Hindcasting

A look in the rearview mirror

Angus Watson
Energy Research Analyst
Meridian Energy

September 2017

Disclaimer

This information in this presentation has been prepared by Meridian Energy Limited ("Meridian") to provide a general overview of Meridian and the New Zealand electricity industry. It has been prepared solely for informational purposes and does not purport to be complete or comprehensive and does not constitute financial produce, investment, tax or other advice. Past performance information provided in this presentation may not be a reliable indication of future performance.

This presentation contains certain forward-looking statements with respect to the financial condition, results of operations and business of Meridian. All such forward-looking statements involve known and unknown risks, significant uncertainties, assumptions, contingencies, and other factors, many of which are outside the control of Meridian, which may cause the actual results or performance of Meridian to be materially different from any future results or performance expressed or implied by such forward-looking statements. There can be no assurance that actual outcomes will not differ materially from the forward-looking statements.

This presentation is not and should not be construed as an offer to sell or a solicitation of an offer to buy Meridian securities and may not be relied upon in connection with any purchase of Meridian securities. In particular, this presentation does not constitute an offer to sell, or a solicitation of an offer to buy, any securities in the United States. Meridian's securities have not been, and will not be, registered under the U.S. Securities Act of 1933 (the "Securities Act") or the securities laws of any state or other jurisdiction of the United States and may not be offered or sold in the United States without registration except in a transaction exempt from, or not subject to, the registration requirements of the Securities Act and any other applicable U.S. state securities laws.

All amounts are disclosed in New Zealand dollars (NZ$) unless otherwise indicated. Certain information in this presentation has been derived from a number of public sources including data released by the Government of New Zealand and the New Zealand Electricity Authority and public filings of other companies. None of Meridian (nor its officers, employees, agents or advisors) gives any warranty or representation (express or implied) of the accuracy, completeness or reliability of the information, and it takes no responsibility for it. The information has not been and will not be independently verified or audited.

Background

- The NZ electricity industry was subjected to an extended unsettled period through much of the 2000s followed by a more settled wholesale market period since the 2010 EIA

- At times outcomes and changes to the market have caused dissatisfaction with perceived market performance among a range of stakeholders

- Hence, Meridian seeks to regularly assess its analytical approach to wholesale market issues through a hindcast (HC) process

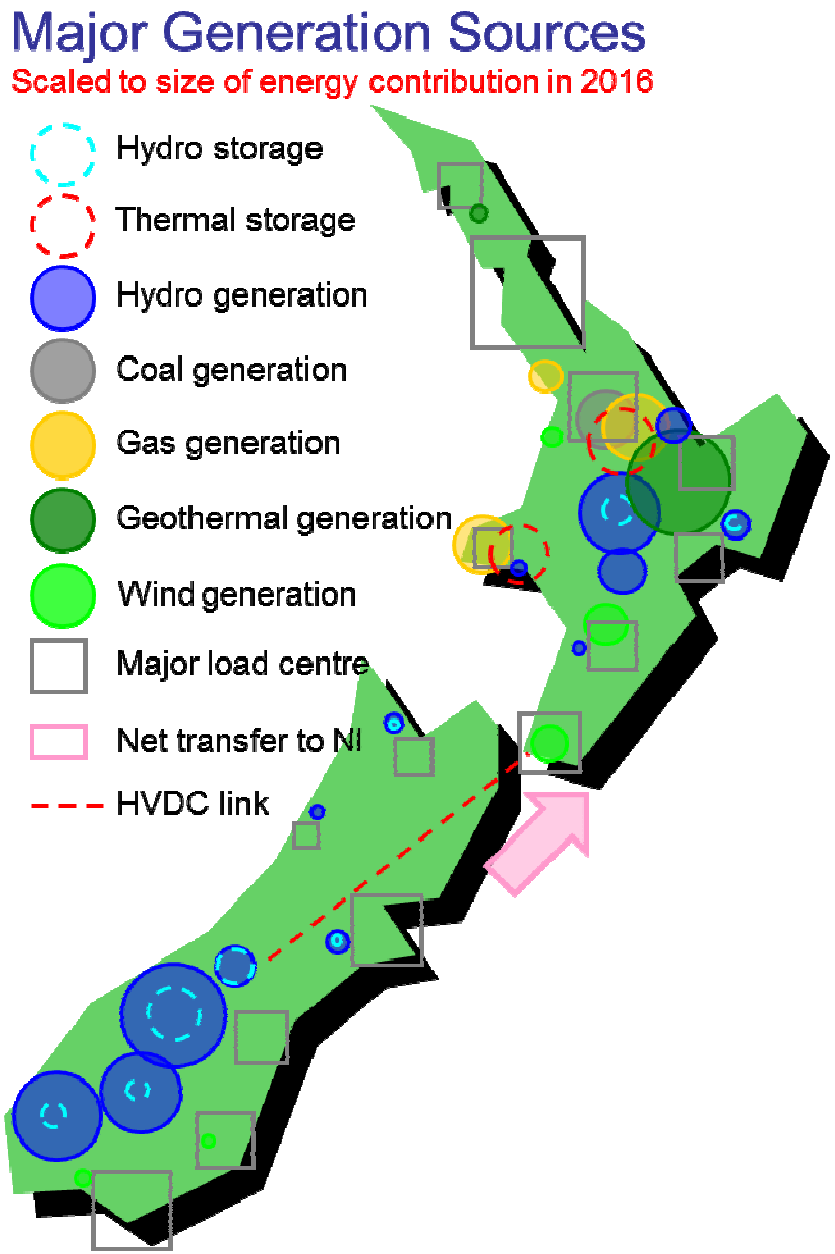
- For the HC process, we use our analytical models in the role of a proxy 'regulatory benchmark':
  1. Determine optimal outcomes given info available,
  2. compare to actual outcomes, hence
  3. determine missed opportunities.

