Low overnight prices

Market Performance Enquiry

Market performance enquiry

21 November 2016

Version control

Version	Date amended	Comments

Investigation stages

An in-depth investigation will typically be the final step of a sequence of escalating investigation stages. The investigations are targeted at gathering sufficient information to decide whether a Code amendment or market facilitation measure should be considered.

Market Performance Enquiry (Stage I): At the first stage, routine monitoring results in the identification of circumstances that require follow-up. This stage may entail the design of low-cost ad hoc analysis, using existing data and resources, to better characterise and understand what has been observed. The Authority would not usually announce it is carrying out this work.

This stage may result in no further action being taken if the enquiry is unlikely to have any implications for the competitive, reliable and efficient operation of the electricity industry. In this case, the Authority publishes its enquiry only if the matter is likely to be of interest to industry participants.

Market Performance Review (Stage II): A second stage of investigation occurs if there is insufficient information available to understand the issue and it could be significant for the competitive, reliable or efficient operation of the electricity industry. Relatively informal requests for information are made to relevant service providers and industry participants. There is typically a period of iterative information-gathering and analysis. The Authority would usually publish the results of these reviews but would not announce it is undertaking this work unless a high level of stakeholder or media interest was evident.

Market Performance Formal Investigation (Stage III): The Authority may exercise statutory information-gathering powers under section 46 of the Act to acquire the information it needs to fully investigate an issue. The Authority would generally announce early in the process that it is undertaking the investigation and indicate when it expects to complete the work. Draft reports will go to the Board of the Authority for publication approval.

The outcome of any of the three stages of investigation can be either a recommendation for a Code amendment, provision of information to a Code amendment process already underway, a brief report provided to industry as a market facilitation measure, or no further action.

From the point of view of participants, repeated information requests are generally concerned with Stage II; trying to understand the issue to such an extent that a decision can be made about materiality.

Executive summary

This report is the result of an enquiry by the Market Performance team into over-night electricity prices in the wholesale Electricity market. The analysis was initially requested by the Electricity Authority Board, which decided that the analysis may also be of interest to a wider audience.

The analysis looks closely at trading period eight (TP8); TP8 is between 3:30am and 4am in the morning when electricity demand is at its lowest. In terms of the daily diurnal cycle, this time of day can be characterised by low demand and generators using plant that must run—hydro to keep minimum flows in rivers, geothermal that runs as baseload, and slow start thermal plant that needs to be kept running at minimum output overnight so it is available later that day.

Our initial analysis suggests that:

- low over-night wholesale prices have occurred less regularly recently, but historically the incidence varies
- there doesn't seem to be any structural change in wholesale market offers
- low over-night wholesale spot prices are being driven by fundamental factors, of which increasing overnight wholesale market demand is important.

Increasing overnight wholesale market demand

The market model that sets wholesale market price, models both grid connected wind generation and smaller embedded generation (that does not offer into the market) as negative demand. A reduction of either type of generation in real-time results in increased demand (from a modelling perspective) and increased wholesale spot prices that were not forecast in the pre-dispatch pricing schedules.

- We have observed grid connected wind generation apparently responding to price in real-time by reducing wind generation if prices fall too low. This behaviour removes generation in real-time and we have observed incidents of it increasing wholesale spot prices. The Electricity Authority is currently consulting with industry on changes to the way wind generation is offered in to the market. This follows recent recommendations by the Wholesale Advisory Group aimed at reducing this type of behaviour.
- Likewise, there appears to be an increasingly negative correlation of smaller embedded generation with wholesale market spot price during over-night periods. This suggests that embedded generation which is exposed to over-night wholesale spot prices may also be responding to low prices. This may also be exacerbated by the growth of small embedded generation during recent years.

The Authority does not currently plan to escalate this Market Performance enquiry beyond what is presented here. However, the Authority will continue its day-to-day Market Monitoring – which includes monitoring wholesale market prices and generator behaviour.

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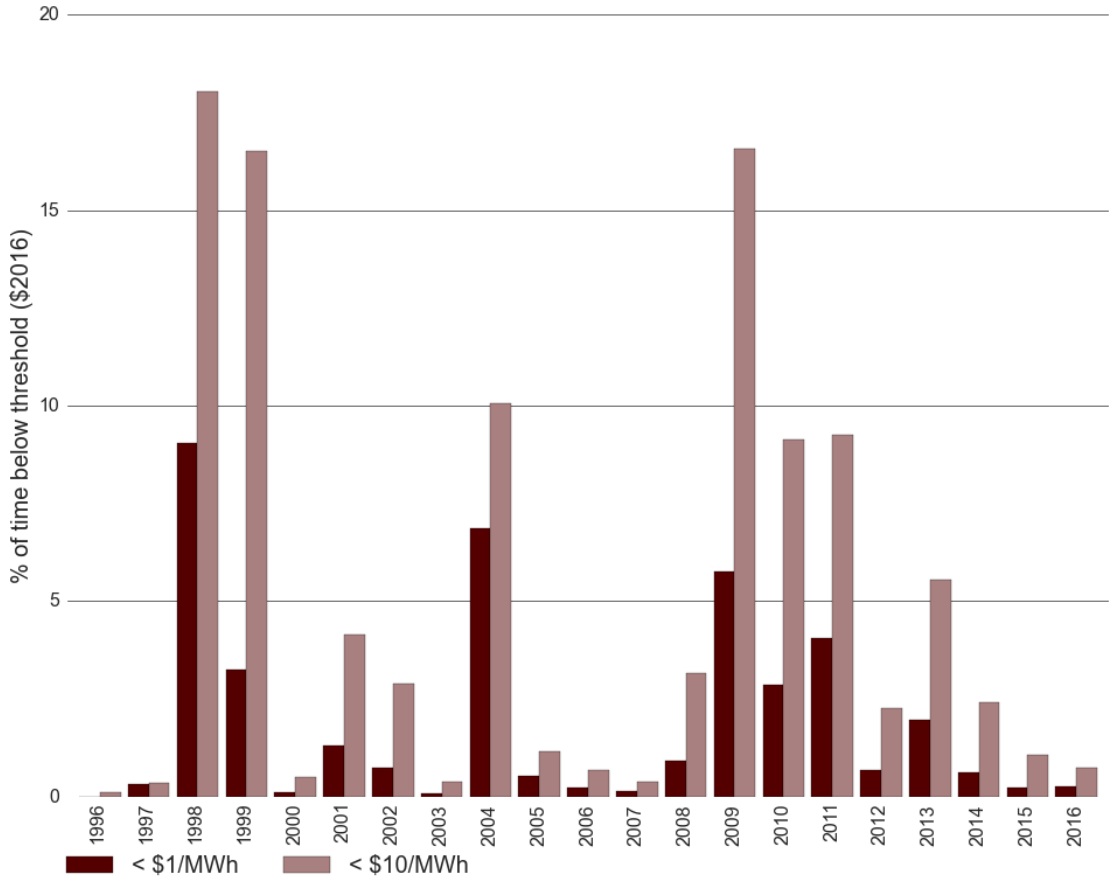
Introduction

