Kaimai Hydro-Electric Power Scheme Re-Consenting

Manawa Energy Limited

Part B – Appendices

B.03 – Appendix D - Kaimai Economic Assessment - New Zealand Institute of Economic Research

Kaimai Hydro Scheme

Economic Assessment for Fast-track Approval Act 2024

NZIER report to Manawa Energy

8 September 2025

About NZIER

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Key points

This report provides an economic assessment of the continued operation of the Kaimai Hydro-Electric Power Scheme (HEPS), consistent with the decision-making framework under the Fast-track Approvals Act 2024 (FTAA). In this regard, the purpose of the FTAA is *'is to facilitate the delivery of infrastructure and development projects with significant regional or national benefits'*.

Kaimai HEPS generates 169 GWh per year– enough to power 24,600 homes

The Kaimai HEPS is located near Tauranga in the Western Bay of Plenty District, and is also within the jurisdiction of the Bay of Plenty Regional Council . The Kaimai HEPS is a run-of-river scheme with an installed generation capacity of 42MW and an annual average output of approximately 169 GWh, and is connected to grid injection point GIP TGA0331.

The Kaimai HEPS makes a substantial contribution to meeting peak demand and total output requirements for Tauranga, where demand for electricity is growing. The Kaimai HEPS contributes approximately 32 percent of Tauranga's total annual electricity demand.

Kaimai HEPS provides controllable intraday generation

Controllable[1] generation from low-cost non-fossil fuel is an increasingly valuable resource in the New Zealand electricity system. The expansion of new wind and solar generation increases the system requirement for controllable generation to cover periods when wind and solar electricity output are lower than expected. In addition, gas supply shortages and equipment failure have reduced the reliability of existing gas fuelled generation.

The principal benefit of the Kaimai HEPS is in harnessing energy from the flow of water to create a valuable product, electricity. In addition, intraday hydro generation is more predictable and controllable than wind and solar generation which means it is a more efficient means of meeting sustained demand for electricity than the other methods of renewable electricity generation that would be most likely to replace it. The output profile of wind or solar does not match the demand profile in the area as closely as the Kaimai HEPS output profile, and is not as controllable. (See Appendix C for a comparison of the intraday volatility of wind and Kaimai HEPS generation.)

It benefits the New Zealand economy

The main economic benefits of the Kaimai HEPS for the wider economy include:

- Maintaining the portfolio of controllable and predictable renewable energy generation, improving security of generation to meet demand and meeting these requirements more efficiently than would be possible through other new renewable generation.
- Avoiding the substantial cost (around $205.5 m) of constructing new generation (probably wind outside the area) and new peaker generation (probably gas fuelled

[1] Controllable generation in this report means generation which can have its output rapidly altered to meet fluctuations in demand. This capability is a function of both the ramp-up time of the plant and the time required to replenish the fuel used for generation.

thermal) to address the mismatch between wind output and the Kaimai HEPS. Our analysis finds that grid scale batteries are not suitable for covering this mismatch because their discharge period is far too short to cover the mismatch.

- Avoiding the potential increase in cost of fuel used for generation for the thermal component of the replacement generation.
- Avoiding the cost of grid upgrade and transmission losses that would be required if electricity had to be imported from outside the region.
- Helping New Zealand meet its emission reduction targets under the Paris Agreement by continuing to displace greenhouse gas emissions from thermal generation for either baseload or peak demand and avoiding an increase in emissions of about 26,693 tonnes of CO_2e per year.
- Provides local employment and investment to maintain the existing power stations and supporting infrastructure.
- Avoiding the risk of load shedding that could be required if Kaimai HEPS was not available to help meet Tauranga peak demand. The grid currently has constraints that limit the amount of electricity that could be supplied to Tauranga from outside the region.

Other policy consideration: Increased residual flows reduce electricity supply

A principle for decision makers to consider is to what extent electricity generation should be reduced to provide residual flows. The **current** residual flows at the Kaimai HEPS reduce electricity supply by 4.9GWh and this effect is included in the in the Kaimai HEPS replacement analysis. The **proposed** residual flows will reduce Kaimai HEPS generation by a further 5.7GWh or 3.4 percent of Kaimai HEPS output. The impact of this reduction could be assessed as 3.4 percent of the estimated impact of replacing the Kaimai HEPS output describe above. Alternatively the impact could be assessed as the cost of increasing thermal output from existing plant to meet the 5.7 GWh reduction plus transmission losses. At a minimum this would require additional fuel and variable operating costs of $0.7m per year and increase annual emissions by 2,651 tonnes of CO_2e per year.

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1 Assessment approach

1.1 Kaimai regional and national benefit

Manawa Energy has commissioned NZIER to undertake an assessment of the economic effects of the continued operation of the Kaimai Hydro-Electric Power Scheme (HEPS), which is located within the Kaimai Ranges[2] and the Wairoa River Catchment. The Scheme is approximately 12km southwest of Tauranga and 25km northwest of Rotorua.

Our approach is to compare the continuation of the Kaimai HEPS with the replacement of its output the next best alternative[3] – wind with a thermal peaker[4]. These facilities would most probably be constructed outside the Bay of Plenty Region and our calculations include average transmission losses of 3.2 percent. – in other words to replace the annual average electricity output of Kaimai HEPs of 169 GWh from outside the region would require 174.6 GWh of electricity output.

The Kaimai HEPS contributes to meeting peak demand and total annual demand requirements for electricity in Tauranga. If the Kaimai HEPS ceased operation this demand would need to be met from outside the Bay of Plenty Region. Due to transmission constraints into the Tauranga area, it would be more difficult to meet peak demand without the Kaimai HEPS (load shedding could be required).[5]

From a national perspective controllable electricity generation is an increasingly valuable resource due to:

- Growing volume demand and peak demand as light vehicle transport and industry process heat are electrified.
- Increasing proportion of the generation mix is wind and solar which does not have a controllable output and needs to be 'firmed' by controllable generation that can cover periods when demand exceeds wind and solar output.

2 The Kaimai HEPS consists of four power stations and three lakes linked by a complex network of tunnels and canals. Kaimai 5 is the first power station on the scheme and is the furthest from Tauranga (33 km). Ruahihi is the last power station on the scheme and is closest to Tauranga.

3 Other alternatives include geothermal and solar. Solar would have a worse match with the Kaimai output than wind and is discarded for that reason. Geothermal produces a steady output and would require significant thermal support. Also geothermal is more expensive to develop than wind and the opportunities for geothermal development are far more limited than those for wind. Battery storage is not suitable for covering the mismatch between the output of Kaimai HEPS and wind generation but the potential contribution of battery storage is described in the analysis of the next best alternative.

4 A thermal peaker burns fuel (usually natural gas) to generate electricity. It can be started and increased to full generating capacity in a matter of minutes and is usually run for short periods - a number of hours or days at a stretch. This main role of this capacity used to be meeting temporary peaks in demand. However, Its combination of rapid start/finish and controllable output makes it suitable for covering fluctuations in wind and solar generation.

5 Transpower 2023 Transmission Planning Report page 174 describes the issue as: '*Since 2020, with low generation at Kaimai, the peak load has exceeded the n-1 capacity of the two circuits connected at Tauranga (see Figure 10-5). The frequency and duration of the overload is very sensitive to the output of the Kaimai generation. ….From winter 2028, dispatching Kaimai generation at maximum output will not prevent the Tauranga peak load from exceeding the Kaitemako–Tauranga n-1 transmission capacity.'* Transpower outlines a solution but this will take several years to implement and notes that interim actions will be required which include: '*variable line rating on the two 110 kV circuits supplying Tauranga*' and '*modifying the Kaitemako intertrip special protection scheme and installing a special protection scheme to trip some load at Tauranga to remove overloads on both circuits connected at Tauranga'*.

- Reduced availability of thermal generation due to retirement of baseload plant and difficulty in securing sufficient fuel supply and increased cost of generation fuel for the remaining thermal plants.

1.1.1 Residual flows reduce electricity supply

Residual flow requirements on rivers and streams that supply the Kaimai HEPS reduce its electricity output. As part of this assessment, we also consider the effect of current residual flows, and the effect of increased residual flows on the electricity generated by the Kaimai HEPS.

The reduction is greatest for residual flows in rivers and streams at the head (or top) of the scheme (upstream of Kaimai 5 power station), but is still significant for the Mangakarengorengo River which supplies the Ruahihi Power Station only.

1.2 Fast track process criteria

This assessment has been prepared to support decision-making on the applications for the Kaimai HEPS under the FTAA. The purpose of the FTAA is *to facilitate the delivery of infrastructure and development projects with significant regional or national benefits.*[6]

The FTAA requires that the assessment panel gives the greatest weight to the purpose of the FTAA[7] when considering applications under the FTAA, but does not elaborate on or define metrics for '*significant regional or national benefits'.* However, the FTAA criteria that the Minister may consider for the referral of an application for consideration under the FTAA[8] provide some indication of potential components of significant regional and national benefit.

Table 1 below summarises the alignment between the main benefits of continuation of the Kaimai HEPS (avoidance of the cost of replacing existing viable hydro generation with a new wind and gas fuelled hybrid) with the FTAA criteria of national and regional benefit.

[6] See FTAA, 3 Purpose, page 8.

[7] See FTAA, 12 Criteria and other matters for assessment of consent application, Section (1)(a), page 167.

[8] See FTAA, 22B Criteria for assessing referral application, section 2 (a), pages 36 to 37.

Table 1 FTA benefit measures delivered by continuation of Kaimai HEPS

High level description of benefits described in more detail in the body of this report

FTA referral criteria	Kaimai HEPS benefit
(a) whether the project—	
(i) has been identified as a priority project in a central government, local government, or sector plan or strategy (for example, in a general policy statement or spatial strategy), or a central government infrastructure priority list:	The National Policy Statement on Renewable Energy Generation (NPSREG) is supportive of continuing existing hydro generation. The objective of NPSREG is: "*To recognise the national significance of renewable electricity generation activities by providing for the development, operation, maintenance and upgrading of new and existing renewable electricity generation activities, such that the proportion of New Zealand's electricity generated from renewable energy sources increases to a level that meets or exceeds the New Zealand Government's national target for renewable electricity generation.*"[1] Ensuring the continued operation of the Kaimai HEPS in the manner proposed in this application will meet the objectives in the NPSREG with respect to national renewable electricity targets.
(ii) will deliver new regionally or nationally significant infrastructure or enable the continued functioning of existing regionally or nationally significant infrastructure:	Enabling the continued functioning of infrastructure that is critical to meeting the electricity demand of Tauranga (and the surrounding area) in aggregate and with the flexibility to be adjusted to intra-day variations in demand efficiently. The Kaimai HEPS meets 32 percent of Tauranga's electricity and due to grid constraints plays an important role in meeting Tauranga's peak demand.
(iv) will deliver significant economic benefits:	Avoid cost and increased greenhouse gas emissions of replacing Kaimai HEPS with hybrid wind and thermal generation and diversion of scarce gas resources to generation. Continued local employment for maintenance work. Approximately 150-200 people, including contractors, work at the Kaimai HEPS over the course of any given year (typically for specific projects for part of the year) (Note: The 150-200 people are not full time employees.)
(vii) will support climate change mitigation, including the reduction or removal of greenhouse gas emissions:	Avoidance of increased greenhouse gas emissions required from thermal generation to replace some of Kaimai HEPS output (estimated at 25,900 tonnes CO_2e per year.) Climate Change Commission advice[2] in 2023 estimated that 657 MW of wind capacity would need to be built over 2026 to 2030. The wind component of the replacement of Kaimai HEPS would add 50 MW to this construction task.

Source: NZIER

1.3 Economics in the Fast-track Approvals Act and Resource Management Act

This economic assessment has been prepared with consideration to the purpose of the FTAA (section 3) and sections 5, 6 and 7 of the RMA.

The purpose of the FTAA is to facilitate the delivery of infrastructure and development projects with significant regional or national benefits. Section 81(4) provides that an Expert Panel may consider the extent of a project's regional or national benefits when taking the purpose of this Act into account. Clause 17(1) Schedule 5 to the FTAA provides that when considering a consent application and setting conditions, the Expert Panel must take into account the purpose of the FTAA (giving the greatest weight to the purpose of the FTAA), the provisions of Parts 2 3, 6, and 8 to 10 of the RMA (excluding section 104D), and relevant provisions of any other legislation that directs decision making under the RMA.

The Kaimai HEPS makes a significant contribution to efficiently meeting Tauranga's total electricity demand and intraday variations in demand., The cost of replacing this capacity with new generation is material (as is detailed later in this report) and can be avoided by providing for the continued operation of the Kaimai HEPS

The purpose of the RMA is to promote the sustainable management of natural and physical resources. Section 5 defines sustainable management as managing the use, development and protection of natural and physical resources in a manner that enables people and communities to provide for their social, economic and cultural wellbeing while:

- sustaining natural and physical resources to meet reasonably foreseeable needs
- safeguarding life-supporting capacities of air, water, soil and ecosystems; and
- avoiding, remedying or mitigating adverse effects of activities on the environment.

The RMA defines the environment broadly to include people and communities and the social, economic and cultural conditions which affect them.

Explicit recognition of economic considerations under the RMA include section 5's references to enabling communities to provide for their economic wellbeing, and section 7(b)'s requirement to have regard to efficient use and development of natural and physical resources.

