Meeting Date: 1 June 2023

2023 ANNUAL SECURITY OF SUPPLY ASSESSMENT

SECURITY AND RELIABILITY COUNCIL

The 2023 annual Security of Supply Assessment, covering energy and capacity adequacy over a ten-year horizon

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

1. Background

The Security and Reliability Council is asked to consider the 2023 annual Security of Supply Assessment

1.1. The Security and Reliability Council's (SRC) functions include offering advice to the Electricity Authority on the security of the power system. One aspect of security is adequacy of generation investment to provide energy and capacity.

1.2. The system operator's annual Security of Supply Assessment (SOSA) is the primary source of information on adequacy of generation investment to provide energy and capacity over a time horizon of years. The 2023 SOSA provides a medium-term view of the balance between supply and demand in the New Zealand electricity system between 2023-2032.

1.3. The SRC is asked to consider the 2023 SOSA, so it can provide meaningful feedback to the system operator. A consultation version of the SOSA is attached as Appendix A (SRC summary paper) and Appendix B (full paper)). The reason for providing the consultation version is to enable members consideration ahead of winter and enable feedback, where possible, to be considered by the system operator in its final report due later this year.

1.4. The secretariat notes that SRC members do not need to read the entire SOSA and offers the following guidance:

a) The SRC summary paper provides a short background to the SOSA and what it measures,

b) Section one (the Executive Summary in the full report) is essential reading,

c) Section four is relevant to the SRC, as it notes the government's aspirational targets and supply additions required to maintain security and reliability,

d) Section two may be useful for readers unfamiliar with SOSA reports, covering background and a summary of the methodology.

1.5. The system operator will attend the SRC meeting to answer any questions about the 2023 SOSA.

The SOSA framework

1.6. The security 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). Note that this margin includes an allowance for instantaneous reserve (IR).

1.7. The margins 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 oversupply that minimises overall cost to the country.

1.8. 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.

1.9. 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.

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

1.11. 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).[1] 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.

1.12. Demand forecasts were updated again this year by Transpower to be consistent with its "*Whakamana I Te Mauri Hiko*" framework,[2] which considers the impact of more renewable generation and electrification.

Annual updates will be provided

1.13. The SRC will be provided with further updated versions of the 2023 SOSA ahead of its annual strategy session in August, and its Q4 meeting, on 26 October 2023.

Approach for 2023 SOSA

1.14. Before 2022, the system operator used four core scenarios for SOSA (low demand, medium demand, high demand, and gas constrained). Under that approach each scenario had a different 'underlying' demand growth rate (for winter only) and a different rate of uptake of electrification and distributed energy resource technologies.

1.15. For 2022 and 2023 SOSA the system operator has used a single reference scenario (reference case) that represents the resources potentially available to the power system over the 10-year assessment horizon. The assumptions and inputs for the reference case are based upon:

a) a market participant survey;

b) Transpower's demand forecast aligned with transmission and strategic planning

[1] https://www.ea.govt.nz/operations/wholesale/security-of-supply/security-of-supply-policy-framework/security-standards-assumptions/

[2] https://www.transpower.co.nz/resources/whakamana-i-te-mauri-hiko-empowering-our-energy-future

c) The Authority's Security Standards Assumptions Document (SSAD)[3]

d) Industry and MBIE gas information

e) Historical market behaviour and other available market information.

Assumptions

1.16. Key assumptions in the reference case:

a) Existing generation and industrial demand will not change unless decommissioning is publicly announced, and decommissioning activities are actively being pursued

b) A medium demand forecast

c) Tiwai remains

d) "Significant" amounts of thermal generation are not decommissioned in the near term

e) Investment in upstream gas sector continues

f) The HVDC interconnector is not upgraded

1.17. Generation is divided into the following categories:

- Stage 1 - existing and committed
- Stage 2 - consented, on hold
- Stage 3 - consented, on hold, requiring reconsent
- Stage 4 - not consented, but consent could be sought soon.

Sensitivities

1.18. Sensitivities may also be applied to each scenario to reflect uncertain changes in supply and demand and represent what the system operator considers as plausible variations from the reference case.

1.19. The range of sensitivities apply to either the demand or supply side, for example decommissioning the Taranaki Combined Cycle generation plant (TCC) and delayed build times for new generation (supply side) and demand growth and changes in peak demand (demand side).

1.20. The system operator has included a new sensitivity this year – *less operational flexibility* simulating what happens when intermittent wind and solar falls below average capacity factors at the same time as thermal generation becomes unavailable. The system operator notes the coordination challenge this presents.

1.21. Because of the large number of potential combinations of scenarios, the report only considers a subset in detail.

2. The key findings of the 2023 SOSA

2.1. As noted in the report overview (p7), there has been a **minor increase in the demand forecast**, mainly from reports from distributors. **If demand were to grow**

[3] Security Standards Assumption Document

faster than the reference case, new investment could be needed as early as 2025.

2.2. Forecasting of *Existing and committed* generation has increased by approximately 215MW but ***consent expected* generation has decreased,** which may be of concern, depending on the level of demand response that may be available to fill the gap.

2.3. **Grid-connected generation enquiries to Transpower up from 124 last year to 334 this year** "indicate that the supply pipeline will continue to grow".

2.4. **98% of the unconsented pipeline is made up of intermittent generation sources** (wind and solar), which "has a larger impact on increasing the energy margin than the capacity margin".

2.5. **The contribution from thermal fuel generation can reduce from 2028**, with the pipeline of renewable generation able to maintain supply, assuming an increase in the rate of renewable build compared to recent years.

2.6. **The reference case for SI-WEM falls below the upper security standard by 2029**, for projects existing and committed. If consented projects are included, the standard is reached for the 10-year assessment horizon.

2.7. The report notes **the NI-WCM, as being heavily impacted by the increase in intermittent generation, with the potential to fall below the standard by 2025** when considering only supply projects existing and committed. A good example of how the sensitivities work, is noted in the key insights on page 8 of the SOSA.

2.8. Additional commentary into this year's SOSA, is available in this recent Energy News article.

3. Questions for the SRC to consider

3.1. The SRC may wish to consider the following questions.

Q1. Is the SRC comfortable with the 2023 SOSA results?

Q2. What comment or feedback does the SRC have for the system operator on its approach to, or findings of, the 2023 SOSA?

Q3. What further information, if any, does the SRC wish to have provided to it by the secretariat?

Q4. What advice, if any, does the SRC wish to provide to the Authority?

4. Appendices

4.1. Appendix A: System operator's summary paper for the SRC

4.2. Appendix B: 2023 annual Security of Supply Assessment (SOSA) Consultation version

4.3. Appendix C: system operator presentation

Appendix A: System operator's summary paper for the SRC

Appendix B: 2023 annual Security of Supply Assessment (Consultation version)

Appendix C: System operator presentation

[to be uploaded when available]

Meeting date:	1 June 2023
Author:	Ramu Naidoo

Security and Reliability Council Paper

Draft Security of Supply Assessment 2023

1 Purpose

This paper summarises the purpose for the annual security of supply assessment (SOSA) and the process followed for the draft 2023 SOSA.

To avoid duplication, the reader is referred to the executive summary of the draft 2023 SOSA report[1] which has a comprehensive summary of the assessment approach and results.

2 What we measure in the SOSA and why

The 2023 SOSA provides a ten-year view (2023 to 2032) of security of supply for different supply and demand scenarios. The purpose is to enable industry stakeholders to compare the risk of supply shortages both between scenarios and over time to inform risk management and investment decisions. Transpower is Code-obligated to produce the assessment, and many of the assumptions used are prescribed by the Electricity Authority (Authority).

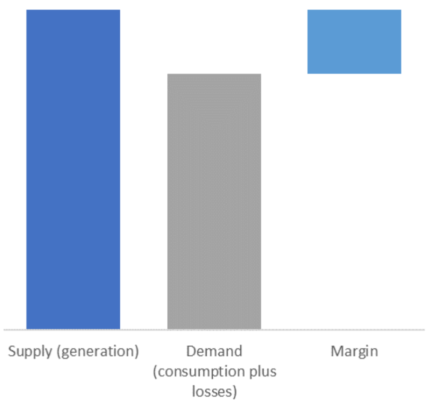

Figure 1: Margin visualisation

The assessment is essentially a long-term view of the balance between supply and demand in the New Zealand electricity system. We present this information using three margins, all of which represent the difference between supply and demand. Generally, an excess of supply (i.e. generation) is maintained in order to ensure that demand can always be met – this excess is referred to as the margin (Figure 1).

The three margins presented in the assessment cover the key areas of risk for the electricity system: the New Zealand and South Island winter energy margins, and North Island winter capacity margin. The energy margins assess whether it is likely that there will be an adequate level of generation and HVDC transmission capacity to meet expected electricity demand across the winter

[1] The draft 2023 SOSA report can be found here

months. The North Island winter capacity margin assesses whether it is likely there will be adequate generation and HVDC transmission capacity to meet peak North Island demand over winter.

The margins are then compared against what is known as the security of supply standards. The standards represent the Authority's view of an efficient level of electricity generation investment. For example, if the margins are below the standards, this implies that investment in new generation would be an economically rational exercise according to the Authority's winter margin assessment. It can also be interpreted as representing the likelihood of electricity shortage – the higher the margin the less likely electricity shortage will be, all else being equal.

3 2023 SOSA consultation

The 2023 draft SOSA was published for consultation[2] on 8 May 2023. The consultation is open for 3 weeks, ending on 26 May 2023. Following this consultation, any required changes will be made to the SOSA. The final SOSA report is planned to be published by 30 June 2023.

[2] See here for the consultation page [Invitation to Comment: Draft Security of Supply Assessment | Transpower]

Security of Supply Assessment 2023

System Operator

Version: 1.0

Date: May 2023

Version	Date	Change
1.0	08 May 2023	First release

IMPORTANT

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Executive Summary

The purpose of the security of supply assessment (SOSA) is to inform risk management and investment decisions by market participants, policy makers, and other stakeholders.

Transpower, as the system operator, publishes the SOSA annually. It provides a 10-year assessment (2023 to 2032) of the balance between supply and demand in the New Zealand electricity system.

Three security of supply margins are evaluated, the:

1. New Zealand Winter Energy Margin (NZ-WEM); adequacy of generation and HVDC transmission capacity to meet expected national electricity demand across the winter months;
2. South Island Winter Energy Margin (SI-WEM); adequacy of generation and HVDC transmission capacity to meet expected South Island electricity demand across the winter months; and
3. North Island Winter Capacity Margin (NI-WCM); adequacy of generation and HVDC transmission capacity to meet peak winter North Island demand.

The SOSA analysis considers the three security of supply margins against security standards set by the Electricity Authority (the Authority) in the Security Standards Assumptions Document (SSAD)[1]. The standards represent an efficient level of reliability—that is, where the expected cost of shortage is equal to the expected cost of new generation.

As an example, the national cost-benefit analysis conducted by the Authority when producing the security standards determined that up to 22 hours per annum of energy or reserve shortfall (as a result of capacity shortage) is economic before additional investment in peaking generation is warranted.

However, falling below the security standards does not equate to electricity shortage. Rather, it implies that investment in new generation would result in an efficient increase in reliability. It can also be interpreted as representing the likelihood of electricity shortage—the higher the actual margin observed the less likely electricity shortage will be all things being equal.

The analysis assesses the supply pipeline against the three security standards based on information provided by market participants, and does not analyse or consider other aspects of future investment such as:

- the availability of transmission and distribution network capacity;
- the deliverability of planned new-build generation; or
- the commercial viability or market incentivises required for resources to be developed.

[1] Electricity Authority, Security Standards Assumptions Document

More detailed security of supply forecasts that highlight shorter term timeframes and operational risk include the Electricity Risk Curves, New Zealand Generation Balance, System Security Forecast, various market insight publications[2], and the Weekly Summary[3].

Changes to Key Inputs for the SOSA 2023

There has been a minor increase in the demand forecast compared to that reported in the 2022 SOSA, largely due to information provided by the distributors from forecasts of expected increases on their networks.

The supply pipeline has changed compared to that reported in the 2022 SOSA. The existing and committed supply pipeline (Stage 1) has increased by approximately 215 MW and the consent expected pipeline (Stage 4) has decreased significantly compared to that reported in the 2022 SOSA. These movements indicate the supply pipeline is being developed, which is further evidenced by the 910 GWh of new wind generation currently under construction. At the time of writing there are 334 enquiries for new grid connected generation[4] - an increase from 63 in 2021 and 124 in 2022 – indicate that the supply pipeline will continue to grow.

98% of the unconsented supply pipeline is made up of intermittent generation sources (wind and solar) and is 100% renewable. Intermittent generation has a larger impact on increasing the energy margin than the capacity margin.

Summary of 2023 Margin Analysis

New Zealand Winter Energy Margin: The reference case[5] (which represents the resources available to the market) falls below the upper security standard by 2027 when considering only those new supply projects that are existing and committed. When including all consented projects, the margin stays above the security standards for the 10-year assessment horizon. This shows that the market has consents to build resources that could maintain the NZ-WEM for the 10-year assessment horizon. It is noted that this assumes a rate of build that is significantly greater than seen in recent years.

We explore the impact of several variations to the reference case assumptions through sensitivities. These sensitivities reflect variations in demand, delays to generation project commissioning, increased HVDC capability and potential reduction in fossil-fuelled generation capability.

The key insights from analysing these sensitivities are:

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[2] Market insights | Transpower
[3] Table 9 in Appendix 5 provides a breakdown of the purpose of each report.
[4] These enquiries are part of the Grid Owner's connection enquiry pipeline. The SOSA supply pipeline uses data sourced from industry as described in Section 2.2.1. Both pipelines exhibit similar trends in expected investment by industry.
[5] Section 2.2 provides a definition of the reference case.

1. Lower than expected growth in demand could delay the margin crossing the upper security standard from 2027 to 2029. If either of the sensitivities that decrease the rate of demand growth occur (Tiwai exits or low demand growth) then investment is still needed before the end of the assessment horizon[6].
2. If demand were to grow faster than the reference case, new investment could be needed as early as 2025.
3. There are four key sensitivities that reflect a transition away from thermal generation and its fuel supply. These are underpinned by:
    a. intentions signalled by the market to decommission or not develop new thermal generation; and
    b. risks to ongoing thermal fuel development and flexibility highlighted by industry groups[7].

    These sensitivities show that the contribution of thermal fuel generation and its supply required to maintain the NZ-WEM above the upper security standard can reduce from 2028. From 2028, the pipeline of renewable generation projects is sufficient to maintain the NZ-WEM above the upper security standard with reduced contribution from thermal resources. The required contribution from the supply pipeline reflects an increase in the rate of renewable build when compared to the rate of build seen in recent years.

South Island Winter Energy Margin: the reference case falls below the upper security standard by 2029 when considering only those new supply projects that are existing and committed. When including consented projects, the reference case shows the margin staying above the upper security standard for the 10-year assessment horizon.

North Island Winter Capacity Margin: The reference case falls below the upper security standard by 2025 when considering only those new supply projects which are existing and committed.

A key reason for the capacity margin falling below the upper security standard earlier than the energy margins is because the supply pipeline is primarily made up of intermittent generation, which has a lower contribution to peak capacity than controllable resources.

When including consented and unconsented projects the margin stays above the upper security standard until beyond the 10-year assessment horizon. Some of these resources have a greater contribution to the peak capacity margin such as non-intermittent generation, batteries and demand response. Some resources can be developed more quickly than others (e.g. demand response[8] does not need to be consented). The building

[6] The "need to invest" in this analysis refers to investment to maintain the margins above the upper security standards.

[7] Gas Market Settings Investigation

[8] Demand response capabilities are not included in our analysis as there was insufficient information provided through the market participant survey.

of new resources that can provide a high contribution to the capacity margin and ideally high levels of flexibility, such as fast start generation, storage, or demand response, is needed more urgently than energy.

We explore the impact of several variations to the reference case through sensitivities. The key insights from these sensitivities are:

1. Lower demand sensitivities have little impact on the NI-WCM. If either sensitivity that decreases the rate of demand growth (Tiwai exits or low demand growth) occur, the NI-WCM still crosses the upper security standards in 2027 and 2025 respectively. This signals a clear need for new resources that have a significant contribution to the NI-WCM in the near term. Beyond dispatchable generation, these can include non-generating assets such as energy storage systems, demand response, non-generation reserve or upgrades to increase the HVDC northward capacity. Some of these resources do not require consenting and could potentially enter the market within one or two years.
2. If demand were to grow faster than the reference case, the NI-WCM would still crosse the security standards in 2025 but to a greater degree than in the reference case.
3. The contribution of thermal fuel generation to maintain the NI-WCM above the upper security standard can reduce from 2027. From 2027, the pipeline of renewable generation projects could be sufficient to maintain the NI-WCM above the upper security standard with reduced contribution from thermal resources. Reducing the contribution of thermal generation may require development of resources that contribute significantly to the NI-WCM beyond those in the unconsented supply pipeline[9].
4. When there is low thermal unit commitment[10], combined with materially less wind generation than forecast, the NI-WCM is operating below the security standards today. This is shown by a new sensitivity (less flexible operational capacity) to demonstrate the operational and market co-ordination challenge of integrating increased intermittent generation with slower start thermal plant. These issues were explored in the System Operator's Winter Review Paper and presentation[11].
5. All committed and consented projects are needed to commission as planned in order to maintain the NI-WCM above the upper security standard until 2028. Beyond 2028, additional projects which do not currently have consents will be required to maintain the NI-WCM above the upper security standard.

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[9] While we recognise thermal fuel supply can have an impact on short term capacity, it is less material or quantifiable than its impact on maintaining the NZ-WEM.

[10] "Unit commitment" refers to the process of deciding when and which generating units at each power station should start-up and shutdown in advance of the anticipated need when taking the technical constraints, potential costs and expected revenue into account.

[11] See System Operator Winter Review Paper and System Operator Winter presentation

2.0 Methodology, Reference Case and Sensitivities

2.1 Methodology

2.1.1 Winter Margins

This assessment provides a 10-year view of the balance between supply and demand in the New Zealand electricity system. It forecasts:

- the Winter Energy Margins for New Zealand (NZ-WEM) and the South Island (SI-WEM). These are winter energy supply, in gigawatt-hours (GWh), divided by winter energy demand, in GWh. The margins are expressed as a percentage of total demand; and
- the North Island Winter Capacity Margin (NI-WCM)[12]. This is the sum of North Island supply capacity, less the expected peak demand, plus surplus South Island supply 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 NI-WCM, and April to September for the NZ-WEM and SI-WEM.

The NZ-WEM and SI-WEM assess whether it is likely there will be an adequate level of supply and, in the case of the South Island, HVDC south transmission capacity, to meet expected electricity demand during the winter. The NI-WCM assesses whether it is likely there will be adequate supply and HVDC north transmission capacity to meet North Island winter peak demand.

In the context of this assessment the term *supply* includes grid connected generation, embedded generation, hydro storage and batteries.

2.1.2 Security Standards

The Authority defines security standards as part of its responsibility to ensure that the regulatory environment promotes an efficient level of reliability. The standards represent an efficient level of reliability—that is, where the expected cost of shortage is equal to the expected cost of new generation.

The current security standards specified in the SSAD are:

- a NZ-WEM of 14–16%;
- a SI-WEM of 25.5–30%; and

[12] Note that our analysis does not make allowances for spinning reserve—that is, the peak demand is not increased by the quantity of reserves required. This means the subsequent margin represents excess supply prior to the provisioning of reserves.

- a NI-WCM of 630-780 MW.

Falling below the security standards does not equate to electricity shortage. Rather, it implies that investment in new generation would result in an efficient increase in reliability. It can also be interpreted as representing the likelihood of electricity shortage—the higher the actual margin observed the less likely electricity shortage will be all things being equal.

2.1.3 Our Assessment

Our assessment evaluates the capacity and energy margins and compares these against the Authority's security standards. We do this for both existing generation and the pipeline of new supply projects that could be potentially built. The objectives of the assessment are to understand:

- when, and under what circumstances, the capacity and energy margins will fall below security standards if no new supply projects are built (other than those already committed); and
- whether the pipeline of new supply projects is adequate to maintain security standards assuming a stable investment environment and adequate market incentives.

While our analysis identifies when a project *could* be developed, we do not attempt to forecast *if* or *when* new supply projects will be developed. Our assessment considers a reference case, valid sensitivities and valid sensitivity combinations.

2.2 Reference Case

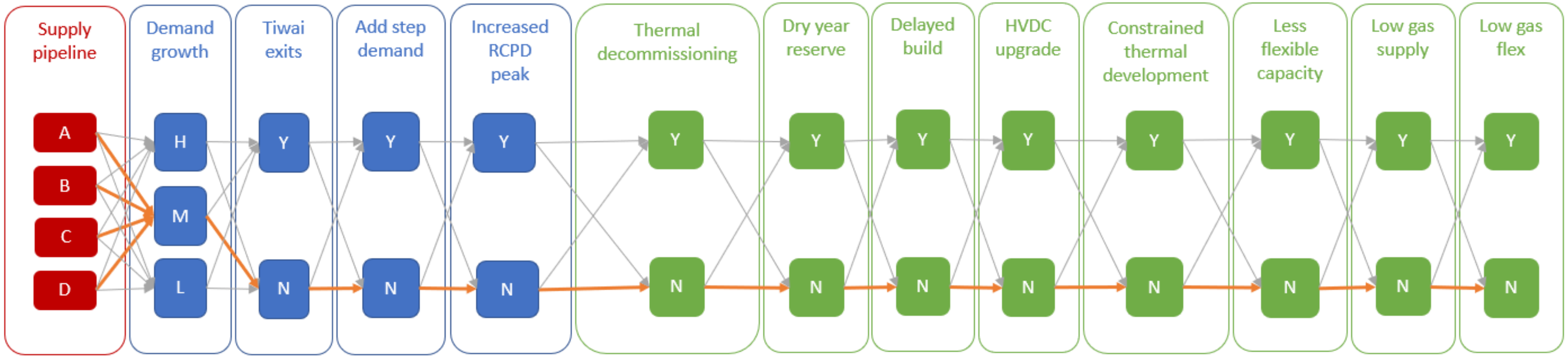
We have used a single reference scenario known as the reference case for the future New Zealand electricity system that represents the resources potentially available to the power system over the 10-year assessment horizon. The reference case represents what the market could develop; not necessarily what it will develop. In making this representation, we use a fixed set of assumptions, and then adjusted these using several key variables, or sensitivities, to test a range of plausible deviations from the reference case and the impact these have on the future capacity and energy margins.

