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- For reader's information, these slides were prepared for the 7th May 2019 MDAG meeting.
 - They address questions raised at previous meetings.
 - The intention of the slides is to help group members to better understand aspects of the market and to assist with decision making.



South Island Market Changes

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7th May 2019

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- Offers on the Clutha scheme have increased in price in recent years.
- Offers are revised close to gate closure differently on the Waitaki:
 - In 2016, offers are revised within the last two hours to offer *less* capacity
 - In 2018, offers are revised within the last two hours to offer *more* capacity
- Price separation (and very low prices in the South Island) occurs less often in recent years.
- Clutha generation during off-peak periods has reduced in recent years.

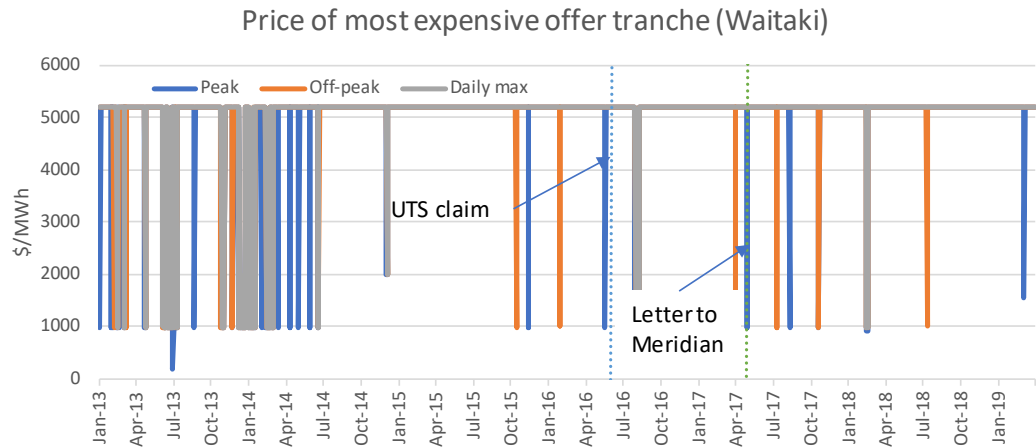
- This report details initial findings from a review of changes to the South Island electricity market in recent years.
- It attempts to determine if any systemic changes in offer behaviour or market outcomes arose after the UTS claim for June 2016.
- Accordingly, it looks for differences between the period prior to June 2016 and the period after the EA's open letter to Meridian was published.
- Note that the South Island electricity market experienced some major physical and regulatory changes in and near the period under investigation that will complicate the analysis. Notably:
 - Pole 3 of the HVDC began operating in 2013
 - The national instantaneous reserve market started in October 2016
 - The way the HVDC is paid for by South Island generators was changed in September 2015
 - Gate closure was shortened in June 2017
- Similarly, hydrology will affect most of the analysis

- This is a broad topic. To focus our efforts, we approach this by positing a series of hypotheses, and attempting to find evidence that supports each hypothesis.
- This process is split into 3 sections:
 - generator behaviour.
 - market outcomes.
 - generator outcomes.
- We summarize the evidence for the hypotheses at the end of each section
- Evidence is ranked by the following scale:
 - none – no evidence was found supporting the hypothesis.
 - some – weak evidence was found supporting the hypothesis.
 - clear – strong evidence was found supporting the hypothesis.
- This analysis is a “first pass”, and does not normally use proper statistical tests. It is intended that this be used to direct further, more detailed analysis.

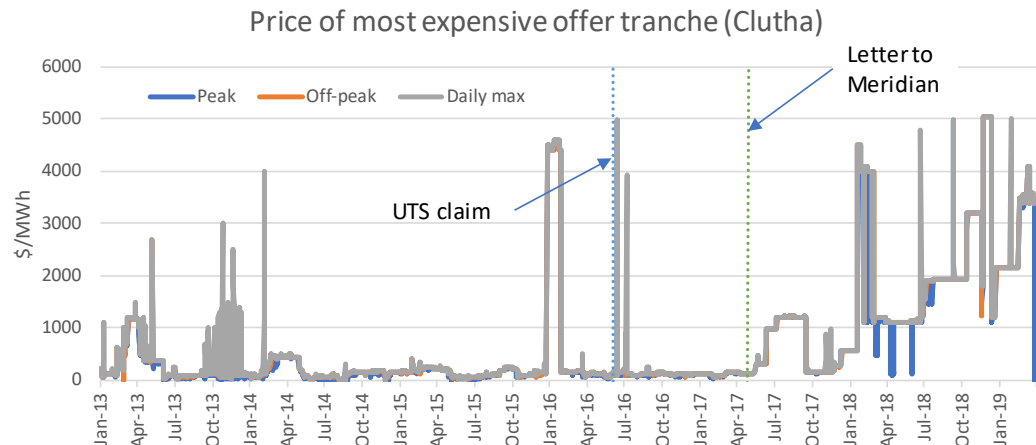
- This first section focusses on *inputs* to the system. These are things that generators have direct control over.
- The hypotheses for this section are:
 - that offers from South Island generators changed. Specifically:
 - that the price of the most expensive offer tranche increased.
 - that the price of the highest “X” MW of generation increased.
 - that the amount of generation offered at less than 1 \$/MWh increased.
 - that generators update their offers close to gate closure less often. This includes:
 - The last time of *any* update to offers.
 - Whether the total amount of generation under “X” \$/MWh was changed in the last 2 hours more often.

Offer prices – Maximum

- For the Waitaki, the highest tranche has normally been just over 5000 \$/MWh.
- There were more instances of a lower maximum price in 2013 and 2014.

