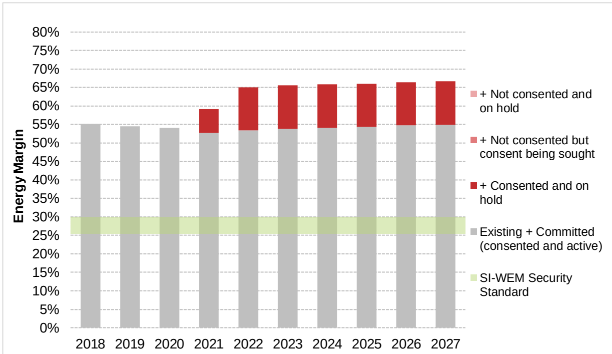


Figure 23: SI WEM – Thermal Remains and Low demand

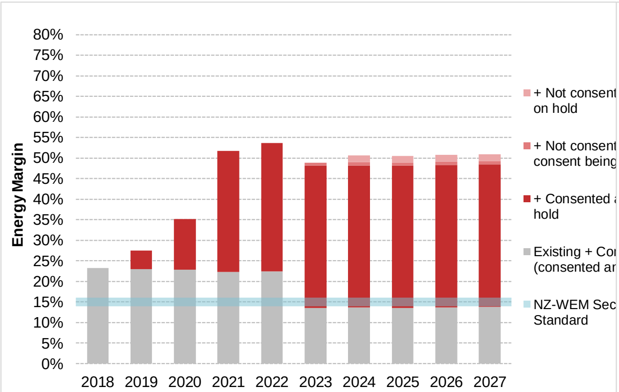


Figure 24: NZ WEM – Thermal Retirement and Low demand

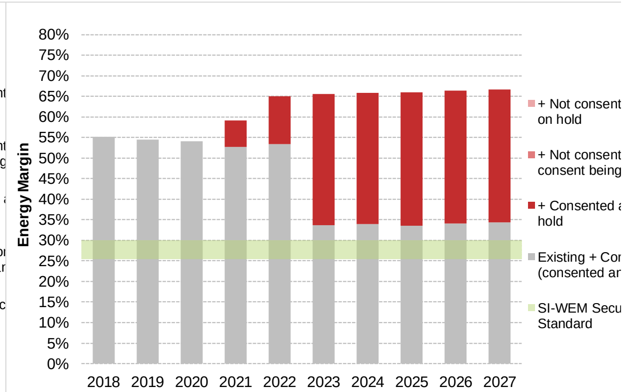


Figure 25: SI WEM – Thermal Retirement and Low demand

2.1.4 Reduced generation availability

New Zealand Winter Energy Margin

South Island Winter Energy Margin

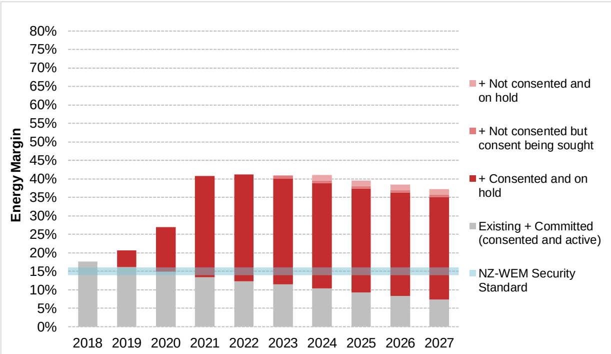


Figure 26: NZ WEM – Thermal Remains and Reduced generation

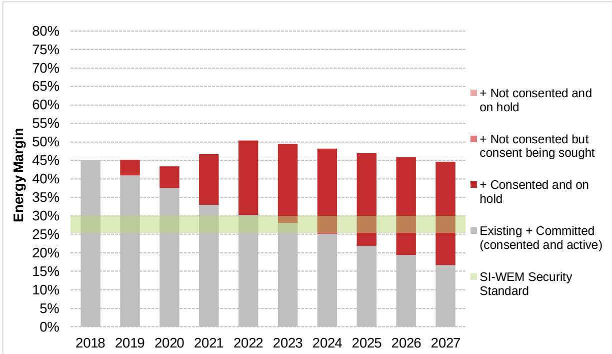


Figure 27: SI WEM – Thermal Retirement and Reduced generation

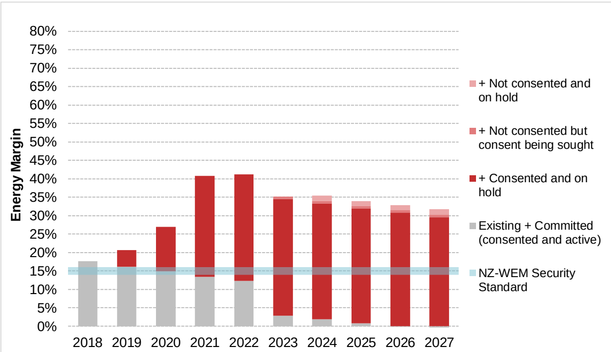


Figure 28: NZ WEM – Thermal Retirement and Reduced generation

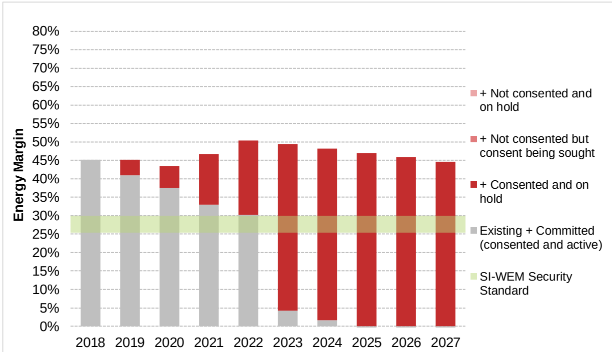


Figure 29: SI WEM – Thermal Retirement and Reduced generation

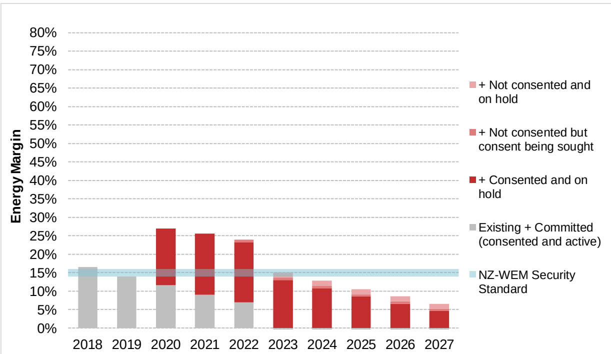


Figure 30: NZ WEM – Low Carbon and Electrification and Reduced generation

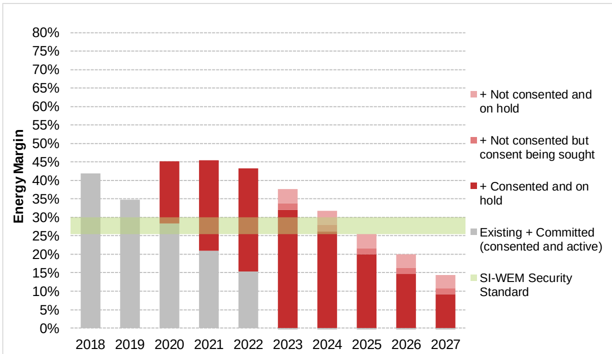


Figure 31: SI WEM – Low Carbon and Electrification and Reduced generation

2.2 Capacity Margin Sensitivities

2.2.1 NZAS closure

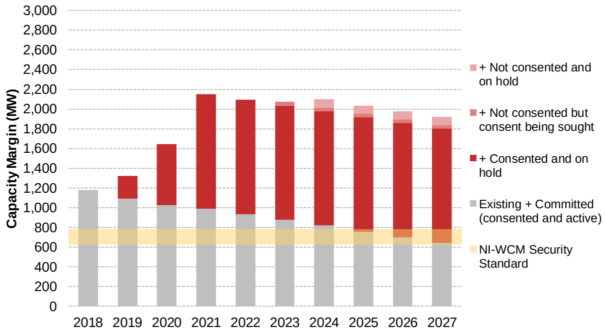


Figure 32: NI WCM – Thermal Remains and NZAS closure

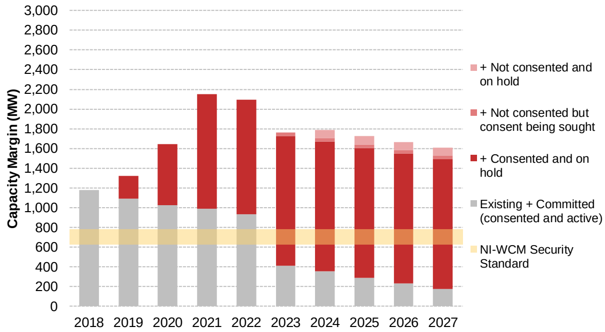


Figure 33: NI WCM – Thermal Retirement and NZAS closure

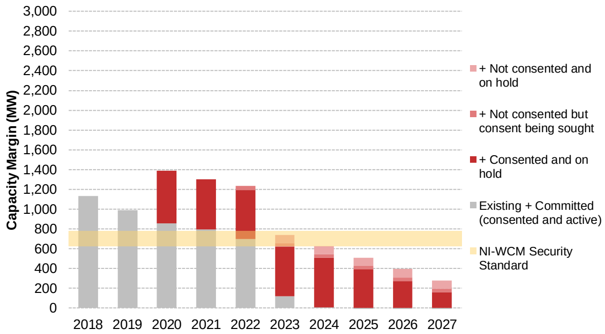


Figure 34: NI WCM – Low Carbon and Electrification and NZAS closure

2.2.2 High demand

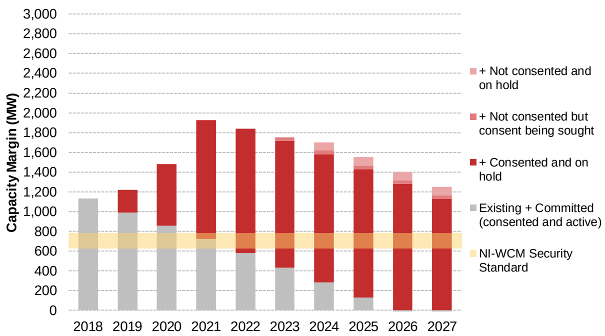


Figure 35: NI WCM – Thermal Remains and High demand

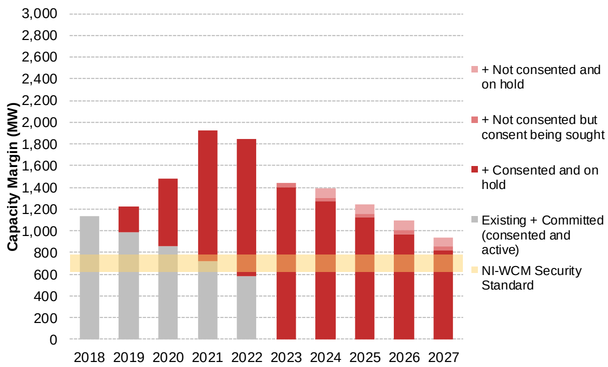


Figure 36: NI WCM – Thermal Retirement and High demand

2.2.3 Low demand

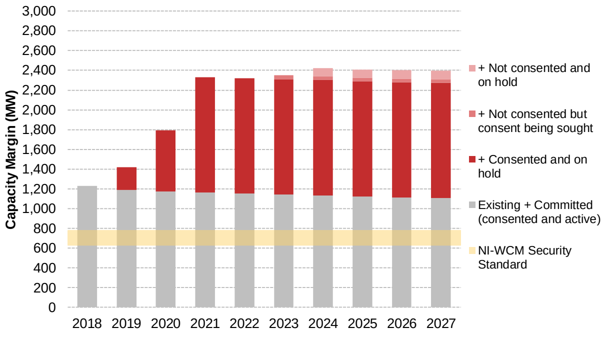


Figure 37: NI WCM – Thermal Remains and Low demand

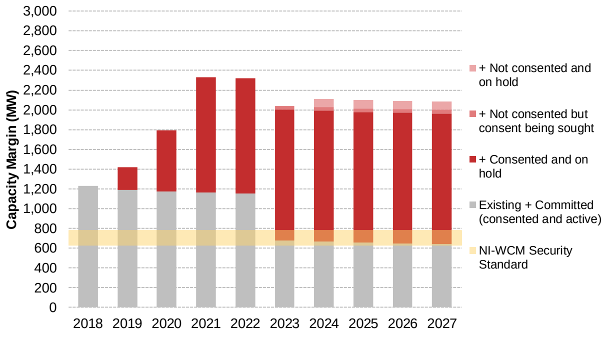


Figure 38: NI WCM – Thermal Retirement and Low demand

2.2.4 Reduced generation availability

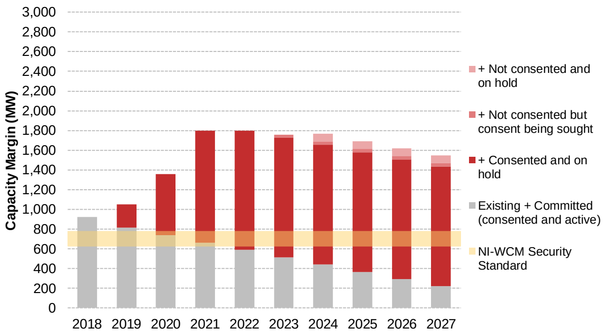


Figure 39: NI WCM – Thermal Remains and Reduced generation availability

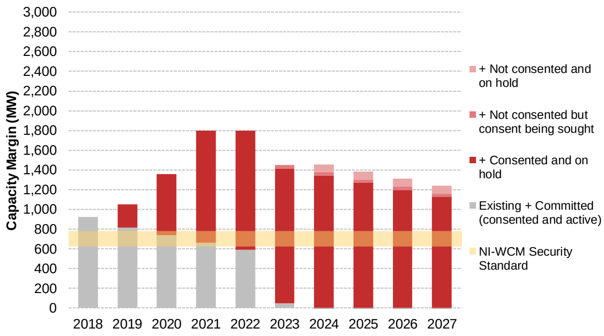


Figure 40: NI WCM – Thermal Retirement and Reduced generation availability

