February 2025

The need for energy storage:

Firming New Zealand's renewable energy

Context

In Aotearoa New Zealand we are fortunate to have a strong history of investing in renewable energy. The continuing investment in renewables is supporting New Zealand to meet the expected increased electricity demand and has largely displaced thermal generation assets from baseload duty.

As with other electricity markets around the world, the use of renewables means the market faces great exposure to climatic conditions – the amount of rain, wind, and sunshine in particular locations – and therefore New Zealand requires significant amounts of 'flexible' generation that can vary output to balance the variations in weather.

Where the weather does not align with electricity demand, the country currently turns to thermal generation. This presents a trilemma of needing to solve energy security, affordability, and decarbonisation as New Zealand grows.

While managing the flexibility needs of a highly renewable system is a common challenge for all countries, New Zealand has some characteristics that make it particularly challenging:

- Our large hydro fleet gives rise to major year-to-year swings in generation of a scale that is much greater than countries whose renewable power is from wind or solar.
- We require significantly more generation in winter than in summer, limiting the extent to which solar can meet our flexibility needs; and
- We are a relatively small, isolated system, thereby not giving us access to the significant diversity benefits of larger, interconnected systems.

The implications are that New Zealand needs not only the short-duration flexible assets that many other countries require to firm solar and wind generation, but also some long-duration flexibility resources. These assets sit idle for years at a time and need to be able to deliver large amounts of energy for a sustained period of weeks and even months, particularly over winter.

Winter 2024 showed the vulnerability New Zealand faces when the weather does not align with energy demands. Lower lake levels, exacerbated by an unexpected inability to readily access gas, meant other measures were required, such as reducing electricity demand from industrial consumers, redirecting gas supplies from industry into generation, and the increased use of the Rankine Units at Huntly.

While this was successful in keeping the country running, it required companies to rapidly pivot and the country faced high electricity prices, peaking at a daily average of $888/MWh on 7 August[1].Off the back of its experience in Winter 2024, Genesis asked KPMG and Concept Consulting to assess the future requirement for Huntly assets to support New Zealand's energy security over the short, medium, and long term.

This white paper presents the key findings of that analysis, including considering a long list of solutions for flexibility and modelling of electricity prices under different scenarios. It concludes with a clear need for thermal 'flexible generation' in the short term and presents the trade-off between lower prices and environmental impact for longer term solutions.

Key takeaways:

1. Having a high degree of renewable energy generation means New Zealand needs the capacity to store energy for the times when nature does not align with needs. The storage system needs to be able to provide days, weeks and months of electricity supply.
2. Concept Consulting's modelling shows that without thermal generation from the Rankine units as part of New Zealand's energy storage solution, wholesale electricity prices would likely be 60% higher in the short-term (the next two-to-three years) and 11% higher in the long-term (ten+ years).
3. The choice of fuel used for storage is critical for security, price stability and environmental impact. There is value in New Zealand having diversity for its storage solutions, as seen by the impact of the lack of gas in Winter 2024.

The scale of the need for flexible generation

To meet New Zealand's goal of Net Zero 2050 the economy is electrifying, and the country is developing more renewable generation. The renewable build to-date has already displaced thermal generation from baseload duties. It is expected that over the coming years as the system moves to even higher percentages of renewable generation, the remaining thermal generation will provide progressively smaller amounts of 'peaking' support during short duration capacity constraints, or longer duration periods of hydro shortage.

Concept Consulting used its proprietary 'ORC' electricity market forecasting model to model four different scenarios examining variations in possible future carbon prices (and hence how renewable the electricity system will become) alongside variations in future gas supply.

For each future year, the model used 43 hypothetical 'weather years' to test how the system would perform across the range of wet / dry, windy / calm, sunny / cloudy situations that New Zealand is likely to experience, and thus the need for flexibility resources to manage such variations. The focus was on longer duration flexibility requirements (periods of weeks or months), such as the needs of Winter 2024, rather than short duration peaking (periods of hours). Refer to Appendix 1 for the assumptions behind the modelling.

