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The economic benefits of the Clutha Pumped Hydro Project

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About the author

Peter Wilson is the owner of Clover Hill Economic Consulting, and has more than forty years' experience in government, consulting, and the private sector. He worked for the New Zealand Treasury in senior roles for fourteen years and was a Principal Economist at the New Zealand Institute of Economic Research for ten years. He has worked on issues including climate change, resource management, electricity distribution, social and tax policy, immigration and labour markets. A list of his publications is attached to this report.

The Economic Benefits of the Clutha Pumped Hydro Project

New Zealand's demand for electricity is set to grow steadily over the next 25 years, driven by population growth, economic expansion, the shift to electric vehicles and the electrification of industry. The proposed Clutha Pumped Hydro (CPH) project would contribute to meeting this demand by providing large-scale, renewable, and reliable energy storage, which would be available to support intermittent sources of renewable energy, such as solar and wind power, and during dry hydro sequences.

The project would pump water from the Mata-Au (Clutha River) up to an enlarged Lake Onslow, storing energy that can later be released to generate up to 1,000 megawatts of power, making it one of the country's largest generation facilities. This stored energy could power New Zealand for months during dry years when hydro inflows are low, reducing reliance on fossil-fuel generation.

The CPH project is a private investment, not a government initiative, and it aims to operate within New Zealand's competitive electricity market. By generating power when prices are high and pumping water when prices are low, it can both stabilise electricity prices and provide backup for intermittent renewable sources such as wind and solar.

Economically, CPH would deliver significant national and regional benefits by:

- Strengthening energy security and helping manage the 'dry year' problem.
- Supporting New Zealand's transition to renewable electricity by 'firming' intermittent generation.
- Potentially lowering overall generation costs by displacing higher-priced fossil-fuel generation.
- Creating employment and regional investment during construction and operation.

The report concludes that, while precise modelling of future outcomes is not yet possible, the evidence strongly supports CPH's referral under the Fast-track Approvals Act 2024. Its scale, storage capacity, and ability to enhance system resilience make it a project of clear national significance for New Zealand's energy future.

Contents

1. Introduction

The Clutha Pumped Hydro Consortium has commissioned this report to support its application to refer the Clutha Pumped Hydro project to the Environment Protection Agency under the Fast-track Approvals Act 2024 (the Act).

1.1 Electricity demand is set to grow

Driven by population and economic growth and decarbonisation of transport and industry, demand for electricity in New Zealand is expected to grow over the next 25 years. In that period, the Huntly coal-fired station is also expected to close.

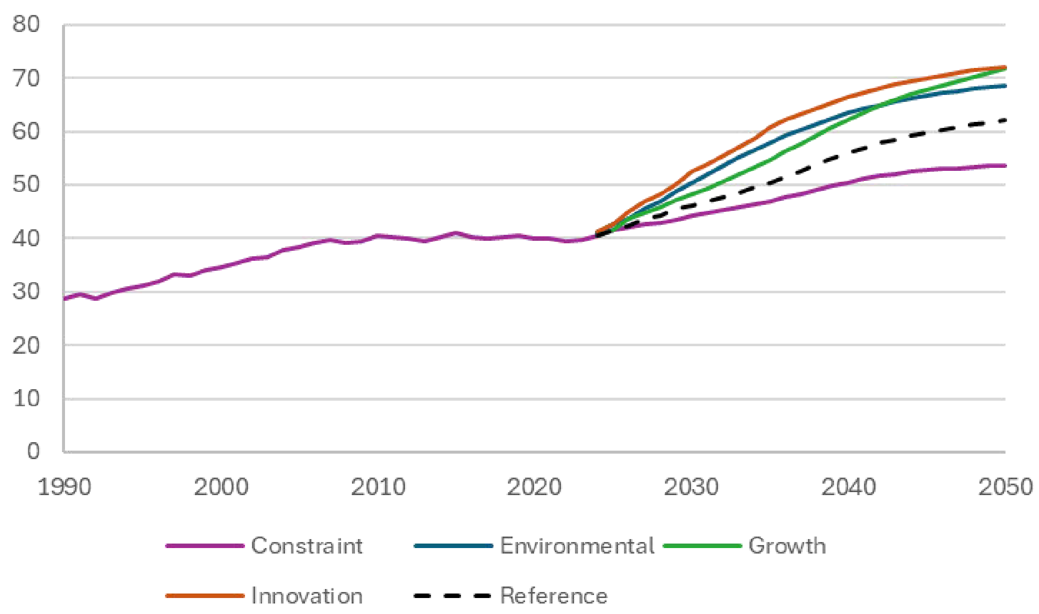
In 2024, the Ministry of Business, Innovation and Employment (MBIE) prepared a set of scenarios that explore potential future electricity demand and how it might be met (Ministry of Business, Innovation and Employment 2024). It calculated five different possible futures:

- Reference: Current trends continue with anticipated changes
- Growth: Higher economic growth drives immigration while policy and investment focus on priorities other than the energy sector
- Innovation: Current economic trends continue, alongside accelerated technological uptake and learning rates
- Constraint: International trends leave little room for domestic growth or innovation
- Environmental: New Zealand targets more ambitious reductions in emissions.

Figure 1 shows the results, compared with historical demand since 1990.

Figure 1 Under all scenarios, electricity demand will grow

TWh



Source: MBIE

To meet this growth in demand, more generation capacity will need to be installed in New Zealand. While not designed to directly meet new demand. CPH supports new sources of wind and solar power to do so, as well as addressing the dry year problem of insufficient water storage.

1.2 The CPH project

The CPH scheme would pump water from the Mata-Au to a reservoir at an enlarged Lake Onslow. By reversing the direction and releasing water to flow from Lake Onslow to Mata-Au, electricity will be generated to reinforce the national energy grid at times of constrained capacity.

The proposal is to build four reversible generating units of 250 MW. Each unit will be capable of both generating and pumping and will be able to operate anywhere between 25 MW and 250 MW. Thus, the maximum capacity of project is 1,000 MW. For comparison, Table 1 shows the capacity of the current five largest generation stations in New Zealand

Table 1 CPH would be New Zealand's largest hydro power station

Capacity MW

Plant	Maximum capacity
Huntly (gas and coal)	1,204
CPH (hydro)	**1,000**
Manapouri (hydro)	850
Benmore (hydro)	540
Clyde (hydro)	432
Roxburgh (hydro)	320

Source: Open Infrastructure Map (2025)

The dam at Lake Onslow will create a very large energy storage facility by New Zealand standards.

At this stage, a storage capacity of 5,000 GWh of energy is planned. This would be sufficient to enable 1,000MW of continuous generation for 6 months and produce more than 4,000GWh.

1.2.1 The physical features of CPH

CPH encompasses the following main elements:

- An upper reservoir formed by raising the existing Lake Onslow through the construction of a new dam on the Te Awa Makarara (Teviot River).
- A tunnel, surge chambers, and shafts to split the tunnel into penstocks.
- A mostly underground powerhouse near Mata Au, where electricity is generated when water is flowing downwards, driving turbines. The same turbines serve as pumps when water is being pumped up to Lake Onslow for storage.

- A lower offtake pond adjacent to the Mata Au. This will serve the twin purpose of being the location from which water from is drawn from Mata Au to be pumped up to Lake Onslow and where water will be discharged when electricity is being generated.
- Connections to the electricity supply network, including an above-ground substation.
- Associated infrastructure for the construction phase: new and relocated road lines, accommodation, transmission lines, and borrow pits.
- Temporary infrastructure for the construction phase, such as building and roading materials and equipment, locations for assembly, use and storage of the tunnel boring machines and other excavation and earthmoving equipment, rock crushing and concrete plants, maintenance and construction, and related facilities.

1.3 Taking an economic approach

The test for referral under the Act is that the "project is an infrastructure or development project that would have significant regional or national benefits" (Section 22(1)).

The term "significant regional or national benefits" is not defined in the legislation. The legislation does, however, suggest that the types of benefits that are relevant include productivity gains, improved infrastructure performance, housing supply, primary industry growth, climate resilience and environmental improvement. Public plans and strategies referencing and promoting similar projects is also an indicator that the project should proceed.

The Resource Management Act (RMA) includes several provisions that explicitly recognise economic considerations. Section 5 refers to communities being enabled to provide for their economic well-being. Section 7 requires decision makers to have regard to the efficient use and development of natural and physical resources. Section 32 provides that assessments under the Act must include the costs, benefits and alternatives of proposals.[1] Since 2012, the RMA has also required opportunities for economic growth and employment to be included in any assessment.

Decisions therefore rely on judgement about the scale of advantage a proposal is likely to deliver for New Zealand as a whole or for specific regions.