- This allows us to analyse the validity of dissatisfaction from an NZ Inc perspective. Previous conclusions suggest that to-date, it has been unwarranted

- This HC analysis focusses on the calendar years <u>2014 to 2016</u>

The hindcast: The LPcon model

- The LPcon model seeks to balance the costs of excess thermal burn against the costs of excess system shortage for NZ:
  - In the face of uncertain hydro inflows it aims to minimise the overall NZ fuel (offer) supply cost.
- LPcon is a traditional power system model:
  1. A stochastic reservoir optimisation (ie an option valuation of water in storage)
  2. A power system simulation using results from #1
- Some features of the model include:
  - Regional (& nodal) transmission, losses, constraints, sources of generation, and demand
  - Dynamic system risks (CE and ECE) and instantaneous reserves
  - Hydro scheme flexibility and full historic inflow volatility (over 1932-2016)
  - Monte Carlo uncertainty for all system elements (outages, demand, capacity)
  - Within-week wind volatility



The hindcast: Reservoir guidance

- LPcon is a traditional power system model:

1. WORK BACK for water values (Opt)

   - The water valuation process is stochastic in nature:

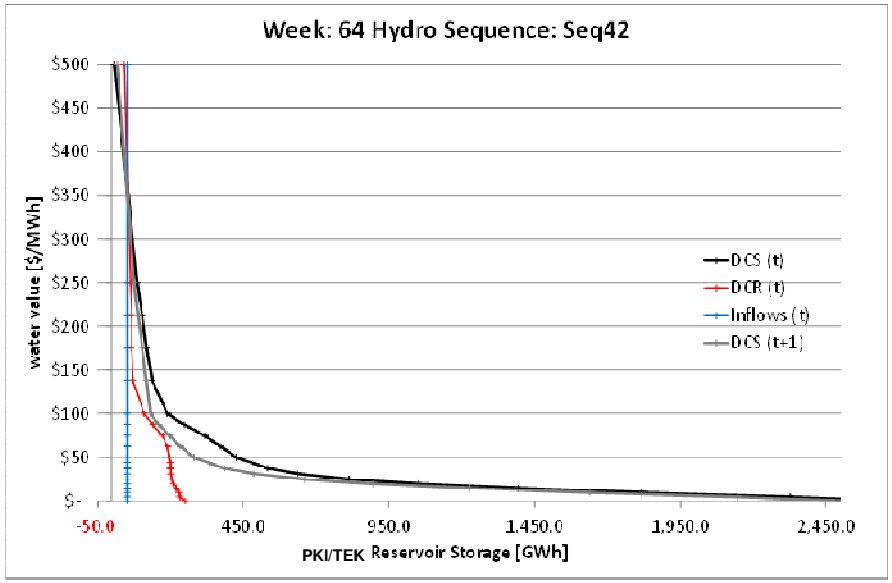
$$DCS(t) = DCS(t+1) - Inflows(t) + DCR(t)$$