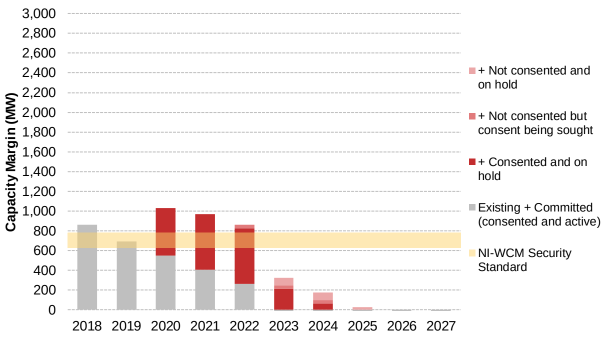


Figure 41: NI WCM – Low Carbon and Electrification and Reduced generation availability

2.2.5 Limited HVDC transfer - monopole outage

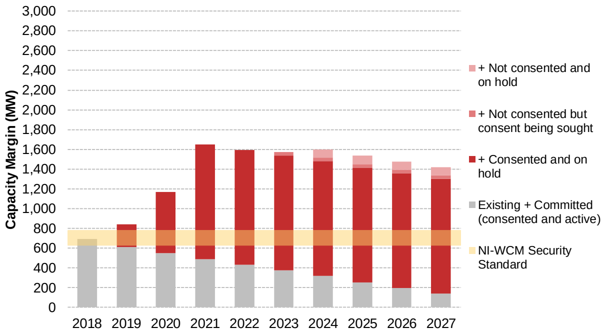


Figure 42: NI WCM – Thermal Remains and HVDC monopole outage

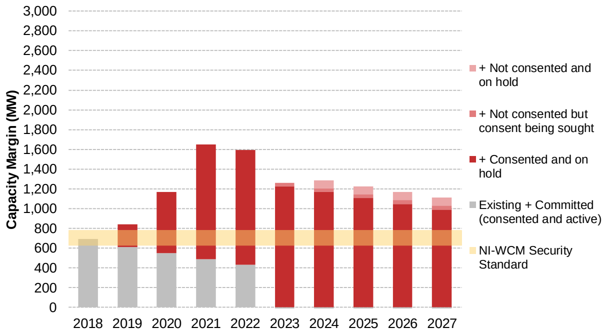


Figure 43: NI WCM – Thermal Retirement and HVDC monopole outage

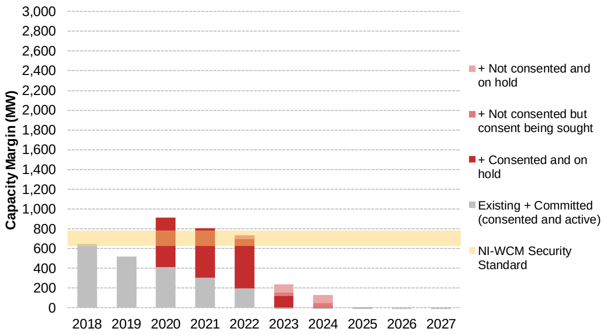


Figure 44: NI WCM – Low Carbon and Electrification and HVDC monopole outage

Appendix 3: METHODOLOGY

3.1 SECURITY OF SUPPLY STANDARDS AND INTERPRETATION

The security of supply assessment enables interested parties to compare projected winter energy and capacity margins over the next 10 years. The margins that define the security of supply standards used in this assessment are determined by the Electricity Authority (the Authority) and are documented within the Code.[21] The Authority derived the margins in 2012 using a probabilistic analysis.[22] The analysis sought to determine:

- the efficient level of North Island peaking capacity, defined as the level that minimises the sum of the expected societal cost of capacity shortage plus the cost of providing peaking generation capacity
- the efficient level of national winter energy supply, defined as the level that minimises the sum of the expected societal cost of energy shortage plus the cost of providing thermal firming capacity
- equivalently, the efficient level of South Island winter energy supply.

The current security of supply standards are:

- a WEM of 14-16% for New Zealand;
- a WEM of 25.5-30% for the South Island;
- a WCM of 630-780 MW for the North Island.

The Authority suggests that assessed margins should be interpreted as:

- A North Island WCM below 630 MW indicates an inefficiently low level of capacity; the cost of adding more capacity would be justified by the reduction in shortage costs at times of insufficient capacity.
- A North Island WCM between 630 and 780 MW indicates an approximate efficient level of capacity.
