Security of Supply
Annual Assessment 2018

Transpower New Zealand Limited
February 2018

Keeping the energy flowing
IMPORTANT

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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
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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 covering 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 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 In this scenario, approximately 500 MW of existing thermal generation is withdrawn from service at the end of 2022.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 are forecast to remain above or within their respective security of supply standards 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.

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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).

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. 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

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

The current security of supply standards⁸ 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:

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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

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\(^9\) 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 reconsigned). 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. 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.

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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

- 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.

- 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.

- 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.
A number of sensitivities to changes in supply and demand were assessed against the scenarios, 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.

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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**

- 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.

- 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.

- 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. 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.\(^\text{17}\)
- 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.\(^\text{18}\)

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

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\(^{19}\) 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

- 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 9: SI WEM – Thermal Remains**

- 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 10: SI WEM – Thermal retirement**

- 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.

**Figure 11: SI WEM – Low Carbon and Electrification**
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>
<thead>
<tr>
<th>Sensitivity</th>
<th>Affects Energy</th>
<th>Affects Capacity</th>
<th>Rationale</th>
<th>Assumptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZAS closure</td>
<td>Yes</td>
<td>Yes</td>
<td>This sensitivity explores the situation where the NZAS aluminium smelter starts reducing its output from 2021 and closes at the end of 2022.</td>
<td>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.</td>
</tr>
<tr>
<td>High demand</td>
<td>Yes</td>
<td>Yes</td>
<td>This sensitivity explores the situation where demand growth is higher than anticipated.</td>
<td>+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 Retirements scenarios (Low Carbon and Electrification scenario already assumes high demand).</td>
</tr>
<tr>
<td>Low demand</td>
<td>Yes</td>
<td>Yes</td>
<td>This sensitivity explores the situation where demand growth is lower than anticipated.</td>
<td>-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.</td>
</tr>
<tr>
<td>Reduced generation availability</td>
<td>Yes</td>
<td>Yes</td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td>Limited north HVDC transfer</td>
<td>No</td>
<td>Yes</td>
<td>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.</td>
<td>Inter-island transfer is limited to 500 MW in the North Island WCM. Applied to all three scenarios</td>
</tr>
</tbody>
</table>
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

South Island Winter Energy Margin

Figure 18: NZ WEM – Thermal Remains and High demand

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. The Authority derived the margins in 2012 using a probabilistic analysis. 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
There are two Winter Energy Margins. The New Zealand Winter Energy Margin is calculated as:

\[
NZWEM = \left( \frac{\text{New Zealand expected energy supply}}{\text{New Zealand expected energy demand}} - 1 \right) \times 100\%
\]

The South Island Winter Energy Margin is calculated as:

\[
SIWEM = \left( \frac{\text{South Island expected energy supply} + \text{expected HVDC transfers south}}{\text{South Island expected energy demand}} - 1 \right) \times 100\%
\]

Table 3: Summarising the New Zealand WEM components

<table>
<thead>
<tr>
<th>Component</th>
<th>Comprises of</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Zealand expected energy supply (GWh)</td>
<td>Thermal GWh</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>Mean Hydro GWh</td>
<td>Expected winter (1 April to 30 September) hydro generation based on mean inflows and expected 1 April start storage of 2,750 GWh.</td>
</tr>
<tr>
<td></td>
<td>Other GWh</td>
<td>Expected winter (1 April to 30 September) energy available from cogeneration, geothermal and wind generation based on long-run average supply.</td>
</tr>
<tr>
<td>New Zealand expected energy demand (GWh)</td>
<td>NZ Energy Demand GWh</td>
<td>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).</td>
</tr>
</tbody>
</table>

