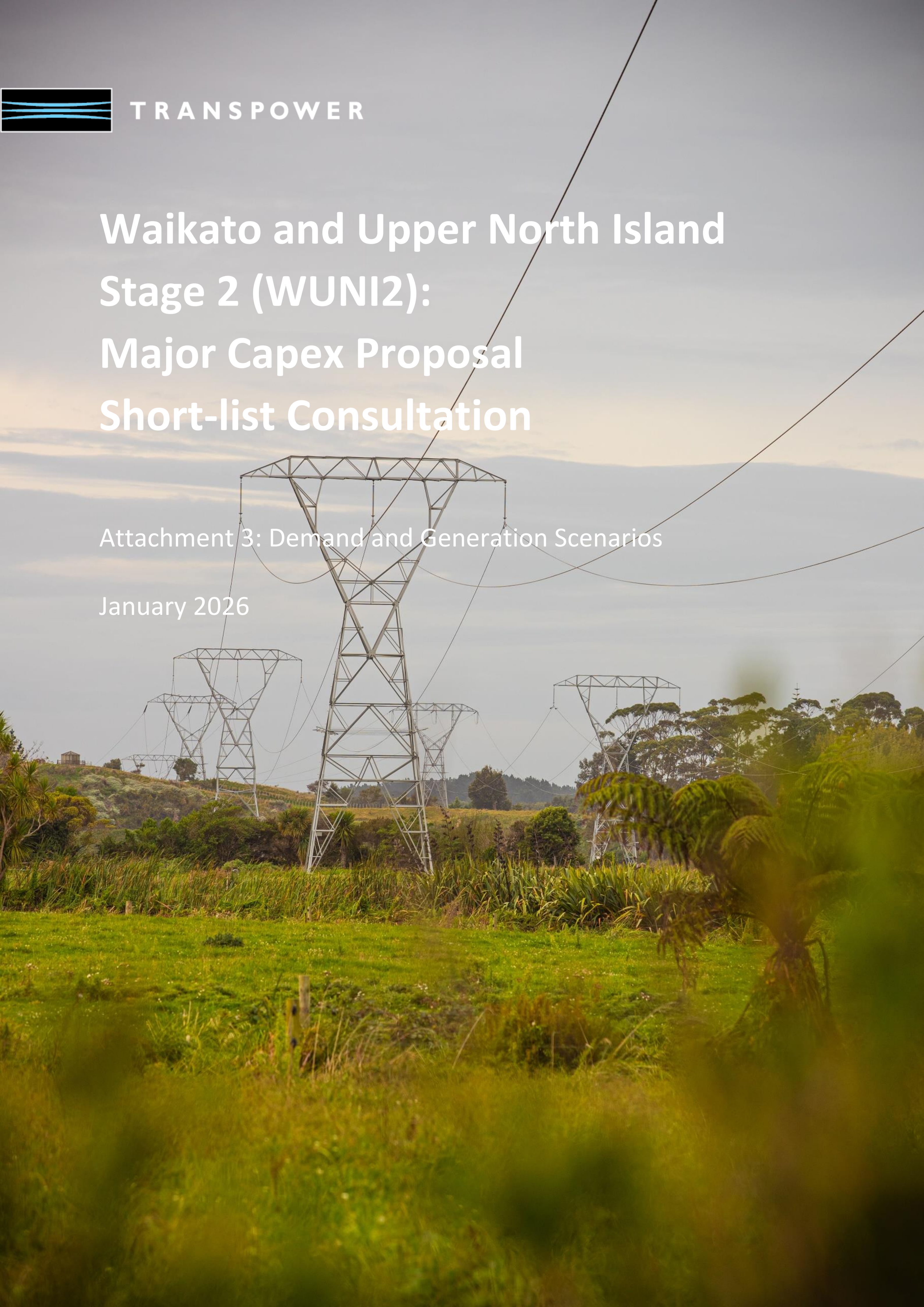
TRANSPOWER

Waikato and Upper North Island Stage 2 (WUNI2): Major Capex Proposal Short-list Consultation

Attachment 3: Demand and Generation Scenarios

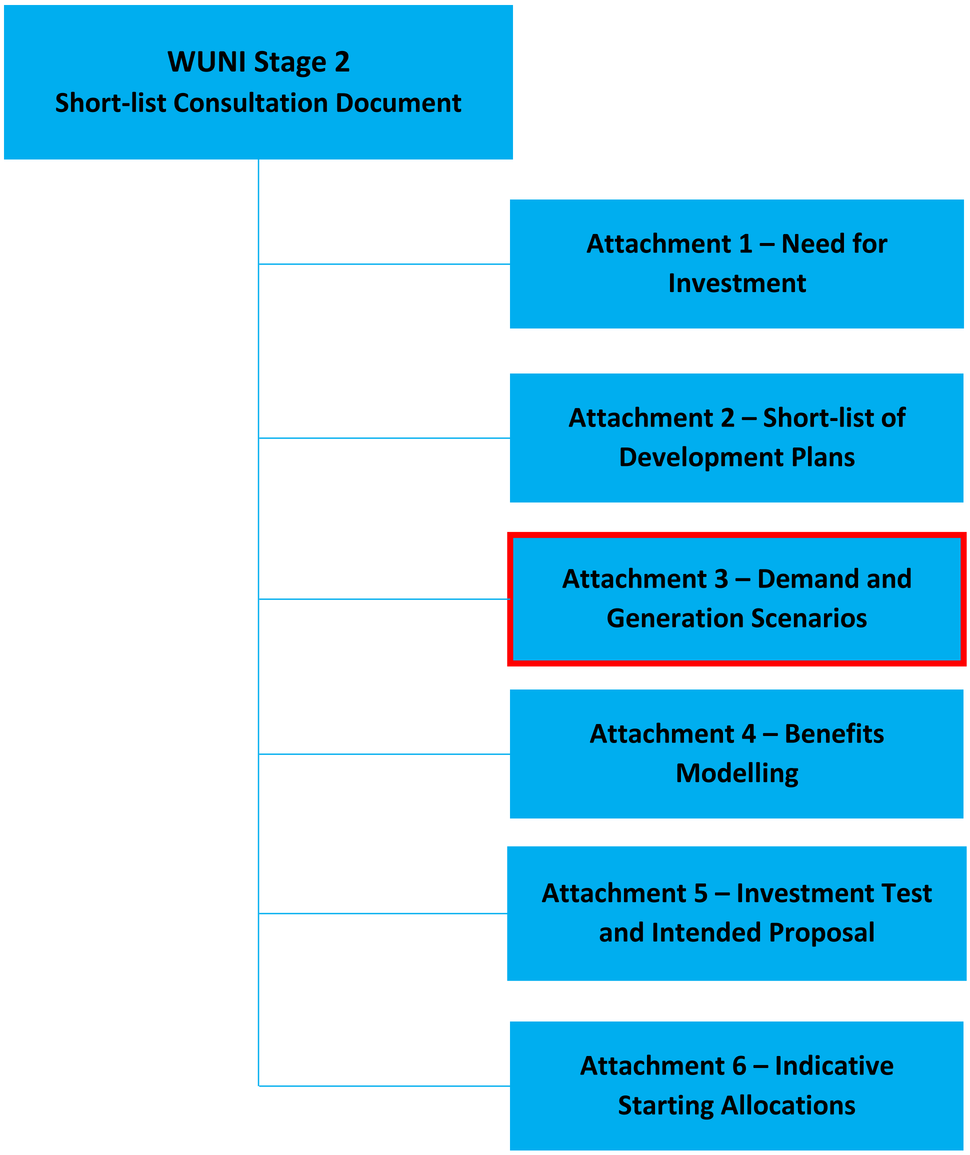
January 2026



Purpose

This Attachment forms part of our Waikato and Upper North Island (**WUNI**) Stage 2 short-list consultation.