In the reference case we assume existing generation and industrial demand will not change unless decommissioning is publicly announced and decommissioning activities are actively being pursued. The reference case assumes a medium demand forecast and that during the 10-year assessment horizon Tiwai remains, ‘significant’ amounts of thermal generation is not decommissioned in the near term, investment in the upstream gas sector continues and the HVDC interconnector is not upgraded.

Section 2.3 defines the sensitivities our analysis explores. In addition to applying individual sensitivities, we have applied valid combinations of sensitivities to the reference case for a more comprehensive range of futures. Figure 1 below provides an illustration of the combinations of sensitivities.

Stakeholders are invited, and may be better placed, to make their own decisions as to which sensitivities should have more weighting than others.

Figure 1: Assessed supply pipeline stages and sensitivities



Stages	Supply pipeline stages
Stage 1	Existing + committed (consented and active)
Stage 2	Consented and on hold/awaiting market conditions to change
Stage 3	Consented and on hold/awaiting market conditions to change - revision or reconsent required
Stage 4	Not consented, but consent likely sought within two years

The orange arrows represent the combination of key variables that make up the reference case. The grey arrows represent the potential combinations of sensitivities.

2.2.1 Detailed Reference Case Assumptions

We have used the following key assumptions for the reference case.

Demand Growth

Our reference case focuses on a *medium* rate of acceleration of electrification across the economy and growth of distributed energy resources[13]. To achieve this, transport electrification (electric vehicles), process heat electrification, solar photo voltaic (PV) and small-scale batteries are specifically modelled in this scenario[14].

The underlying rate of demand growth covers sectoral changes in electricity efficiency and intensity and sectoral shifts in energy demand, as well as growth of population and the economy.

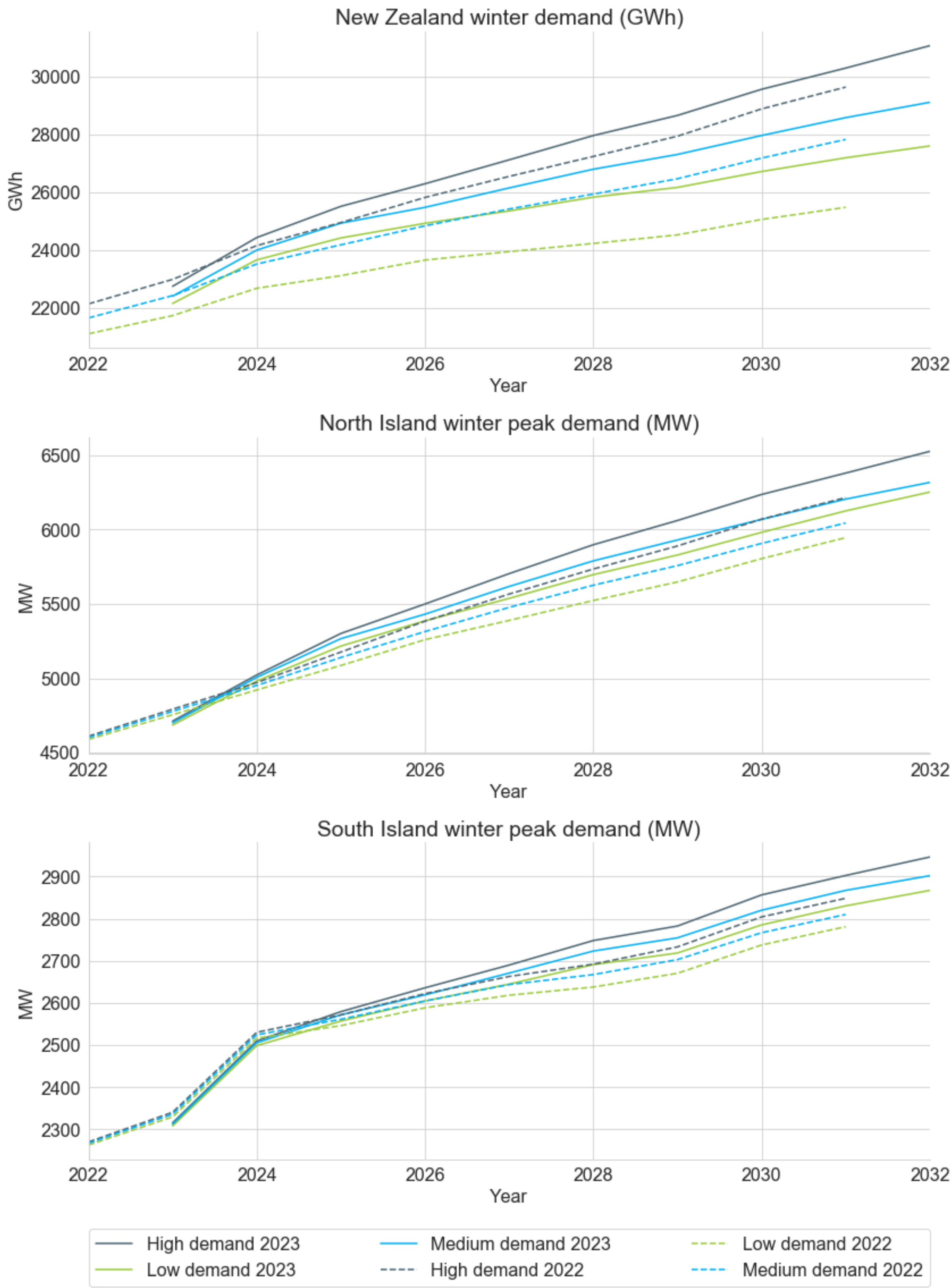
Figure 2 shows the winter energy and peak demand forecasts. They include the demand forecasts used in the 2022 SOSA to show the relative increase for both energy and peak demand this year compared to last year. The NI-WCM is measured against the North Island winter peak demand forecast; the South Island winter peak demand forecast is used as part of this calculation as it impacts the HVDC transfer.

The peak and energy demand forecast used in the 2023 SOSA has increased compared to the 2022 SOSA. This increase is largely due to information provided by distributors in preparing this year's demand forecast on expected increases in step loads (as an example, data centres and electrification of process heat).

[13] Distributed energy resources provide energy and capacity at a household level, offsetting grid demand. For this reason, the expected rate of uptake is modelled in the demand forecast rather than as a supply sensitivity.

[14] Appendix 2 sets out the demand forecast modelling process.

Figure 2: New Zealand winter energy, North Island winter peak and South Island winter peak demand forecasts compared to the 2022 Security of Supply Assessment



Tiwai Smelter Load

The reference case includes the Tiwai smelter load over the 10-year assessment horizon. The current Tiwai contract is scheduled to expire at the end of 2024. However, New Zealand Aluminium Smelters (NZAS) have indicated that it intends to remain operating beyond this date.

HVDC Capacity

The reference case assumes that the HVDC will not be upgraded throughout the 10-year assessment horizon. The Authority's SSAD describes the capacity of the HVDC.

Supply Pipeline Stages

As in the 2022 SOSA, the supply pipeline is based on information provided by market participants on a confidential basis. The reference case is analysed across the four supply pipeline stages shown in Table 1.

Table 1: Supply pipeline stages

Stage	Short description	Long description
Stage 1	Existing and committed	Existing, consented and committed to being developed
Stage 2	Stage 1 + consented, on hold	Includes: • existing, consented and committed to being developed • consented and on hold/awaiting market conditions to change
Stage 3	Stage 2 + consented, on hold, requiring reconsent	Includes: • existing, consented and committed to being developed • consented and on hold/awaiting market conditions to change • consented and on hold/awaiting market conditions to change—consent revision or reconsenting will be required
Stage 4	Stage 3 + consent expected	Includes: • existing, consented and committed to being developed • consented and on hold/awaiting market conditions to change • consented and on hold/awaiting market conditions to change—consent revision, or reconsenting will be required • not consented, but consent likely to be sought in the

Stage	Short description	Long description
		next two years

We assume that existing generation remains available unless decommissioning is publicly announced and decommissioning activities are being actively pursued.

Figure 3 shows the contribution of the supply pipeline stages for both energy and capacity. New supply project timings are based on commissioning dates provided by market participants, and if a date has not been provided, we have used an estimated earliest potential build date[15]. Any subplots in Figure 3 should not be interpreted as a forecast of new generation build.

The three subplots in Figure 3 titled *Stage 3—Consented, on hold, requiring reconsent* show the potential winter energy and capacity capability from existing and committed generation in the grey bars and the pipeline of new supply projects that are consented but on hold (some requiring reconsent).

The three subplots in Figure 3 titled *Stage 4-Consent expected* show the potential winter energy and capacity capability from existing and committed generation in the grey bars, the pipeline of new supply projects that are consented but on hold (some requiring reconsent) and projects that are not consented but where consent is likely to be sought in the next two years. The large increase in potential contribution to winter energy and capacity margins in Stage 4 (compared to Stage 3) indicates the significant interest in new supply resources beyond those already consented[16]. However, given these projects are not yet consented, they entail a higher degree of uncertainty.

The capacity of the South Island supply pipeline stages are shown in the two subplots at the bottom of Figure 3. This capacity, less South Island peak demand, contributes to the calculation of the NI-WCM but is limited by the HVDC capability.

[15] Table 6 within Appendix 3 defines earliest build dates.
[16] This observation is supported by Transpower in its role as Grid Owner; the Grid Owner has seen a large increase in customer enquiries from both generation and demand, as highlighted in Transpower's New Connection Enquiries Dashboard.

Figure 3: Contributions of supply pipeline to the New Zealand Winter Energy and North Island Winter Capacity margins

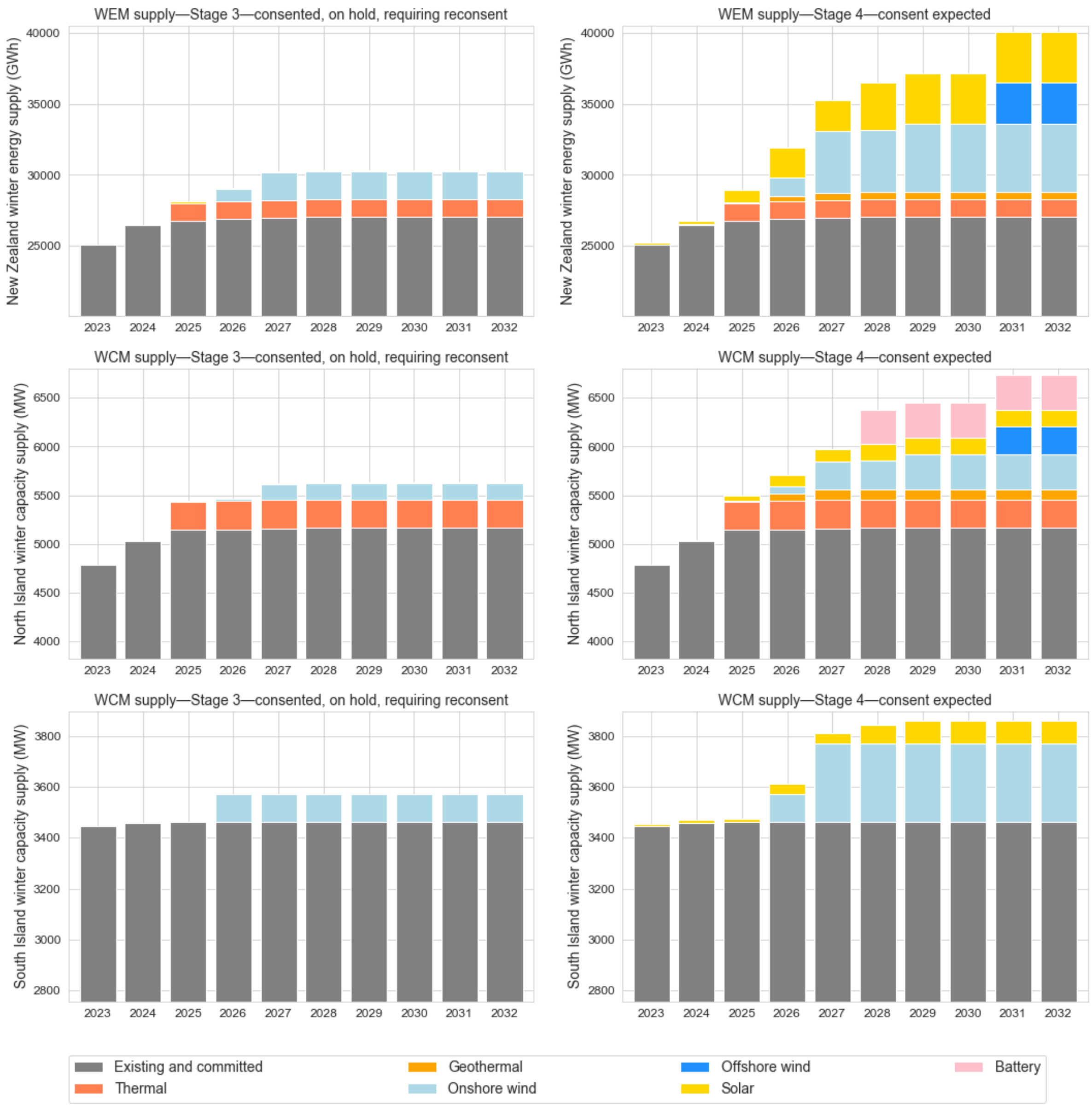


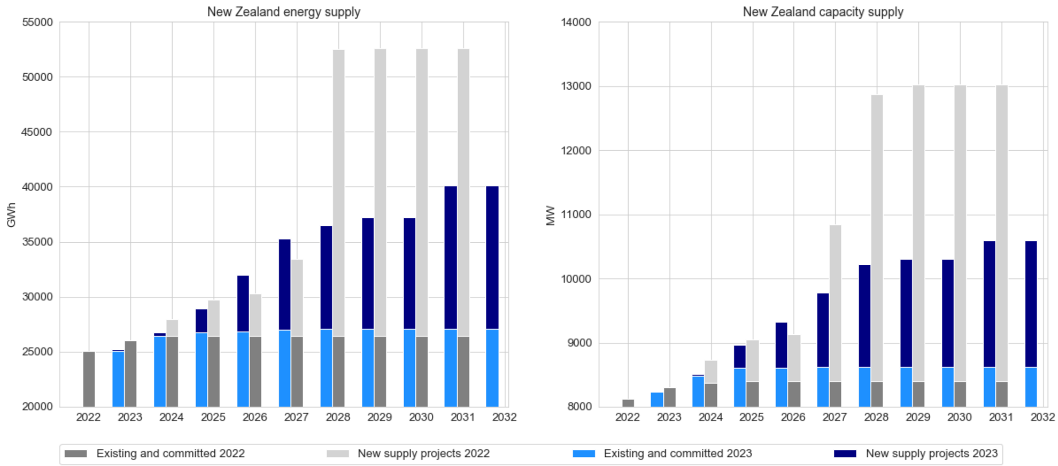
Figure 4 shows existing and committed and new supply projects pipelines. They include the pipelines used in the 2022 SOSA to show the changes to Stages 1 to 4 of the supply pipeline as reported in the 2023 SOSA compared to last year.

Figure 4 shows that from 2024, the existing and committed supply pipeline is higher in the 2023 SOSA compared with the 2022 SOSA for both energy and capacity supply. This reflects an approximate 215 MW increase of supply projects that fall into the Stage 1 category (see Table 1). This is a positive change, as the existing and committed supply projects have the highest level of certainty in being delivered.

This movement suggests that the supply pipeline is being developed. This is supported by 910 GWh of new wind generation currently under construction and 334 enquiries for new grid connected generation, an increase from 63 in 2021 and 124 in 2022.

The 2022 SOSA reported a significant step change in new supply projects in 2028, reflected in both the energy and capacity supply subplots. This step change was a result of a large number of unconsented intermittent generation projects with earliest commissioning dates of 2028. This step change is not reflected in the 2023 SOSA, as the unconsented supply pipeline has been refined by industry participants. This has resulted in a decrease in new supply projects in both the energy and capacity subplots in Figure 4 when compared to the equivalent information reported in the 2022 SOSA. This decrease reinforces that the projects that fall into Stage 4 (see Table 1) are currently unconsented and there is a higher level of uncertainty around delivery of these projects.

Figure 4: Winter energy and capacity supply in 2023 compared to 2022



Gas Supply

For the reference case we have assessed the gas supply availability (for gas generation) by estimating a dry year gas supply margin for the 10-year assessment horizon as used for the purposes of the 2022 SOSA[17]. Gas supply assumptions use confidential information from gas producers for 2023 to 2024 and Ministry of Business, Innovation and Employment (MBIE) statistics[18] for the latter years.

The dry year gas supply margins[19] indicate that we expect sufficient gas to run over winter periods under the reference case. This is primarily due to expected ongoing investments in the gas sector to enable additional gas supply over the coming years, including the development of potentially recoverable contingent reserves, assuming reallocation of gas from industrial gas users if needed for increased electricity generation during dry years and substitution of gas demand from industrial processes.

[17] 2022 Security of Supply Assessment

[18] MBIE's Petroleum Reserves 2021

[19] Appendix 4 defines the process for determining the dry year gas supply margins.

2.3 Sensitivities

We have identified several key variables that we explore as sensitivities in our analysis. These sensitivities represent plausible variations from the reference case that could occur over the 10-year assessment horizon.

In addition to applying individual sensitivities to the reference case, we consider applying all valid sensitivity combinations to the reference case to form a wider range of plausible futures. We have assessed the reference case and the sensitivities (and their feasible combinations) for different potential future generation[20] scenarios, which we refer to in the SOSA as supply pipeline stages.

We planned to include a *greater demand response* sensitivity to explore the impact of increased uptake in demand response in both the North and South Islands. We sought additional information from electricity distribution businesses and industrial users on expectations of demand response, but did not receive a sufficient response to be able to generate a sensitivity.

We also planned to include a *New Zealand battery* sensitivity to explore the impact of one potential outcome of the New Zealand battery project, a pumped hydro scheme at Lake Onslow. However, a recent release from MBIE[21] identified that "the P50 estimated deliverable timeline for the Lake Onslow option has commissioning and performance testing completed in Q4 2037". Therefore, the commissioning of Lake Onslow has fallen outside of the 2023 SOSA's assessment horizon, and we have not assessed it.

The 2021 and 2022 SOSAs considered the Government's aspirational target of 100% renewable energy by 2030 as a separate case study. We have included this assessment in the 2023 SOSA (see Section 4.0).

2.3.1 Supply Side Sensitivities

Thermal Decommissioning

This sensitivity tests the potential impact of the decommissioning of significant fossil-fuelled thermal generation assets throughout the assessment horizon.

Dry Year Reserve

This sensitivity assumes a small number of 'baseload' fossil-fuelled thermal generators change their operation so that they only provide dry year reserve from 2027 onwards. This sensitivity tests the impact on the NI-WCM if these generators were not available to

[20] This also includes batteries.
[21] New Zealand Battery Project: Progressing to the Next Phase

contribute to short-term, unanticipated supply shortages (unrelated to hydrology). Existing fossil-fuelled thermal generation installed capacity will be reduced by 480 MW when calculating the NI-WCM. As this capacity will still be available for dry year reserve, it will still be included when calculating both the NZ-WEM and SI-WEM.

Low Gas Supply

This sensitivity is intended to show a constrained case of gas supply for electricity generation over the 10-year assessment period[22]. It reflects concerns that future capital investment in the upstream gas industry may be at risk, given anticipated changes in gas demand and perceived uncertainties as to the transition away from carbon intensive fossil fuels. Further information can be found in the Gas Industry Company's Gas Market Settings Investigation[23] final report.

In this sensitivity, we assume that gas supply after 2025 is limited to estimated 1P reserves, where these are known reserves that have a 90% chance of being 'recovered' or produced. We also assume that there is no investment to unlock contingent gas resources or to import natural gas. This is consistent with this sensitivity's underlying assumption of minimal levels of investment in upstream gas sector infrastructure. Domestic gas production begins to decline substantially from 2026. This results in a progressive curtailment of existing gas generation, with only gas co-generation plant contributing to security margins from 2030.

Low Gas Demand Flex

This sensitivity is intended to explore the impact that gas reallocation from industrial gas users to gas-fired electricity generators has in the event of low gas supply. In this sensitivity we assume that less gas demand reallocation occurs from industrial gas users when needed for increased electricity generation.

Delayed Build Times

This sensitivity explores the impact of delaying the commissioning dates for all new generation by one year. This sensitivity is intended to cover a range of possible eventualities. For example, new generation may be delayed due to transmission constraints, resource consent issues or investment uncertainty.

HVDC Upgrade

The exit of Tiwai and/or new South Island generation capacity may result in surplus South Island generation capability that could be exported to load centres in the North Island, which could result in the upgrade of the HVDC link, including through the addition of a

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[22] This sensitivity is based on the low gas supply sensitivity assessed in the 2022 SOSA.
[23] Gas Market Settings Investigation

fourth cable. The Net Zero Grid Pathways scenarios consider the earliest this could occur is 2027[24].

Constrained Thermal Development

In this sensitivity we consider the impact if no new fossil-fuel generation is developed during the 10-year assessment horizon (2023 to 2032). This could be for a variety of reasons, as we transition towards lower carbon economy.

Less Flexible Operational Capacity

This sensitivity explores the market co-ordination challenge of integrating increased intermittent generation with slower start thermal plant. This challenge can lead to scenarios with lower levels of committed slower start thermal plant and intermittent generation thus resulting in lower levels of available operational capacity availability over peak demand periods, as described in the System Operator's market insights paper and presentation[25]. While the SOSA does not provide a nuanced analysis of this issue, this sensitivity gives an indication of how this situation can impact the NI-WCM.