Table 4: Summarising the South Island WEM components

<table>
<thead>
<tr>
<th>Component</th>
<th>Comprises of</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Island expected energy supply (GWh)</td>
<td>Mean Hydro GWh</td>
<td>Expected winter (1 April to 30 September) hydro generation based on mean inflows and assumed 1 April start storage of 2,400 GWh.</td>
</tr>
<tr>
<td></td>
<td>Other GWh</td>
<td>Expected winter (1 April to 30 September) wind generation based on long-run average supply.</td>
</tr>
<tr>
<td>Expected HVDC transfers south (GWh)</td>
<td>HVDC GWh</td>
<td>Expected winter (1 April to 30 September) HVDC transfers received in the South Island.</td>
</tr>
<tr>
<td>South Island expected energy demand (GWh)</td>
<td>SI Energy Demand GWh</td>
<td>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).</td>
</tr>
</tbody>
</table>

\[<\text{Cogeneration has not been treated as thermal generation as it is assumed the primary fuel supply is based on industrial processes and not controlled in the same way as major thermal generators.}\]
3.3 CAPACITY MARGIN ASSESSMENT

The North Island Winter Capacity Margin is calculated as:

\[ NI\ WCM = \text{North Island expected capacity} - \text{North Island expected demand} \]
\[ + \text{expected HVDC transfer north (function of SI capacity} - \text{SI demand)} \]

**Table 5: Summarising the North Island WCM components**

<table>
<thead>
<tr>
<th>Component</th>
<th>Comprises</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Island expected capacity (MW)</td>
<td>NI Thermal MW</td>
<td>Installed capacity of North Island thermal generation sources allowing for forced and scheduled outages, available fuel supply and operational and transmission constraints.</td>
</tr>
<tr>
<td></td>
<td>NI Hydro MW</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>NI Other MW</td>
<td>Expected winter peak generation from geothermal, wind, cogeneration and uncontrolled hydro scheme generation.</td>
</tr>
<tr>
<td>North Island expected demand (MW)</td>
<td>NI Peak Demand MW</td>
<td>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.</td>
</tr>
<tr>
<td></td>
<td>NI Demand Response and Interruptible Load MW</td>
<td>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.</td>
</tr>
<tr>
<td>Expected HVDC transfer north</td>
<td>South Island MW</td>
<td>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.</td>
</tr>
</tbody>
</table>
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. Each generator has an energy and capacity rating which allows for scheduled and forced outages.