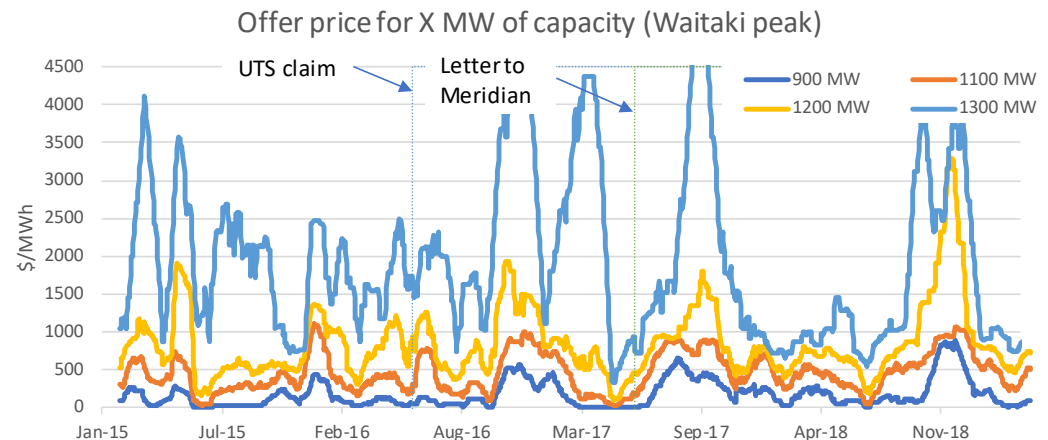
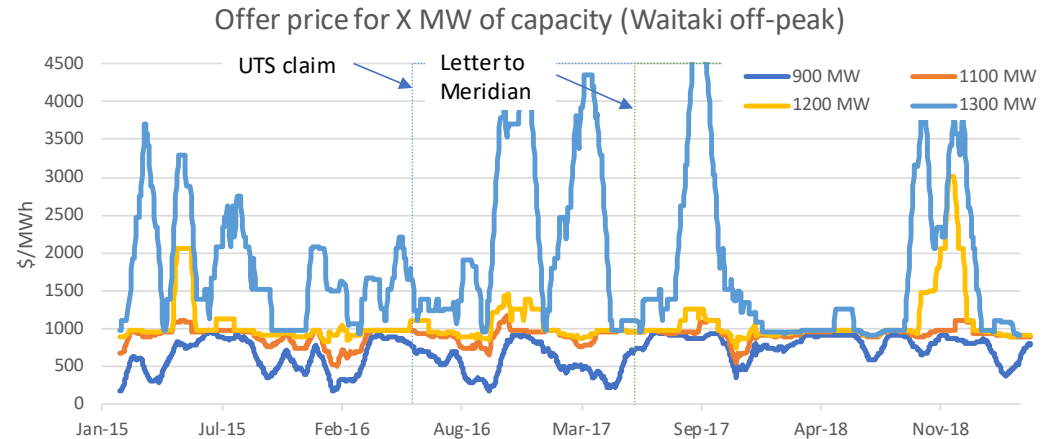


- For the Clutha, the price of the highest tranche has increased recently.

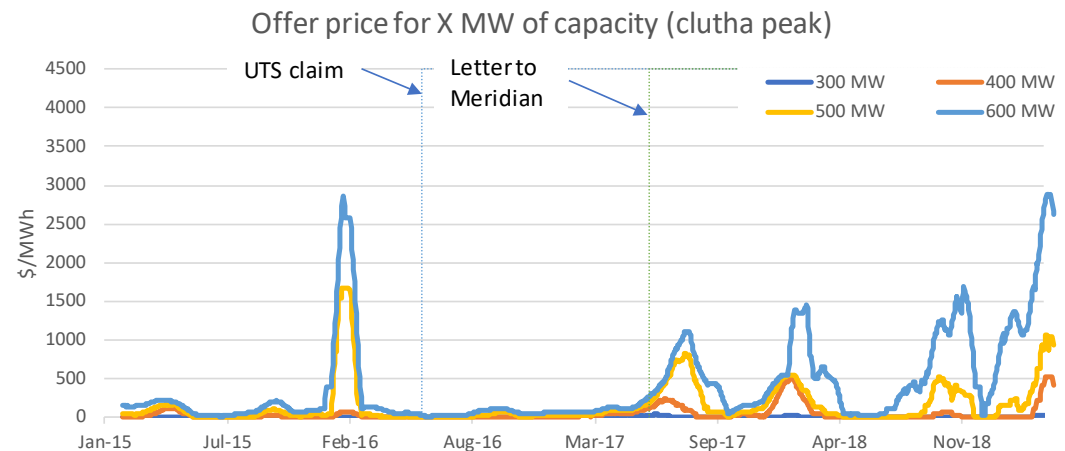
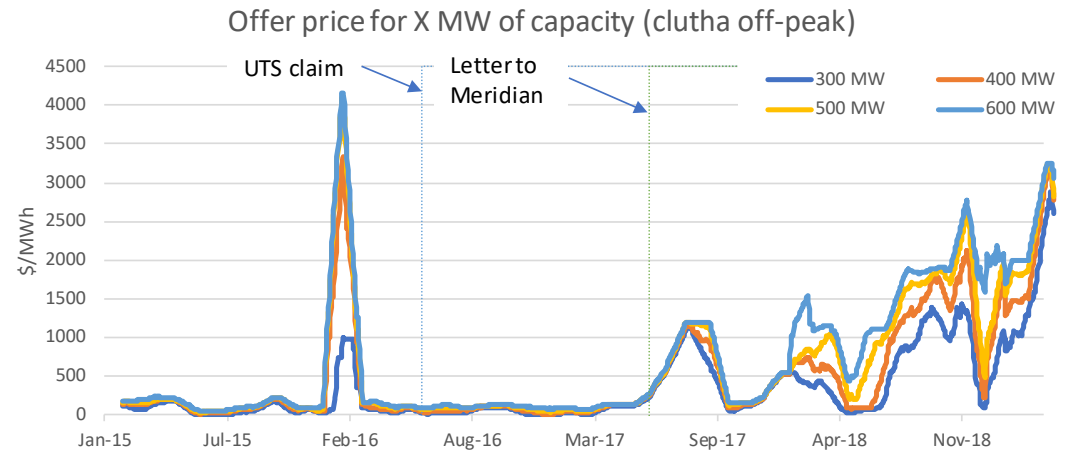


- As well as the absolute highest, we also looked at the price for “X” MW of capacity for each scheme.
- This is a useful way of visualizing the generator’s offer stack through time.
- These prices are much more variable than the price of the absolute highest tranche, so results are presented as a rolling monthly (30 day) average.
- Two graphs are shown: one for peak and one for off-peak.

- No major change in offers for the Waitaki during off-peak periods.
- 900MW quantity is priced slightly higher since mid 2017.
- Statistical test suggests time series is “different” from earlier period.
- No observable (or statistical) change for offers during peak periods.

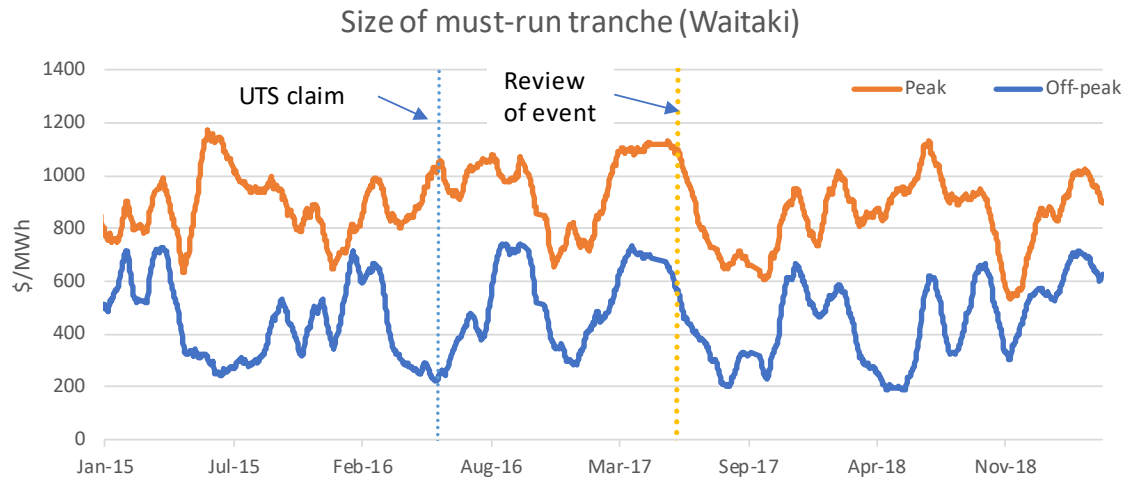


- Apart from a spike in early 2016, the price of high offers was consistently below 300 \$/MWh until mid 2017.
- Since then, offer prices have become more variable, with many periods above 1000 \$/MWh.
- This occurs both during peak and off-peak, although off-peak is more pronounced.
- (Bear in mind, these are rolling average prices).