In my view, an economic approach should be taken in deciding what benefits should be considered. This would involve looking at both benefits and costs. At the same time, the fast-track approval process, as the name implies, is designed to allow the timely consideration of projects of national significance. This means that what is required is not a highly granular assessment of all the benefits, or a detailed discussion of the countervailing costs. Rather, the minister should be focusing on whether there is sufficient evidence available to conclude that the project should proceed to the next phase of the approval process.

It is quite likely that in later stages of the approval process, more data will be required to be collected and analysed using a more detailed set of assessment tools.

[1] Section 32 does not apply to applications for resource consents.

1.4 CPH is a private investment

CPH is being proposed by private parties who will eventually invite investors to participate.

That said, the project is to build a large electricity generating facility in a market dominated, both historically and currently, by government investment and regulation. Governments have sought to achieve multiple goals in the electricity sector, including efficiency, equity, protecting the environment, industry policy, regional development, meeting New Zealand 's international obligations, all conducted in an often highly charged political environment.

However, under the Act, the minister and other decision-makers are not focusing on wider policy issues. They are making decisions about whether projects should be approved using well-understood processes that apply to a wide range of private investments. They are not making decisions as potential owners of a facility.

CPH has some features of the NZ Battery Project considered by the previous government. But much of the analysis of that project undertaken by officials was for another purpose: it was to provide Ministers with information upon which to make decisions about whether to invest in a battery and, if so, what sort and when; and what regulatory action would be required to integrate the battery into the New Zealand electricity market.

That project was considered within the context of the previous government's goal of 100% gross renewable electricity generation in the medium term.

Given this different purpose, I have only considered those pieces of analysis of the NZ Battery Project that are relevant for decision-making under the Fast-track Approval Act.

1.5 Outline

This report proceeds as follows. First, to put the potential benefits in context, I outline briefly the New Zealand electricity market within which the CPH project will operate.

Then I describe in more detail the physical characteristics of the CPH project and how it will operate. We then proceed to discuss the concepts of costs and benefits as they might apply to this application.

We then examine the different benefits that CPH will provide, both during construction and while operating.

2. A quick primer on the economics of the price of electricity in New Zealand

How CPH operates within the current electricity market will be a key determinant of its national benefits.

We discuss two separate issues.

The first is the short-run marginal cost of generation, which is determined by the operation of the wholesale electricity market. In the short run, some generation in the electricity system, such as the capacity of a power station, is fixed, and this creates a barrier to further generation. For example, in the very short term (say a trading period of 30 minutes) some power stations cannot instantaneously come online, but can later in the day or week.

The second is the long-run marginal cost of electricity, which is a measure of total cost of the resources that are required to create new capacity. The long run cost is, by definition, not subject to any short run constraints, as it is looking at the cost of adding additional capacity to the system.

There is, however, an important connection between short-run and long-run costs.

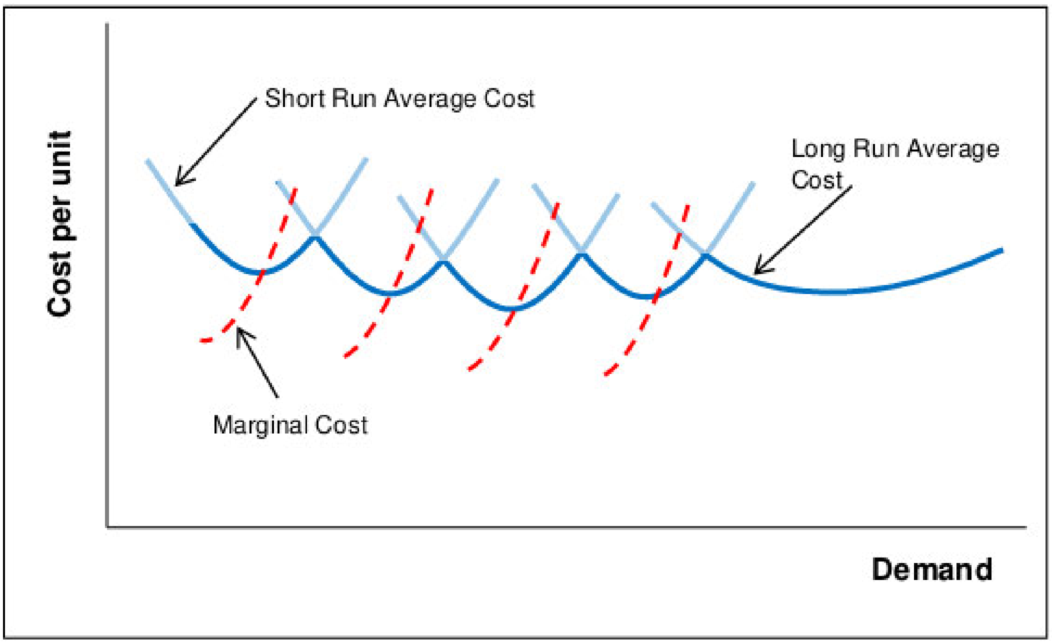
If demand at any point is approaching available supply, then the wholesale market will generate a short-term price signal that will encourage generators to make more capacity available (including using water stored in hydro dams), as well as signalling to consumers to reduce demand.

Consistently high short-run prices send a signal to the market that it may be profitable to build new capacity to meet demand. If, as in New Zealand, demand is expected to grow due to population and economic growth and fuel switching associated with decarbonisation, then short-run costs would stay high if capacity is not coming on stream to meet this demand.

New capacity comes in discrete amounts, driven by the size of new individual generators. This means that there is often a saw-tooth effect, as short-run marginal costs increase until a new plant is constructed, and then they drop. Figure 2 shows how a series of individual marginal cost curves for each plant translate into a average cost curve through time.

Figure 2 The saw tooth effect of short-run marginal cost on prices

Cost per unit as quantity supplied increases



Source: Tooth (2025)

2.1 The short-run wholesale electricity market

Most residential and commercial users of electricity buy their power from a retailer at a fixed price per kilowatt hour (KWh). This includes the cost of the power itself, and the cost of transmission and distribution.[2]

Sitting behind this retail part of the system is a wholesale market, where power is bought and sold as a commodity.[3]

The key economic concept in this market is “spot price”, which is what wholesale buyers pay, and wholesale sellers receive for each unit of electricity. This is determined by the interaction of supply and demand in each of 48 30-minute trading periods over each day. Transpower, as the system operator, calculates the price using a piece of software called SPD, short for Scheduling, Pricing and Dispatch.

The main inputs into SPD are:

- Supply offers: the amount of power each seller will be able to deliver to the market and the price they are offering for different parcels of power (which depends on the type of generator)
- Demand bids, which is how much each market participant is expecting to buy
- Information about the state of the network, including the constraints on transferring power between different regions
- The amount of reserves required to support the market.[4]

SPD creates an offer stack of available generation and reserve capacity by price, from lowest to highest in each period. It then selects the cheapest offer to be dispatched first and continues up the stack until all demand is met.

The market or spot price is the price offered to supply the last, or marginal unit. Transpower describes the spot price as:

> *The nationwide price level is set by the marginal cost of meeting energy demand for that trading period, which is usually the least expensive dispatchable generation or demand resource required to meet the final megawatt of energy demand in that period after all other cheaper options have been exhausted.* (Transpower 2025b)

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2 Generation, transmission and distribution are the physical elements of the system. Transmission is the high voltage system operated by Transpower which moves energy from generating plants to the main centres of use. Distribution is the medium and low voltage system used to deliver power to homes and businesses. It is operated by regulated distribution or lines companies.

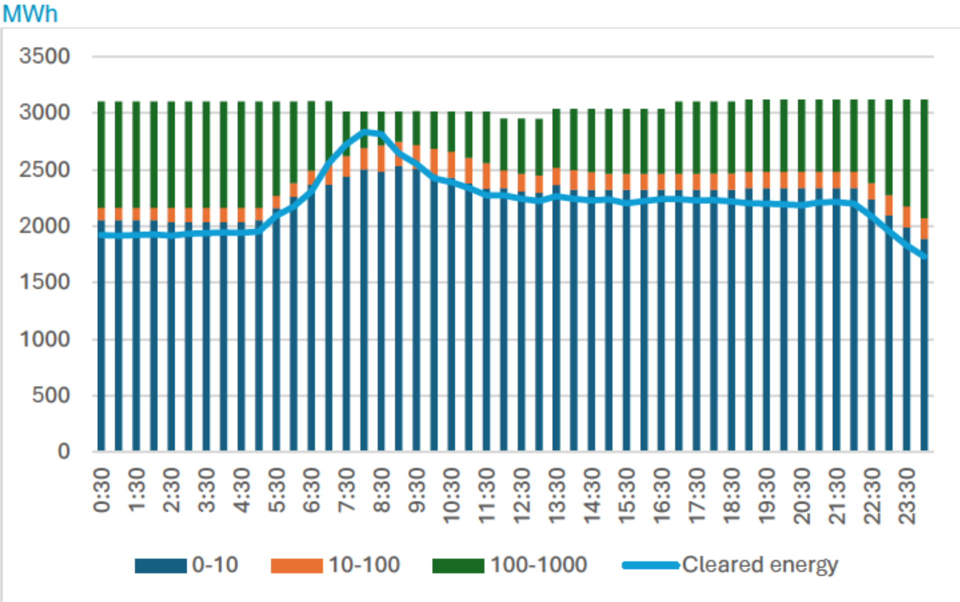
3 For a history of the development of the electricity market, see Evans and Meade (2005) and Ministry of Business, innovation and Employment (2015).