- A North Island WCM above 780 MW indicates a capacity level that is inefficiently high in terms of the trade-off between supply costs and the cost of shortage at times of insufficient capacity (but may still be efficient for other reasons).

Assessed WEMs should be interpreted in a similar fashion.

The Authority's security of supply standards are expressed as winter requirements, reflecting when New Zealand's power system demand is highest and the impact of low thermal plant availability and low hydro inflows are greatest.

---

[21] See Part 7, clause 7.3 of the Electricity Industry Participation Code 2010 for more information

[22] http://www.ea.govt.nz/about-us/what-we-do/our-history/archive/dev-archive/work-programmes/market-wholesale-and-retail-work/security-of-supply-standards/consultations/#c13932

3.2 Energy Margin Assessment

There are two Winter Energy Margins. The New Zealand Winter Energy Margin is calculated as:

$$NZ\ WEM = \left(\frac{New\ Zealand\ expected\ energy\ supply}{New\ Zealand\ expected\ energy\ demand} - 1\right) \times 100\%$$

The South Island Winter Energy Margin is calculated as:

$$SI\ WEM = \left(\frac{South\ Island\ expected\ energy\ supply + expected\ HVDC\ transfers\ south}{South\ Island\ expected\ energy\ demand} - 1\right) \times 100\%$$

Table 3: Summarising the New Zealand WEM components

Component	Comprises of	Description
New Zealand expected energy supply (GWh)	Thermal GWh	Maximum expected thermal generation available to meet winter (1 April to 30 September) energy demand allowing for forced and scheduled outages, available fuel supply and operational and transmission constraints.
	Mean Hydro GWh	Expected winter (1 April to 30 September) hydro generation based on mean inflows and expected 1 April start storage of 2,750 GWh.
	Other GWh	Expected winter (1 April to 30 September) energy available from cogeneration[23], geothermal and wind generation based on long-run average supply.
New Zealand expected energy demand (GWh)	NZ Energy Demand GWh	Expected winter demand, allowing for the normal demand response to periods of high spot prices (excluding any response due to savings campaigns or forced rationing).