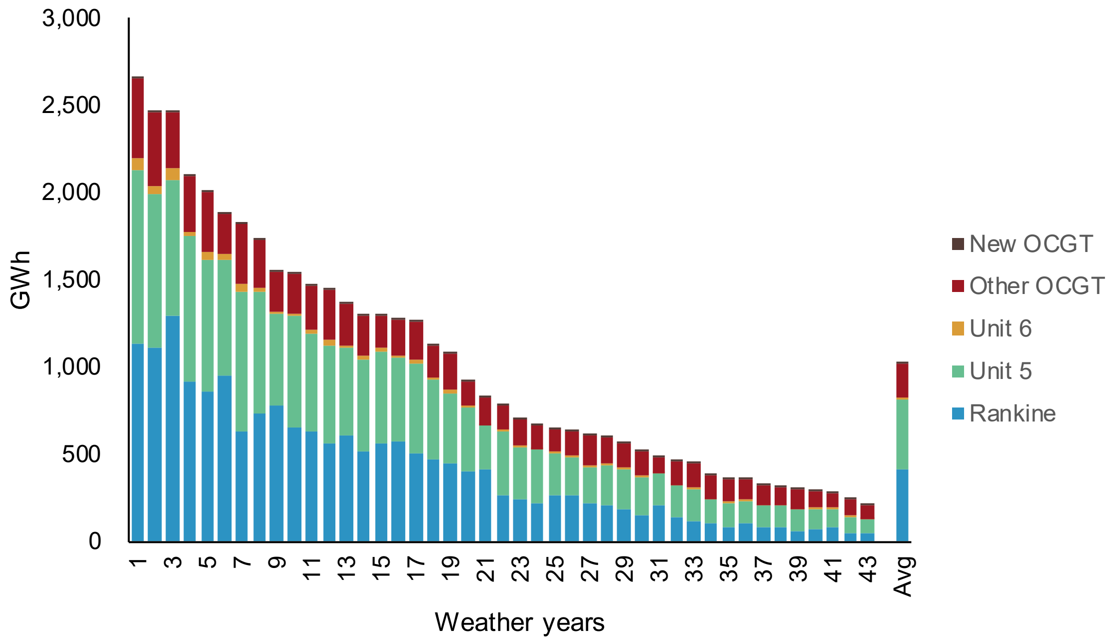
A simple illustration of the need for flexibility is shown in Figure 1. This shows the modelled amount of generation needed by thermal units across the 43 different weather years for 2035 in the 'Renewable Push' scenario. This features a relatively high carbon price

[1] Prices at the Otahuhu grid exit point in Auckland.

($230/$tCO_2$) with the resultant build of renewables resulting in a 98% renewable electricity system on average (99% if the Huntly Rankine station were fuelled by biomass).

As can be seen, even though the need for thermal generation is approximately 1,000 GWh on average, this ranges from 200 GWh in the wettest year to 2,700 GWh in the driest year. The majority of the extra GWh in the driest years are from sustained periods of long-duration operation (weeks and months) to cope with low hydro inflows.

Figure 1: Modelled 2035 thermal generation for the Renewable push scenario



To deliver the flexible generation required, New Zealand needs a solution that can balance the trilemma of security, affordability, and environmental impact. An optimal solution would:

1. Have sufficient storage capacity to be able to cover weeks or months of demand.
2. Reliably deliver the energy when required. If it is from a thermal station (fossil or biomass) this requires some form of stockpile, or the ability to reliably increase fuel production, or import fuel from overseas.
3. Have a relatively low capital cost, given that it will operate infrequently, and therefore support affordable pricing.
4. Support the decarbonisation path.

Options for providing the flexible generation

New Zealand has a number of options available to fulfil the long duration flexible generation need, as briefly summarised below. The preference placed on each option depends on the weighting put on each of the four characteristics above.

- ***Industrial curtailment:*** Rather than looking for new generation options, New Zealand could instead rely on agreements where large users reduce electricity demand during periods of lower renewable generation. This would need to be from electricity-heavy industrial businesses to provide the long duration flex that is required, other than the Tiwai aluminium smelter (whose response was already included in the Concept modelling).

However, a provisional analysis indicates that it is unlikely there are enough other users of this kind to cost-effectively meet the scale of need.