This report demonstrates the regional and national benefits of continuation of the Kaimai HEPS by describing the following:

- The significant contribution of the Kaimai HEPS to the local and national electricity supply by providing electricity output which can be varied to meet intra-day fluctuations. This capacity is increasingly scarce in the system and the high cost of replacing any loss in the generation capacity and output of the Kaimai HEPS can be avoided by providing for the continued operation of the Kaimai HEPS. Even though the Kaimai HEPS is embedded in a local lines network, it still provides national benefit by reducing the demand that must be met from other generation across the national grid, and in times of surplus generation it can export power across the grid to meet other demands beyond its local region.
- Estimated difference between the output patterns of the Kaimai HEPS output and generic wind generation producing the same annual output as the Kaimai HEPS.
- Indicative additional cost of the next best alternative (wind and gas fuelled thermal generation combination) required to replace the Kaimai HEPS if it ceased operation. The additional generation capacity required is small relative to the size of new wind and existing thermal plants. Accordingly this assessment assumes that if the additional capacity was required it would be added to another wind project or expansion of

thermal plant outside the region. The assessment also includes the cost of transmission losses.

Constraints on the capacity of the grid supplying Tauranga prevent it from replacing all of the Kaimai HEPS supply with imports of electricity from outside the region. The potential for load shedding in Tauranga if the Kaimai HEPS output is reduced is an additional risk to the security of supply for Tauranga. The cost of potential load shedding has not been quantified in this analysis but should be kept in mind by decision makers

Transpower has received 'draft decision approval' from the Commerce Commission [9] for a major capital project to increase the capacity of the grid supplying Tauranga. However, this project will not be fully commissioned until 2032. The project plan assumes the Kaimai HEPS will continue to operate[10].

2 The existing environment around the Kaimai HEPS

2.1 Impacts of the Kaimai HEPS on its region

Assessments of environmental effects in support of consent applications commonly start with a description of the existing environment to act as counter-factual against which to compare the effects of a new proposal. Rather than focus on the biophysical characteristics of a proposed site, for economic assessments of an existing HEPS the environment consists of the economy and the wider electricity system to which it contributes and which would be impacted if the HEPS were no longer able to operate.

The economic environment is primarily that of the region which will be most affected by continuation of the HEPS, as any project has a much smaller proportional impact on the national economy. For the electricity system the perspective is more that of contribution to national issues such as the security of electricity supply, its emissions profile and short run marginal cost (SRMC) of the highest priced generator that runs in any given trading period[11].

2.2 Electricity situation in the Bay of Plenty region and New Zealand

2.2.1 The national electricity supply system

Electricity is a vital energy source for modern societies, powering industrial production as well as residential consumption. For some uses, such as electronic appliances, there is no substitute. It is currently not technically or cost-effectively feasible to store electricity in

[9] Commerce Commission '(2025) 'Transpower's Western Bay of Plenty (WBOP) major capex project proposal [DRAFT] decision and reasons paper Date of publication: 3 April 2025' downloaded from https://comcom.govt.nz/__data/assets/pdf_file/0023/365414/Transpower27s-Western-Bay-of-Plenty-major-capex-project-5BDRAFT5D-decision.pdf

[10] Transpower (2024) Western Bay of Plenty Development Plan: Major Capex Proposal Attachment 3 - Demand and Generation Scenarios, December 2024', page 18, section 3.2

[11] The New Zealand electricity market is an energy only market. Generators offer to supply set volumes of electricity at varying prices depending on their short run marginal cost (SRMC) and other factors such as warm-up times and other obligations. The system operator 'dispatches' the supply offers in ascending price order until the demand is met for the trading period. The highest offer price that is dispatched sets the wholesale price for the trading period irrespective of the volume supplied (as long as it is greater than zero). .All generators that are selected to supply electricity in the trading period receive the wholesale price for the trading period irrespective of their offer price.

large quantities so continuous supply is required if disruptive power outages are to be avoided. Too far from other countries to be connected to their reticulated energy infrastructure, New Zealand has to be self-sufficient in its electricity supply. It does this with a mix of generation across both main islands, with a national transmission grid linking generation sources with areas of demand.

More detail on the New Zealand electricity system is included in Appendix A.

2.2.2 Electricity generation in the Bay of Plenty region

The region has three main clusters of generation activity:

- 'Tauranga' consisting of the Kaimai HEPS and a small gas-fuelled thermal cogeneration plant at Mount Maunganui owned by Ballance Agri-Nutrients Ltd.
- 'Rotorua': consisting of the Wheao HEPS and small wood fuelled thermal cogeneration plant just outside Rotorua owned by Red Stag.
- 'Kawerau-Matahina -Edgecumbe' which contains most of the generation capacity in the region and produces the bulk of the electricity generated in the region (as the output per MW of capacity is much higher for geothermal and hydro than for solar). Kawerau has 191 MW of geothermal generation capacity, Matahina and Aniwhenua have 80 and 25 MW of hydroelectric generation capacity respectively ,and Edgecumbe has 10 MW of gas fuelled generation plus 24 MWac[12] of solar generation

More solar generation capacity Is planned for Edgecumbe with the construction of 115 MW (connected)[13] solar farm by a joint venture between Genesis and Helios. In addition to these clusters a 41 MW solar farm is nearly complete at Waiotohe[14].

Roopu Whakarite Mahi Limited Partnership has also been granted consent to construct Taheke Geothermal Power Station - a 25 MW to 40 MW electricity generation plan to be located at Okere Falls, Rotorua.

Table 2 below outlines the existing electricity generation plant connected to the national grid or distribution networks. Our description of electricity generation in the region is based on Transpower's 2023 Transmission Planning Report[15] updated for the actual development of new solar generation over 2024.

12 The capacity of the Lodestone Edgecumbe farm is stated as 32 MWp at https://lodestoneenergy.co.nz/edgecumbe/ To ensure all of the capacity amounts were stated in MWac -I estimated the MWac capacity of the Edgecumbe farm at just under 80% of MWp - 25 MWac based on reported output for other solar farms.

13 Genesis reports that the nominal capacity of the solar farm will be 127 MW with an expected annual average output of 54 GWh – see www.genesisenergy.co.nz/about/news/genesis-secures-new-solar-site-in-bay-of-plenty. Transpower's Generation Connection Pipeline - updated 18 Dec 2024 available on https://www.transpower.co.nz/connect-grid/connection-enquiry-information lists the maximum connection for the next Edgecumbe solar plant at 115 MW. It is normal for solar farms to have a grid connected capacity that is lower than their maximum photovoltaic capacity.

14 The solar farm is called Te Herenga o Te Rā is owned by Lodestone and is expected to generate 69 GWh per year. Transpower's Generation Connection Pipeline states a maximum capacity for this connection of 58 MW which suggests an expansion may be planned.

15 Transpower, Transmission Planning Report 2023 , Table 10-2: Existing and committed generation capacity at Bay of Plenty grid injection points, page 169

Table 2 Existing generation in the Bay of Plenty region

Capacity (MW) and annual output (GWh)

Plant	Fuel	Capacity (MW)	Grid injection point	Output for YE 30 Sep 2023 (GWh)	Output for YE 30 Sep 2024 (GWh)
Tauranga					
Kaimai[1]	Hydro	40	TGA0331	206	201
Ballance Agri	Gas	7	MTM0331	4	4
Sub total		**47**		**210**	**205**
Rotorua					
Wheao Flaxy	Hydro	26	ROT1101	147	85
Red Stag[2]	Wood waste	3	ROT0331	3	6
Sub total		**29**		**150**	**92**
Edgecumbe			EDG0331	8	24
Bay Milk	Gas	10			
Rangitaiki[3]	Solar	24			
Sub total		**34**		**8**	**24**
Kawerau					
Kawerau – KAG	Geothermal	107	KAW1101	662	878
Onepu[4]	Geothermal	60	KAW0112	189	232
Te Ahi O Maui	Geothermal	24	KAW0111	197	189
Sub total		**184**		**1,047**	**1,299**
Matahina			MAT1101	563	375
Matahina	Hydro	80			
Aniwhenua	Hydro	25			
Sub total		**105**		**563**	**375**
Total		**499**		**1,978**	**1,995**

Notes:

1 Kaimai injects electricity at the Tauranga 33 kV bus (TGA0331).

2 Transpower reports this scheme as Fletcher Forests but it is now owned by Red Stag. The plant is a wood waste fuelled cogeneration plant that meets the steam and electricity requirements of the sawmill.

3 Rangataiki began operating in 2024 and is expected to generate 54 GWh per year on average. Its nominal photo voltaic capacity is 32 MW but Transpower report its connected capacity at 24 MW.

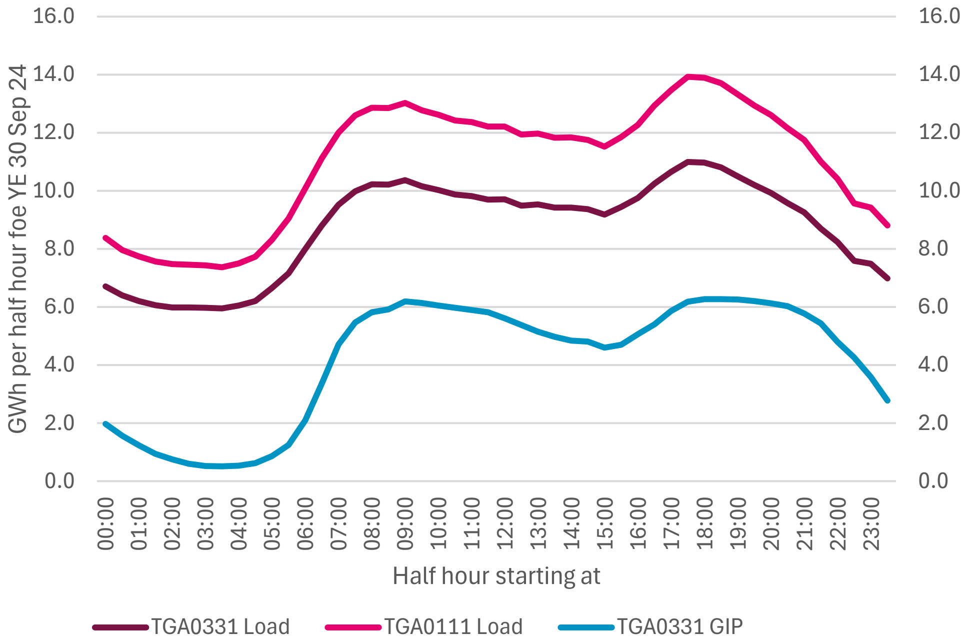
4 Onepu is the market designation for the aggregation of the following four generators: GDL/KA24 (9 MW), TA2 (16 MW), TA3 (8 MW) and TOPP1 (27 MW).

Source: NZIER

2.2.3 Role of Kaimai HEPS

The Kaimai HEPS annual average generation output of approximately 169 GWh makes a significant contribution to meeting Tauranga's demand[16] for electricity of 528 GWh (about 32 percent of Tauranga's electricity use over the year ended (YE) 30 September 2024) and provides controllable generation that can be varied with changes in Tauranga demand during the day as shown in Figure 1

Figure 1 Tauranga demand and Kaimai generation by half hour



Source: NZIER

The generation shortfall of 359 GWh needs to be imported. If Kaimai HEPS ceased operation, the shortfall would be increased by 47 percent. Similarly, if significant changes were made to the operation of the Kaimai HEPS (i.e. increased residual flows), then the shortfall would need to be imported.

Transpower's network planning

Grid constraints prevent Tauranga from importing all the electricity it requires from outside the region at peak periods and it needs the output from the Kaimai HEPS to cover the gap between Tauranga demand and imports.

Transpower's plan[17] provides the following additional insight into how the Kaimai HEPS helps to match demand and supply for Tauranga:

- In 2023 some Western Bay of Plenty electricity demand was met from outside the Bay of Plenty region via Kaitemako. Overloads on this circuit can be managed

[16] This is the combined load of TGA0111 and TGA0331.

[17] Transpower 2023 'Transmission Planning Report, 2023' pages 173 and 174, Available at https://static.transpower.co.nz/public/uncontrolled_docs/Transmission%20Planning%20Report%202023.pdf.

'*operationally post-contingency, by increasing Kaimai generation. This operational measure is expected to become insufficient by 2026-2027'*[18].

- *Since 2020, with low generation at Kaimai, the peak load has exceeded the n-1 capacity of the two circuits connected at Tauranga (see Figure 10-5). The frequency and duration of the overload is very sensitive to the output of the Kaimai generation*[19].

Both peak and gross energy demand are expected to grow rapidly in Tauranga and Mount Maunganui due to a combination of population growth and step load changes such as expansion of the Port of Tauranga. In 2023, Transpower, forecast prudent annual peak demand for the two Tauranga grid exit points (GXP) and was 127 MW in 2024 increasing by 17 percent to 149 MW by 2030.[20] In 2024 Transpower increased the forecast rate of demand growth with peak demand in 2030 forecast at 180 MW for 2030[21].

As stated in more detail section 1.3, Transpower intends to increase the capacity of the grid supplying Tauranga but the upgrade will not be completed until 2032 and assumes the Kaimai HEPS will continue to operate.