4 It is a physical requirement that the electricity system must be balanced at all times: the amount supplied must equal the amount demanded (Electricity Authority 2022a). If the system becomes unbalanced, then it can become unstable and blackouts can occur. One way to prevent this from happening is for the system operator to seek bids from generators for load that can either be switched off very quickly (for example, hot water heaters in consumers’ homes) or can be turned on quickly. The latter are called instantaneous reserves and are provided either through generators operating below their full capacity or a unit that can be started in seconds.

That price is paid to all the elected offers, regardless of their offer price. This is a fundamental part of market design. It creates an incentive for generators to make offers based on their actual cost of generation and thus facilitates the lowest total cost electricity being supplied to the market in every trading period.

Figure 3 shows the offer stack and the amount supplied in the South Island on 17 October 2025.

Figure 3 Offer stack and cleared energy South Island 17 October



Source: Electricity Authority

Focusing on the period when the price was highest, between 8.00 and 8.30 am, the effect of the market is clear. In this period, demand was 2,834.84 MWh. Generators offered 2,502.5 MWH in the price band $0-10/ MWh, which was insufficient to meet demand. Transpower therefore accepted offers from the next price band, $10-100 MWh.

Table 2 The offer stack at 8.00 am

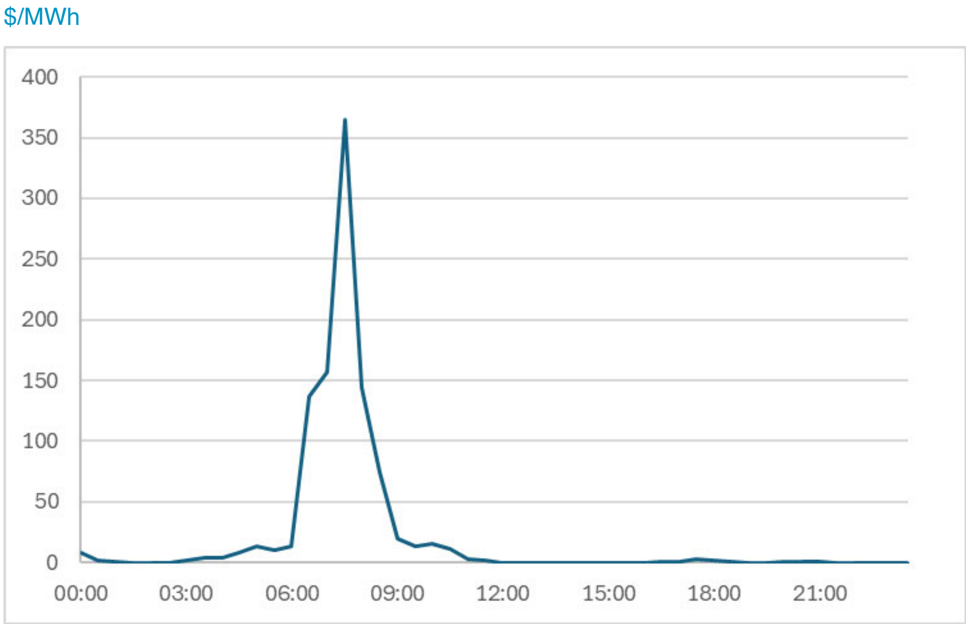
Price in dollars, amount in MW

Price range	Amount
0-10	2,502.5
10-100	191.0
100-1000	321.5

Source: Electricity Authority

Figure 4 shows the resulting prices in the wholesale market for the day.

Figure 4 Wholesale spot price, South Island 17 October



Source: Electricity Authority

To move the market, that is to lower the spot price, a generator must offer enough supply to displace the highest (clearing) price in the dispatched stack.

2.1.1 What determines offers?

The cheapest generation types are plants that must be running, which includes:

- Wind power (when the wind is blowing)
- Solar power (when the sun is shining)
- Baseload geothermal power
- Inflexible thermal power plants
- Hydro power when it is raining heavily.
- Hydro power that is sufficient to maintain minimum river flows set in resource consents

At the top of the stack, some of the most expensive sources are:

- Flexible thermal power plants
- Hydro power being conserved in case of upcoming periods of low rainfall
- Batteries
- Dispatchable demand (Transpower 2025b, 8).

2.2 The long-run marginal cost of electricity

The wholesale market is where the price of generating electricity from existing generation assets is determined on a half-hour by half-hour basis. The focus of generators is making the most of those assets during very short periods, rather than taking a long-run view of required returns. The availability and cost of the fuel used to generate the marginal output of the system is a key determinant of price, as is the fact that the quantity of power that can be supplied by each existing asset is fixed in the short run.

Over time, an efficient system will result in additional capacity being built if it is economically viable. That is, if prices are sufficient to cover all the costs of generation, not just fuel and other short-term operating costs.

Because the definition of the long run is that all variable factors can change, determining the long-run marginal costs is a dynamic process that involves the interaction of many inter-related effects.

On the supply side, how different types of generation can interact can have material effects on the outcome of market decisions.

As I discuss below, while new solar and wind power can have low long-run marginal costs, they are intermittent and thus must be supported by 'firming' generation that is available at short notice to come on stream if the wind or sun cannot provide the expected power.

3. The CPH

This section outlines what CPH will involve from the perspective of its potential benefits.

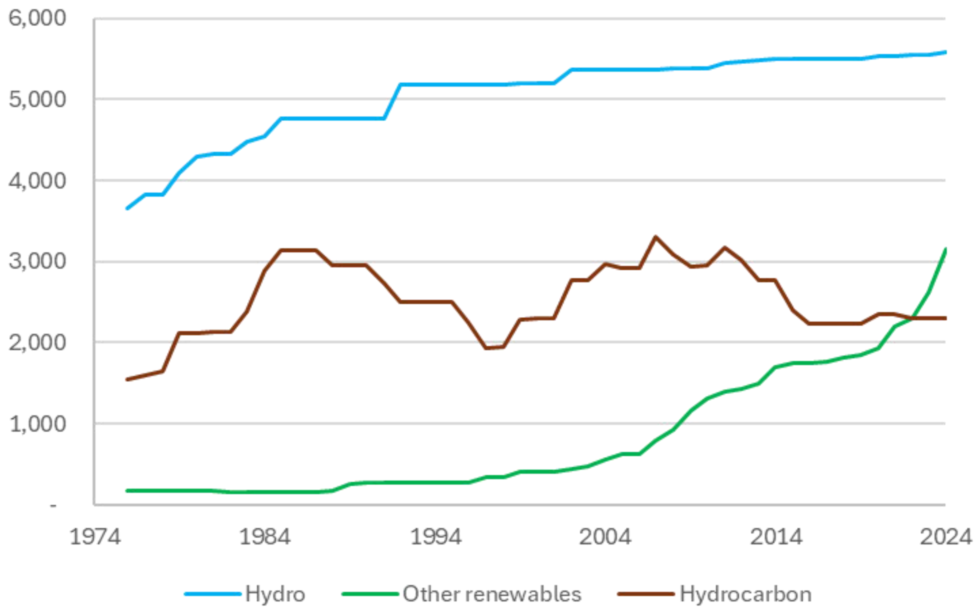
3.1 Background

Hydro power is the backbone of the New Zealand electricity system.

Figure 5 shows installed generation capacity by type. While hydro power is the largest fuel type used in New Zealand, the amount of generation capacity is only growing slowly. Last year, about 16 per cent of total energy generation was from generation plants that used hydrocarbons as a fuel.