Table 4: Summarising the South Island WEM components

Component	Comprises	Description
South Island expected energy supply (GWh)	Mean Hydro GWh	Expected winter (1 April to 30 September) hydro generation based on mean inflows and assumed 1 April start storage of 2,400 GWh.
	Other GWh	Expected winter (1 April to 30 September) wind generation based on long-run average supply.
Expected HVDC transfers south (GWh)	HVDC GWh	Expected winter (1 April to 30 September) HVDC transfers received in the South Island.
South Island expected energy demand (GWh)	SI Energy Demand GWh	Expected winter demand, allowing for the normal demand response to periods of high spot prices (excluding any response due to savings campaigns or forced rationing).

[23] Cogeneration has not been treated as thermal generation as it is assumed the primary fuel supply is based on industrial processes and not controlled in the same way as major thermal generators.

3.3 CAPACITY MARGIN ASSESSMENT

The North Island Winter Capacity Margin is calculated as:

$$NI\ WCM = North\ Island\ expected\ capacity - North\ Island\ expected\ demand$$
$$+ expected\ HVDC\ transfer\ north\ (function\ of\ SI\ capacity - SI\ demand)$$

Table 5: Summarising the North Island WCM components

Component	Comprises	Description
North Island expected capacity (MW)	NI Thermal MW	Installed capacity of North Island thermal generation sources allowing for forced and scheduled outages, available fuel supply and operational and transmission constraints.
	NI Hydro MW	Installed capacity of North Island controllable hydro schemes allowing for forced and scheduled outages and de-rated to account for energy and other constraints which affect output during peak times.
	NI Other MW	Expected winter peak generation from geothermal, wind, cogeneration and uncontrolled hydro scheme generation.
North Island expected demand (MW)	NI Peak Demand MW	Expected average of the highest 200 half hours (or 100 hours) of demand in winter inclusive of losses. This is referred to as H100 NI demand.
	NI Demand Response and Interruptible Load MW	Expected demand response and interruptible load over the highest 200 half hours of demand during winter peak. This is subtracted from NI Peak Demand to calculate NI expected demand.
Expected HVDC transfer north	South Island MW	The net amount of MW the South Island can supply to the North Island during peak periods. This is a similar calculation to above (supply capacity minus H100 NI demand); however, also takes into account HVDC transfer capability.

Appendix 4: Detailed Supply Assumptions

The calculation of winter margins requires some assumptions about the capacity and availability of existing and new generation as well as the contribution of the HVDC. Many of the assumptions discussed are based on the Security Standards Assumption Document (SSAD) published by the Authority.

4.1 Existing Generation

The following tables summarise the existing generation that is used in the assessment. Embedded generation has only been included where there is historical dataset available.[24]

Each generator has an energy and capacity rating which allows for scheduled and forced outages.

Table 6: Existing North Island Supply

Plant	Type	MW	Assumed Contribution to Capacity Margins (MW)	Assumed Contribution to Energy Margins (potential GWh over April - Sep)	Winter Capacity Rating	Winter Energy Rating
Aniwhenua	Hydro - Inflexible run-of-river	25	18	60	72.2%	54.8%
Arapuni	Controlled Hydro	192	See Waikato scheme*	*	*	*
Aratiatia	Controlled Hydro	78	See Waikato scheme*	*	*	*
Atiamuri	Controlled Hydro	74	See Waikato scheme*	*	*	*
Glenbrook	Thermal - Cogen	74	49	210	66.0%	64.5%
Huntly Rankines	Thermal - Coal	480	466	1962	97.0%	93.0%
Huntly U5	Thermal - Gas	385	373	1595	97.0%	94.3%
Huntly U6	Thermal - Gas	45	44	186	97.0%	94.3%
Kaimai	Hydro - Flexible run-of-river	38	32	82	83.0%	49.1%
Kaitawa	Controlled Hydro	36	See Waikaremoana scheme*	*	*	*
Kapuni	Thermal - Cogen	25	17	85	66.0%	77.6%
Karapiro	Controlled Hydro	96	See Waikato scheme*	*	*	*
Kawerau	Geothermal	104	96	440	92.3%	96.2%

[24] Transpower's SCADA system was used to gather data on embedded generators. If no SCADA data was available for a generator it was not included in the supply calculation. Those embedded generators which are not included in the supply calculation will have the effect of reducing demand.

Plant	Type	MW	Assumed Contribution to Capacity Margins (MW)	Assumed Contribution to Energy Margins (potential GWh over April - Sep)	Winter Capacity Rating	Winter Energy Rating
Kawerau Onepu	Geothermal	60	55	213	92.3%	80.9%
Kinleith	Thermal - Cogen	28	18	88	66.0%	71.8%
Kiwi Dairy, Hawera (Whareroa)	Thermal - Cogen	70	46	227	66.0%	73.8%
Mangahao	Hydro - Inflexible run-of-river	42	30	70	72.2%	38.1%
Maraetai	Controlled Hydro	352	See Waikato scheme*	*	*	*
Matahina	Controlled Hydro	80	66	133	98.0%	37.9%
McKee	Thermal - Gas	100	97	414	97.0%	94.3%
Mill Creek	Wind	60	15	119	25.0%	45.2%
Mokai	Geothermal	112	103	458	92.3%	93.1%
Nga Awa Purua	Geothermal	135	125	570	92.3%	96.2%
Ngatamariki	Geothermal	83.2	77	362	92.3%	99.2%
Ngawha	Geothermal	26	24	103	92.3%	91.0%
Ohaaki	Geothermal	40	37	140	92.3%	79.8%
Ohakuri	Controlled Hydro	106	See Waikato scheme*	*	*	*
Patea	Controlled Hydro	32.2	27	53	98.0%	37.1%
Piripaua	Controlled Hydro	44	See Waikaremoana scheme*	*	*	*
Poihipi	Geothermal	55	51	222	92.3%	91.7%
Rangipo	Hydro - Inflexible run-of-river	120	87	279	72.2%	52.9%
Rotokawa	Geothermal	34.5	32	143	92.3%	94.2%
Stratford Peaker	Thermal - Gas	200	194	829	97.0%	94.3%
Tararua I	Wind	31.68	8	57	25.0%	41.0%
Tararua II	Wind	36.3	9	66	25.0%	41.6%
Tararua III	Wind	93	23	161	25.0%	39.5%
TCC	Thermal - Gas	377	366	1562	97.0%	94.3%
Te Āpiti	Wind	90	23	114	25.0%	28.9%
Te Huka	Geothermal	28	26	117	92.3%	94.7%
Te Mihi	Geothermal	166	153	669	92.3%	91.7%
Te Rapa	Thermal -	44	29	164	66.0%	84.9%