The purpose of this Attachment is to provide an overview of the demand and generation scenarios that we have used for our project analysis and application of the Investment Test. To undertake the Investment Test, we must make assumptions about the future demand and generation in the region, which drive the need for investment. This Attachment outlines the key demand and generation assumptions underpinning our analysis.



Contents

1 Approach to Developing Demand and Generation Scenarios

We conduct economic evaluations of options to meet the deterministic limb of the Grid Reliability Standards (**GRS**)[1] using a range of market development scenarios. A market development scenario is an internally consistent set of input assumptions that represents a plausible future of the electricity system. Using market development scenarios ensures that our economic analysis considers a range of different demand and generation futures.

A market development scenario includes assumptions about:

- future electricity demand, including assumptions regarding base demand, electric vehicle (**EV**) uptake, solar PV uptake and distributed energy storage
- existing, decommissioned and future new generation connected to the national grid
- capital and operating costs for both existing and future generation assets
- fuel costs for generation
- fuel and carbon costs associated with generation
- grid-connected energy storage solutions.

The Investment Test uses the *market development scenarios* produced by the Ministry of Business, Innovation and Employment (**MBIE**) or reasonable variations of its scenarios. MBIE's scenarios are called the Electricity Demand and Generation Scenarios (**EDGS**).[2]

For this investigation we have based our analysis on the 2019 EDGS with several updates and variations. We updated the 2019 EDGS to reflect consultation we undertook as part of the Net Zero Grid Pathways 1 (**NZGP1**) workstream in 2021 (we refer to these as the 2019 EDGS Variations).[3] These updates aimed to ensure the EDGS reflect the potential for rapid change in New Zealand's energy sector and are plausible futures to use in our evaluation of investment proposals.

In addition, for this investigation we have updated some more specific information relating to demand in the WUNI region. The EDGS focus on national and island-level demand, meaning we must use a variety of allocation mechanisms to allocate the national and island-level information to the regional and Grid Exit Point (**GXP**) levels to complete our analysis. To do this, we incorporated information from electricity lines companies about GXP level growth. We also updated some of our generation assumptions to reflect more recent information.

To simplify the modelling while using a wide range of demand and generation inputs, we used three of the EDGS Variations for our WUNI Stage 2 modelling:

1 The deterministic limb of the GRS requires Transpower to maintain at least an N-1 reliability on the core grid.

2 See Electricity Demand and Generation Scenarios (EDGS)

3 See NZGP Phase One | Transpower

- **Reference:** Current trends continue
- **Growth**: Accelerated economic growth
- **Environmental:** Sustainable transition.

We consider three scenarios are sufficient to consider for this project. Consistent with prior investigations, we have not considered the Global scenario due to its unreasonably low level of growth. We have also omitted the Disruptive scenario, as it is within the range of the three selected scenarios so does not provide additional insights.

We seek any updated information that might change our scenarios, as part of this consultation. We will consider if we should update our assumptions and analysis used in our proposal to the Commerce Commission.

In July 2024, MBIE released a new version of EDGS. Our intention is to continue to base our analysis on the 2019 EDGS Variations we have developed and consulted on as the foundation of our analysis. We note that the new EDGS contain limited regional information, such that if we were to adopt them, we would still have to draw heavily on the regional detail we have gathered for this project. Our view is that the 2019 EDGS Variations and our forecasts presented below provide a suitable basis for assessing this project.

Section 2 presents the demand forecasts we have used for this investigation; generation assumptions are presented in section 3.

2 Demand Assumptions

2.1 Regional Forecasts and Assumptions

This subsection provides a brief overview of the demand forecast and assumptions for the WUNI region.

Forecast Overview

Figure 1 and Figure 2 present our peak and energy demand forecasts, respectively, for the WUNI region for each Transpower's 2024 update of the 2019 EDGS Variations. Table 1 and Table 2 present the summer and winter peak forecasts in 2025, 2035, 2045 and 2055, broken down by the factors contributing to the growth:

- Base growth – the underlying growth in demand driven by factors such as population and economic growth
- Step loads – new demand that might appear from new developments, such as new commercial and residential developments
- EV – the uptake of EVs and the "smartness" of their charging
- Solar – the uptake of residential and commercial solar photovoltaic panels

- Battery – the uptake of residential and commercial battery storage packs
- Electrification – the electrification of industrial processes such as the conversion of coal and diesel boilers to electric boilers.

Each scenario has different assumptions for each of these factors, leading to the overall variation in the forecasts. The methodology we have employed to model these components is similar to that used in recent short-list consultations such as the Upper South Island upgrade project and the HVDC Link Upgrade Programme.

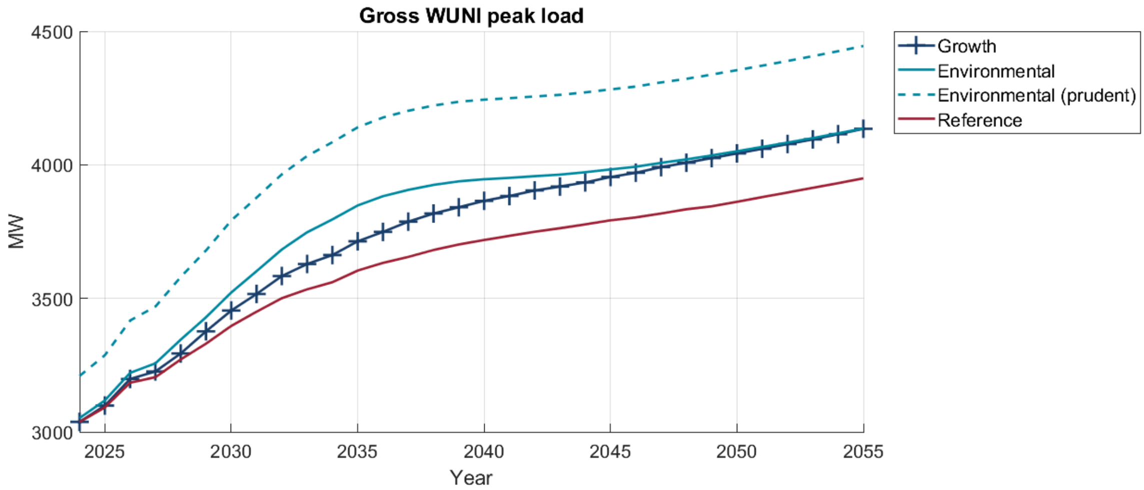


Figure 1: Annual WUNI gross peak load forecast

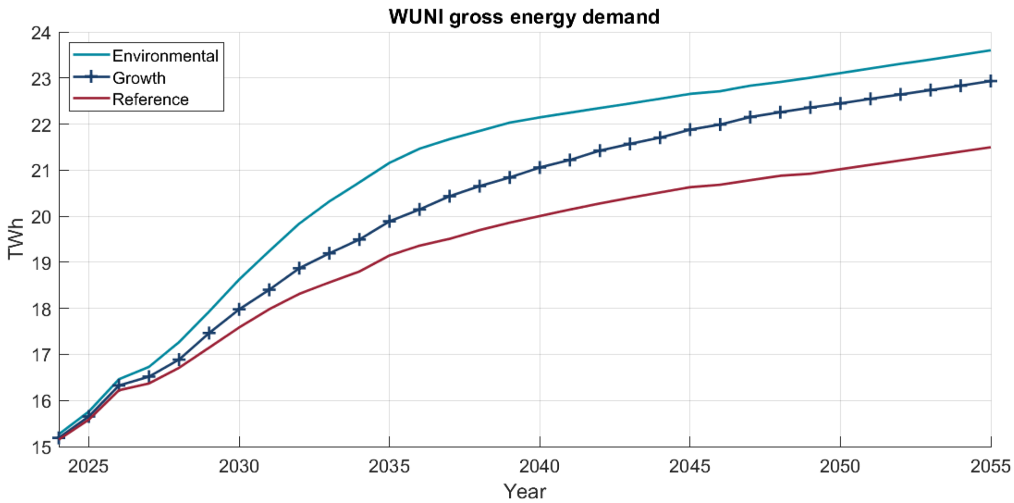


Figure 2: Annual WUNI gross energy demand forecast

Table 1: WUNI winter demand forecast assumptions, in MW

Scenarios	Year	Peak	Base	Step loads[4]	EV	Solar[5]	Battery	Electrification
Growth	2025	3099	2949	124	17	0	-0.3	4
	2035	3714	3124	387	68	-12	-3	112
	2045	3954	3302	400	193	0	-64	122
	2055	4135	3501	400	295	0	-168	120
Environmental	2025	3118	2947	124	36	0	-0.4	9
	2035	3848	3094	387	115	-6	-18	261
	2045	3983	3234	400	233	0	-158	286
	2055	4136	3395	400	306	0	-233	283
Reference	2025	3092	2943	124	17	0	-0.3	2
	2035	3604	3061	387	75	-10	-3	56
	2045	3792	3190	400	192	0	-53	61
	2055	3949	3335	400	296	0	-133	61

