Optimisation methods for real-time trading

Sam Turner, Tony Downward and Brian Lee

Agenda for today

The Australian context

- Market fundamentals – the NEM versus NZEM.
- A bit of data to set the scene – what can the NEM tell us about spot trading?

Our portfolio is evolving and increasingly diverse

- Contact’s portfolio is changing and so is the market.

Real-time spot trading is a part of that transition

- BatMan – Battery Manager.
- HOWARD – Hydro Optimization With Advanced Real-time Dispatch.

Australian context

Our observations

The NEM versus NZEM

A far larger amount of intermittent renewable generation, but without the hydro back-bone of the New Zealand system and without the ‘dry-year’ risk. This included behind-the-meter solar. Significant spot market volatility, the presence of pumped hydro and a lot of grid-scale batteries coming online. A more extensive array of contingency and regulation ancillary services. The market design was in a state of flux, while the State Governments, as well as Federal Government, were playing an active role.

Generation mix

- Coal dominates – but retiring.
- Significant wind & solar.
- Significant behind-the-meter solar.

The grid and demand

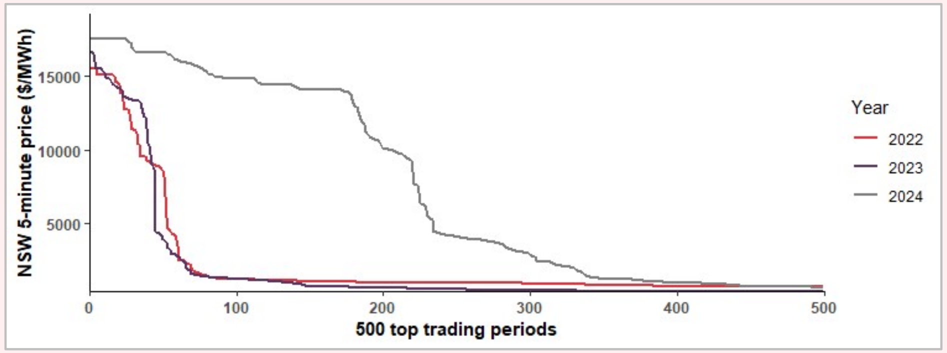
- 40,000 km of transmission.
- 10,000,000 customers.
- 54,000 MW capacity.
- 180,000 GWh annual demand (operational).

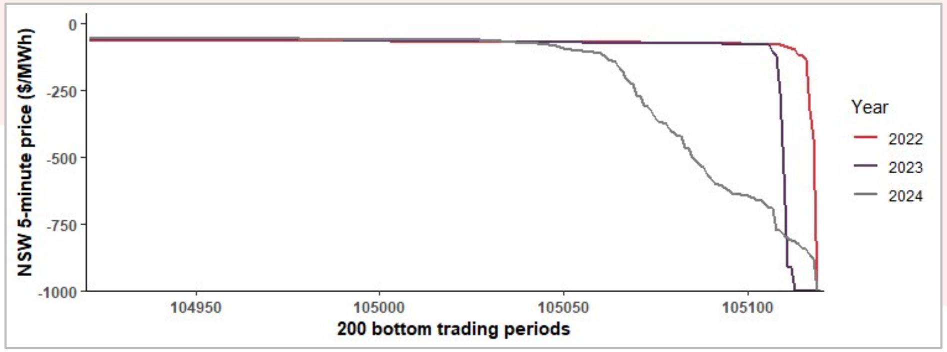
Market design

- Energy-only spot market.
- Settled every 5 minutes.
- Cap = $17,500/MWh.
- Floor = -$1,000/MWh.
- Price bands set day in advance (and volume managed)
- 10 frequency control ancillary services markets – co-optimised with energy.
- All energy bought & sold on spot market.
- Market participants use financial contracts to manage risks.

What can the NEM tell us about spot trading?

The Australian market for real time trading is a leading indicator for the NZEM. The Australian market has been through its first round of investment in real-time, spot trading. It has matured and participants are preparing for the next capital cycle.





Learnings for Trading & Technology

- The backdrop is a rapidly decarbonising power market that is increasingly volatile over short periods of time.
- At some point – the demand growth will outstrip the existing flexibility resources, e.g. peak capacity.
- Heuristics are giving way to methods of optimisation and more advanced methods of trading volatility.
- Our own scarcity pricing levels have been lifted materially to enable a clear price signal.