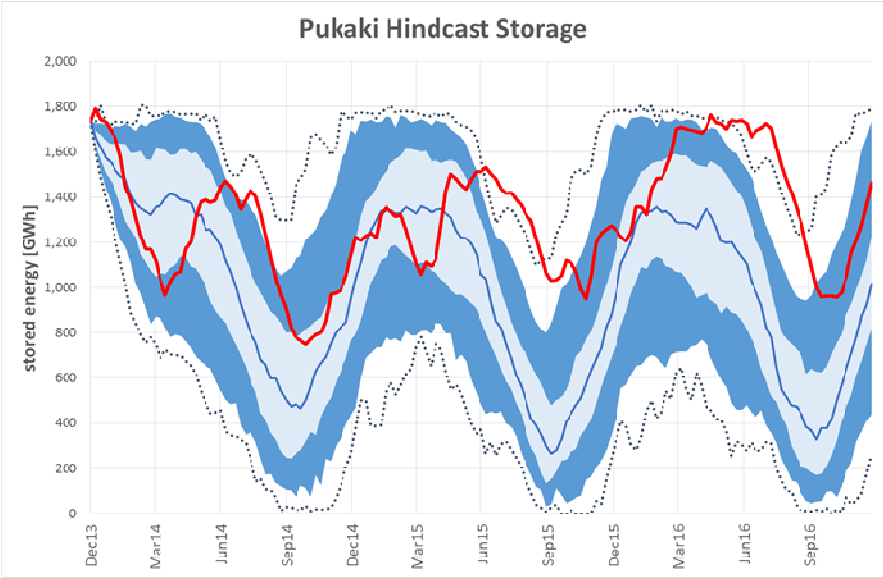
uncertainty

   - Averaging across all DCS/DCR curves for all static storage positions produces a *convolved* water value curve for week t.

2. WORK FORWARD for forecast (Sim)

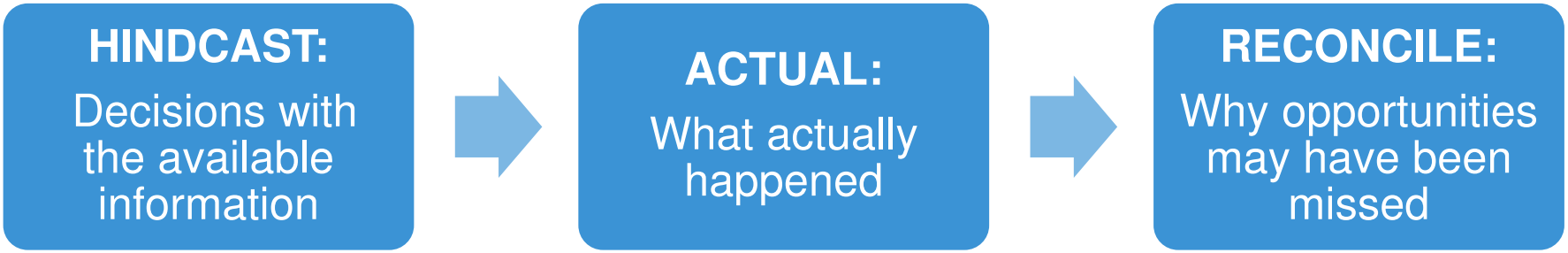
   - In reality all parties do not have the same data available to them