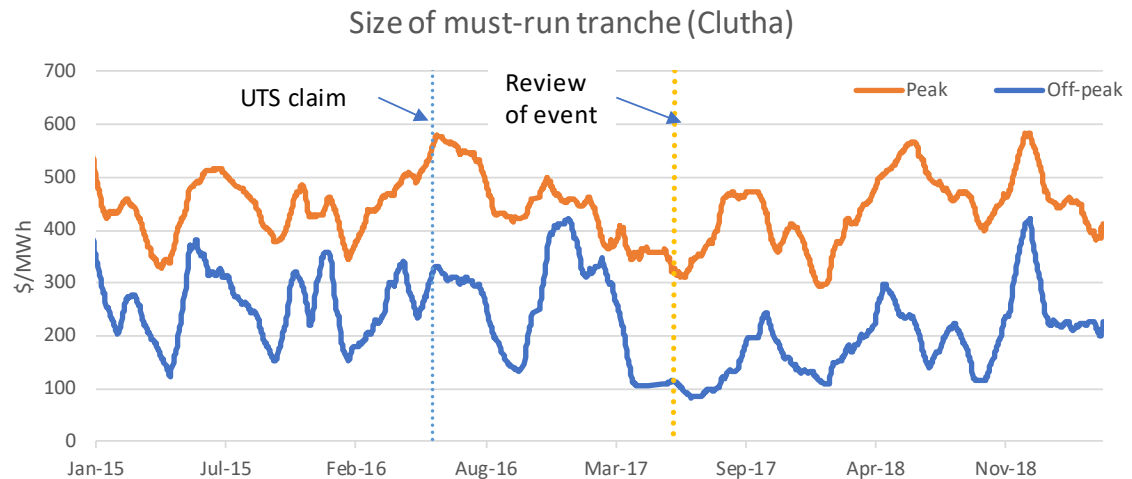


- This section investigates how much capacity a generator offers for less than 1 \$/MWh.
- At this price, it is highly likely that the generation will be dispatched, so this is often referred to as the “must run” tranche.
- This measure is highly dependent on water storage and tributary flows, so any changes may reflect hydrology, rather than a change in behaviour.

- No apparent change to Waitaki offers.

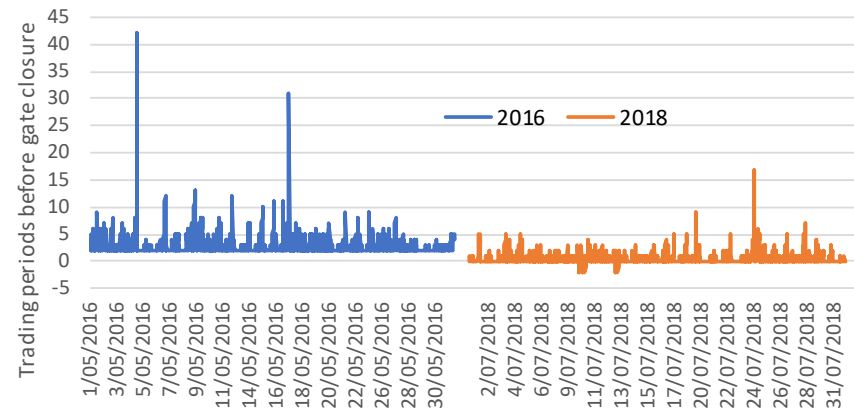


- For Clutha, the off-peak must run tranche appears slightly smaller in recent years – but this may be due to hydrology.

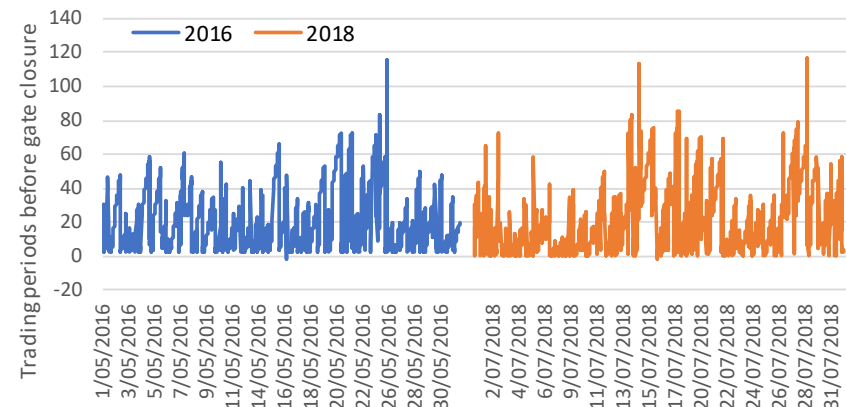


- We looked at how far ahead of gate closure generators revised their offers for each period.
- We compared two months – May 2016 and July 2018.
- The UTS and response to the UTS occurred between these two dates.
- Also between these two dates, gate closure was changed to be two trading periods later.
- There is no apparent difference between the two months.

Time of last revision of offers (Waitaki)

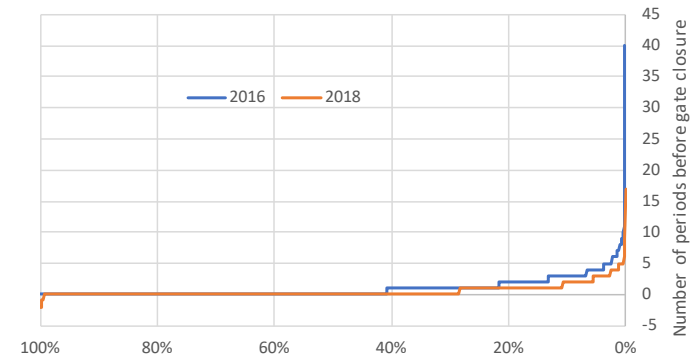


Time of last revision of offers (Clutha)

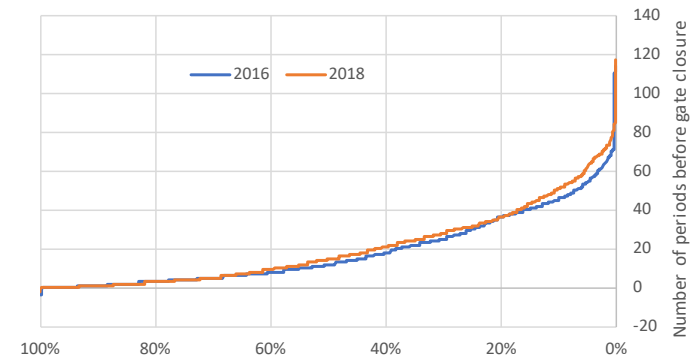


- To make any differences more obvious, we sorted the two previous graphs, and adjusted for changes to gate closure.
- There remains no apparent difference between the two months for either scheme.