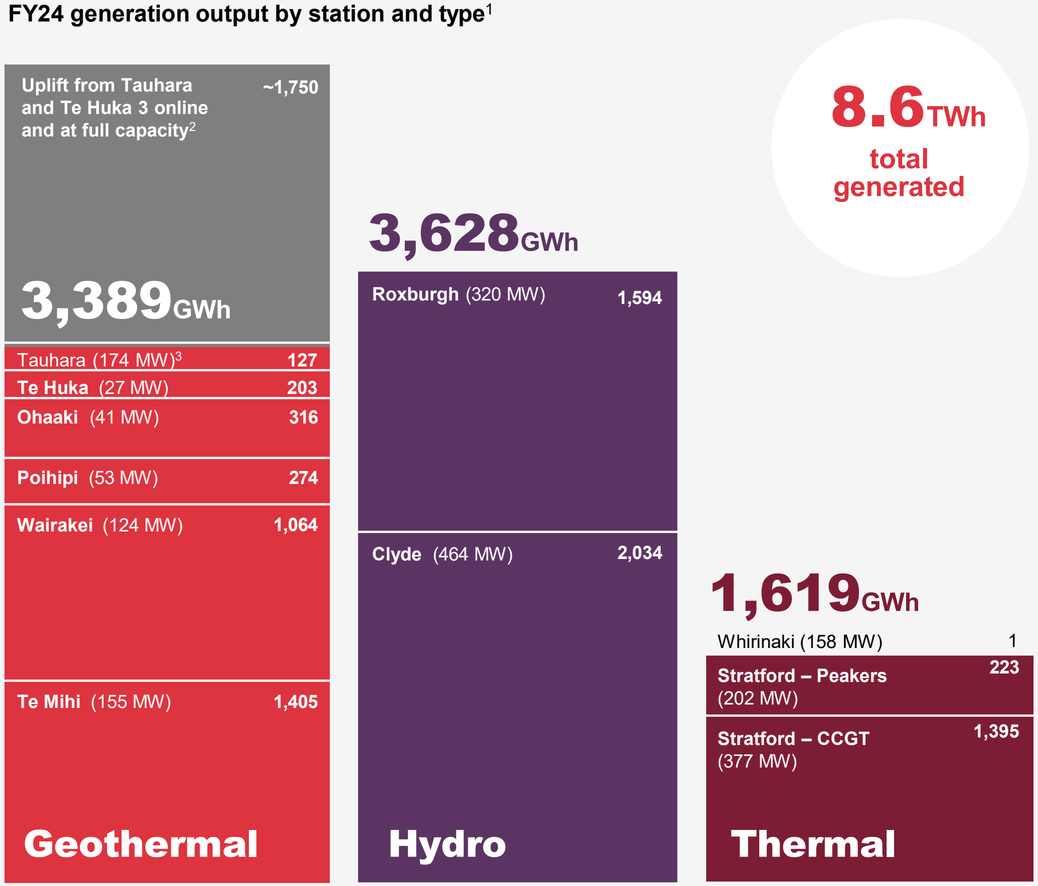
Product	Past prices ($/MWh)	New prices ($/MWh)
Energy	$10,000 – $20,000	$21,000 – $50,000
Reserve SIR	$3,000 – $4,000	$6,500
Reserve FIR	$3,500 – $4,500	$7,000
Controllable load	$9,000	$20,000

Contact's portfolio

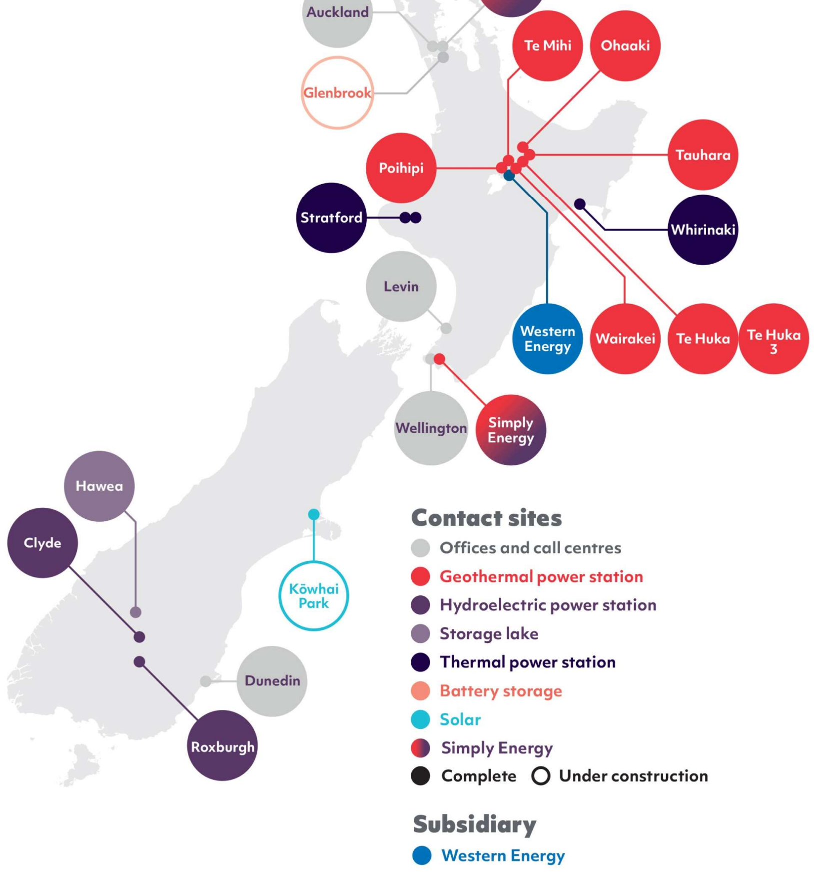
Our changing portfolio

Contact has a diversified and resilient portfolio of generation assets

FY24 generation output by station and type[1]



Where we are



[1] Numbers shown are net capacity.
[2] Based on capacity of 174 MW and 51 MW for Tauhara and Te Huka 3 and 95% capacity factors. Less FY24 Tauhara generation.
[3] First steam May 2024. 127GWh produced FY24.