Plant	Type	MW	Assumed Contribution to Capacity Margins (MW)	Assumed Contribution to Energy Margins (potential GWh over April - Sep)	Winter Capacity Rating	Winter Energy Rating
	Cogen					
Te Rere Hau	Wind	48.5	12	56	25.0%	26.1%
Te Uku	Wind	64	16	104	25.0%	36.9%
Tokaanu	Controlled Hydro	240	216	357	98.0%	33.9%
Tuai	Controlled Hydro	59	See Waikaremoana scheme*	*	*	*
Waipapa	Controlled Hydro	54	See Waikato scheme*	*	*	*
Wairakei incl. binary	Geothermal	132	122	549	92.3%	94.7%
West Wind	Wind	142	36	255	25.0%	40.9%
Whakamaru	Controlled Hydro	110	See Waikato scheme*	*	*	*
Wheao	Hydro - Flexible run-of-river	24	20	54	83.0%	51.2%
Whirinaki	Thermal - Diesel	155	150	30	97.0%	4.4%

* Energy and capacity contributions of this plant are detailed in the aggregated hydro schemes shown in Table 8.

Table 7: Existing South Island Supply

Scheme	Type	MW	Assumed Contribution to Capacity Margins (MW)	Assumed Contribution to Energy Margins (potential GWh over April - Sep)	Winter Capacity Rating	Winter Energy Rating
Aviemore	Controlled Hydro	220	See Waitaki scheme*	*	*	*
Benmore	Controlled Hydro	540	See Waitaki scheme*	*	*	*
Branch	Hydro - Inflexible run-of-river	11	8	25	72.2%	50.7%
Clyde	Controlled Hydro	432	See Clutha scheme*	*	*	*
Cobb	Controlled Hydro	32	31	93	98.0%	65.8%
Coleridge	Controlled Hydro	39	38	130	98.0%	75.6%
Deep Stream	Hydro - Flexible run-of-river	6	5	12	83.0%	43.6%
Highbank/Montalto	Hydro - Flexible run-of-river	26.8	22	48	83.0%	40.8%

Scheme	Type	MW	Assumed Contribution to Capacity Margins (MW)	Assumed Contribution to Energy Margins (potential GWh over April - Sep)	Winter Capacity Rating	Winter Energy Rating
Kumara/Dillmans/Duffers	Hydro - Flexible run-of-river	10.5	9	20	83.0%	42.3%
Mahinerangi Wind	Wind	36	9	52	25.0%	32.6%
Manapouri	Controlled Hydro	800	784	2685	98.0%	76.4%
Ohau A	Controlled Hydro	264	See Waitaki scheme*	*	*	*
Ohau B	Controlled Hydro	212	See Waitaki scheme*	*	*	*
Ohau C	Controlled Hydro	212	See Waitaki scheme*	*	*	*
Paerau/Pateroa	Hydro - Inflexible run-of-river	12.25	9	27	72.2%	50.2%
Roxburgh	Controlled Hydro	320	See Clutha scheme*	*	*	*
Tekapo A	Controlled Hydro	30	See Tekapo scheme*	*	*	*
Tekapo B	Controlled Hydro	154	See Tekapo scheme*	*	*	*
Waipori	Hydro - Flexible run-of-river	83.6	69	87	83.0%	23.7%
Waitaki	Controlled Hydro	105	See Waitaki scheme*	*	*	*
Whitehill	Wind	58	15	89	25.0%	34.9%

* Energy and capacity contributions of this plant are detailed in the aggregated hydro schemes shown in Table 8.

Table 8: Existing New Zealand controllable hydro supply

Scheme	Island	MW	Assumed Contribution to Capacity Margins (MW)	Assumed Contribution to Energy Margins (potential GWh over April - Sep)	Winter Capacity Rating	Winter Energy Rating
Waikato	NI	1062	982	2331	98%	50.0%
Waikaremoana	NI	139	136	266	98%	43.6%
Tekapo	SI	184	180	2775	98%	36.4%
Waitaki	SI	1553	1522		98%	
Clutha	SI	752	737	1417	98%	42.9%
Start storage	NI	n/a	n/a	350	n/a	n/a
Start storage	SI	n/a	n/a	2400	n/a	n/a

4.2 New Generation

Figures 48 and 49 show the expected capacity and energy contributions from new generation in aggregate form. Each graph shows contributions by the generator type, and in which island the generation is based.

Overall, there is a very small increase in new generation reported compared to the 2017 Security of Supply Annual Assessment. The total energy contribution of future generation has increased from 8,877 GWh in 2017 to 8,954 GWh in 2018. Similarly, the expected capacity contribution from future generation has increased from 1,774 MW in 2017 to 1,878 MW in 2018.

