Wholesale market review

Comment on thermal generation

NZIER report to MEUG

14 December 2022

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Authorship

This paper was prepared at NZIER by Mike Hensen.

It was quality approved by John Yeabsley

Registered office: Level 13, Willeston House, 22–28 Willeston St | PO Box 3479, Wellington 6140
Auckland office: Ground Floor, 70 Shortland St, Auckland
Tel 0800 220 090 or +64 4 472 1880 | econ@nzier.org.nz | www.nzier.org.nz

Key points

Phase-out of thermal generation

The key market pricing issue caused by the replacement of thermal generation with wind and solar is that wind and solar do not offer controllable flexibility of generation output and therefore cannot respond to variations in demand. This creates two effects:

- The generator response to variations in load over peak period is further concentrated with the existing hydro generators that have stored hydro capacity.
- To meet the average demand additional wind capacity is required which would potentially depress wholesale prices for no-peak periods but will still leave the system short of reliable capacity in peak periods.

These effects are likely to make wholesale prices more volatile overall and broaden the range of pricing offers that can be justified as reasonable. In turn this will make it harder for the monitoring techniques proposed by the Authority to identify instances where generators exercise market power.

Investment in new generation

The estimate of new generation provided in the Issues Paper seem to be too low to replace fossil fuel generation let alone provide firming capacity for the increased reliance on renewables.

The pipeline of new generation projects listed in Table 5 of the Issues paper is heavily reliant on solar energy over 2023 to 2025 which will require more investment in firming than wind (which is already a poor match for the thermal capacity that it is replacing).

Effect of carbon prices

We agree with the Authority that estimating windfall gains associate with increases in the price of carbon is not clear-cut. In addition to the complicating factors listed by the Authority, it is also difficult to establish when fossil fuel prices rather than water values (based on conservation of generation capacity) are driving high wholesale prices. The Authority estimate of the effect of carbon prices and fossil fuel prices on wholesale electricity prices is much higher than is suggested by quarterly data published by Genesis. The assumptions about the use of coal based also add an upward bias to the estimate.

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1 Scope

This report comments on the following questions in the EA wholesale markets review issues Paper[1] published in October 2022 (WMR Issues Oct 22). The questions are from Chapter 2:

1. Do you agree that a key competition issue in the transition is that it weakens competition in extended times when intermittent generation cannot run?

2. Do you have any comments on the contents of this chapter?

and Chapter 3:

4. Do you agree that the lag in investment is not due to anticompetitive behaviour to slow down investment and discourage entry, or can you provide instances or other evidence to the contrary?

5. Do you have any other comments on the role and impact of carbon pricing on investment and wholesale market competition or the other content of this chapter?

In analysing these questions we have focused on two sets of data:

- Nodal prices and volumes which provide the output generated and the price received in $ per MWh at each point of connection by half-hour trading period[2].
- Genesis quarterly operational reports which provide information on electricity generated by gas or coal, the average prices of those fuels and the emission for each of the fuels.

2 Effect on competition

2.1 Questions 1 and 2

This section comments on the extent to which the intermittency of renewables is the key factor weakening competition during transition and makes some other comments on the contents of Chapter 2. Our assessment is that the key factor that will limit competition in the transition to renewables is that wind and to a much greater extent solar are not good substitutes for the controllable flexibility of generation offered by fossil-fuelled thermal capacity.

The mismatch between wind and thermal generation is described in section 2.2. Average wind generation output does not vary nearly as widely as fossil fuelled thermal generation across either trading periods and or quarters.

Chapter 2 summarises the key characteristics of generation capacity in 2022 but:

1 'Promoting competition in the wholesale electricity market in the transition toward 100% renewable electricity', Issues Paper, Electricity Authority 12 Oct 2022.

2 This dataset was published by the EA until 31 October 2022 and is available at https://www.emi.ea.govt.nz/Wholesale/Datasets/DispatchAndPricing/Pre1November2022Archive/NodalPricesAndVolumes Following the introduction of real-time pricing on 1 November 2022, the Authority temporarily stopped publishing the volume component of the series.