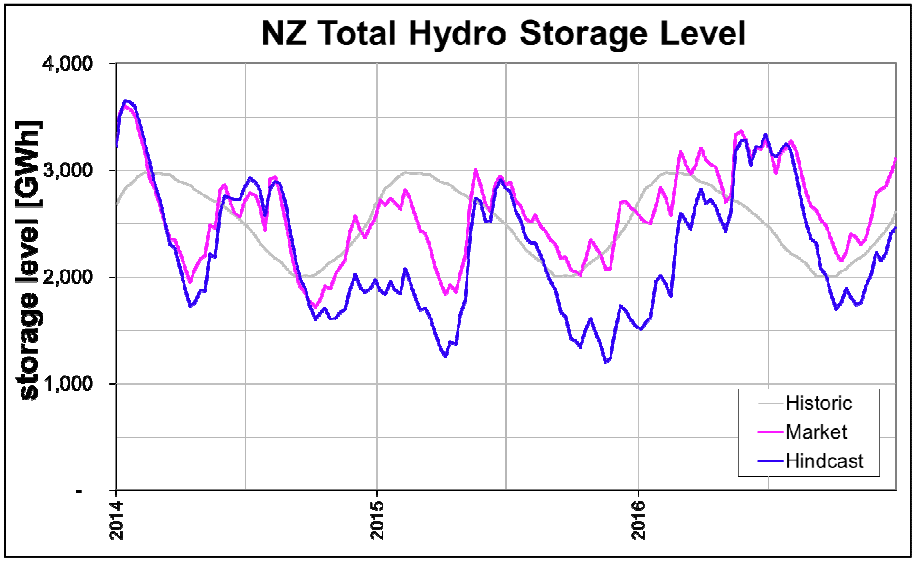
The hindcast: methodology

- For the hindcasting process the perspective of a risk-neutral EFFICIENT centralised planner
- To take this perspective, hence analyse the behaviour of the market players given only hydro inflow uncertainty, several "uncontrollable" factors are eliminated for the 2014-16 period:
  - Demand
  - HVDC + plant outages
  - Thermal offers
  - Beginning hydro storage levels
  - "Must-run" generation data including wind, geothermal, cogeneration

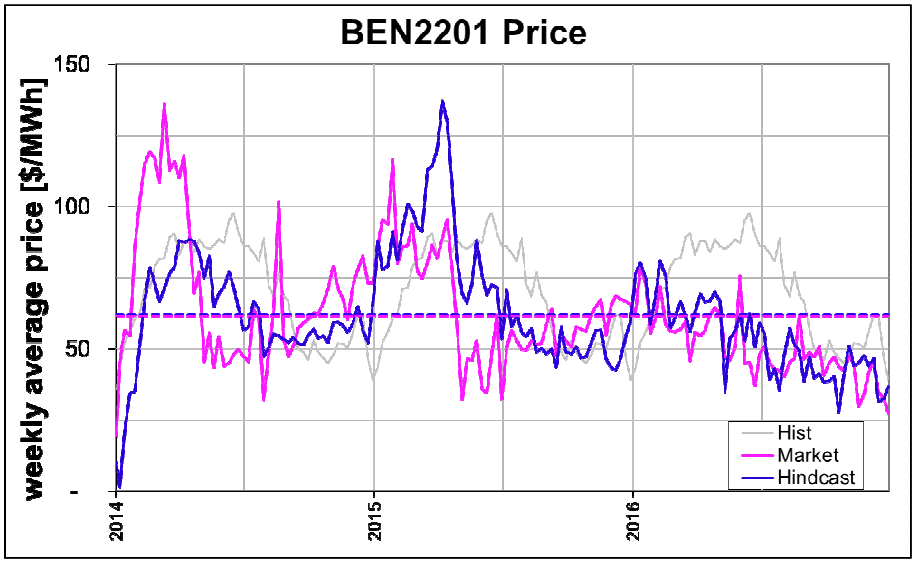


What actually happened

- In aggregate, the total NZ hydro storage position remains higher in the market than in the hindcast (HC) results:
  - The 'high' market levels suggest that lakes were kept higher than a risk neutral central planner would have kept them.
  - At first glance this storage result could suggest a form of risk aversion may be present in the market.