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

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.
<table>
<thead>
<tr>
<th>Plant</th>
<th>Type</th>
<th>MW</th>
<th>Assumed Contribution to Capacity Margins (MW)</th>
<th>Assumed Contribution to Energy Margins (potential GWh over April - Sep)</th>
<th>Winter Capacity Rating</th>
<th>Winter Energy Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kawerau Onepu</td>
<td>Geothermal</td>
<td>60</td>
<td>55</td>
<td>213</td>
<td>92.3%</td>
<td>80.9%</td>
</tr>
<tr>
<td>Kinleith</td>
<td>Thermal - Cogen</td>
<td>28</td>
<td>18</td>
<td>88</td>
<td>66.0%</td>
<td>71.8%</td>
</tr>
<tr>
<td>Kiwi Dairy, Hawera (Whareroa)</td>
<td>Thermal - Cogen</td>
<td>70</td>
<td>46</td>
<td>227</td>
<td>66.0%</td>
<td>73.8%</td>
</tr>
<tr>
<td>Mangahao</td>
<td>Hydro - Inflexible run-of-river</td>
<td>42</td>
<td>30</td>
<td>70</td>
<td>72.2%</td>
<td>38.1%</td>
</tr>
<tr>
<td>Maraetai</td>
<td>Controlled Hydro</td>
<td>352</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Matahina</td>
<td>Controlled Hydro</td>
<td>80</td>
<td>66</td>
<td>133</td>
<td>98.0%</td>
<td>37.9%</td>
</tr>
<tr>
<td>McKee</td>
<td>Thermal - Gas</td>
<td>100</td>
<td>97</td>
<td>414</td>
<td>97.0%</td>
<td>94.3%</td>
</tr>
<tr>
<td>Mill Creek</td>
<td>Wind</td>
<td>60</td>
<td>15</td>
<td>119</td>
<td>25.0%</td>
<td>45.2%</td>
</tr>
<tr>
<td>Mokai</td>
<td>Geothermal</td>
<td>112</td>
<td>103</td>
<td>458</td>
<td>92.3%</td>
<td>93.1%</td>
</tr>
<tr>
<td>Nga Awa Purua</td>
<td>Geothermal</td>
<td>135</td>
<td>125</td>
<td>570</td>
<td>92.3%</td>
<td>96.2%</td>
</tr>
<tr>
<td>Ngatamariki</td>
<td>Geothermal</td>
<td>83.2</td>
<td>77</td>
<td>362</td>
<td>92.3%</td>
<td>99.2%</td>
</tr>
<tr>
<td>Ngawha</td>
<td>Geothermal</td>
<td>26</td>
<td>24</td>
<td>103</td>
<td>92.3%</td>
<td>91.0%</td>
</tr>
<tr>
<td>Ohaaki</td>
<td>Geothermal</td>
<td>40</td>
<td>37</td>
<td>140</td>
<td>92.3%</td>
<td>79.8%</td>
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<tr>
<td>Ohakuri</td>
<td>Controlled Hydro</td>
<td>106</td>
<td>See Waikato scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Patea</td>
<td>Controlled Hydro</td>
<td>32.2</td>
<td>27</td>
<td>53</td>
<td>98.0%</td>
<td>37.1%</td>
</tr>
<tr>
<td>Piripaua</td>
<td>Controlled Hydro</td>
<td>44</td>
<td>See Waikaremoana scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Poihipi</td>
<td>Geothermal</td>
<td>55</td>
<td>51</td>
<td>222</td>
<td>92.3%</td>
<td>91.7%</td>
</tr>
<tr>
<td>Rangipo</td>
<td>Hydro - Inflexible run-of-river</td>
<td>120</td>
<td>87</td>
<td>279</td>
<td>72.2%</td>
<td>52.9%</td>
</tr>
<tr>
<td>Rotokawa</td>
<td>Geothermal</td>
<td>34.5</td>
<td>32</td>
<td>143</td>
<td>92.3%</td>
<td>94.2%</td>
</tr>
<tr>
<td>Stratford Peaker</td>
<td>Thermal - Gas</td>
<td>200</td>
<td>194</td>
<td>829</td>
<td>97.0%</td>
<td>94.3%</td>
</tr>
<tr>
<td>Tararua I</td>
<td>Wind</td>
<td>31.68</td>
<td>8</td>
<td>57</td>
<td>25.0%</td>
<td>41.0%</td>
</tr>
<tr>
<td>Tararua II</td>
<td>Wind</td>
<td>36.3</td>
<td>9</td>
<td>66</td>
<td>25.0%</td>
<td>41.6%</td>
</tr>
<tr>
<td>Tararua III</td>
<td>Wind</td>
<td>93</td>
<td>23</td>
<td>161</td>
<td>25.0%</td>
<td>39.5%</td>
</tr>
<tr>
<td>TCC</td>
<td>Thermal - Gas</td>
<td>377</td>
<td>366</td>
<td>1562</td>
<td>97.0%</td>
<td>94.3%</td>
</tr>
<tr>
<td>Te Āpiti</td>
<td>Wind</td>
<td>90</td>
<td>23</td>
<td>114</td>
<td>25.0%</td>
<td>28.9%</td>
</tr>
<tr>
<td>Te Huka</td>
<td>Geothermal</td>
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<td>26</td>
<td>117</td>
<td>92.3%</td>
<td>94.7%</td>
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<tr>
<td>Te Mihi</td>
<td>Geothermal</td>
<td>166</td>
<td>153</td>
<td>669</td>
<td>92.3%</td>
<td>91.7%</td>
</tr>
<tr>
<td>Te Rapa</td>
<td>Thermal -</td>
<td>44</td>
<td>29</td>
<td>164</td>
<td>66.0%</td>
<td>84.9%</td>
</tr>
<tr>
<td>Plant</td>
<td>Type</td>
<td>MW</td>
<td>Assumed Contribution to Capacity Margins (MW)</td>
<td>Assumed Contribution to Energy Margins (potential GWh over April - Sep)</td>
<td>Winter Capacity Rating</td>
<td>Winter Energy Rating</td>
</tr>
<tr>
<td>---------------------</td>
<td>------------</td>
<td>-----</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------------------------------</td>
<td>-----------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Aviemore</td>
<td>Controlled Hydro</td>
<td>220</td>
<td>See Waitaki scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Benmore</td>
<td>Controlled Hydro</td>
<td>540</td>
<td>See Waitaki scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Branch</td>
<td>Hydro - Inflexible run-of-river</td>
<td>11</td>
<td>8</td>
<td>25</td>
<td>72.2%</td>
<td>50.7%</td>
</tr>
<tr>
<td>Clyde</td>
<td>Controlled Hydro</td>
<td>432</td>
<td>See Clutha scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Cobb</td>
<td>Controlled Hydro</td>
<td>32</td>
<td>31</td>
<td>93</td>
<td>98.0%</td>
<td>65.8%</td>
</tr>
<tr>
<td>Coleridge</td>
<td>Controlled Hydro</td>
<td>39</td>
<td>38</td>
<td>130</td>
<td>98.0%</td>
<td>75.6%</td>
</tr>
<tr>
<td>Deep Stream</td>
<td>Hydro - Flexible run-of-river</td>
<td>6</td>
<td>5</td>
<td>12</td>
<td>83.0%</td>
<td>43.6%</td>
</tr>
<tr>
<td>Highbank/Montalto</td>
<td>Hydro - Flexible run-of-river</td>
<td>26.8</td>
<td>22</td>
<td>48</td>
<td>83.0%</td>
<td>40.8%</td>
</tr>
</tbody>
</table>