- Presents a high (2,402 MW) estimate of the available thermal capacity as:
  - The Genesis capacity of 1,203 MW includes 3 Rankine Units (250 MW each) which can only be operated simultaneously for short periods
  - Contact intends to retire the Taranaki combined cycle plant (377 MW) in 2023
- Does not discuss how a replacement of thermal capacity with wind capacity might affect the offer behaviour of hydro generators and tacitly assumes that offers from hydro generators can be re-shuffled to meet demand in shoulder periods and peaks.

2.2 Wind and solar are not a substitute for thermal generation

The key market pricing issue caused by the replacement of thermal generation with wind and solar is that wind and solar do not offer controllable flexibility of generation output and therefore cannot respond to variations in demand as predictably as thermal generation. This creates a challenge to the viability of wind generation as a replacement for fossil-fuelled generation because it implies that if wind generation is built to replace average or upper quartile levels of thermal generation then there will be extended periods where the wind generation will either need to displace hydro generation to other trading periods or the wind will need to be 'spilled'.

2.2.1 Quarterly generation comparison

Our starting point is that the recent patten of thermal generation was an efficient supplement to the generation available from hydro and geothermal resources. If wind or solar generation can replace thermal generation, the propositions in the Issues Paper that investment in renewables generation will increase competition among generators and wholesale prices will move toward the lower 'cost' of wind and solar seem reasonable. However to the extent that wind and solar are not fully reliable substitutes for thermal generation, markets have to deliver a new solution to the 'firming' problem and the propositions in the Issues Paper about increased competition are unlikely to hold.

Quarterly fossil-fuelled generation calculated from the nodal price and volume data has varied between 630 GWh and 2,365 GWh over the period 1 April 2021 to 31 December 2021. While this is the most extreme variation over the period 1 January 2019 to 30 September 2022, quarterly variations in output of +/- 30 percent are common as shown Table 1 below. The annual thermal generation for the plants listed in Table 1 was about 6,200 GWh in the 2019 and 2021 calendar years and about 6,500 GWh in the 2020 calendar year but is unlikely to exceed 5,000 GWh for the 2022 calendar year.

Table 1 Selected thermal generation by fuel

Quarterly output in GWh

Quarter ended	Huntly Coal	Huntly Gas	Other gas[1]	Total[2]	Change on previous quarter
31-Mar-19	533.6	755.9	374.8	**1,664.3**	
30-Jun-19	341.7	669.3	514.5	**1,525.4**	-8%
30-Sep-19	369.6	712.0	771.4	**1,853.0**	21%
31-Dec-19	320.8	579.5	238.7	**1,139.0**	-39%
31-Mar-20	492.5	709.0	282.3	**1,483.8**	30%
30-Jun-20	438.0	820.6	401.6	**1,660.2**	12%
30-Sep-20	590.3	727.1	848.8	**2,166.2**	30%
31-Dec-20	397.2	605.4	192.9	**1,195.5**	-45%
31-Mar-21	876.4	595.5	227.3	**1,699.2**	42%
30-Jun-21	1,215.1	499.9	650.3	**2,365.2**	39%
30-Sep-21	382.6	724.3	405.4	**1,512.3**	-36%
31-Dec-21	31.2	550.1	49.3	**630.7**	-58%
31-Mar-22	332.5	658.1	385.3	**1,375.9**	118%
30-Jun-22	383.0	685.9	658.4	**1,727.3**	26%
30-Sep-22	155.9	494.8	243.7	**894.5**	-48%

Note:

1 Other gas includes generation by Contact at Stratford and Todd at Junction Road, McKee and Kapuni.

2 Covers the main electricity only plants but excludes cogeneration.

Source: NZIER

2.3 Example scenarios for thermal displacement

The standard approach to estimating the average output from a windfarm is to apply a capacity utilisation factor (usually about 40 percent) to the windfarm capacity (MW). Applying this approach to the quarterly thermal output listed in Table 1 would imply that:

- To deliver the minimum quarterly thermal output of 631 GWh[3] (31 December 2021) would require wind farm capacity of about 719 MW. Based on the thermal generation over 2019 to 2021 and with 719 MW of wind capacity, thermal plant would need to generate about 800 to 1,000 GWh per quarter but it would still be a combination of 'base' and 'peak' load. In this scenario it is likely that the role of existing thermal plant in meeting peaks would be similar to what it is now.
- To deliver the average thermal quarterly output of about 1,526 GWh (average of the quarterly outputs in Table 1 and equal to 6,100) would require wind farm capacity of about 1,742 MW. Based on the thermal generation over 2019 to 2021 required

[3] This is about 90 percent of our estimate of quarterly average wind farm generation over the year to 30 September 2022 and represents almost a doubling of current wind-farm capacity.

thermal generation would be a maximum of about 600 to 840 GWh for two quarters, 140 to 340 GWh for four quarters and no thermal generation for 6 quarters. During the quarters with zero thermal generation the wind generation would exceed the amount required to replace thermal generation by an average of about 280 GWh per quarter.

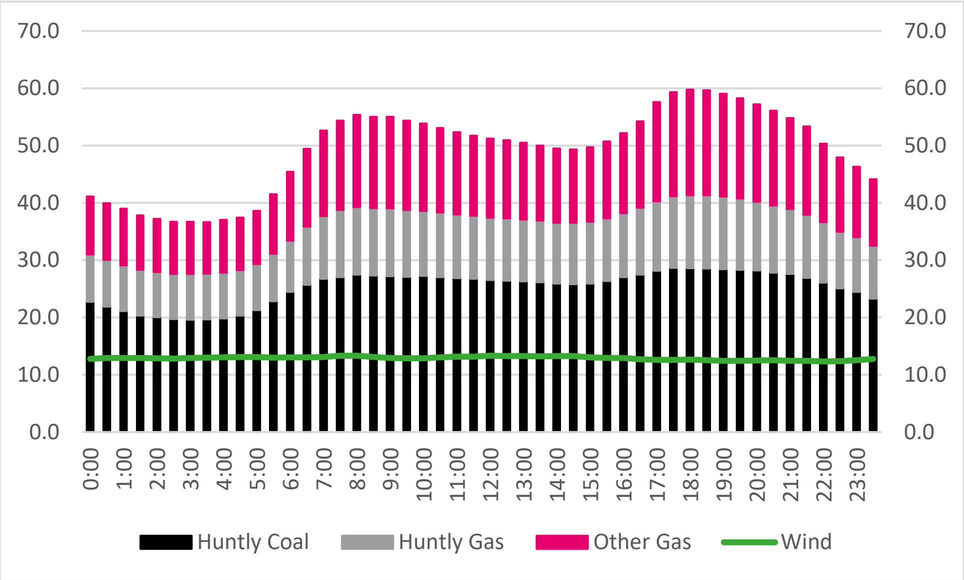
2.3.1 Trading period generation comparison

To illustrate much greater variability in fossil fuelled thermal generation over trading periods compared to variability in wind generation we have compared the quarterly output from thermal and wind generation in GWh by trading period over two quarters:

- High thermal generation (2,364 GWh) and wind generation of 619 GWh – quarter ended 30 June 2021 - Figure 1.
- Low thermal generation (1,376 GWh) and wind generation of 637 GWh – quarter ended 31 March 2022 - Figure 2.

For both quarters the total volume of wind generation was almost constant for each trading period with wider variations for individual stations between trading periods offsetting each other.