1.1 This paper looks at TP8 to try to determine whether there has been a change in the level of prices over time and what may be driving the changes.

Historic trends in wholesale market prices

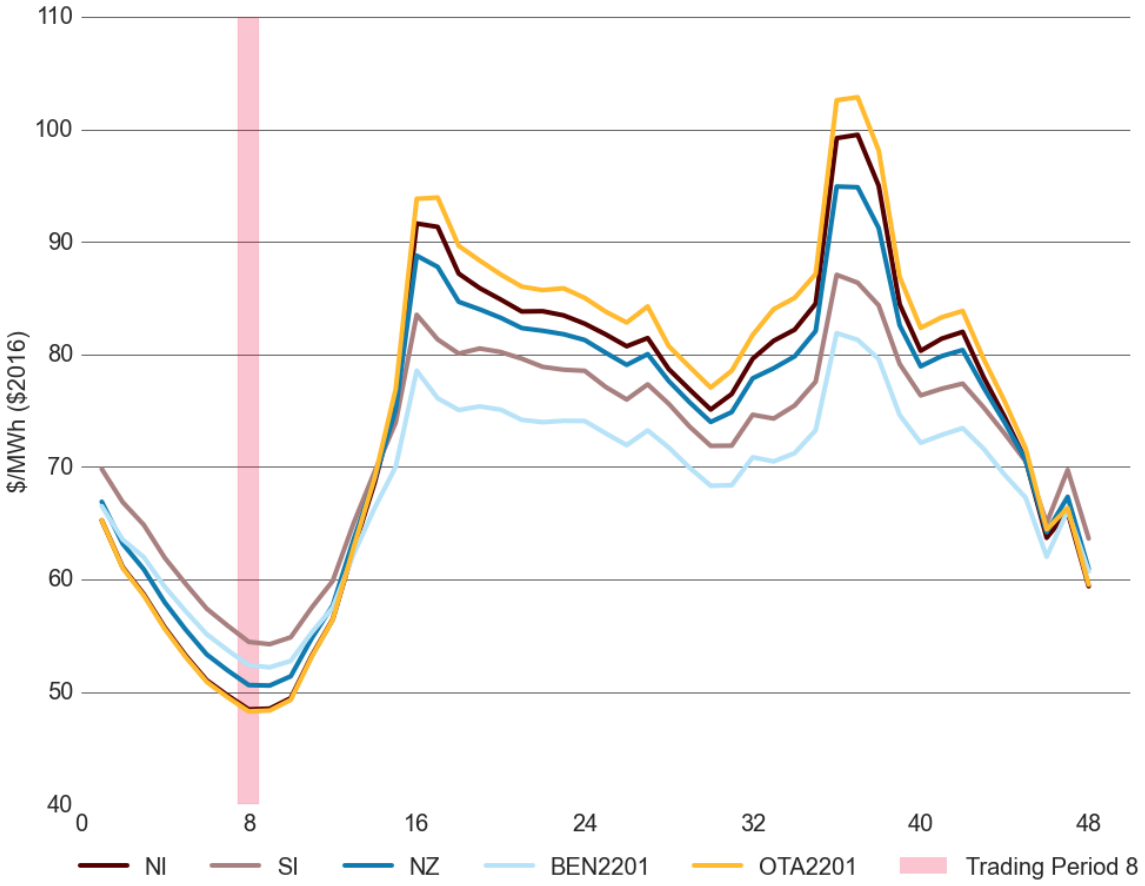
1.2 Since October 1996, there have been several other years that recorded low numbers of low priced trading periods (1997, 2000, 2003 and 2005-2007). Figure 1 illustrates this trend with prices below $10/MWh dropping from sixteen per cent of the time in 2009, to less than one per cent of the time so far during 2016. The chart shows New Zealand average prices for all trading periods over all grid exit/injection points that are under $1/MWh (dark brown bars) and under $10/MWh (light brown bars). The pattern is similar regardless of the threshold.

Figure 1 Percentage of time NZ mean wholesale spot price—all periods—less than $1/MWh and $10/MWh



1.3 Figure 2 illustrates the daily average price curves for Otahuhu, Benmore, the North and South Island mean price and the mean New Zealand price.

Figure 2 Daily average price curves (prices since 1996, adjusted for inflation)



1.4 As high-lighted, prices are lowest around TP8 (3:30am-4am). To better understand low overnight prices we have visualised trends and modelled TP8 prices in the remainder of this report.