Table 2: WUNI summer demand forecast assumptions, in MW

Scenarios	Year	Peak	Base	Step loads	EV	Solar	Battery	Electrification
Growth	2025	2346	2241	114	16	-29	-0.3	7
	2035	2806	2285	366	55	-76	-4	128
	2045	2865	2373	380	166	-84	-67	118
	2055	2845	2431	380	280	-74	-171	80
Environmental	2025	2357	2234	114	33	-30	-0.4	16
	2035	2889	2257	366	88	-108	-22	278
	2045	2892	2310	380	220	-88	-151	265
	2055	2846	2331	380	292	-100	-203	249
Reference	2025	2340	2237	114	17	-28	-0.3	3
	2035	2726	2249	366	62	-71	-4	70
	2045	2760	2307	380	161	-77	-55	64
	2055	2795	2354	380	291	-43	-148	21

[4] The numbers presented here are the maximum demand of each step load, rather than their demand at the time of WUNI peak. This gives a clearer indication of the variation in step loads between scenarios.

[5] The solar contribution to the peak is generally zero in winter due to an evening peak except for a small part of the forecast when the peak moves earlier in the day.

Base Demand

Base level demand relates to underlying demand, plus increases we expect to occur from factors such as economic and population growth.

We model base demand by combining national and island level base demand energy forecasts informed from our NZGP1 EDGS variations, with GXP level peak base demand forecasts from local electricity distribution businesses (**EDBs**). We use a reconciliation approach where we develop half-hourly GXP demand profiles that sum nationally and by island to align with national and island level NZGP1 EDGS base demand forecasts. This approach ensures that the aggregated demand profiles are consistent with the national and island levels, while also maintaining strong alignment with GXP-level forecasts. GXP-level forecasts provided by EDBs are given higher weighting in the reconciliation process in early years to place higher value on nearer term information from EDBs. Modelling demand profiles is important as factors such as EV charging and residential/ commercial battery use will have a significant impact on future peak demand.

Figure 3 shows the resulting base peak demand forecasts for the WUNI region. The growth of the base peak is modest, with additional growth coming from customer steps and our scenario uptake assumptions of process heat and EVs as discussed below.

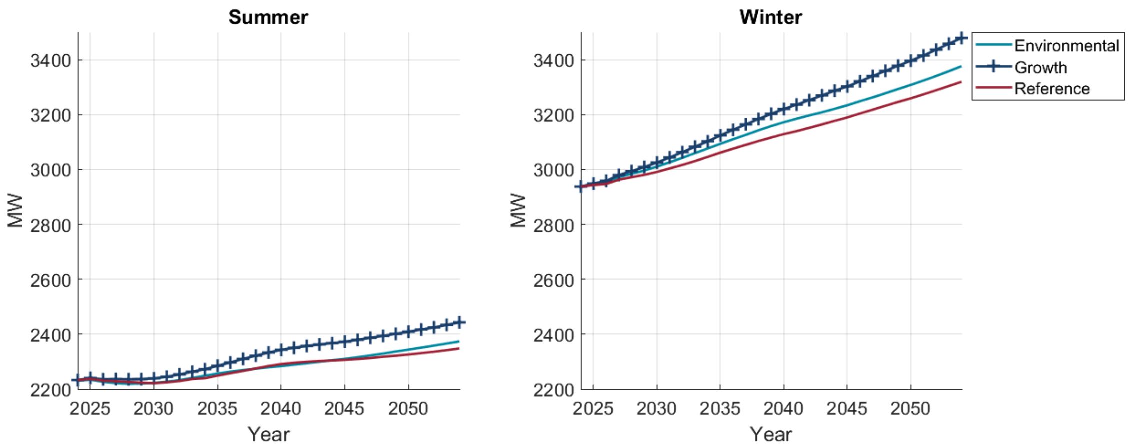


Figure 3: Base peak demand growth for the WUNI region, MW

Step Loads

New step loads are expected to play a major role in driving growth in the region over the next 10 years. These are new developments expected to occur in the region that will lead to a step increase in electricity demand. Figure 4 shows that step loads contribute around 400 MW to peak load growth by 2035.

We model step changes by assigning a half-hourly demand profile to each step change based on the type of demand expected (e.g., industrial, residential etc.) and then scaling so that the peak of the profile aligns with the expected peak demand of the step load. We then add this profile to the existing forecast demand at the GXP where the step is expected.

Distribution companies and industrial companies have provided us with details of the step loads expected in the region. Where a step load appears to be also captured in another modelled component (e.g., process heat) we reduce the other modelled component by the size of the step change to reduce the chance of double counting.

Table 3 lists the major new developments we are aware of and have incorporated into our scenarios.

Table 3: Step loads in the WUNI region

Step load	GXP
Reswax Awanui stage 1-3	Kaikohe 110 kV
Various data centre loads	Henderson, Silverdale, Takanini, Hobson Street, Albany 33 kV
Electric furnace commissioning	Glenbrook 33 kV (NZ Steel load only)
Kiwi Rail development	Penrose 25 kV and Southdown 25 kV
Watercare water treatment plant expansion	Bombay 110 kV
Drury South industrial development	Bombay 110 kV
Hynds development	Bombay 110 kV
Residential council development	Bombay 110 kV
Paerata Rise development	Bombay 110 kV
Belgium Road and Golding/ Birch subdivision	Bombay 110 kV
Leamington substation development	Hautapu
APL load increase	Hautapu
Various step loads at Huntly	Huntly
Various step loads at Hamilton	Hamilton 33 kV, Hamilton 11 kV
Tainui Group Holdings development	Hamilton 33 kV
Taharoa Mine Site Central Mines Zone Sub de-carbonisation	Hangatiki 110 kV
Various residential development	Te Awamutu
Waikeria Prison development	Te Awamutu
Various step loads in Auckland region	Pakuranga, Liverpool Street, Penrose 33 kV, Wiri, Wairau Road, Roskill 22 kV and Hepburn Road
Various step loads in Waikato region	Te Kowhai, Waikino, Cambridge, Hautapu, Piako, Arapuni 110 kV, Hamilton 11 kV and Kopu

The step load information was primarily collected as part of the 2024 Transmission Planning Report being the latest information available at the time the modelling began. We are aware that new information may now be available. We welcome feedback on new information about step loads that can inform our investment proposal.

Figure 4 shows the maximum demand each step load can contribute to the WUNI peak demand. Their actual contribution to the WUNI peak may be less, and vary from year to year, due to the nature of modelling the step loads using profiles.