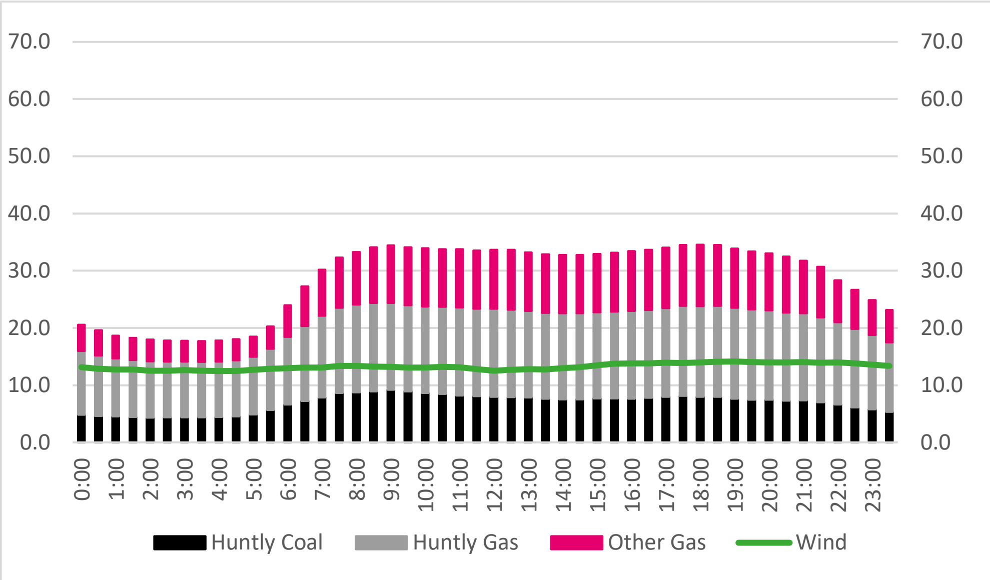
Figure 1 Generation by trading period quarter ended 30 June 2021



Source: NZIER

In contrast the level of thermal generation varied by about 23 GWh or an average of 260 MW for June 2021 quarter and 17 GWh or an average of 187 MW for the quarter ended March 2022.

Figure 2 Generation by trading period quarter ended 31 March 2022



Source: NZIER

The apparent average steadiness of wind output compared with the variation in thermal generations suggests that using the annual total for thermal generation to calculate the required renewable capacity may significantly understate both the required level of wind capacity and the amount of rebalancing between the wind and hydro generation to meet demand within each trading period.

The mismatch between the variability of fossil fuel and wind generation output from quarter to quarter and also between trading periods during each quarter described above is a separate issue from the uncertainty about what level of wind generation will be available in a trading period due to weather variations.

2.4 Effect on assessment of market power

The Issues Paper notes that Concept Consulting forecast that projects of about 6,200 GWh per year will be required and separates this into 3,000 GWh per year for electrification and 3,200 GWh for the replacement of fossil fuel generation. It is not clear from the Issues Paper what proportion of fossil fuel generation this is expected to replace or what degree of firming will be necessary and how it would be delivered.

The framing of the discussion in the Issues Paper as a change in the fuel used to deliver a given level of generation output overlooks the change in how the generators can respond to meet excess demand as the fuel mix changes:

- Under the current generation fuel mix, stored hydro and thermal operators can both offer to meet excess demand and supply with a reasonable degree of certainty about their cost and ability to cover expected excess demand in the near future.
- Wind and solar generation cannot offer the same flexibility of output as thermal or degree certainty that they can provide. Therefore as wind and solar generation replace thermal generation:

- The pool of generation that can be reliably offered to meet excess demand shrinks toward the owners of stored hydro which should increase the market power of the owners of stored hydro and to a lesser extent owners of the remaining thermal capacity.
- The overall capacity of generators to reliably meet peak demand will decline.
- The pattern of run of river hydro and baseload generation offers may also to change as on average more wind generation Is offered in off-peak periods. The effect of this change on wholesale prices is harder to predict

The market share and price/volume outcomes of these competing influences cannot be reliably quantified from a simple comparison of the aggregate volume of generation and generation costs[4] from fossil fuel as opposed to wind. Simulation modelling of generator offers under different scenarios for the phase-out of thermal generation along the same lines as was completed by the Market Development Advisory Group (MDAG) in its 2021 analysis[5] would be very helpful in both analysing the potential for price volatility and concentration of market power.