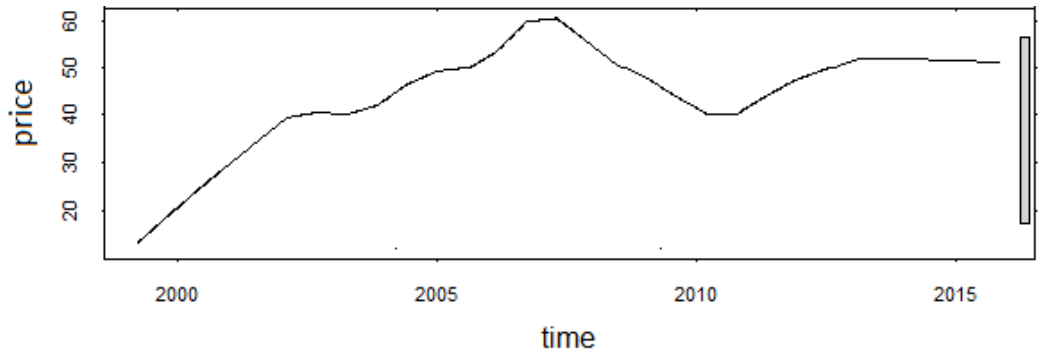
Longer term trends in TP8 prices show an increase over time, but prices have been stable recently

1.5 We modelled how wholesale TP8 prices[1] changed with time. We first calculated the seasonal component of the price series by taking the mean of each week to account for seasonality and then de-seasoned the series.

1.6 We then used a rolling window (300 weeks) in which we applied a statistical technique (locally weighted scatterplot smoothing) to help indicate longer term trends in TP8 price.[2] The results are shown in Figure 3.

1.7 The TP8 prices came down from around 2007 then started going up again around 2010. They have flattened out since 2013. While not conclusive, this trend is consistent with our observation of fewer low priced trading periods recently.

Figure 3: Smoothed trend in TP8 prices



There have been structural breaks in TP8 prices

1.8 We have also modelled TP8 prices to determine statistically when they changed; i.e. when changes in TP8's price level are too unlikely to have occurred through pure chance. To do this we removed the effects of seasonality to get a transformed price series. This involves treating each week of the year as a separate season and adjusting prices to account for which week they fall into, removing the seasonal noise from the data.

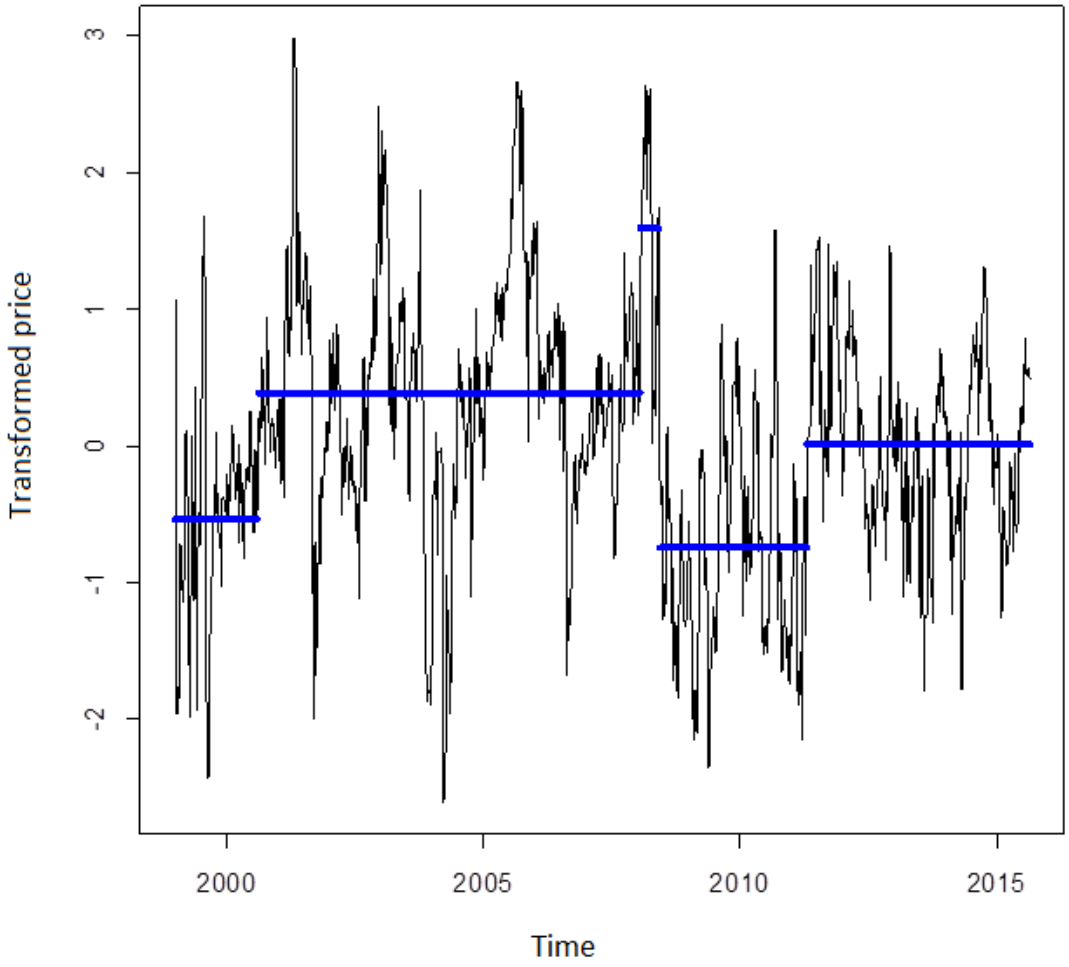
1.9 We did this with our full set of data (1999 to 2015) and on a subset of data (2009 to 2015). The idea of using the subset of data was to choose a shorter time frame to control for changing spot market rules over time—the shorter the time frame, the fewer changes to rules. The results are shown in Figure 4 and Figure 5 where the y-axis measures the transformed price.

1.10 Figure 4 shows that there have been four structural breaks and five distinct periods in TP8 prices between 1999 and 2015, the latest structural break being about 2012.

[1] Where TP8 price is the mean price over all grid exit and injection points.