- ***Batteries:*** Investment in batteries has been increasing in New Zealand and around the world, particularly to firm up solar generation. The capital cost is currently relatively high, meaning batteries are better suited for short-duration, regularly-cycled peaking, rather than the long-duration flexibility this paper is addressing. Unless there is some major new battery technology breakthrough, batteries seem unlikely to be able to provide long-duration flexibility for the foreseeable future.

- ***Upstream gas:*** Local gas is in a state of decline and there is a reducing ability of New Zealand's gas field's to flex. While more gas could be found, there is considerable uncertainty around this, which calls into question how firm an option it is for providing supply security in the long term.

- ***Imported gas/LNG:*** A working group is studying the supply chain security and affordability of importing LNG. This paper cannot draw conclusions on the cost of developing the terminal and the commodity price until the working group reports back. However market commentators have noted that LNG is not anticipated to be a low-cost option and will have greater environmental impacts than domestic gas (and potentially even coal, depending on the source) when considering the additional energy used for liquefaction and transportation and the extent of whole-of-supply-chain methane leaks.

- ***Coal:*** There is no debate that coal is not a desirable fuel due to its environmental impact. The fact that coal can be stored for long periods of time and has a secure supply chain, means it scores highly on the supply security and affordability legs of the trilemma. Effort needs to be put into alternative fuels that have similar qualities without the environmental downside.

- ***Biomass:*** Certain forms of biomass could work as a coal replacement in time. The ability to store biomass as a stockpile makes it a promising option to deliver the long-duration flexibility that New Zealand needs. Work would be needed to shore up the supply chain and test the affordability. Other alternative fuels, such as hydrogen, may also be options in the future but significant further work is needed to develop the technology and make affordable.

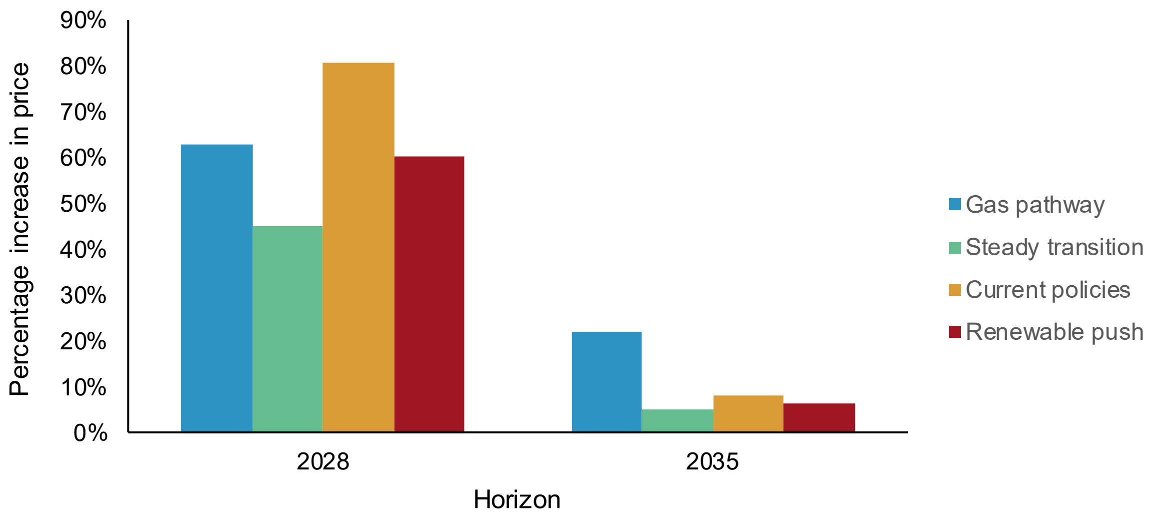
- ***Wind, solar, geothermal:*** Using additional renewables for flexibility supports the environmental objectives. However, the capital investment required for new assets that are not frequently used, makes this an expensive option. For example, while it is relatively cost-effective to build a windfarm whose output is required 90% of the time, it is very expensive to build a windfarm whose output is only required 10% of the time. Furthermore, the profile of variable renewables makes them poorly-suited for providing some flexibility duties: solar exacerbates the winter/summer mismatch and wind (being loosely correlated with hydro) potentially increasing the dry-year need.