2.3.2 Demand Side Sensitivities

Demand Growth

The demand growth sensitivities explore higher and lower rates of electricity demand growth compared to the reference case. Each of these will differ by varying the rates of acceleration of electrification across the economy and growth of distributed energy resources. To achieve this, we have specifically modelled transport electrification (electric vehicles) and process heat electrification for each growth rate. We have also modelled different rates of solar PV and small-scale batteries, as they can offset growth in demand from the grid[26].

Tiwai Exits

This sensitivity assumes that the Tiwai aluminium smelter exits the New Zealand market when its current contract expires (at the end of 2024). In this sensitivity, we assume a 'hard' exit, with no ramp-down in demand from the smelter up to and including 2024.

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[24] See Net Zero Grid Pathways

[25] See System Operator Winter Review Paper and System Operator Winter presentation

[26] Appendix 2 defines the demand forecast modelling process.

Step Change Increase in Demand

This sensitivity explores the potential impact of new industrial sources of demand, such as data centres, other new industries or electrification of process heat demand. In this sensitivity we consider an additional step of load in both the North and South Islands.

Change in Peak Transmission Pricing

This sensitivity considers a residual peak demand increase as the electricity sector continues to adjust to a change in transmission pricing.

The revised Transmission Pricing Methodology removed the use of Regional Coincident Peak Demand (RCPD) in allocating transmission interconnection charges. The new Transmission Pricing Methodology (without RCPD allocation) came into effect in April 2023. This implies the use of RCPD (from September 2021) is not used for allocating interconnection charges.

In the 2022 SOSA, we estimated that peak demand may increase (from forecast levels) by 236 MW in the North Island and 68 MW in the South Island. A report released by the Authority estimated that daily peak consumption increased by around 150 MW during the top 300 consumption periods in 2022[27].

In the 2023 SOSA, this sensitivity applies an increase in winter peak demand by 118 MW in the North Island and 34 MW in the South Island. This adjustment is only applied in 2023 for this sensitivity.

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[27] Electricity Authority "The impact of the RCPD change removal on peak demand"

3.0 Results

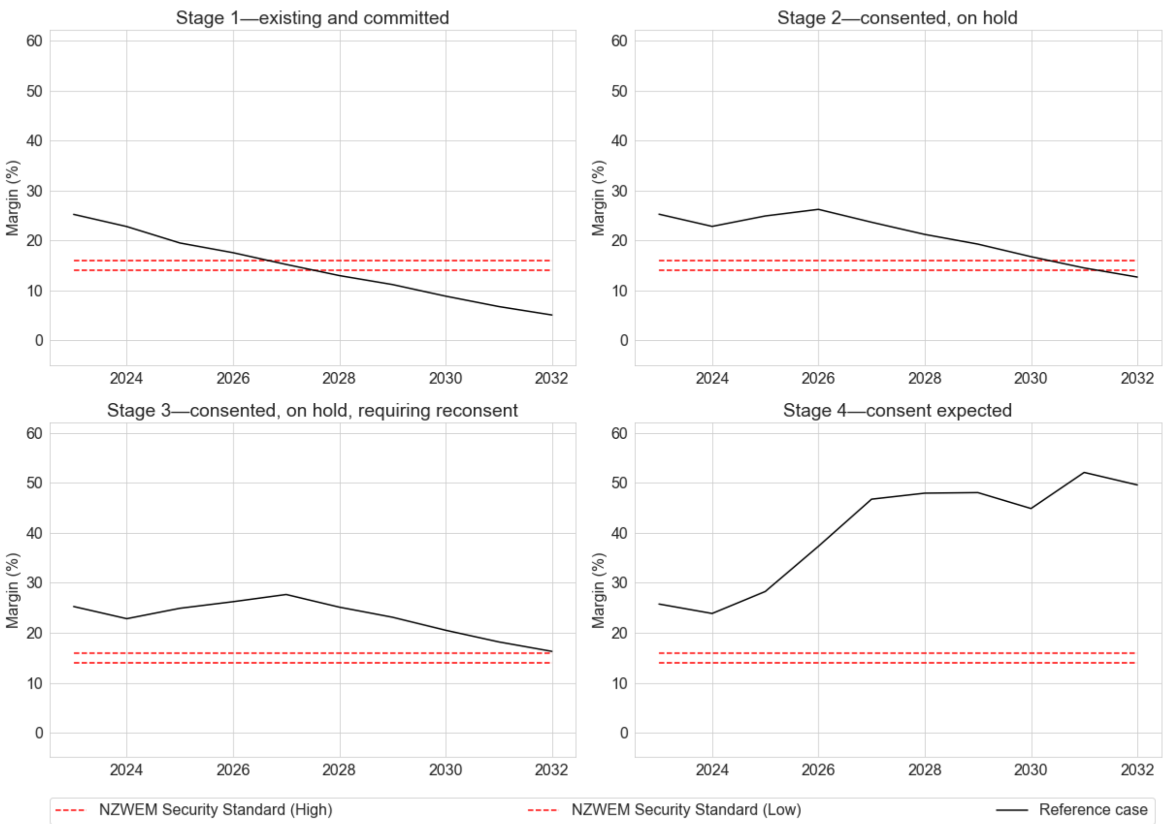
3.1 Winter Energy Margin Results

3.1.1 New Zealand Winter Energy Margin Reference Case Results

Figure 5 shows the NZ-WEM results for the reference case. This illustrates that:

1. with existing and committed generation (Stage 1) the NZ-WEM declines and crosses the upper security standard in 2027;
2. for the reference case to maintain the NZ-WEM above the upper security standard throughout the assessment horizon, in addition to the existing and committed generation, most of the consented and on-hold supply projects (including those requiring reconsent) would need to be developed (Stages 3); and
3. from 2026, a large amount of generation that is currently expecting to seek consent within the next two years could begin to come online. These projects have a higher degree of uncertainty, but due to their renewable nature are not reliant on thermal fuel development as some existing consents are.

Figure 5: New Zealand Winter Energy Margin reference case results

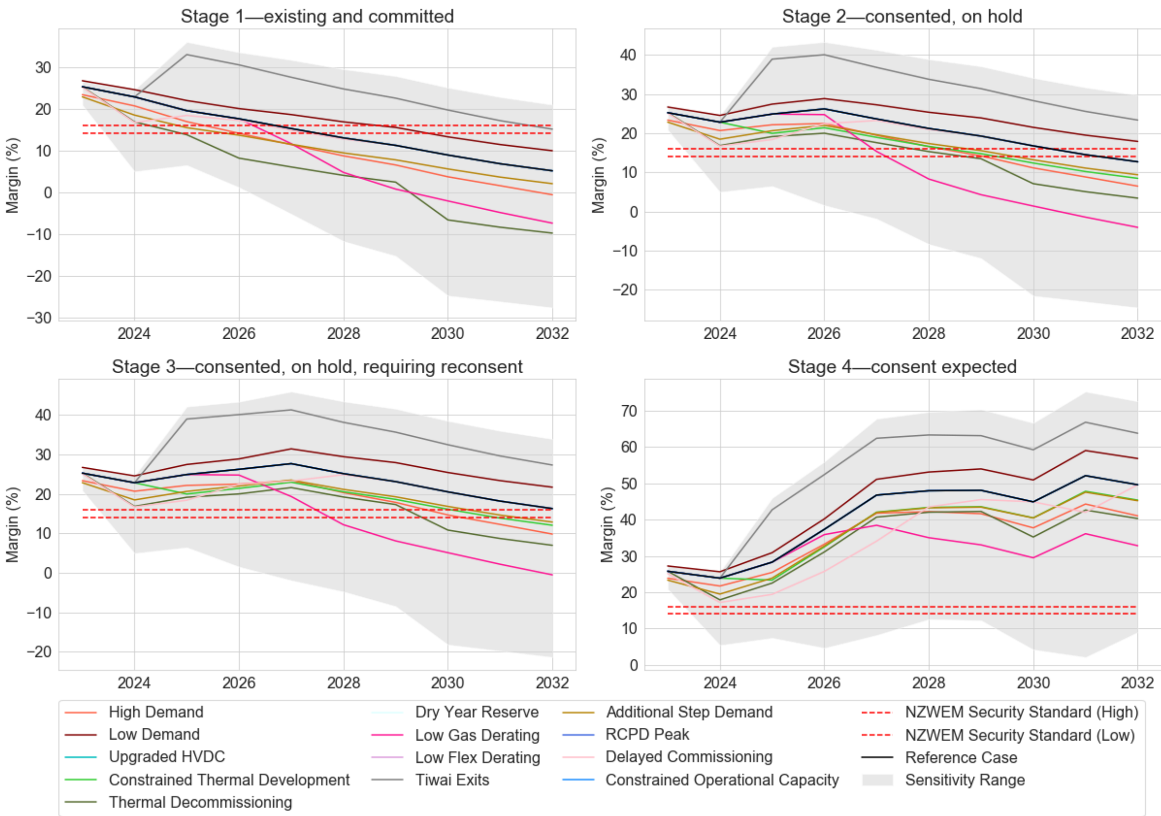


3.1.2 New Zealand Winter Energy Margin Sensitivities

In this section we present the impact the sensitivities have on the reference case and discuss whether these impacts accelerate or delay the NZ-WEM crossing the upper security standard.

Figure 6 shows the impact of each of the sensitivities when applied independently to the reference case for each of the four supply pipeline stages. The grey shaded area defines the boundary for the best and worst case of the plausible sensitivity combinations. Applying each sensitivity independently from one another allows us to observe the magnitude of each sensitivity's impact on the NZ-WEM (relative to the reference case).

Figure 6: New Zealand Winter Energy margins for the reference case and all sensitivities



The sensitivities that have the greatest impact on the NZ-WEM are Tiwai exits, thermal decommissioning, high and low demand growth and low gas supply.

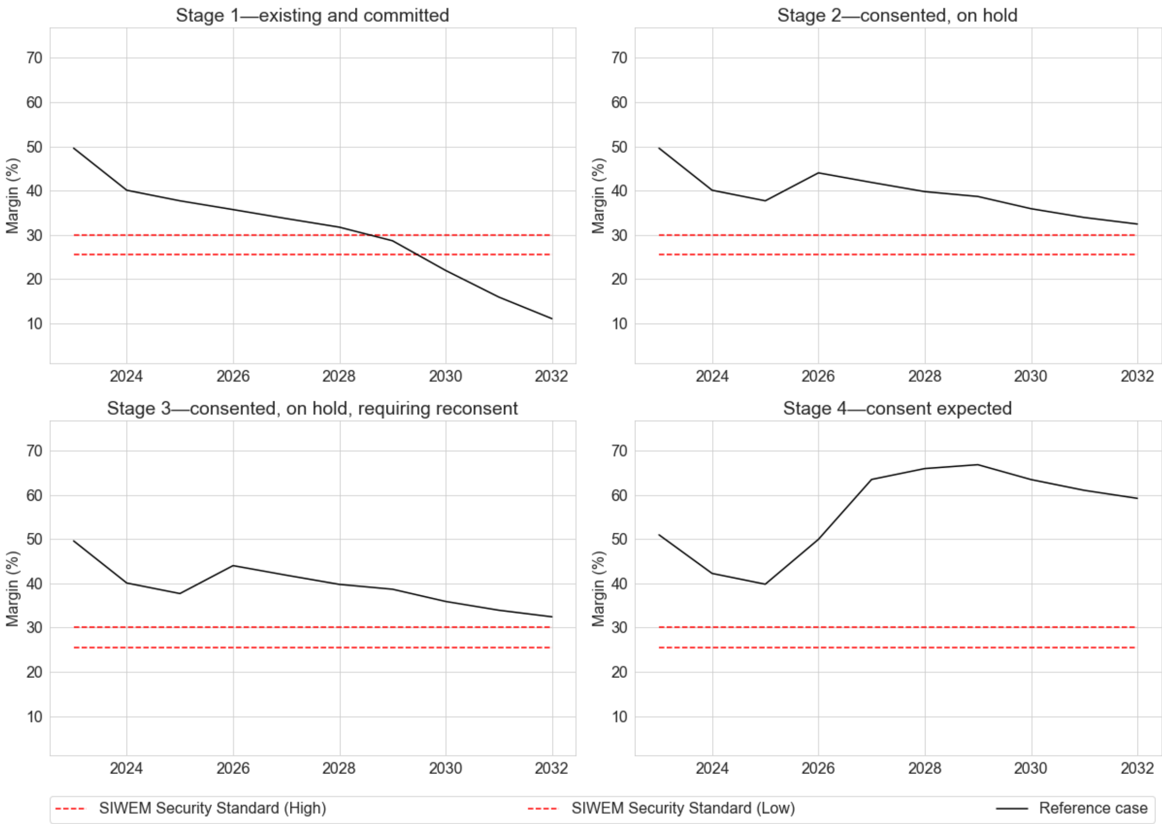
3.1.3 South Island Winter Energy Margin Reference Case Results

The SI-WEM results for the reference case are shown in Figure 7. This illustrates that:

1. the SI-WEM is significantly higher than the NZ-WEM;

2. with existing and committed generation (Stage 1) the SI-WEM declines and crosses the upper security standard in 2029; and
3. for the reference case to maintain the SI-WEM above the upper security standard throughout the assessment horizon, in addition to the existing and committed generation, most of the consented and on hold supply projects would need to be developed (Stages 2 or 3).

Figure 7: South Island Winter Energy Margin reference case results

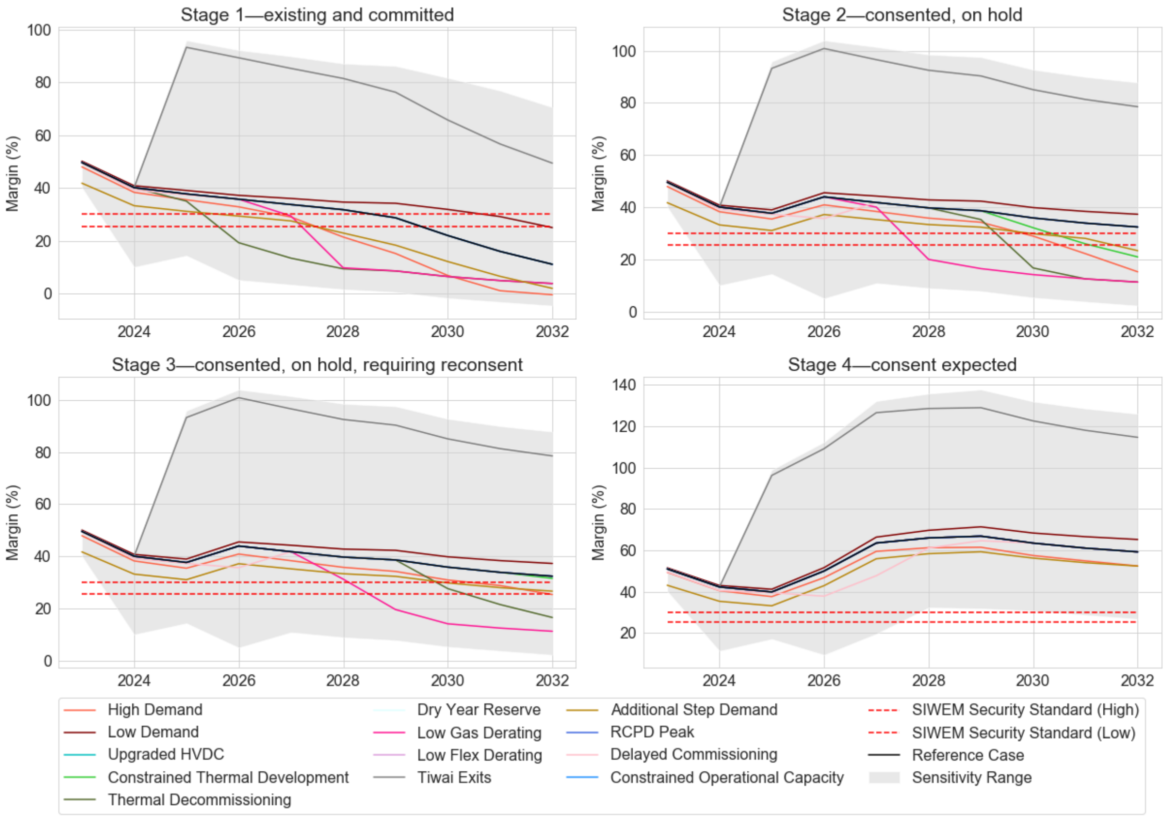


3.1.4 South Island Winter Energy Margin Sensitivities

In this section we present the impact the sensitivities have on the reference case and discuss whether these impacts accelerate or delay the SI-WEM crossing the upper security standard.

Figure 8 shows the impact of each of the sensitivities when applied independently to the reference case for each of the four supply pipeline stages. The grey shaded area defines the boundary for the best and worst case of the plausible sensitivity combinations. Applying each sensitivity independently from one another allows us to observe the magnitude of each sensitivity's impact on the SI-WEM (relative to the reference case).

Figure 8: South Island Winter Energy Margins for the reference case and all sensitivities



The sensitivities that have the greatest impact on the SI-WEM are Tiwai exits, additional step demand, thermal decommissioning and high demand growth.

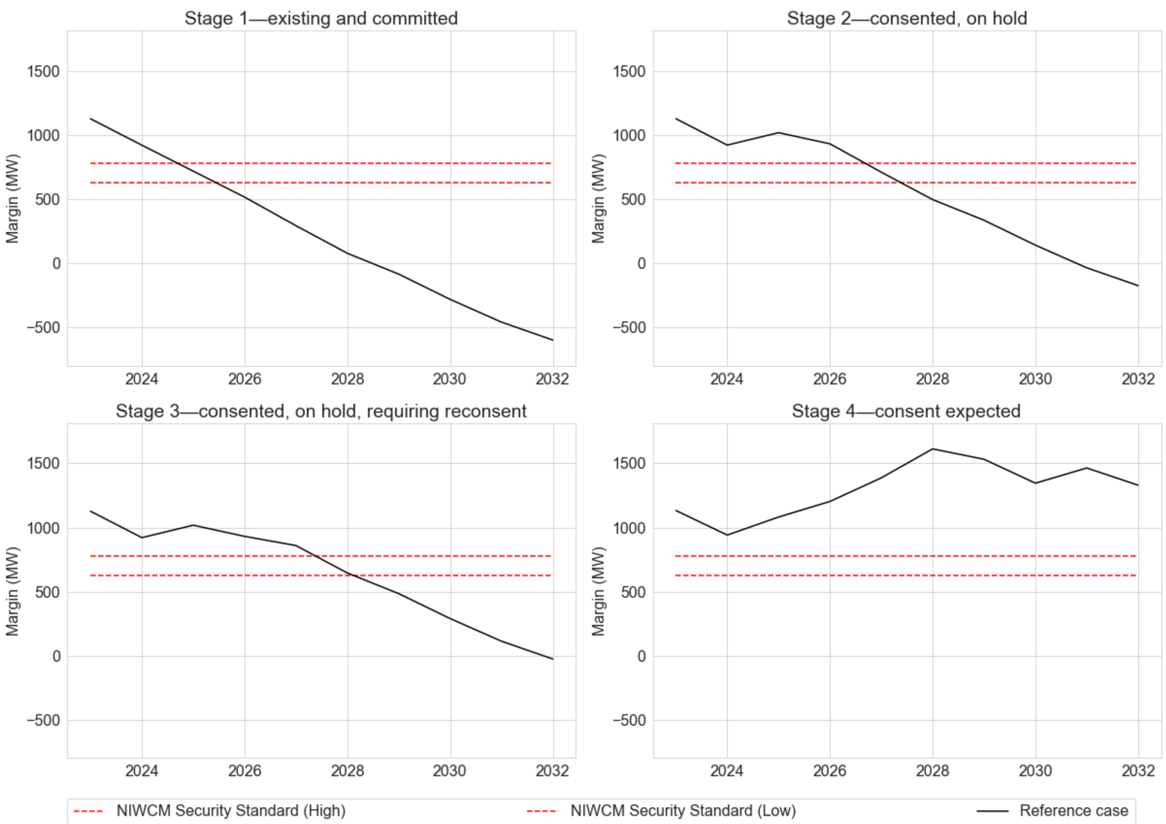
3.2 Winter Capacity Margin Results

3.2.1 North Island Winter Capacity Margin Scenario Results

Figure 9 shows the NI-WCM results for the reference case. This illustrates that:

1. with existing and committed generation (Stage 1) the NI-WCM declines and crosses the upper security standard in 2025;
2. the addition of consented and on hold projects (Stages 2 and 3) helps maintain the NI-WCM above the upper security standard through to approximately 2027 and
3. additional unconsented projects (Stage 4) would be needed to maintain the NI-WCM beyond 2027 for the remainder of the assessment horizon. These projects have a higher degree of uncertainty, but due to their renewable nature are not reliant on thermal fuel development as some existing consents are.