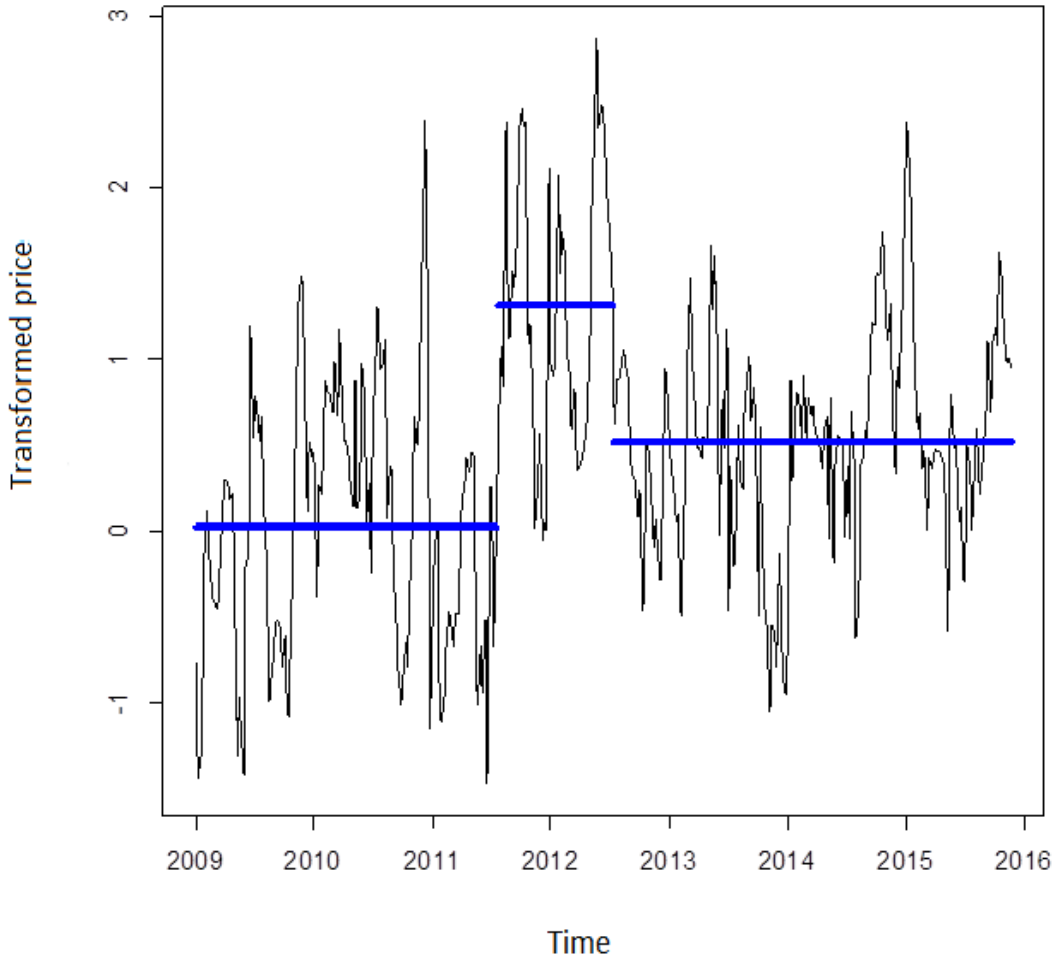
[2] Within the moving window this technique first fits a line to the price data. It then weights each point with decreasing weights the further away the point is from the centre of the window and the fitted line. Using regression on the weights we were able to obtain a trend value using the intersection of the regression and the centre of each window. We moved the window across the data and obtained a trend curve.

Figure 4: structural changes 1999-2015



1.11 Figure 5 shows that there were two structural breaks in TP8 prices between 2009 and 2015, with the period around 2012 having relatively high prices. This is most likely due to hydro storage at that time with the first 6 months of 2012 having very low inflows. Overall Figure 5 shows there has been a rise in TP8 prices since the beginning of 2009.

Figure 5: structural change 2009-2015



We find evidence that TP8 prices are determined by fundamental factors

1.12 We also investigated the dependence on TP8 prices on fundamental factors. We did this by attempting to estimate TP8 prices based on historic time-series data of gross underlying demand (that is, actual quantities consumed), thermal generation, hydro storage, and wind and embedded generation. We modelled the spot market in TP8 as a supply equation and a demand equation, transforming these equations into suitable equations for estimation.

1.13 The relevant equation is the price equation which is:

Equation 1

$$\text{Price} = \text{a function of } (\text{constant} + \text{demand} + \text{thermal generation} + \text{hydro storage} + \text{wind generation} + \text{embedded generation} + \text{noise})$$

1.14 This equation uses fundamental factors that we believe explain price. The idea is that if the factors on the right hand side of the equation explain price well, then we have some confidence that fundamentals are driving TP8 prices rather than anything unusual.

1.15 Using data from 2009 to the end of 2015, we found that 64 per cent of the variation in price can be explained by the fundamental factors in Equation 1. This is a reasonably good result for this type of estimation.

1.16 Of the variables that explain TP8 price, we find that electricity consumption during TP8 is by far the most influential variable. This is followed by thermal generation and hydro storage. However, electricity consumption has ten times more percentage influence in the variation in prices than thermal generation and twenty times more than hydro storage (under the model specified in 1.13).

1.17 For the time period studied, we found that overall wind and embedded generation appear to have little influence on TP8 price. However, between 2009 and 2015, we find that both of these types of generation are likely to be having more influence on TP8 prices.