Last revision (Waitaki)

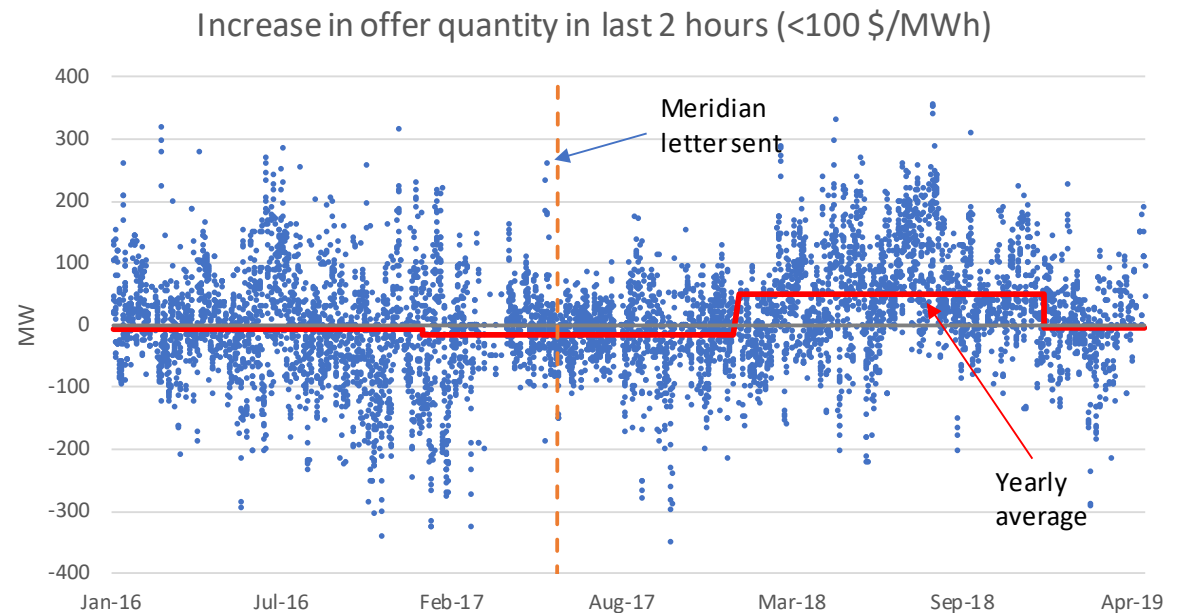


Last revision (Clutha)

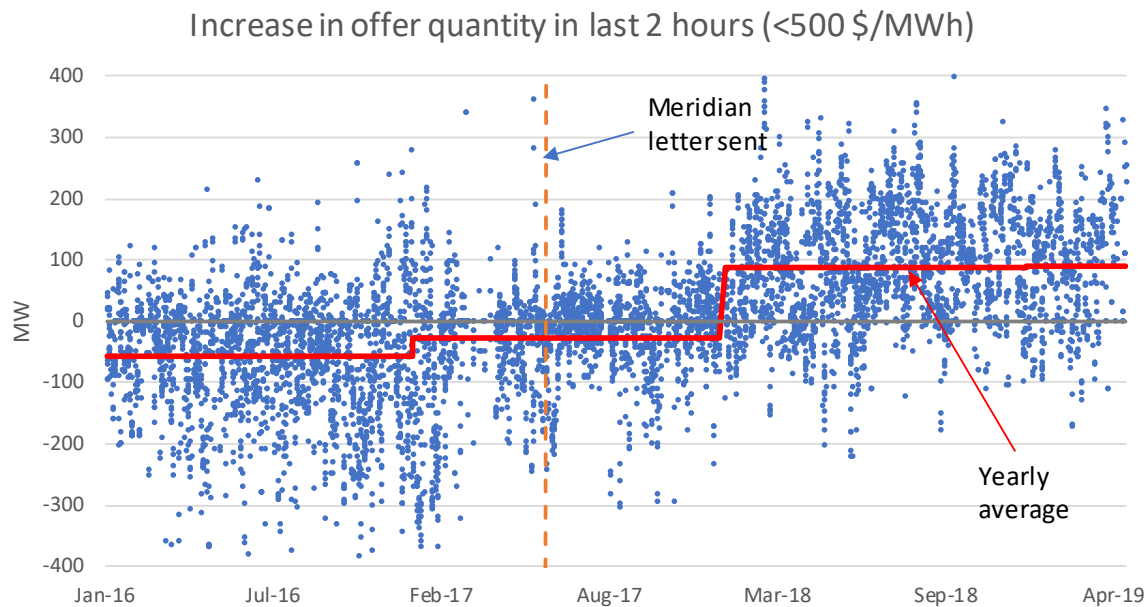


- To understand how generators revised their offers leading up to gate closure, we compared two values:
 - Total quantity of generation offered under “X” \$/MWh at gate closure, and
 - Total quantity of generation offered under “X” \$/MWh *2 hours prior to* gate closure.
- We looked at how the difference between these two numbers changed over recent years.
- A positive value indicates that a generator’s final offers provided more capacity to the market than their earlier offers.