3 Investment in renewable generation

3.1 Barriers to investment

The focus of the Issues Paper analysis is to consider what impediments to entry explain the slower than expected investment in new (renewable) generation and if any of those impediments is attributable to the exercise of market power. The Issues Paper[6] notes that:

- The wholesale market review published in October 2021 found forward wholesale prices have been 50 percent above the cost of new supply for longer than expected[7] in a competitive market.
- Current forward prices ($140 to $190 per MWh) for 2024 and 2025 are substantially higher than the estimated long run marginal costs of new generation ($75 to $85 per MWh).
- An additional 3,200 GWh of renewable generation would need to be built by 2025 to displace fossil fuelled generation (where it is economic to do so) and to align prices with cost of supply.
- The timeframe over which market power could be exercised by incumbents because of delay in new generation investment due to other regulations such as the Resource

4 The Issues Paper discusses thermal and wind generation costs but does not specify how the costs are calculated. The discussion of thermal costs is based on the cost of coal fuel and associated emission plus operating costs. The estimate for the cost of wind generation seems to be based on the average wholesale electricity price required to recover windfarm construction cost, operating cost and return on capital.

5 See 'Price Discovery with 100% Renewable Electricity Supply Final', Prepared for Market Development Advisory Group, 10 December 2021 by Concept Consulting and John Culy.

6 The following comments are paraphrased from the Issues Paper - pages 16 to 24. The last bullet point starting 'In the medium term …' is a quoted from paragraph 4.50, page 24 of the Issues Paper.

7 The duration of 'longer than expected' is not specified. On page 24, the Issues Paper notes that '*by standard competition benchmarks, entry or expansion should be within two years following a price increase to be regarded as sufficiently timely to constrain the exercise of market power.*' but goes on to argue why this period might be too short for the electricity sector.

Management Act or the Overseas Investment Act may be regarded as a legitimate cost of the objectives of these regulations.

- The new generation investment expected by 2025 (wind and solar) might not be a good substitute for thermal generation. The question of how this new generation is firmed and the associated competition effects should be considered in the Gas Transition Plan.
- In the medium to long term, the market may or may not deliver on generation or demand flexibility solutions at a scale that provides sufficient competition for stored hydro in providing flexible generation during extended periods of low wind and sun.

3.2 Comment

The Issues Paper analysis of forward prices relative to long run marginal cost of generation, the survey of generation investment intentions and the issues investors consider in the determining the timing and size of investment are informative. We agree with the observation that renewable generation is not a good substitute for thermal generation and recommend the modelling of scenarios for different types of transition away from thermal generation particularly with respect to the following questions:

- What is the basis for the estimate in the Issues Paper that 3,200 GWh of energy is required to replace fossil fuel generation and how is the test ‘where it is economic to do so’ defined?
- How can the volume and price effects of the mismatches between thermal and renewable generation be modelled?
- How does the capability of the system to meet peak and shoulder loads change?
- How will the role indicators such as water values in the setting of electricity prices change as reliance on thermal generation is reduced?

4 Role of carbon prices

The Issues Paper includes an explanation of the impact of carbon prices on electricity prices and generator earnings (Box 2[8]). The analysis is based on the international wholesale price of coal and assumes that this is the relevant fuel cost for thermal generators to use in the calculation of their short run marginal cost which they would then use to set their offer price for thermal generation. If these offers were the highest offers accepted for dispatch, they would set the wholesale electricity price

4.1 Comparison of Issues Paper and Genesis thermal generation cost

The Authority has used a similar framework in its previous wholesale market review. The following table and charts summarise the information published by Genesis in its quarterly operating reports. Table 2 below lists:

[8] Issues Paper, page 25.

- Estimated gas and coal fuel cost in $/MWh calculated from Genesis reported weighted average gas and coal burn cost in $/GJ, gas and coal used in generation and electricity volume generated from gas and coal.
- Estimated cost of emissions in $/MWh calculated from Genesis reported gas and coal used in generation and electricity volume generated from gas and coal, Ministry for Environment emission factors and a simple quarterly average of the NZU price.

Figure 3 and Figure 4 below compare the estimated quarterly average electricity prices received at Huntly with the estimated cost (fuel plus emissions) of the coal and gas used to generate electricity.

Analysis of the coal and gas fuel costs published by Genesis and wholesale electricity data published by the Authority suggests the following:

- Fuel (coal) prices reported by Genesis and presumably used in their electricity pricing decisions have not climbed nearly as sharply since 2021 as suggested in Box 2 of the Issues Paper.
- Increases in electricity prices for Huntly generation in mid-2021 were not driven by an increase in the fossil fuel prices (based on the fuel price information published by Genesis).
- Focusing on the price of coal as an indicator of the potential short-run cost of thermal generation overstates the potential for increase in thermal generation prices as Genesis has successfully switched from coal to gas.