Figure 5 Hydro generation capacity is growing slowly

Generation capacity by fuel type, MW



Source: MBIE

3.2 The dry year problem

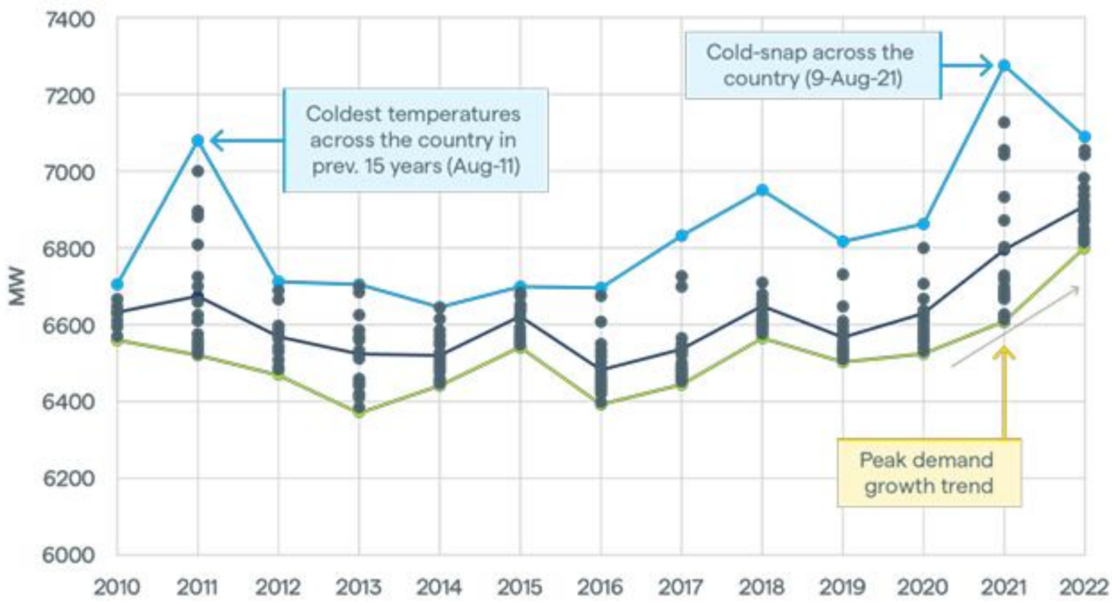
Even though it is such an important source of electricity, there is a security of supply issue with how hydro power is generated in New Zealand. Hydro storage in New Zealand is based on hydrology: rainfall and snowmelt feeds water into rivers and lakes (which are either natural or have been formed by dams). However, because of geology, the storage lakes are small relative to New Zealand's frequent and often intense rainfall, and the system is largely 'run of river'. Some schemes use water multiple times, as it flows to the sea, e.g. the Waikato River scheme and the Waitaki hydropower scheme, taking advantage of large falls in altitude along the rivers.

This is the heart of the 'dry year problem': dry sequences of up to six months in some years combined with small storage capacity result in extreme shortages of hydro power (Electricity Authority 2022b).

Transpower has concluded that peak demand for electricity in New Zealand is increasing (Transpower 2023).

Figure 6 Peak demand is growing

Top twenty daily peak demand January 2010 to September 2022



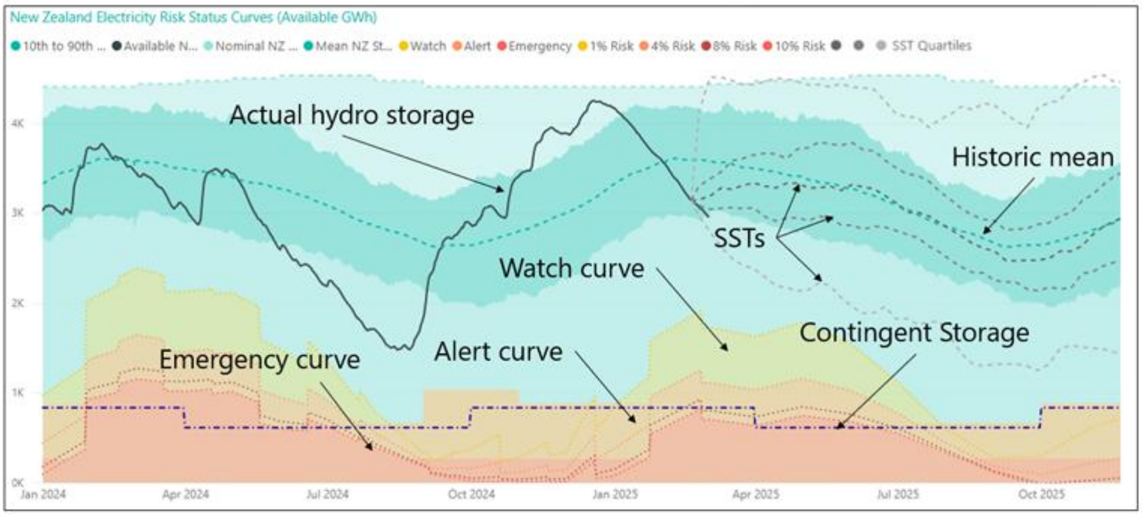
Source: Transpower (2023)

Transpower and the Electricity Authority constantly monitor the state of hydro storage to ensure that it is above set risk thresholds.[5]

Figure 7 is taken from Transpower (2025a) and shows an historical example of how it assesses the security outlook. It shows actual storage and projected storage compared with risk thresholds that would trigger action. In winter last year, for example, storage was well below the historical average, but not low enough to trigger interventions such as releasing contingent water storage or calling for a national electricity savings campaign.

5 For overviews, see Transpower (2025a) and Electricity Authority (2025b).

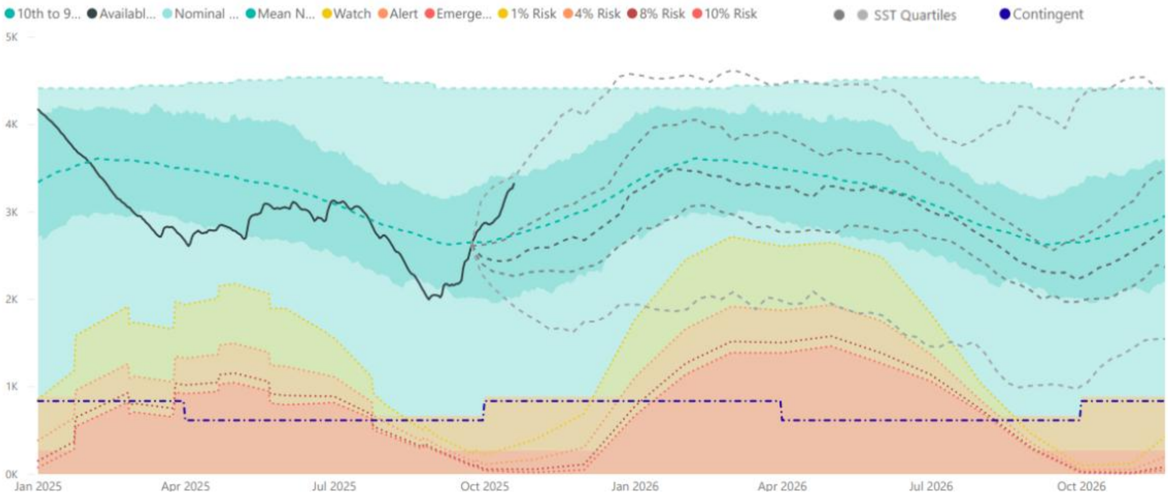
Figure 7 Security of supply outlook



Source: Transpower (2025a)

Figure 8 is the latest assessment, which shows that storage is currently well above historical levels.

Figure 8 Current outlook



Source: Transpower (2025a)

The current remedy to the dry year problem is to use thermal generation, principally the energy stored in the Huntly power station 's coal stockpile, to make up the short-term shortfall in hydro generation and to conserve water.

Over the longer term, the solution is to have reliable, low-cost generation capacity that is not dependent on hydrology or hydrocarbon.

3.3 CPH is a different type of hydro

CPH is not like current hydro power plants operating in New Zealand that have relatively small storage.

Its turbines, which normally generate electricity, can be reversed to draw electricity from the grid to become pumps that move water from the Mata Au to the higher storage reservoir at Lake Onslow. Thus, it is a consumer of electricity when it is pumping and a source of electricity when generating. It effectively allows water to be "reused". But the laws of physics mean that there are some losses and the amount of electricity used to pump the water uphill is greater than the amount generated when it passes back down the tunnel.

The estimated round-trip efficiency (RTE) for CPH is approximately 75%. The efficiency of a conventional hydro generator is usually greater than 90%. The difference is made up of pumping efficiency, the slightly lower efficiency of combined generator/pumps and water evaporation.

3.4 Arbitrage

Arbitrage (pumping water when the price of electricity is low, generating when the price is high) overcomes the laws of physics, because the price of electricity is variable.

While the energy used to pump water up to the upper reservoir is the same regardless of when it is pumped, the value of the use to which that water is put varies. It is this arbitrage that makes the scheme economically viable. The extent of profitability will depend on many factors, but that is a commercial risk the owners of the project are willing to take.