Trends in low priced offers and demand for TP8

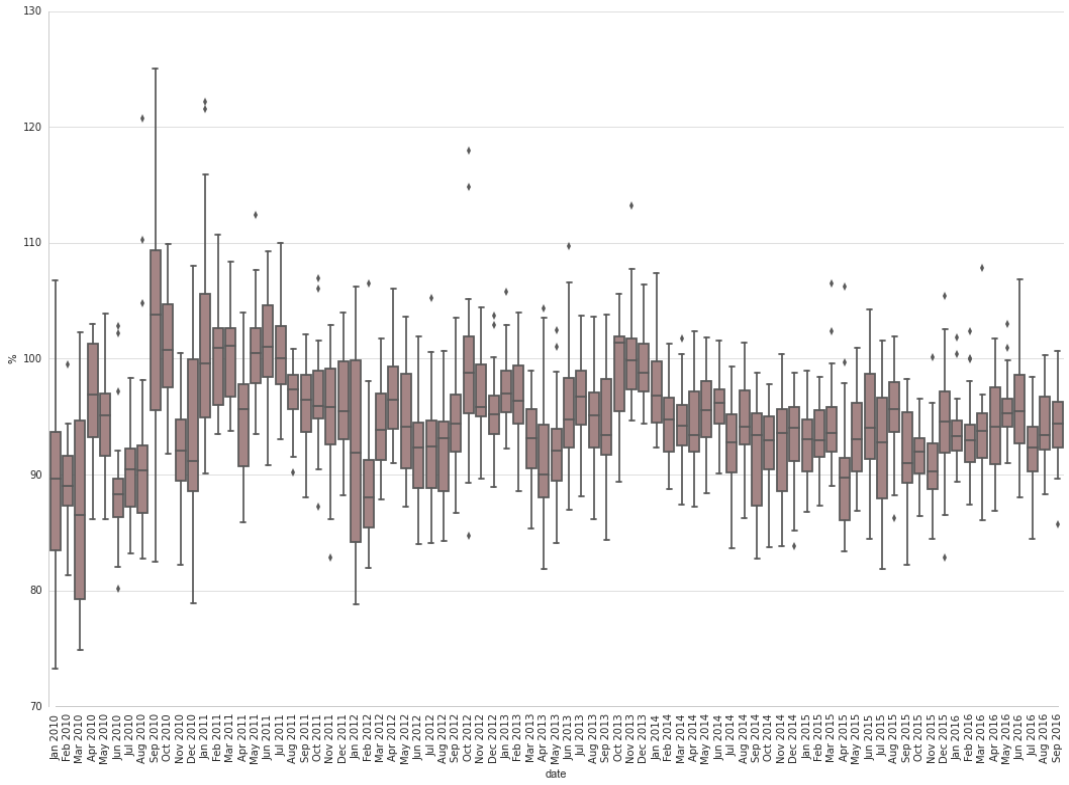
1.18 To better determine what may have been driving TP8 prices, we have visualised time series trends in both low priced offers (less than $1/MWh) and actual total New Zealand wholesale market demand during TP8.

1.19 As generator-retailers tend to cover a large portion of their demand positions with low priced generation offers we have plotted the percentage of low priced offers that make up total New Zealand demand during TP8.

1.20 Figure 6 illustrates this with a monthly boxplot of TP8 offers (below $1/MWh) as a percentage of wholesale market demand. Values above 100 per cent indicate times when TP8 prices were likely below $1/MWh; since the amount of generation offered below $1/MWh exceeded wholesale market demand in those times.

1.21 Visualising aggregate offers as shown in Figure 6 is useful as it highlights the shape of the aggregate supply curve in TP8, and whether there have been any structural changes in offering behaviour through time.

Figure 6 Trend in offers (<$1/MWh) as percentage of wholesale market demand during TP8

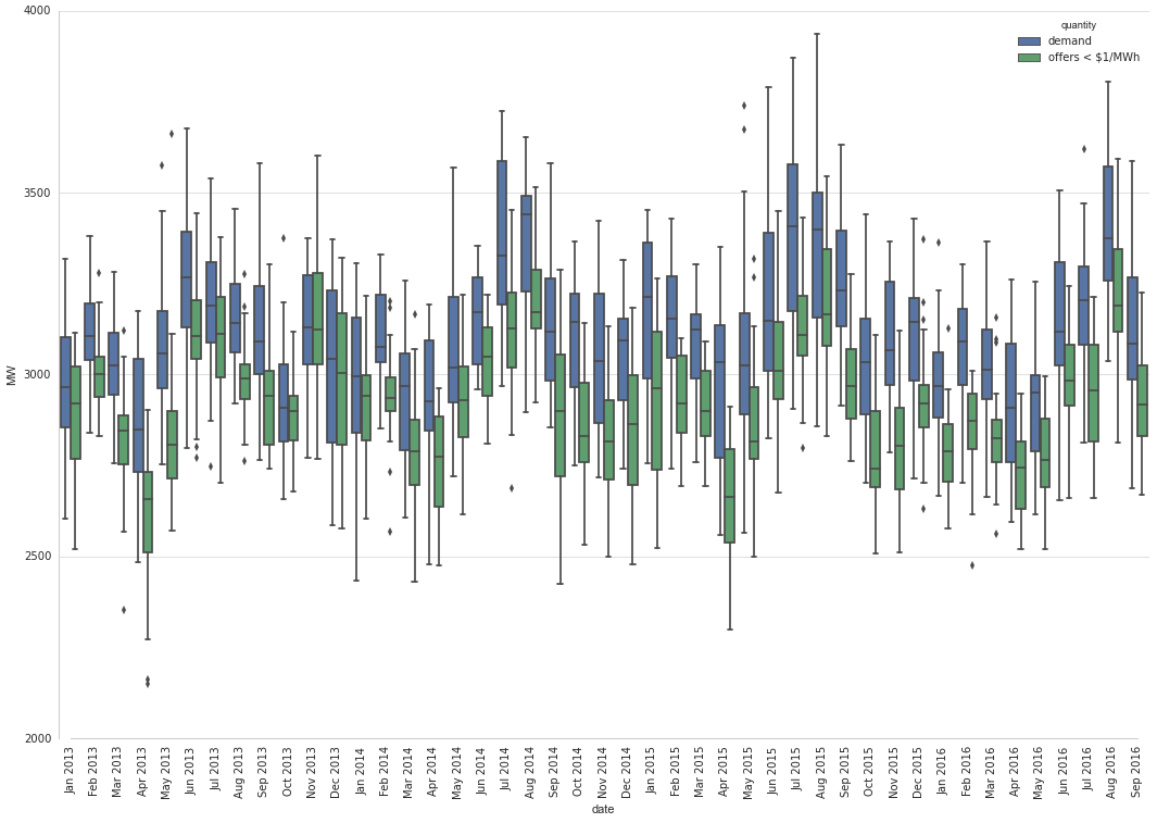


1.22 Around 95 per cent of offers appear to be below $1/MWh during TP8. We observe a slight downward trend starting in 2014; the relative distance between wholesale market demand and the amount of low priced offers in TP8 has widened leading to a reduced incidence of price collapse. This observation is aligned with the trend in Figure 1. However, either higher wholesale market demand or reduced quantity of low-priced offers could be driving this trend.