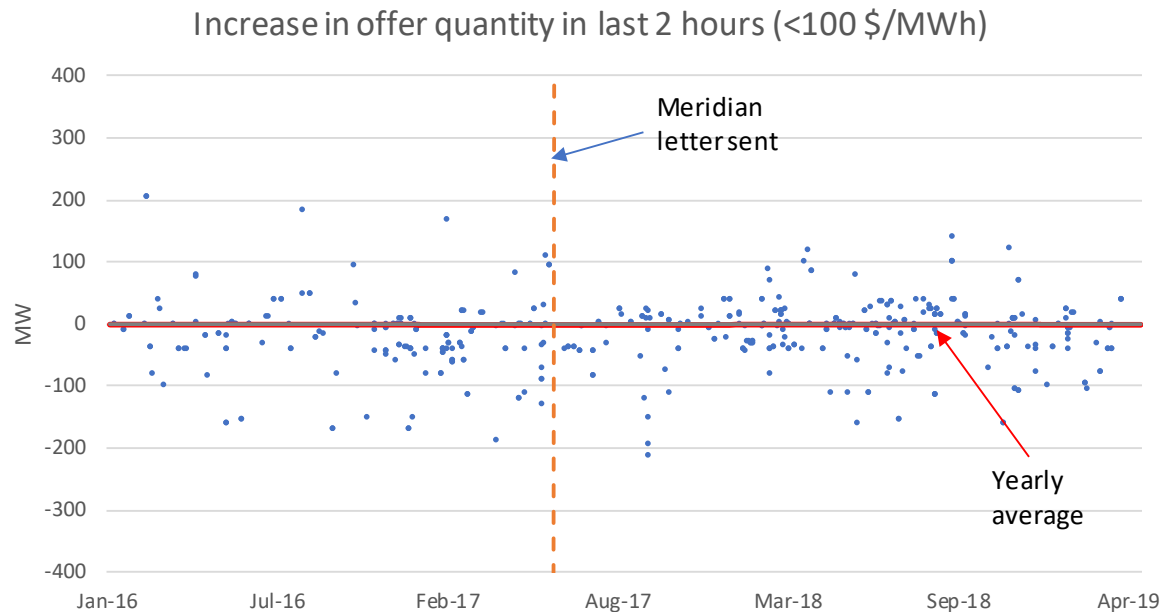
- Revisions to Waitaki offers under 100 \$/MWh changed in recent years.
- They were not significantly biased in either direction in 2016 and 2017.
- However, in 2018 quantity was increased close to gate closure:
 - About 50MW on average.
 - This trend was similar across all times of day.
- For the start of 2019, offers have reverted to earlier behaviour.



- Under 500 \$/MWh the change is similar, but more pronounced.
- In 2016, quantity was normally decreased close to gate closure.
 - A change of about -50 MW on average.
- In 2018 and 2019, quantity was normally increased close to gate closure.
 - A change of about 90 MW on average.



- Offers were revised in only 6% of periods.
- When offers were revised, capacity was reduced close to gate closure, on average.
- Offers under 500 \$/MWh were similar.
 - The reduction in capacity was less in recent years.



- We briefly looked at whether similar trends were apparent in other schemes.
- In general, other schemes have much less change to offers prior to gate closure, which means any impact of their behaviour is reduced.
- In particular:
 - Manapouri only revised offers in 5% of periods. When it did, changes followed the same trend as for the Waitaki scheme.
 - Huntly station only revised offers in 15% of periods. When it did, it tended to reduce quantity slightly (< 10 MW).
 - Waikato's behaviour differed for offers < 100 \$/MWh and < 500 \$/MWh:
 - Offers < 100 \$/MWh were revised for 55% of periods. It tends to reduce quantity slightly.
 - Offers < 500 \$/MWh were only revised in 30% of periods. There has been a gradual change to behaviour in recent years. In 2016, 30 MW of quantity was removed on average. In 2019, this was only 10 MW.
 - For reference, the Waitaki revised offers in 85% of periods.

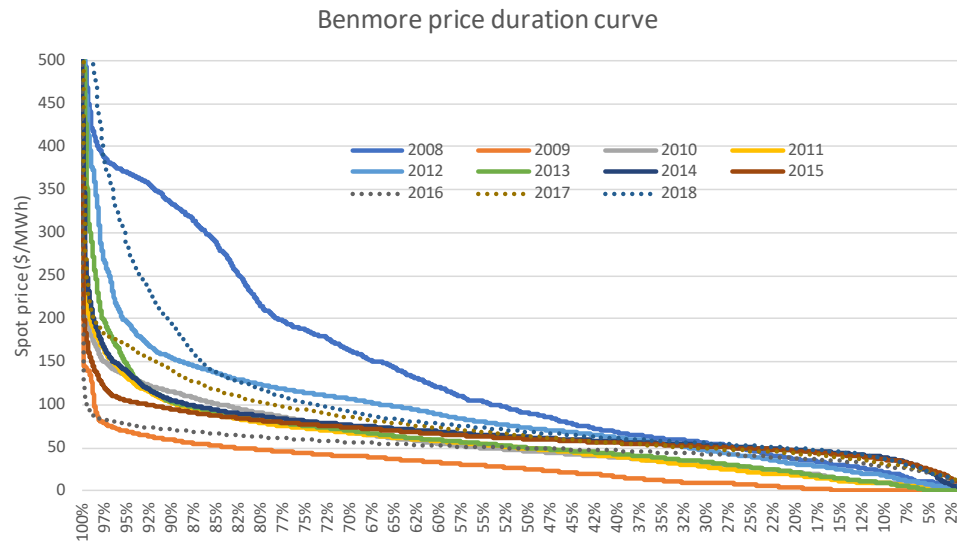
- That offer pricing strategy changed:
 - that the price of the most expensive offer tranche increased.
 - No evidence for Waitaki. Clear evidence of this for Clutha.
 - that the price of the highest “X” MW of generation increased.
 - Some evidence for Waitaki. Clear evidence for Clutha.
 - that the amount of generation offered at less than 1 \$/MWh increased.
 - No evidence for Waitaki. Minor evidence that this has *decreased* for Clutha.
- That generators update their offers close to gate closure less often:
 - The last time of *any* update to offers.
 - No evidence of any change.
 - Whether the total amount of generation under X \$/MWh was changed in the last 2 hours more often.
 - There is clear evidence that the Waitaki scheme has changed how they revise their offers close to gate closure.

- The hypotheses in this section focus on what happened in the electricity system. Participants do not have direct control over these outcomes, but can indirectly influence them with their behaviour.
- They include:
 - That the structure and level of spot prices changed.
 - That the relative price between the two islands changed.
 - That flow on the HVDC changed.

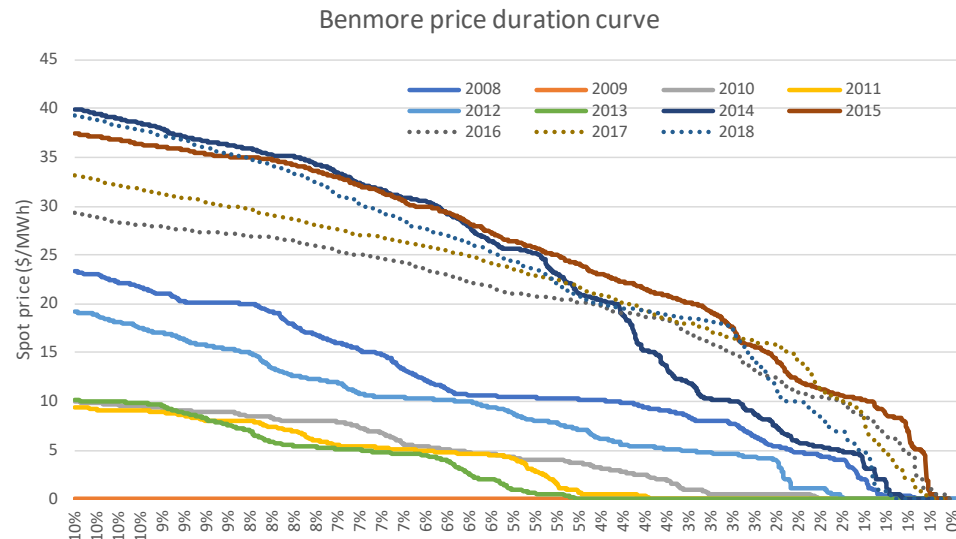
- We investigate many of the outcome hypotheses by using duration curves.
- Duration curves rank each trading period in a year from highest to lowest, and are a useful way of visualizing how a variable is distributed across many trading periods.
- There is one curve for each year.
- Sometimes only part of the duration curve is shown, allowing closer examination of relevant periods.
 - For example, to focus on the highest or lowest priced periods.