- ***Hydro:*** A hydro solution would ideally be an asset that can be controlled, such as pumped hydro. A scheme that was large enough to meet the flexibility needs would come at a considerable capital cost and consequent price implications. However, smaller schemes, depending on their cost and storage characteristics, may make useful contributions to meeting some of New Zealand's flexibility needs.

Concept's long-term modelling (2035+) sought to optimise the combination of the above resources to meet New Zealand's flexibility needs at least cost given the underlying drivers for the four scenarios (ie, variations in carbon price, gas price, and solid fuel price). For the short-term modelling (2028), the fleet of stations was held static between the scenarios reflecting the limited ability to significantly change the mix of New Zealand's generation fleet at short notice.

Given that a key focus of this analysis was the potential value the Rankines brought to the electricity system, for each of the scenarios, the modelling also considered sub-scenarios with variation in how many Rankine units were available (3, 2, or 0). The high-level results of this are shown in Figure 2.

Figure 2: Increase in wholesale electricity price from moving from a 3 Rankine unit future to closure of the Rankine station across the four scenarios[2].



The price impact of closing the Rankine station is less in the long-term as the system has time to adjust by building replacement resources: a combination of additional wind, solar, batteries, and Open Cycle Gas Turbines (OCGTs) – plus some additional demand curtailment.

What this means for the short term (2025 to 2028)

Over the short term there is little time to develop new generation assets or technology. New Zealand will need to work with its existing assets and optimise the use of fuels to deliver security, affordability and minimise the environmental impact.

Further demand agreements could be investigated, but additional options will be needed. With the current gas uncertainty, it would be a risk to rely on the gas turbines and New Zealand will need to have a backup fuel for security. Current conditions mean that this will

[2] The four scenarios are explained further in the Appendix.

need to be coal through the Rankine units, which demonstrates the need to start thinking now about the plan for flexible generation in the medium to long term.

Figure 2 above illustrates the need to utilise the Rankines at Huntly in the short term. Concept's modelling indicates that is the Huntly Rankine units were not available in 2028, wholesale electricity prices would be approximately 60% greater.

A plan for the medium to long term (2028 onwards)

The modelling has shown that the scale of the need for long-duration, flexible generation continues into the future. The option analysis has shown that the options for addressing this broadly come down to:

1. Continue using the Rankines at Huntly as a core part of the solution, using gas when available, and accelerate work to secure the supply chain for alternative fuels (e.g. biomass).
2. Build new generation or storage assets, recognising that renewables could be an expensive option, but the investment case for new gas turbines is currently difficult.
3. Investigate new technologies that could be used for providing energy flexibility e.g. hydrogen, biomethane, biodiesel, or gravity-based storage technologies.

Continuing to use the Rankines in the long term is the lower cost option for the country due to minimal need for additional capital. Genesis has stated that their upcoming investments should renew the Rankine assets to deliver reliability out to 2040.

- Decommissioning the Rankines is forecast to lead to higher prices in the long term, but these price increase are not as extreme as in the short term (over 10% higher in 2035 than if the units were to continue based on the Concept Consulting modelling). Refer to Figure Two above. The modelling reveals that if the Rankines are decommissioned the sector will need to invest in more wind, solar, batteries, and gas peakers and call upon greater amounts of demand curtailment. It is understandably more expensive to invest in new assets rather than rely on existing assets, but the decarbonisation impact would need to be analysed.
- Even in the high carbon price scenarios with the Rankines using high-priced biomass, in the no-Rankine scenario wholesale electricity prices were 7% higher and gas-fired generation was greater. Furthermore, there is a risk in this scenario that higher electricity prices could affect the extent of decarbonisation-through-electrification for the rest of the economy. The extent to which the potential emissions reduction from closure of the Rankines would be offset by increased emissions from reduced electrification of the rest of the economy (and increased gas-fired generation) was not evaluated in this analysis.

The Rankines also provide more security in a market where gas supply is now uncertain. The unique benefit of the Rankines is they are multi-fuel, burning gas, or coal, or alternative fuels such as biomass. Continuing to use the Rankines over the medium term, keeps open the option of using them for alternative fuel generation in the longer term or providing time for new technology to emerge (whether that is using a new fuel in the Rankines or developing a new generation asset). This is important because the investment horizon of new fuels and technology is unknown, and it will be valuable to have a secure source of flexible generation while the new technologies and supply chains are being established.