Table 2 Estimated Huntly fuel and carbon costs

Quarterly average fuel and GHG emissions costs in $ per MWh

Quarter ended	Coal[1]			Gas		
	Fuel	NZU	Total	Fuel	NZU	Total
31-Mar-19	77.81	27.44	**105.25**	66.30	10.05	**76.35**
30-Jun-19	71.30	24.10	**95.40**	70.66	10.96	**81.61**
30-Sep-19	82.37	25.78	**108.15**	68.81	9.81	**78.62**
31-Dec-19	81.40	26.44	**107.84**	74.34	10.29	**84.63**
31-Mar-20	74.14	27.91	**102.05**	73.68	11.64	**85.31**
30-Jun-20	71.02	27.89	**98.90**	68.83	11.69	**80.52**
30-Sep-20	69.71	35.54	**105.26**	68.31	13.78	**82.09**
31-Dec-20	67.69	37.48	**105.17**	69.88	15.06	**84.93**
31-Mar-21	68.38	39.84	**108.22**	72.99	15.78	**88.77**
30-Jun-21	71.19	39.47	**110.66**	86.87	16.66	**103.53**
30-Sep-21	84.37	55.89	**140.26**	98.83	21.97	**120.80**
31-Dec-21				72.84	28.11	**100.95**
31-Mar-22	90.11	85.91	**176.02**	73.23	32.52	**105.75**
30-Jun-22	87.39	77.22	**164.61**	72.25	31.38	**103.64**
30-Sep-22	89.80	83.44	**173.24**	71.44	33.69	**105.13**

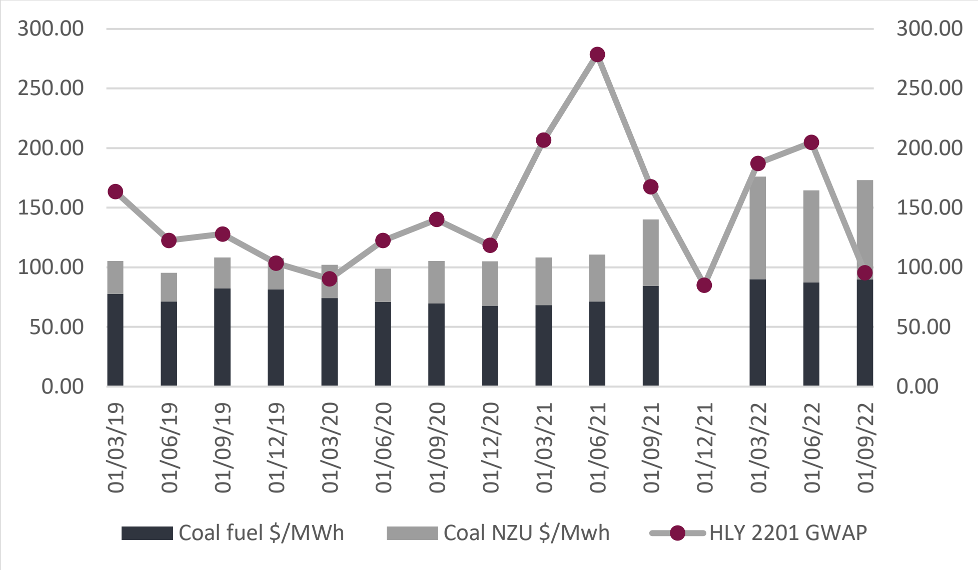
Note:

3 An estimate of coal fuel cost is not available for the quarter ended 31 Dec 2021 because electricity generation from coal was near zero (6 GWh).

Source: NZIER analysis of Genesis quarterly performance reports

Figure 3 and Figure 4 compare the estimated quarterly gas and coal fuel and emission costs from Table 2 with the generation weighted average wholesale electricity prices available from the Authority.