Duration curves – South Island spot price

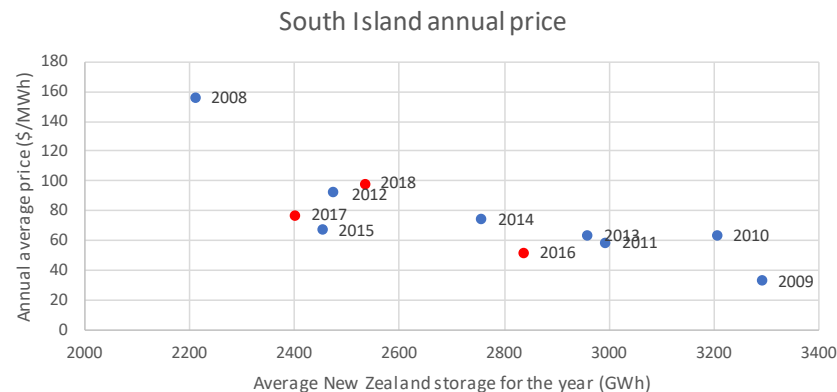
- No obvious change to structure of prices in recent years.
- More recent years dashed.



- This is just the bottom 10% of the previous duration curve, focussing on low priced periods.
- There *is* a clear trend over time.
 - More recent years have very low prices less often.
- May just be due to increased HVDC capacity since 2013.



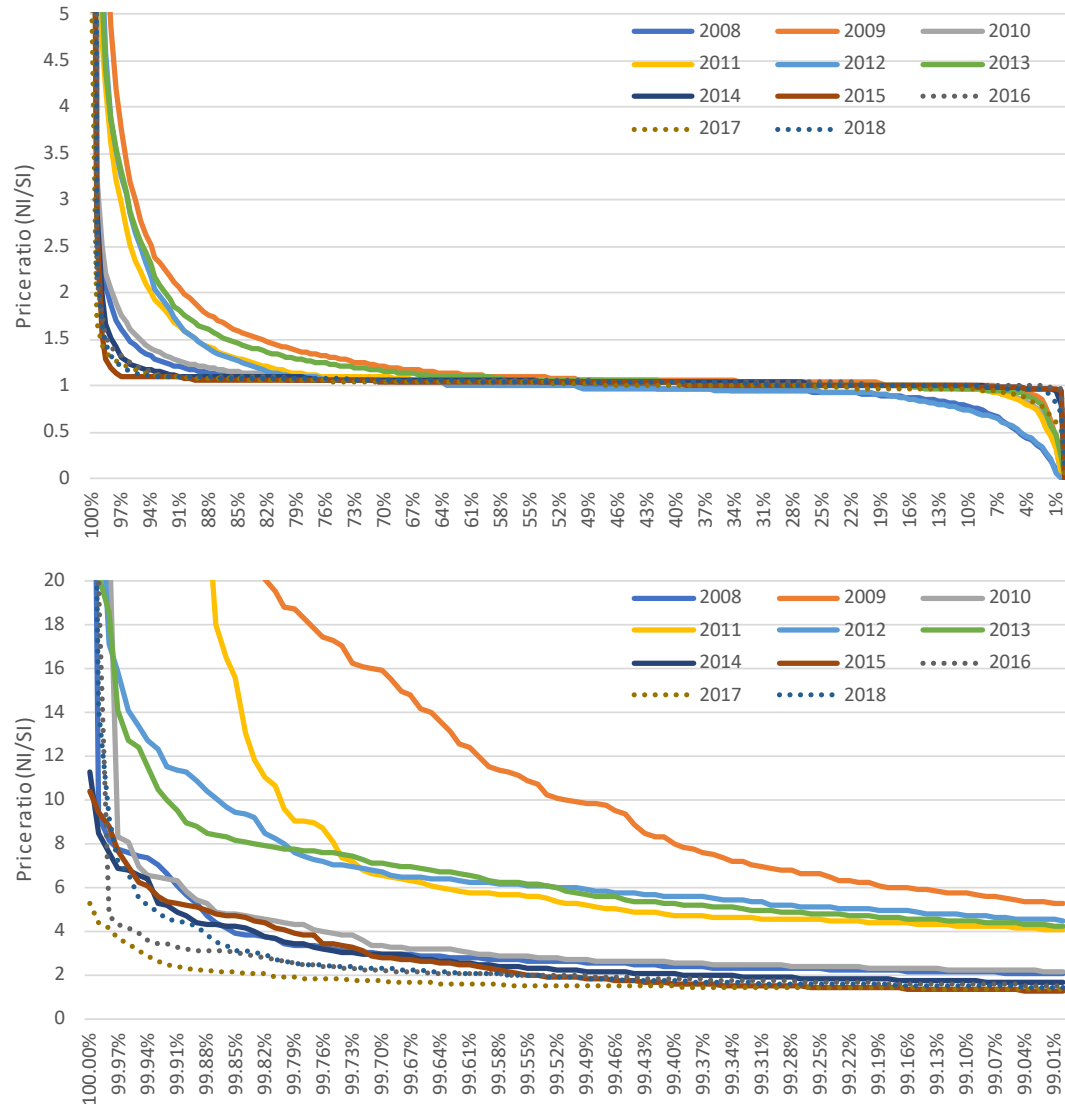
- The duration curves above show that South Island spot prices vary greatly over time.
- One key driver of South Island spot price is the amount of stored water, and there is a clear relationship between average stored energy and average spot price.
- After adjusting for stored energy, the level of prices in recent years appears consistent with earlier years.