Renewable builds: Online and underway

Projects Online in the last 12 months

Tauhara

~200,000 *Equivalent homes powered*

May 2024 *Online date*	**$924m[1]** *Total Investment*
174MW *Installed Capacity*	**1,450GWh** *Estimated Annual Output*

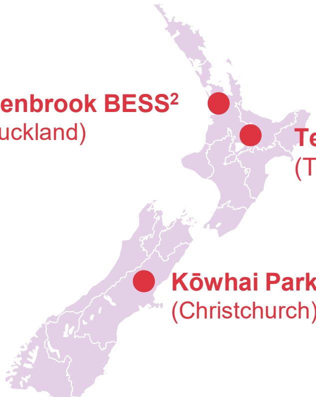
Te Huka 3

~60,000 *Equivalent homes powered*

Dec 2024 *Online date*	**$300m[1]** *Total Investment*
51MW *Installed Capacity*	**430GWh** *Estimated Annual Output*

[1]Total under current approvals.

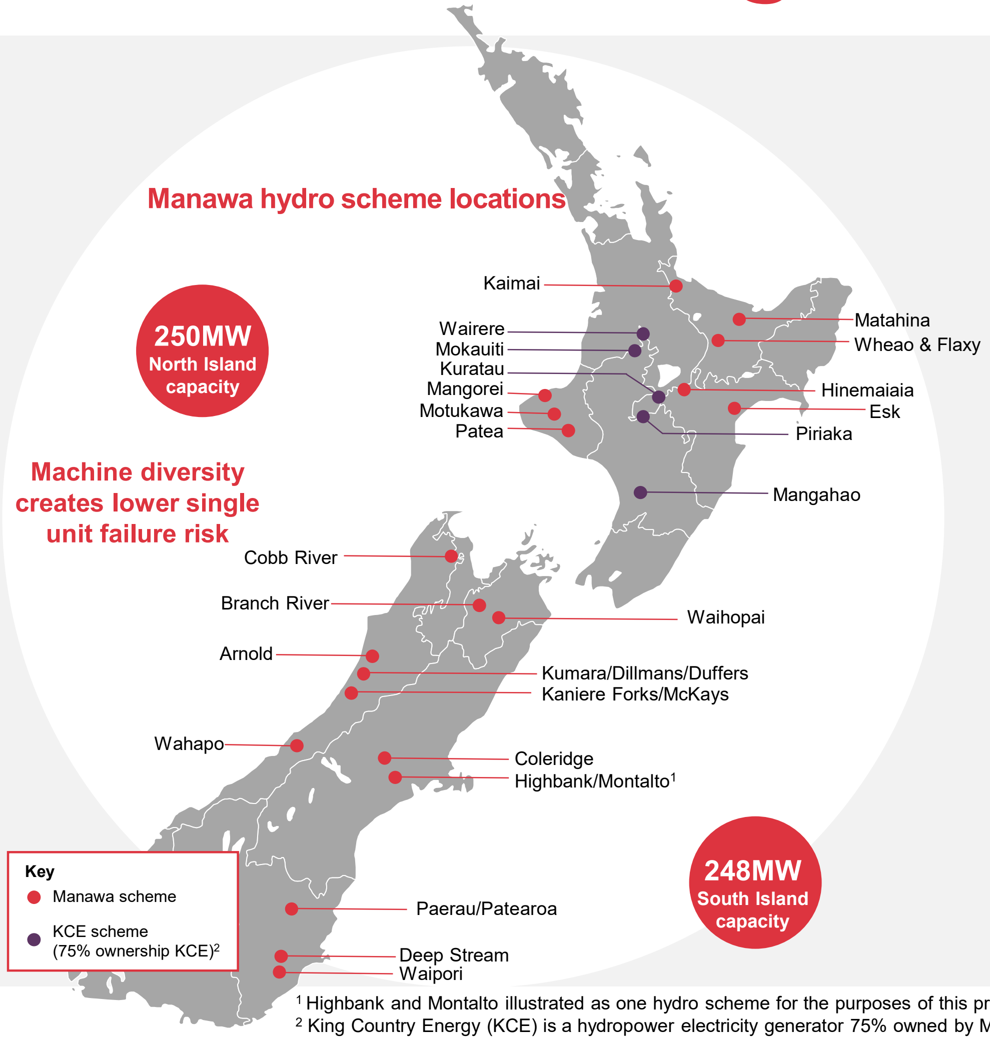
Projects Under Construction



Announcement Date	1 July 2024	16 Aug 2024	13 Nov 2024
	 **Glenbrook BESS[2]**	 **Kōwhai Park Solar**	 **Te Mihi Stage 2 Geothermal**
Installed capacity / Estimated annual output	100MW	168MWp | 275GWh	101MW | 830GWh
Expected online date	On track Q1 CY2026	On track Q2 CY2026	On track Q3 CY2027

[2] Battery Energy Storage System.

Manawa owns and operates 25 hydro schemes with winter-weighted generation



[1] Highbank and Montalto illustrated as one hydro scheme for the purposes of this presentation.
[2] King Country Energy (KCE) is a hydropower electricity generator 75% owned by Manawa and 25% owned by King Country Trust.