- HC price outcomes broadly reflect actual market outcomes:
  - Average price levels between HC and market are almost identical
  - But with a few short term blips



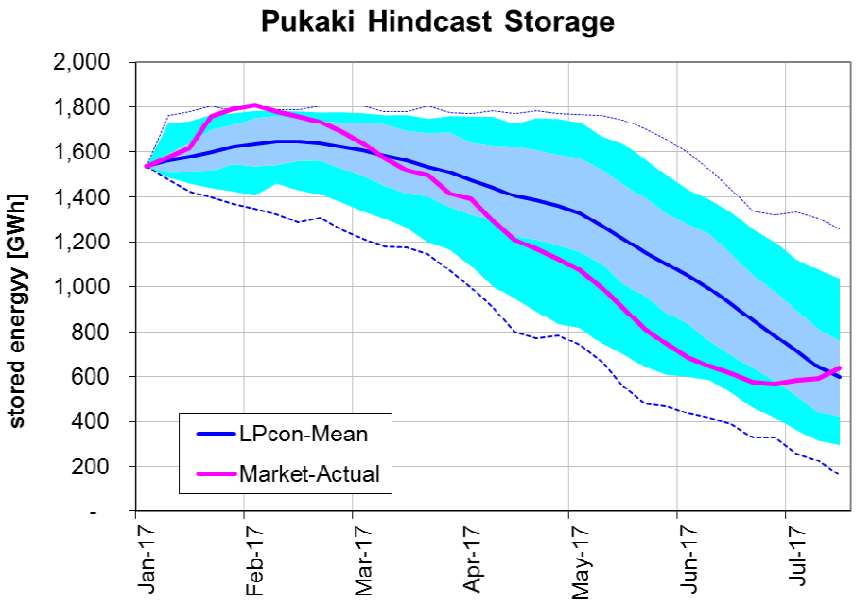
Possible factors causing “risk aversion”

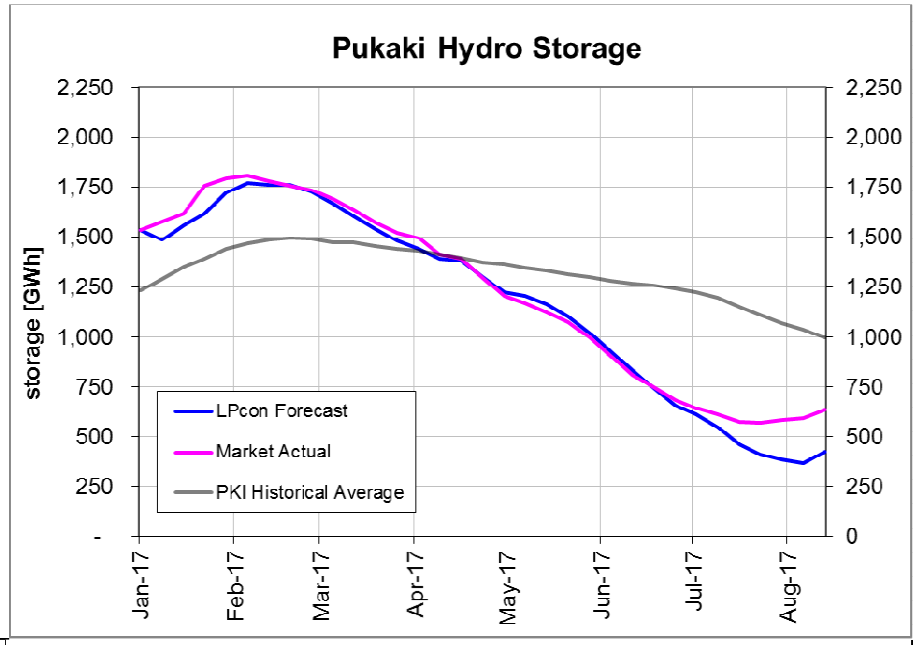
- We investigate whether the market’s ‘risk aversion’ is due to hindcast model assumptions through the use of 20+ sensitivities