2.2.4 Effect of residual flows on generation

The annual 'missed' output from the Kaimai HEPS attributable to the existing residual flows is estimated at 4.9 GWh comprising:

- Opuiaki River – 3.84 GWh due to a residual flow of 0.28 m^3 per second which lowers the output of the Kaimai 5, Lloyd Mandeno and Lower Mangapapa power stations.
- Ngatuhoa Stream – 0.82 GWh due to a residual flow of 0.06 m^3 per second which also lowers the output of the Kaimai 5, Lloyd Mandeno and Lower Mangapapa power stations.
- Mangakarengorengo Stream – 0.24 GWh due to a residual flow of 0.04 m^3 per second which lowers the output of the Ruahihi power station.

See Appendix D for the methodology used for this estimate and in particular Table 12 for estimates of the effect of the consented residual flows on each of the power stations that comprise the Kaimai HEPS. The water flows in our analysis are reported in cubic metres (m3) per second - 1 m^3 per second equals 1,000 litres per second.

2.3 Alternatives to Kaimai HEPS – overview

As Kaimai HEPS provides controllable renewable generation within the network it serves, it will be harder and more expensive to replace with new supply than it would be to continue the scheme. While the volume of energy produced by Kaimai HEPS could be generated from wind, it cannot match the profile or controllability of the Kaimai HEPS output. From a cost benefit analysis (CBA) perspective, the cost of any alternative to the Kaimai HEPS has four components:

18 Transpower 2023 'Transmission Planning Report, 2023' page 173

19 Transpower 2023 'Transmission Planning Report, 2023' page 174

20 Transpower 2023 'Transmission Planning Report, 2023' page 168

21 Transpower 2024, 'Western Bay of Plenty Development Plan: Major Capex Proposal Attachment 3 - Demand and Generation Scenarios', Table 11: Disruptive scenario expected GXP peak demand, page 24.

- Capital cost of the new generation to supply the annual average output of the Kaimai HEPS.
- Transmission losses and cost of bringing forward transmission upgrades.
- Capital costs of the solution used to replicate the Kaimai HEPS output profile.
- Increased electricity production costs to the extent that the new methods of generation have higher operating cost.

2.3.1 Meeting annual average demand

If the Kaimai HEPS average annual electricity output of 169 GWh[22] was not available it would need to be replaced by another form of generation. The most likely method of replacement for the average annual electricity output would be wind generation[23]. The total electricity generated by Kaimai HEPS of 169 GWh would need to be replaced along with additional output to cover transmission losses estimated at 5.4 GWh (3.2 percent of output[24]) if the new generation plant had to be located outside the Bay of Plenty Region. Therefore the total replacement average annual electricity output would be 174.4 GWh - Kaimai HEPS of annual average electricity output 169 GWh plus annual average transmission losses of 5.4 GWh .The capacity of the Tauranga GXP and the transmission links would need to be upgraded to cover the loss of generation from Kaimai.

Assuming a capacity utilisation factor of 40 percent the wind farm capacity required to supply an annual average output of 174.4 GWh (to replace the Kaimai HEPS average annual output plus transmission losses) would be approximately 50.0 MW. The estimated construction cost for wind farms have been rising over the past three years and vary with location. For this analysis we have used an estimate of $3.33 m per MW[25] which suggests a capital cost of $166.5 m to replace the output for a period of 25 to 30 years. (In addition, the windfarm will incur operating cost estimated at $2.6 m to $3.5 m per year based on an assumption of $15 to $20 per MWh.)

2.3.2 Wind cannot meet intraday variation in demand

However, the additional wind generation alone would not be sufficient to replace the Kaimai HEPS as the output profile of the Kaimai HEPS is much better suited to meeting the daily demand pattern at the Tauranga GXP than wind generation. This is illustrated in Figure 2 below which compares total electricity volumes for each half hour period:

- Tauranga demand from TGA0331 and TGA0111.

22 This is the average output of the scheme stated by Manawa Energy and is used as the basis for the replacement cost calculations in this report.

23 We have based our analysis on wind generation being used to replace the Kaimai HEP annual average output because we believe this will be the lowest cost and most readily available alternative. Although wind and solar capital costs required to produce the same annual average output are comparable, the profile of wind output is a better match to the profiles of local demand and the output delivered by the Kaimai HEPS than the profile of solar output. This means wind generation would require less thermal firming than solar. At the time of writing the potential for expansion of electricity output from wind is higher than for geothermal.

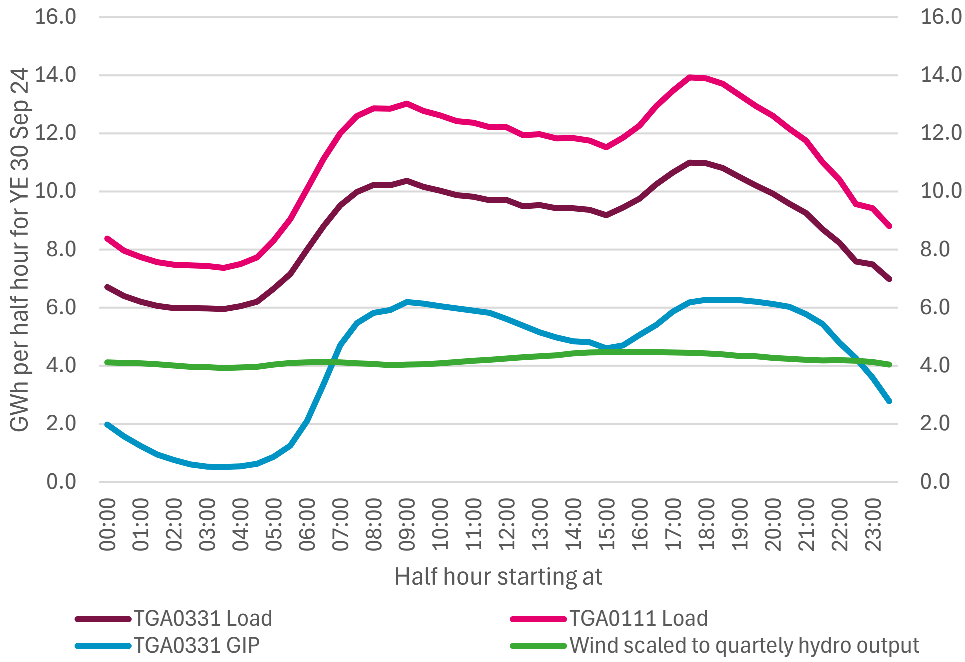
24 MBIE , 2024, 'Electricity data tables, 2 – Annual GWh' reports Net Generation of 43,488 GWh and Total Line Losses -Transmission of 1,404 GWh or 3.2 percent of Net Generation. (This information is for the 2023 calendar year. MBIE does not include transmission losses in its quarterly data.)

25 Mercury Energy has recently announced the commencement of construction of two new wind farms:

- Kaiwera Downs Stage 2 at a cost of $486 m for an additional 155 MW of capacity – average cost of $3.14 m per MW. See https://www.mercury.co.nz/about-us/renewable-energy/new-builds-and-upgrades .
- Kaiwaikawe at a cost of $287 m for 77 MW -average cost of $3.72 m per MW. See https://www.mercury.co.nz/about-us/renewable-energy/wind-generation/kaiwaikawe-wind-farm .

- Electricity injected at TGA0331 – the grid injection point for the Kaimai HEPS
- Wind generated electricity output for New Zealand scaled to the total electricity injected at TGA0331output in each quarter.

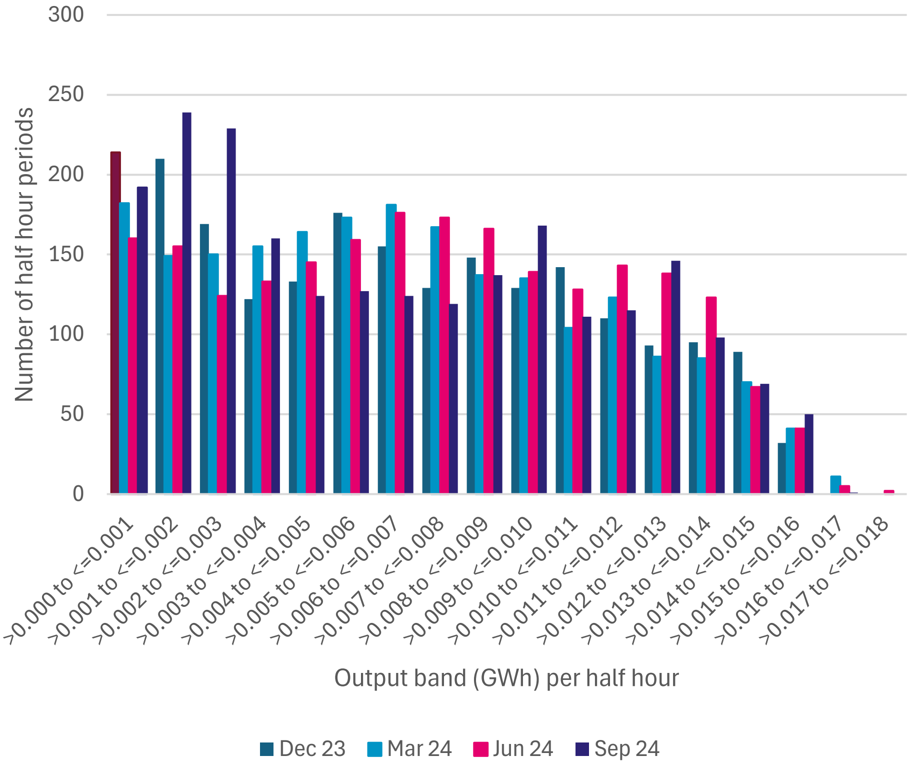
Figure 2 Electricity volume for the quarter ended 30 September 2024



Source: NZIER

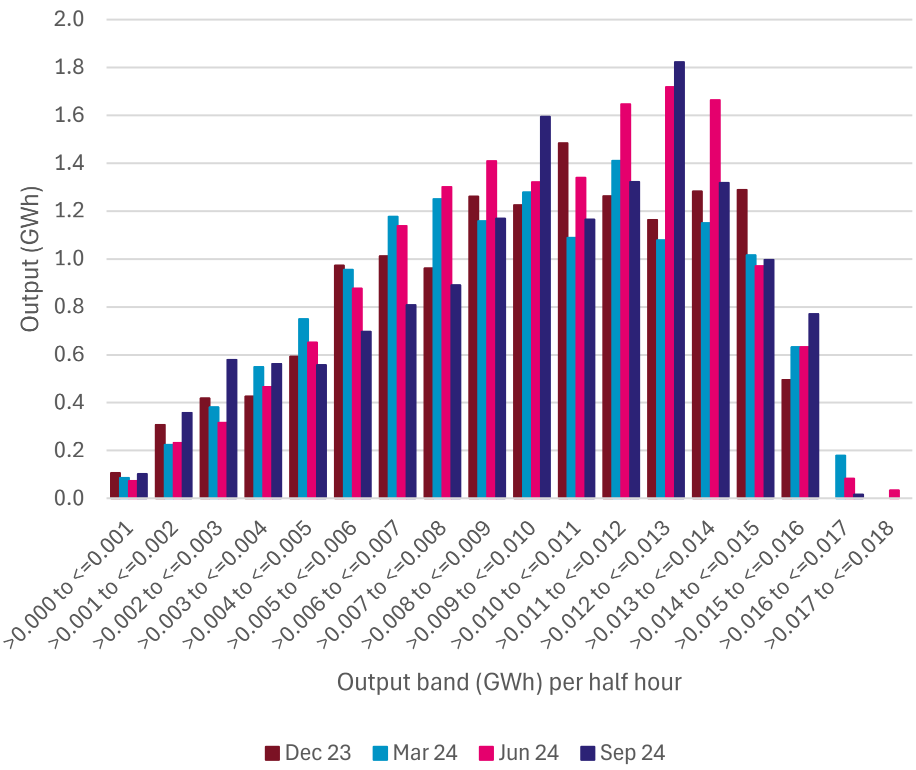
Figure 3 and Figure 4 below provide a more granular analysis of the output supply gaps based on that would arise if wind generation were used to replace the Kaimai HEPS at its stated average output of 169 GWh per year plus transmission losses.

Figure 3 Number of half hour supply gap periods grouped by half hour output



Source: NZIER

Figure 4 Total output supply gap in 0.1GWh bands



Source: NZIER

2.3.3 New wind generation requires thermal firming

For wind generation to substitute for the Kaimai HEPS on average it would need to be supplemented by .additional controllable peak generation that would cover the periods where wind generation is projected to be lower than the Kaimai HEPS generation (as illustrated in Figure 4). Our analysis assumes that this would be gas fuelled thermal generation[26]. The required capacity and energy output for the thermal generation would be determined by the gap between wind and the Kaimai HEPS output (plus transmission losses for the energy output).