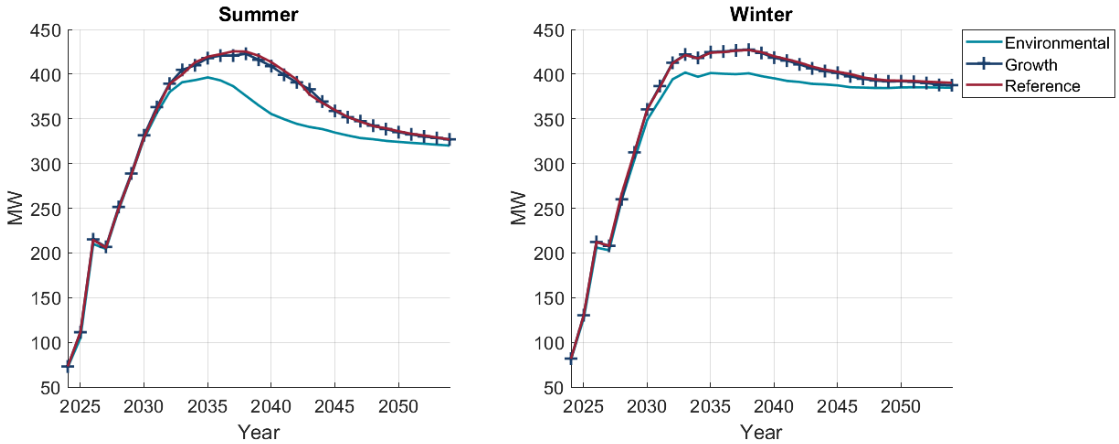


Figure 4: Step load growth contribution

Electric Vehicles

We have aligned our national EV assumptions closely with our NZGP1 EDGS variations. We model the impact of EVs by first adopting the assumed national uptake rates of EVs (broken into light, and heavy categories) as given by each NZGP1 EDGS variation scenario. National uptake rates are then allocated at a regional level using the light passenger vehicle kilometres travelled in each region, and at a GXP level using the number of relevant Installation Control Points (**ICPs**) behind each GXP. In Table 4 we show the approximate number of EVs across each scenario in the WUNI region.

Table 4: Approximate number of EVs contributing to WUNI demand, by scenario and year[6]

	Environmental	Growth	Reference
2025	102,000	45,000	45,000
2035	683,000	347,000	322,000
2045	1,345,000	901,000	760,000
2055	1,780,000	1,387,000	1,174,000

For peak demand forecasts, it is also critical to make assumptions about when EVs will be charged. We model the timing of EV charging by assuming some proportion of EVs have a fixed profile (e.g., they tend to charge after work or when it is convenient) and the remaining proportion have a "smart" profile, and charge in a way that avoids regional peaks. In our demand forecasting models, the charging of "smart" EVs is moved to avoid peak periods. In this way, "smartness" reduces our peak demand forecasts.

6 Assuming each EV travels an average of 12,000 km annually, and has an efficiency of 0.19 kWh/km

We have aligned our "smartness" assumptions with our NZGP1 EDGS variations except we have reduced the "smartness" in the Disruptive scenario from 60% to 50%, such that 50% of all EV demand is "smart" charging by 2050. We have done this to create some additional diversity in our forecasts and to recognise that there are risks that EV charging may be less smart. Table 5 summarises the "smartness" assumptions for all scenarios.

Table 5: EV smartness assumptions, by scenario, by 2050[7]

	Environmental	Growth	Reference
Proportion smart charging	60 %	50 %	40 %

Figure 5 and Figure 6 show the resulting megawatt contribution that fixed and smart EV charging each make to the WUNI peak demand. As is demonstrated, "smart" EV charging is very effective in avoiding peak periods, with a contribution of less than 30 MW under all scenarios. Note that in Figure 5, the amount of smart charging at the time of peak decreases towards 2050. This is due to the dynamic nature of how smart EVs are modelled and the time of the WUNI peak moving. That is, the peak time is moving to a time during the day that has less smart charging. The decrease in the amount of smart EV charging is very small in comparison to the WUNI peak load shown in Figure 1.

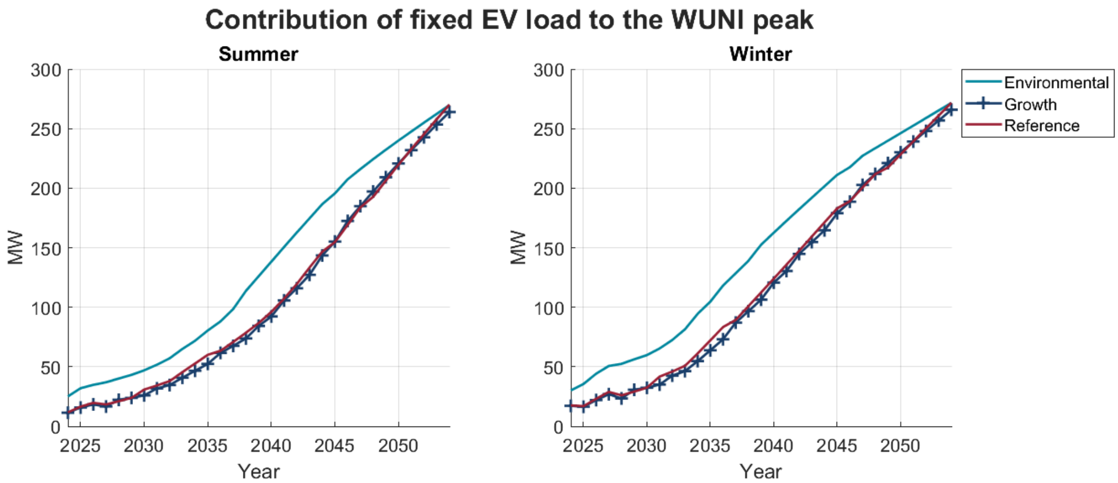


Figure 5: Fixed electric vehicle demand growth

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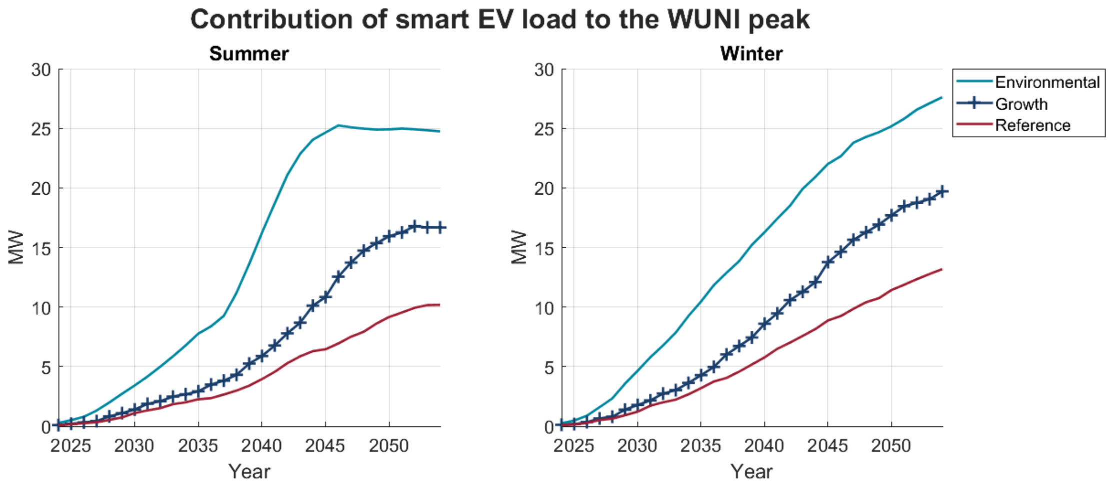

Figure 6: Smart electric vehicle demand growth

Solar Uptake

We have aligned our national level solar and residential/commercial uptake rates with the assumptions we consulted on in developing the NZGP1 EDGS variations.

We model solar uptake by adopting national uptake rates consistent with our NZGP1 EDGS variations. We then allocate the national uptake rates to a GXP level using the number of ICPs behind each GXP and the solar propensities for each region. In Table 6 we give the number of solar installations in the WUNI region for each scenario.

Table 6: Approximate number of solar installations in the WUNI region, by scenario and year

	Environmental	Growth	Reference
2025	27,000	25,000	25,000
2035	164,000	76,000	68,000
2045	488,000	232,000	195,000
2055	747,000	543,000	430,000

We use solar irradiance data at a regional and hourly level to estimate the amount of solar generation that is being produced at a half-hourly level.