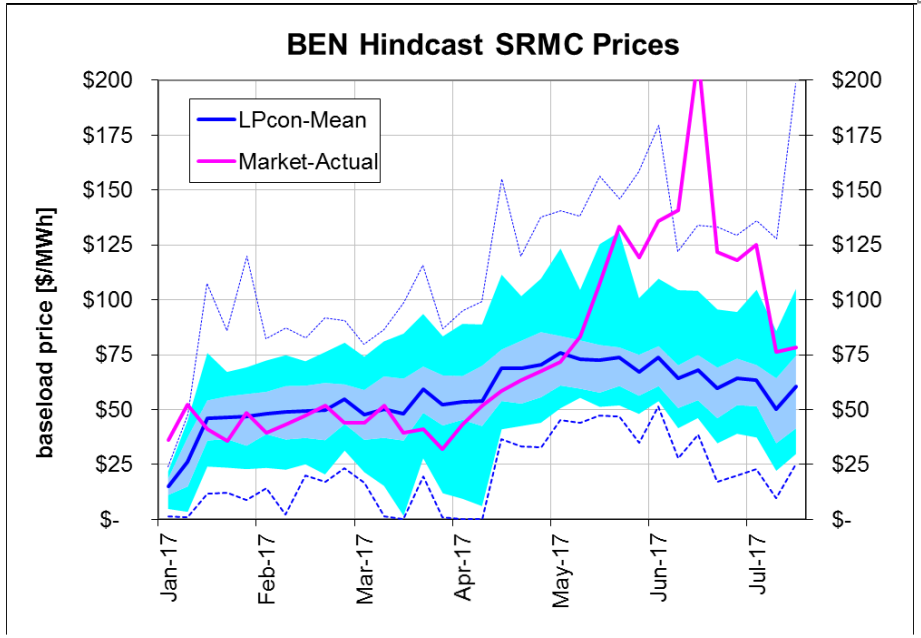
- Two types of changes to the storage result emerged:
  - Vertical shift sensitivities displayed a consistent vertical shift (less/more risk aversion) of the hindcast total storage curve, with respect to the HC base case, across all seasons.
    - *Nodal*
    - *N-S HVDC limits*
    - *All reservoirs*
    - *Tekapo volatility increase*
    - However the HC base case /market difference was not constant across seasons, hence ‘shift’ sensitivities had limited explanatory value
  - Shape change sensitivities, where the seasonal shape of the hindcast result was different to the HC base case:
    - *Portfolio dynamics*
    - *Reduced HVDC flow*
    - *Demand increasing*
    - *Discretionary storage available*

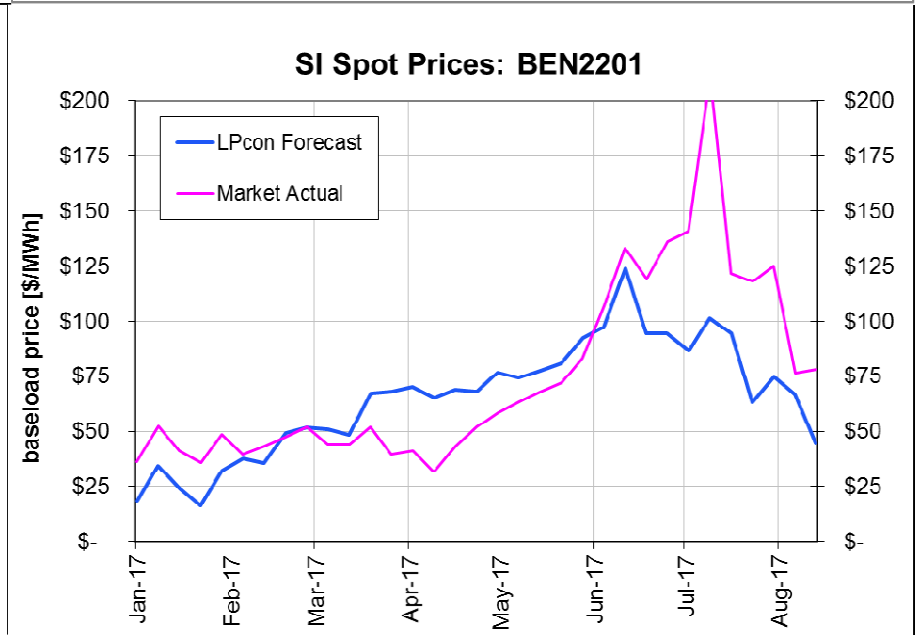
2017

Early 2017 was unremarkable in terms of the storage distribution; while prices have risen occasionally beyond the extremes of the forecast envelope









