NZIER
NEW ZEALAND INSTITUTE OF ECONOMIC RESEARCH

Options to strengthen competition

Price discovery in a renewables-based electricity system

NZIER report to MEUG

6 March 2023

About NZIER

NZIER is a specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice.

We undertake and make freely available economic research aimed at promoting a better understanding of New Zealand's important economic challenges.

Our long-established Quarterly Survey of Business Opinion (QSBO) and Quarterly Predictions are available to members of NZIER.

We pride ourselves on our reputation for independence and delivering quality analysis in the right form and at the right time. We ensure quality through teamwork on individual projects, critical review at internal seminars, and by peer review.

NZIER was established in 1958.

Authorship

This paper was prepared at NZIER by Mike Hensen.

It was quality approved by John Yeablsey.

The assistance of [authors or organisations] is gratefully acknowledged.

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

MDAG modelling is a good start for competition analysis with less thermal capacity

The MDAG papers provide a very good foundation for discussion of the transition to 100% renewables mainly through the modelling that supports competition issues analysis. The modelling is particularly useful in two respects:

- It considers gross margins and cash flow at risk for both established generators and new entrants and price duration curves for the wholesale markets.
- It assesses the capacity and incentives for existing generators to influence the returns to independent intermittent generators

This is a top-down forward-looking approach to the analysis of competition which contrasts with and complements the bottom-up approach in weekly market monitoring work by the Electricity Authority (EA). (The EA weekly market monitoring looks for price outliers based on the historical distribution of prices and price variation that cannot be 'explained' by variables such as lake levels, short-run marginal cost of thermal generation and water values.)

Retirement of thermal capacity will thin competition in 2035

In a separate report on competition issues, MDAG extends modelling developed in 2021 and finds evidence for the following propositions:

- Established generators with large flexible generation resources are likely to have the capacity to increase 'volatility of volatility' and are insulated from the cost of increasing 'volatility of volatility'.
- Increased 'volatility of volatility' is likely to deter the entry of new intermittent generators which in turn is likely to increase the returns earned by established generators with large flexible generation resources.

In reaching these conclusions, MDAG estimates the size of the incentives for incumbent generators to block entry of new competitors. The measures used by MDAG are changes in mean gross margin and cashflow at risk (based on modelled price duration curves

In addition MDAG notes the following:

- Flexible peak capacity falls from 4,984 MW now to 3,563 MW in 2035. Although the competition issues analysis compares 2022 to 2035 – the retirement of gas and coal fired thermal capacity is expected to occur before 2035 (limiting the thermal capacity to 600 MW of biofuel or hydrogen).
- Price duration curves will become steeper than they are now and compared to the initial 2021 modelling. This will make the cost of 'firming' intermittent generation capacity much higher than at present and increase the proportion of wholesale electricity cost at peak period beyond the already levels described in Appendix A.

But the effects of lower thermal capacity are already being felt

However, the issues of shortage of flexible generating capacity at peak periods is pressing for markets now – it would be immensely helpful for the details of the modelling that inform the options discussion to be released, and for the modelling time periods to consider the medium-term future (2025 to 2030).

Options to strengthen competition are indirect and need more definition

The Market Developments Advisory Group (MDAG) has suggested options to strengthen competition in the wholesale market to maintain public confidence that competition is influencing price setting and to promote a stable regulatory environment but has not either described the options in detail, quantified the impact of these options on competition, or the extent to which they overlap.

The 'strengthen competition' options supported by MDAG are focused on changing information disclosure and processes for requesting forward contracts. The linkage between measures to strengthen competition and encouragement of investment are not clearly explained, particularly with respect to how spot price setting affects investment incentives and how new futures products would overcome the issue of lack of physical capacity at peak periods. But the challenge is that in the 2035 system, competitive demand side response rather than competition among generators limits peak and average prices.

Contents

Appendices

Figures

Tables

1 Scope

1.1 MDAG proposal

The purpose of this report is to:

- Comment on the implications for wholesale electricity price- setting and the effectiveness and efficiency of the competition strengthening measures proposed by MDAG in 'Chapter 10 Strengthen competition' of the Market Development Advisory Group (MDAG) options paper[1].
- Comment on how the modelling presented in the previous MDAG consultation paper 'Price Discovery with 100% Renewable Electricity Supply, 10 December 2021' could be updated to provide policy makers and market participants with quantitative estimates of the discrete incremental change of each option and if collectively, there are any multiplier or offsetting effects.

1.2 Role of competition

The MDAG issues paper argues that competition in the spot market is necessary to support public confidence in the way that prices are set. The tone of the discussion suggests that competition can be measured and that the measure can be linked to the pricing outcomes during the periods of scarce supply. The analysis completed for the wholesale market review by the Electricity Authority highlights the difficulty of reaching unambiguous actionable linkages between high prices and exercise of market power. In particular, the EA measures seems to struggle with obtaining consensus of the valuation of water in periods of scarce capacity (using the water today as opposed to saving it for a period of greater scarcity). The EA market monitoring measures are able to use the short-run marginal cost (SRMC) of fossil fuelled thermal generation as a crosscheck on the reasonableness of hydro generator offers for all but the periods of highest excess demand. In the market in which the proposed MDAG competition measures will operate, thermal capacity will be much lower and its SRMC much higher than in the present system.

1.3 Options to strengthen competition

MDAG has considered and qualitatively assessed 8 options on three criteria: benefit (used interchangeably with net benefit), scope for unintended harm and complexity. This qualitative assessment is used to define preferred options, and to provide an illustrative ranking of the options. Most of the preferred options[2] (D1, D2 and D4) seem to be an extension of the EA Wholesale Market Review approach and Weekly Market Monitoring. These approaches attempt to identify prices that may have been influenced by market power by comparing them to recent price history or explanatory variables of short run cost. This approach is much less likely to deliver unambiguous actionable evidence in markets

[1] 'Price discovery in a renewables-based electricity system, Options paper 2022', Market Development Advisory Group, 6 December 2022. This paper is referred to as the MDAG options paper in the rest of this report.

[2] D1 Competition indicators for flexibility segment of wholesale market, D2 Greater transparency of hedge information, and D4 Extend trading conduct rules to hedge market.

going through rapid structural change toward a system that is reliant one source of flexible generation.