1.23 Splitting out generation offers and wholesale market demand is illustrated in the paired monthly boxplot (since 2013) shown in Figure 7. Although subtle, on closer inspection it appears that wholesale market offers below $1/MWh have remained fairly constant while wholesale market demand appears to have increased slightly during this time.

1.24 This tends to indicate that the trend in increased wholesale market over-night prices may be being driven by increased wholesale market demand. An increase in wholesale market demand may be caused by underlying demand growth, reduced wind generation or reduced embedded generation during this time. This is consistent with the regression above which uses demand in the right hand side to help explain TP8 prices.

Figure 7 Wholesale market demand vs offers below $1/MWh for TP8



Our conclusion is that increased demand resulted in higher wholesale prices during TP8

1.25 Overall, it appears the quantity of low priced offers have remained fairly static over time, while wholesale market demand has increased slightly during recent years.

1.26 Before ruling out wholesale offers as a factor explaining TP8 prices, we also explored the dependence of low priced offers on 'must-run' generation types for TP8. We found that while there has been a reduction in low priced offers from large slow start thermal plant, there has been an offsetting (roughly equal) increase in low priced offers from new base load geothermal generation.

Increased wholesale market demand

1.27 We speculate that the increase in wholesale market demand during TP8 could be the result of:

- Increased under-lying demand growth (or demand shifting). For example, consumers exposed to wholesale prices and/or to distribution time-of-use tariffs facing increased incentives to shift electricity consumption from higher priced peak periods to lower priced off-peak periods
- grid connected wind generation and embedded generation——responding to low prices in real-time which increases the wholesale market demand used in the market model.

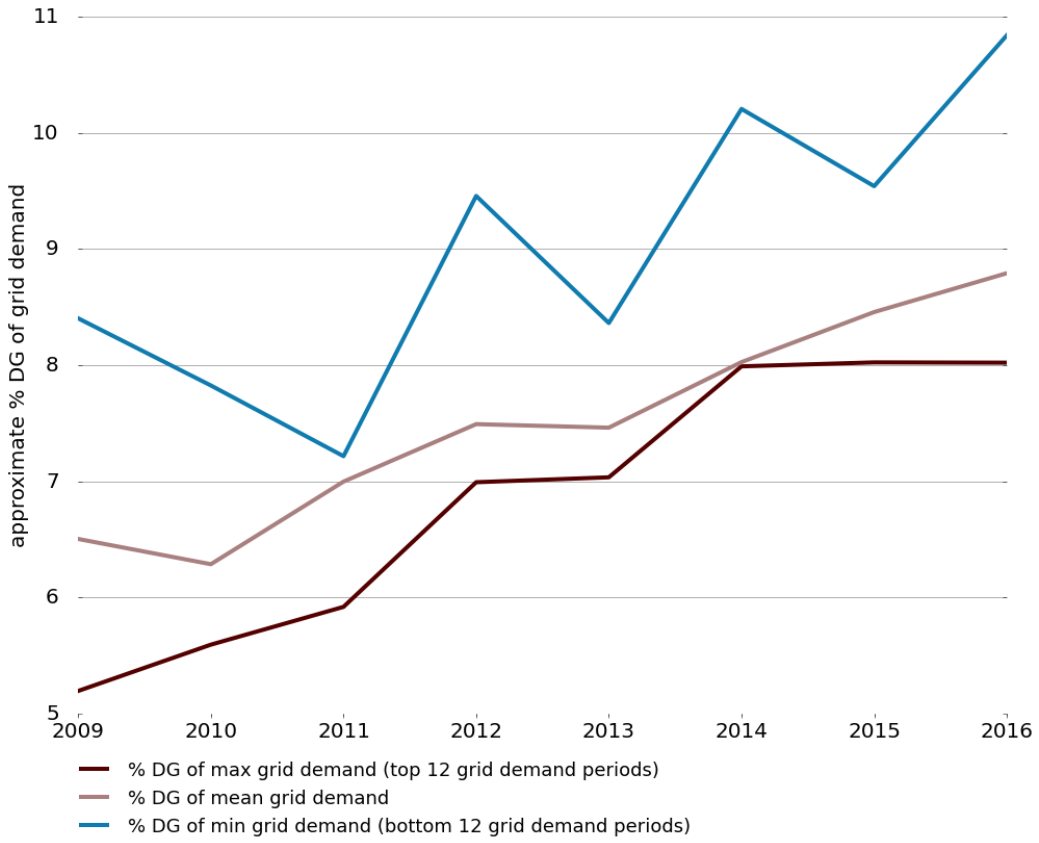
DG responding to low over-night prices

1.28 The quantity of DG on the network has grown significantly in recent years. This has been exacerbated to some extent by incentives under the current transmission pricing methodology. DG are considered price-taking and typically do not offer into the wholesale market unless they are larger than 10MW.

1.29 We are able to estimate the total amount of embedded generation by subtracting metered GXP demand from total reconciled demand behind each GXP, then summing over all GXPs. The difference can be considered a close proxy of the quantity of DG.