Concluding remarks

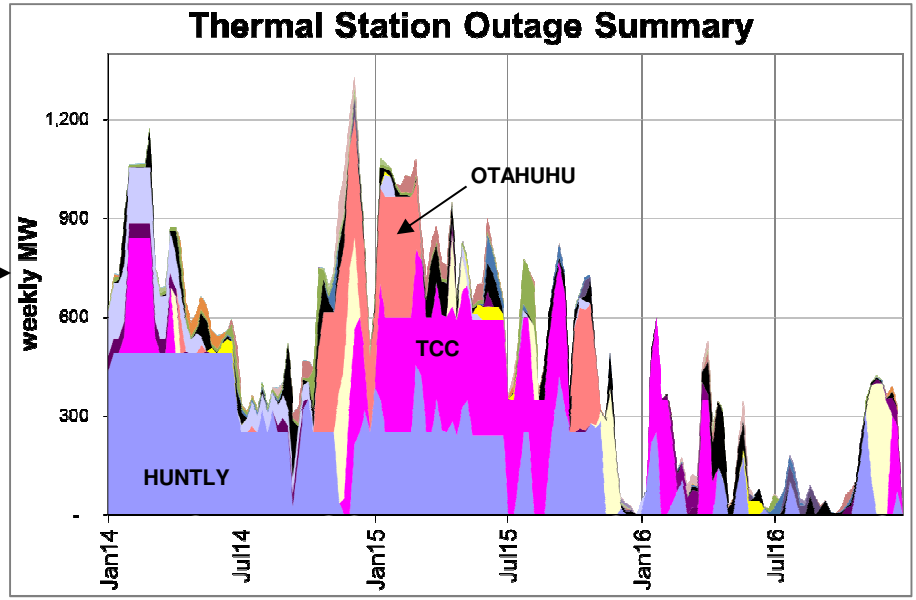
- Is there any evidence of lakes are being driven to low levels too often?
  - No…
- Is there any evidence of risk aversion in lake management?
  - Possibly….
- Is there any evidence of prices being held above efficient levels?
  - No …
  - But timeframes matter
    - <1% average difference over the three year period
    - But greater difference during certain periods
- Should we renationalise the major generators?
  - Ask NZ First