The scales used to rank 'complexity', 'harm' and 'benefit' are not described in detail and neither is their potential contribution to delivering the core objective of the recommendations[3]:

- Ensuring economically efficient price signals form short to long term
- Encouraging competition, reliability of supply and efficient operation of the electricity system

The MDAG options paper states that this qualitative assessment will be *followed by a more thorough evaluation of costs and benefits, which will inform our final selection of options for our Recommendations Paper, which is due around May-June next year.*[4]

2 Rationale for strengthening competition

2.1 Outlook for competition

2.1.1 MDAG options paper

The opening section of chapter 10[5] recaps the findings from the MDAG issues paper 2021:

- Use of batteries may increase competition in the provision of short-term flexibility services and some ancillary services
- Competition may thin in the provision of flexibility services for a week or longer as fossil-fuel thermal fired plant is retired, and the provision of long-term flexibility is concentrated with generators that have flexible hydro capacity.
- New sources of flexibility may include flexible demand sources, renewable over-build (with greater hydro and wind spill), pumped hydro storage and biofueled thermal generation

These comments do not quantify the potential future loss of competition from the concentration of the supply of flexible generation or the potential impact on spot wholesale prices. The remainder of the chapter before the description of the options makes the following observations:

- Advice from international competition experts[6]:
  - Limited competition in the supply of flexibility services (firming for intermittent generation) could deter investment in new generation and limit competition in the retail market.
  - Parties that have sufficient market power to sustainably alter the structure of spot prices, would likely be able to influence competition in other parts of the wholesale market. If these parties could increase the 'volatility of volatility'

[3] MDAG options paper, heading 'This project', page 3.

[4] MDAG options paper paragraph 6.29 page 51.

[5] MDAG options paper page 77, paragraphs 10.5 to 10.8.

[6] Paraphrased from MDAG options paper page 78, paragraphs 10.11.

(uncertainty about the future structure of prices), this might deter some types of new entry and increase average prices.

- Assessment of the effects of the move to 100% renewables on larger generators with flexible resources which include:
  - *'greater means to significantly and rapidly raise volatility of volatility'*
  - low exposure *'to direct cost or disruption from raising the volatility of volatility'*
  - *'significant volatility of volatility'* is likely to *'deter potential new entrant intermittent generators'*
  - opportunity *'to derive material gain if new entry is deterred'*
  - potential for '*higher average prices* If *increased volatility of volatility hinders new generation entry'*.

The comments in the MDAG options paper do not quantify the potential change in the market power from the move to 100% renewables let alone quantify how the proposed options to strengthen competition will address this shift (by encouraging more independent generation investment and increase the volume and competition in supply of flexible generation resources.)

The MDAG options library[7] paper adds some comment to the description of the options but does not include any further quantitative analysis of the options.

The only section of the MDAG options paper which does provide a quantitative indication of the use of contracting tools to mitigate price risk is an analysis of what physical resources are likely to be operating under different price levels and therefore '*would be natural backing for risk management products at these price levels'*. This estimate is based on the *'Issues Paper reference case scenario for 2035'*, but it is not clear from the text whether 2035 reference scenario is from the 2021 version of the issues paper, or it has been updated. A copy of the chart is attached in section A.2 as Figure 5. The report makes three observations on the implications of the availability of the generation resources for the development of contracts[8]:

- 'Shaped' contracts that enable offsetting of the price risk of wind and solar generation '*are likely to become much more important*'.
- The natural providers include flexible hydro generators and potentially '*green peakers, energy storage providers and parties with demand side-flexibility*'.
- If developers could purchase a cap, this would lower the volatility of their revenue and encourage investment by independent generators. (Caps are used in the analysis as a proxy for 'shaped contracts' and may not be the most suitable product for the New Zealand market.)

The MDAG options paper does not describe:

- The financial incentives for hydro generators with flexible resources to provide capped contracts at any price let alone the relatively low levels of $300 or $500 per MWh analysed in the paper. Our analysis of wholesale revenue in Appendix A suggests that

[7] 'Price discovery in a renewables-based electricity system, LIBRARY OF OPTIONS', MARKET DEVELOPMENT ADVISORY GROUP, 6 December 2022 Chapter 5 pages 65-70.

[8] MDAG options paper page 63. Paragraphs 8.19 (a), 8.19 (b).and 8.20.

generator revenue is sensitive to their ability to earn high prices at peak periods and that this sensitivity will increase with the higher levels of spill and steeper price duration curves expected in a 100% renewables system.

- How much additional investment in intermittent generation would be encouraged by the availability of cap contracts at the prices modelled.
- How the provision of cap or shaped contracts increases the reliable availability of flexible generation capacity at peak periods. (The MDAG options paper does not describe the characteristics of shaped contracts in detail but does indicate that they are more complex than simple cap contracts.)

The comments in the MDAG options paper about the potential for reduction of competition following the transition to 100% renewables are less forthright than those in the MDAG analysis of competition issues which is discussed in more detail in section 2.1.2 below.

2.1.2 MDAG competition issues 2022

A companion paper '100% renewable electricity supply – competition issues'[9] (referred to as 'MDAG competition issues 2022' in this report), analyses the means and incentives for large generators with flexible resources to exercise market power to delay the entry of new generation and lift average spot prices. The projected wholesale prices in the 'new generator deterred' scenario are about 10 percent above those in the 'new generator encouraged' scenario. The price duration curves for the new generator scenarios have a similar shape but have a different shape to the base case reference scenario and the base case sensitivity scenarios– see section A.3. It is unclear which group of scenarios – 'new w

The modelling scenario for 2035 is: all fossil fuelled plant is retired, 600 MW of green peaker capacity is spread between Contact, Genesis and other participants while other generation remains under current ownership[10]. The comments on the MDAG competition issues paper 2022 are separated into two sections:

- Comparison of the MDAG competition issues paper 2022 scenarios with the modelled wholesale prices and generation mix for 2035 in 'Price Discovery with 100% Renewable Electricity Supply Final'[11] (referred to as 'MDAG price discovery 2021' in the rest of this report.
- The results of the four competition hypotheses tested which formed the basis for the comments in the MDAG options paper summarised in section 2.1.1 above which included partial quantification of the likely impact.

Capacity forecasts in 2021 and 2022

MDAG competition issues 2022[12] reports that the flexible hydro/thermal capacity falls from 4,984 MW now to 3,563 MW in 2035 and that the Herfindahl Hirshmann Index (HHI) - a measure of market concentration increases from 2,482 now to 2,617. An HHI of 2,500+ is considered 'highly concentrated – so the change in the HHI suggests the flexible capacity

9 '100% renewable electricity supply – competition issues, Material for MDAG meeting', 24 August 2022'.