Figure 9: North Island Winter Capacity Margin reference case results

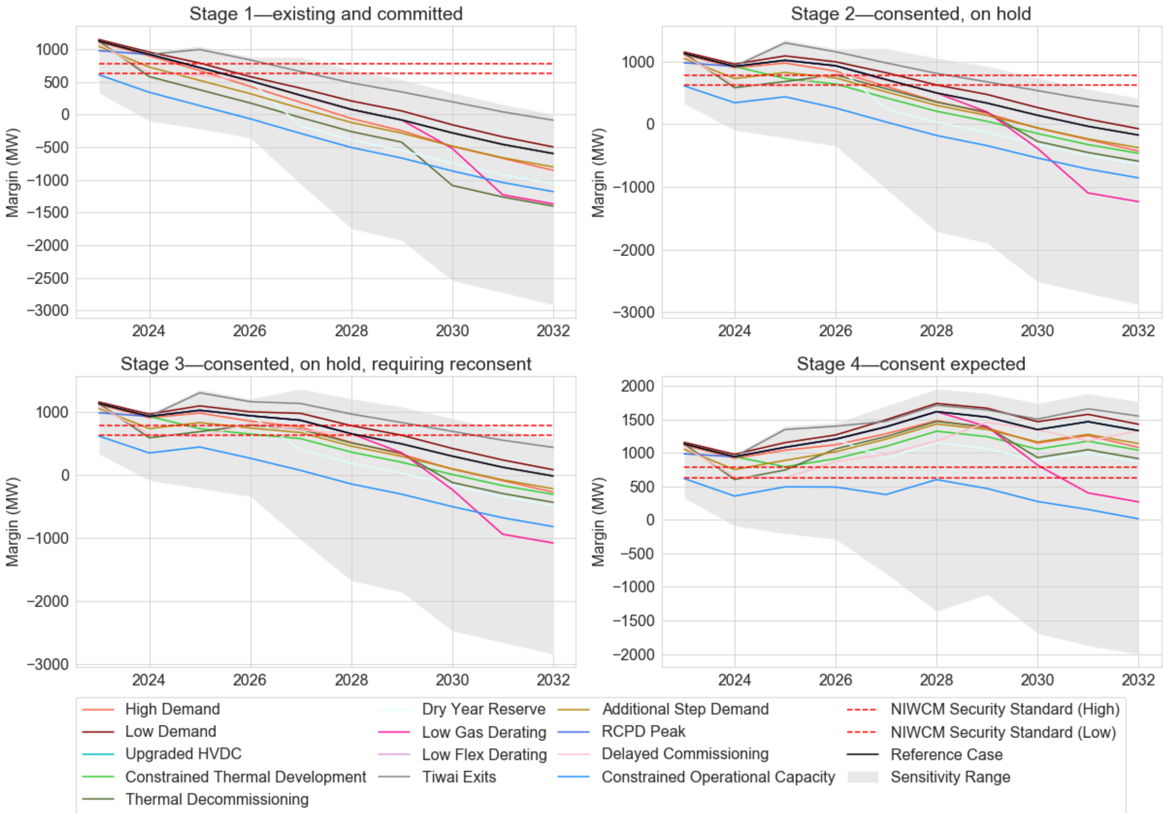


3.2.2 North Island Winter Capacity Margin Sensitivities

In this section we present the impact the sensitivities have on the reference case and whether these accelerate or delay the NI-WCM crossing the upper security standard.

Figure 10 shows the impact of each of the sensitivities when applied independently to the reference case for each of the four supply pipeline stages. The grey shaded area defines the boundary for the best and worst case of the plausible sensitivity combinations. Applying each sensitivity independently from one another allows us to observe the magnitude of each sensitivity's impact on the NI-WCM (relative to the reference case).

Figure 10: North Island Winter Capacity Margins for the reference case and all sensitivities



The sensitivities that have the greatest impact on the NI-WCM are Tiwai exits, thermal decommissioning, no new thermal development, dry year reserve and constrained operational capacity.

3.3 Comparison with the 2022 Security of Supply Assessment

Figure 11 and Figure 12 below show the NZ-WEM and NI-WCM reference case results for this year's SOSA compared to the 2022 SOSA.

When considering only the existing and committed supply projects (Stage 1), both the NZ-WEM and NI-WCM cross the upper security standards in the same year in both assessments, 2027 and 2025 respectively. This is primarily due to the slight increase in the demand forecast (Figure 2) being matched with a corresponding increase in existing and committed generation (Figure 4).

When considering all of the consented supply projects (Stages 2 and 3), we can see that for the entirety of the assessment horizon the 2023 SOSA's reference case is lower than that reported in the 2022 SOSA. This is primarily due to the consented projects pipeline remaining fairly consistent with that reported in the 2022 SOSA, while the demand forecasts reported in the 2023 SOSA have increased. These changes have resulted in a net decrease in both the NZ-WEM and NI-WCM across the assessment horizon.

When considering the entire supply projects pipeline (Stage 4), the 2023 SOSA has less of a step change in 2028 as in the 2022 SOSA. This is a result of a reduction in consent-expected projects from the supply pipeline as well as a corresponding increase in demand growth. This is a good example of the higher level of uncertainty in the unconsented projects pipeline and the corresponding impact on the NZ-WEM and NI-WCM.

Figure 11: New Zealand Winter Energy Margin reference case comparison, 2022 and 2023

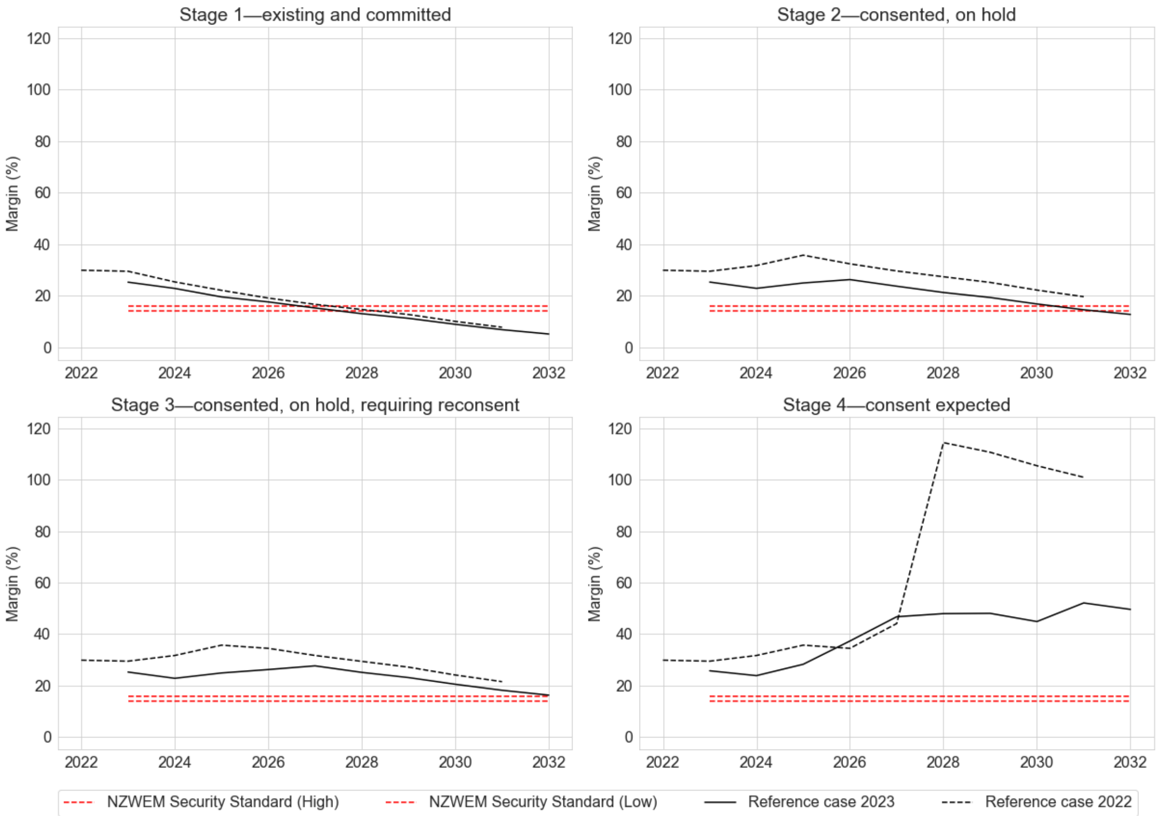
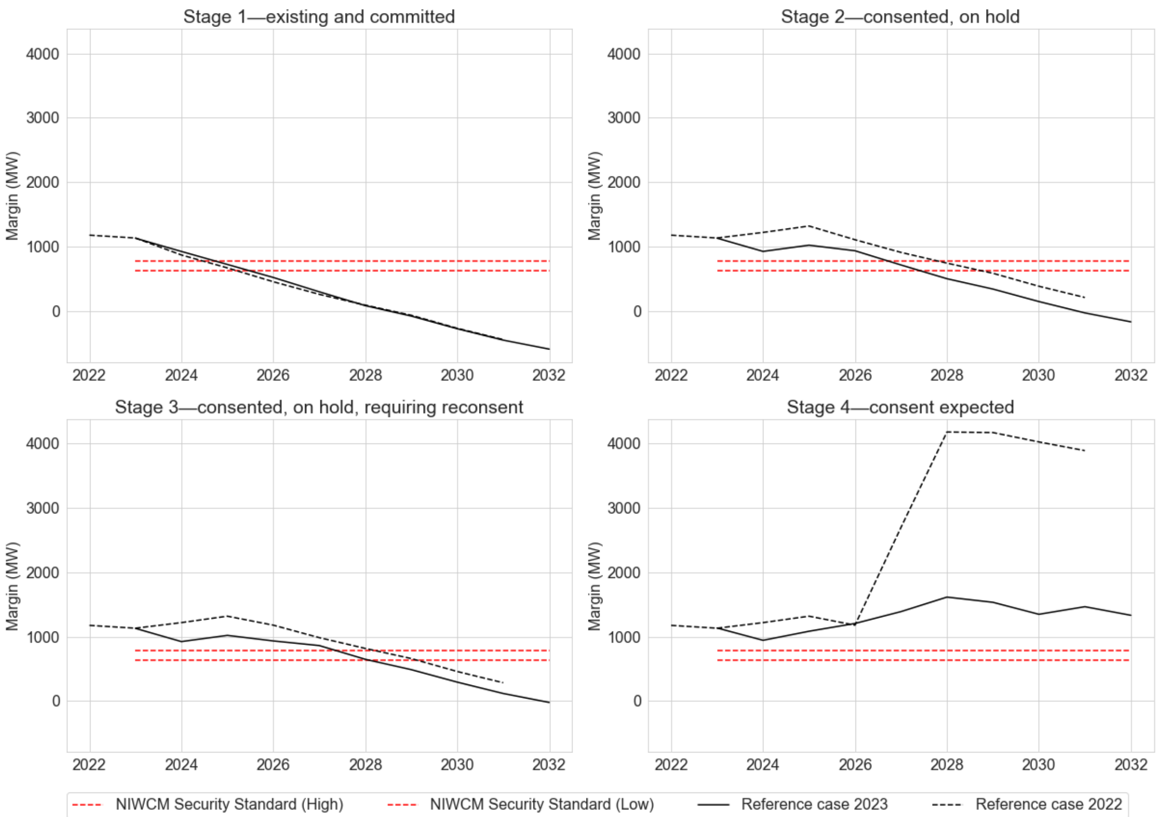


Figure 12: North Island Winter Capacity Margin reference case comparison, 2022 and 2023



3.4 Key Insights

3.4.1 Energy

Tiwai Exit

Tiwai exit would delay the need for investment to maintain the NZ-WEM by five years, but not remove this need altogether.

Figure 6 shows the impact of Tiwai leaving from 2025, where national energy demand is assumed to decrease by approximately 400 GWh every month from 2025. This is observed in Figure 6 by a noticeable increase in NZ-WEM from 2025 onwards, compared with the reference case. The general trend from 2025 onwards aligns with the reference case.

However, the Tiwai exit sensitivity crosses the upper security margin in 2032 when assessed against Stage 1 of the supply pipeline. This demonstrates that even if Tiwai was to exit the market in 2025, the existing and committed generation would not be sufficient to maintain the NZ-WEM above the upper security standard from 2032. Therefore, the uncertainty around Tiwai's exit may delay the need for investment by five years but not remove this need altogether.

Changes in Demand Growth

Changes in the rate of demand growth could accelerate or delay the need for investment to maintain the NZ-WEM by 2 years.

Figure 6 shows the impact of different sensitivities that adjust the rate of demand growth, including both high and low demand growth sensitivities as well as a sensitivity that demonstrates the impact of a 200 MW step increase in demand in 2024. Figure 6 shows that for all supply pipeline stages the high demand growth and additional step change in demand sensitivities have resulted in the NZ-WEM crossing the upper security standard at an accelerated rate when compared with the reference case. Additionally, Figure 6 shows that for all supply pipeline stages the low demand growth sensitivity has resulted in a delay in the NZ-WEM crossing the upper security standard when compared with the reference case.

Table 2: New Zealand Winter Energy Margin earliest crossing of the upper security standard for the reference case and demand sensitivities

Sensitivity	Stage 1	Stage 2	Stage 3	Stage 4
Reference case	**2027**	**2031**	**>2032**	**>2032**
Demand step change	2025	2029	2031	>2032

High demand	2026	2029	2030	>2032
Low demand	2029	>2032	>2032	>2032

Table 2 identifies the years in which the NZ-WEM for the reference case and demand related sensitivities crosses the upper security standard for all supply pipeline stages.

When considering only the existing and committed generation (Stage 1), the rate of demand growth can cause the NZ-WEM to cross the upper security margin as early as 2025 or delay the crossing to 2029. However, if we consider Stage 4 of the supply pipeline, the NZ-WEM does not cross the upper security standard for either the reference case or any of the demand related sensitivities.

The demand related sensitivities show that demand changes create uncertainty around the timing of when additional supply projects will be needed; they all indicate development is needed before the end of the decade to maintain the NZ-WEM.

Reduced Gas Availability

Reduced gas availability could cause the NZ-WEM to fall below the upper security standard unless currently unconsented projects are developed before 2028. If gas availability does reduce the impact of gas demand flexibility towards maintaining the security standards increases.

Figure 6 shows the impact of two different sensitivities that reduce the availability of gas to produce electricity:

- **low gas supply,** in which gas supply after 2025 is limited to estimated 1P reserves; and
- **low gas demand flex,** in which less gas demand reallocation occurs from industrial gas users to gas-fired electricity generators.

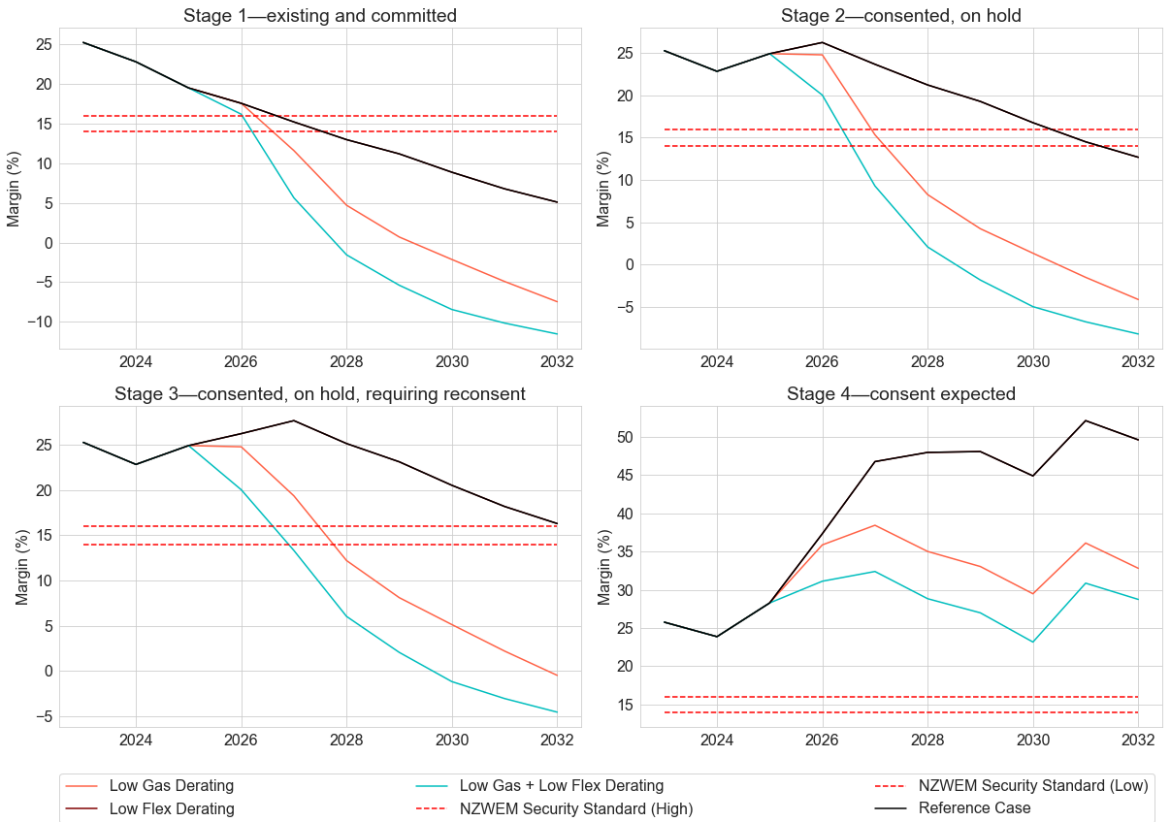
Figure 6 shows the impact of the low gas supply sensitivity: a noticeable decrease in NZ-WEM from 2026 until 2028, compared with the reference case. The general trend from 2028 onwards aligns with the reference case. The low gas supply sensitivity crosses the upper security margin in 2026 when assessed against Stage 1 of the supply pipeline, which is a year before the reference case crosses in 2027. For the impact of this sensitivity not to cause the NZ-WEM to cross the upper security margin, supply projects from the consent expected pipeline (Stage 4) would need to be developed prior to 2028, at which point the projects from Stages 2 and 3 of the supply pipeline would no longer be sufficient to maintain the NZ-WEM above the upper security margin.

Figure 6 also shows the impact of the low gas demand flex sensitivity. This sensitivity assumes some gas demand flexibility (although less than the reference case, as discussed in the Appendix) and similar to the reference case, assumes some contingent gas reserves are developed over the assessment horizon. Together these indicate potentially sufficient gas resources for electricity gas generation over the assessment horizon. This indicates that provided there is additional gas supplies coming to the market, there will be reduced need for gas flex from industrial gas users for increased electricity generation. This is apparent in Figure 6 when the low gas demand flex sensitivity aligns with the reference case for each of the supply pipeline stages throughout the assessment horizon.

Figure 13 shows the impact of the low gas supply sensitivity, the impact of the low gas demand flex sensitivity and finally the impact of the low gas supply and low gas demand flex sensitivities on the NZ-WEM if they were to occur simultaneously. When the low gas demand flex sensitivity is applied to the reference case individually there is no visible impact to the NZ-WEM as there is an assumption of sufficient investment in developing gas supply. However, when low gas demand flex occurs simultaneously with low gas supply there is a tangible impact to the NZ-WEM for each of the supply pipeline stages as the loss of the additional gas from the low gas demand flex sensitivity exacerbates the issue.

When considering only the existing and committed generation (Stage 1), the combination of sensitivities causes the NZ-WEM to cross the upper security standard in 2026. This is a full year earlier than each of the individual sensitivities cause the NZ-WEM to cross the upper security standard in 2027.

Figure 13: New Zealand Winter Energy Margins for the reference case and sensitivities that reduce gas availability



Thermal Availability

Uncertainty in the availability of significant thermal generation assets could cause the NZ-WEM to fall below the upper security standard unless consented projects are delivered by 2025 and currently unconsented projects are developed before 2030.

Figure 6 shows that the first sensitivity that causes the NZ-WEM to cross the upper security margin is thermal decommissioning. The thermal decommissioning sensitivity represents the decommissioning of significant fossil-fuelled thermal generation assets throughout the assessment horizon.

Figure 6 shows that when considering only the existing and committed generation (Stage 1), the thermal decommissioning sensitivity crosses the upper security margin in 2025, which is two years before the reference case crosses in 2027.

When the remainder of the consented projects pipeline is considered (Stage 2 and Stage 3), the thermal decommissioning sensitivity's crossing of the upper security standard is delayed until 2028 and 2030 respectively. For the impact of the thermal decommissioning sensitivity not to cause the NZ-WEM to cross the upper security margin, supply projects from the consent expected pipeline (Stage 4) would need to be developed prior to 2030.

Figure 14 below shows the impact of the thermal decommissioning sensitivity, the impact of the constrained thermal development sensitivity and finally the impact of the thermal decommissioning and constrained thermal development sensitivities on the NZ-WEM if they were to both occur. When considering only the existing and committed generation (Stage 1), the combination of sensitivities has an identical impact on the NZ-WEM as the thermal decommissioning, as Stage 1 of the supply pipeline does not contain any thermal generation projects.

When we consider the consented supply pipeline (Stage 2), the reference case does not cross the upper security standard until 2031 and the individual thermal decommissioning and constrained thermal development sensitivities cross in 2028 and 2029 respectively. However, when these two sensitivities are combined the NZ-WEM crossing of the upper security standard is accelerated to 2025.

Figure 14: New Zealand Winter Energy Margins for the reference case and sensitivities that reduce thermal availability

The sensitivities around thermal generation indicate that the reliance on thermal fuel generation and its supply to maintain the NZ-WEM above the upper security standard begins to decrease in 2028. To remove this dependence will require significant development of current consented generation, and development of unconsented renewable projects.

3.4.2 Capacity

Peak Capacity Factors of Intermittent Renewable Resources

The intermittency of generation resources in the supply pipeline reduces the contribution of the pipeline to capacity margins, however this could be supplemented by non-generating assets.

Table 3 compares the years that the reference case crosses the upper security standard for the NZ-WEM and NI-WCM when considering each of the supply pipeline stages.

- For existing and committed supply projects (Stage 1), the reference case for the NI-WCM crosses the upper security standard two years before the NZ-WEM.
- For the consented projects pipeline (Stages 2 and 3), the reference case for the NI-WCM crosses the upper security standard four years before the NZ-WEM.

The reason that the difference between the NI-WCM and the NZ-WEM crossing the upper security standard increases from two years in Stage 1 to four years for both Stages 2 and 3 is due to the make-up of the consented projects pipeline being primarily renewable intermittent generation projects, as Figure 3 shows.

While the contribution of intermittent generation assets to energy requirements over the entire winter period is relatively predictable, their contribution to capacity requirements for a specific capacity peak is less certain. However, this issue could be addressed with the addition of non-generating assets such as North Island energy storage systems, demand response, non-generation reserve or upgrades to increase the HVDC northward capacity. Some of these assets, do not need consenting, and can be brought into the market within one or two years.