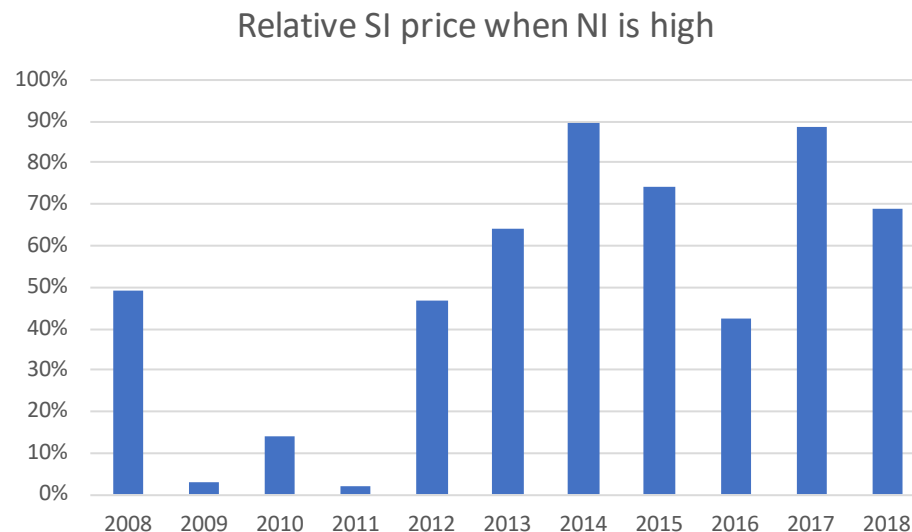
Duration curves – Price separation

- Price separation is much less likely to occur in recent years.
 - Particularly at the very top of the curve.
- May be influenced by increased HVDC capacity.
- Excludes periods with price < 10 \$/MWh in South Island.

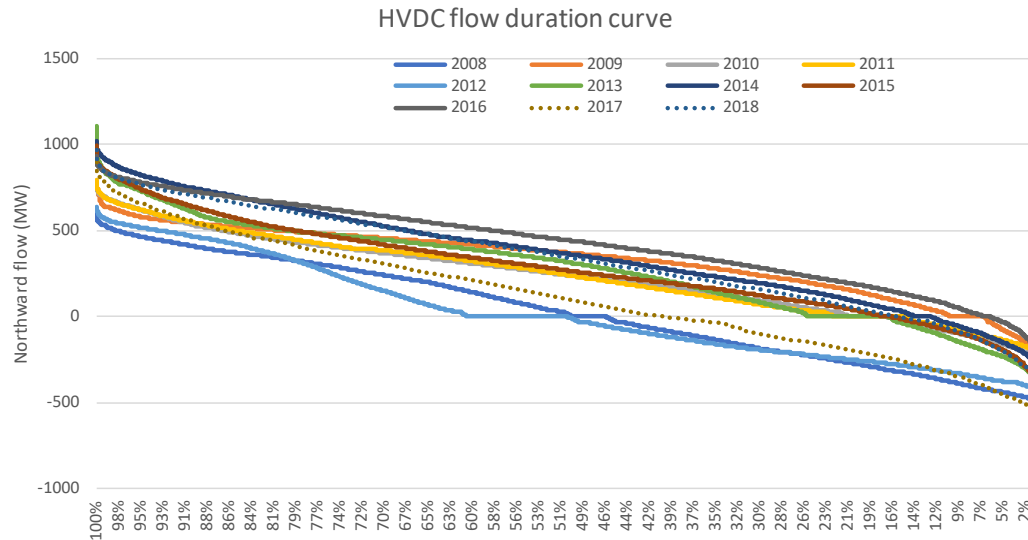
Price separation duration curve



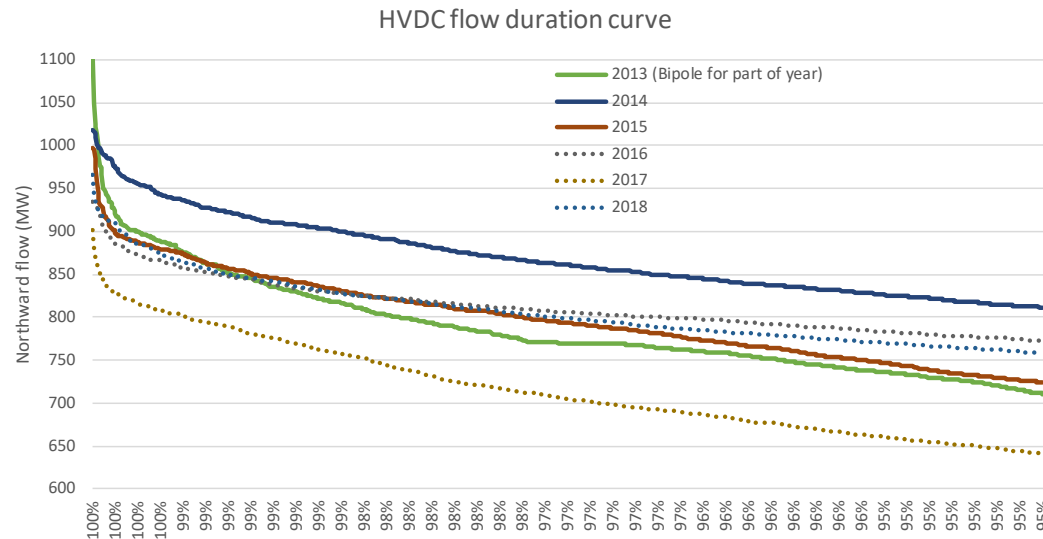
- Another way to consider price separation is by looking at prices in the two islands when prices in the North Island are high.
- This graph shows the relative price for the top 20 NI periods in each year.
- In recent years, the price in the South Island is also high during these periods, whereas in earlier years, the price was often not.



- Highly dependent on hydrology.
- No clear trends present.



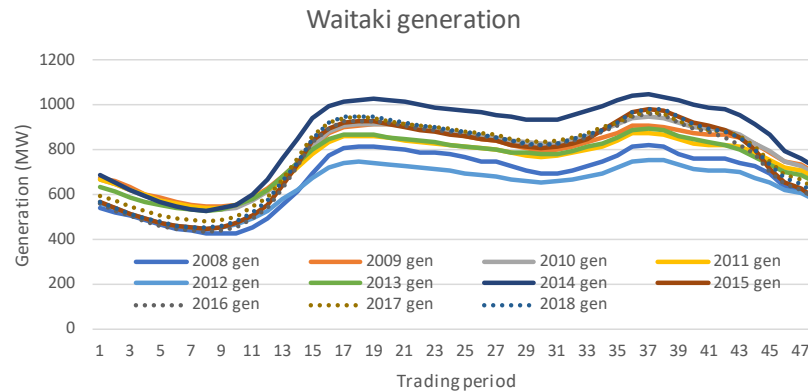
- Just focussing on the very top of the duration curve, and ignoring years with just a single pole (earlier years are all lower).
- More recent years have lower peak flow.