10 See MDAG competition issues 2022, page 2. A more detailed description is provided on page 6 which shows capacity increases by a net 6GW to 15 GW in 2035 with the increase made up of wind 2.8 GW, solar 1.7 GW, rooftop PV 1.3 GW and smaller increases from geothermal, batteries, demand response and load shifting.

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

12 MDAG competition issues 2022, page 13.

market is moving from 'on the edge' to 'within' the HHI range for highly concentrated/low competition market.

In addition to much lower flexible generation capacity in 2035, peak demand is also likely to be slightly higher in 2035 than in 2020. The forecast volume demand in 2035 for both the MDAG competition issues 2022 and MDAG price discovery 2021 is 49 GWh in 2035 but the 2020 starting point is different:

- 'MDAG competition issues 2022' reports volume demand in 2020 at 41 GWh[13].
- 'MDAG price discovery 2021[14]' reports:
  - Volume demand in 2020 of 37 GWh excluding NZAS and 42 GWh including NZAS
  - Forecast base demand excluding NZAS of 40GWh by 2035 and total volume demand of 49 GWh with the additional 9GWh made up of electric vehicle (EV) charging 5 GWh, dairy process heat 2GWh and other process heat 2GWh.

Price forecasts in 2021 and 2022

The peak period prices reported in MDAG competition issues 2022[15] are much higher than the peak prices reported in MDAG price discovery 2021[16]. Price duration curves for the 10 percent of periods with the highest prices show:

- Prices for at least 4 percent of the trading periods starting at $400 per MWh and increasing to a maximum of $1,100 to $2,000 per MWh in MDAG competition issues 2022, depending on the scenario.
- Prices for at least 4 percent of the trading periods starting below $400 per MWh and increasing to a maximum of $500 per MWh in MDAG competition issues 2022, depending on the scenario.

2.2 MDAG competition hypotheses

MDAG competition issues 2022[17] reported the results of four tests of the changes in competition due to the transition to 100% renewables. These results indicate large generators with flexible capacity have both capacity and incentive to increase average prices and block the entry of new independent generation. Also, the results are more pessimistic about the exercise of market power than MDAG price discovery 2021. The results of the hypothesis test are summarised in Table 1 below.

However, the competition analysis does not provide a clear guide about how measures could be developed that would:

- Estimate what competitive market wholesale market price outcomes (particularly at peak period) and investment in new generation would be.
- Attribute the difference between the competitive market and actual market outcomes to the exercise of market power rather than differences in risk appetite, expectations of price duration curves and water values during periods of scarce capacity.

[13] MDAG competition issues 2022, page 6.

[14] MDAG price discovery 2021, page 6.

[15] MDAG competition issues 2022, pages 14 and 20.

[16] MDAG price discovery 2021, page 19.

[17] MDAG competition issues 2022, page 13.

Detailed comment on demand side response is outside the scope of this report but the clear thrust of the MDAG options paper is that demand side response is the expected to be the main brake on wholesale price spikes during periods of peak scarcity. The MDAG paper's discussion of demand side flexibility focuses on the steps required to develop demand side flexibility capacity. However, the paper is largely silent on the mechanisms needed to ensure competition in this market both between aggregators of demand side flexibility and between aggregators and generators. The explanation of what would drive the investment required to create demand side flexibility and how it would be offered into the wholesale market as a dispatchable alternative to generation is very brief.

Table 1 Competition under 100% renewables

'Proposition' and 'Result' are quoted from MDAG analysis.

Proposition	Result	Comment
Would some generators have materially greater scope to the raise volatility of volatility under 100% renewable supply?	*Potentially yes. Spot price volatility is sensitive to hydro offer behaviour and a range of possible offer strategies appear feasible.* *The key uncertainty … is whether volatility of volatility could be raised by a single generator …*	As discussed in section 2.1.2 above: • Ownership of the flexible generation capacity will be more concentrated in 2035 than in 2020 and the capacity will be smaller. • Price duration curves forecast higher prices at peak periods than forecast in MDAG price discovery 2021 for either 2035 or the simulated 2020 average. • Events of 2018 to 2022 provide a clear demonstration of the sensitivity of wholesale prices to unexpected reduction in capacity
Would generators with significant flexible resources face much direct cost/disruption from raising volatility of volatility?	*Generators with the larger flexible hydro bases appear to be relatively well insulated from changes in volatility of volatility.*	The MDAG analysis does not comment on the much higher level of spill or the flattening of the right-hand side of the price duration curves projected for 2035 relative to 2020 and how these factors might affect the offer behaviour of larger flexible hydro generators in peak periods. 'MDAG price discovery 2021' (page 18) forecast average wholesale prices in 2035 of $77 per MWh versus $87 per MWh for the simulated 2020 average.
Would potential new entrant intermittent generators without access to flexibility services be deterred if there is significant volatility of volatility	*Likely yes. Independent wind or solar generators would not be well insulated against changes in volatility of volatility. This is based on analysis of… cashflow at risk and preferred contracting levels for intermittent generators under different PDC scenarios*	The MDAG analysis of barriers to new investment in wind and solar generation is not translated into a forecast for investment in new capacity let alone scenarios for new investment by large existing or new independent generators. The MDAG analysis of the volatility is based on assumptions about generators selling sufficient contracts to minimise variation in revenue at the 5 percent level and wind and solar developers selling baseload swaps. The analysis does not describe how closely these assumptions reflect actual market practice.
Would generators with significant flexible resources face a likely material gain if new entry is deterred (i.e. delayed).	*Likely yes. If new entry is deterred on a sustained basis, this would be expected to raise average prices and appreciably increase gross margins for incumbent suppliers … early/delayed entry have asymmetric price effects for any given MW volume.*	Major generators mean gross margins are estimated to be 7.6 to 11.1 percent higher if new generator entry is delayed but the scope and timing of the delay is not specified. As discussed in section 2.1.2 above the left-hand side (0 to 10) percent section of the 2022 forecast price duration curves appears to be above the 2021 forecast suggesting higher average prices.