Table 3: Comparison of years in which the New Zealand Winter Energy Margin and North Island Winter Capacity Margin cross the upper security margins

Reference case	Stage 1	Stage 2	Stage 3	Stage 4
New Zealand Winter Energy Margin	2027	2031	>2032	>2032
North Island Winter Capacity Margin	2025	2027	2028	>2032

Changes in Demand Growth

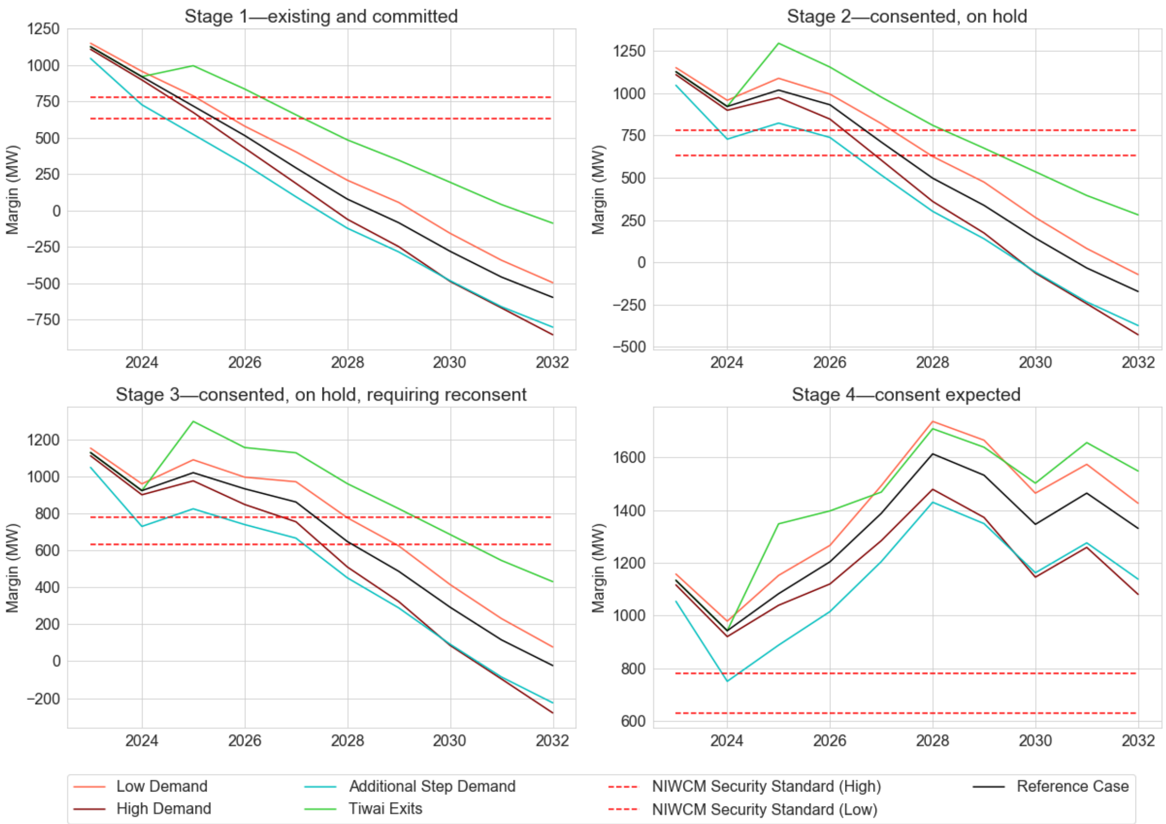
Uncertainty in the pace of underlying demand growth could accelerate or delay the need for additional capacity by up to 2 years.

Figure 15 shows the impact of different sensitivities that adjust the rate of demand growth. Two of these sensitivities decrease the rate of demand growth (low demand growth and Tiwai exits).

For existing and committed supply projects (Stage 1), the Tiwai exit sensitivity delays the NI-WCM crossing of the upper security standard until 2027. However, the low demand growth sensitivity still causes the NI-WCM to cross the upper security standard in the same year as the reference case, 2025 (albeit to a lesser degree). Two other sensitivities increase the rate of demand growth (high demand growth and additional step change in demand). When considering only the existing and committed supply projects (Stage 1), the step change in demand sensitivity accelerates the NI-WCM crossing of the upper security standard to 2024. However, the high demand growth sensitivity still causes the NI-WCM to cross the upper security standard in the same year as the reference case, 2025. Despite the crossing of the upper security standard in the same year as the reference case, the high demand sensitivity crosses to a greater degree.

When considering the entire supply pipeline (Stage 4) the only demand related sensitivity that crosses the upper security standard is additional step change in demand. This sensitivity crosses the upper security standard in 2024 but recovers from 2025 until the end of the assessment horizon.

Figure 15: North Island Winter Capacity Margin crossing the upper security standard for the reference case and demand sensitivities



Less Flexible Operational Capacity

Integrating a mix of slow start thermal generation and intermittent renewable generation will keep the NI-WCM below the security standards during specific operational conditions for the coming decade regardless of whether expected investment is developed. This could be offset relatively quickly by flexible non-generating assets such as batteries or demand response.

Figure 10 shows that the first sensitivity that causes the NI-WCM to cross the upper security margin is less flexible operational capacity. The less flexible operational capacity sensitivity represents the market co-ordination challenge of integrating increased intermittent generation with slower start thermal plant which can lead to situations with lower quantities of committed slower-start thermal units and intermittent generation thus resulting in lower levels of available operational capacity over peak demand periods, as described in the System Operator's market insights paper and presentation[28]. This scenario is simulated in

[28] See System Operator Winter Review Paper and System Operator Winter presentation

the SOSA by reducing the capacity factor of intermittent generation over peak periods while simultaneously removing the availability of a significant slow starting fossil-fuelled generator.

Figure 10 shows that regardless of the supply pipeline stage being considered the less flexible operational capacity sensitivity is below the upper and lower security standards from the beginning of the assessment horizon and remains below the security standards for the entire assessment horizon. When considering the entire supply pipeline (Stage 4), the NI-WCM for the less flexible operational capacity sensitivity increases in 2028, which is the year that the first Stage 4 battery project is due to be commissioned. However, from 2029 the NI-WCM trends downwards as additional unconsented intermittent generation projects are commissioned.

Thermal Availability

If significant thermal generation assets are decommissioned and no new thermal generation is built, the NI-WCM will be below security standards from 2024 to 2027 – after which meeting the security standards will rely on development of unconsented resources.

Figure 10 shows the impact of different sensitivities that vary the availability of thermal generation assets, including:

- constrained thermal development, in which no new thermal generation is developed;
- thermal decommissioning, in which significant thermal generation assets are decommissioned over the assessment horizon; and
- dry year reserve, in which a small number of 'baseload' fossil-fuelled thermal generators change their operation so that they only provide dry year reserve from 2027 onwards.

Once these sensitivities take effect they result in the NI-WCM crossing the upper security standard earlier than the reference case. For example, the dry year reserve sensitivity takes effect in 2027, which means that until 2027 this sensitivity matches the reference case. However, from 2027 onwards the NI-WCM declines at an accelerated rate when compared with the reference case.

Table 4: North Island Winter Capacity Margin earliest crossing of the upper security standard for the reference case and reduced thermal generation sensitivities

Sensitivity	Stage 1	Stage 2	Stage 3	Stage 4
Reference case	**2025**	**2027**	**2028**	**>2032**
Thermal decommissioning	2024	2024	2024	2024
Constrained thermal development	2025	2025	2025	>2032
Dry year reserve	2025	2027	2027	>2032

Table 4 identifies the years in which the NI-WCM for the reference case and reduced thermal generation sensitivities cross the upper security standard for each supply pipeline stage.

- For existing and committed generation (Stage 1), the reduction of thermal generation can cause the NI-WCM to cross the upper security margin by as early as 2024.
- For the consented supply projects pipeline (Stages 2 and 3), the thermal decommissioning sensitivity temporarily lifts above the security standard before declining through the upper security standard for a second time in 2027.
- For the entire supply pipeline (Stage 4), the thermal decommissioning sensitivity recovers in 2026 and subsequently remains above the upper security standard for the remainder of the assessment horizon.
- Regardless of the supply pipeline stage the thermal decommissioning sensitivity will cause the NI-WCM to fall below the upper security standard.

Figure 16 below shows the impact of the thermal decommissioning sensitivity, the impact of the constrained thermal development sensitivity and finally the impact of the thermal decommissioning and constrained thermal development sensitivities on the NI-WCM if they were to both occur. When considering only the existing and committed generation (Stage 1), the combination of sensitivities has an identical impact on the NI-WCM as the thermal decommissioning, as Stage 1 of the supply pipeline does not contain any thermal generation projects.

When considering Stage 4 of the supply pipeline, the thermal decommissioning sensitivity still crosses the upper security standard in 2024, and remains below until 2026, while the no new thermal sensitivity barely remains above the upper security standard. If these two sensitivities were to occur simultaneously, the time spent below the upper security standard in the near term would be extended until 2027.

Figure 16: North Island Winter Capacity Margins for the reference case and sensitivities that reduce thermal availability

Regional Coincident Peak Demand Change Impact

Removal of the RCPD charge lowers the NI-WCM but is not expected to cause it to fall below the upper security standard.

Figure 10 shows the impact of the RCPD change in 2023, where national capacity demand is assumed to increase by 152 MW.

From 2024, this sensitivity realigns with the reference case it is unlikely that RCPD change sensitivity will be investigated in the 2024 SOSA.

4.0 Maintaining Security Margins with Greater Proportions of Renewable Generation

4.1 Overview and Summary

The Government has an aspirational target of 100% renewable electricity by 2030. In this section we look at the impact of increasing the proportion of renewable generation in 2030 on the NZ-WEM and NI-WCM. Our approach is to investigate five thermal generation scenarios, which consider progressively smaller amounts of thermal generation. For each of these scenarios we estimate the contribution from renewable generation and other technologies that would be required to maintain the NZ-WEM and NI-WCM above the security standards.

This analysis is exclusively focused on security of supply; we have not investigated economic or technical issues outside of this brief. Consistent with the margin forecasts we present in Section 3.0, we do not attempt to forecast or otherwise determine the likelihood of whether any of these scenarios could occur.

This assessment shows that significant new supply additions will be required to replace existing thermal generation and increase the proportion of renewable energy to 100%, satisfy the increased future demand and maintain efficient levels of supply reliability.

From our supply pipeline (see Table 1) there are indications that:

- there are sufficient potential renewable supply projects to provide the additional energy required to maintain the NZ-WEM at the upper security standard for the first three thermal scenarios (see Table 5: THM1–THM3); and
- there are insufficient potential renewable supply projects to provide the additional capacity required to maintain the NI-WCM at the upper security standard for any of the five thermal scenarios (see Table 5: THM1–NoTHM).

In order to meet the Government's aspirational target of 100% renewable electricity by 2030 (NoTHM), while also maintaining both the NZ-WEM and NI-WCM above the upper security margins, additional renewable supply projects will need to be developed beyond those already in the consented and unconsented pipeline.

The entire renewable supply pipeline (Stage 4) could contribute 31,746 GWh of winter energy and around 4,703 MW of winter capacity. To bring this renewable supply pipeline to market (even though it would be insufficient to meet the aspiration for 100% renewable by 2030) would require a significant increase in the pace of development, including consenting, construction and regulatory development[29]. To achieve 100% renewable electricity by 2030 requires an additional 1,021 GWh of winter energy and around 2,125 MW of winter capacity resources beyond the resources included in all supply pipelines of the 2023 SOSA analysis. Outside of the supply pipeline non-generating assets such as

[29] An example of regulatory development required to support the supply pipeline is the development of regulation for offshore wind generation.

North Island energy storage systems, demand response, non-generation reserve or upgrades to increase the HVDC northward capacity could contribute to the NI-WCM.

For the purposes of this chapter, thermal generation refers exclusively to generation that is fuelled by either diesel, natural gas or coal[30].

[30] Our analysis does not explore future supply options that may utilise thermal generation technologies that are carbon zero in some form.

4.2 Thermal Generation Scenarios

We have developed five thermal generation scenarios, set out in Table 5 below. These scenarios consider progressively less thermal generation than current levels. Figure 17 sets out the scenarios' relative contributions to winter energy and capacity margins.

These thermal generation scenarios should not be interpreted as indicating a potential or likely pathway to higher proportions of renewable generation. It is possible that the pathway to higher proportions of renewable generation will involve step changes in thermal generation that vary from the thermal generation scenarios that this analysis considers.

Table 5: Thermal generation scenarios

Scenario	Description
THM1 One Rankine unit (dry year support only), one closed cycle gas turbine (CCGT) remains	One Huntly Rankine unit remains for dry year support, while two are decommissioned. We assume that this Rankine unit will not contribute to winter capacity margins. One CCGT remains at Huntly, which contributes to both energy and capacity margins; the other CCGT at Stratford (TCC) is decommissioned. All other remaining thermal generation is available to contribute to winter energy and capacity security margins.
THM2 No Rankine units, one CCGT remains	All Huntly Rankine units are decommissioned. Note this scenario has the same contribution to the NI-WCM as the THM1 scenario, as Figure 17 and Figure 18 show. This is because, even though THM1 has one Huntly Rankine unit in service, it does not contribute to the NI-WCM. The CCGT at Huntly continues to contribute to winter energy and capacity security margins, the other CCGT at Stratford (TCC) is decommissioned. All other remaining thermal generation is available to contribute to winter energy and capacity security margins.
THM3 No Rankine or CCGT units	The CCGT and all Rankine units at Huntly are decommissioned, the other CCGT at Stratford (TCC) is decommissioned.

Scenario	Description
	All other remaining thermal generation is available to contribute to winter energy and capacity security margins.
THM4 Whirinaki and co-generation	Only gas co-generators and the Whirinaki diesel generator remain. All other remaining thermal generation is available to contribute to winter energy and capacity security margins.
NoTHM No thermal, including Whirinaki and co-generation	There is no gas, coal or diesel thermal generation.

Figure 17: Thermal scenarios' contribution to winter energy margins

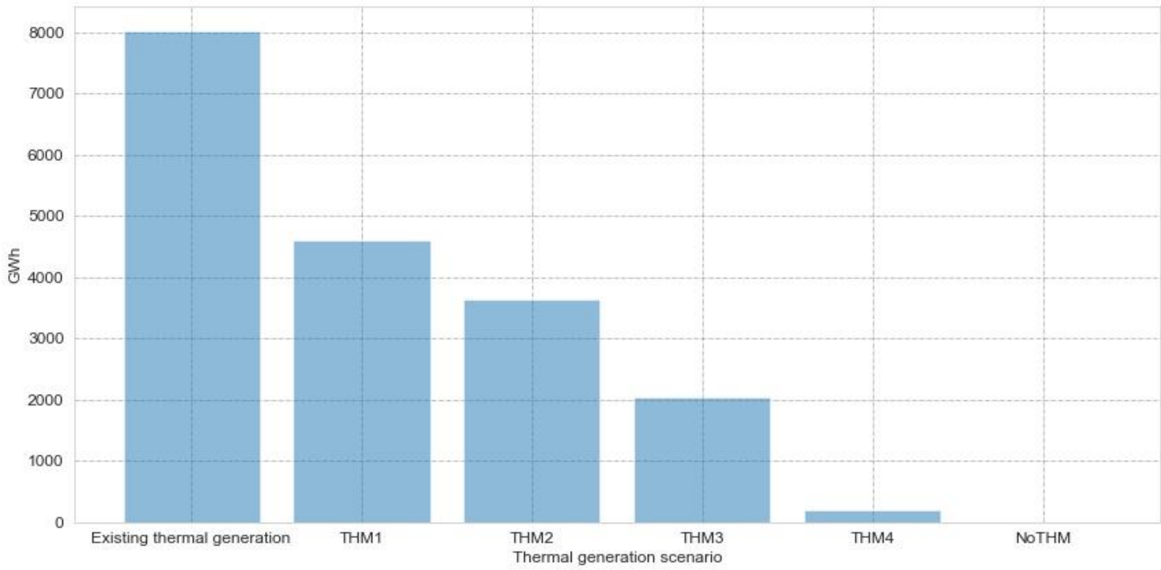
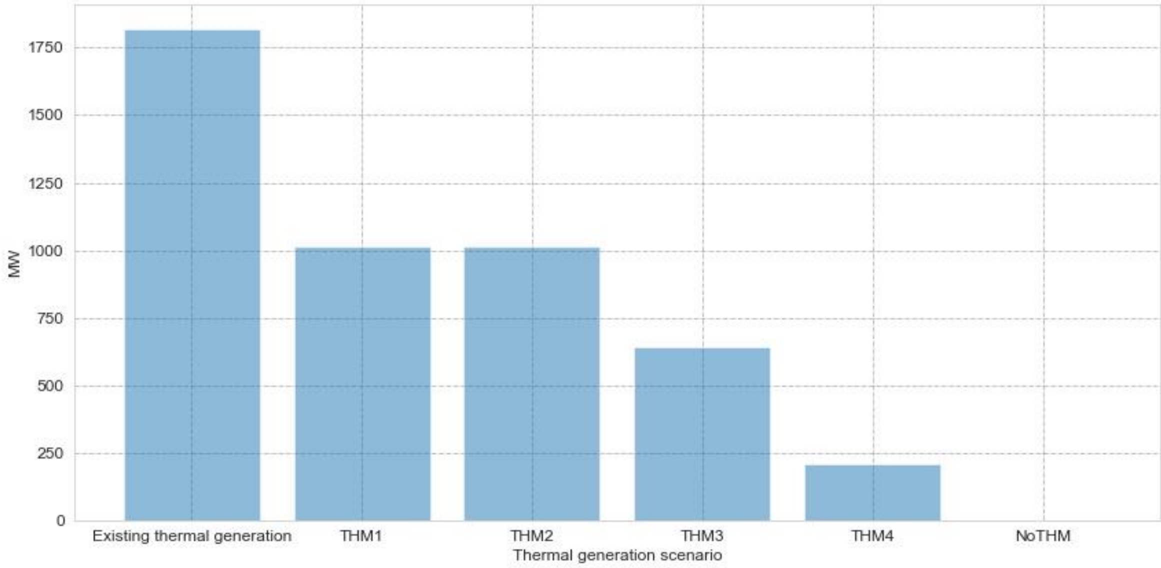


Figure 18: Thermal scenarios' contribution to winter capacity margin



4.3 Security Margin Impacts

4.3.1 Winter Energy Margins

Figure 19 compares the energy required to maintain the NZ-WEM at the upper security standard to the energy contribution in each of the thermal generation scenarios and from the renewable supply pipeline in 2030.

These contribution calculations use the reference case. The green bars show potential contributions from known consented renewable projects in the supply pipeline (Stages 2 and 3: see Table 1). The blue bars show the potential contributions from known unconsented renewable projects (Stage 4: see Table 1). The grey dotted line shows the amount of energy required to maintain the NZ-WEM above the upper security margin.

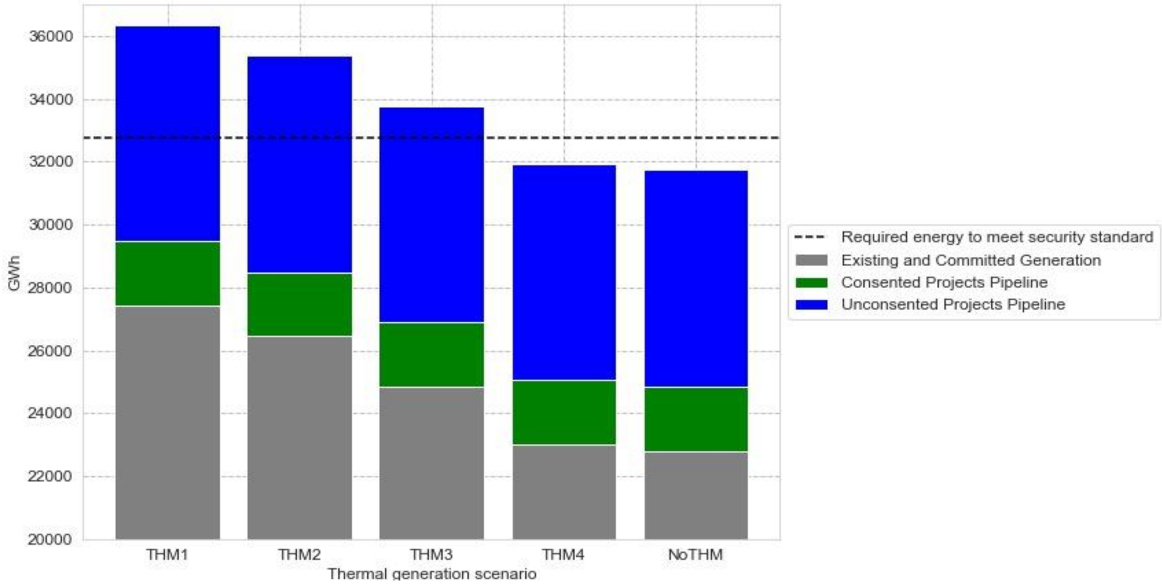
In order to displace the thermal generation in each of the scenarios, supply the increased level of demand, and maintain the NZ-WEM above the upper security margin, the majority of the renewable contribution will need to come from projects in addition to those in the consented renewable projects pipeline.

- The consented and unconsented projects pipeline is sufficient to maintain the NZ-WEM at the upper security standard for the first three thermal scenarios (THM1-THM3).
- In order for the NZ-WEM to be maintained above the upper security standard for the THM4 and NoTHM scenarios, additional renewable projects will be required beyond the unconsented projects pipeline[31].

The entire renewable supply pipeline (Stage 4) could contribute 31,746 GWh of winter energy. To meet the 100% renewable electricity aspiration in 2030 requires an additional 1,021 GWh of winter energy from new renewable supply projects that are not currently in the supply pipeline.

[31] As noted previously, given these projects are currently unconsented, there is a higher level of uncertainty around their delivery.