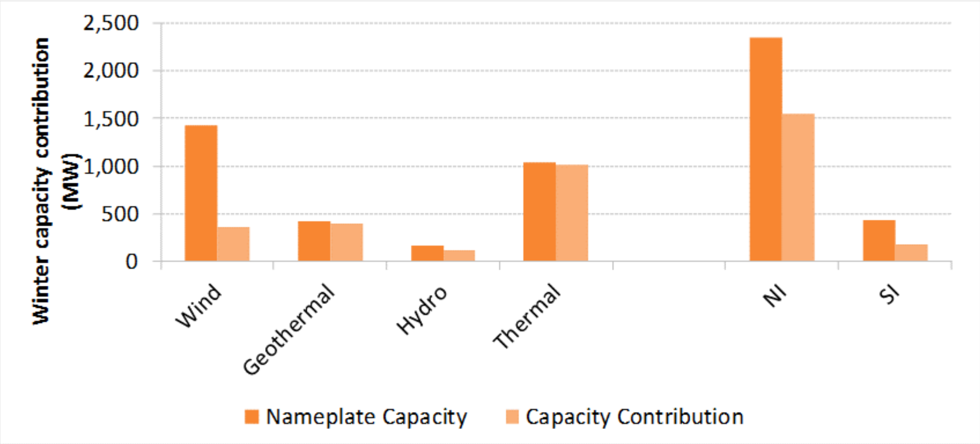


Figure 48: Winter Capacity Contribution from New Generation

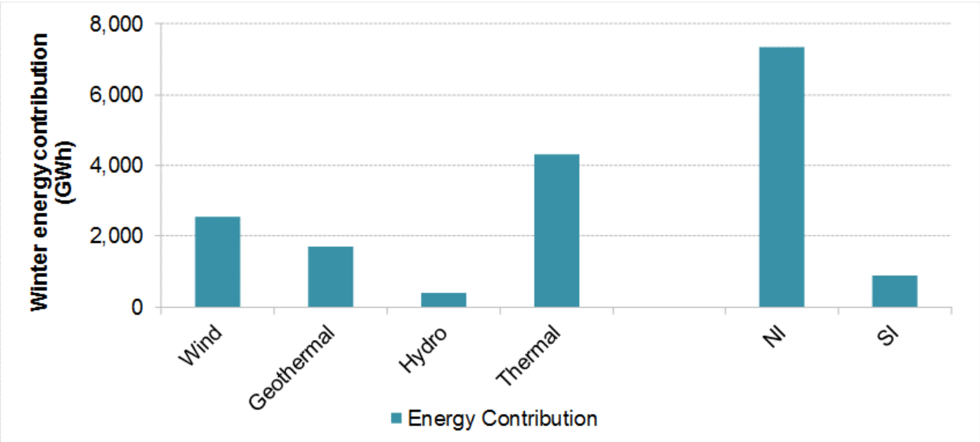


Figure 49: Winter Energy Contribution from New Generation

The following tables summarise new generation used in the assessment. This year investors indicated the current status of new generation projects (rather than the likelihood of the project proceeding, which was used in previous years). The dates at which new generation becomes available is based on the type of generation, and its consent status (see appendix section 4.2.1).

Table 9: New generation aggregated by type

Type	Nameplate MW	Assumed Contribution to Capacity Margins (MW)	Assumed Contribution to Energy Margins (potential GWh over April - Sep)
Wind	1,426	356	2,554
Geothermal	425	388	1,706
Hydro	163	112	398
Thermal	1,040	1,009	4,296

Table 10: New generation aggregated by island

Island	Nameplate MW	Assumed Contribution to Capacity Margins (MW)	Assumed Contribution to Energy Margins (potential GWh over April - Sep)
NI	2,350	1,546	7,324
SI	434	172	907

4.2.1 New generation commissioning dates

The dates at which new generation becomes available is based on the type of generation, and its consent status. The table below shows the earliest commissioning dates for different types of generation and the consent status in the Thermal Remains and Thermal Retirement scenarios. These commissioning dates are used for all sources of new generation.

Table 11: New generation commissioning dates based on consent status and generation type

	Consented and proceeding	Consented and on hold	Not consented, but consent likely to be sought	Not consented and on hold
Thermal	Estimated build date	2020	2022	2023
Geothermal	Estimated build date	2021	2023	2024
Wind	Estimated build date	2021	2023	2024
Hydro	Estimated build date	2022	2024	2025

We have not considered the lapsing of consents in this assessment, and assume that all currently consented projects will be reconsented should that be required. We have also not explicitly accounted transmission build times into these commissioning dates, as transmission builds vary from project to project.

4.2.2 New generation in the Low Carbon and Electrification scenario

For the Low Carbon and Electrification scenario it is assumed that there will be no new thermal generation built. In response to this, it is also assumed that renewable generation projects will be brought forward. The commissioning dates for the Low Carbon and Electrification scenario are shown below.

Table 12: New generation commissioning dates based on consent status and generation type

		Consented and proceeding	Consented and on hold	Not consented, but consent likely to be sought	Not consented and on hold
Geothermal	Estimated build date		2020	2022	2023
Wind	Estimated build date		2020	2022	2023
Hydro	Estimated build date		2021	2023	2024

4.3 Other Generation Assumptions

4.3.1 Other generation de-ratings are applied

The following de-ratings are applied to generation:

- In the assessment of the New Zealand WEM and South Island WEM, thermal generation has been reduced by 92 GWh in the North Island to reflect spinning reserve and frequency keeping requirements.[25]
- In the assessment of the North Island WCM, to account for limited short-term storage availability, these generators are not treated as run-of-river hydro:
  - Matahina de-rated by 13 MW
  - Patea de-rated by 5 MW
  - Tokaanu de-rated by 20 MW.
- The Waikato hydro scheme is de-rated by 60 MW to account for the impact of chronological flow constraints in the derivation of the North Island WCM.

4.3.2 Fuel or operational limits do not constrain thermal generation

With the exception of Whirinaki it is assumed thermal fuel availability, or operational limitations, do not limit thermal generation.[26]

To reflect on-site fuel storage and delivery limitations, Whirinaki's energy contribution is limited to 30 GWh per year in the derivation of the WEMs.

[25] This is different than that suggested in the SSAD. This difference is due to various technological and regulatory changes over recent years; lower quantities of ancillary services are required compared to when the SSAD was published. The Authority has provided us with analysis of 2012 and 2013 dry spells that estimates the reduction in thermal generation due to spinning reserves and frequency keeping at 92 GWh.

[26] This assumption is currently being reviewed in response to recent information on thermal fuel contracted limitations. As this review is still ongoing, we have not assumed any additional thermal fuel limitations other than those discussed below.

4.3.3 Average hydro storage conditions are assumed

The winter start storage for assessing WEMs are those specified in the SSAD. The start storage levels are:

- 2,750 GWh for New Zealand
- 2,400 GWh for the South Island.

4.3.4 Run-of-River Hydro, Cogeneration, Geothermal and Wind Capacity Contribution

The capacity contributions of run-of-river hydro, cogeneration and geothermal generation assumed for the North Island WCM are determined from historical generation at peak periods.

Generation output for the 500 trading periods with highest demand is collected. This is then analysed to determine the average contribution of run-of-river hydro, cogeneration and geothermal during peak periods. Flexible run-of-river hydro is assumed to contribute 83.0% of maximum nameplate capacity, inflexible run-of-river hydro is assumed to contribute 72.2% of capacity, geothermal is assumed to contribute 92.3% of capacity and cogeneration is assumed to contribute 66.0% of capacity.

For wind generation, this assessment assumes a wind capacity contribution of 25% as defined in the SSAD.

Appendix 5: TRANSMISSION

Inter-island transmission assumptions are required for assessment of the South Island WEM and the North Island WCM. North Island energy supply can meet some South Island energy demand in the assessment of the South Island WEM. Similarly, South Island capacity can meet some North Island demand in the assessment of the North Island WCM.