Key metrics

Total hydro generation volumes of 1.9TWh in FY24

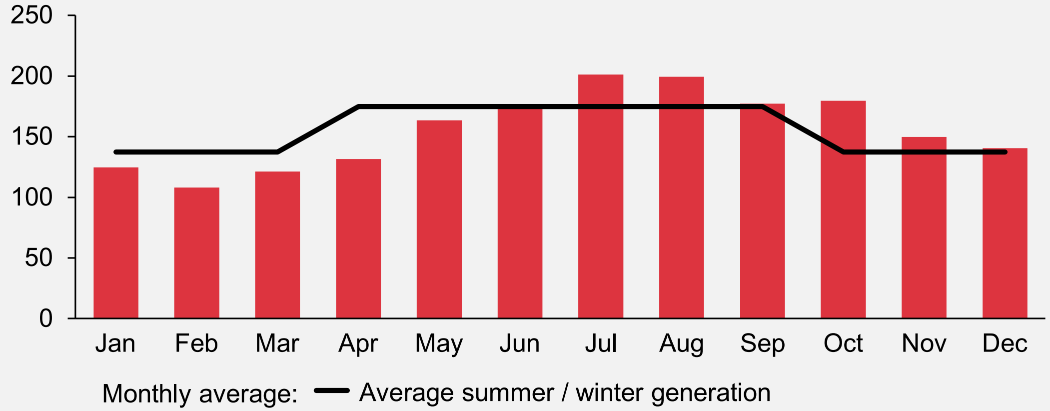
>99% of FY24 generation from renewable sources

Owns and operates 25 hydro schemes with ~500MW of capacity and one diesel peaking station

40% / 60% summer / winter generation (long term average)

Winter dominated generation[3]

Average output by month (GWh)



[3] Manawa company information. This data is from 2017-2023 to include King Country Energy generation information.

BatMan

For Glenbrook-Ohurua

Glenbrook-Ohurua BESS

Contact is developing its first grid-scale BESS

- 100 MW | 200 MWh BESS at Glenbrook (South of Auckland).
- COD Q1-26.
- Tesla is the OEM.
- Short duration flexibility to respond to market conditions and support Contact's portfolio as intermittent renewables are built out.

...and people always like videos.

What is an 'optimiser'?

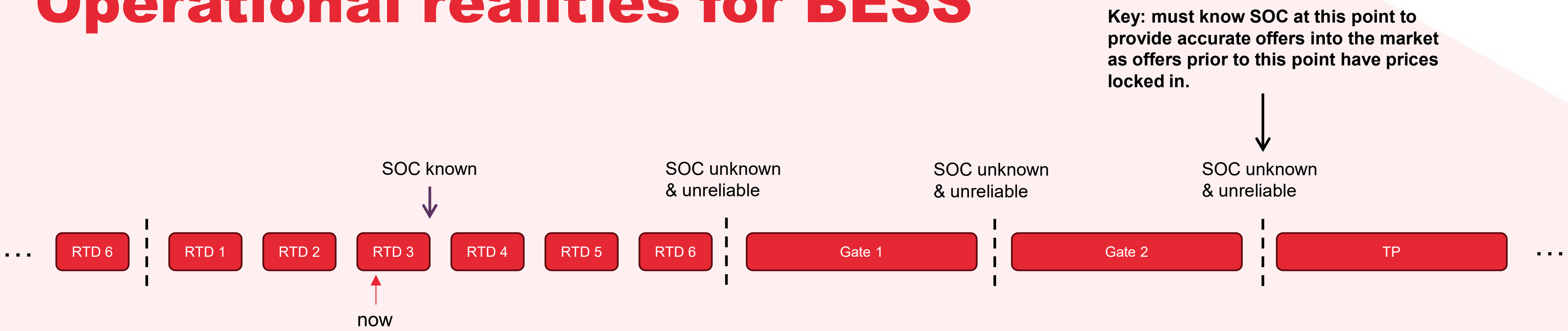
It is an algorithm that ingests a forward view of price and then simulates how best to maximise revenue, typically through mixed-integer linear programming. It then takes that simulation and creates a trading strategy in the form of offers and bids in real time.

