MDAG engagement

The future of the NZ power system with 100% renewables

Grant Telfar

Living in uncertain times: 100% renewable energy & dry year flexibility

The Government has stated its intent for a 100% renewable system by 2030:

- They are proposing the Onslow-Manorburn pump storage scheme as a key plank towards this goal
- Newly committed wind and geothermal projects (2.7TWh) will move the system to 90% renewable over the next few years

Hydro inflow deficits of 5TWh annually have historically been managed by maintaining thermal capacity, flexible thermal fuel storage, and flexible thermal fuel deliveries:

- As more wind enters the system, it too can face extreme annual deficits of 8-10%. Solar also faces deficits of up to 3-5%

A Tiwai smelter closure by the end of 2024 could see 5TWh of excess Southland-Otago generation attempting to flow northward creating a regional energy imbalance:

- In response, large-scale demand stimulation projects are being pursued

The retirement of NI thermal plant is both a problem to be solved but also a unique opportunity to move faster towards a 100% renewable power system:

- A range of solutions beyond Onlsow has been proposed to help transition the power system towards 100% renewable:
    - remaining at 95-98% renewable
    - thermal-co / thermal reserve schemes, 99% renewable
    - renewable overbuild
    - increased hydro flexibility
    - demand response

Significant new demand in Southland that is also flexible could address regional energy imbalance and create an alternative mechanism for dry-years

Some history : market deregulation rationale and performance

Motivation for the current NZ wholesale electricity market and regulatory structures in the 1990s:

- International movement towards co-ordination by markets:
  - underpinned by new technologies lowering the cost of entry for what previously was a natural monopoly
- Efficient pricing of scarce resources:
  - learning lessons of the 1992 shortage
- The government removing itself from central planning:
  - avoiding picking political and economic winners, often with wider ambiguous goals
- Spreading decision-making risks across a range of investors:
  - taxpayers / consumers no longer bearing the costs of sometimes poor decisions that they have no control over
  - McLaughlin 1985 report (NZ Treasury)

What has the market delivered since 1996?

- Adapted to changing needs of the market, consumers, and policy
- 23.5TWh (4.9GW) and $11.5B of capital spend on generation plant (and more on new transmission lines):
  - diversity of views in where, what, & how to invest + operate
  - cost over-runs being limited but borne by investors
- Retirement of thermal and renewable plant that has reached end-of-life and and/or no longer recovering costs:
  - 2,400MW and 6,000GWh since 1996
- Signaling well ahead of time evolving scarcity concerns during times of tight supply – with no hydro-related blackouts:
  - complex financial agreements to help manage dry-year risks: CEN and MEL swaptions with GNE
  - complex multi-party agreements to help manage large counterparty risks: NZAS contracting
- Wholesale prices averaging $90/MWh over 1996-2021 (real):
  - through several extreme hydro and thermal events
  - broadly consistent with the prevailing costs of new entry

How does Meridian view investment dynamics?

Revenue adequacy:

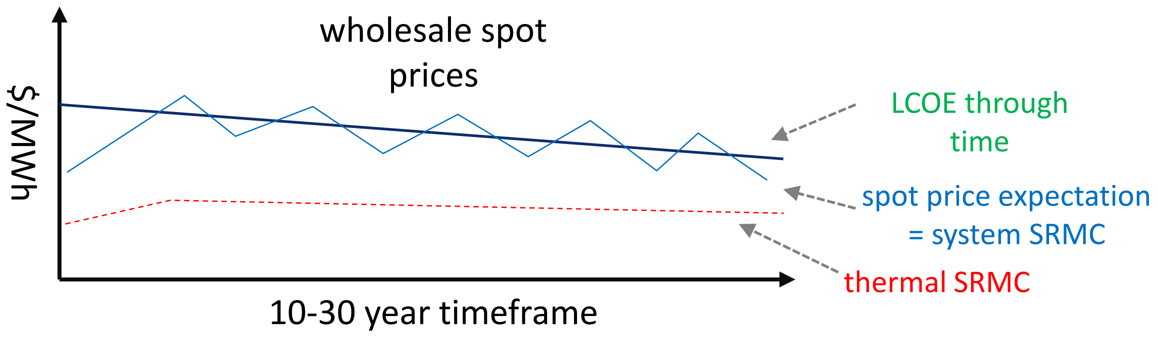
- Companies invest when, where, and in what technologies that they think they can make adequate returns (WACC) on capital, ongoing marginal, & operating costs over asset life-time
- Levelised cost of energy, LCOE (including short-run marginal costs, SRMC) versus generation price, GWAP.
  - peaking: Nova Junction Road, 2019
  - baseload: Eastland, Ngawha, Tauhara, 2018-2022
  - intermittent: Waipipi, Turitea, Harapaki, grid-scale solar investigations (Lodestone, Helios, et al), 2021-2023
  - new technology: grid-scale BESS investigations, 2021-2023