We have considered the use grid scale battery storage also called battery energy storage system (BESS)[27] to cover the mismatch between the wind and Kaimai HEPS generation profiles. However, as the following analysis in section 2.4 shows, grid scale batteries are poorly suited to bridging the gap between wind output. Most of the continuous periods

[26] The supplementary generation needs to be 'dispatchable' – output that can be adjusted to meet demand (subject to availability of fuel.) The most readily available source of this capability would be gas fuelled thermal capacity. Coal fired thermal is a theoretical but very unlikely alternative. Genesis the owner of the only large scale coal fired generator in New Zealand regards coal as a transition fuel to support energy security and intends to replace coal with biomass – as soon as a domestic torrefied wood pellet supply chain can be developed. (See Genesis Energy Limited Integrated Report 2025 pages 5 and 12. Downloaded from https://media.genesisenergy.co.nz/genesis/investor/2025/genesis_fy25_integrated_report.pdf .)

[27] A BESS would store the excess energy generated from about 23:30 to 7:00 the next day and between 11:00 and 16:30 so that it could be discharged during peak demand periods of 7:00 to 11:00 and the 16:30 to 23:30. Assuming a round-trip efficiency of 85 percent use of batteries would require a further 17.6 percent of energy in addition to the energy output that the battery replaces. This would further increase the new wind generation capacity required to replace the Kaimai HEPS. (The source for the round trip efficiency is National Renewable Energy Laboratory, 2024, 'Utility-Scale Battery Storage, Annual Technology Baseline' available at https://atb.nrel.gov/electricity/2024/utility-scale_battery_storage .

(strings) over which Kaimai HEPS output exceeds wind output are too long for the discharge capacity of batteries let alone effective operation of the battery electricity price arbitrage model. (This model relies on intraday electricity price fluctuation which suggest one or at most two charge/discharge cycles per day.)

2.4 Comparing Kaimai HEPS and wind output – year ended 30 September 2024

Wind generation output is much more volatile than the smooth output shown in Figure 2 and the battery would also need to cover this volatility. We have estimated the task required for battery storage by comparing the half hourly output from Kaimai HEPS to the half hourly output from wind generation (scaled back to the stated output of Kaimai HEPS) over the year ended 30 September 2024. From this comparison we have identified continuous strings of half hour trading periods where output from the Kaimai HEPS exceeds the output from the hypothetical replacement wind farm generation. The results from this analysis are summarised in:

•

- Table 3 below, which reports the number of ‘strings’ and the total excess demand for those strings grouped in bands of 0.1 GWh (100 MWh) for the total excess demand for each string. This indicates the gross gap that needs to be bridged by storage technology to match wind farm output to the Kaimai HEPS output profile.
- Table 4 below, which reports the total length of the strings and the average length of the strings counted in half hour periods. This indicates how long the storage needs to be able to discharge to cover the excess period. This is much longer than the length of cycle used in the BESS energy arbitrage model and implies discharge during a combination of low and high priced periods which is further departure from the BESS electricity price arbitrage model.
- Table 5 below which reports the total excess demand per string and average excess demand per half hour period. This indicates that the required ratio of energy storage to power capacity is much higher than that offered by existing battery technology.

Table 3 Kaimai HEPS excess output – string totals by 0.1 GWh band

Using wind generation for YE 30 September 2024 scaled to Kaimai output of 169 GWh plus transmission losses

Band (GWh)	Number of excess demand strings					Total excess demand (GWh)				
	Dec 23	Mar 24	Jun 24	Sep 24	Total	Dec 23	Mar 24	Jun 24	Sep 24	Total
>0.0 to <=0.1	107	73	69	97	346	2.5	2.0	1.8	2.3	8.6
>0.1 to <=0.2	11	17	28	21	77	1.6	2.5	3.9	2.9	10.9
>0.2 to <=0.3	10	21	19	11	61	2.6	5.2	4.7	2.8	15.2
>0.3 to <=0.4	14	6	14	13	47	5.0	2.2	4.7	4.5	16.4
>0.4 to <=0.5	2	4	2	4	12	0.8	1.7	0.8	1.7	5.1
>0.5 to <=0.6										
>0.6 to <=0.7				1	1				0.6	0.6
>0.7 to <=0.8		1			1		0.7			0.7
>0.8 to <=0.9	2				2	1.7				1.7
>0.9 to <=1.0										
Total	**146**	**122**	**132**	**147**	**547**	**14.3**	**14.4**	**15.9**	**14.7**	**59.2**

Source: NZIER

The key points from Table 3 for the output replacement requirements are:

- The challenge is material and difficult with storage output of just over 69 GWh (41 percent of the Kaimai HEPS output) required over 547 separate strings - a small number of cycles compared to those assumed in the BESS arbitrage modelling.
- There are two distinct output replacement challenges:
  - Small output gaps that occur often – the 346 strings in the top row of Table 3 with a total output gap of 8.55 GWh and an implied average output gap of 0.025 GWh per string. If these strings were short duration (one to two hours) they could be met by a small battery with a capacity of 13MW to 25MW. However, because the number of strings is low the battery would be underused.
  - Large output gaps that occur infrequently - the 201 strings in the 17 rows below the top row of Table 3 with a total output gap of 50.67 GWh and an implied average output gap of 0.252 GWh per string. If these strings were short duration (one to two hours) they would require a large battery 125MW to 250MW.

Even at the high-level analysis in Table 3, BESS does not look like a suitable solution for matching the Kaimai HEPS and replacement wind farm profiles as the matching task requires discharge of larger amounts of energy on a much smaller number of occasions than the BESS energy arbitrage model.[28] The lack of suitability of BESS for this task is more obvious from the analysis in Table 4 which summarises the average length of the ‘strings’ in half hour period and the average energy output required per half hour period.

28 The modelling assumes that the replacement wind generation has the same characteristics as the diversified portfolio of existing wind farms and allows for transmission losses.

Table 4 Kaimai HEPS excess output – total and average string length in half hours

Using wind generation for YE 30 September 2024 scaled to Kaimai output of 169 GWh plus transmission losses

Band (GWh)	Total length of excess demand strings (half hour periods)					Average length of excess demand strings (half hour periods)				
	Dec 23	Mar 24	Jun 24	Sep 24	Total	Dec 23	Mar 24	Jun 24	Sep 24	Total
>0.0 to <=0.1	747	576	473	727	2,523	7.0	7.9	6.9	7.5	7.3
>0.1 to <=0.2	287	369	526	421	1,603	26.1	21.7	18.8	20.0	20.8
>0.2 to <=0.3	317	715	590	374	1,996	31.7	34.0	31.1	34.0	32.7
>0.3 to <=0.4	534	221	514	469	1,738	38.1	36.8	36.7	36.1	37.0
>0.4 to <=0.5	84	146	74	154	458	42.0	36.5	37.0	38.5	38.2
>0.5 to <=0.6										
>0.6 to <=0.7				64	64				64.0	64.0
>0.7 to <=0.8		86			86		86.0			86.0
>0.8 to <=0.9	177				177	88.5				88.5
>0.9 to <=1.0										
Total	**2,146**	**2,113**	**2,177**	**2,209**	**8,645**	**14.7**	**17.3**	**16.5**	**15.0**	**15.8**

Source: NZIER

The numbers in Table 4 are counts of half hour periods and need to be divided by two to convert them to hours. The key points from Table 4 for the storage requirements are:

- The replacement output is required over a long period, 4,322.5 hours which is about 49 percent of a year.
- There are at least two distinct output requirements:
  - Short duration output – the 1,261.5 hours of output with an average string length less than 4 hours in the first row of Table 4.
  - Long and very long duration discharges – the 3,061 hours in the 17 rows below the top row of Table 4. For all these bands (>0.1 GWh of energy) the average discharge duration is just over 15 hours and the minimum average discharge duration is 9.5 hours. These discharge durations are outside the effective operating range of the BESS energy arbitrage model.

Table 5 Kaimai HEPS excess output – average energy per string and half hour

Using wind generation for YE 30 September 2024 scaled to Kaimai output of 169 GWh plus transmission losses

Band (GWh)	Average energy per excess demand string (GWh)					Average energy per half hour period (GWh)				
	Dec 23	Mar 24	Jun 24	Sep 24	Total	Dec 23	Mar 24	Jun 24	Sep 24	Total
>0.0 to <=0.1	0.023	0.027	0.026	0.024	0.025	0.003	0.003	0.004	0.003	0.003
>0.1 to <=0.2	0.147	0.148	0.138	0.138	0.142	0.006	0.007	0.007	0.007	0.007
>0.2 to <=0.3	0.259	0.248	0.246	0.252	0.250	0.008	0.007	0.008	0.007	0.008
>0.3 to <=0.4	0.358	0.366	0.337	0.345	0.350	0.009	0.010	0.009	0.010	0.009
>0.4 to <=0.5	0.425	0.427	0.419	0.413	0.421	0.010	0.012	0.011	0.011	0.011
>0.5 to <=0.6										
>0.6 to <=0.7				0.611	0.611				0.010	0.010
>0.7 to <=0.8		0.739			0.739		0.009			0.009
>0.8 to <=0.9	0.847				0.847	0.010				0.010
>0.9 to <=1.0										
Total	**0.098**	**0.118**	**0.120**	**0.100**	**0.108**	**0.007**	**0.007**	**0.007**	**0.007**	**0.007**

Source: NZIER

The key points from Table 5 for the storage requirements mirror the observations drawn from Table 4:

- The ratio of the average energy output to the average capacity required[29] is about 7.9 compared with 2 for BESS planned for New Zealand.
- There are at least two distinct output replacement requirements:
  - Potentially BESS compatible – the average ratio of energy output to capacity required is 3.65 for the first row of Table 5. Although this is higher than the ratio of 2 for BESS planned for New Zealand it is less than the ratio of 4 to 6 for BESS used in Australia.
  - Not compatible with BESS – the average ratio of energy output to the average capacity required is 15.23 for the 17 rows below the top row of Table 5.

2.4.1 Role of storage and new thermal generation

The analysis in Table 3, Table 4 and Table 5 indicates that the short term storage task is about 14 percent of the energy output gap which occurs over 29 percent of the duration of the output gap. The remaining 86 percent of the energy output gap which covers 71 percent of the duration of the output gap would definitely require new controllable generation. In this section we analyse the suitability of BESS for the short-term storage task by comparing BESS capability to the length of the excess demand strings.

29 The ratio is calculated from the data in Table 5 as 'Average energy per excess demand string'/(Average energy per half hour period *2).

BESS – potential 14 MW to cover 2 percent of the energy output gap

BESS configurations used in New Zealand can only play very a limited role in covering the difference between the Kaimai HEPS output and wind farm output (when the Kaimai HEPS output exceeds wind farm output). For this analysis, I calculate the BESS required to cover strings with a length of up to 4 hours (8 half hour periods). The excess demand pattern for the year ended 30 September 2024 is shown in Table 6 below. The BESS would need to deliver 1.25 GWh of energy. Based on the data used to prepare Table 6, I estimate the BESS would need a capacity of 14 MW[30]. The estimated capital cost[31] of this BESS would be $28.5m and the arbitrage income[32] would be approximately $0.15m per year. This would be less than 10 percent of the income required to cover the capital cost of the battery.

The BESS cost estimates used above are based on Australian installations because they offer the 4 hour discharge period used in the modelling. The costs for recent New Zealand battery installations which only offer a 2 hour rather than 4 hour discharge period are substantially higher than the Australian cost estimates.

Table 6 Kaimai HEPS excess output – potential BESS coverage

Using wind generation for YE 30 September 2024 scaled to Kaimai output of 169 GWh plus transmission losses

Number of half hour periods	Number of excess demand strings					Total excess demand (GWh)				
	Dec 23	Mar 24	Jun 24	Sep 24	Total	Dec 23	Mar 24	Jun 24	Sep 24	Total
1	26	15	16	10	67	0.01	0.00	0.01	0.01	0.03
2	14	9	8	10	41	0.03	0.01	0.01	0.02	0.08
3	5	8	3	13	29	0.01	0.02	0.00	0.05	0.08
4	6	2	1	8	17	0.05	0.02	0.01	0.04	0.12
5	5	2	2	7	16	0.04	0.02	0.01	0.05	0.13
6	3	2	4	1	10	0.06	0.01	0.06	0.01	0.13
7	6	2	3	4	15	0.10	0.04	0.04	0.08	0.26
8	3	4	4	5	16	0.05	0.15	0.10	0.12	0.42
Total	**68**	**44**	**41**	**58**	**211**	**0.36**	**0.28**	**0.24**	**0.37**	**1.25**

Source: NZIER

New controllable generation – 18 MW to cover 98 percent of the energy gap

New controllable generation capacity would be required to cover the remaining gap between the Kaimai HEPS output and wind farm output (when the Kaimai HEPS output exceeds wind farm output) after battery storage. For this analysis, we start by calculating the thermal generation capacity required to cover any excess demand for strings longer

30 Calculated as twice the maximum energy delivered for any half hour within all strings with a length up to 4 hours.

31 The estimated cost of a four-hour battery is $2.034m per MW of capacity. This is based on the 240 MW / 1,030 MWh four-hour duration grid-forming battery that has been approved by Origin Energy for construction at Eraring Power Station in New South Wales for an expected cost of AUD 450m. An article on the approval is available at www.pv-magazine-australia.com/2024/07/25/origin-stage-two-battery-approval-elevates-erarings-storage-capacity-over-2-gwh/ . The AUD 450m cost of the battery has been converted to NZD 488.1m using an exchange rate of 0.92189 AUD per 1 NZD.