Figure 7 shows the contribution of new residential/commercial solar installations to WUNI energy (TWh) demand. Note that solar generated electricity reduces the amount of electricity needing to be supplied from the GXPs (i.e., solar uptake reduces demand forecasts during the times of day it can produce electricity). As shown in Table 1, solar output reduces the winter peak by a small amount as peak demand tends to be outside solar operating times.

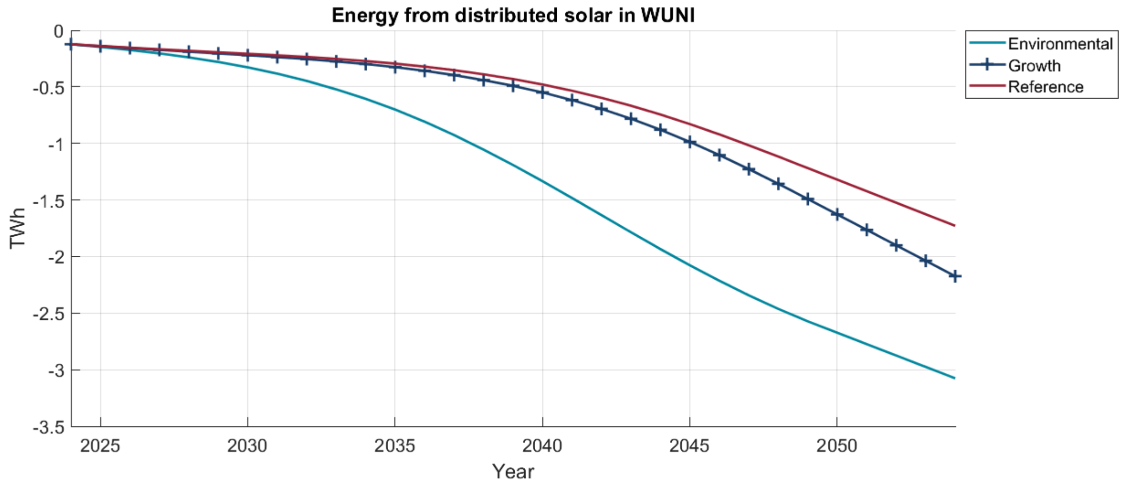

Figure 7: Solar demand growth production contribution to demand, TWh

Battery Uptake

We have aligned our battery uptake with the approach taken in our NZGP1 EDGS variations and set it as a percentage of solar uptake. We assume that the battery allocation at a GXP level is the same as the solar allocation. We also assume that a small fraction of EV batteries is available to reduce peak demand. In Table 7 we give the number of batteries in the WUNI region for each scenario. The amount of storage available for peak shaving from each installation is a modest 6.4 kWh. We are aware of new information that indicates the 2025 numbers are underestimated. Inspection of EMI data suggests the number of batteries in the WUNI region is well over 6,000. While this is significantly higher than our current estimate, the number is still relatively modest such that if we did update them, it is unlikely to materially impact project timings. As can be seen in the figures below, even in 2035 the impact of batteries is very modest.

Table 7: Approximate number of battery installations in the WUNI region, by scenario and year

	Environmental	Growth	Reference
2025	1,000	1,000	1,000
2035	32,000	6,000	6,000
2045	244,000	110,000	93,000
2055	354,000	260,000	206,000

We assume batteries are charged in trough periods and discharged in peak periods in such a way as to reduce the overall peak demand. In our modelling, batteries are assumed to reduce the daily peak load at a GXP.

Figure 8 shows the resultant contribution of new residential/commercial batteries to the WUNI region peak demand.

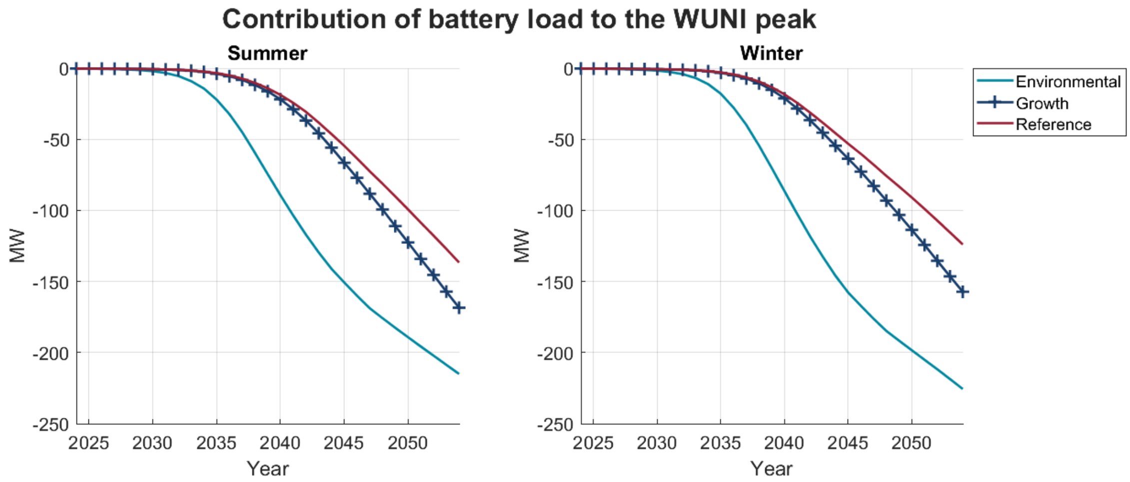

Figure 8: Battery uptake demand growth, MW

Process Heat

We have aligned our process heat 2050 totals closely with our NZGP1 EDGS variations.

However, we have updated the trajectory of heat electrification to follow an s-curve. An s-curve is a more common form of uptake for new products. It has some period of ramp up in uptake followed by a flattening in uptake.[8]

We model heat electrification by allocating national totals for different temperature heat electrification to a region using data on energy use by sector, fuel type and technology. We allocate the heat load at a GXP level using boiler databases, knowledge of major plants on the grid and by identifying any step loads which are electrifying process heat.

Figure 9 shows the resultant contribution of new process heat electrification to the WUNI peak demand. During summer, solar and battery contributions can shift the peak demand time. Consequently, the amount of electrified process heat contributing to the peak decreases at this new peak time.

8 We also removed high-temperature process heat electrification, which was initially considered in the Disruptive scenario, and is no longer included at all. This is not relevant for this proposal as we are proposing to not use the disruptive scenario in our modelling.

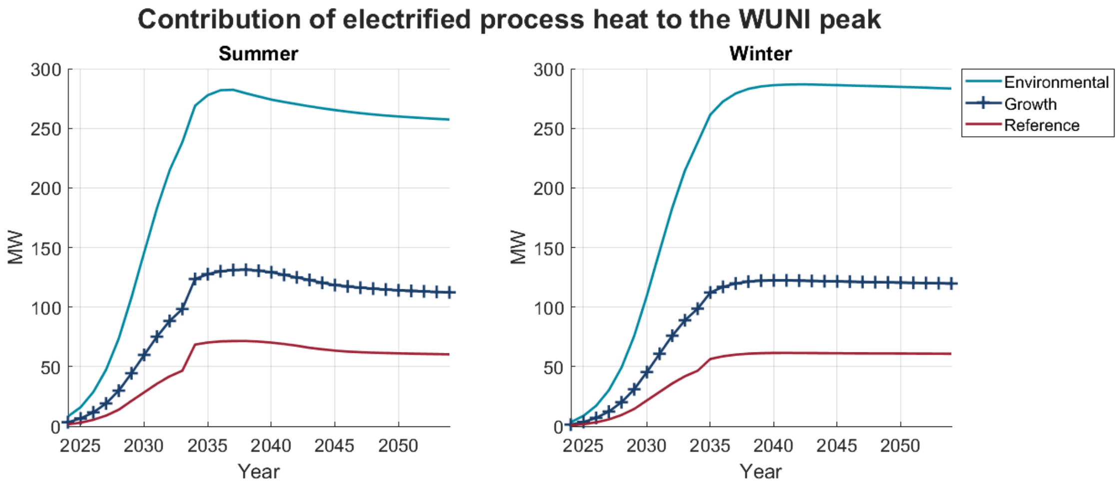

Figure 9: Process heat demand growth

Planning Forecast

As a prudent asset manager, we want to invest in a timely manner to ensure we can supply demand in all but the most unusual circumstances. While the forecasts outlined above take account of many of the potential drivers of growth in the WUNI region, they do not account for the potential for peak demand to be high due to an unusual event, such as a cold weather event.