While the Rankines have a price and security advantage for the country, the downside of continuing to use them is, if there is not a high enough carbon price, there may not be sufficient incentive to switch away from coal.

Regardless of the flexibility solution(s) that is chosen, the provision of long-duration flexible energy that can be used infrequently has a significant value for the country and the sector. The cost of holding and maintaining these infrequently used assets, however, sits with individual asset owners.

Conclusion

New Zealand has both an immediate need and a long-term need for flexible generation to underpin its highly renewable generation system. The need is different to many other countries because New Zealand requires flexible generation that can be little-use for years, but then be able to supply weeks and months of electricity supply during dry years.

Concept Consulting's modelling shows that continuing to use the Rankine units at Huntly helps to keep prices down in both the short and long term, and the qualitative analysis shows they can provide security of supply because they are multi-fuel generators. The current drawback is the environmental impact of the fuels currently being used at Huntly. The only way for the Rankines to be viable solutions as New Zealand works towards Net Zero 2050 is to accelerate the work on alternative fuels, such as biomass, that can be sourced and stored reliably.

Appendix: Background to the modelling

Concept Consulting used its proprietary 'ORC' electricity market forecasting model to model four different scenarios examining variations in possible future carbon prices (and hence how renewable the electricity system will become) alongside variations in future gas supply.

For each future year, the model used 43 hypothetical 'weather years' to test how the system would perform across the range of wet / dry, windy / calm, sunny / cloudy situations that New Zealand is likely to experience, and thus the need for flexibility resources to manage such variations. The focus was on longer duration flexibility requirements (periods of weeks or months), such as the needs of Winter 2024, rather than short duration peaking (periods of hours).

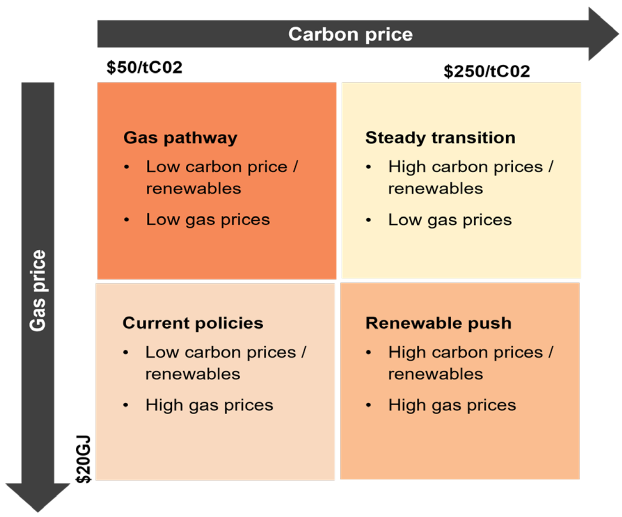
<u>Four scenarios</u>

The four scenarios were constructed by focusing on two factors that have material impact on New Zealand's electricity market:

1 **Future carbon prices:** The need for thermal assets to provide long-duration flexibility will vary considerably between a high and low renewable energy market. Carbon prices are likely to be a principal driver of both supply and demand investment decisions and operating choices.
2 **Future gas prices:** The inability of the gas sector to supply sufficient gas was a key factor driving the extreme prices experienced in Winter 2024. The future availability and cost of gas is highly uncertain. Variations in this dimension will affect the competitiveness of the Rankine Units and Unit 5 and 6 to provide long-duration flexibility and will impact the likely returns from gas storage investments and procurement commitments.

The above two factors were then used to build out four scenarios. These are shown in Figure 3.

Figure 3: Market scenario overview[3].



[3] Shows the minimum and maximum carbon and gas price. The price can vary depending on the horizon.

Other elements in the modelling

Alongside the four scenarios, the modelling tested various Huntly asset combinations, including:

- 2 Rankine Units, plus Unit 5 and 6.
- 3 Rankine Units, plus Unit 5 and 6.
- Retire Rankine Units, leaving only Unit 5 and 6.

The modelling studied three different time horizons: 2028, 2035 and 2045.