32 Calculated as $120 per MWh multiplied by total generation.

than 4 hours – excess demand not covered by the BESS. This would require thermal generation with a capacity of 18 MW and output of 58.0 GWh. Adding back the supply gap task that could be covered by BESS to the supply from gas generation gas task does not require additional capacity and only slightly increases the volume of generation to 59.2 GWh.

The form of generation that would most probably be able to meet this demand would be an open cycle gas fuelled turbine (OCGT). We have estimated the cost of this 18 MW plant by scaling down modelling completed for the New Zealand Battery project[33] as:

- Plant cost of $39.0m (assuming a cost per 100MW of $216.7m prorated to an 18 MW plant).
- Fixed operations and maintenance (O&M) cost of $1.1m per year and variable O&M of $0.8m.
- Fuel cost of $6.0m per year (assuming a gas price of $12 per GJ) plus carbon emissions costs of $1.6m per year at current prices.

This would imply a utilisation rate for the replacement thermal capacity of 37.56 percent which is very high compared with the current utilisation of thermal peakers at about 12.3 percent and almost four times the utilisation of 5.7 percent for the NZ Battery project modelled peaker assumptions as listed in Table 7 below.

Table 7 Utilisation of peaker capacity

Comparison of recent experience with modelled results

Plant	Capacity (MW)	Output (GWh)	Utilisation
Stratford peakers[1]	200	215	12.27%
Modelled peaker[r2]	1,200	595	5.66%
Kaimai HEPS supplement	18	59	37.56%

Notes:

1 The Stratford peakers are owned and operated by Contact Energy. Output over the past five years in GWh was: 2020 – 291, 2021 – 234, 2022 – 179, 2023 – 148 and 2024 – 223 with an average output of 215 GWh. (See, Contact Energy, 19 August 2024, '2024 full year results presentation, Twelve months ended 30 June 2024' page 46 available at https://contact.co.nz/getContentAsset/d6f25cfb-c2e9-4ddb-a097-ede10c448d04/a677e4b4-b3c2-492c-ae74-9399720288b8/fy24-full-year-results-presentation.pdf?language=en

2 The modelled peaker assumes an average gas use of 4 to 6 PJ per year and up to 20 PJ in a dry year. Based on a heat rate of 8,400 GJ/GWh, these levels of gas use would imply electricity output of 476 to 714 GWh and 2,381GWh respectively. The output and utilisation shown in the table are based on the midpoint gas use of 5PJ.

Source: NZIER

[33] Ministry of Business, Income and Employment - Hikina Whakatutuki, 11 May 2023, 'MODELLING ASSUMPTIONS FOR FOSSIL-FUELLED PEAKER GENERATION SUPPLEMENTARY TO NZ BATTERY OTHER TECHNOLOGIES FEASIBILITY STUDY' page 5. Available at https://www.mbie.govt.nz/dmsdocument/28355-modelling-assumptions-for-fossil-fueled-peaker-generation-may-2023 . The relevant modelling assumptions for a twelve 100MW OCGCT (total capacity 1,200MW) using the General Electric LMS100 OCGT were: start time 8 minutes from cold with a ramp rate of 50MW per minute; plant costs of $2,600m for twelve 100MW OCGT units; fixed operating and maintenance (O&M) costs of $70m per year; Variable O&M $13.8 per MWh; and asset life 30 years. The heat rate for the LMS 100 is reported at 8,400 GJ/GWh – see https://www.gevernova.com/gas-power/products/gas-turbines/lms100

The gas fuelled thermal generation is exposed to the increased gas prices over the next 10 years and then both increased prices and increased risk that the required gas supply will not be reliably available after 10 to 15 years. Prices for carbon emissions may also increase over this period.

Therefore, this part of the Kaimai HEPS replacement solution exposes the market to the risk of increased electricity generation costs over a much higher number of trading periods than the price risk attributable to either existing peakers or the NZ Battery Project modelled peakers.

2.5 Operational cost of replacing Kaimai HEPS output

Replacing the Kaimai HEPS output with a hybrid of wind and thermal generation imposes additional capital cost on the market and exposes the market to higher operating costs (mainly fuel) than would be the case if the Kaimai HEPS continued to operate. The additional upfront capital cost has been described in the previous sections and is relatively straightforward to estimate. Both the increase in variable cost for gas fuelled thermal generation and its impact on market electricity prices are less certain and therefore harder to quantify accurately.

Wholesale electricity prices are generally set by the dispatched generator with the highest short run marginal cost (SRMC). In peak demand periods this can be either the cost of thermal generation or the value of stored water used by hydro generators. There are three factors that affect the influence of new thermal capacity required to replace the Kaimai HEPS on future wholesale electricity prices:

- SRMC cost of the replacement thermal capacity relative to other thermal capacity that would be dispatched at the same time. The existing peakers (Stratford and Junction Road) are less efficient than the proposed new capacity and therefore would have a higher SRMC than the replacement thermal capacity. However, the replacement thermal capacity would run more often and therefore potentially would be the marginal generator when the existing peakers are not operating.
- Outlook for gas prices. The cost of gas is expected to rise over time as current reserves are depleted and gas industry switches to more expensive alternative sources of supply - domestic production of fossil gas from reserves that are more expensive to extract, imported liquefied natural gas (LNG) or biogas. The Gas Industry Company (GIC) has both published quarterly outlooks[34] for gas production and commissioned Ernst and Young (EY) to prepare an outlook[35] for the gas industry.
  - The GIC quarterly outlook for September forecast gas supply in 2035 just under 40PJ per year and in 2040 less than 20PJ per year compared with a current supply of around 120PJ but does not include quantitative price forecasts.
  - The EY analysis forecast has[36] a slightly more pessimistic supply decline outlook but the most optimistic scenarios forecast gas prices to increase from $10 to $12

[34] Gas Industry Company. 2024. '*Quarterly Update April 2024*'. '*Quarterly Report: June 24, Published July*' and '*Quarterly Report: September 2024*' available at https://www.gasindustry.co.nz/about/news-and-publications/quarterly-reports/.

[35] Ernst and Young. 2024. '*Gas Supply and Demand Study 2024'* released on 28 November 2024 available at https://www.gasindustry.co.nz/our-work/work-programmes/supply-and-demand-2024/#gas-supply-and-demand-study-2024

[36] Ernst and Young. 2024. '*Gas Supply and Demand Study 2024', 'Figure 9: Forecast supply from each source out to 2050*, page 28 and 'Figure 4: The price of gas ($/GJ) across all quantitative scenarios in 2026 and 2035', page 14.

per GJ in 2024 to $16 to$17 per GJ in 2026 and to $28 to$31 per GJ in 2035 (under the *‘Low intervention’* and ‘*Methanex exits immediately’* scenarios.

These forecast gas price levels suggest a minimum increase of 50 percent in the fuel cost for electricity generation by 2035 and a potential increase of 100 percent if LNG imports set the market price for gas.

- Whether hydro or thermal generation is the marginal generator that sets the wholesale price. Depending on the value hydro generators with large storage capacity place on their water reserves, they can become the ‘marginal generator’ in some trading periods and their offers set the wholesale electricity price. In these instances, while thermal SRMC does not set the market price it does contribute to the valuation of water reserves by hydro generators[37] which they use to set their offer prices.

While we cannot quantify the impact in the third bullet point, the effects on the market described in the first two bullet points clearly expose the electricity market to increased cost of production and lower reliability of supply if part of the Kaimai HEPS output is replaced by thermal generation capacity (which is the next best alternative given the current technology).

2.5.1 Greenhouse gas emissions

In addition, the use of gas to generate electricity which was produced by the Kaimai HEPS will increase carbon dioxide emissions by an average of 26,142[38] tonnes per year. At the current NZU price of $61 per tonne of CO_2e, these emissions would cost $1.59m per year.

2.6 Economic impact of Kaimai HEPS operation

The operation of the Kaimai HEPS contributes to local economic activity through the local content of operation and maintenance expenditure, as well as the capital expenditure on the Kaimai HEPS itself. Based on estimates from Manawa Energy, we estimate that the annual average Kaimai HEPS:

- Operating expenditure is about $2.4m (which contributes to the ‘Electricity, gas, water and waste services’ sector)
- Capital expenditure is about $2.0m (which contributes to the ‘Construction’ sector).

The gross domestic product (GDP)[39] for the Western Bay of Plenty District, in which the Kaimai HEPS is located was $2,864m for the year ended 31 March 2024. The estimated[40]

37 Hydro generators value the water stored in schemes based on the revenue it could earn depending on when it was used to generate electricity. This is based on the expected wholesale prices in future periods which are in turn affected that thermal generation will be the marginal generator that is dispatched.

38 Assuming CO2 emissions of 53.6591 tonnes/TJ of gas and use of 0.487PJ of gas. The CO2 emission rate is calculated from . Ministry for the Environment. 2024. ‘*Measuring emissions: A guide for organisations: 2024 detailed guide. Table A2: Underlying data used to calculate fuel emission factors’* on page 138.

39 The Modelled Territorial Local Authority (TLA) GDP data set is published by the Ministry of Business Innovation and Employment (MBIE) and is based on Statistics New Zealand regional GDP data. The TLA GDP data for the year ended 31 March 2024 was released on 8 August 2025. (The data was downloaded from https://www.mbie.govt.nz/assets/Data-Files/Business-employment/regional-economic-development/modelled-territorial-authority-gdp-release-2025.csv) .

40 The estimated GDP for these industries is based on the industry shares in Infometrics, *‘Regional Economic Profile Western Bay of Plenty District 2024’* multiplied by the MBIE TLA GDP for the Western Bay of Plenty District. The in Infometrics, *‘Regional Economic Profile Western Bay of Plenty District 2024’* was downloaded from at https://rep.infometrics.co.nz/western-bay-of-plenty-district/economy/structure?compare=new-zealand on 18 September 2025.

GDP in the District for the 'Electricity, gas, water and waste services' sector was $7m and for the 'Construction' sector was $207m.

The stations provides local employment – typically 150-200 people per year do some type of work at the Kaimai HEPS. Manawa Energy noted that in 2024, there were 275 people who completed inductions to work at Kaimai HEPS. Most people are contractors and work for a few weeks during annual outages. (The numbers quoted in this paragraph do not refer to full time employees.)

2.7 Other policy considerations

2.7.1 Contribution to climate change

In 2019 New Zealand passed its Climate Change Response (Zero Carbon) Act to set the framework for New Zealand to meet its Nationally Determined Contribution target in line with the 2015 Paris Agreement. It adopted a split gas approach, seeking by 2050 to reduce biogenic methane emissions by 24 percent to 47 percent below 2017 levels, whereas other long-lived gases (CO_2, N_2O and synthetic gases) were required to meet Net Zero Carbon.

Principal implications for electricity generation arising from that Act include:

- Reduced availability of fossil fuelled generation to meet peak time demands and cover the intermittency of wind and solar generation and dry-year risk as:
  - Existing fossil fuel generation assets are retired due to asset age, rising fuel cost and inability to meet flexibility requirements of wind and solar generation.
  - New replacement thermal assets are not constructed due to uncertainty about future commercial viability and fuel availability.
- New generation is required to meet increasing electricity demand in pursuit of zero carbon[41], because of both general economic growth and new demands for electricity from the electrification of the light vehicle fleet and replacement of fossil-fuelled industrial boilers by electrical options, as indicated in the Government's Emissions Reduction Plan.
- Discontinuation of existing renewable generation hinders the achievement of emissions reduction targets both by diverting new renewable capacity to replacing old capacity and by creating a new need for fossil fuelled generation to bridge the gap between the output profile of new renewables and demand.

2.8 Increasing residual flows reduces electricity supply

The analysis in this report assumes that the residual flows will remain unchanged from existing levels and that the Kaimai HEPS will continue to generate around 169 GWh per year. Any increase in residual flows for any of the water sources that supply the Kaimai HEPS will lower its output and require replacement from other generation sources outside the region. A question for policy makers to consider is to what extent electricity generation should be reduced to provide residual flows.

41 Transpower's future modelling suggests in three of its five scenarios that new generation capacity in excess of New Zealand's current total capacity will need to be built by 2050 to meet increased demand https://www.transpower.co.nz/sites/default/files/uncontrolled_docs/Transpower_NZGP_Scenarios%20Update_Dec2021.pdf.

The annual ‘missed’ output from the Kaimai HEPS attributable to the existing residual flows is estimated at 4.9 GWh. The annual generation foregone from the proposed minimum flows is estimated at 5.7 GWh. Together, the existing and proposed residual flows at Kaimai will reduce electricity generation by ~6% (approximately 1,500 households). Tauranga has approximately 60,000 households.

Replacing the generation output from the proposed residual flows using the method followed in sections 2.3, 2.4 and 2.5 would increase greenhouse gas emissions by 881 tonnes of CO_2e.