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

Table 7: Existing South Island Supply
<table>
<thead>
<tr>
<th>Scheme</th>
<th>Type</th>
<th>MW</th>
<th>Assumed Contribution to Capacity Margins (MW)</th>
<th>Assumed Contribution to Energy Margins (potential GWh over April - Sep)</th>
<th>Winter Capacity Rating</th>
<th>Winter Energy Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kumara/Dillmans/Duffers</td>
<td>Hydro - Flexible run-of-river</td>
<td>10.5</td>
<td>9</td>
<td>20</td>
<td>83.0%</td>
<td>42.3%</td>
</tr>
<tr>
<td>Mahinerangi Wind</td>
<td>Wind</td>
<td>36</td>
<td>9</td>
<td>52</td>
<td>25.0%</td>
<td>32.6%</td>
</tr>
<tr>
<td>Manapouri Ohau A</td>
<td>Controlled Hydro</td>
<td>800</td>
<td>784</td>
<td>*</td>
<td>98.0%</td>
<td>76.4%</td>
</tr>
<tr>
<td>Manapouri Ohau B</td>
<td>Controlled Hydro</td>
<td>212</td>
<td>See Waitaki scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Manapouri Ohau C</td>
<td>Controlled Hydro</td>
<td>212</td>
<td>See Waitaki scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Paerau/Patearoa</td>
<td>Hydro - Inflexible run-of-river</td>
<td>12.25</td>
<td>9</td>
<td>27</td>
<td>72.2%</td>
<td>50.2%</td>
</tr>
<tr>
<td>Roxburgh</td>
<td>Controlled Hydro</td>
<td>320</td>
<td>See Clutha scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Tekapo A</td>
<td>Controlled Hydro</td>
<td>30</td>
<td>See Tekapo scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Tekapo B</td>
<td>Controlled Hydro</td>
<td>154</td>
<td>See Tekapo scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Waipori</td>
<td>Hydro - Flexible run-of-river</td>
<td>83.6</td>
<td>69</td>
<td>87</td>
<td>83.0%</td>
<td>23.7%</td>
</tr>
<tr>
<td>Waitaki</td>
<td>Controlled Hydro</td>
<td>105</td>
<td>See Waitaki scheme*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Whitehill</td>
<td>Wind</td>
<td>58</td>
<td>15</td>
<td>89</td>
<td>25.0%</td>
<td>34.9%</td>
</tr>
</tbody>
</table>