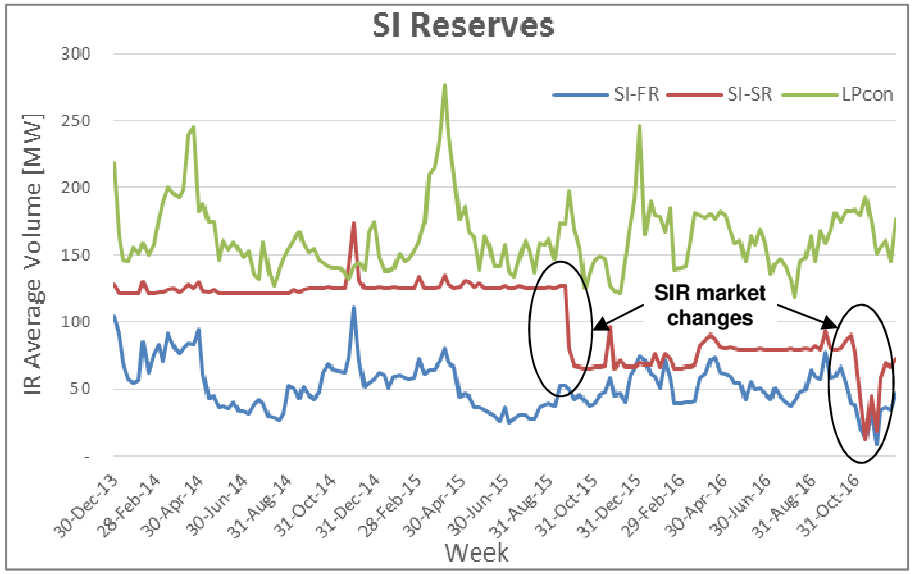
Appendix

Additional information

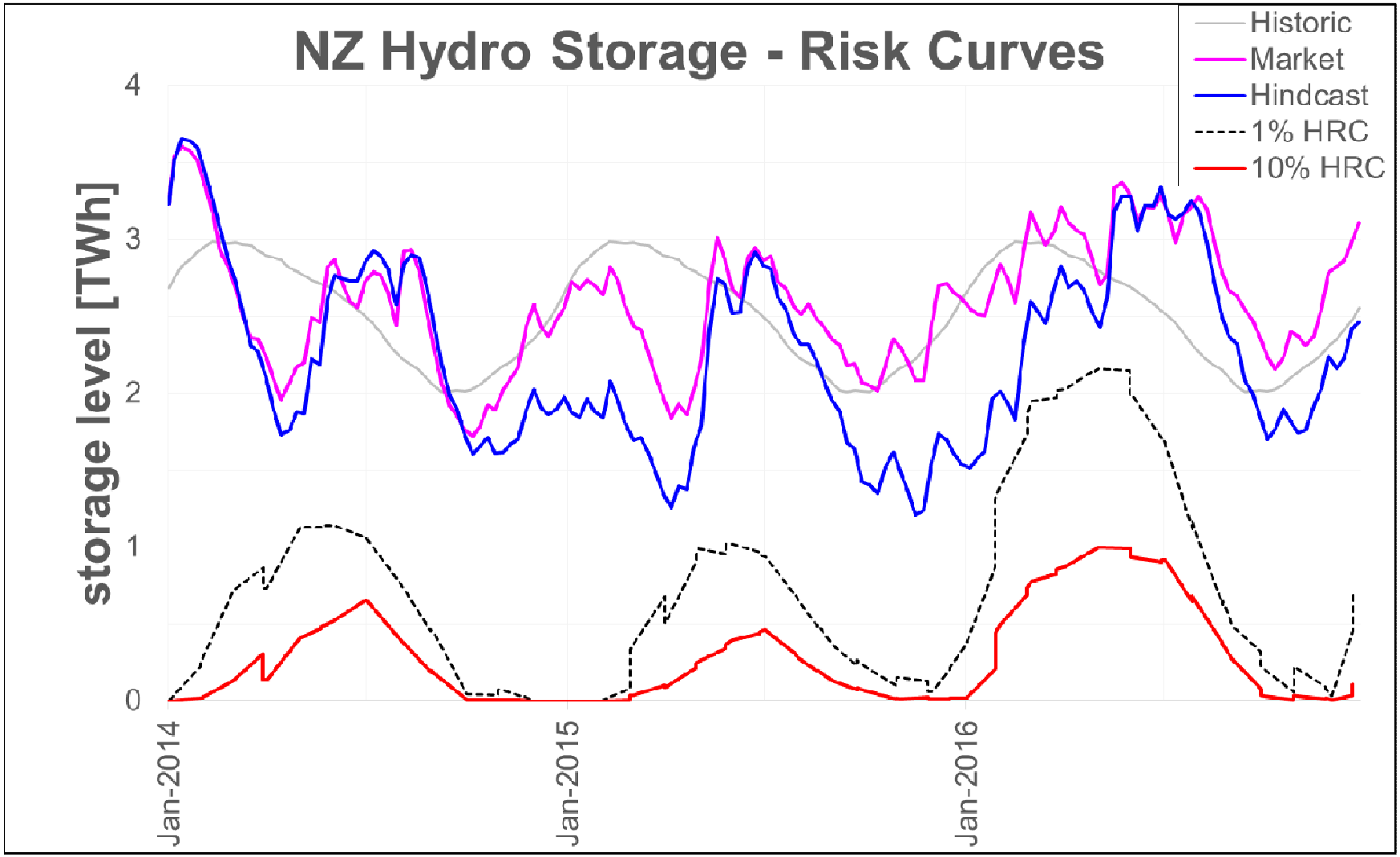
Key market events: 2014-16

- Commissioned generation
  - Mill Creek, 60MW, Oct-14
  - Flat Hill Wind Farm, 6.8MW, Oct-15
  - Solar (approx. 51 GWh)
- Major outages
- Decommissioned generation
  - Huntly Unit 3, 250MW, Jun-15, Genesis
  - Otahuhu B, 398 MW, Sep-15, Contact
  - Southdown, 170MW, Dec-15, Mercury
- Market setup
  - 60MW SIR sharing, Sep-15
  - 220MW SIR sharing (dynamic), Nov-16
- Controlled hydro storage remained well above hydro risk curves for the three year period





Another influence?



Data sources

- EA Electricity Market Information (EMI)
  - Reconciled demand
  - Reconciled generation
- System Operator
  - POCP plant outage data
  - Thermal offer trances inferred from market data
- NZX Hydro
  - Hydro storage and inflow data to complement the Meridian plant data
- MBIE
  - Solar generation