BESS in the NZEM

Background

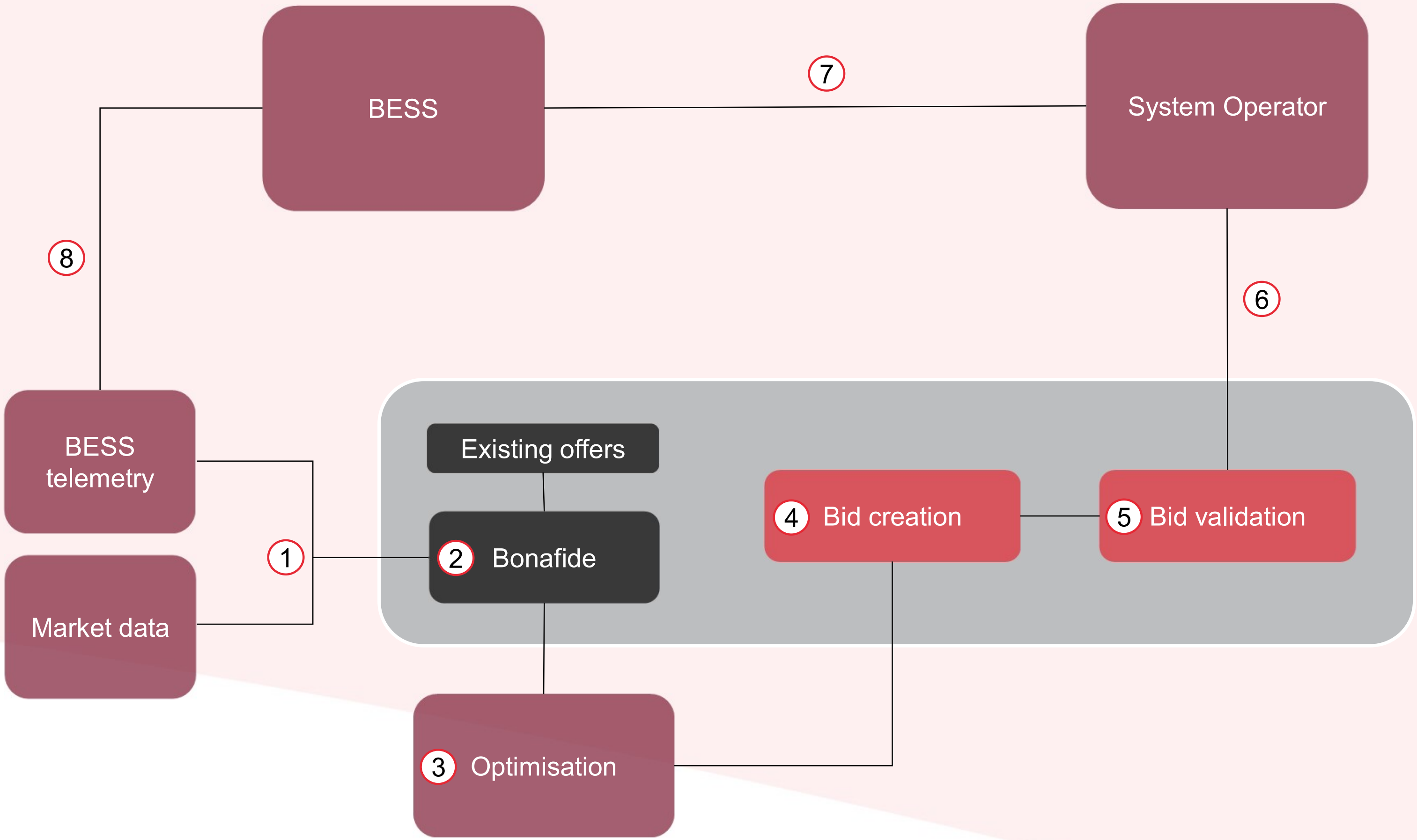
- BESS are able to participate in 5 markets with the following 7 offer and bid types: ***generation, generation SIR / FIR, dispatchable demand, interruptible load SIR / FIR and frequency keeping***.
- BESS not currently accommodated in SPD: discharging and charging are split into separate generation and dispatchable demand stations (not bidirectional).
- Real time dispatch (5 minutes):
    - Costs/revenues are settled on TWAP of the six real time prices in a trading period.
    - Offers apply to a half hour trading period.
- Low ramp rates of slow-starting plant, offer stack steepness and high volatility of wind output contribute to high volatility in 5 minute prices.
- 1 hour gate closure:
    - Restrictions on changing price and quantities in existing market offers for current (TP) and two subsequent trading periods (TP+1, TP+2).
    - **Prices for tranches cannot be changed** while volumes in tranches can be reduced from original MW's down to 0 MW, from highest to lowest priced tranches (and lowest to highest priced tranches for bids).
- Available information for BESS:
    - Current real time dispatch period's dispatch instructions, instantaneous BESS state data (state of charge, charge/discharge MW's…).
    - Half hourly scheduled dispatch volumes (MW) for each offer type.
    - Half hourly schedule prices (short, long & WDS).

Operational realities for BESS



- Accurately knowing state of charge (SoC) is crucial:
  - Real time state of charge only known for a maximum of 5 minutes ahead. SoC at all other points are forecasts based on scheduled dispatch over a trading period.
  - 30 minute scheduled dispatch can be volatile.
  - Dispatch in real time occurs every 5 minutes – no guarantee of being dispatched at volumes indicated by scheduled dispatch.
- Charge and discharge sides of a BESS must be bid as separate station types (generation, generation FIR, generation SIR vs. dispatchable demand, IL SIR and IL FIR).
  - Bids must be created so that dispatch instructions are physically compliant (e.g. cannot charge and discharge at the same time).
  - To maximise revenues, different combinations of offer types must be compliant with market rules.
- Solution:
  - Co-optimise BESS to offer into physical energy and ancillary services within physical (e.g. minimum and maximum state of charge) and market constraints (e.g. valid bids).
  - Profit maximising objective – optimise over price series and additional parameters to drive different BESS behaviour.

Contact's system – BatMan (Battery Manager)