There are three main examples of arbitrage:

- Daily, with power prices being high in the morning and in the early evening, moving in line with residential and commercial demand (industrial demand tends to be flatter over the day).[6]
- Seasonally, with power prices in summer tending to be lower than those in winter (although the increase in people installing heat pumps is affecting this trend)
- Across years: being able to arbitrage the differences between years with dry and wet hydrology.

Appendix A provides examples of the extent of price volatility in New Zealand.

3.5 What CPH does

CPH will have four potential roles within the electricity system:

- Storing large quantities of water high above the powerhouse that can be released to produce large quantities of electricity that can be sold into the spot market to make up for dry hydro inflow sequences as the lake is drawn down in a dry year.
- Firming intermittent renewables
- Other services, including system voltage support and fast reserves

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6 There will always be some delay between CPH pumping water and being able to use that water for generation, as pumping is not instantaneous. This means that it will not be economically viable to take account of all arbitrage opportunities.

- Displacing higher-cost supply.

3.5.1 Storage

CPH has the ability (subject to pricing) to effectively recycle water. Water that would otherwise run to the sea can be pumped to the higher pond for reuse. before it is eventually released.

Pumping water to the upper storage pond means that in this mode, CPH operates more as a battery than an instantaneous source of power.

As noted above, price arbitrage can operate over different periods. CPH will be the most beneficial, however, when its storage is available for dry hydrological sequences, since it is in these years that the spot price of electricity will be consistently high. And while the frequency of dry sequences (defined by a 15 percent shortfall in hydro generation) used to be once in 20 years, there were four such events between 2000 and 2010 (2001, 2003, 2005 and 2008). As noted above, last winter was a dry sequence, although storage did not fall low enough to trigger emergency responses.

CPH in storage mode

Economically, when it is operating in storage mode, CPH is an insurance policy against low levels of other hydro power, and thus high prices.

In the current New Zealand electricity market, there are few physical options available for consumers to insure against low volumes of power. Some of the options are:

- Install their own back-up generation capacity. This is very costly, in terms of both capital and operating costs and fuel, which is carbon-based
- Install batteries that can provide short-term back-up. These are currently very expensive and can only operate for a short period before they need to be recahrged
- Participate in a demand management arrangement, where they agree to, in effect, sell electricity back to the market when supply is critically low. This means, however, that business and production are necessarily reduced, which has its own economic costs.

The current hedge market insures against price volatility, not power availability. The sellers of hedges must have generation capacity available to fulfil their side of the bargain.

There are two main ways in which CPH could provide its insurance-like services.

Firstly, it could operate as a normal market participant, but with long-term supply agreements that require it to always have capacity available during dry years. This is currently what Huntly does, using its coal stockpile as a large energy reserve. CPH would then sell that power into the wholesale market at the spot price, which by definition would be very high. The revenue from the wholesale market would provide a financial return on the assets invested. The difference between CPH and current hydro-generators is that CPH would have the capacity to deliver its contractual obligations by pumping water into the upper storage pond when the price of electricity is low.

The second approach, which would be new to the new Zaland electricity system, would be for CPH to operate as an insurance company and agree to provide power at a market-based hedge price for an additional fee, akin to an insurance company setting a premium.

In any insurance scheme, there are two economic issues to be addressed.

The first is adverse selection: only people with a high risk will buy insurance, meaning that there is no pool of low-risk consumers to spread the risk across. The solution, as seen in many markets, is some sort of compulsory insurance scheme. So, in the context of Clutha, a small levy imposed on all consumers in all years to allow them to receive a "payout" in a dry year overcomes this.[7]

The second is moral hazard: being insured by itself increases your incentive to take risks. This will particularly be the case for large energy users, who will face less incentive to be efficient and take their own precautions (owning back-up generators, agreeing to participate in load-shedding schemes). In the presence of CPH, this might also apply to other generators, who would have fewer incentives to save water to be used in an otherwise dry year. The solution is to have some sort of "excess" or co-pay. When you make a claim, you have to pay the first part of the cost.

3.5.2 Firming intermittent renewables

Some renewable electricity generation options, principally, solar and wind power, are intermittent, due to the variability of sunshine or wind.

To be usable by the electricity system, such power needs to be 'firmed' by some more stable source of power as back-up that can be called on at short notice by the system operator to maintain the balance of supply and demand.

Currently, firming is provided by a combination of:

Hydro storage and flexible operation

Hydro lakes can conserve their water reserves when other renewable generation is high and then use the conserved water to generate power when other renewable generation is low. This is a medium-term approach to firming. It means that one type of renewable power generation is firming another. But because existing storage is relatively small and lake levels and minimum river flows must meet consent conditions, this existing flexibility is limited and is mostly used to service daily load variations.

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[7] This also overcomes the issue of how to deal with energy being injected into the grid being non-excludable: there is no physical link between the energy injected by one generator and the energy drawn by a particular user. This is currently addressed by the regulatory system, with connection to the grid requiring a contract with a retailer, who then arranges with a lines company (or Transpower in the case of large users) to make the physical connection through a metered point. Non-excludability is one of the conditions for being a public good. A public good is a special type of good or service that has two charasterics: it is non-rivalrous in consumption and non-excludable. Electricity is rivalrous – only one person can use the energy once and, in the context of a grid, is generally excludable, in that retainers can prevent their customers from accessing the grip without payment. However, the insurance-type power provided by CPH is non-excludable, in the sense that if the power is injected into the grip, it can be drawn on by any connected users. Put another way, it is not possible for the operators of CPH to only insure part of the market, as is the case with, say, property insurance. If CPH does operate as an insurance company, this type of regulatory issue would need to be addressed. I do not discuss this further in this report, as they are outside the scope of the decision required under the Fast-track Approval Act.

Backup generation (thermal and peaking plants)

Gas- or diesel-fired stations provide electricity during periods of low wind or sunshine, or when hydro storage is low. These sorts of generators can ramp up output quickly to meet sudden reductions in solar or wind output or other plants failures. This is a short-term approach and relies on non-renewable generation firming renewables. These plants tend to have the highest short-run marginal cost of all the generation sources in the system, meaning that when they are operating, the spot price of electricity is likely to be high. Being power by fossil fuels, they can also have high environmental effects.

Demand response:

Large consumers can adjust usage to balance overall supply and demand from the grid. For example, the Tiwai Point Aluminium Smelter or data centres can reduce demand when renewable output is low, helping maintain system stability. This can either be very short-term (load shedding) or medium-term (demand being reduced over an expected period of low generation capacity). It relies on all available sources of generation firming renewable output.

Storage:

Traditionally, most electricity consumption was powered by instantaneously drawing power from the grid. New devices (computers, smart phones) and transport modes (electric vehicles) involve charging a battery for later use. Distributed solar generation is also being matched with small-scale on-site batteries that allow users to better match their generation (during the day, when the sun is bright) with demand (at night, or when there is high cloud cover). Industrial and grid-scale batteries are being developed that can store significant amounts of electricity, but usually only for short periods of time. For example, the Waratah Super Battery in New South Wales can provide up to 850MW but only for two hours, as it only stores 1,700MWh, at a cost of over $A1 billion (Energy Connects 2025).

Market and contractual arrangements

In the wholesale electricity market, firming can also refer to contractual products that give retailers or large users confidence that supply will be available even when renewables underperform. Generators might offer "firmed" products that bundle variable renewable output with guaranteed backup capacity.

Firming is not directly priced as a separate service in the New Zealand electricity market, but its value is reflected through the spot price of electricity. This price volatility provides a market signal that rewards generators and investors who can provide firming capacity.

In the contract market, retailers and large consumers manage exposure to spot price volatility by trading hedge contracts that match their exposure to high spot prices or firm supply agreements. These financial products indirectly monetise the value of firming, as they transfer risk of variable renewable output to parties capable of providing reliable backup.[8]

[8] The Electricity Authority, the Commerce Commission and the Ministry of Business, Innovation and Employment have an active work programme in place that is continuing to refine the regulation of the hedge market. (Electricity Authority 2025a)

CPH in firming role

In its firming role, CPH will be selling electricity through the wholesale market or via the hedge market.

In this mode, there is little to distinguish CPH from any other source of instantaneous electricity generation. It will provide an additional source of electricity to the market, albeit a large one.

One impact of CPH on the long-run marginal cost of electricity in New Zealand will be how it supports the building of more intermittent, but low-cost, renewable generation capacity.

CPH will be reducing the risk that renewable energy cannot be operated profitably, because there is insufficient firm capacity in place. Providing that capacity via CPH will, in effect, make it cheaper, on a risk-adjusted basis, to build and operate new renewable plant. This will reduce the break-even cost of capital of such construction, which will, under competitive market structures, flow through to consumers in the long run.

3.5.3 Other services including system support

Other services, such as voltage support and fast start reserves are currently competitively supplied to the power system and, while viable, will not be a large part of CPH's income.