To address this concern, we have produced a prudent version of the Environmental forecast. The prudent Environmental forecast is the same as the Environmental forecast above but adds a margin to account for the year-to-year variability of demand due to factors such as weather and system conditions. As with the Environmental forecast, it includes most but not the most speculative step loads increases. We have used this forecast to inform the need and timing of investment in our development plans.

To derive the prudent component, we have:

- Used regression analysis to regress historical peak demand against time.
- Determined the expected value and regression statistics associated with the variance of the regression fit.
- Calculated the ratio of the expected value to the 10% probability of exceedance value.
- Applied the ratio to the Environmental forecast.

This is illustrated in Figure 10. As seen the prudent component is approximately 7% of total peak demand in 2050.

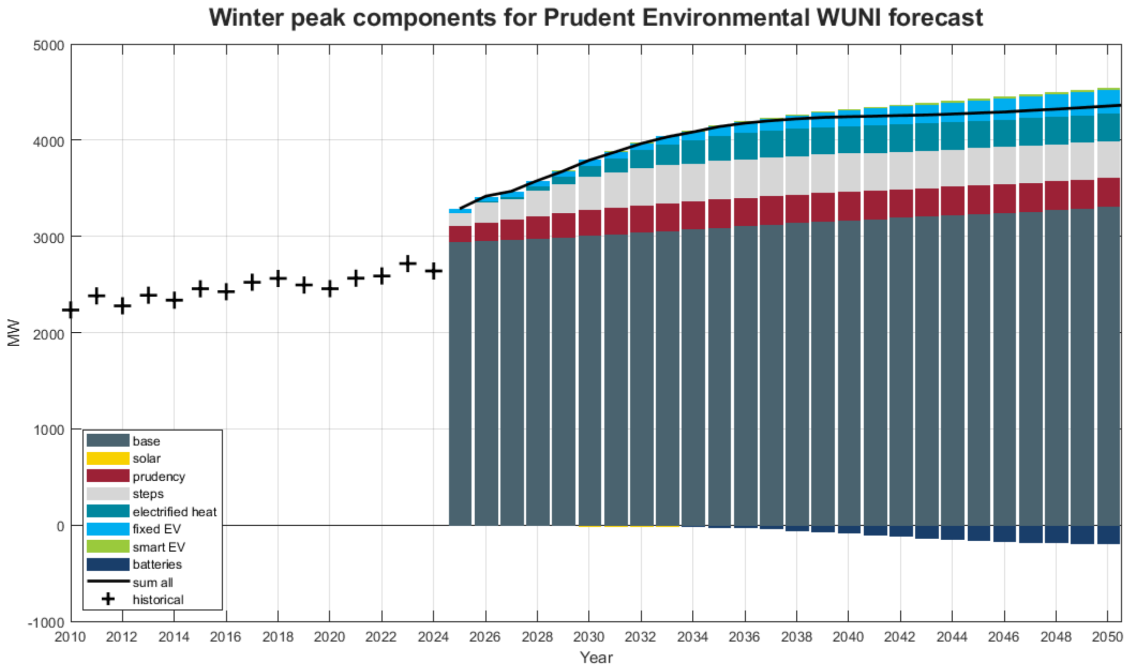

Figure 10: Prudent planning forecast broken down by component

The other scenarios have been used to assess economic benefits with the timing of investment based on the prudent Environmental scenario. For example, although we have calculated the benefits (to use in the Investment Test) using the Growth scenario, the timing of upgrades in each short-listed option has been informed by the prudent Environmental forecast.

Demand Forecasts in Other Regions

The focus of this investigation is on the WUNI region. In addition, we have developed a full set of forecasts for the rest of New Zealand. Section 2.2 presents the national peak and energy forecasts we intend to use for this investigation in combination with our WUNI demand forecasts.

2.2 National Demand Forecasts Reference

Figure 11 and Figure 12 present national demand forecasts consistent with the model runs we used to create the WUNI Stage 2 project forecasts.

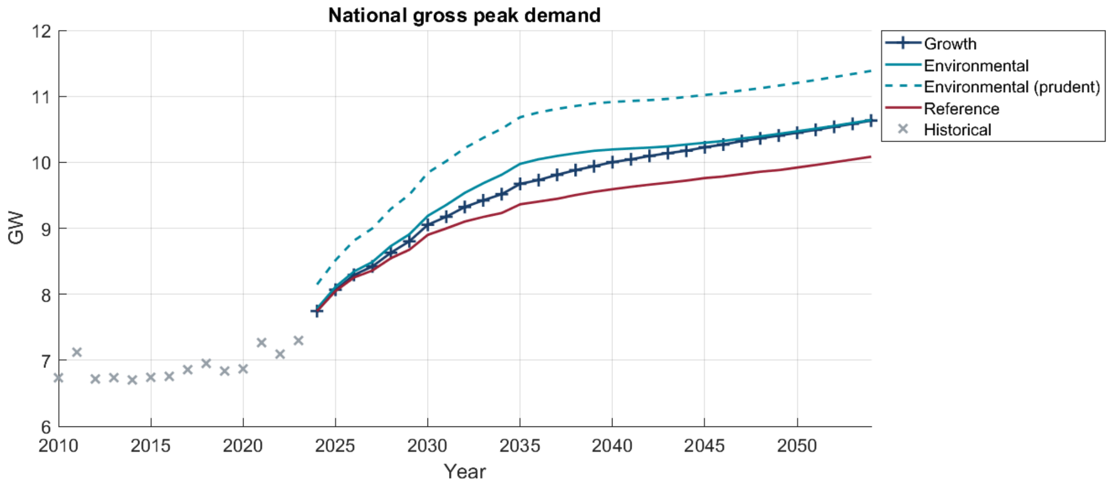

Figure 11: National peak demand forecasts, GW

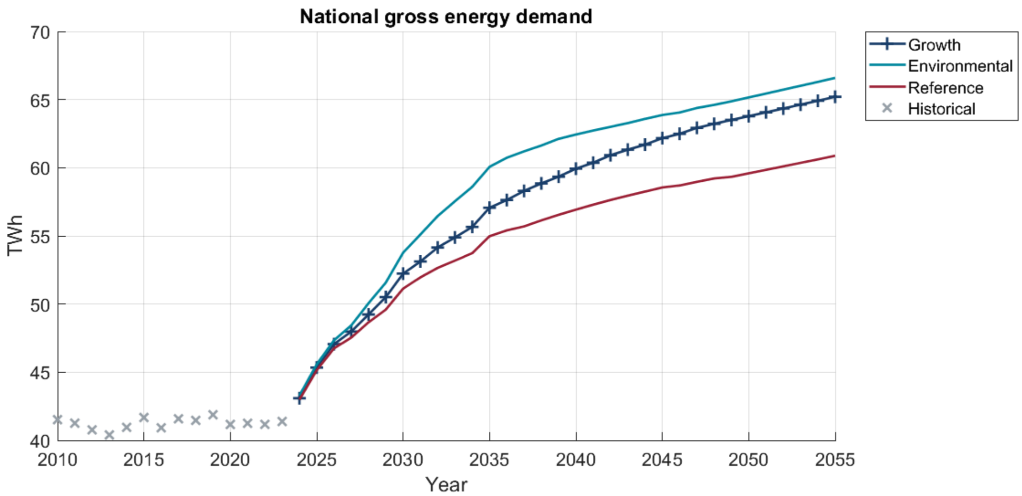

Figure 12: National energy forecasts, annual TWh

2.3 Updates from NZGP1

Our assumptions are based on those made for our NZGP1 project. However, we have made some refinements to the data and approach to reflect new information since that time. These include:

- updating data based on recent historical information and feedback from electricity lines businesses in line with the 2024 EDB planning survey
- assuming the Tiwai Point aluminium smelter remains open throughout the forecast horizon.