It runs on a loop

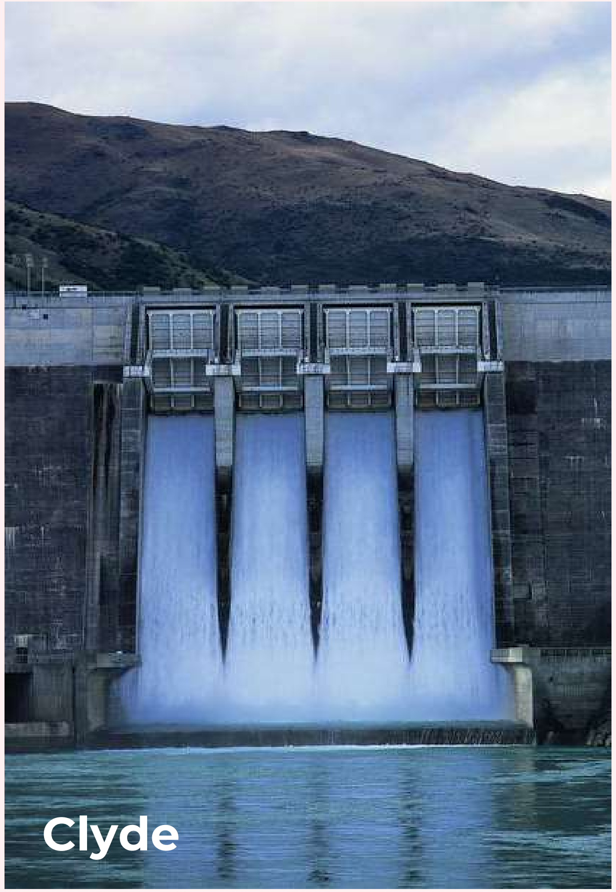
1. Retrieve latest market data and dispatch instructions.
2. Bonafide existing offers to make SOC feasible.
3. Optimise BESS over market data and additional parameters.
4. Tranche market offers (physical & ancillary) from optimisation results.
5. Validate created bids to comply with market rules and BESS' physical capabilities.
6. Send bid files to System Operator.
7. Receive dispatch instructions from SO.
8. Receive dispatched volumes from BESS.

HOWARD

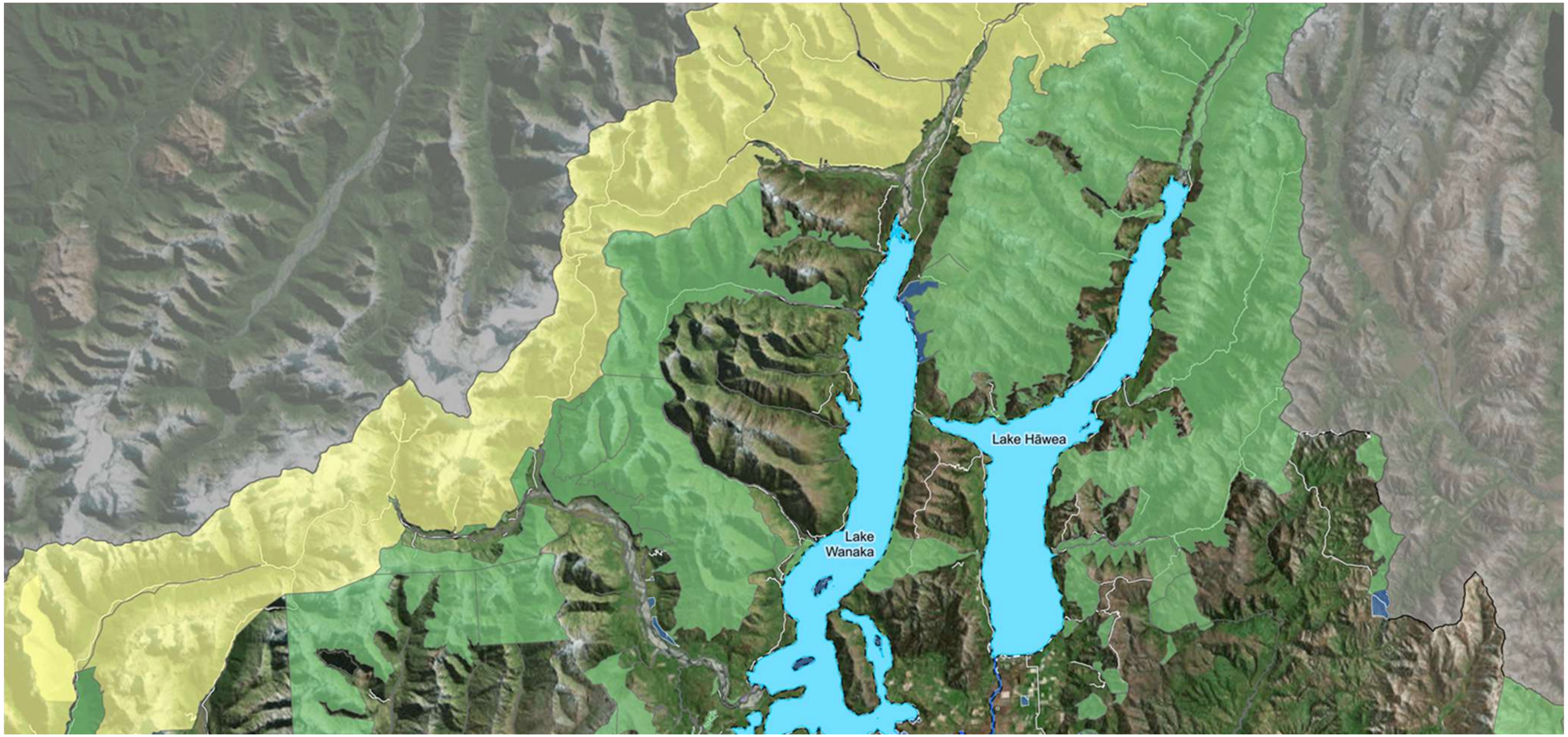
For the Clutha

The Clutha scheme

- Clyde and Roxburgh are run-of-river power stations – circa 3.4 TWh per annum.
- Lake Hawea provides some controllable releases – circa 500 GWh per annum.
- Lake Hawea's capacity is 285 GWh.
- The head ponds at Clyde and Roxburgh are relatively small.
- There are flow delays for water released out of Hawea reaching Lake Dunstan.
- Complex consenting conditions, including significant minimum flow requirements reduces flexibility during periods of low inflows.