3 Conclusion

The continuation of the Kaimai HEPS has a number of economic benefits for the Tauranga area, Bay of Plenty Region and New Zealand as a whole, which can be divided between:

- Continuing to supply 32 percent of Tauranga’s annual electricity demand and meet Tauranga demand peaks which cannot be fully met by importing electricity from outside the region. Both peak and gross energy demand are expected to grow rapidly in Tauranga and Mount Maunganui due to a combination of population growth and step load changes such as expansion of the Port of Tauranga.
- Avoiding the increased capital and operating cost of a less efficient supply solution than the Kaimai HEPS for the energy demand met by the Kaimai HEPS;
- Avoiding the need for expensive grid and network upgrades. Grid constraints prevent Tauranga from importing all the electricity it requires from outside the region at peak periods and it needs the output from the Kaimai HEPS to cover the gap between Tauranga demand and imports.
- Generating electricity to meet demand in the region and elsewhere in New Zealand;
- Aligning with Government and Local Council Policies[42] towards renewable energy and environment; and
- Contributing to greenhouse gas emissions reductions in line with international agreements.

Continuation of the Kaimai HEPS, with a peak capacity of 42 MW and an annual average output of 169 GWh avoids the following efficiency losses:

- Capital expenditure in excess $205.5 m comprising $166.5 m for wind generation and $39.0m for thermal generation to replace the supply profile of the Kaimai HEPS. (This estimate excludes the BESS option as the new thermal plant can bridge the supply gap more efficiently than the BESS).
- Operational inefficiency of at least 3 percent of the Kaimai HEPS output due to transmission losses as a result of the electricity demand at the Tauranga GIP being met from more remote services. (This comment excludes the cost of capacity upgrade of

[42] The Bay of Plenty Regional Council has a goal to achieve chieve net zero emissions by 2050, with an interim target of a 25% reduction in gross emissions by 2026-27 (relative to 2022-2023). The ‘’Bay of Plenty Regional Council Climate Change Action Plan Te Mahere Mahi mō te Huringa 2024-26’’ includes action plans to work with sectors on decarbonisation and supporting transition to renewable energy. (see page12).

the Tauranga circuit. The proposed Transpower upgrade assumes the Kaimai HEPS will still be available.)

- Transmission and distribution network expenditure that would be required to import the additional electricity.
- Increased average annual emissions of 26,693 tonnes CO_2e.
- Increased exposure of wholesale electricity prices to upward pressure from rising gas prices due to the longer period over which the thermal capacity required to partially replace the Kaimai HEPS output.

An increase in residual flows that reduces Kaimai HEPS output by 1 GWh per year increases the cost of the 'alternative' wind/thermal generation combination by 0.592 percent including allowance for transmission losses.

Appendix A New Zealand electricity system

A.1 Electricity supply and demand in New Zealand

Since 1996 electricity in New Zealand has been supplied through a wholesale electricity market, in which different generators offer to supply power for every half-hour period through each day, and Transpower, the system operator, selects the least costly offers to dispatch across the grid to meet demand. Generators are incentivised to offer at low prices that just cover their short run marginal cost in order to be selected, but all dispatched supply is paid for at the price required by the marginal plant last selected for dispatch. Low-cost renewable suppliers like wind and hydro generators therefore earn a profit if they supply at the same time as higher-cost generators like thermal plants.

There are regional variations in supply and demand for electricity, with most of New Zealand's generation in the South Island and most of its large demand centres in the North Island. The South Island has more generation capacity (mostly hydro) than it needs to meet South Island demand so its power can be exported to the North Island via the HVDC cable. The North Island has more mixed generation with hydro, wind, geothermal and fossil-fuelled thermal plant, the latter being used to cover short term peaks and some base load.

Access to markets is provided by the national grid for cross-country transmission and local lines networks for distribution to consumers. The grid system operator, Transpower, has procedures for continually monitoring the grid to identify where improvements to reduce capacity constraints and ensure options exist for alternative routing of transmitted power around grid bottlenecks. It applies a grid investment test to prioritise its selection of improvements to obtain maximum benefit from additional investments it makes.

A.1.1 Demand trends

Figure 5 shows there was consistent annual growth in electricity consumption over the years 1974 to 2007 across the four consumer categories of agricultural, commercial, industrial and residential[43], but following the Global Financial Crisis (GFC) in 2008 growth flattened across all sectors apart from agriculture and there was shrinkage in industrial demand. Combined consumption across the four sectors grew from 17,306 GWh in 1974 to 38,737 GWh in 2007, equivalent to an average annual growth rate of 2.5%nearly three times the annual average annual growth in population of 1% over that period.

In the years since 2008 total consumption has experienced near to zero growth, fluctuating around an average of 38,925 GWh per year and in 2024 it was only 0.8% above that in 2007. That contrasts with population growth that increased at an annual average rate of 1.4% over the years 2008 to 2024[44].

The flattening in demand has been partially attributed to some 'shake-out' of electricity use caused by the GFC and improvement in energy efficiency, particularly in commercial and

[43] A fifth electricity consumer sector recorded by MBIE data is transport. It is excluded here because reliable data only goes back to 1990 and because in 2022 it accounted for 0.5% of electricity consumption, primarily comprising electric rail transport and road vehicle charge up. That share is expected to increase with electrification of land transport to achieve emission reductions.

[44] The estimated population of New Zealand at 31 December 2024 is 5.35 million compared with 4.28 million at 31 December 2008. See 'Estimated resident population of New Zealand: At 31 December 2024' downloaded from https://www.stats.govt.nz/topics/population on 14 March 2025.

industrial applications. However since its peak in 2019[45] industrial demand has declined and at the end of 2024 was 16 percent below 2019 levels. Some industrial users have either:

- Closed, partly in response to high wholesale electricity prices for example Oji Fibre's shutdown of paper recycling at Penrose. (Oji Fibre intends to halt paper production at Kinleith, Tokoroa by June 2025[46].)
- Reduced output as generators invoke contract provisions to divert generation to the residential market when supply is short for example:
  - Methanex idling of it is plant in winter 2024 and 2025 enabling sale of the gas it would have used for methanol production to electricity generators[47].
  - NZAS curtailment of its output in 2024.

This decline in industrial demand is an indication of a lack of sufficient generation capacity that can deliver electricity at affordable prices. The following sections describe long run trends in demand and generation and the recent fluctuations in spot wholesale prices.

Residential demand was flat between 2008 and 2017 and then started to increase and exceeded industrial demand in 2023 and 2024 (the first time since 1982). The slow growth in demand over 2020-2022 contrasts with the expected increase in demand due to electrification of transport and industrial process heat modelled by the Climate Change Commission Advice to the Government on the direction of policy for its second emissions reduction plan (2026-30). [48]

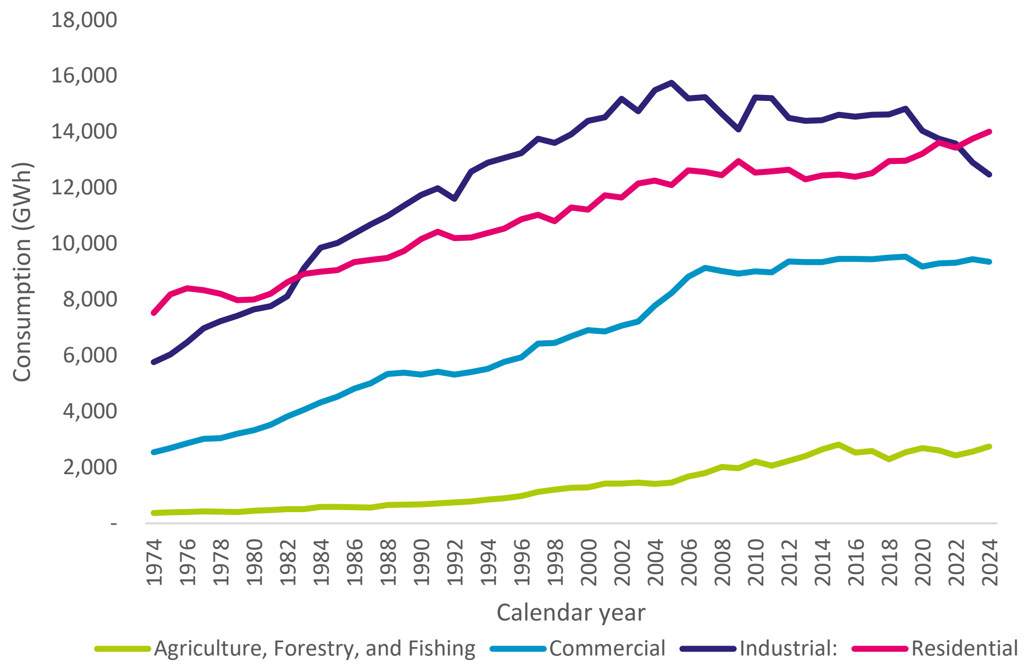
[45] Industrial consumption in 2019 was 14,827 GWh, the highest level since 2011. The all-time peak for industrial consumption was 15,756 GWh in 2005. Over the period 1975 to 2024, industrial consumption has been above 2019 levels over 2004 to 2007 (pre GFC) and over 2010 to 2011.The closures of Kawerau Pulp and Paper Mil in 2021 Marsden Point Oil Refinery in 2022 were due to a range of factors including rising electricity costs and contributed to the initial decline in demand.

[46] See 'OjiFS Confirms Kinleith Mill Decision, Media Statement - 14 February 2025'downlaoded from https://ojifs.com/ojifs-confirms-kinleith-mill-decision .

[47] Over August 2024 to October 2024 Methanex made available 3.5 PJ of gas to Contact Energy and 3.2 PJ of gas to Genesis Energy. In May 2025 Methanex has agreed to sell up to 2.8 PJ of gas to Contact Energy and 1.7 PJ of gas to Genesis Energy. Genesis Energy can generate up to 127 GWh per PJ of gas. Contact Energy's maximum output per PJ of gas is slightly lower.

[48] He Pou a Rangi Climate Change Commission | 2023 Advice on the direction of policy for the Government's second emissions reduction plan, page 278.

Figure 5 Electricity consumption by sector 1974-2024[49]



Source: MBIE Energy Statistics[50]

A.1.2 Supply trends

Figure 6 shows the corresponding trajectory of total generation in New Zealand, showing consistent growth averaging 2.2%per annum over the years 1974-2007. But generation growth flattened after the GFC in 2008, to a yearly average of about 0.3%per year from 2009 to 2024. Net generation dropped for two years from its pre-GFC high of 42,423 GWh in 2007, recovered to 43,571 GWh in 2010 and has since fluctuated around an average of around 43,277 GWh in the years to 2024, however growth appears to be accelerating. Net generation increased sharply in 2024 to 43,872 GWh about 1.0%higher than the average for the previous three years (2021 to 2023).

The priority for investment in generation has shifted from meeting expected population-driven consumption growth to reducing fossil fuelled electricity generation in response to New Zealand's international obligations for emissions reduction under the 2016 Paris Agreement, the Climate Response Act 2002 and Climate Change Response (Zero Carbon) Amendment Act 2019, and the Second Emissions Reduction Plan. These in turn are expected to stimulate electricity demand, to charge up increasing numbers of electric vehicles and power electric heating and boilers installed to replace fossil fuelled equipment.

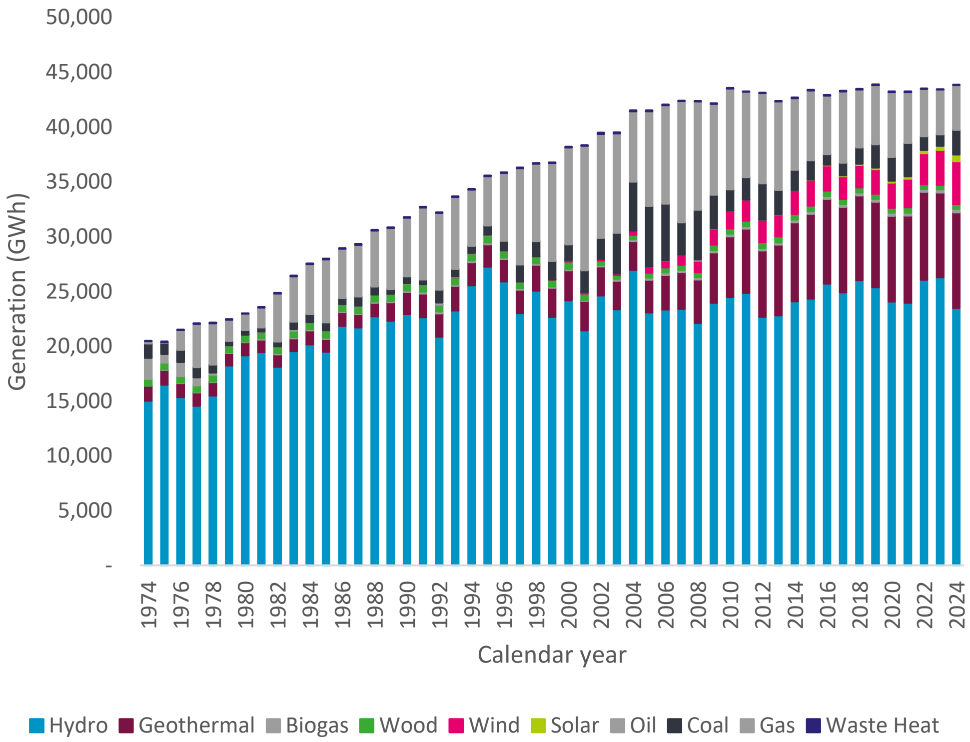
Figure 2 shows hydro is the major source of generation in New Zealand, but its proportional share of total generation has diminished since the 1970s, and the prospect for new large hydro generation projects being built have become increasingly challenging with respect to

[49] MBIE reports electricity consumption by sector for calendar years from 1975 but did not begin reporting this information quarterly until 2013.