Figure 19: Energy available to meet NZ-WEM upper security standard in different thermal scenarios



4.3.2 Winter Capacity Margins

Figure 20 compares the capacity required to maintain the NI-WCM at the upper security standard to the capacity contribution in each of the thermal generation scenarios and from the renewable supply pipeline in 2030.[32]

The extent to which South Island generation can contribute to the NI-WCM is limited by the capacity of the HVDC. For our assessment of capacity margins, we assume that the current northward capacity of the HVDC is constrained to ~950MW[33].

This assessment shows that the consented and unconsented projects pipeline is not sufficient to supply the additional capacity required to maintain the NI-WCM at the upper security standard for any of the five thermal scenarios (THM1–NoTHM).

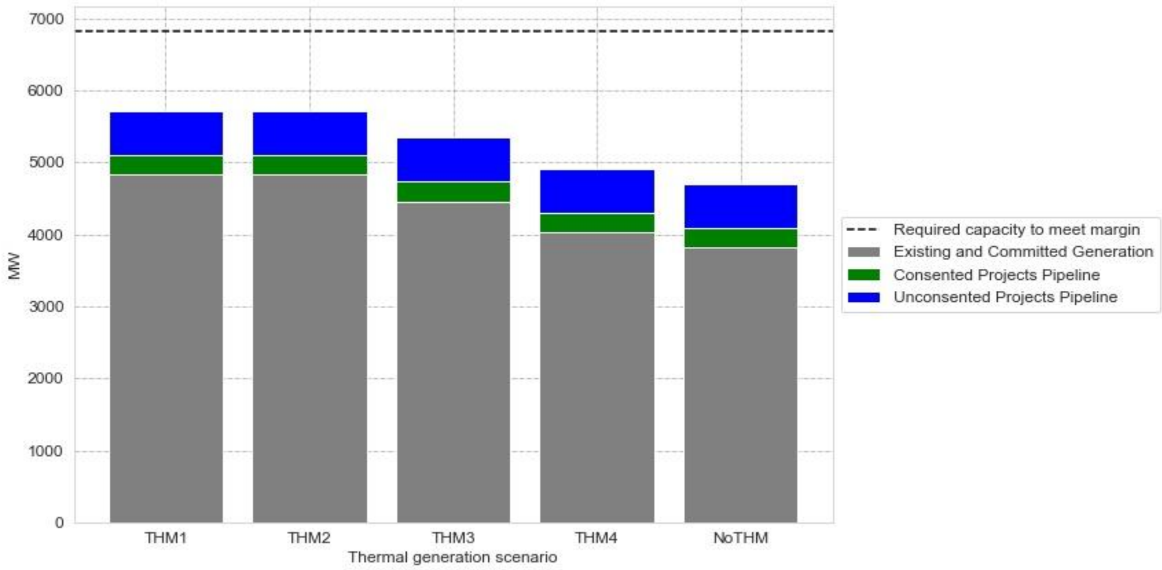
The contribution of unconsented projects to the capacity margin is considerably lower than for the energy margin, given that the majority of the projects that are still unconsented are wind and solar, which have a lower contribution to winter peak demand compared with energy over the winter period.

The entire renewable supply pipeline (Stage 4) could contribute 4,703 MW of winter capacity. This includes material amounts of offshore wind. To meet the Government’s 100% renewable electricity aspiration would require an additional 2,125 MW of winter capacity

[32] Note the THM1 scenario has the same contribution to the NI-WCM as the THM2 scenario. This is because even through THM1 has one Huntly Rankine unit in service (whereas the THM2 scenario has none), this unit does not contribute to the NI-WCM in the THM1 scenario.
[33] This is without the HVDC fourth cable.

resources from new renewable supply projects that are not currently in the supply pipeline or other resources such as demand response or distributed energy resources.

Figure 20: Capacity available to meet NI-WCM upper security standard in different thermal scenarios



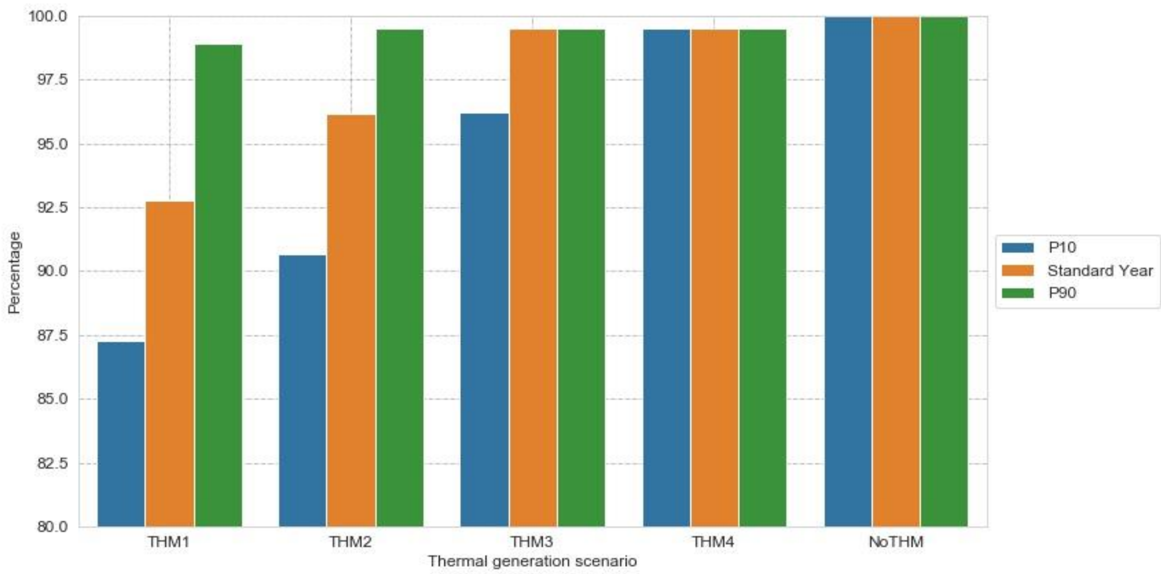
4.4 Renewable Generation Percentage Estimates

Figure 21 shows annual renewable generation as a percentage of forecast demand for each thermal generation scenario. Renewable generation percentages are shown for a standard hydrological year (orange bar), as well as dry (P10, blue bar) and wet (P90, green bar) hydrological years. P10 and P90 refer to the lower and upper percentile range of historical hydro inflows respectively. The amount of generation assumed for each scenario is equal to that required to maintain NZ-WEM at the upper security standard.

For the THM2 scenario and other scenarios with less thermal generation to maintain the NZ-WEM security standards, this implies a level of renewable generation 'over build'. This means that for wet years the amount of renewable generation capacity will be greater than required to meet demand, resulting in spilling of renewable resources when there is insufficient storage capability.

Except for the NoTHM generation scenario, we assume the maximum amount of renewable generation (produced in a given year) is constrained by gas co-generation. This type of generation is likely to operate on a 'must run' basis, given that it is likely to also generate process heat for its host industrial facility.

Figure 21: Renewables percentages: medium demand scenario and as required to maintain a 16% security standard



We have not considered the use of alternative technologies, such as pumped storage or large industrial demand response, in our analysis; these would alter our P10 and P90 estimates. These alternative technologies may also reduce the quantity of excess generation developed (and excess energy generated).

The amount of new renewable generation that this analysis assumes to meet energy margin security standards would not be sufficient to maintain the NI-WCM above the upper security standard. While it is uncertain how the NI-WCM would be maintained for each thermal generation scenario; it is likely that a mix of complementary technologies could be used. This could, for example, include a combination of renewable generation over build, demand flexibility, storage or renewable thermal fuels such as hydrogen or biomass.

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2023 Security of Supply Assessment summary

24 May 2023

What is the SOSA?

Transpower, as the system operator, publishes the SOSA annually. It provides a 10-year assessment (2023 to 2032) of the balance between supply and demand in the New Zealand electricity system.

Three security of supply margins are evaluated, the:

- New Zealand Winter Energy Margin **(NZ-WEM)**
- South Island Winter Energy Margin **(SI-WEM)**
- North Island Winter Capacity Margin **(NI-WCM)**

The margins are compared against Security Standards set by the Authority.

They represent an efficient level of reliability. Where the expected cost of shortage is equal to the expected cost of new generation

Limitations of the SOSA

It does not consider:

- It assumes all projects are commercially viable, and will be offered in the market over peak periods
- Availability of transmission capacity
- Deliverability of projects

Key Insights across the time horizon

Inputs – Demand and supply are growing

1. Expectations of demand growth are increasing
2. The supply pipeline is being developed and is largely renewable and intermittent

Energy – Development of the pipeline needed

1. The supply pipeline, if developed in time, is sufficient to maintain margins
2. Development of the pipeline is needed under nearly all demand sensitivities
3. Thermal generation and its fuel is needed to maintain margins for some years

Capacity – Development of flexible resources needed with more urgency than energy

1. Margins drop below the standards by 2026; projects need to be developed beyond those with consent
2. Thermal generation is required to maintain margins through to the end of the forecast horizon
3. High levels of intermittent generation on the system will drive more periods with low margins
4. Non-generation resources can contribute to the supply pipeline (e.g. batteries or demand response) and can come online quickly

Interpreting results

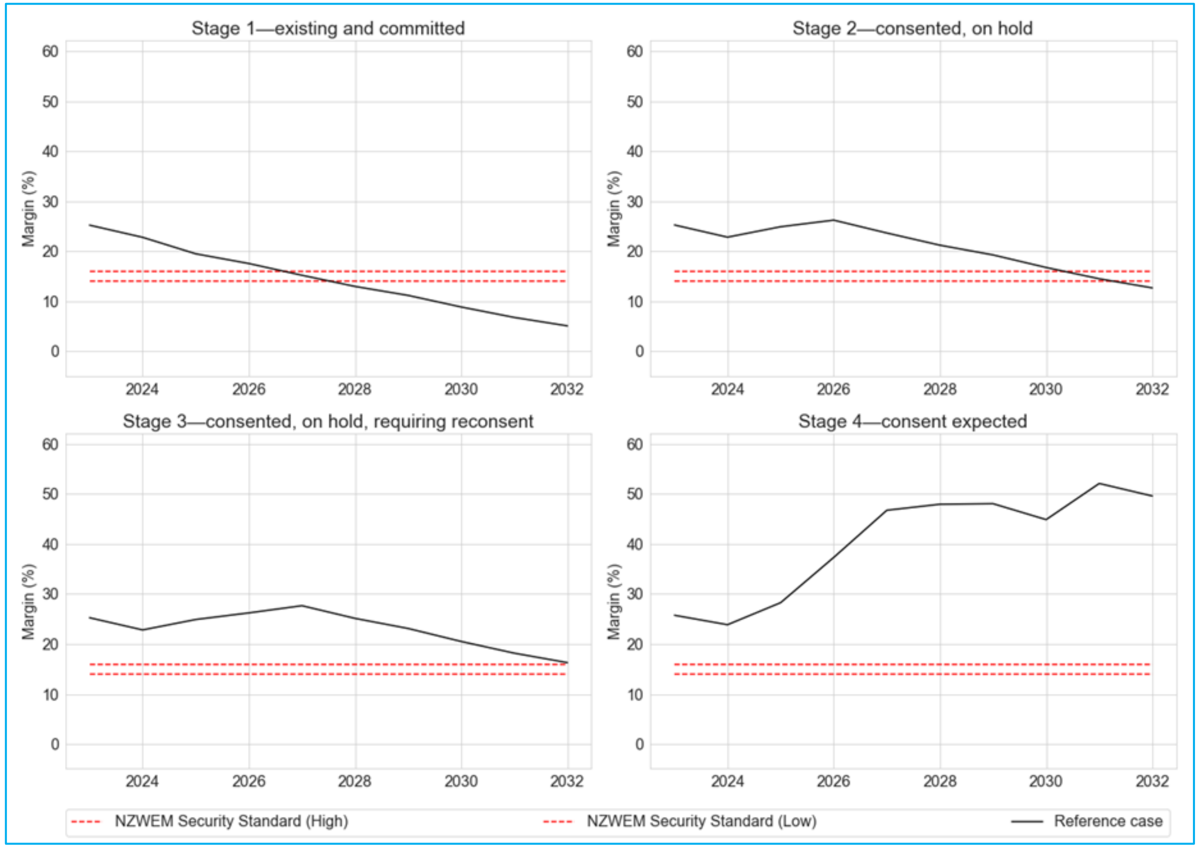
Interpreting results

The reference case:

- Represents all resources available to the market regardless of generation type
- Assumes plant decommissioning once decommissioning activity is committed to

Uncertainty is explored through:

- 4 stages of supply pipeline (the market is not likely to develop every resource it has available)
- 12 sensitivities themed around:
  - Less thermal generation
  - Reduced thermal fuel
  - Changes in demand
  - Market co-ordination



Interpreting results

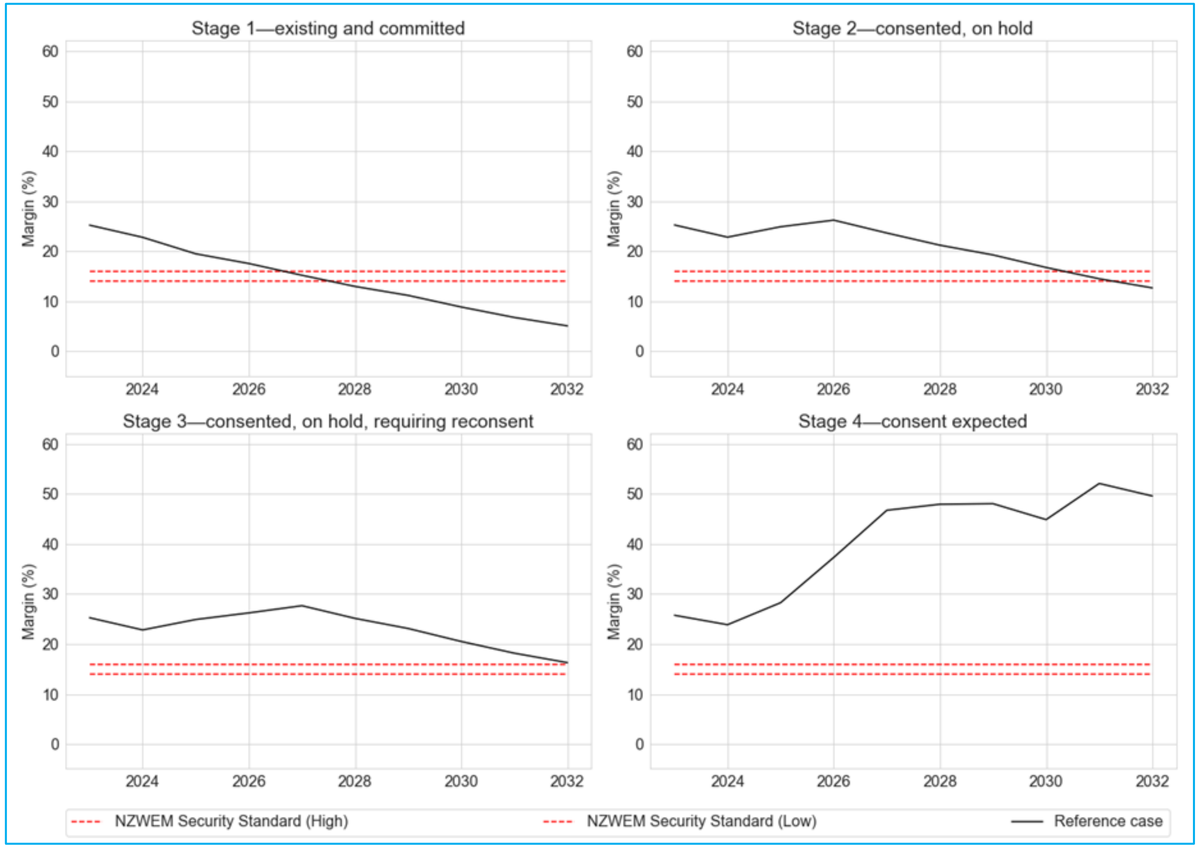
When each Stage of the pipeline crosses the standards it represents that:

- There is a need to develop more from the next stage to maintain margins above the standards
- It is economically efficient to develop the next stage

Each stage includes the one previous (e.g. Stage 3 is Stage 1 + Stage 2 + Stage 3)

For example, if the margins drop below the standards in Stage 3, all consented generation would need to be developed to maintain margins above the standards

Through the SOSA and this presentation we talk to what is needed to maintain a margin above the standards

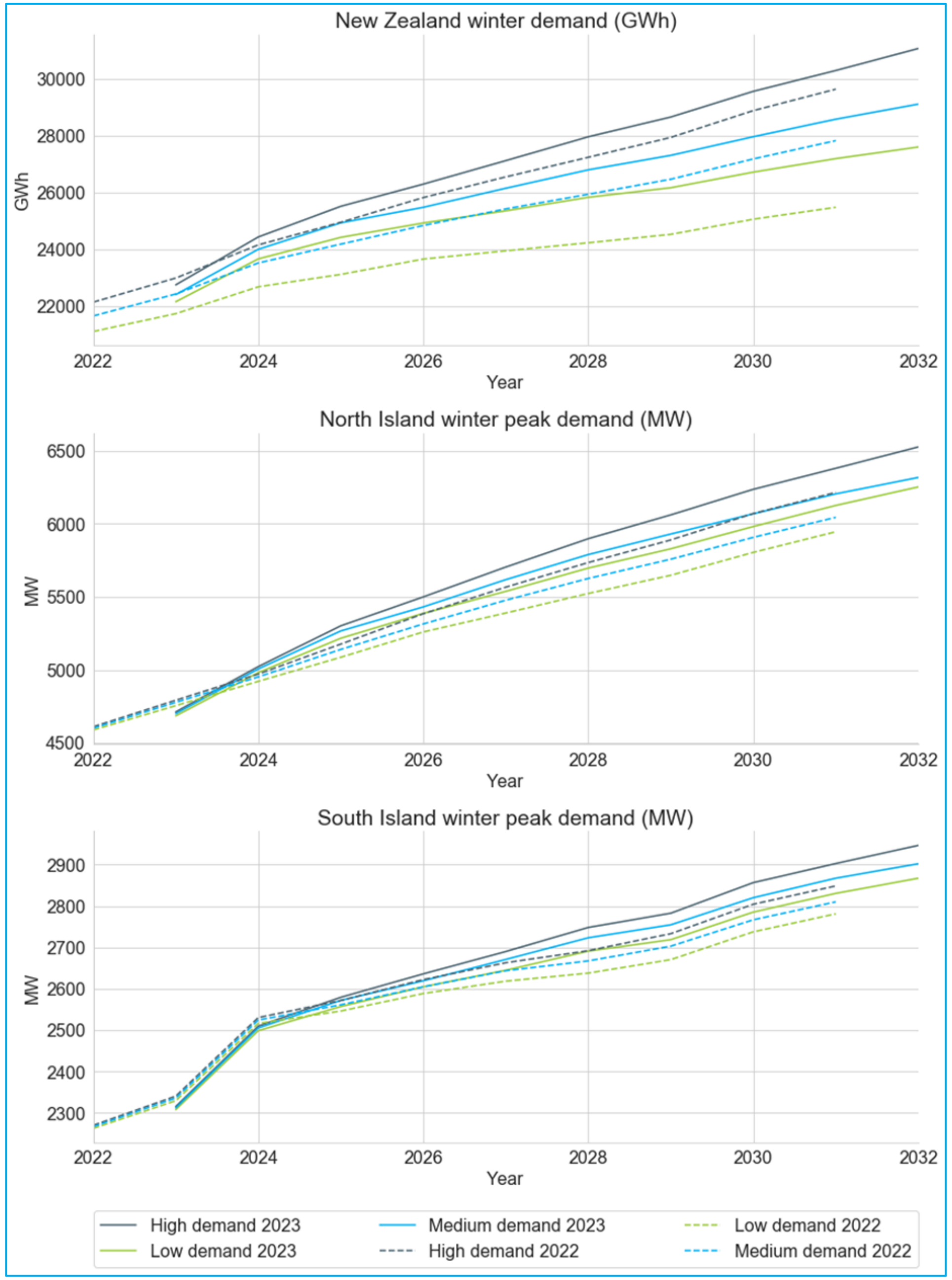


Input changes from 2022

Demand forecast

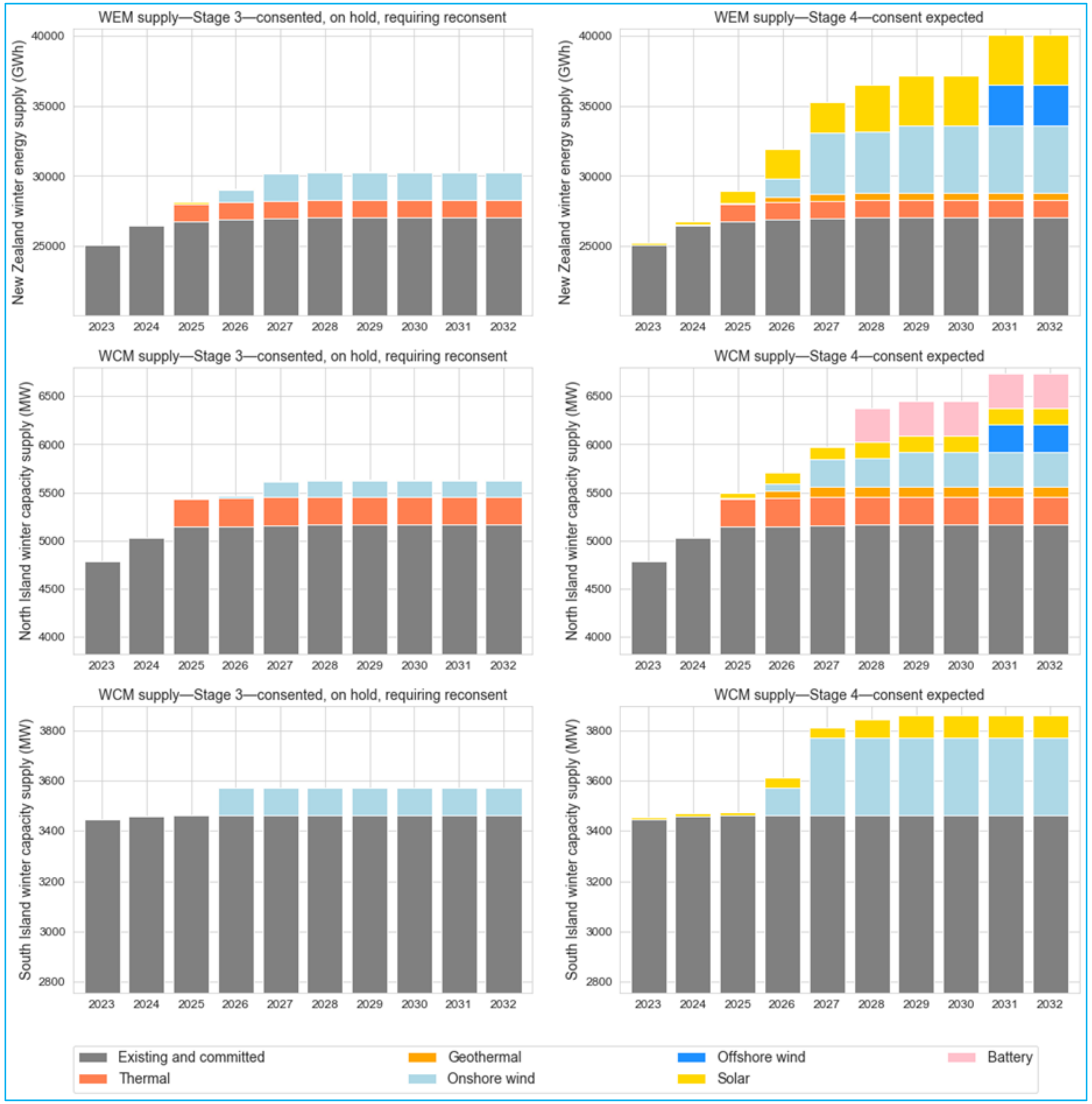
The load forecast comes from Transpower's Grid Development division. It is updated annually including consultation