It is assumed that the HVDC capability will be the combined capability of Pole 2 and Pole 3 for all key scenarios. Sensitivities explore the loss of one or both poles.

5.1 HVDC FLOW SOUTH CONTRIBUTES TO SOUTH ISLAND WEM

It is assumed that the North Island will be able to supply the South Island with 2,101 GWh (480 MW average transfer[27]) of energy during the winter period. This energy transfer is dependent on the North Island having the required surplus energy available. To allow for this restriction the lesser value of 2,101 GWh or the net NI energy surplus, which is determined in the same way as the South Island WEM, is used.

5.2 HVDC FLOW NORTH CONTRIBUTES TO WCM

It is assumed during winter the South Island has the potential to supply the North Island with capacity.

The contribution of South Island capacity to North Island demand is a function of surplus capacity available in the South Island, depicted in Figure 51. The contirbution is determined in the same way as the North Island WCM. The function used in this process was derived using simulation analysis[28], taking account of:

- HVDC capacity
- transmission losses
- North Island instantaneous reserve requirements
- the low probability of forced outages on the HVDC link.

This assessment assumes that both Pole 2 and Pole 3 are available at all times in the three key scenarios.

[27] As discussed in the System Security Forecast, on occasion the HVDC southward limit will be restricted to 260 MW due to low wind generation in the Wellington region, however at times south transfer is also expected to reach 650 MW.

[28] Changes to the capability and operation of the HVDC such as the National Market for Instantaneous Reserves will impact this analysis. We are working with the Authority to review the SSAD, including the South Island Contribution Curve. Any changes to the assumptions will be incorporated in a future Annual Assessment.

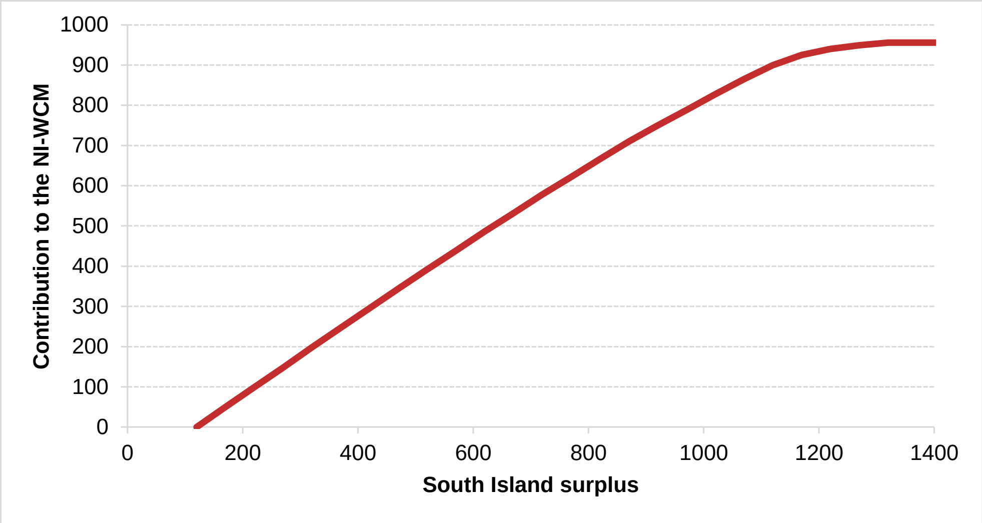


Figure 51: Relationship between South Island surplus and its contribution to the North Island WCM

5.3 AC Transmission Assumptions

This assessment does not explicitly model AC transmission constraints. The implicit assumption is that AC constraints will not reduce inter-island transfers below the limits specified above.

Appendix 6: DETAILED DEMAND FORECAST ASSUMPTIONS

The demand forecast used in this assessment is based on Transpower's 2017 long-term electricity demand forecast, which we refer to as the demand forecast. The base year for this forecast is 2017 (this is the most recent year where there is actual data).

The underlying demand forecast predicts demand at GXP level, which does not include any demand served by embedded generation (generation connected below the GXP). This approach is used internally as it best suits the purposes of modelling grid asset requirements. Ideally the Security of Supply Annual Assessment should include all electricity generation regardless of where it is connected, and therefore embedded generation has been added to the underlying demand forecast wherever SCADA data is available.[29]

6.1 DEMAND FORECAST METHODOLOGY

For energy margin calculations, the demand forecast is adjusted by:

- adding transmission losses, then
- adding embedded generation, then
- reducing wholesale energy demand (GXP demand + transmission losses + embedded generation) to account for demand response (2% for energy and 176 MW for capacity), then
- converting annual energy demand to winter energy demand (this step is not done for winter peak demand (H100)).

The Expected energy demand is calculated as:

$$\begin{aligned} &Winter\ energy\ demand \\ &\qquad = (wholesale\ energy\ demand) \times demand\ response\ factor\ \times winter\ scaling\ factor \end{aligned}$$

Transmission losses are only applied to net GXP demand. Demand response and conversion to winter demand are applied to wholesale energy demand (inclusive of transmission losses and embedded generation).

For all energy margin calculations winter demand (1 April – 30 September) is assumed to be 52.0% of average national annual demand, and 51.5% of South Island annual demand.

6.1.1 Demand Response

Winter energy demand forecasts have been reduced by 2% to allow for voluntary demand response.

Winter peak demand (H100) forecasts in the North Island have been reduced by 176 MW to account for demand response at peak times.

These reductions include voluntary demand response resulting from high spot prices or retailer pricing initiatives, but excludes reductions in demand as a result of savings campaigns or forced rationing.

6.1.2 Transmission Losses (for WEMs)

In the calculation of the WEMs static loss factors have been applied, as defined in the SSAD. These are:

- 3.5% losses for New Zealand
- 4.5% losses for the South Island

[29] Transpower's SCADA system was used to gather data for embedded generators. Where no historical SCADA data is available for a generator it was not included in the modelling.

6.1.3 Peak Demand (H100) Forecast

The underlying demand forecast models the single highest half-hourly demand in a year. For the Security of Supply Annual Assessment, the Authority recommends use of the H100 demand, which is an average of the 100 highest hours (or 200 half hours) of demand falling between 7am and 10pm, 1 April and 31 October.

This assessment has derived an H100 demand that is consistent with the supply assumptions by determining demand for generation in 2017.[30] This is achieved by firstly identifying the H100 peak demand periods using aggregate data for the North and South Islands. Then, generation from each generator (modelled to include embedded generation) during those peaks is aggregated to determine demand for generation for each of those peak periods. Finally, these aggregate values were averaged to determine a single H100 figure for 2017.

The percentage growth rates from the underlying demand forecast was then applied to the 2017 H100 figure to determine an H100 forecast out to 2027.