* 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

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

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

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

Table 10: New generation aggregated by island

<table>
<thead>
<tr>
<th>Island</th>
<th>Nameplate MW</th>
<th>Assumed Contribution to Capacity Margins (MW)</th>
<th>Assumed Contribution to Energy Margins (potential GWh over April - Sep)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NI</td>
<td>2,350</td>
<td>1,546</td>
<td>7,324</td>
</tr>
<tr>
<td>SI</td>
<td>434</td>
<td>172</td>
<td>907</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Consented and proceeding</th>
<th>Consented and on hold</th>
<th>Not consented, but consent likely to be sought</th>
<th>Not consented and on hold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal</td>
<td>Estimated build date</td>
<td>2020</td>
<td>2022</td>
</tr>
<tr>
<td>Geothermal</td>
<td>Estimated build date</td>
<td>2021</td>
<td>2022</td>
</tr>
<tr>
<td>Wind</td>
<td>Estimated build date</td>
<td>2021</td>
<td>2023</td>
</tr>
<tr>
<td>Hydro</td>
<td>Estimated build date</td>
<td>2022</td>
<td>2024</td>
</tr>
</tbody>
</table>

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>
<thead>
<tr>
<th>Generation Type</th>
<th>Consented and proceeding</th>
<th>Consented and on hold</th>
<th>Not consented, but consent likely to be sought</th>
<th>Not consented and on hold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geothermal</td>
<td>Estimated build date</td>
<td>2020</td>
<td>2022</td>
<td>2023</td>
</tr>
<tr>
<td>Wind</td>
<td>Estimated build date</td>
<td>2020</td>
<td>2022</td>
<td>2023</td>
</tr>
<tr>
<td>Hydro</td>
<td>Estimated build date</td>
<td>2021</td>
<td>2023</td>
<td>2024</td>
</tr>
</tbody>
</table>

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 contribution 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.
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:

\[
\text{Winter energy demand} = (\text{wholesale energy demand}) \times \text{demand response factor} \times \text{winter scaling factor}
\]

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 to 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](image-url)

---

\(^{30}\) 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).
Table 13: Annual energy demand forecast

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>Energy demand excluding demand response (GWh/year)</th>
<th>Winter Demand incl. demand response</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017</td>
<td>13,965</td>
<td>15,327</td>
</tr>
<tr>
<td>2018</td>
<td>14,049</td>
<td>15,415</td>
</tr>
<tr>
<td>2019</td>
<td>14,274</td>
<td>15,650</td>
</tr>
<tr>
<td>2020</td>
<td>14,456</td>
<td>15,840</td>
</tr>
<tr>
<td>2021</td>
<td>14,748</td>
<td>16,145</td>
</tr>
<tr>
<td>2022</td>
<td>14,939</td>
<td>16,345</td>
</tr>
<tr>
<td>2023</td>
<td>15,068</td>
<td>16,479</td>
</tr>
<tr>
<td>2024</td>
<td>15,204</td>
<td>16,622</td>
</tr>
<tr>
<td>2025</td>
<td>15,325</td>
<td>16,748</td>
</tr>
<tr>
<td>2026</td>
<td>15,463</td>
<td>16,892</td>
</tr>
</tbody>
</table>

Table 14: Annual peak demand forecast

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>North Island Demand (MW)</th>
<th>South Island Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak forecast</td>
<td>H100 forecast</td>
</tr>
<tr>
<td>2017</td>
<td>4,237</td>
<td>4,378</td>
</tr>
<tr>
<td>2018</td>
<td>4,327</td>
<td>4,471</td>
</tr>
<tr>
<td>2019</td>
<td>4,408</td>
<td>4,555</td>
</tr>
<tr>
<td>2020</td>
<td>4,467</td>
<td>4,616</td>
</tr>
<tr>
<td>2021</td>
<td>4,523</td>
<td>4,674</td>
</tr>
<tr>
<td>2022</td>
<td>4,578</td>
<td>4,730</td>
</tr>
<tr>
<td>2023</td>
<td>4,635</td>
<td>4,789</td>
</tr>
<tr>
<td>2024</td>
<td>4,690</td>
<td>4,846</td>
</tr>
<tr>
<td>2025</td>
<td>4,744</td>
<td>4,901</td>
</tr>
</tbody>
</table>
## Calendar Year

<table>
<thead>
<tr>
<th>Calendar Year</th>
<th>North Island Demand (MW)</th>
<th>South Island Demand (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Peak forecast</td>
<td>H100 forecast</td>
</tr>
<tr>
<td>2026</td>
<td>4,799</td>
<td>4,959</td>
</tr>
<tr>
<td>2027</td>
<td>4,853</td>
<td>5,015</td>
</tr>
</tbody>
</table>