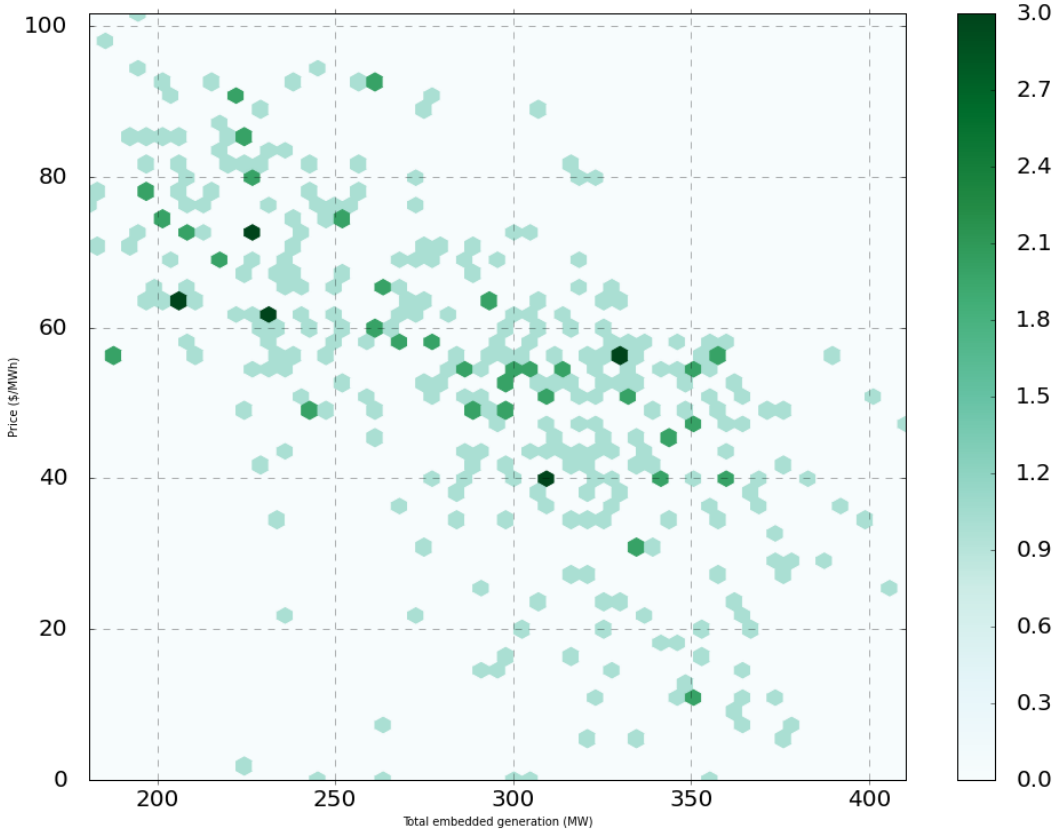
1.30 Figure 8 illustrates the recent growth in small DG as a percentage of grid demand at different times. We estimate that total small DG was close to 500MW during peak demand periods in 2016.

Figure 8 Recent growth in small distributed generation



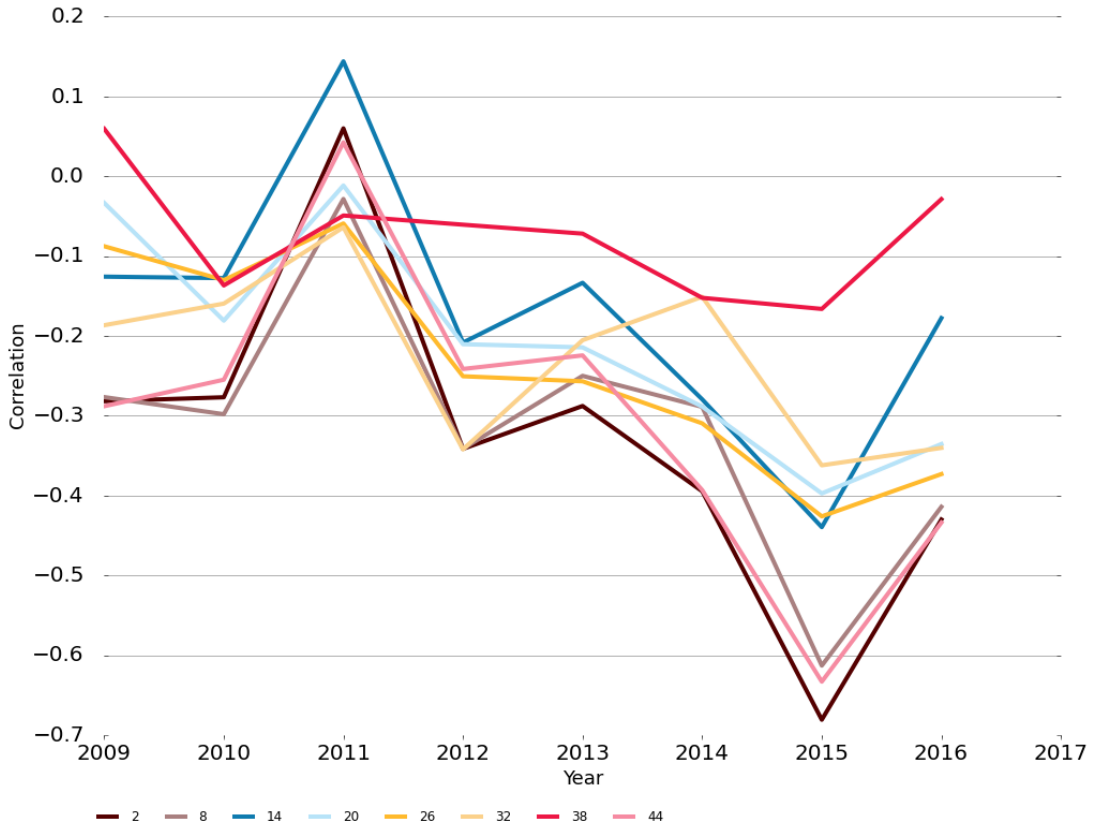
As most of this DG does not offer into the market, a reduction in DG increases wholesale market demand and therefore price. We are therefore interested in the relationship of this DG with wholesale market price at different trading periods, including TP8. Figure 9 shows a scatterplot illustrating a reasonably strong negative correlation of wholesale spot price vs total embedded generation for TP8 during 2015.

Figure 9: Scatter plot of TP8 price and embedded generation



Calculating the correlation annually since 2009 and for several other trading periods is illustrated in Figure 10.

Figure 10 Correlation between embedded generation and wholesale spot price for different trading periods



1.31 The over-night trading periods have seen a reasonably increased negative correlation with wholesale market price in recent years, particularly in 2015. The correlation is much closer to zero during peak periods which is what would be expected from intermittent price-taking run-of-river hydro or wind generation.

1.32 This tends to indicate that smaller embedded generation have been reacting to low wholesale spot prices by reducing or turning off generation during these times (in particular during 2015)—if this was due to variation in wind only, which we expect to be random, then the correlation should be zero between price and generation. This may help explain the small increases seen in wholesale market demand and consequent increases in wholesale spot prices for TP8.