2.4 GXP Forecasts

More detailed information relating to the forecasts assumed at each GXP in WUNI is provided in the accompanying spreadsheet (Appendix A).

3 Generation Assumptions

This section presents information relating to the generation assumptions used for this project. Generation assumptions apply to our:

- Generation expansion plan model, **OptGen**, which determines the location, timing, and technology of new (modelled) generation.
- Dispatch model, **SDDP**, which simulates the wholesale electricity market by calculating a least cost optimal dispatch over the study horizon.

We use these models to evaluate the electricity market benefits for different investment options. For more information on this modelling refer to Attachment 4.

3.1 Basis of Our Assumptions

Generation assumptions for our SDDP and OptGen modelling are based on the Benefit-Based Charges (**BBC**) Assumptions Book v.2.0 ("Assumptions Book")[9].

3.2 Existing Generation

The WUNI region has over 2.6 GW of total installed capacity with over 92% of this located in the Waikato region. Therefore, the typical flow of electricity is northwards from Whakamaru to Ōtāhuhu and Pakuranga. The distribution of capacities by technology and region as of January 2025 is shown in Figure 13.

We assume that most existing generation will continue to operate throughout the analysis period, except for the plants expected to retire as shown in Figure 14 and as set out in the Assumptions Book.

Note that the generation assumptions in this part of the analysis differ slightly from the assumptions used for assessing the investment need as laid out in Attachment 1, particularly for the Huntly Rankine units. The benefit modelling based on the assumptions presented here is only

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relevant for the calculation period which starts after commissioning of the proposed investments (2034-55).

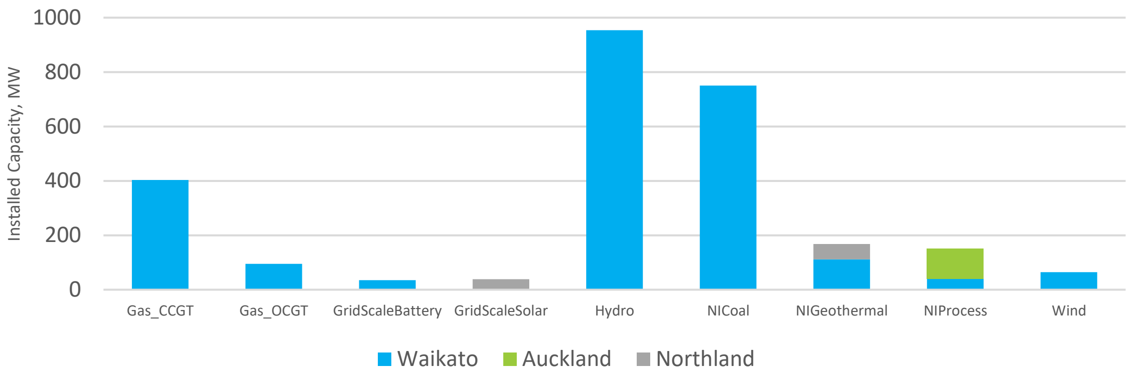

Figure 13: Installed capacities per technology in the WUNI region

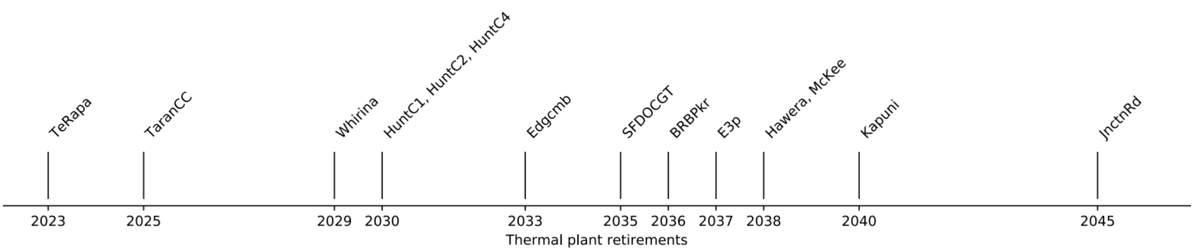

Figure 14: Modelled thermal plant retirement timeline

3.3 Committed Generation

In our generation expansion modelling we include 'committed' generation projects which we judge as likely to proceed. The timing of these builds is exogenously specified in the generation expansion model based on publicly reported development schedules. The criteria for classifying a project as committed are specified in clause D8(1) of the Transpower Capital Expenditure Input Methodology 2012 (as amended) (**Capex IM**).

These plants are listed in Table 8. The timing of these builds is exogenously specified in the generation expansion model based on publicly reported development schedules.

Table 8: Modelled WUNI committed generation

Type	Modelled Transmission Node[10]	Name	Capacity (MW)
GridScaleSolar	WHU110	Solar_WHU_1	147
GridScaleSolar	BRB220	Solar_BRB_1	120
GridScaleSolar	OHW220	Solar_OHW_1	119
GridScaleSolar	OHW220	Solar_OHW_2	152
GridScaleSolar	KPU110	Whitianga	24
GridScaleBattery	BRB220	Ruakaka	100
GridScaleBattery	HLY220	HLY_PS2h	100
GridScaleBattery	GLN220	Glenbrook_2h	100
Wind	MPE110	Kaiwaikawe	73

While there is considerable interest in other renewable generation development in the region, we judge other projects to be less certain at present.

3.4 Potential Generation

The WUNI region has significant potential for the development of different generation projects. The potential generation projects in our stack are listed on the Assumptions Book v.2.0.[11] The generation expansion model determines a capacity expansion plan from these candidate projects based on a least cost optimisation condition (i.e., the capacity expansion plan provides the lowest cost mix of generation which can meet demand, see Attachment 4 for more information about the construction of the generation expansion plans).

> **Q8. Do you have any additional information that could materially affect our electricity demand forecast or generation assumptions?**

10 We model the AC transmission network down to 66 kV in SDDP. Generation which connects below this level is represented at a nearby model node.

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4 Proposed EDGS and BBC Assumptions Book Variations

Below we summarise the main EDGS and BBC Assumptions Book variations we intend to use with this project.

4.1 EDGS Variations

Table 9: Demand variations

<table>
<tr><th>Assumption</th><th>2019 EDGS Value</th><th>Variation from EDGS</th><th>Rationale</th></tr>
<tr><td>Tiwai closure</td><td>Tiwai stays open in all scenarios. The reference scenario has a sensitivity case where Tiwai closes in 2030</td><td>Tiwai remains operational in all scenarios.</td><td>It has been announced that the Tiwai Point Aluminium Smelter contract has been extended to the end of 2044 (with an exit option from the end of 2034).</td></tr>
<tr><td>Base energy growth rate</td><td><table><tr><td>Scenario</td><td>CAGR (%)[12]</td></tr><tr><td>Reference</td><td>0.8</td></tr><tr><td>Growth</td><td>1.2</td></tr><tr><td>Global</td><td>0.2</td></tr><tr><td>Environmental</td><td>0.9</td></tr><tr><td>Disruptive</td><td>0.7</td></tr></table></td><td><table><tr><td>Scenario</td><td>CAGR (%)</td></tr><tr><td>Reference</td><td>0.5</td></tr><tr><td>Growth</td><td>0.7</td></tr><tr><td>Global</td><td>0.1</td></tr><tr><td>Environmental</td><td>0.6</td></tr><tr><td>Disruptive</td><td>0.4</td></tr></table></td><td>Consistent with NZGP1</td></tr>
<tr><td>Electrification of Process heat</td><td>2050 energy demand:<table><tr><td>Scenario</td><td>2050 demand by temperature (TWh)</td></tr><tr><td>Reference</td><td>Low: 1.5</td></tr><tr><td>Growth</td><td>Low: 1.9</td></tr><tr><td>Global</td><td>Low: 1.2</td></tr><tr><td>Environmental</td><td>Low: 1.9
Med: 4.6</td></tr><tr><td>Disruptive</td><td>Low: 1.9
Med: 4.9
High: 6.5</td></tr></table></td><td>2050 energy demand:<table><tr><td>Scenario</td><td>2050 demand by temperature (TWh)</td></tr><tr><td>Reference</td><td>Low: 4</td></tr><tr><td>Growth</td><td>Low: 5.1</td></tr><tr><td>Global</td><td>Low: 3.2</td></tr><tr><td>Environmental</td><td>Low: 5.1
Med: 3</td></tr><tr><td>Disruptive</td><td>Low: 5.1
Med: 3.2
High: 0</td></tr></table></td><td>The amount of low and medium temperature process heat is consistent with NZGP1. Conversion of high temperature heat has been removed. An s-curve has been used to better reflect the likely path of electrification.</td></tr>
</table>