Source: MDAG competition issues 2022, pages 11-21 and 23

The MDAG analysis concludes that competition will be weaker during peak periods in a system with 100% renewables and implies that comparison of the returns to generators with different rates of new entry can be used to measure the effect of competition. This a positive start but the analysis needs to be explained in more detail and linked clearly to wholesale prices and volumes supplied before it can be used in measuring the harm as

defined by MDAG: *Market power can be regarded as significant if the economic cost of the harm exceeds economic cost of the remedy.*[18]

3 Comment on options

3.1 Overview

The preferred MDAG options are focused on changing contracting around access to flexible generation capacity but do not make it clear how the change will moderate:

- The wide range of estimates of the future value of water which makes it difficult to distinguish generator offer behaviour that reflects the economic value of scarce fuel as opposed to the exercise of market power.
- The lack of flexible generating capacity to deal with peak loads. The proposed measures are not modelled as encouraging increased peaker capacity. At best, the measures proposed could encourage the faster entry of intermittent generation which may lower prices in the middle and right-hand side of the price duration curve. The potential link between strengthen competition options and faster development of demand side flexibility and batteries is not discussed for the supported options.

Table 2 MDAG 'supported' options to strengthen competition

'Option' and 'Assessment' are quoted from MDAG analysis.

Option	Assessment	Comment
D1 Competition indicators for flexibility segment of wholesale market.	*Improve assessment of change in competition for flexibility products.*	The MDAG options paper does not describe what the indicators would be or how they would improve upon the indicators already used by the EA to monitor wholesale markets, particularly with respect to providing an unambiguous measure of the exercise of market power.
D2 Greater transparency of hedge information.	*Increased transparency by itself is unlikely to significantly restrain market power. However, it could assist other measures to be effective.*	The benefit of this option is uncertain. The MDAG competition analysis paper also notes this option could also impede competition by providing more information to suppliers and by encouraging parties to use other contract methods to avoid disclosure.
D3 Develop flexibility access code (non-price elements).	*Intended to make it easier for participants and regulators to detect any abuse of market power in flexibility contracts market.*	Not clear how setting a process for how generators must respond to requests for flexibility contract changes the physical capacity to offer contracts or the pricing of the contracts.
D4 Extend trading conduct rules to hedge market.	*Require suppliers to make offers that are consistent with those expected from a party that does not have significant market power.*	The option does not describe how the offers that reflect the exercise of market power would be identified and how the contribution of market power could be measured.

Source: MDAG options paper pages 80 to 83 and MDAG competition issues 2022, page 24

[18] MDAG competition issues 2022, page 79.

Table 3 MDAG 'partially supported' options to strengthen competition

'Option' and 'Assessment' are quoted from MDAG analysis.

Option	Assessment	Comment
D5 Market-making for shaped contract products	*Expected to encourage investment in intermittent generation by reducing the revenue risk.*	The paper does not define 'shaped products' but models the effect of cap contract as a proxy. The reduction in cashflow at risk through capped contracts is modelled for wind and solar but the impact on investment in these forms of generation let alone the impact on peak capacity and prices is not explained.
D7 Virtual disaggregation of flexible generation base	*A potential backstop measure if conduct measures are not effective.*	A virtual disaggregation would require an unambiguous and credible assessment of the price changes attributable to exercise of market power as opposed to the fair valuation of scarce generating resource with an uncertain replenishment rate. This was difficult to achieve in the EA wholesale market review and will be more difficult in a 100% renewables market. MDAG suggest auctioning flexible supply contracts could be used to achieve virtual disaggregation. This seems to be a variant of the preferred options D2, D3 and D4 A more detailed description of the of auctioning flexible supply contracts would be useful. It would help to clarify under what conditions an auction: • Could limit the exercise of market power and related increase in wholesale prices. • Create incentives for demand side flexibility.

Source: MDAG competition issues 2022, page 24

The MDAG options paper also considers but does not support two other options:

- D6 Physical disaggregation of flexible generation base
- D8 Price caps applied in the electricity spot market

We agree with the MDAG view on these options.

Appendix A Wholesale market revenue

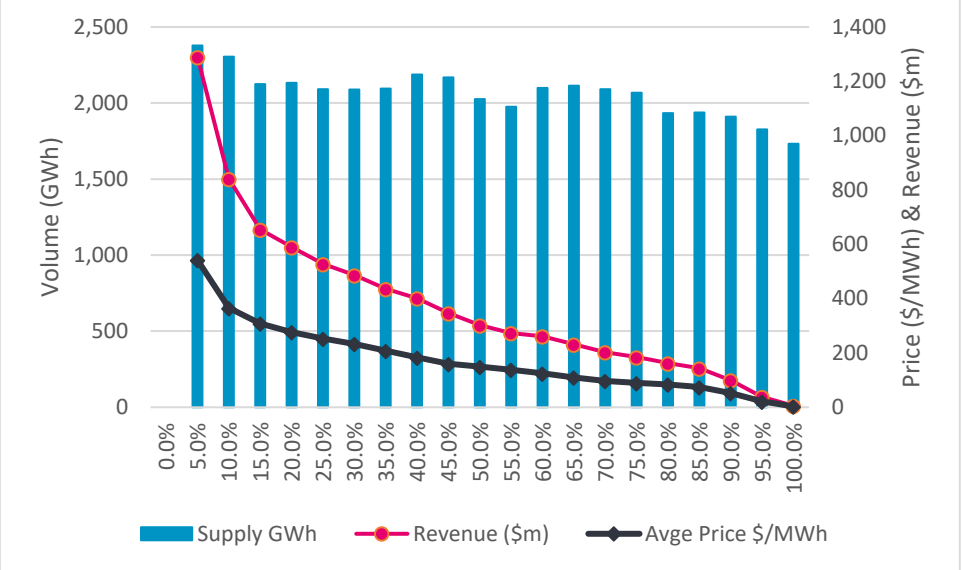
A.1 Price duration curves - 2017 to 2022

The MDAG analysis uses price duration curves to describe the shape of market demand and supply, but these curves do not explicitly show either the supply at the different prices or the implied wholesale revenue at each price period. The following tables and charts provide summarised information on the price duration curve on supply and wholesale market revenue over the period 2016 to 2022. The key points are:

- Total volume supplied for each block of trading periods is similar from year to year. The demand growth envisaged in the MDAG modelling is likely to move demand in low price periods toward that in medium price periods assuming that electric vehicle charging is shifted toward off-peak periods.
- Revenue has varied widely both from year to year and with respect to the trading periods revenue is earned within years. This suggests that the feasibility and value of the futures market development and the demand side flexibility will vary widely from year to year and that the likely outturn is likely to be very difficult for participants to predict. It also suggests quite different revenue risk profiles for wind and solar generators as wind generators seem to have a higher likelihood of running during high price periods than solar generators.