[50] MBIE 2025, 'Electricity data tables, Annual electricity generation and consumption'. Downloaded on 15 September 2025 from https://www.mbie.govt.nz/assets/Data-Files/Energy/nz-energy-quarterly-and-energy-in-nz/electricity-june-2025-q2.xlsx .

cost, consenting hurdles, and the risks of adding to dry year risk for electricity supply. Major increase in hydro generation capacity seems unlikely and some existing schemes are at risk of additional generation constraints imposed during reconsenting processes. Geothermal generation has increased to meet base load demands, but expansion of this capacity is limited by the size of accessible geothermal resources found only in some North Island regions. Wind generation is a more ubiquitous resource, and generation has grown from small beginnings in the 1990s, with significant concentrations in generation in the Tararua/Ruahine ranges around the Manawatu Gorge, the Maungaharuru range in Hawkes Bay and other clusters in the Southland and Otago regions. There has been some recent interest in developing offshore wind farms, but none has yet been realised as they await implementation of the consenting regime . Current utility scale solar capacity is modest but a sharp increase is expected over the next five years.

Figure 6 Electricity generation by energy source 1974 to 2024



Source: MBIE Energy Statistics[51]

Table 8 shows the current New Zealand-wide portfolio of large grid-connected power generation and annual output in 2024, distinguished by types of generation. In 2024, the renewable electricity categories of hydro, geothermal, biogas, wind and solar had a combined share of 77.9% of national generation capacity, and 84.5% of annual generation. Figure 6 shows the renewables share of annual generation exceeded 90% in 1975, 1980 and 1981, but had dropped to less than 66% in 2001, 2005 and 2008. Since then, the renewables share of installed generation capacity has been growing slowly, mostly due to new wind farms and geothermal capacity. The renewables share of annual generation has

51 MBIE 2025, 'Electricity data tables, Annual electricity generation and consumption'. Downloaded on 15 September 2025 from https://www.mbie.govt.nz/assets/Data-Files/Energy/nz-energy-quarterly-and-energy-in-nz/electricity-june-2025-q2.xlsx .

also been growing but with a more variable trajectory, depending on variations in environmental conditions and the supply of renewable fuel like wind and water. In 2022 the renewable share of annual generation reached 87.1% and in 2023 it reached 88.1% but in 2024 it fell to 85.5%[52].

Table 8 New Zealand electricity generation capacity and annual output

Year ending 30 December 2024

Generation capacity estimate[1]			Generation output[2]		
Fuel	**MW**	**Share**	**Fuel**	**GWh**	**Share**
Hydro	5,581	50.6%	Hydro	23,490	53.5%
Geothermal	1,275	11.6%	Geothermal	8,741	19.9%
Biogas	40	0.4%	Biogas	310	0.7%
Wind	1,265	11.5%	Wind	3,919	8.9%
Solar	567	5.1%	Solar	595	1.4%
Oil	198	1.8%	Oil	25	0.1%
Coal	500	4.5%	Coal	2,243	5.1%
Gas	1,236	11.2%	Gas	4,082	9.3%
Co-generation	364	3.3%			
			Wood	442	1.0%
			Waste Heat	27	0.1%
Total	**11,025**		**Net Generation**	**43,872**	

Notes:

1 The capacity numbers in this table are from MBIE Electricity data tables - Plant type (MW) for the year ended 31 December 2024

2 Generation and co-generation output are combined for each fuel and are not reported separately

Source: MBIE Electricity data tables: Annual GWh, Electricity Balance and Plant type (MW) Downloaded from https://www.mbie.govt.nz/assets/Data-Files/Energy/nz-energy-quarterly-and-energy-in-nz/electricity-june-2025-q2.xlsx on 15 September 2025.

Appendix B Battery output profile

B.1 Rationale for considering grid scale batteries

BESS can potentially be used to cover intra-day generation and demand mismatches by charging the battery (buying electricity) during off-peak periods when wholesale prices are low and discharging the battery (selling electricity) during peak periods when wholesale prices are high. This arbitrage revenue helps cover the cost of the battery but is not sufficient to fully recover the cost BESS . Unfortunately, publicly available information on the revenue streams of batteries is limited.

52 Electricity generation from wood accounted for 1.0 percent of generation in 2024. Adding this contribution to the 84.5% of annual generation from hydro, geothermal, biogas, wind and solar lifts the total share of renewable electricity generation for 2024 to 85.5%.

B.2 Grid scale batteries in New Zealand

Grid scale battery energy storage system (BESS) deployment is in its infancy in New Zealand (35 MW installed) compared with other countries such as Australia (985 MW primarily in the National Electricity Market[53]) and the United Kingdom (3,465 MW providing 1,018 GWh in 2023[54]). There are two main revenue sources for BESS: frequency control ancillary services (FCAS) and energy arbitrage[55]. For the BESS in the National Electricity Market, energy arbitrage revenue now exceeds revenue from FCAS.

The grid scale batteries proposed for New Zealand provide an indication of the cost of battery capacity and the charge/discharge cycle on which they are expected to operate.

B.2.1 Installed

The first grid scale battery constructed in New Zealand was a 35MW/35MWh[56] in Waikato at an expected cost of $25 m[57]. An indication of the output of this battery is provided in the data[58] in Table 9.

53 AEMO 2024 | Quarterly Energy Dynamics Q2 2024,page 37.

54 Department for Energy Security & Net Zero (DESNZ), . Available at https://assets.publishing.service.gov.uk/media/66a7dae449b9c0597fdb06c9/DUKES_5.16.xlsx

55 Energy arbitrage involves charging the battery from the grid when there is excess supply and wholesale prices are low and discharging the battery into the grid when there is excess demand and wholesale prices are low.

56 The description MW/MWh refers to capacity expressed in MW and the amount of energy the battery can supply in MWh.

57 Colthorpe A, 24 October 2023, New Zealand's 'first grid-scale battery storage project' in commissioning phase' available at https://www.energy-storage.news/new-zealands-first-grid-scale-battery-storage-project-in-commissioning-phase/

58 Electricity Authority ,16 April 2024, 'Unlocking the potential for batteries to contribute to security of supply'. Downloaded from https://www.ea.govt.nz/news/eye-on-electricity/unlocking-the-potential-for-batteries-to-contribute-to-security-of-supply/

Table 9 WEL battery activity[59]

Over the period 10 January 2024 to 17 March 2024

Activity	Periods		Price ($/MWh)	
	Number	Share (%)	Mean	Median
Discharge into grid	473	13	236	219
Charge from grid	625	17	123	132

Source: NZIER

Based on the chart[60] of the discharge and charge activity and the number of periods:

- The mean discharge appears to be around 12MWh per half hour and the mean charge rate is around 9MWh per trading period.
- The battery discharges on average 6.9 trading periods per day and is recharged on average just over 9.2 trading periods per day.

In combination this information indicates the battery runs through at least two cyclers per day and the discharge cycle is just under 1.5 hours and that the revenue is approximately $0.64m over the period or potentially about $3.4m per year.

B.2.2 Planned batteries

Meridian, Contact and Genesis have all announced plans to build grid scale BESS. The expected capital cost of the 100MW/200MWh batteries is: Meridian[61] $186m, Contact[62] $163m and Genesis[63] $150m.

Meridian - Ruakākā

Meridian is proposing to build a 100MW/200MWh battery alongside a 130MW solar farm with the following characteristics:

- *$20m - $30m EBITDAF p.a. (average, low - high scenarios)*
- *$6m operating costs p.a. mainly transmission costs (connection, benefit-based investment and residual charges)*
- *Up to $35m revenue p.a. from price arbitrage, reserve market participation, indirect revenue[64].*

Meridian expects the Ruakākā battery to have a positive net present value but the description of the expected revenue does not state the expected level of revenue from

59 There is a discrepancy between the number of trading periods in the stated date range of 3,264 (68 days with 48 half hour trading periods per day) and the share of discharge periods 473/0.13=3,638 and the share of charge periods 625/0.17=3,676.

60 Electricity Authority ,16 April 2024, ‘Unlocking the potential for batteries to contribute to security of supply’ See ‘Figure 1: Charging and discharging of the WEL Networks battery, 10 January - 17 March 2024’.

61 Meridian, 15 December 2022, ‘RUAKĀKĀ BATTERY ENERGY STORAGE SYSTEM’, available at https://www.meridianenergy.co.nz/public/Investors/RUAKAKA-BATTERY-ENERGY-STORAGE-SYSTEM.pdf

62 Contact, 1 July 2024, ‘Contact to develop a grid-scale 100 MW battery in Auckland’ available at https://contact.co.nz/aboutus/media-centre/2024/06/30/contact-to-develop-a-gridscale-100-mw-battery-in-auckland

63 Genesis, 22 Aug 2024, ‘Strategy on track despite challenging year’

64 Price arbitrage is explained in the previous section. Reserve market participation refers to providing ‘fast’ and ‘sustained’ instantaneous reserve and is expected to occur ‘alongside’ price arbitrage activity. The ‘índirect’ revenue includes two components: increased reserve capacity in the North Island allows more transfer of South Island generation to the North Island with reduced use of thermal generation and reduced separation between South and North Island generation prices.

energy price arbitrage. However, the daily timing of demand peaks and troughs in the New Zealand wholesale electricity market suggests that batteries can achieve energy arbitrage in excess of $100 per MWh for at most two cycles per day. This implies revenue from energy arbitrage of about $14.6m per year (400 MWh per day at gross revenue of $100 per MWh for 365 days per year) or just under half of the average gross revenue of $31m (EBITDAF of $20m to $30m plus $6m of operating costs). The assumptions do not state the round-trip efficiency of the battery which is usually around 85 percent. We have not allowed for this in the assumed average arbitrage price.

B.2.3 Observation on battery contribution

The two key observations from the above information on New Zealand batteries are:

- The two hour output configuration of the batteries combined with the expected arbitrage price difference of $100 per MWh and daily load patterns (peak in morning and evening with shoulder during the day and off-peak prices at night) suggest their maximum daily arbitrage output is around two discharges to the grid of two hours each.[65] A BESS with a four to six hour output capacity and recharging overnight would deliver higher arbitrage revenue particularly in the winter than the current BESS with 2 hour output.
- Energy price arbitrage revenue is not the sole, let alone the main, source of revenue for the batteries which means they are only viable for energy arbitrage if they can also earn other sources of revenue.

General information on BESS technology indicates the maximum available discharge period is six to eight hours.

For the purpose of assessing a wind and BESS hybrid as a replacement for the output from the Kaimai HEPS, the best-case assumptions are:

- Other sources of revenue, combined with the arbitrage revenue give the BESS investment a zero net present value.
- The only additional cost from the arbitrage function is the round-trip energy loss from charging and discharging the BESS.

This still leaves the issue that BESS does not offer the mix of rapid charge and slow discharge required to match the output profile of the Kaimai HEPS.

Appendix C Comparison of intraday volatility for wind and Kaimai

C.1 Method for comparing change in output from one half hour to the next

To compare the intraday volatility of wind generation and generation at Kaimai HEPS we have compared the change in generation output from one trading period to the next for each quarter of the year ended 30 September 2024. The generation output data is provided in for half hourly intervals (trading periods). The calculation steps for are:

[65] This applies whether the BESS is standalone or integrated with a wind or solar farm.

- Calculate the average output for all trading periods that cover the same time of day. The output from this calculation is 48 averages that are used as the comparator for a 'normal' level at that time of day for that quarter.
- Calculate the change in output from the 'current' trading period (starting at time 'hh:mm') to the 'next' trading period starting half an hour later and then divide this difference by the average output for all the trading periods starting at the same time. as the 'current' trading period. This restates the absolute difference as percentage change and is used to group the differences in bands.
- Table 10 is the proportion of the count of all 'next' trading periods where the percentage change in output falls within the band under the heading 'Change in output band'.

Table 10 Change in output – share of total number of trading periods

Number of trading periods with output change in each band as percentage of trading periods per quarter

Change in output	Wind				Kaimai			
	Dec 23	Mar 24	Jun 24	Sep 24	Dec-23	Mar24	Jun 24	Sep 24
<= -20%	1%	1%	2%	1%	6%	9%	9%	9%
-20% < & <= -10%	6%	6%	7%	6%	3%	3%	3%	3%
-10% < & <= -5%	12%	12%	12%	12%	7%	5%	5%	6%
-5% < & <= 0%	33%	33%	30%	32%	67%	67%	67%	65%
0% < & <= 5%	29%	28%	27%	30%	0%	0%	0%	0%
5% < & <= 10%	12%	13%	13%	11%	6%	5%	5%	5%
10% < & <= 20%	6%	7%	7%	5%	3%	3%	3%	3%
> 20%	1%	1%	2%	2%	8%	9%	9%	9%

Source: NZIER

C.2 Analysis

C.2.1 Trading period count

The wind generation data shows approximately symmetric variation around the average output. Around 60 percent of the fluctuations are within plus or minus 5 percent of the average output and a further 24 percent are either 5 percent to 10 percent above or below the average.