12 CAGR: Compound Annual Growth Rate

Assumption	2019 EDGS Value	Variation from EDGS	Rationale
		Process heat electrification has been modelled using an updated s-curve.	
EV demand	2050 energy demand by scenario (No assumptions around smartness given) Scenario – 2050 EV demand (TWh) Reference – 4.1 Growth – 5.0 Global – 3.2 Environmental – 7.6 Disruptive – 7.6	Scenario – 2050 EV demand by smartness (TWh) Reference – Fixed: 3.2 Smart: 2.3 Growth – Fixed: 3.2 Smart: 3.5 Global – Fixed: 3.3 Smart: 0.9 Environmental – Fixed: 3.4 Smart: 5.6 Disruptive – Fixed (Light): 3.4 Smart (Light): 5.6 Fixed (Heavy): 1.7	Consistent with NZGP1 with minor updates.
EV charging smartness	Not specified	Smartness by 2050: Scenario – Smartness by 2050 (%) Reference – 40 Growth – 50 Global – 20 Environmental – 60 Disruptive – 50	The smartness in all scenarios except the Disruptive scenario is consistent with NZGP1. The smartness in the Disruptive scenario is set to 50% to better reflect uncertainties in EV charging.
Solar generation	Scenario – Generation in 2050 (TWh) Reference – 2.3 Growth – 2.8 Global – 0.9 Environmental – 4.6 Disruptive – 4.6	Scenario – Generation in 2050 (TWh) Reference – 3.1 Growth – 3.9 Global – 1.1 Environmental – 6.4 Disruptive – 6.4	Consistent with NZGP1
Residential solar uptake	Scenario – Number of 3 kW solar installations in 2050 Reference – 531,620 Growth – 655,330 Global – 190,210 Environmental – 1,076,300 Disruptive – 1,076,300	Scenario – Number of 3 kW solar installations in 2050 Reference – 797,420 Growth – 983,000 Global – 285,310 Environmental – 1,614,440 Disruptive – 1,614,440	Consistent with NZGP1

While not part of the EDGS assumptions, our demand forecasts for this project reflect:

- Updated information on step changes
- Recent historical demand
- Updated base peak demand across all scenarios to be more in line with EDB's GXP level forecasts.

Table 10: Generation variations[13]

<table>
<tr><th>Assumption</th><th>2019 EDGS Value</th><th>Variation from EDGS</th><th>Rationale</th></tr>
<tr><td>Generation stack</td><td>Details in generation stack not specified e.g., capital costs, named projects, capacity factor</td><td>Incorporate information from the 2020 generation stack updates, recent Transpower connection queries and news articles.</td><td>To incorporate newer and more detailed information.</td></tr>
<tr><td>Wind repowering</td><td>Wind repowering not mentioned in EDGS</td><td>Assume that all wind farms are repowered at the end of their 30-year lifetime (with increased capacity), or earlier if indicated by developers.</td><td>Assumption is consistent with the BBC Assumptions Book v2.0.</td></tr>
<tr><td>BESS (batteries)</td><td>Grid scale batteries not mentioned in EDGS</td><td>Include two, four and eight-hour batteries in our generation stack, based on cost information from the National Renewable Energy Laboratory (NREL).</td><td>To add an alternative peaking option. Assumption is consistent with the BBC Assumptions Book v2.0.</td></tr>
<tr><td>New generation cost decline</td><td>LRMC changes by 2050 are specified for wind and solar generation.

<u>Solar</u>
<table>
<tr><td>Scenario</td><td>Change</td></tr>
<tr><td>Reference</td><td>-50%</td></tr>
<tr><td>Global</td><td>-50%</td></tr>
<tr><td>Disruptive</td><td>-45%</td></tr>
</table>

<u>Wind</u>
<table>
<tr><td>Scenario</td><td>Change</td></tr>
<tr><td>Reference</td><td>-13%</td></tr>
<tr><td>Global</td><td>-7%</td></tr>
<tr><td>Disruptive</td><td>-27%</td></tr>
</table></td><td>Use future cost decline scenarios from NREL's 2023 annual technology baseline (ATB) to scale capital and fixed O&M (FOM) costs of generation stack projects. Wind, solar, geothermal and BESS project costs are scaled, and the cost decline is varied by scenario. The changes in the costs by 2050 are given in the tables below.

<u>Solar</u>
<table>
<tr><td></td><td>FOM change</td><td>CAPEX change</td></tr>
<tr><td>Environmental Disruptive</td><td>52%</td><td>40%</td></tr>
<tr><td>Reference Growth</td><td>60%</td><td>49%</td></tr>
<tr><td>Global</td><td>70%</td><td>64%</td></tr>
</table></td><td>Assumption is consistent with the BBC Assumptions Book v2.0.</td></tr>
</table>

13 Note that only the Environment, Growth and Reference scenarios are relevant for this analysis. We include information relating to all the scenarios for reference.

<table>
<tr><th>Assumption</th><th>2019 EDGS Value</th><th>Variation from EDGS</th><th>Rationale</th></tr>
<tr><td></td><td></td><td>Wind<table><tr><th>Scenario</th><th>FOM change</th><th>CAPEX change</th></tr><tr><td>Environmental Disruptive</td><td>51%</td><td>62%</td></tr><tr><td>Reference Growth</td><td>77%</td><td>68%</td></tr><tr><td>Global</td><td>88%</td><td>81%</td></tr></table></td><td></td></tr>
<tr><td>Geothermal emission</td><td>Not mentioned in EDGS but provided in 2020 geothermal generation stack.</td><td>Reduce emission rates from geothermal generation stack by 50% in the Growth scenario.</td><td>To account for the potential of CO2 reinjection.</td></tr>
<tr><td>Biofuel</td><td>Not mentioned in EDGS.</td><td>Add biofuel as a potential fuel source in our thermal generation stack</td><td>To add an alternative dry year option.</td></tr>
<tr><td>Long-term carbon price</td><td>NZ$66/t by 2050, except Environmental scenario (NZ$154/t by 2050)</td><td>Use long-term carbon prices from CCC10F[14] i.e., NZ$250/t by 2050 in all scenarios except Environmental. The carbon price from the International Energy Agency’s Net Zero Emissions scenario[15] is used for the Environmental scenario.</td><td>Assume long term carbon prices are consistent with net-zero emissions.</td></tr>
</table>

4.2 Assumption Book Variations

- The Ruakākā grid scale battery project schedule is updated from 2024 to 2025 based on more recent information.[16]
- AC losses for the WUNI region and the rest of the North Island were adjusted from the approach outlined in the Assumptions Book as described in Section 2.2 of Attachment 4 – Benefits Modelling.

[14] Climate Change Commission

[15] Net Zero Emissions by 2050 Scenario (NZE) – Global Energy and Climate Model – Analysis - IEA

[16] As the benefit modelling starts after 2025 this has no impact on the results.

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