We see competitive market outcomes with the free trading of risk as delivering the same outcomes as an efficient central planner:

- We expect that a workably competitive market will deliver prices determined by both SRMC and LCOE
- Hindcast analysis is a useful test/benchmark here

Implications of this commercial discipline for long-run prices:

- A period of weak demand and/or surplus supply drives lower wholesale prices -> Investment slows or stops as the ability for new investors to monetise capital becomes challenging
- As demand grows and/or plant retirement occurs, wholesale prices begin to rise and opportunities for investment occur -> investment will occur when some party can see a profitable project
- This creates an expectation of “saw tooth” prices around an LCOE trajectory through time



Source: Meridian

What might happen to spot prices?

Spot market design is intended to reflect the underlying marginal costs of electricity production:

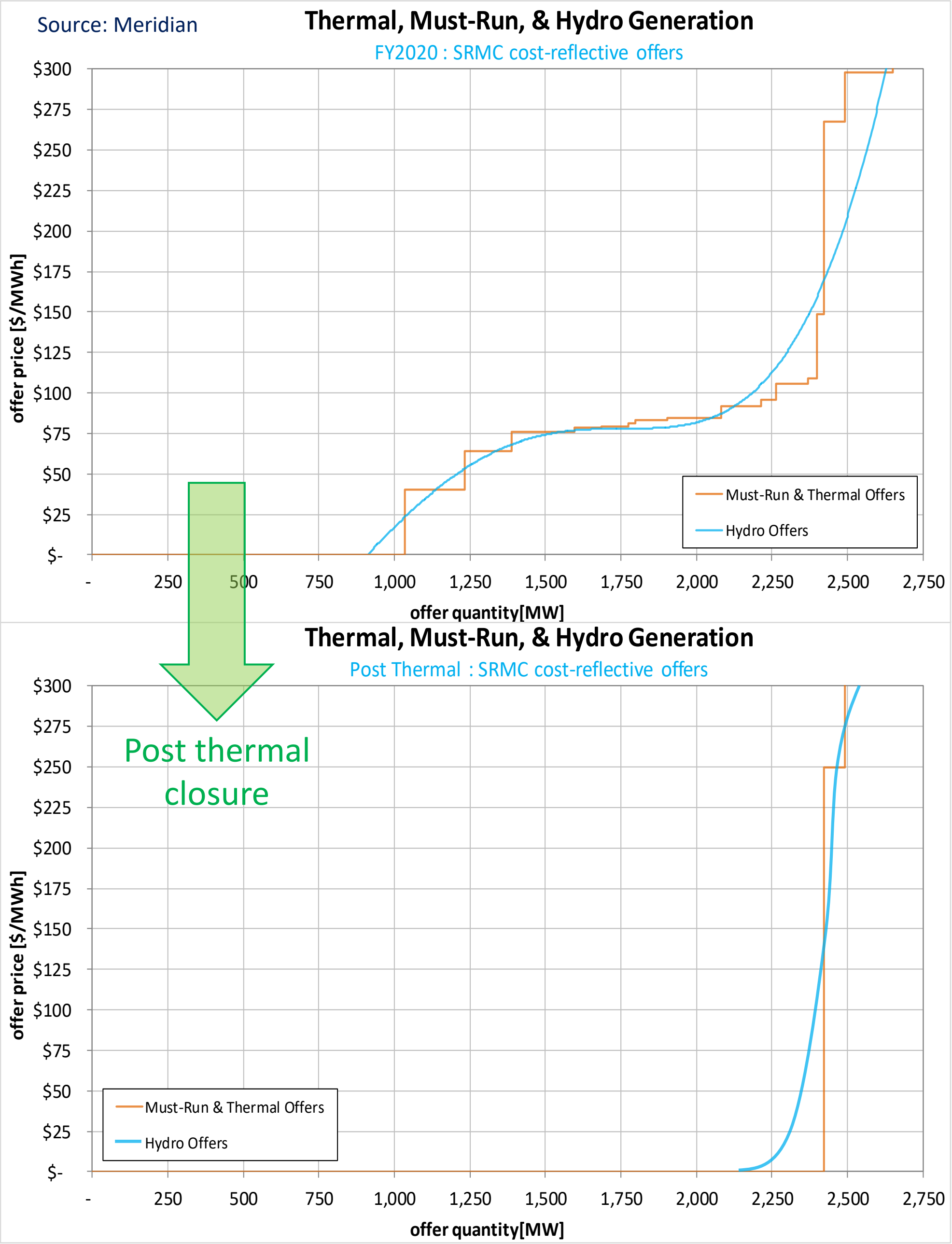
- Traditionally system SRMC (short-run marginal cost) = how much more does it cost to produce one more MWh?
- A significant departure from this would represent market inefficiency and/or market power