The Kaimai HEPS output shows a pattern of controlled generation. Output is constant for most periods with a small number of periods of large change. This pattern is consistent with intra-day generation that is a series of low and high plateaux connected by short rapid ramping up and down of generation between the plateaux.

Appendix D Impact of increased residual flows

D.1 Estimate of lost generation

Setting minimum residual flows on the rivers and streams that supply water to the Kaimai HEPS reduces the generation output from the scheme. The reduction in electricity generation output for each residual flow varies depending on which of the Kaimai HEPS stations would have used the water flow to generate electricity . The annual 'missed' output from the Kaimai HEPS attributable to the existing residual flows is of the existing residual flows on the output (GWh) of the Kaimai is estimated at 4.9 GWh comprising:

- Opuiaki River – 3.84 GWh due to a residual flow of 0.28 m3 per second which lowers the output of the Kaimai 5, Lloyd Mandeno and Lower Mangapapa power stations.
- Ngatuhoa Stream – 0.82 GWh due to a residual flow of 0.06 m3 per second which also lowers the output of the Kaimai 5, Lloyd Mandeno and Lower Mangapapa power stations.
- Mangakarengorengo Stream – 0.24 GWh due to a residual flow of 0.04 m3 per second which lowers the output of the Ruahihi power station.

D.2 Scope

This section describes the calculation of the effects of a residual flow increase (which is equivalent to a reduction in the average flow available for generation). The general description of the system[66] used in the preceding analysis is maximum capacity maximum capacity of 42.1 MW and annual average output of 169 GWh. In Appendix D we use two sources of information to allocate the stated annual output to the components of the scheme:

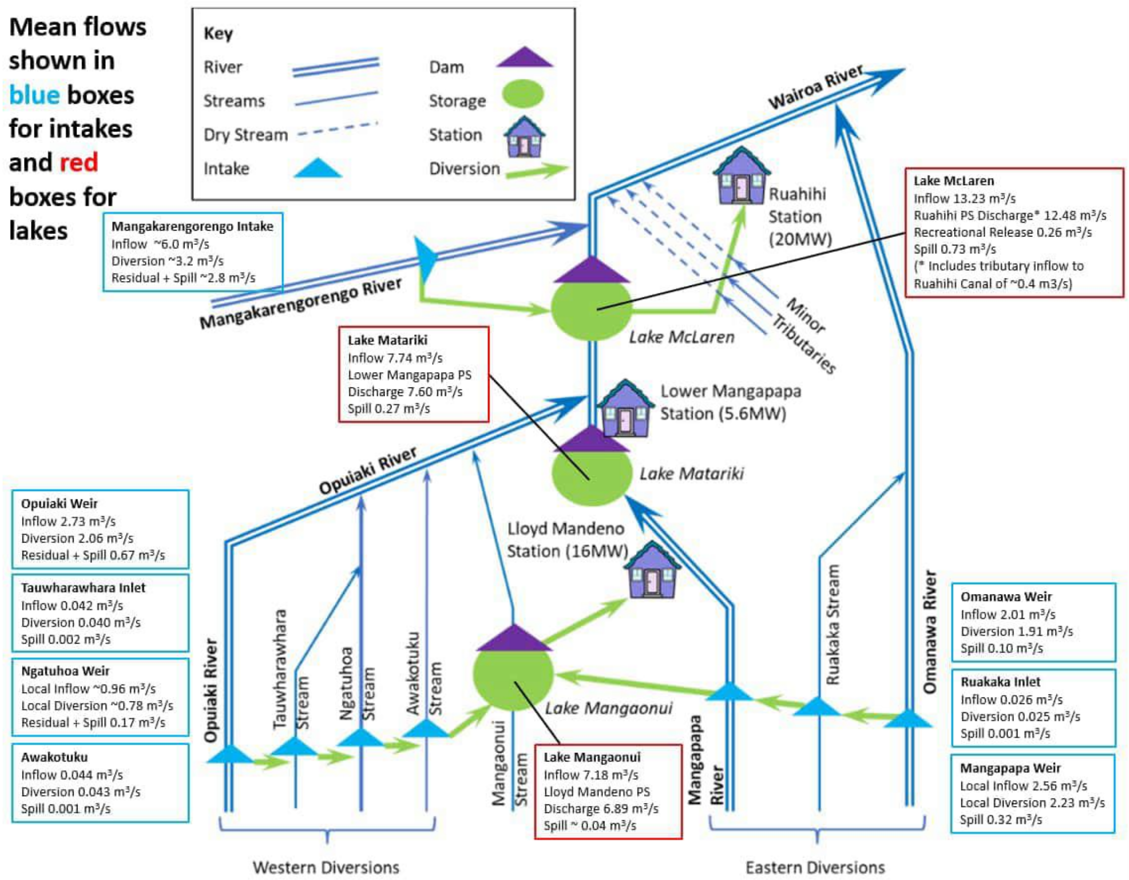
- Kaimai HEPS hydrology assessment[67] which describes the generating capacity and water flows through each its four power stations: Kaimai 5 (0.3 MW), Lloyd Mandeno (16 MW), Lower Mangapapa (5.6 MW) and Ruahihi (20 MW). See Figure 7 below for a diagram of the Kaimai HEPS which also includes three major man-made reservoirs: Lakes Mangaonui, Matariki and McLaren.
- Kaimai HEPS output description[68] which reports the initial expected annual output for three of the four power stations: Lloyd Mandeno (70 GWh), Lower Mangapapa (17 GWh) and Ruahihi (70 GWh). The average utilisation for these schemes were used to estimate the output of Kaimai 5 at (1 GWh). The total of the initial expected outputs at 158 GWh is about 7 percent below the stated output of the scheme of 169 GWh so they are scaled-up for the analysis of water use in each part of the Kaimai HEPS.

66 Downloaded from https://www.manawaenergy.co.nz/kaimai-power-scheme on 18 April 2025

67 APPENDIX D Hydrology Assessment –Tonkin & Taylor Ltd, Reconsenting of Kaimai Hydroelectric Power Scheme – Hydrology Report',Manawa Energy Ltd, ,June 2023' 1page 120, 121-124

68 Downloaded from https://www.delahyde.com/tauranga/index.html .

Figure 7 Hydrological operation of Kaimai scheme[69]



Source: NZIER

The scaled output for each of the four Kaimai HEPS power stations and their respective water inflows are listed in Table 11.

69 'APPENDIX D Hydrology Assessment – Tonkin & Taylor - Reconsenting of Kaimai Hydroelectric Power Scheme Hydrology Report Prepared for Manawa Energy Ltd Prepared by Tonkin & Taylor Ltd Date June 2023', 'Figure E2 Diagrammatic representation of the Kaimai Scheme with estimated mean flows shown in boxed text', page 8.

Table 11 Kaimai HEPS power stations

Capacity in MW, output in GWh, mean flow rate in m3/s and annual water use in 1,000m3 per year

Station	Electricity generation		Water use		
	Capacity (MW)	Output[1] (GWh)	Mean flow[2] m3/s	Annual use 1,000m3	Conversion 1,000m3 /GWh
Kaimai 5 (K5)	0.3	1.2	2.650	73,812	61,000
Lloyd Mandeno	16.0	74.8	6.890	3,104	41
Lower Mangapapa	5.6	18.2	7.600	14,098	776
Ruahihi	20.0	74.8	12.480	5,622	75
Total	41.9	169.0			

Notes:

1 The output for the power-stations is calculated in two steps :

a Kaimai 5 output is estimated as the capacity of 0.3 MW multiplied by the average utilisation of 43 percent for the other three power stations in the Kaimai HEPS.

b Scaling the estimated Kaimai 5 output plus the initial outputs for Lloyd Mandeno, Lower Mangapapa and Ruahihi up by 6.87 percent so that the total output is about 169 GWh.

2 Mean flow data is taken from 'APPENDIX D Hydrology Assessment – Tonkin & Taylor':

a Table 4.26 Water balance component mean flows for K5 Power Station, page 120.

b Table 4.27 Water balance component mean flows for Lloyd Mandeno Power Station, page 122.

c Table 4.28 Water balance component mean flows for Lake Matariki, page 123.

d Table 4.29 Water balance component mean flows for the Ruahihi Power Station, page 124.

Source: NZIER

D.2.1 Effect of current residual flows[70]

The scheme currently has minimum residual flows on the Mangakarengorengo Stream, Opuiaki River and Ngatuhoa Stream as part of its current consent conditions and which have been in place since commissioning. The annual generation foregone from these minimum flows is estimated in the top half of Table 12 below and totals 4.90 GWh for the Kaimai HEPS (mainly through reduced output from the Lloyd Mandeno power station). The lower half of Table 12 shows the annual generation foregone from a 0.1 m3/s increase in the existing residual flows which totals 3.34 GWh for the Kaimai HEPS.

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Table 12 Kaimai HEPS effect of consented residual flow on annual generation

Current residual water flow (m3/s) and foregone annual generation output (GWh) by power station

Water course inflow (m3/s)	Residual flow	Power station output (GWh)				
		Kaimai 5 (K5)	Lloyd Mandeno	Lower Mangapapa	Ruahihi	Total
Current consented residual						
Mangakarengorengo River	0.04				0.240	**0.240**
Opuiaki River	0.28	0.128	3.040	0.669		**3.837**
Ngatuhoa Stream	0.06	0.027	0.651	0.143		**0.822**
Total		**0.155**	**3.692**	**0.813**	**0.240**	**4.900**

Source: NZIER

D.2.2 Effect of proposed new minimum flows[71]

Manawa Energy is proposing new minimum residual flows on 3 additional rivers: Omanawa River, Mangapapa River and McLaren Dam. The annual generation foregone from these proposed minimum flows is estimated in the top half of Table 13 below and totals 5.71 GWh for the Kaimai HEPS. The lower half of Table 13 shows the annual generation foregone from a 0.1 m3/s increase in the residual flows which totals 4.45 GWh for the Kaimai HEPS.

Table 13 Kaimai HEPS effect of proposed residual flow on annual generation

Proposed residual water flow in (m3/s) and foregone annual generation output (GWh) by power station

Water course inflow (m3/s)	Residual flow	Power station output (GWh)				
		Kaimai 5 (K5)	Lloyd Mandeno	Lower Mangapapa	Ruahihi	Total
Proposed residual						
Omanawa River	0.15		1.629	0.359	0.899	**2.886**
Mangapapa River	0.1		1.086	0.239	0.599	**1.924**
McLaren Dam	0.15				0.899	**0.899**
Total			**2.714**	**0.598**	**2.398**	**5.710**

Source: NZIER

There are 3 additional rivers with **no** current or proposed minimum flows. These are (along with their average flows): Ruakaka Stream (0.026 m3/s), Tauwharawhara Stream (0.042 m3/s) and Awakatoku Stream (0.044 m3/s).

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Appendix E Expert statement

E.1 Qualifications and Experience

This report was prepared by Mike Hensen and quality approval by Peter Clough. Our qualifications and relevant experience are as follows..

Mike Hensen Senior Economist at NZIER (BCA (Hons) Economics) has extensive experience in analysing the impacts of price and competition regulation on businesses and applying cost benefit analysis to public policy decisions in the electricity sector and preparation of applications for resource consent applications. Mike has:

- Led the preparation of economics impact assessments for consent applications for proposed Wind Farms at Pahiatua, Huriwaka and Mahinerangi Stage 2 and for renewal of consents for the Wheao hydroelectric power scheme. (Except for Pahiatua all of these applications were made under the FTAA.)
- Assisted with the preparation of applications for resource consent for Wind Farms at Kaiwaikawe (Omamari), Mimihau and Kaihiku as well as the Taheke Geothermal development and several quarry extensions. (These applications were a mixture of FTAA, COVID-19 Recovery (Fast-track Consenting) Act and the RMA.)

Peter Clough, Senior Economist at NZIER, with a long track record of preparing and presenting economic assessments and evidence statements in RMA hearings and the Environment Court, including:

- Consenting of new wind farms at Mahinerangi, Kaiwera Downs, Turitea, Puketoi, Waipipi (Waverley) and Kaiwaikawe (Omamari), four of which are now built in full or in part and in operation
- Work supporting consenting of two other windfarms in Southland and two geothermal power stations in Bay of Plenty, using both standard RMA and fast-track consenting provisions of the COVID 19 Recovery Act.

E.2 Code of conduct for expert witness statement – Michael Hensen

As the author of this report I, Michael Hensen state the following:

- In the context of this application which is made under the Fast-track Approvals Act 2024, and in relation to which there may be no hearing, I have been asked to confirm that the reporting has been prepared in accordance with the Environment Court's Code of Conduct for Expert Witnesses.
- I confirm that I have read the Environment Court's Code of Conduct for Expert Witnesses, as contained in section 9 of the Environment Court's Practice Note 2023, and I agree to comply with it.
- The data, information, facts and assumptions that I have considered in forming my opinions are set out in my technical report. The reasons for the opinions expressed are also set out in the technical report.
- I confirm that the matters addressed in the technical report are within my area of expertise, with the exception of where I confirm that I am relying on information provided by another person. I have not omitted to consider material facts known to

me that might alter or detract from my opinions expressed. I have specified where my/our opinion is based on limited or partial information, and I have identified any assumptions I have made in forming my opinions.

Michael Hensen

Signed Michael Hensen