The Clutha catchment

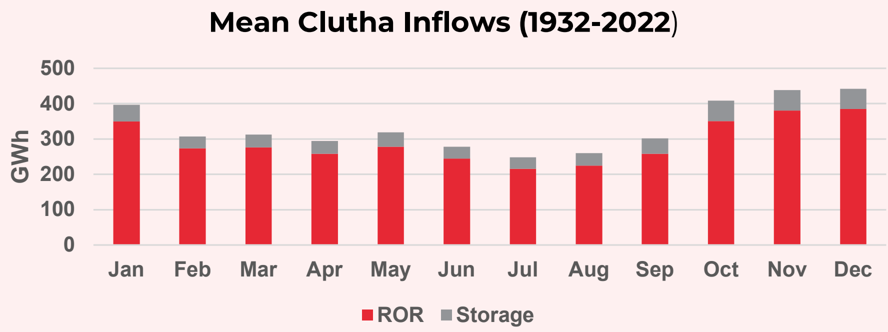


Adapted from: https://www.orc.govt.nz/media/4100/reserves-and-tracks-map.pdf

Generation characteristics

Inflows and consent conditions

- Hawea has a min. release of 10 cumecs, and a max of 200 cumecs. This is lowered to 60 cumecs over the summer months.
- Clyde and Roxburgh have minimum downstream flow requirements.
- Both run-of-river and storable inflows are lowest in Q3 and highest during Q4.



HOWARD

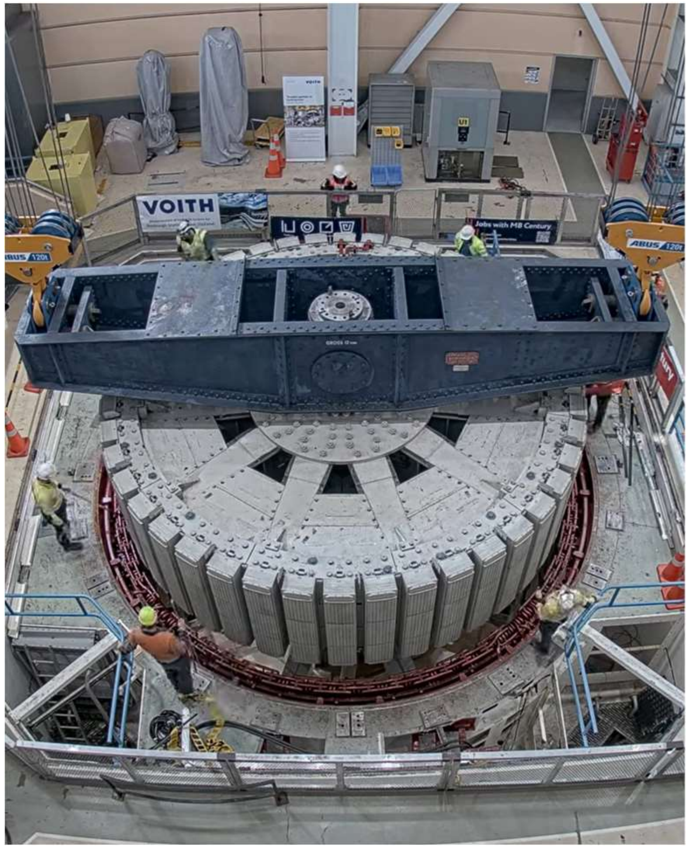
Hydro Optimisation With Advanced Real-time Dispatch

HOWARD is a mixed-integer optimisation model, bridging the physical hydro system and the spot market.

Physical Model
- Head ponds sizes.
- Natural and controlled flows.
- Resource consents.
- Turbine operating limits and efficiency.

Spot Market
- Forward schedule of prices (PRSS, PRSL).