- The load forecast has increased compared to 2022
- The increase is largely driven by distributors' expectations supplied to Transpower as part of the forecasting process



Supply pipeline

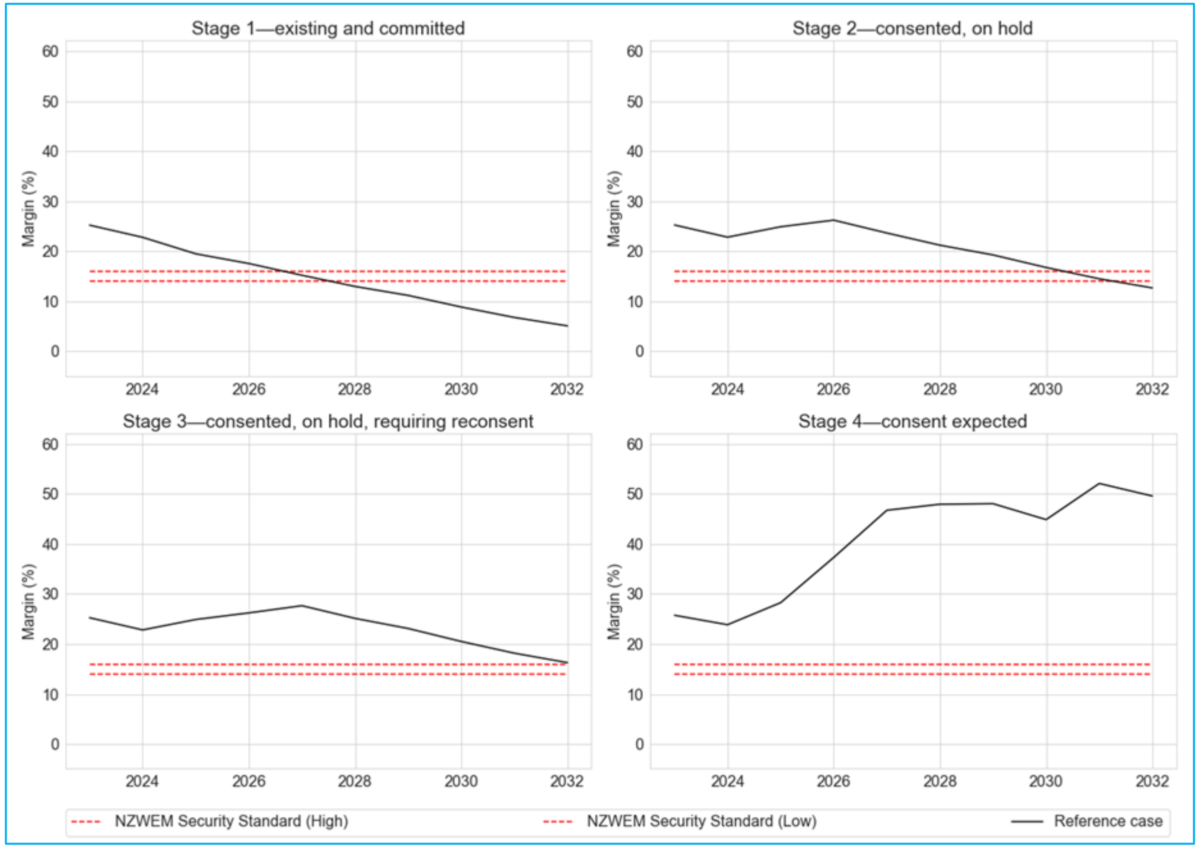
- The supply pipeline is progressing year on year
- The *existing and committed* supply pipeline (Stage 1) has increased by approximately 215 MW as projects are being built
- *Consent expected* pipeline (Stage 4) has decreased significantly as project plans are refined
- Significant interest in new projects continues with 334 new connection enquires to Transpower YTD
- Except for historical consents, the pipeline is 100% renewable
- Intermittent renewable generation makes a larger contribution to energy margins than capacity margins



Energy Margin Key Insights

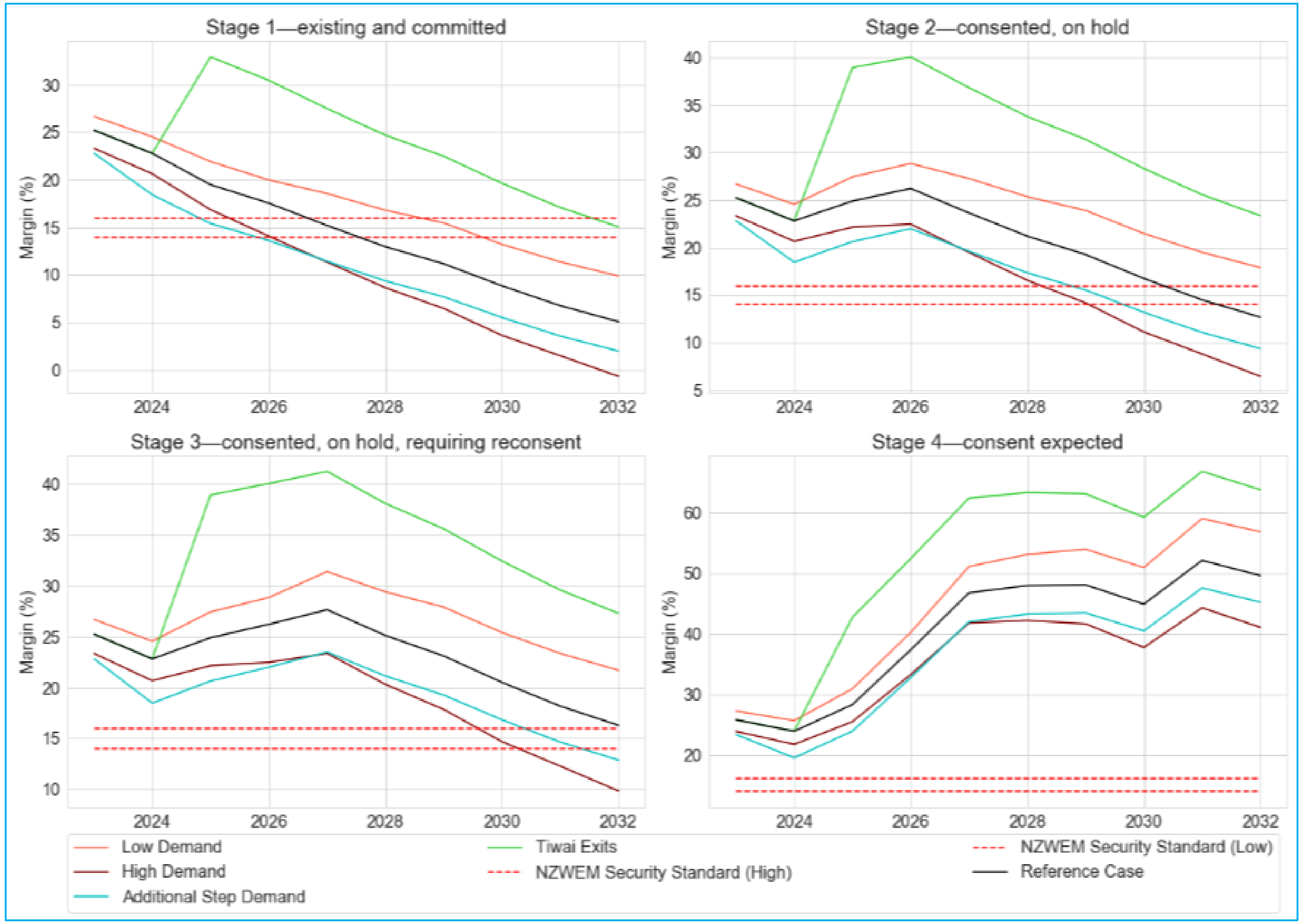
Key Insights – NZ WEM reference case

- The market has access to generation resources to maintain the security standards across the forecast horizon
- New generation will need to be developed by 2027 to maintain the margin above the security standards
- Existing consents - if developed - will be sufficient to maintain the margins to the end of the forecast horizon



Key Insights – NZ WEM demand

- Investment in new generation is needed in the forecast horizon even if demand growth is low
- If Tiwai exits, development of consented projects will still be needed but at the end of the forecast horizon
- The high demand sensitivities show that resources which are expecting consent will need to be developed by 2031

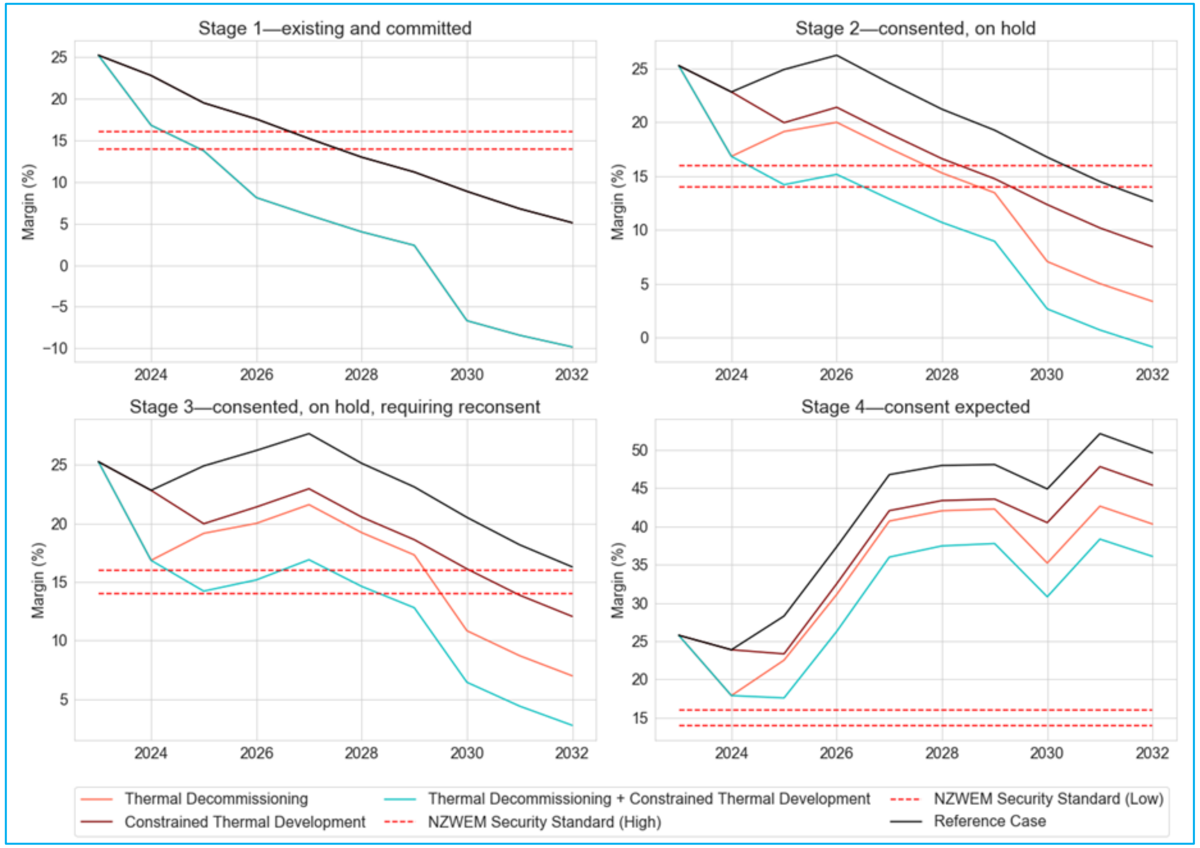


Key Insights – NZ WEM reduced thermal generation

- If existing consented thermal generation is not developed, more resources expecting consent need to be developed by 2030
- If existing thermal generation was decommissioned inline with signalled intent, and existing consented thermal generation is not developed, then more resources would need to be consented and developed by 2028
- There would also be a period of being "on the margin" through 2024 to 2028

This indicates:

- There is a reliance on thermal generation until new renewable projects are consented and developed

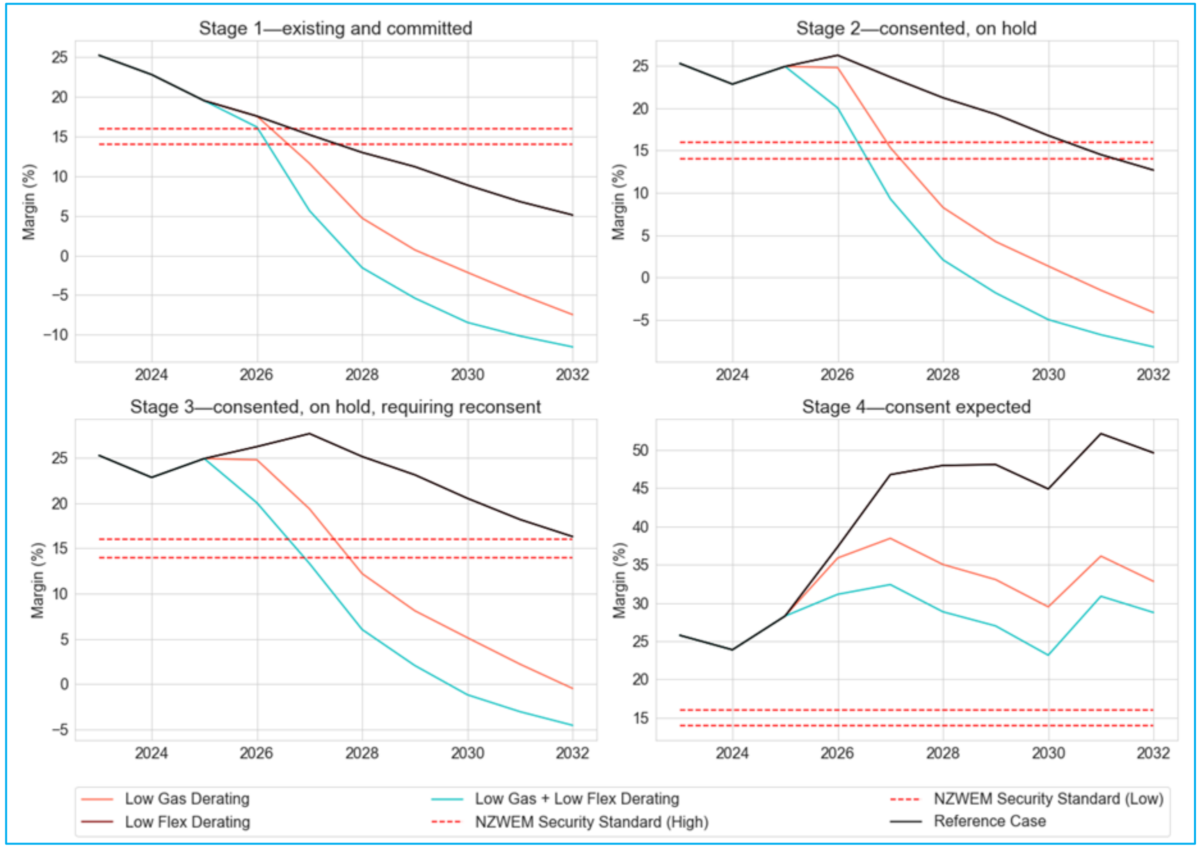


The decommissioning sensitivity is only a portion of existing baseload thermal generation

Key Insights – NZ WEM reduced gas availability

Key Insights:

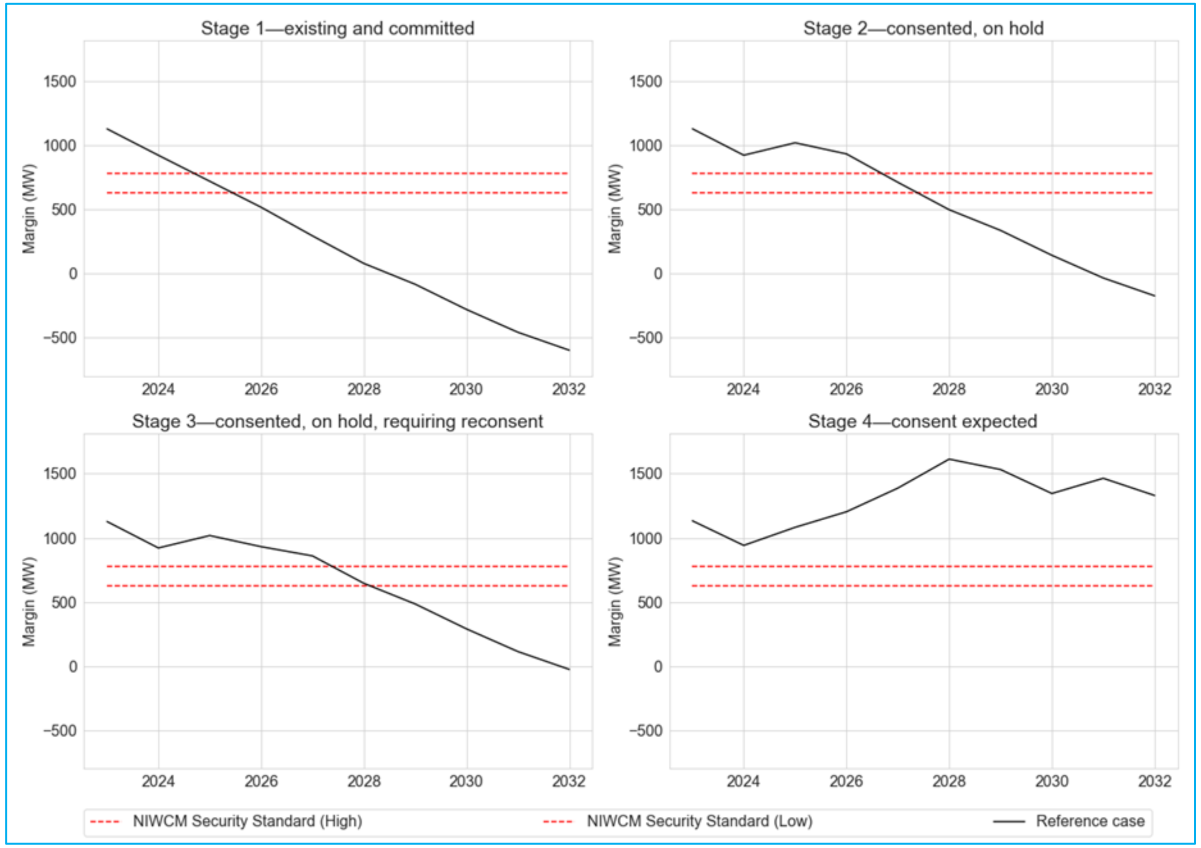
- Until large amounts of renewable generation currently expecting consented are developed, there will be a reliance on continued investment in gas production P2, P3 on to supply the existing thermal generation in order to maintain the margin above the standards
- As gas supply declines the importance of gas flexibility from other major users becomes increasingly important