1.33 Individual generators smaller than 10MW are considered to be price-taking and therefore unlikely to affect wholesale market prices. This is reflected in Part 13 (Trading arrangements) of the Code which specifies what is required to be offered by generating plant. In this case, generators smaller than 10MW are typically not required to submit offers unless otherwise required by the System Operator.

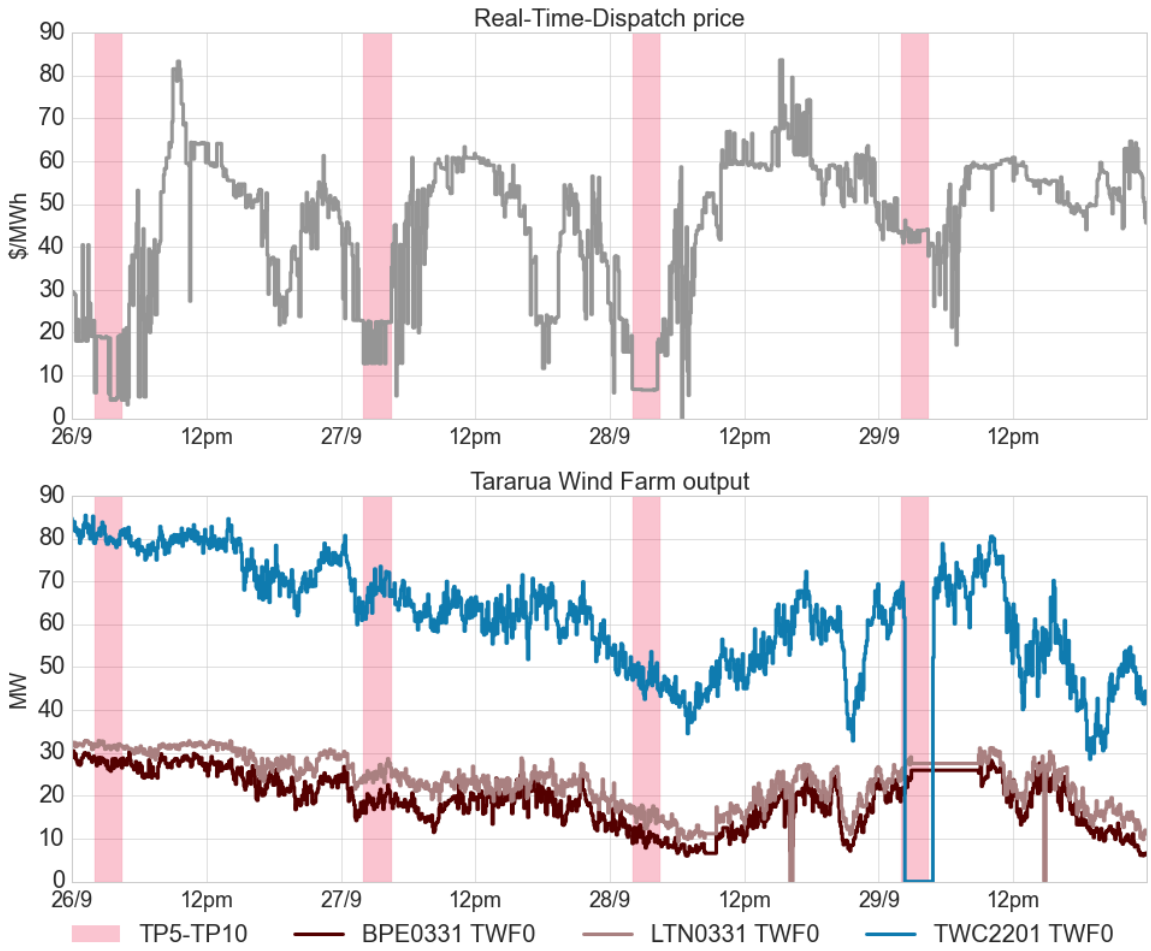
1.34 The results here appear to indicate that the collective behaviour of DG can now affect wholesale market price. It may be of benefit to review the requirements around small embedded generation and how this is offered into the market. Participants whose portfolios consist of significant amounts of small (<10MW) embedded generation may have substantially greater amounts when all their embedded generation is considered together and may need to be treated as large generators for the purposes of the market rules. This report will be passed to the Authority's market design team for consideration.

Wind generation appears to respond to real time prices

1.35 We have also observed grid connected wind generation responding to price in real-time by switching off if prices fall too low. This behaviour removes generation in real-time and also increases wholesale spot prices.

1.36 Figure 11 illustrates such an example. The chart shows the real time price (grey line) and Tararua Wind Farm generation between Monday 26 September and Thursday 29 September, 2016. TWF is owned by Trustpower and injects at three difference GIPs, indicated by the brown and blue lines. The pink areas highlight the same over-night period each day (between 2am and 4:30am - trading periods 5 to 10).

Figure 11 Tararua Wind Farm responding to low forecast overnight prices



1.37 Low over night prices were present between 2am to 4:30am from Monday to Wednesday with reasonable wind generation volumes. At the same time on Thursday 29 September the Tararua Wind Farm reduced its wind generation by around 70 MW (blue line). The brown lines do not display the same reduction in output and we conclude that this is not due to wind conditions—as these windfarms are all in the same area and the BPE0331 and LTN0331GIPs are not similarly affected. This sort of behaviour increases the real time price.

1.38 In this instance, prices settled at around the $40/MWh mark, as opposed to around $10/MWh in the preceding days.

1.39 Like DG, grid connected wind generation is considered a price-taker in the wholesale market. The difference is that wind is offered into the market with a single fixed offer

tranche of $0.01/MWh. By turning off in real-time, the Tararua Wind Farm appears to have been able to increase wholesale market prices.

1.40 The Electricity Authority is currently consulting with industry on changes to the way grid connected wind generation is offered in to the market. This follows recent recommendations by the Wholesale Advisory Group aimed at reducing wind plant turning off generation with no warning while prices are low.