Figure 1 and Figure 2 illustrate that the extreme features of the MDAG price duration curves forecast for 2035 are already being experienced in the market despite the presence of a much larger amount of thermal generation than in the 2035 projections.

Figure 1 2021 price duration curve with volume and revenue 5 percent bands

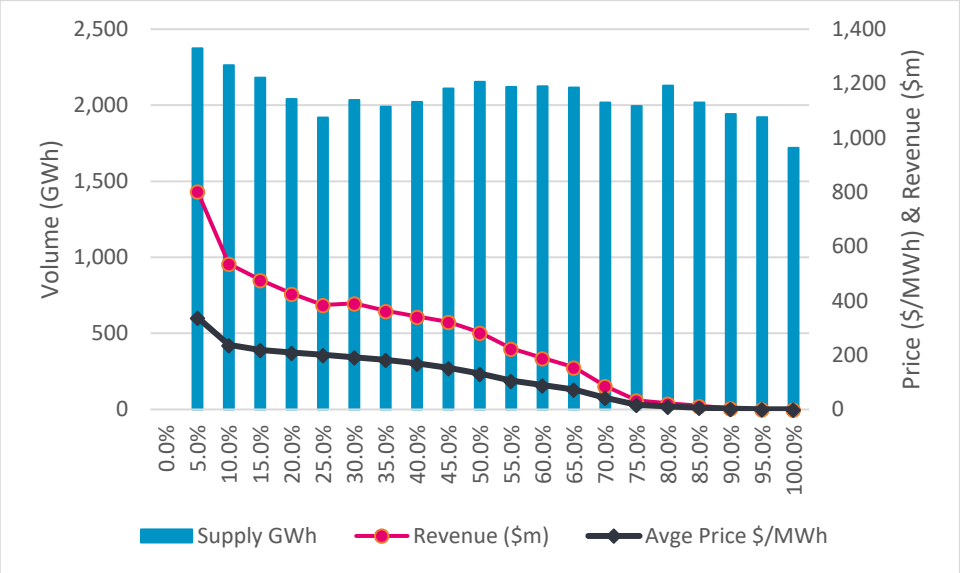


Source: NZIER analysis of EMI data

Figure 1 shows peak average prices of around $1,000 per MWh for the top 5 percent of price periods which exceeds the MDAG competition analysis prices for the same period

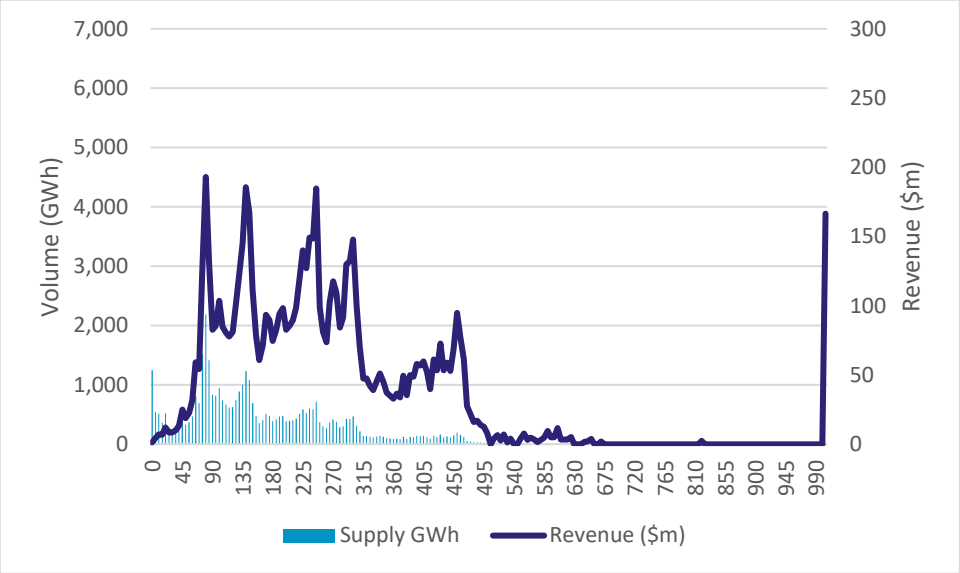
with average prices well above the MDAG scenarios.[19] Conversely Figure 2 illustrates that even with wholesale prices near zero for about 25 percent of trading periods average prices for the remaining periods are higher than the MDAG average.

Figure 2 2022 price duration curve with volume and revenue 5 percent bands



Source: NZIER analysis of EMI data

Figure 3 2021 volume and revenue in $5 per MWh price bands



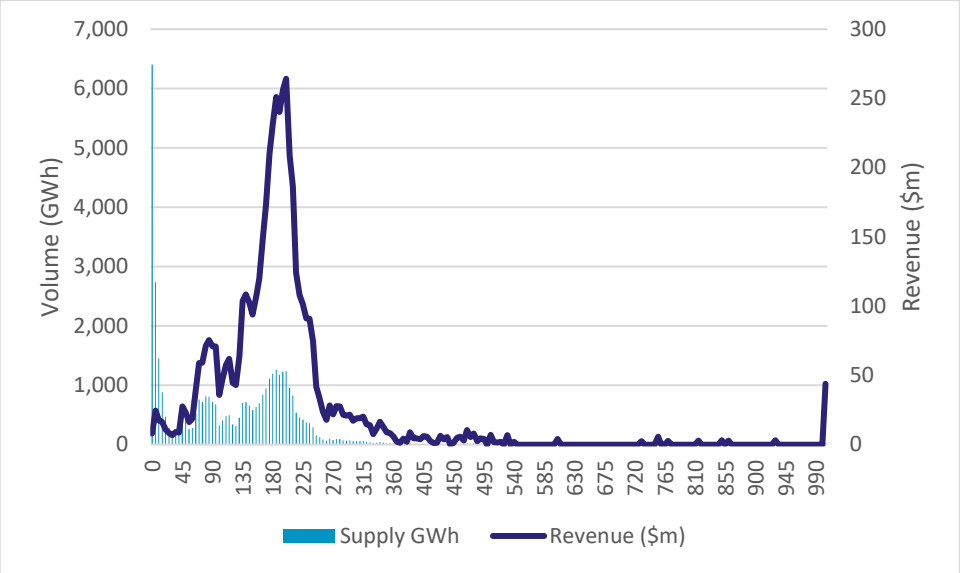
Source: NZIER analysis of EMI data

Figure 3 and Figure 4 illustrate how moderate variations in the shape of the price duration curve affect the distribution of wholesale electricity market revenue across different time

[19] The lack of availability of the data used to draw the charts in the MDAG papers prevents a more accurate comparison. The MDAG 'More Bang Bang' price duration curve shows a range of prices from $400 per MWh to $2,000 per MWh over the highest priced trading periods.

periods. Baseload generators are affected by volatility indirectly through its impact on the average price. Generators that can shift their load have an opportunity to substantially increase their share of revenue if they can focus output in .peak periods.