In a competitive marketplace there are different views and information sets that inform system SRMC – historically made up of:

- Low cost/must-run plant ~= $0
- Thermal costs: heat rate x fuel cost + carbon ~= $80-120/MWh
- Cost of extended shortage = $5k-20k/MWh+
- With (hydro) storage & uncertainty creating curvature and filling in price “gaps”
- There is *always* more uncertainty and more cost than you might think

Without thermal costs anchoring the market, storage SRMC in the short-term collapses to being determined by must-run plant costs and shortage:

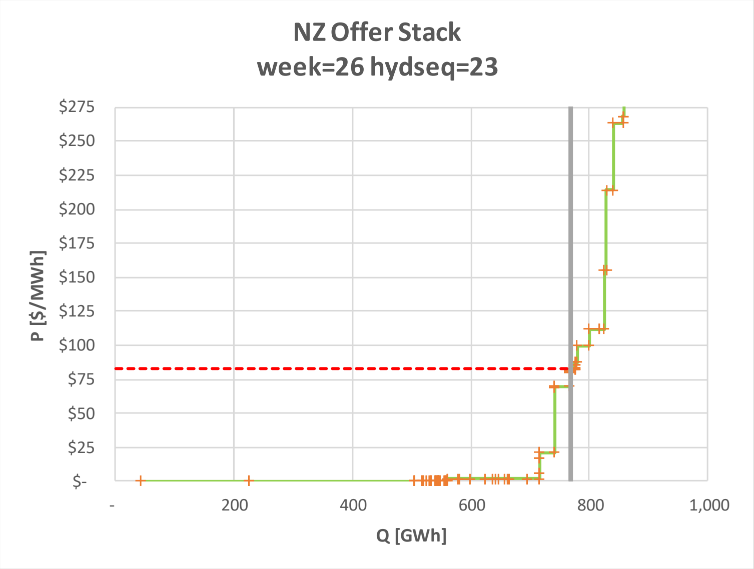
- Price discovery can still be resolved but it will be fragile and volatile
- Emission costs from geothermal and demand response can add some marginal information back into system SRMC
- Without those things energy only pricing may be challenging



Supply, demand & the discovery of marginal pricing

Market price setting process: the classic supply & demand stack drives everything today and is capable of doing so in the future:

- Thermal SRMC: heat rate x fuel cost is a deliberate simplification
- Renewables with no storage have a SRMC of zero (~ish)
- Renewable spill will have a role to play in the future
- Renewables with storage have a marginal opportunity cost in the face of future uncertainty, eg water-values
- Demand currently has little marginal response today; but with V2G, BESS, smart-load, & load response this could rapidly change



Question: Does the wholesale market continue to function as NZ moves towards 100% renewables?

- As long as there is some gas in the system, the current market price mechanism and investment can continue to work well
- Up to 95-98% renewable penetration is possible

Question: Beyond gas peakers, can the energy only market mechanism continue to function?