3.5.4 Displacing high-cost supply

CPH is a large power station by New Zealand standards. While demand for electricity is increasing (due to both a growing economy and population and the penetration of electric vehicles), CPH will add about 9 percent to current capacity. In the short term, and depending on how much other capacity is added, it is possible that at some times, it will displace other, higher-cost and higher environmental-impact fuel types, which tend to be coal and gas.

Table 3 compares CPH's planned capacity with the capacity of other generation by fuel type.

Table 3 CPH's capacity in context

Installed capacity, 2024, MW

Fuel source	Current installed capacity
Hydro	5,581
CPH	**1,000**
Geothermal	1,275
Biogas	40
Wind	1,265
Solar PV	567
Diesel	198
Coal/Gas	500
Gas only	1,236
Co-generation	364
Total	**11,025**

Source: MBIE

If it can displace sufficient high-cost generation to change the composition of the price stack, then this could lower the short-run marginal price of electricity in those trading periods.

Even if it does not totally replace these fuel types, then from a national perspective, the total cost of generation will be reduced, because cheaper types of fuel are powering part of the electricity being generated.

Over the long term, CPH should support the construction of lower-cost, but intermittent, renewable energy which will allow New Zealand to lower the amount of fossil fuels that the power system consumes.

3.5.5 These roles are not necessarily mutually exclusive

CPH can perform more than one role at the same time.

For example, if CPH sells long-term hedging contracts to allow firming renewables, it can do so out of fuel that has been pumped back to the upper pond. If that firming displaces coal and gas-based generation, that will have environmental benefits as well.

However, in calculating the benefits of CPH, double-counting will need to be avoided.

4. How to analyse costs and benefits

As noted in the Introduction, the criteria for referral under the Fast-track Approval Act is that the proposal has "significant regional or national benefits".

There are two general approaches that could be taken to analysing the benefits of the proposal.

4.1 Cost benefit approach

The first is a cost benefit approach, which seeks to include all the effects of any proposal into the analysis.

Dreze and Stern define the purpose of cost benefit analysis as being to "provide a consistent procedure for evaluating decisions in terms of their consequences" (Dreze and Stern 1987, 909). Conceptually, cost benefit analysis involves four separate steps:

- Identifying all the costs and benefits of a project
- Converting the costs and benefits into monetary values that can be compared
- Converting streams of costs and benefits that accrue through time into a single value, by way of discounting
- Comparing the costs and benefits thus converted to find the best project, which is the one with the highest ratio of benefits to costs.

In this case, the legislation does not specifically refer to net benefits, which are benefits minus costs, but considering some of the main negative effects of the proposal would be prudent.

The simplest approach to cost benefit analysis is to only include elements for which there is an observable market price, on either the cost or benefit side. This is relatively easy, provided data is available. But non-market values are a significant theoretical and practical issue. There is now strong support in the literature for the idea that (a) non-market values exist; (b) they are large enough to make a difference to social decisions and (c) they have traditionally either been ignored (given zero value) or used as a veto (given infinite value) in decision-making processes (Baker and Ruting 2017).

The difficulty with nonmarket values – leaving aside concerns that it is inappropriate to place a value on nature[9] – is that they tend to be unobservable. Complicating matters further is the existence of a number of different types of uses that have value. For example, one common justification for the conservation of natural environments is that people derive value from knowing that those environments exist, even if they do not personally visit them.

Externalities

Cost benefit analysis is focussed on all the resources used in achieving an outcome and all the benefits. It is often called 'social cost benefit analysis' as a result (The Treasury 2015).

In economics, social means the sum of *all* private costs or benefits. This definition of social does not connote the idea that there are some benefits *additional* to those received by individuals; nor are social costs a type of cost that are additional to those incurred by individuals. Rather, the idea is that not all of the costs or benefits of a transaction accrue fully to the parties to the transaction. Some fall to others. This leads to the idea of externalities.

When either a cost or a benefit does not accrue to an individual engaged in the activity, an externality arises, meaning that some party external to the decision-making is affected by the decision. While the decision maker will still seek to equalise the marginal costs and benefits they face, they will generally not take into account the costs and benefits to others.

As a result, either too much (a negative externality) or not enough (a positive externality) will be supplied by a competitive market.

Bryan Caplan therefore defines externalities in terms of what markets do:

> *Positive externalities are benefits that are infeasible to charge to provide; negative externalities are costs that are infeasible to charge to not provide.* (Caplan 2024)

One thing that is definitely not an externality in this framework is a reduction in prices because of an investment Scitovsky (1954)

The expenditure incurred is a cost

In cost benefit analysis, the expenditure involved in completing a project is a cost: it represents the use of real resources that have alternative uses that are valuable. The concrete used to build a dam cannot be used to construct another building elsewhere. The time spent by skilled contractors working on site, and the designers, engineers and architects working on the project cannot be employed on another project. In economic terms, these are opportunity costs: their value is the opportunity forgone by their use on one activity.

The New South Wales government's guidance on cost benefit analysis defines benefits in these terms:

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9 The economists' answer to this is that by their actions, people do place a value on nature. Our task is to find out how much they value it and make sure that this value is reflected in decisions.

Benefits are an increase in welfare associated with an initiative's economic, social, environmental and cultural outcomes. Benefits can be monetary or non-monetary and an initiative's key benefits should flow directly from meeting its objectives. (New South Wales Treasury 2023)

The following table shows some examples of the difference between costs and benefits.

Table 4 Cost and benefits

Example	**Benefits**	**Costs**
Roads	Travel time savings Lower vehicle costs Reduced accidents Reduction in emissions	Construction costs Maintenance costs Noise, air pollution, and lower amenity around new road
Hydro dams	Increased electricity generation Lower greenhouse gas emissions if it displaces thermal generation Recreational activities	Construction costs Maintenance costs Inundation of land, leading to displacement of flora and fauna.
Education	Benefits to employers from higher productivity Reduction in crime and other social costs	Cost of delivering education services Student costs including income foregone and out-of-pocket expenses

Source: Adapted from New South Wales Treasury (2023)

A comprehensive cost benefit approach would consider all material effects of a proposal and expresses them in comparable terms. Cost benefit analysis aims to support consistent decisions by identifying costs and benefits, valuing them where possible, discounting future outcomes, and comparing net gains across options (Dreze and Stern 1987). It recognises that investments use scarce resources that have alternative productive uses and that externalities mean some costs or benefits fall on people other than investors. Observable market prices are generally the most reliable basis for valuation, but the literature is clear that non-market values are real, often substantial, and can shift the outcome of a social decision if included or excluded (Baker and Ruting 2017). In principle, a full assessment would examine economic, social and environmental effects and estimate the welfare impacts that flow from them.

In the case of the CPH project, a comprehensive cost benefit analysis is not feasible. Many of the relevant benefits and costs lack observable prices or accepted valuation methods. Key non-market effects are uncertain and difficult to quantify without extensive primary research. Decisions will therefore need to rely on qualitative assessments informed by economic reasoning rather than a formal comparison of net benefits.

4.2 Economic impact analysis

A way of incorporating the beneficial effects of the construction of a project is to use economic impact analysis, which as the name suggests, focusses on the impact of a project or an event.

This sort of analysis commonly focusses on:

- total revenues from a project
- value added – the projects contribution to GDP, based on total returns to labour and capital
- employment – the number of FTEs employed, both during construction and once the project is operating.

The baseline for economic impact analysis is a counterfactual of the project not existing. It is asking the question: what happens to the economy as a result of the project proceeding?

Economic impact assessment typically identifies a hierarchy of effects:

- direct effects, which are the immediate consequences of any project. These include wages paid to employees, payments to suppliers for intermediate goods and services purchased.
- indirect effects, which occur when businesses supply direct inputs make their own purchases. For example, a supplier who buys their own inputs.
- induced effects, which arise when the employees of the project spending their earnings in the economy.

Calculating direct effects uses data from the project, broken down by type.

Indirect and induced effects must be calculated, using input-out tables produced by statistical agencies. Input-out tables show the relationship between industries, the goods and services they produce and the purchasers of their outputs.[10] This is called "multiplier analysis", because of the idea that spending cascades through supply chains.

While useful for analysing the impact of an existing facility, multiplier analysis has limitations when it comes to assessing the impact of a new proposal. The most serious concern is that this type of analysis assumes that there is an unlimited amount of labour and capital available in the economy, which implies that any increase in demand does not flow through to prices (Gretton 2013, 4). To quote the Treasury:

> *Unless there is significant unemployment of people with the requisite skills, it is therefore likely that multiplier effects do not exist.* (The Treasury 2015, 19)[11]

As a result, economists prefer using more sophisticated techniques like Computable General Equilibrium (CGE) models which overcome the unlimited supply assumption and reflect changes in relative prices resulting from increases in demand.