Figure 4 2022 volume and revenue in $5 per MWh price bands



Source: NZIER analysis of EMI data

Table 4 Price duration curve – volume supplied

All data reported in GWh unless otherwise stated.

Periods	2016	2017	2018	2019	2020	2021	2022
5.0%	2,311	2,402	2,230	2,396	2,510	2,378	2,374
10.0%	2,123	2,308	2,131	2,272	2,398	2,305	2,263
15.0%	2,101	2,244	2,154	2,175	2,298	2,125	2,180
20.0%	2,077	2,176	2,155	2,167	2,342	2,133	2,041
25.0%	2,070	2,136	2,097	2,161	2,292	2,091	1,919
30.0%	2,093	2,111	2,012	2,160	2,170	2,088	2,034
35.0%	2,163	2,099	2,067	2,125	2,119	2,096	1,991
40.0%	2,122	2,114	2,087	2,146	2,076	2,188	2,022
45.0%	2,126	2,098	2,154	2,094	2,132	2,169	2,111
50.0%	2,139	2,089	2,128	2,200	2,054	2,026	2,153
55.0%	2,090	2,076	2,162	2,144	2,054	1,975	2,120
60.0%	2,030	2,077	2,145	2,114	1,990	2,099	2,125
65.0%	2,043	2,074	2,144	2,092	1,943	2,115	2,117
70.0%	2,026	2,021	2,090	2,055	1,955	2,091	2,018
75.0%	1,973	1,993	2,031	2,009	1,938	2,068	1,995
80.0%	2,004	1,952	1,992	1,960	1,894	1,934	2,129
85.0%	1,952	1,884	1,929	1,917	1,837	1,938	2,018
90.0%	1,877	1,846	1,917	1,833	1,816	1,910	1,943
95.0%	1,789	1,804	1,853	1,911	1,750	1,827	1,921
100.0%	1,638	1,665	1,692	1,772	1,592	1,733	1,719
Total	**40,747**	**41,170**	**41,173**	**41,702**	**41,162**	**41,288**	**41,192**

Source: NZIER analysis of EMI data

Table 5 Price duration curve – wholesale market revenue

All data reported in $ million unless otherwise stated.

Periods	2016	2017	2018	2019	2020	2021	2022
5.0%	287.3	521.8	1,085.0	706.8	817.6	1,289.3	803.2
10.0%	171.3	356.4	544.0	458.9	480.4	841.3	536.0
15.0%	158.3	287.7	391.6	381.8	370.5	654.5	477.0
20.0%	147.8	243.4	305.9	347.0	334.5	589.6	426.2
25.0%	139.4	214.8	255.9	322.8	305.9	527.5	384.8
30.0%	133.8	194.4	215.9	302.8	273.8	486.2	390.7
35.0%	132.8	177.8	200.3	280.0	252.6	435.7	362.9
40.0%	126.1	166.4	184.3	268.7	235.0	401.0	341.9
45.0%	122.1	154.9	178.9	251.6	229.0	346.2	322.2
50.0%	119.3	144.5	166.4	254.2	206.9	301.6	283.2
55.0%	113.2	135.3	158.8	237.8	195.0	272.9	224.2
60.0%	106.6	127.7	148.7	224.0	177.1	261.0	189.0
65.0%	103.8	121.2	141.3	210.5	161.7	231.3	154.8
70.0%	98.6	111.0	129.9	194.8	151.4	202.3	86.3
75.0%	91.1	103.0	120.2	177.6	137.4	184.4	33.4
80.0%	87.9	95.1	111.3	159.0	117.7	162.0	22.0
85.0%	80.0	84.5	100.5	140.9	99.5	143.2	12.9
90.0%	68.5	72.4	90.4	112.1	75.2	98.9	3.8
95.0%	50.7	54.2	69.2	58.7	40.8	38.1	0.1
100.0%	24.4	27.2	30.4	15.6	8.8	5.2	0.0
Total	**2,363**	**3,394**	**4,629**	**5,106**	**4,671**	**7,472**	**5,055**

Source: NZIER analysis of EMI data

Table 6 Price duration curve – average price

All data reported in $ per MWh unless otherwise stated.

Periods	2016	2017	2018	2019	2020	2021	2022
5.0%	124.32	217.28	486.54	294.99	325.72	542.16	338.34
10.0%	80.67	154.39	255.23	202.03	200.28	365.07	236.89
15.0%	75.33	128.18	181.79	175.55	161.22	307.94	218.74
20.0%	71.16	111.83	141.93	160.18	142.78	276.43	208.79
25.0%	67.35	100.57	122.02	149.40	133.46	252.25	200.55
30.0%	63.93	92.08	107.30	140.19	126.19	232.79	192.12
35.0%	61.38	84.70	96.89	131.80	119.19	207.90	182.29
40.0%	59.44	78.68	88.28	125.24	113.17	183.26	169.05
45.0%	57.45	73.84	83.05	120.14	107.44	159.66	152.65
50.0%	55.78	69.18	78.16	115.51	100.75	148.91	131.53
55.0%	54.15	65.18	73.46	110.89	94.95	138.13	105.77
60.0%	52.50	61.48	69.31	105.94	88.98	124.36	88.91
65.0%	50.79	58.46	65.91	100.64	83.22	109.35	73.10
70.0%	48.65	54.89	62.16	94.80	77.45	96.74	42.79
75.0%	46.16	51.69	59.19	88.40	70.87	89.18	16.73
80.0%	43.85	48.73	55.89	81.11	62.17	83.79	10.33
85.0%	40.98	44.86	52.10	73.54	54.16	73.88	6.38
90.0%	36.50	39.19	47.15	61.16	41.42	51.80	1.97
95.0%	28.32	30.02	37.36	30.71	23.32	20.86	0.06
100.0%	14.89	16.33	17.98	8.79	5.52	2.97	0.02
Total	**57.99**	**82.43**	**112.43**	**122.43**	**113.47**	**180.98**	**122.71**