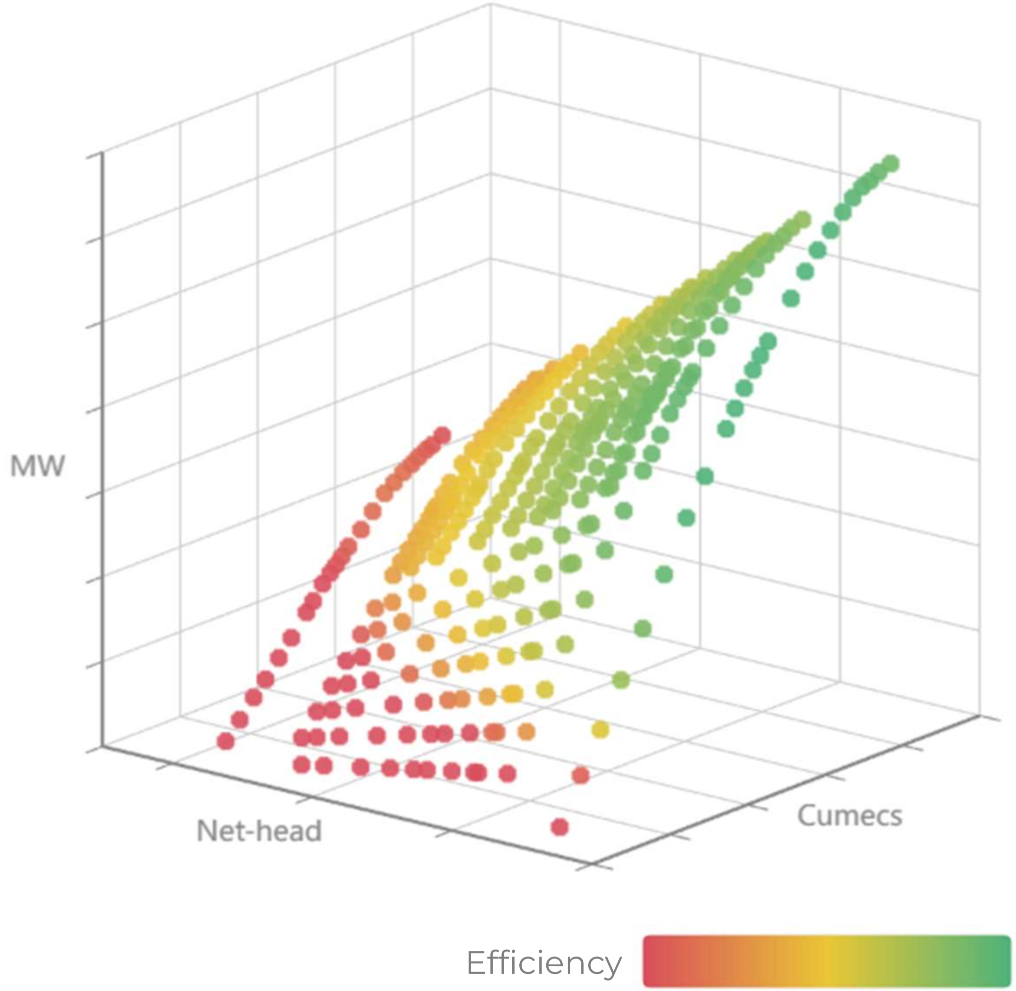
HOWARD seeks to use the available water efficiently in periods of the most value to maximize returns.



Clutha scheme

Roxburgh upgrades

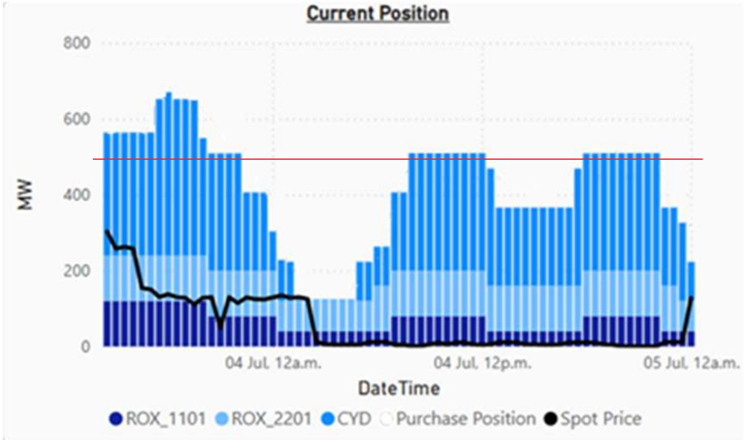
- Contact is in the process of upgrading 4 of its 8 units at Roxburgh.
- These new units have a different efficient point than the existing units.
- Net-head depends on the difference between the head-water level and tail-water level.
- This means that the combined station's efficiency curve will now depend on both the head water level, and unit order.
- We are process of recalibrating these efficiency curves as a function of unit order, and developing a process to automatically update the curves within HOWARD, as the remainder of the upgrades are completed.

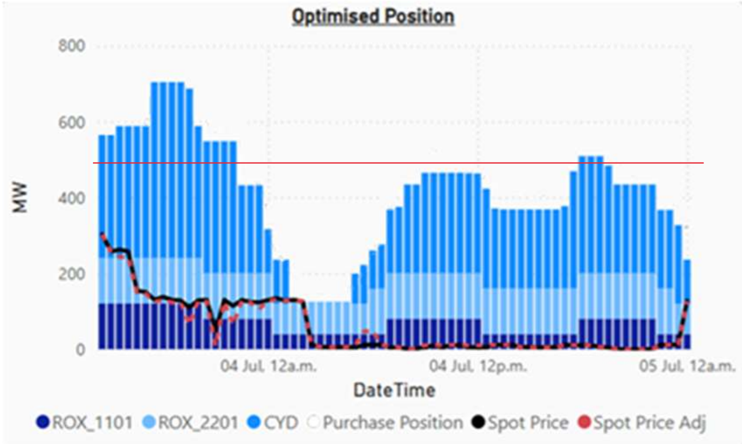


Illustrative results

Capturing value

- Near term price signals (black line) indicate that more generation is needed earlier in the day, with the market signalling oversupply overnight and into the following day (with near zero pricing).
- HOWARD suggests shifting generation into the higher-priced periods, and reducing generation during lower-priced periods, such that the same amount of water is used.
- The optimisation balances the cost to start up and shut down individual units, and the efficiency unit at the optimised solution against the high GWAP attained.





Wrap up

- The New Zealand Electricity Market is in the midst of a transition with significant electrification underway and more anticipated, reductions in gas availability and lots of solar under construction.
- Similarly Contact is in the middle of a period of significant change, with Kowhai Park and the Glenbrook BESS under construction, and the closure of TCC.
- Data-driven, optimization-based trading tools are being developed and deployed within Contact as automated systems with decision support functionality to assist the trading desk in managing increasing complexity within Contact's portfolio and the market.