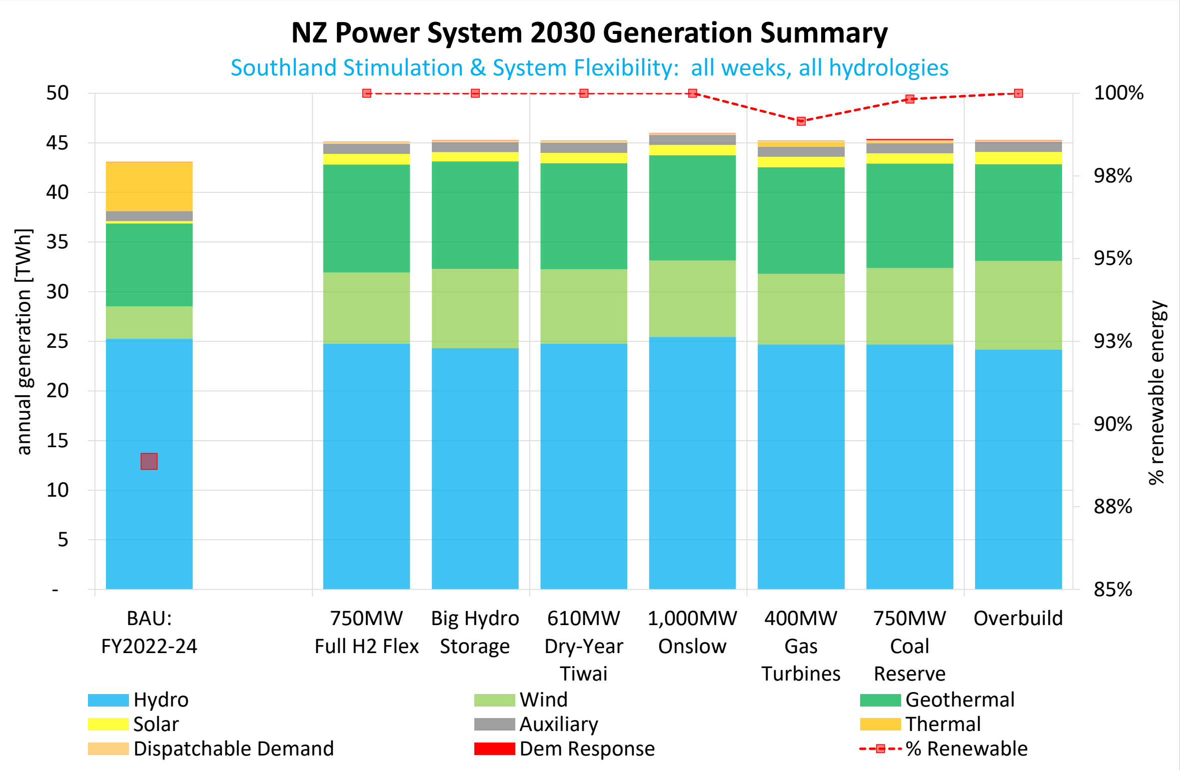
- Yes – at least over time. But it will require a strong demand-side participation and spill pricing within the price setting process
- This is not a 2021 problem – technological advancements will continue to evolve and help globally over the decades ahead
- Novel approaches to managing price and risk will likely be needed

Supporting analysis:

- Lew Evans (2018) concludes that pricing mechanisms can still function in a 100% renewables world due to storage (conventional and batteries) which create cost dependencies through time.
- Grant Read (2009) suggests that real-world thermal SRMC is much more complicated than simplified model assumptions suggest: thermal storage , O&M, take-or-pay, binary inventory decisions, …

Forecast changes to the power system by 2030+

- A large volume of new renewable energy (RE) generation is needed: 12TWh, 3GW, and $7B of new *grid* generation
- A secure, low carbon, power system can occur in different ways:
  - retaining thermal generation, 99% RE can be delivered
  - with Onslow, hydro expansion, system overbuild, or large-scale demand flexibility the power system can achieve 100% RE
- All solutions rely on other power system components *also* flexing: hydro capacity, dispatchable demand, renewable spill, BESS, ...
- The pace of change and sheer scale of this challenge is enormous, regardless of the solution to dry-year flexibility
- Wide-reaching changes are expected: storage, prices, and generation all alter dramatically from today's expectations
- Any of these solutions ***can*** do the job: delivering a secure power system with low carbon emissions, a high level of RE, and a return on investment
- Costs of some solutions, cost allocation, and implications for market design are more challenging for some solutions