Source: NZIER analysis of EMI data

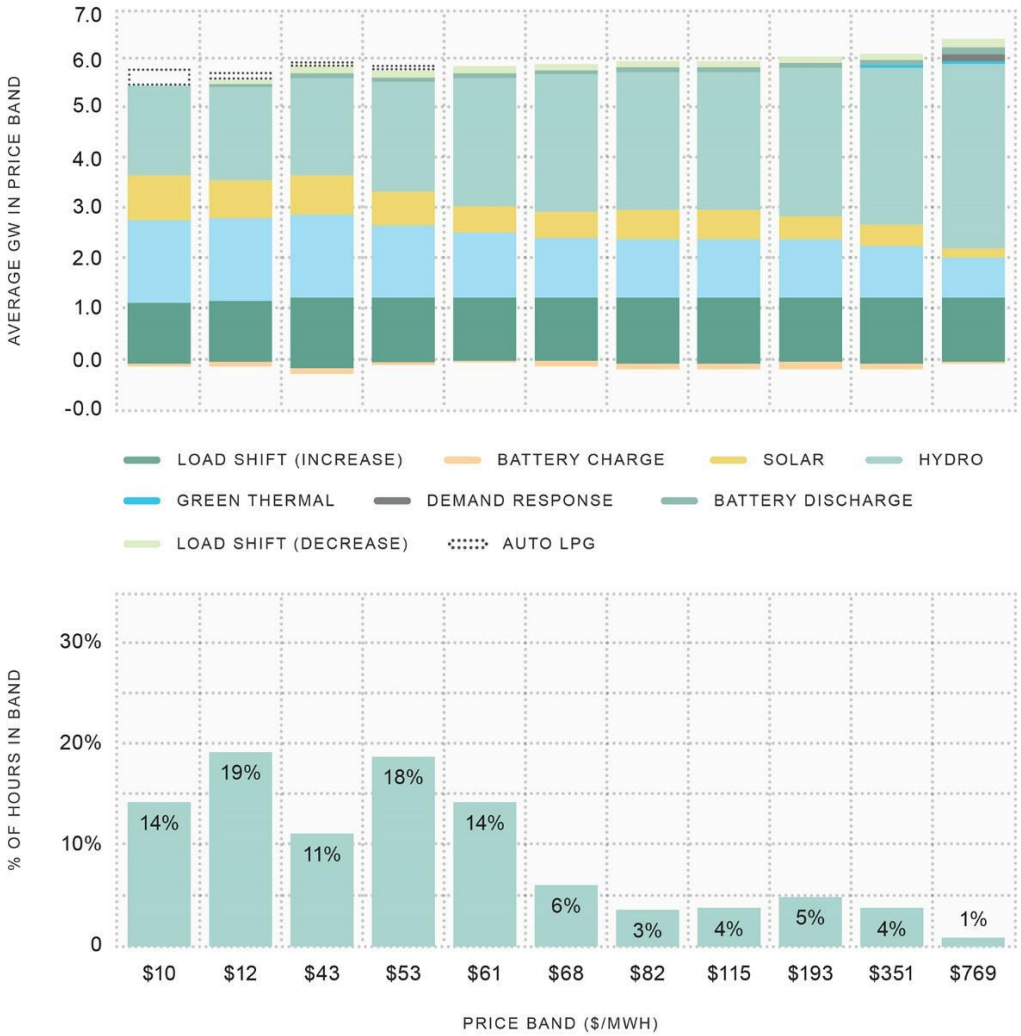
Augmenting the price duration curve to include volume supplied (and revenue for clarity) assists with the assessment of the size and shape of the challenge that the 'strengthen competition' and 'demand side flexibility' options face in altering outcomes for peak and average prices. This information should be readily available from the MDAG modelling that was completed for the MDAG competition issues and its release would materially assist with assessment of the quantitative effects of the measures proposed in the MDAG options paper.

A.2 MDAG hints about volume by price band

The MDAG options paper provides a glimpse of this information on page 62 Figure 9. This chart shows the different shares of generation by type at each price band. The flattening of the demand curve over the various price bands means that variation in demand will have less impact on prices than currently while the availability of intermittent generation will have much more impact. Unfortunately, the comments do not include a description of how the outcomes would vary under increased 'volatility of volatility' and the analysis is not

linked to the modelling of the impact of established generator returns in the MDAG competition analysis.

Figure 5 Contribution from resource types by price band (2035 reference case)



Source: MDAG options paper, page 62 Figure 9

Our analysis of prices and volumes over 2017 – 22 in Appendix A indicates that the demand curve is already relatively flat over the range of price periods and that similar levels of peak demand have caused widely varying peak price responses.

A.3 MDAG price duration curve scenarios

The MDAG competition analysis paper presents graphs of price duration curves for five scenarios[20]:

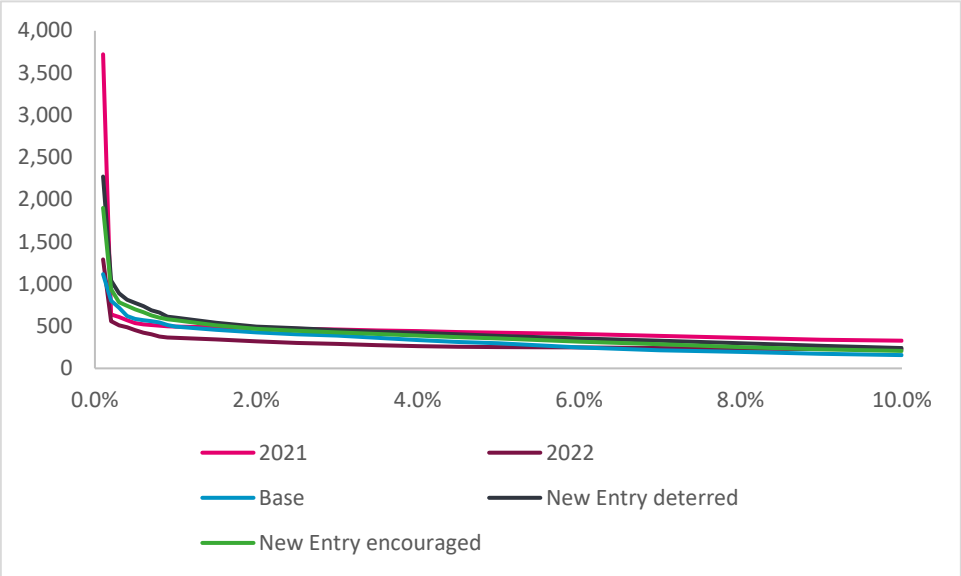
- Base – central reference case with two sensitivity cases:
  - Less bang-bang – lower volatility than base
  - More bang-bang – higher volatility than base
- Entry new generators:
  - Deterred
  - Encouraged.