This approach removes the need to explicitly account for transmission losses. This methodology for calculating demand is not expected have a material impact on the WCM results and is intended to make the derivation of H100 less resource intensive, less prone to errors and easier to align with supply assumptions.

6.2 Demand Data used for the 2018 Annual Assessment

The charts shown below (Figure 52 and Figure 53) are the demand forecasts that are used in the derivation of the margins. They include transmission losses and embedded generation, but not demand response or the conversion to winter energy (as this removes ability to compare with historical data). For data that includes *all* adjustments please refer to Table 13 and Table 14 below.

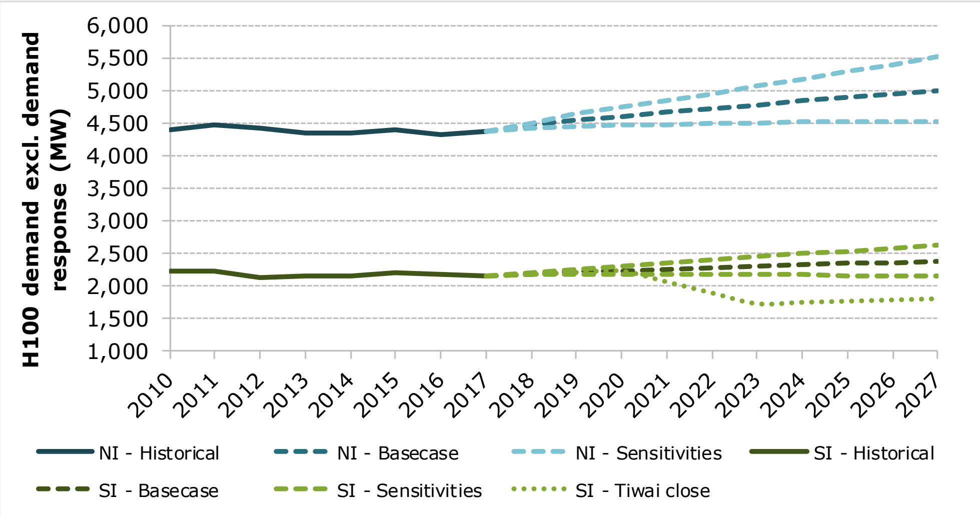


Figure 52: H100 demand excluding demand response

[30] Demand for generation is demand measured at the point of generation. This eliminates the need to adjust for embedded generation (we measure and aggregate all generation that is modelled on the supply side, including embedded generation) and transmission losses (these are implicitly included).

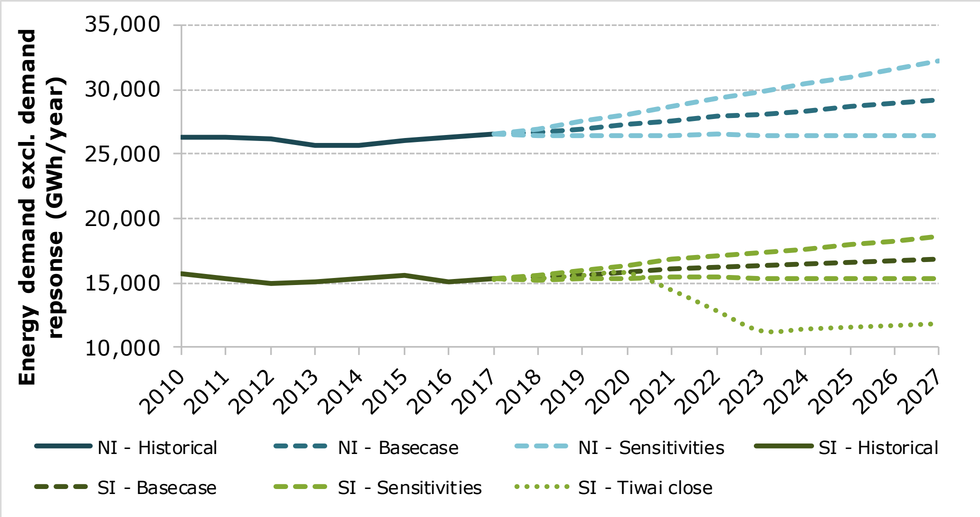


Figure 53: Energy demand excluding demand response

Table 13: Annual energy demand forecast

Calendar Year	South Island Demand (GWh)					New Zealand Demand (GWh)				
	Energy forecast	Transmis-sion losses	Embedded generation	Expected annual demand	Winter Demand incl. demand response	Demand forecast	Transmis-sion losses	Embedded generation	Expected annual demand	Winter Demand incl. demand response
2017	13,965	628	734	15,327	7,736	35,761	1,252	4,841	41,854	21,329
2018	14,049	632	734	15,415	7,780	35,937	1,258	4,841	42,036	21,422
2019	14,274	642	734	15,650	7,899	36,512	1,278	4,841	42,631	21,725
2020	14,456	651	734	15,840	7,995	36,966	1,294	4,841	43,101	21,964
2021	14,748	664	734	16,145	8,149	37,546	1,314	4,841	43,701	22,270
2022	14,835	668	734	16,236	8,194	37,943	1,328	4,841	44,113	22,480
2023	14,939	672	734	16,345	8,249	38,251	1,339	4,841	44,431	22,642
2024	15,068	678	734	16,479	8,317	38,653	1,353	4,841	44,847	22,854
2025	15,204	684	734	16,622	8,389	39,039	1,366	4,841	45,246	23,058
2026	15,325	690	734	16,748	8,453	39,404	1,379	4,841	45,625	23,250
2027	15,463	696	734	16,892	8,526	39,799	1,393	4,841	46,033	23,458

Table 14: Annual peak demand forecast

Calendar Year	North Island Demand (MW)			South Island Demand (MW)	
	Peak forecast	H100 forecast	H100 forecast incl. demand response	Peak forecast	H100 forecast
2017	4,237	4,378	4,202	2,037	2,165
2018	4,327	4,471	4,295	2,062	2,192
2019	4,408	4,555	4,379	2,091	2,223
2020	4,467	4,616	4,440	2,111	2,244
2021	4,523	4,674	4,498	2,131	2,265
2022	4,578	4,730	4,554	2,150	2,285
2023	4,635	4,789	4,613	2,173	2,310
2024	4,690	4,846	4,670	2,192	2,330
2025	4,744	4,901	4,725	2,208	2,347

Calendar Year	North Island Demand (MW)			South Island Demand (MW)	
	Peak forecast	H100 forecast	H100 forecast incl. demand response	Peak forecast	H100 forecast
2026	4,799	4,959	4,783	2,227	2,367
2027	4,853	5,015	4,839	2,245	2,386