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10 See Stats NZ (2021) for New Zealand's latest input-out tables.

11 The then Chairman of the Australian Productivity Commission, Gary Banks, was more explicit: "In reality the science of multipliers is the economics of the free lunch" (Banks 2002).

Given the limited data available, and the methodological difficulties with economic impact assessments that do not use appropriate techniques, I do not favour this approach in relation to CPH.

4.3 Other studies

In his study of the estimated gross costs of the NZ Battery options, John Culy defined his methodology in these terms:

> *Gross benefits are measured at the national level based on the change in the total electricity system cost enabled by each NZ Battery option. System costs include the capital costs for new generation and smaller scale batteries, fuel and carbon costs, and the costs of demand response.*
>
> *…*
>
> *I do not calculate estimates of net benefits because I do not have information on the costs of different NZ Battery options.* (Culy 2022)

This approach focuses on the impact of the project on the electricity system in which it will operate, rather than trying to take an economy-wide approach which requires an appropriate methodology and data. That said, his analysis was very comprehensive, factoring in the many different components of the Battery and its interaction with nature (hydrology) and other parts of the electricity system.

4.4 The approach in this study

To calculate the full net benefits of a new generation source like CPH requires a detailed model that can simulate the effect of new generation on the whole economy over different market conditions.

It would require evaluating the project against a counterfactual in which it is not built. As we saw in section 1.1, electricity demand, and thus generation capacity is forecast to grow steadily till 2050. Thus, the counterfactual will be a dynamic one, where both the volume and fuel-source of electricity generation will be changing.

If CPH were constructed and operated as proposed, it itself would have an effect on the future scenarios. By firming intermittent renewable generation, CPH could make that type of generation more attractive to generators, both incumbents and new entrants. By providing insurance against dry years, it could reduce the risk of a reduction in economic output in dry sequences, which would be expected to further increase demand.

To determine the impact on the wholesale price of electricity requires knowing where CPH will sit in an offer stack that is also likely to be changing, especially if the Huntly coal-fired Rankine units retire in 2035.

It is not practical to repeat this level of modelling at this stage of the fast-track process (or indeed at all, since in part these are commercial considerations for the sponsors of the project).

Within the context of the Fast-track Approval Act, what is required is an assessment of whether CPH meets the “significant regional or national benefits” threshold for referral, rather than a precise prediction of its impacts.

This study takes the approach that the main benefit from CPH would be the electricity that it can produce, when it produces it and the effect that that will have on the overall quantity of power in New Zealand.

5. Analysis

This section outlines, and where possible, quantifies the benefits of the CPH project.

5.1 The benefits of dry year storage

The main economic benefit of CPH in storage mode will be the reduction in the uncertainty of supply in a dry year, on the grounds that it is the additional supply that cannot be provided by the current wholesale market without dry year insurance.

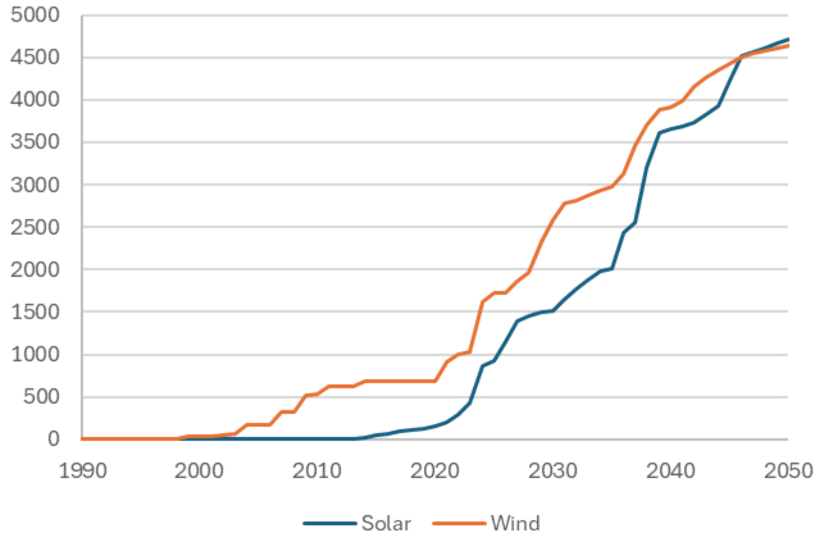
CPH ’s planned storage capacity of over 5,000 GWh of energy would be sufficient to enable 1,000MW of continuous generation for 6 months and produce more than 4,000GWh. Table 3 on page 17 shows the contribution that CPH, if fully operational, would make to the current generation capacity of the New Zealan electricity system. It would increase hydro generation capacity by 18 percent and total capacity by 9 percent. The benefits of firming

The simplest measure of the benefits from CPH providing firming for renewables is the amount of new renewable power that could be firmed by CPH.

This will be a function of the amount of renewable generation from intermittent sources that exists. The Ministry of Business, Innovation and Employment “reference scenario” in their modelling of future demand and capacity predicts that there will be strong growth in these fuel types.

Figure 9 Solar and wind capacity

Reference Scenario, MW



Source: MBIE

This suggests that there will be sufficient demand for firming to consume a large proportion of CPH's capacity.

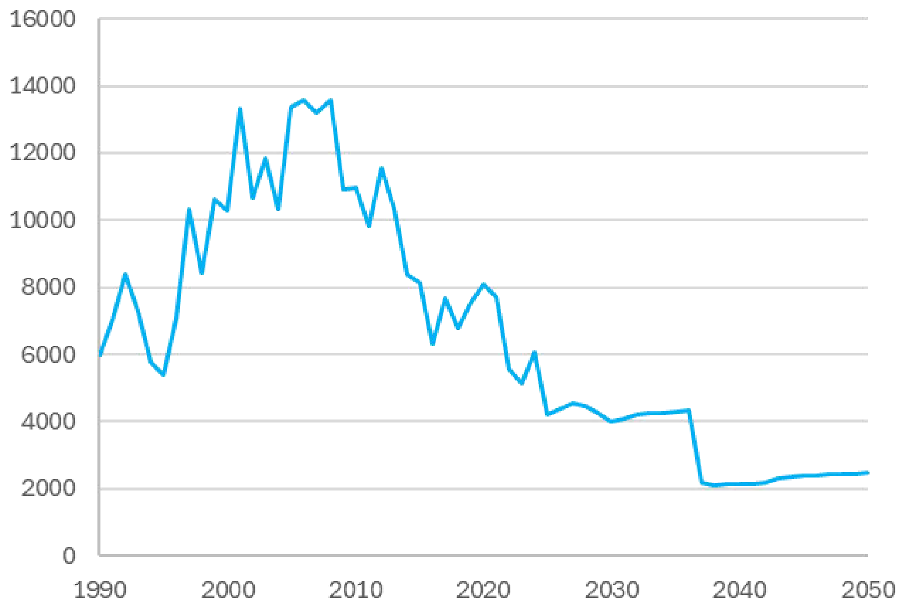
5.2 The benefits of generation

As with power that is used to firm renewables, the simplest measure of the benefits from CPH generating using recycled water is the amount of power generated and the likelihood that it would displace higher-cost power from the price stack at certain periods.

Figure 10 shows MBIE's 'reference scenario' protections of generation from fossil fuels.

Figure 10 Generation from fossil fuels will continue

Reference scenario, GWh



Source: MBIE

To put this in context, CPH, with a storage capacity of over 5,000 GWh would be sufficient to enable 1,000MW of continuous generation for 6 months and produce more than 4,000GWh.

6. Summary and conclusions

CPH is infrastructure that, in my view, provides significant national and regional benefits, in both the short and long run.

Once operational, it will be one of the largest power stations in New Zealand, backed by a significant storage capacity. The ability to arbitrage price differentials will allow the project to renew that capacity independently of hydrology, thus providing a long-sought way of alleviating the current dry year problem.

I would expect that a competitive electricity market that includes a pumped hydro facility such as CPH will have more intermittent renewable energy generation, at lower long-run marginal costs.

Predicting the future shape of the New Zealand electricity system over the life of a facility like CPH is fraught with difficulty. The system is dynamic and various parts of that system interact with others in complex ways. This make defining a counterfactual against which to assess CPH and then making the assessment a significant modelling exercise.

Fortunately for the current application by Clutha Pumped Hydro Consortium to refer the CPH project to the Environment Protection Agency under the Fast-track Approvals Act, this modelling exercise is not necessary. Because this is a private sector proposal, the modelling required to attract potential investors will be undertaken by the Consortium in due course and is likely to be highly commercially sensitive.

For now, what the Minister needs to be satisfied with is that CPH meets the criteria for referral.

My view is that it does.