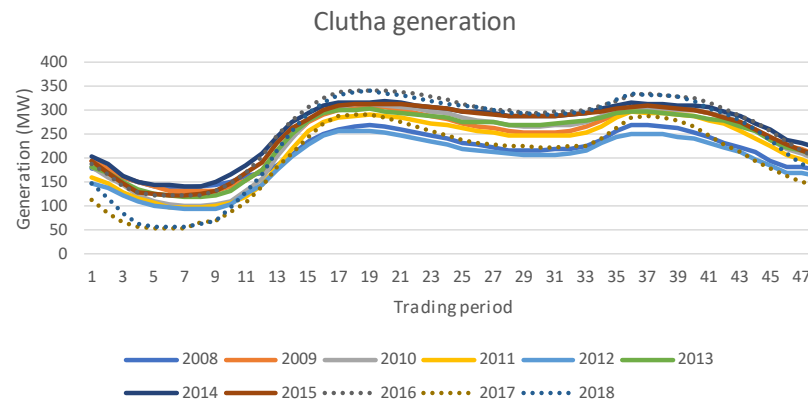
- That the structure and level of spot prices changed:
 - No evidence was found that average prices changed.
 - Clear evidence was found that very low prices occurred less often in recent years.
- That the relative price between the two islands changed:
 - Clear evidence was found that price separation occurs less since the HVDC bipole was installed in 2013.
- That flow on the HVDC changed:
 - No evidence was found that average flows have changed in recent years.
 - Some evidence was found that very high South to North transfers occur less frequently in recent years.

- These hypotheses in this section focus on outcomes to generators in the South Island.
- These include:
 - That a generator's daily generation profile has changed. (Note that changes to total generation are not investigated, because this depends primarily on hydrology).
 - That the relationship between generation and price received for that generation has changed.

- Waitaki generation follows the familiar diurnal shape with a morning and evening peak.
- The shape has not changed significantly from year to year.
- The level of generation changes year to year depending on hydrology.

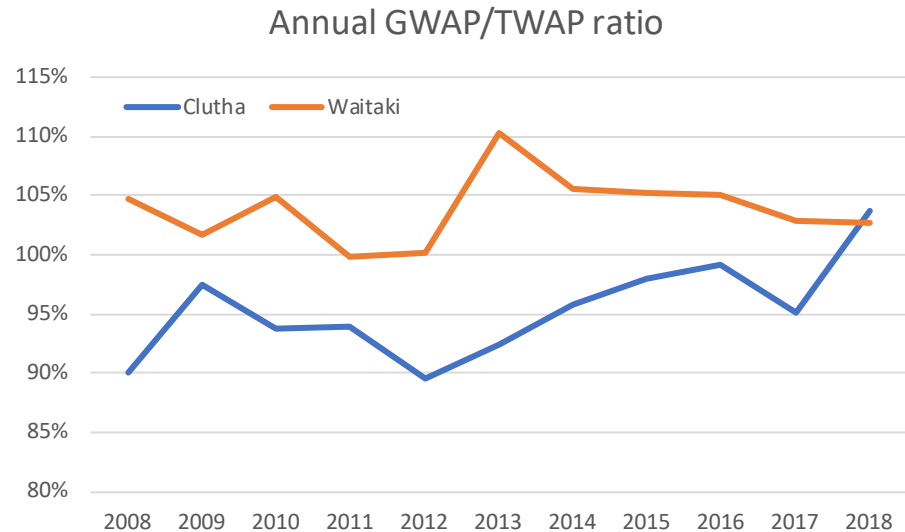


- Clutha generation follows a similar shape to Waitaki.
- However, generation during off-peak periods has dropped noticeably in the past two years.
 - Similarly, peak generation has increased during this time period.
- May be influenced by HAMI/SIMI changes in late 2015.
- The level of generation changes year to year depending on hydrology.



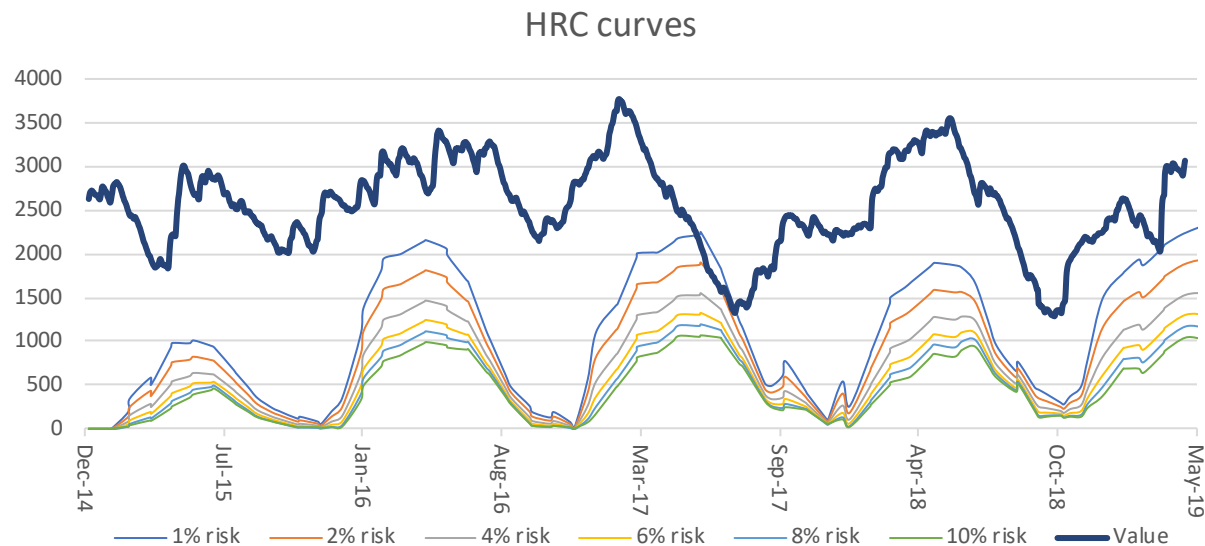
- Generators will make more money by generating when the spot price is high. Unfortunately for hydro generators, high spot prices often occur during dry periods when generators can't generate much.
- One way to assess a generator's ability to generate during high prices is comparing the “generation weighted average price” (GWAP) to the “time weighted average price” (TWAP).
- A generator that is able to generate more when the price is high will have a higher GWAP than TWAP.

- The Waitaki is normally able to achieve a GWAP/TWAP ratio of greater than 1, and this hasn't changed in recent years.
- On the other hand, the Clutha normally can't.
 - However, Clutha had a GWAP/TWAP ratio of greater than 1 in 2018.
 - A single point – not a clear trend.
- The difference between the schemes mostly reflects their different storage capacities.



- That generators' daily generation profile has changed:
 - Some evidence was found that generation on the Clutha has dropped during off-peak periods, and increased during peak periods.
 - No evidence was found that Waitaki generation profile changed.
- That the relationship between generation and price received for that generation has changed:
 - No evidence was found for this for either scheme.

- Hydrology can have a large impact on much of this analysis.
- National storage for recent years is shown for reference.



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