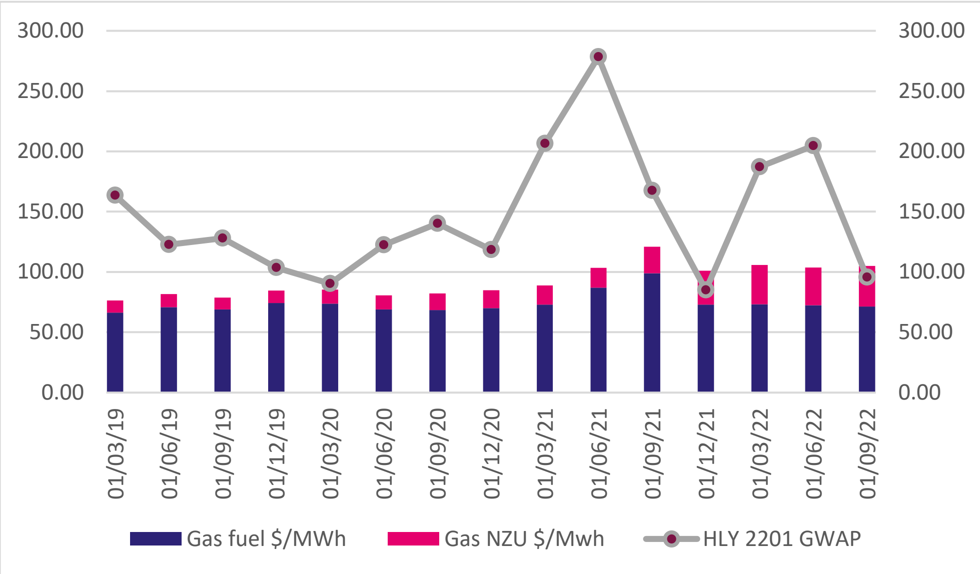
Figure 3 Huntly coal fuel costs and generator weighted average price



Source: NZIER

Huntly generation from coal in the quarter ended 31 December 2021 was negligible (6 GWh) and the rounding in the Genesis data made it impossible to accurately estimate the reported fuel cost. Based on the preceding and following quarters we estimate the fuel cost would have been about $160 per MWh – almost double the estimated average wholesale electricity price for the same period.

Figure 4 Huntly gas fuel costs and generator weighted average price



Source: NZIER

Another point of difference between the Genesis fuel cost/electricity price data presented above and the calculation in the Issues Paper is that the data presented above includes the additional cost of running the Huntly plant during warm-up periods (at least 2 hours[9]) in anticipation of excess demand.

4.2 Effect of carbon price on investment and wholesale market prices

It is very difficult to comment on the Issues Paper estimates of windfall gains to owners of renewable generation attributable to the increase in the cost of carbon without a more detailed explanation of the methodology used.

However the comment at the end of Box 2 quoted below seems to both overstate the role of carbon charges in encouraging the transition away from gas and coal generation as well as oversimplifying the drivers of changes in wholesale electricity prices.

> *Overall, the acceleration in the renewable generation investment pipeline suggests that carbon pricing is doing what it is meant to do … The trade-off is an increased cost to consumers in the 'short run', that is during the time that carbon pricing facilitates the transition of electricity generation out of coal and gas.*

The wholesale market review completed in October 2021 included the gas price and carbon costs for thermal generators as one of several factors but most of the increase in wholesale prices was explained by a dummy variable linked to the time of the Pohokura outage. Monthly average wholesale electricity prices traded in a higher range over 2021 than in the first nine months of 2022 despite much higher average NZU prices over 2022 than in 2021.

9 The time required for a Rankine unit to reach its full rated output of 250MW depends on the start condition and varies as follows: dry storage - 36 hours, wet storage - 24 hours, cold (hasn't run in 4 or more days) - 10 hours, warm - 4 hours and hot (run in last 10 hours) - 2 hours. The time required for Unit 5 to reach its full rated output of 403 MW varies as follows: post outage - 36 hours, cold - 10 hours, warm - 4 hours and hot - 2 hours. Source: https://www.genesisenergy.co.nz/about/generation/huntly-power-station