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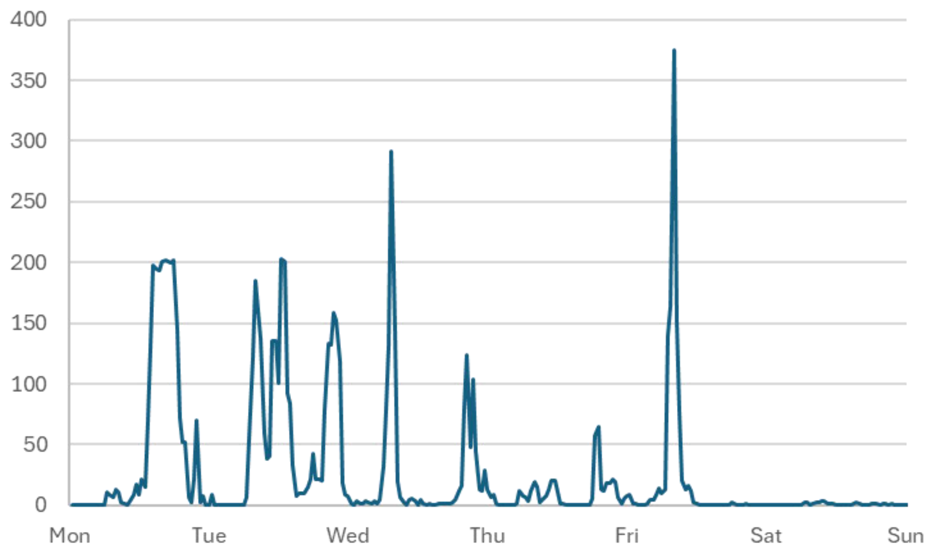
Appendix A Volatility in electricity prices

This appendix provides examples of the volatility in the wholesale price of electricity in New Zealand.

Figure 11 shows the New Zealand average wholesale electricity price over the last week. Over this period, the lowest price was $0.01, between 2.00 am and 6.00 am on 13 October, while the peak was $374.99 at 8.00 pm on 17 October.

Figure 11 Daily price volatility

Wholesale electricity price, $/MWh, all trading periods, 13 October to 19 October 2025

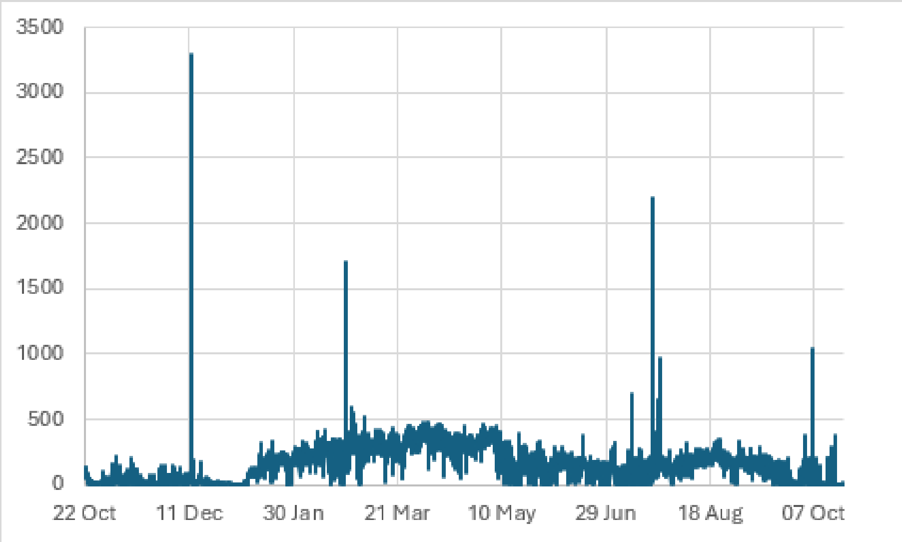


Source: Electricity Authority

Figure 12shows the price of electricity over the last year. Note that this year was not a dry year, and energy prices did not spike over winter. There were multiple instances of the price being $0.0, always in the early morning. The highest recorded price over the year was $3,209.60, between 8.30 am and 9.00 am on 12 December 2024.

Figure 12 Price volatility over a year

Wholesale electricity price, $/MWh, all trading periods, 22 October 2024 to 21 October 2025



Source: Electricity Authority

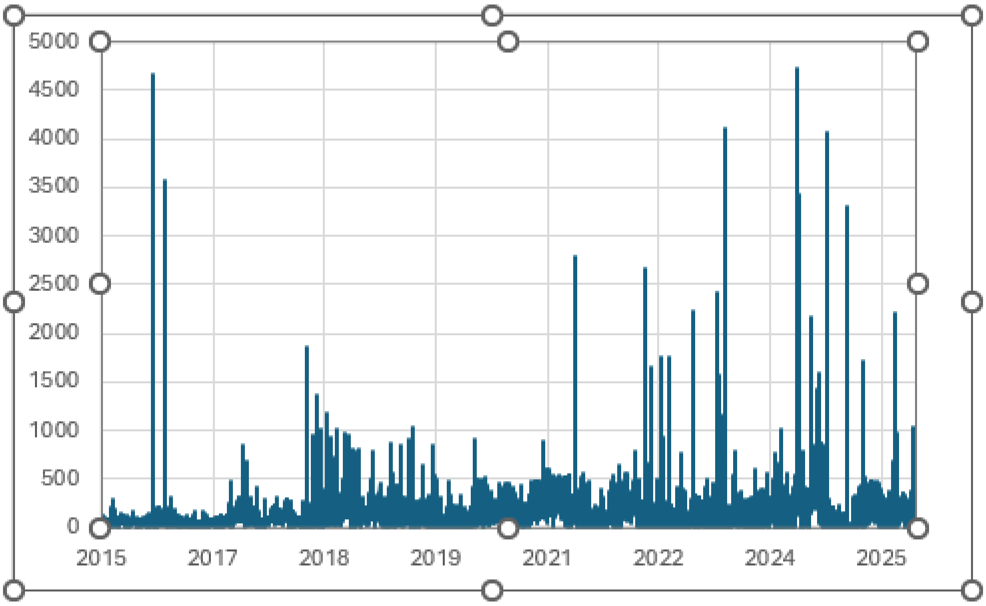
Figure 13 looks back over the last decade and shows that short-term price spikes have become more common.[12]

The highest price in this decade was $4,733.78 between 7.30 am and 8.00 am on 8 March 2024.

12 Note that these figures are not adjusted for inflation, so the recent real increase in prices is not shown.

Figure 13 A decade of price volatility

Wholesale electricity price, $/MWh, all trading periods, 19 October 2015 to 19 October 2025

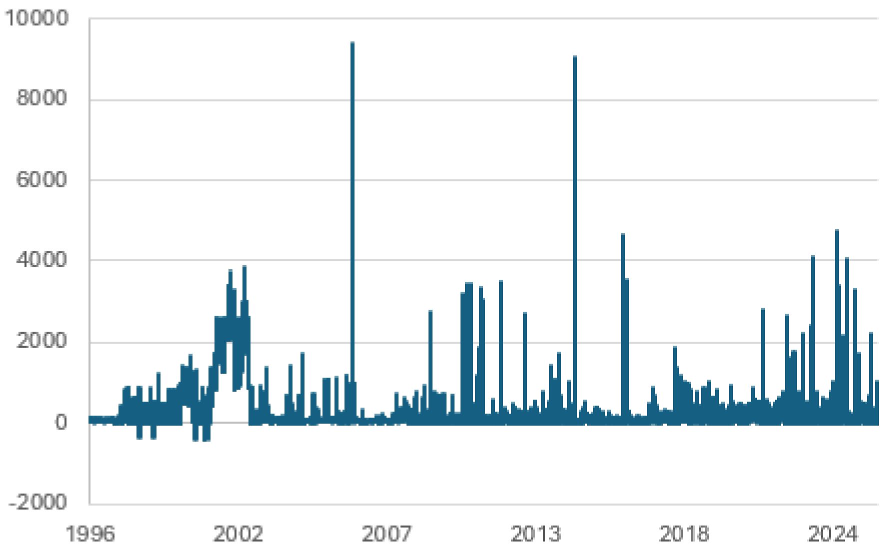


Source: Electricity Authority

And finally for completeness, Figure 14 shows all the data contained in the Electricity Authority 's database, going back to 1996.[13] The all-time peak trading period price was $9,369.41, set between 7.30 pm and 6.00 pm om 19 June 2006.

Figure 14 29 years of volatility

Wholesale electricity price, $/MWh, all trading periods, 1996 to 2025



Source: Electricity Authority

13 Again, this is nominal data. Note that in the early days of the wholesale electricity market, prices could be negative, which mean that generators paid people to take their power.

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