The trading period bands are reported in the following sizes:

- 0.1 percentage point for <=1 percent of trading periods
- 0.5 percentage point for >1 percent to <=5 percent of trading periods
- 1.0 percentage point for >5 percent to <=99 percent of trading periods
- Final bands of >99.0 to <=99.5 percent, >99.5 to <=99.9 percent and >99.9 to <=100.0 percent

The forecast price duration curves have a much steeper left-hand side (10 percent of trading periods with the highest prices) but are flatter with lower prices for the remaining 90 percent of trading periods than recent years. Figure 1Figure 6 and Table 7 show the MDAG competition analysis 2022 price duration curve scenarios and the 2021 and 2022 price duration curves.

Figure 6 Price duration curves 10 percent of trading periods with highest prices



Source: NZIER

[20] MDAG competition issues 2022, page 20. The MDAG price duration data in the following charts and tables was extracted from the MDAG competition issues 2022 paper by displaying and copying the data labels from the slides.

The projected prices for the 10 percent of trading periods with the highest prices for the base reference case are lower than the prices for either of the new generator scenarios. The prices for the new generator deterred are about 10 percent above new generator encouraged scenario. The actual prices for 2021 and 2022 have a similar shape to the MDAG projections for the 10 percent of trading periods with the highest prices. (Table 7 is included because the very high prices for 0.1 percent of trading periods obscure the differences between price for the next highest priced 9.9 percent of trading periods.

Table 7 MDAG Price duration curve – top 2

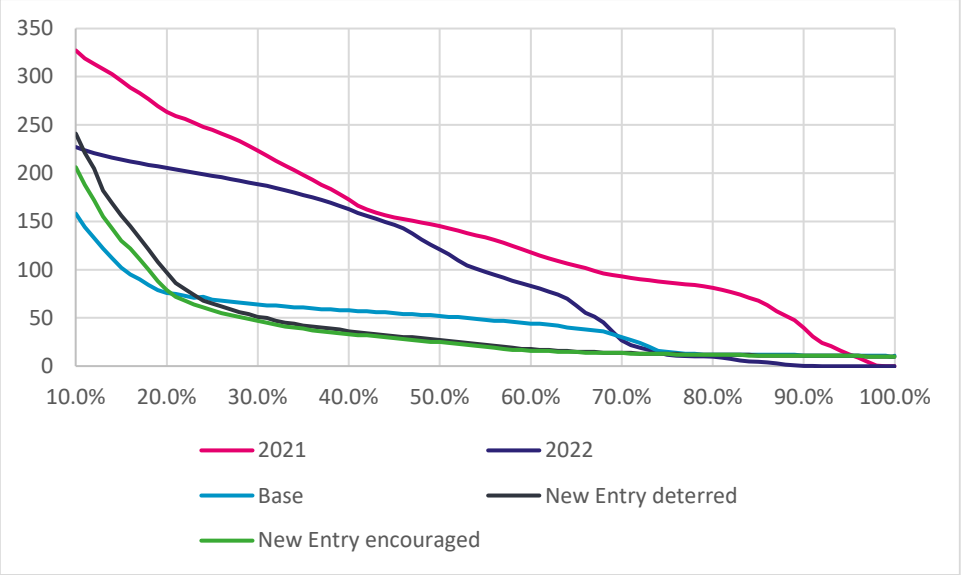
All data reported in $ per MWh unless otherwise stated.

Trading period band	Less bang-bang	Base	More bang-bang	New Entry encouraged	New Entry deterred	2021	2022
<= 0.1%	1,040	1,116	1,973	1,900	2,273	3,719	1,290
>0.1% to <= 0.2%	761	804	1,005	940	1,042	638	559
>0.2% to <= 0.3%	686	719	852	784	888	610	510
>0.3% to <= 0.4%	597	621	776	743	814	572	489
>0.4% to <= 0.5%	567	586	747	699	776	537	455
>0.5% to <= 0.6%	536	572	709	665	739	522	425
>0.6% to <= 0.7%	520	561	679	628	689	514	404
>0.7% to <= 0.8%	498	544	622	600	661	506	378
>0.8% to <= 0.9%	474	515	607	584	612	501	369
>0.9% to <= 1.0%	460	496	588	571	603	498	363
>1.0% to <= 1.5%	414	457	523	509	540	489	345
>1.5% to <= 2.0%	380	426	482	469	496	480	320
>2.0% to <= 2.5%	356	405	456	445	477	470	303
>2.5% to <= 3.0%	323	389	436	426	453	460	289
>3.0% to <= 3.5%	302	363	421	409	436	451	275
>3.5% to <= 4.0%	275	336	406	391	424	442	265
>4.0% to <= 4.5%	256	315	386	369	406	432	258
>4.5% to <= 5.0%	235	297	369	355	385	424	254
>5.0% to <= 6.0%	207	251	337	317	355	408	248
>6.0% to <= 7.0%	186	217	304	287	328	386	241
>7.0% to <= 8.0%	171	195	275	255	298	362	236
>8.0% to <= 9.0%	162	174	243	228	267	342	231
>9.0% to <= 10.0%	156	158	225	206	241	327	227

Source: NZIER analysis of EMI data

Figure 7 shows that recent actual prices for the remaining 90 percent of trading periods are generally higher than the MDAG projected prices. Also, the reference base case scenarios switches from being below to being above the new generator scenarios for the middle range of trading periods (25th to 75th percentile).

Figure 7 Price duration curves 90 percent of trading periods with lowest prices



Source: NZIER