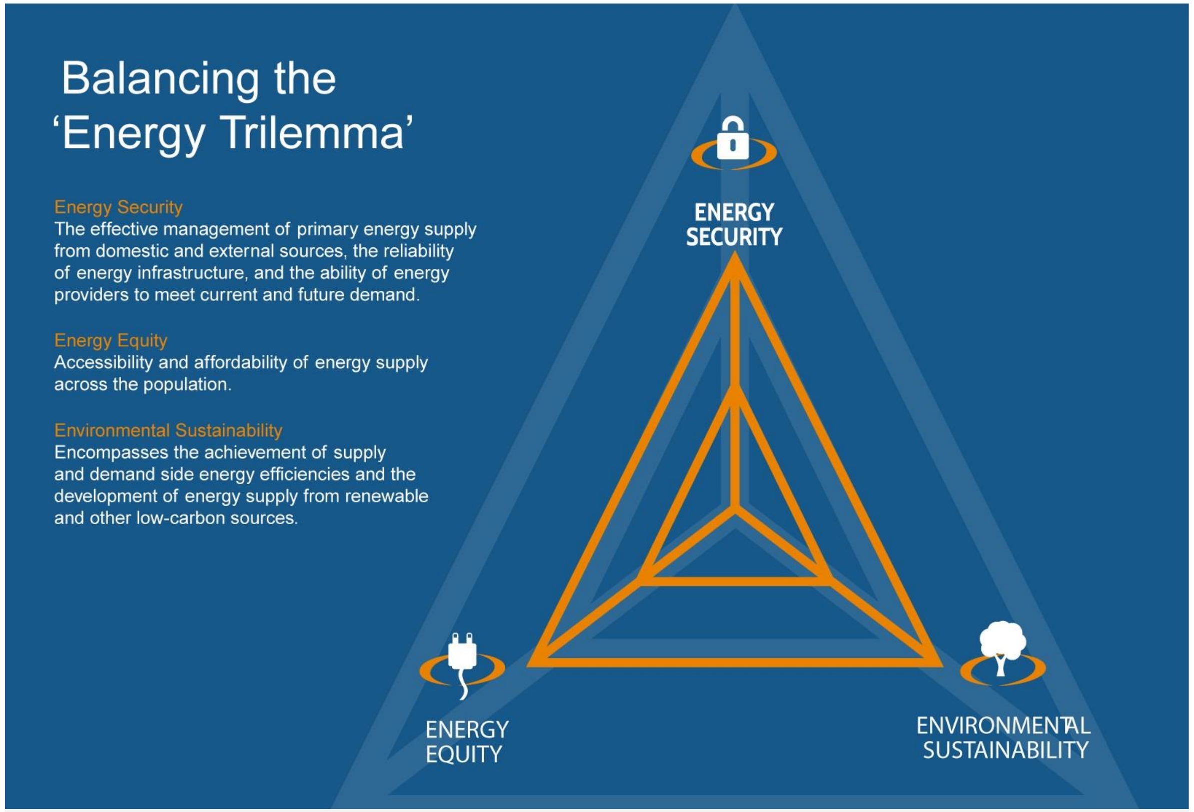


Source: Meridian

There is a range of valid ways a secure future power system with low emissions could be delivered

How to measure good?

- Cost is not the only metric for New Zealanders (the Government, regulators, investors) to consider when thinking about future outcomes:
  - carbon, sustainability, security, volatility, and investment/market stability are all important
  - trade-offs are often inherent in any comparison
  - avoiding throwing the baby out with the bathwater is something to avoid
- The World Energy Council's energy trilemma is a useful framework to contextualise this:
  - 3 needs (axes) to balance
  - *how* the balance is maintained is also important



Trying to improve <u>and</u> balance *all* needs

Balancing occurs via well regulated, energy-only, efficient market mechanism and supporting policy

Establishing the 'best' future NZ outcome

- There is no single solution to dry-year flexibility and a 100% renewable power system that produces a desirable outcome measured against all trilemma metrics:
  - a compromise outcome is required – not an exact science
- Of the solutions explored for the 2030 NZ power system:
  - flexible demand response solutions or additional hydro flexibility can achieve good combined outcomes
  - the additional capital costs of flexibility may change this view
  - thermal solutions or system overbuild fare less well
- Flexible demand response, especially if it can manage dry-years *and* intermittency, represents a fantastic opportunity
- A market facing arrangement (rather than a reserve scheme based on storage or other triggers) presents a better overall outcome for NZ
- Solutions do not need to be mutually exclusive. There is a role for multiple solutions to work happily alongside each other in a complementary fashion

- The scale and pace of change required to move the NZ power system to 100% renewable energy is significant
- Changes expected in wholesale market outcomes and performance will be dramatic at times:
  - modest mean prices sufficient to give a return on investment
  - but price volatility *significantly* higher than seen today (4-5x)
  - storage levels are held higher, creating an insurance buffer
  - carbon emissions will be low but NOT zero (geothermal)
  - expected system shortage is greater than today's market but manageable – *if* market behaviour aligns to need
  - significant renewable energy spill (wind, geothermal, solar) adds to the hydro spill seen in today's market
- The analysis of a 100% renewable power system strongly suggests that it is mathematically achievable
- Preserving what is good about the market system we have today while aligning behaviours and encouraging market outcomes towards what is achievable should be the goal for regulatory efforts