Capacity Margin Key Insights

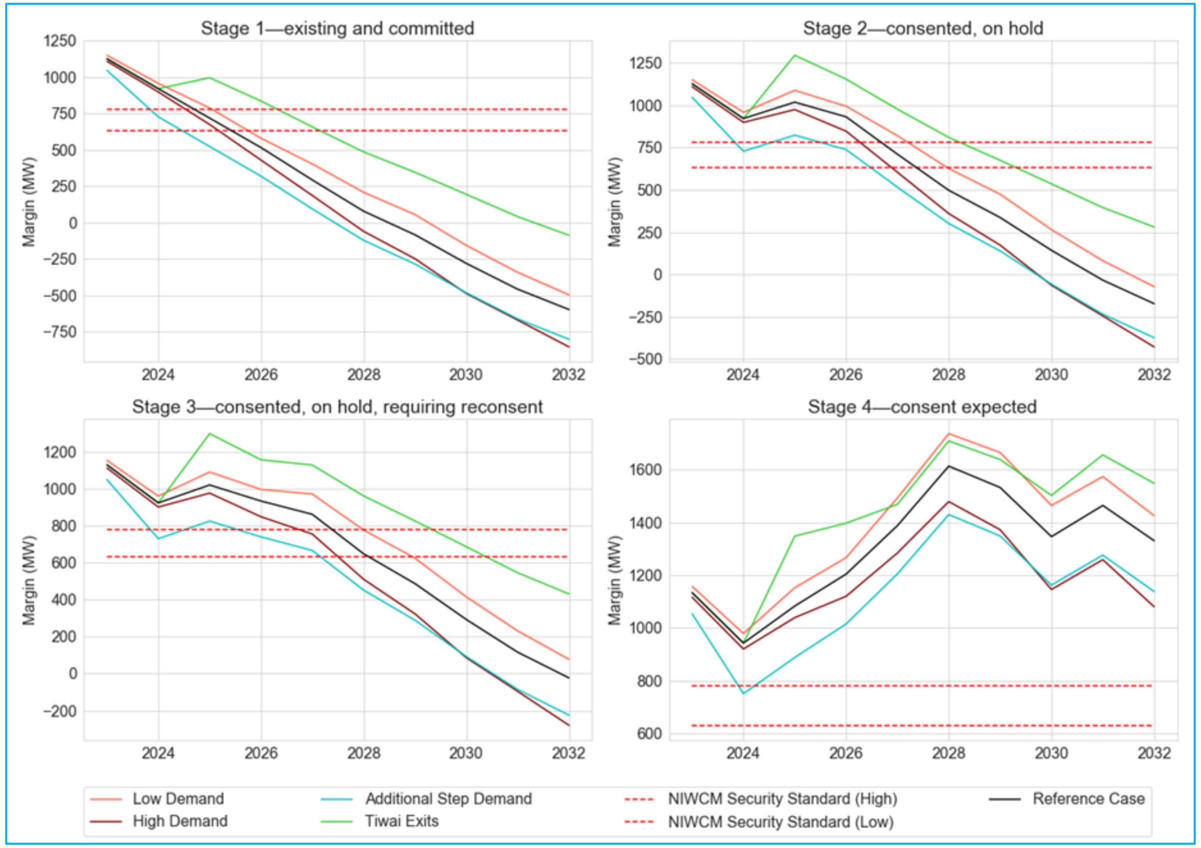
Key Insights – NI WCM reference case

- The supply pipeline is mostly intermittent generation, which provides less contribution to capacity than energy
- With only existing and committed generation the margin will be below standards by 2026
- The addition of consented and on hold projects helps maintain the NI-WCM above the upper security standard through to 2027. However unconsented projects will be needed to maintain the margin above the standards beyond that
- Given lead times for new development, additional flexible resource needs to be committed to with urgency
- Flexible resources that contribute to capacity but not energy such as batteries and demand response can come online quickly in comparison to generation resources



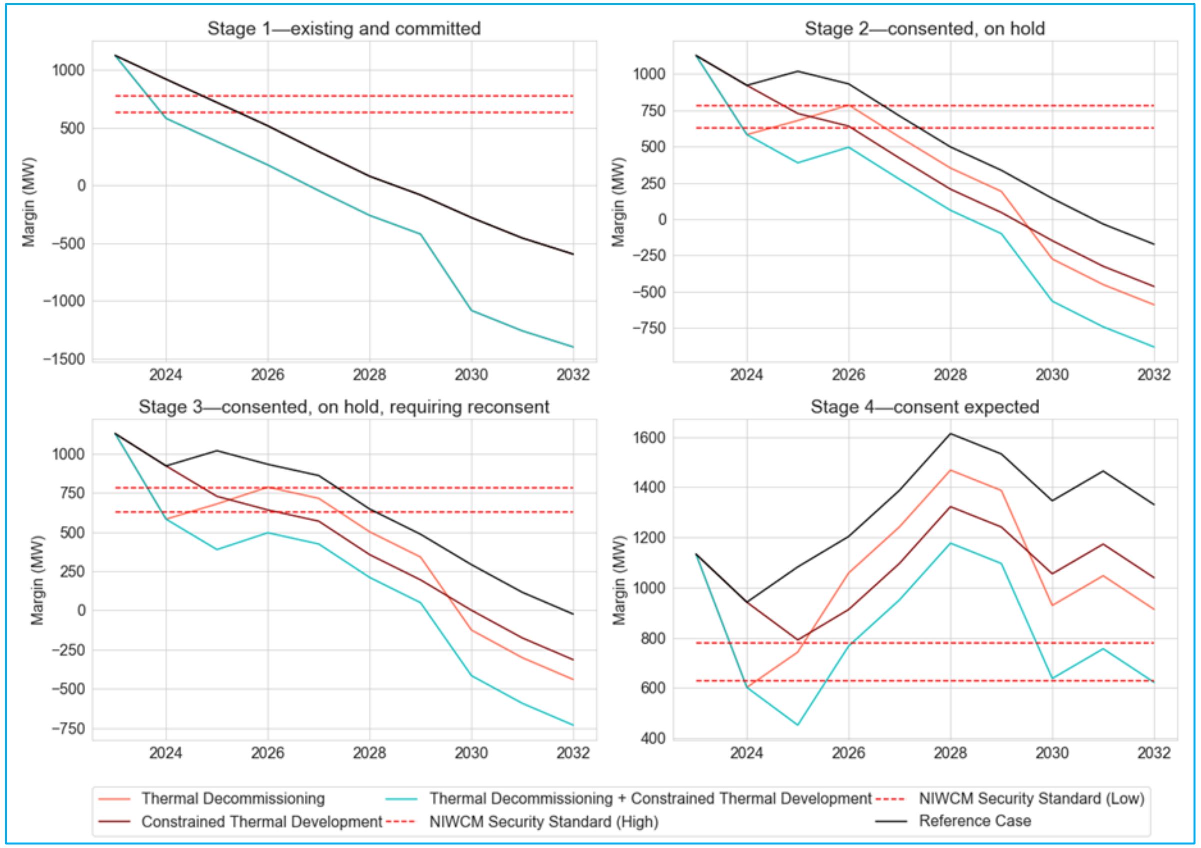
Key Insights – NI WCM demand

- There is need for additional resources before 2025 or 2027 under all demand sensitivities
- Under all sensitivities more generation needs to be consented and developed
- Step increases in demand, such as industrial processes, need to be either flexible or be supported by increased generation capacity or flexible resources such as batteries



Key Insights – NI WCM Reduced Thermal Availability

- If existing thermal generation was decommissioned inline with signalled intent, and existing consented thermal generation is also not developed, then more resources would need to be consented and developed than is currently in the supply pipeline to maintain the margins above the standards between 2024 and 2027
- Developing consented resources will maintain margins above the standard to 2030, and be on the standard from 2030 to the end of the forecast horizon

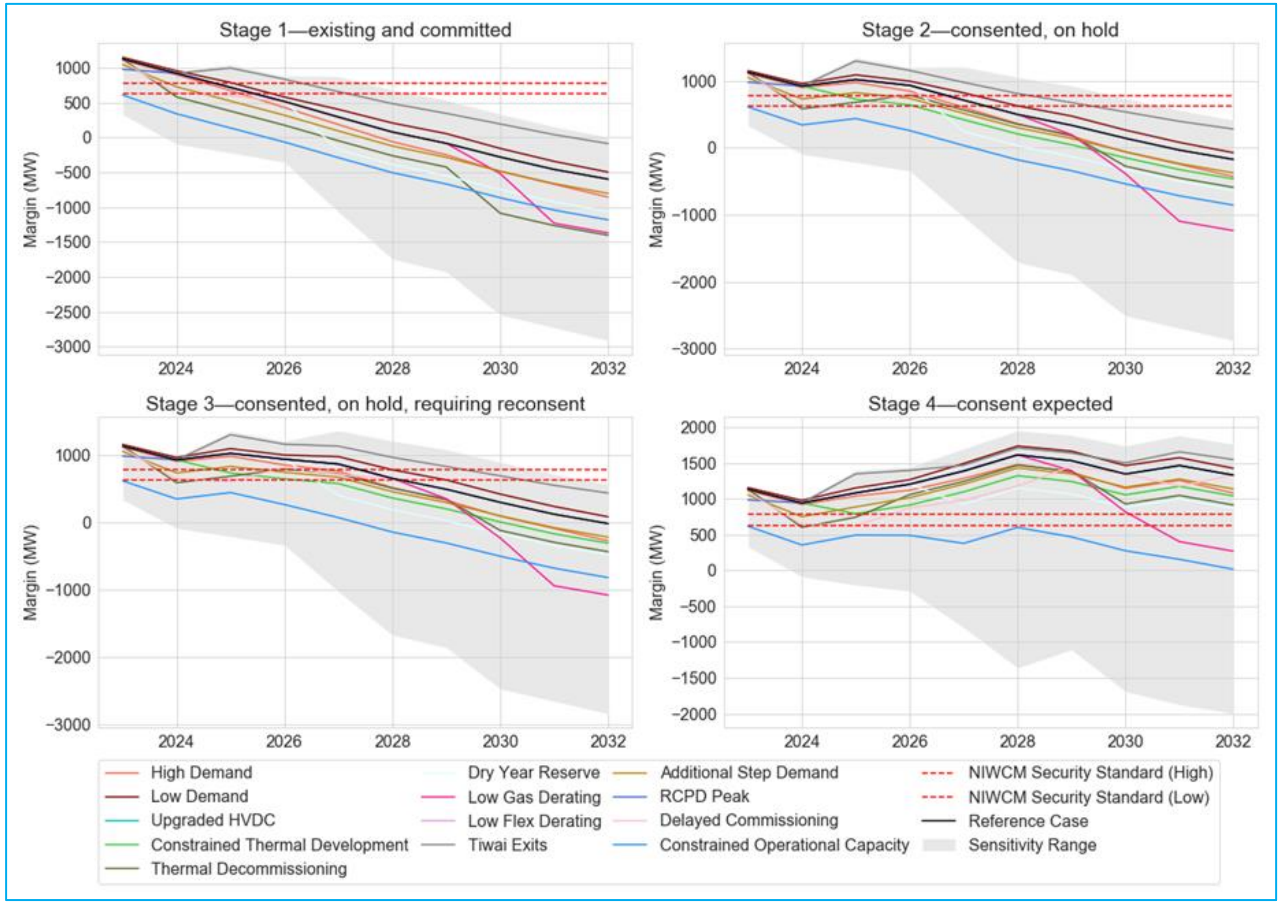


Key insights – NZ WCM Less Flexible Operational Capacity

This sensitivity provides an imperfect proxy for the nuanced issues outlined in the system operator's recent market insight publications and the Authority's consultation on winter 2023

The sensitivity shows:

- When the market does not co-ordinate resources optimally, the margin is below the standards across the entire forecast horizon
- This requires more investment in flexible resources which could come from sources such as gas peakers, batteries or demand response



Being 100% renewable

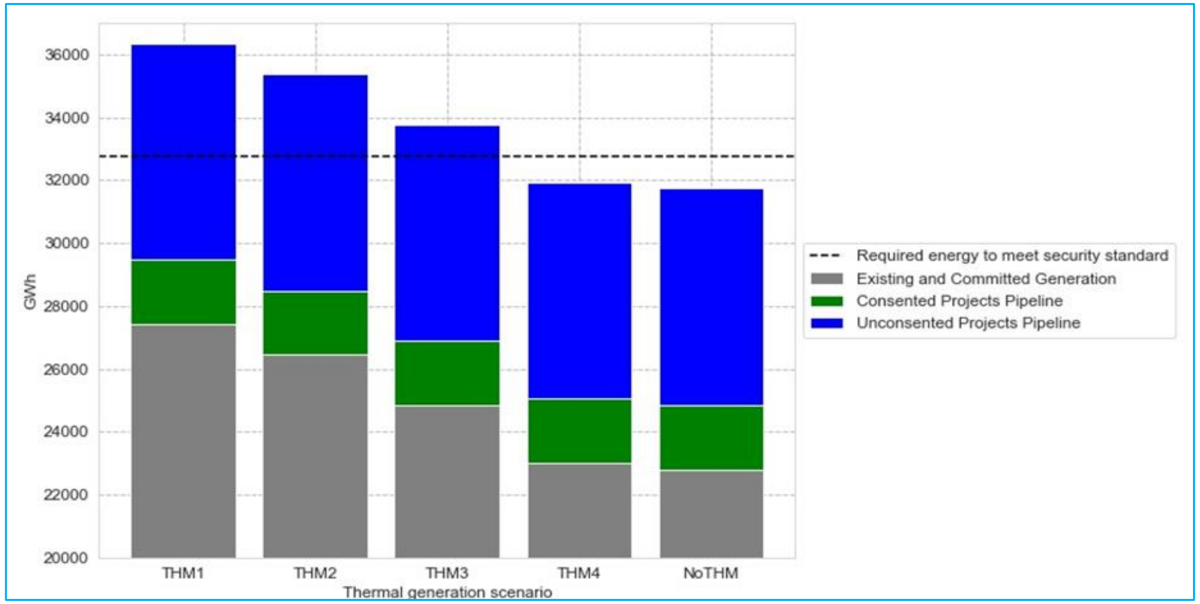
2030 100% Renewable case study

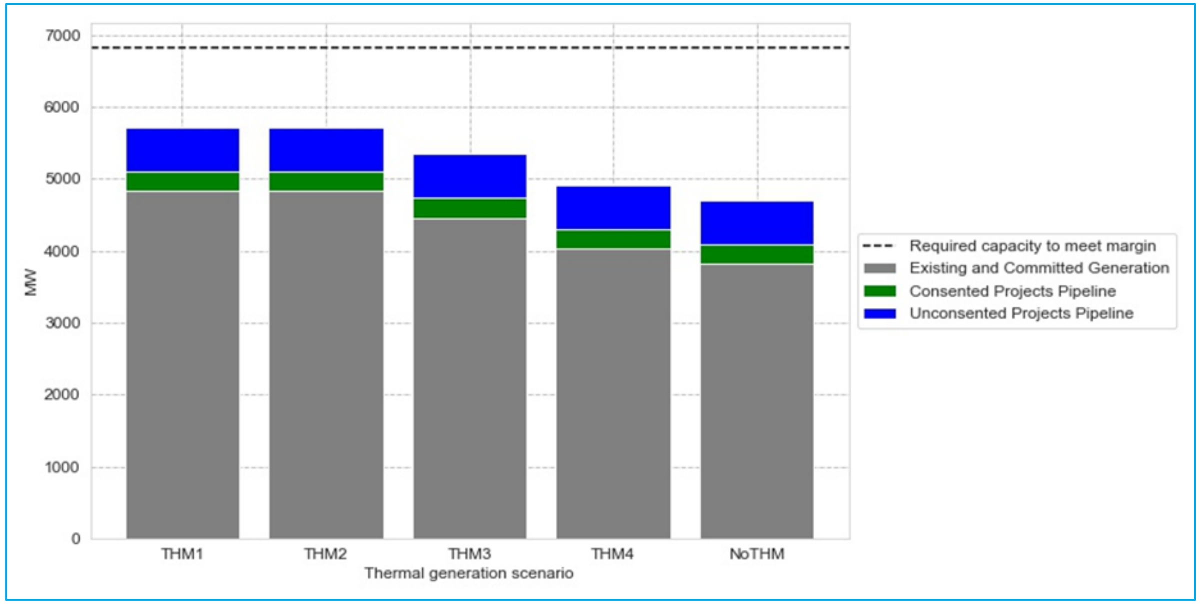
The supply pipeline for the year 2030 is adjusted to reflect the five renewable scenarios below, and compared against the standards. The five scenarios are in the table below

Scenario	Level of assumed thermal generation
THM1	One Rankine unit (dry year support only), one closed cycle gas turbine (CCGT) remains
THM2	No Rankine units, one CCGT remains
THM3	No Rankine or CCGT units
THM4	Whirinaki and cogeneration
THM5	No thermal generation

Key Insights - 2030 100% Renewable case study

- There are sufficient potential renewable supply projects to provide the additional energy required to maintain the NZ-WEM at the upper security standard for the first three thermal scenarios (THM1–THM3)
- There are insufficient potential renewable supply projects to provide the additional capacity required to maintain the NI-WCM at the upper security standard for any of the five thermal scenarios (THM1–NoTHM)





Thank you

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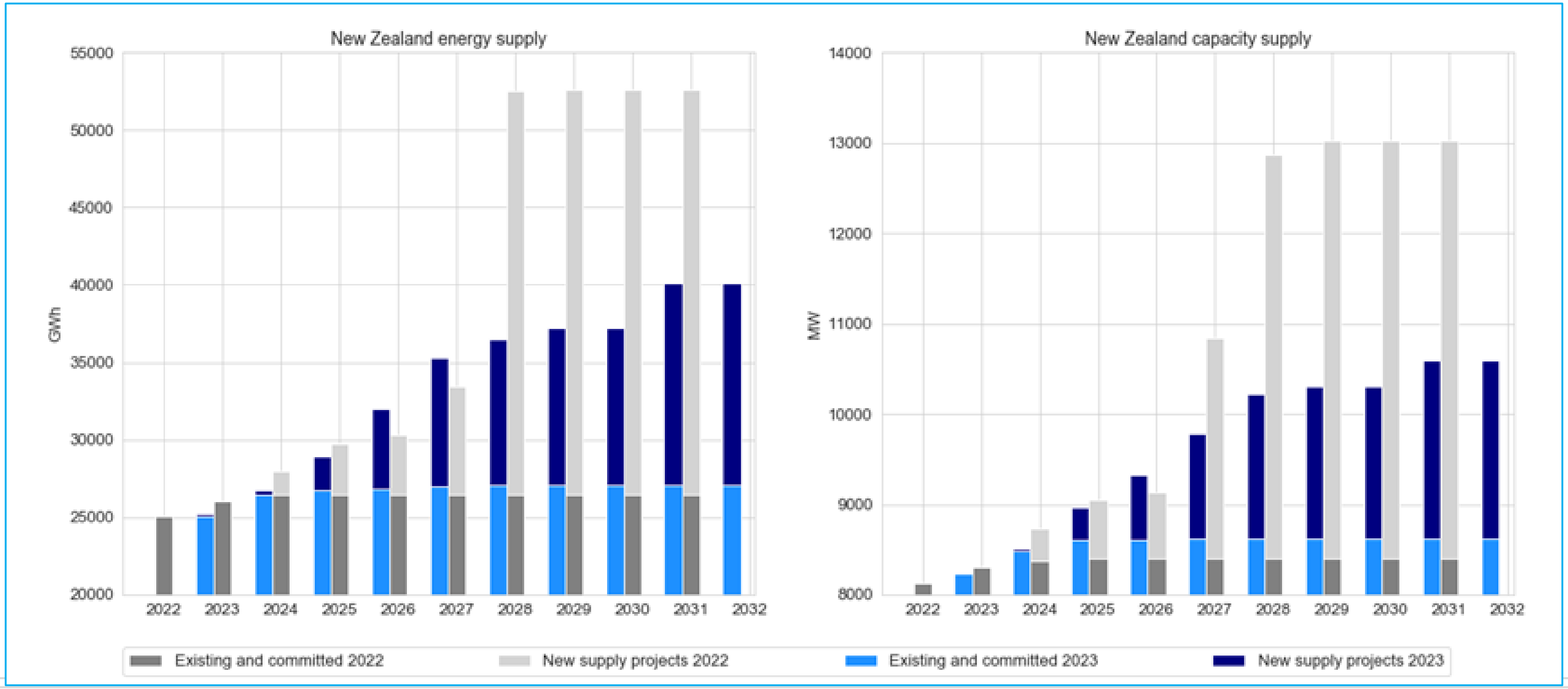
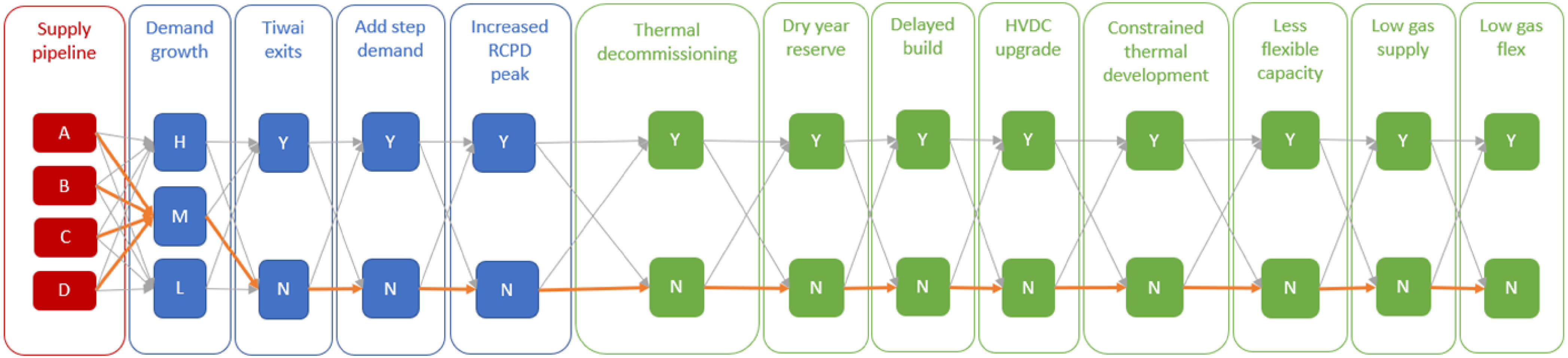
Supply Pipeline – Significant interest in new projects continues

- At the time of writing there are 334 enquiries for new grid connected generation - an increase from 63 in 2021 and 124 in 2022 – indicating that the supply pipeline will continue to grow.
- 98% of the unconsented supply pipeline is made up of intermittent generation sources (wind and solar) and is 100% renewable.



Sensitivity Combinations

- We have identified several key variables that we explore as sensitivities in our analysis. These sensitivities represent plausible variations from the Reference Case that could occur over the 10-year assessment horizon.



Stages	Supply pipeline stages
Stage 1	Existing + committed (consented and active)
Stage 2	Consented and on hold/awaiting market conditions to change
Stage 3	Consented and on hold/awaiting market conditions to change - revision or reconsent required
Stage 4	Not consented, but consent likely sought within two years