Building New Zealand's Green Electricity System

Andy Philpott

Electric Power Optimization Centre,
University of Auckland

GEEC Workshop, Auckland
April 12, 2024

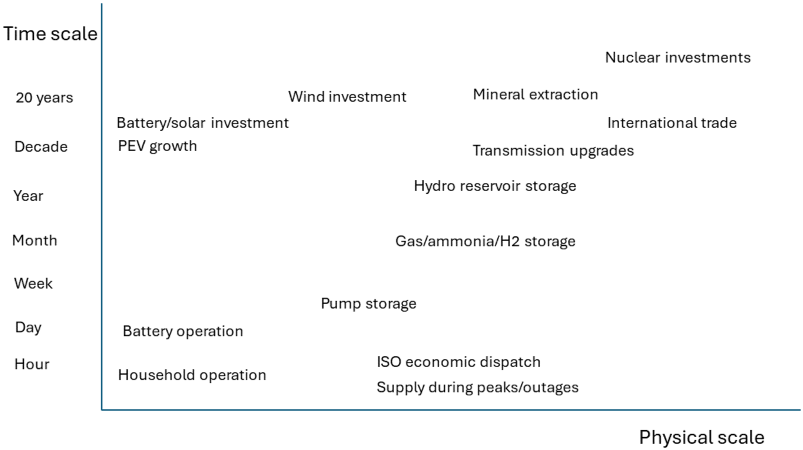
Introduction

- NZ Climate Change Commission sets budgets for emission reduction.
- New Zealand has to accelerate electrification of transport and industry to meet its agreed CO_2 emission targets.
- This requires building more electricity generation and transmission.
- Generation is planned and built by the private sector.
- Transmission is built by government (Transpower) to ensure energy reliability.
- How can optimization and equilibrium models help policy makers? This talk gives some examples.

The big questions

- What is the electricity investment needed to get to 2050?
- Are we on track to get there?
- Will an energy-only electricity market deliver it?
- What settings are needed?
- How does risk and uncertainty affect outcomes?

Time and space scales



Optimization models at different scales

- Household/hapu/small business
- Industry/iwi/microgrid
- Distribution network/aggregator/retailer/solar farm
- Transmission network/large generator/dry-year security
- Transactions between nations/trade tariffs/carbon certificates

Capacity and energy

- Do we have enough capacity to meet peak demand?
- Do we have enough stored energy to meet dry winters?
- Storage mechanisms have different conversion losses and costs
  - Batteries
  - Pump storage
  - Large reervoirs
  - Hydrogen
  - Ammonia
  - Green methane

Storage investment for increasing renewable overbuild

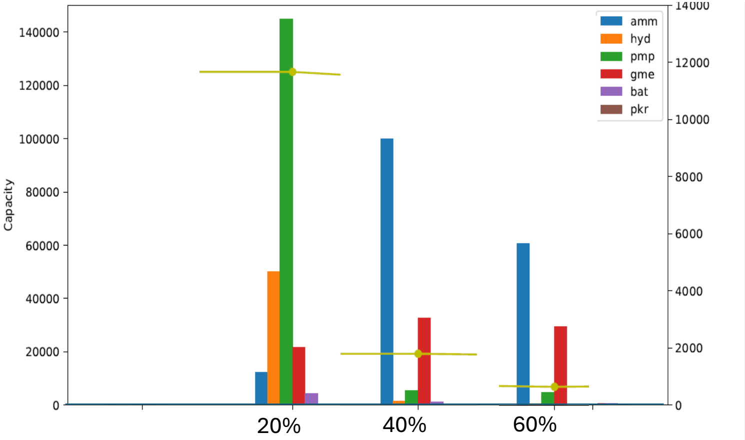
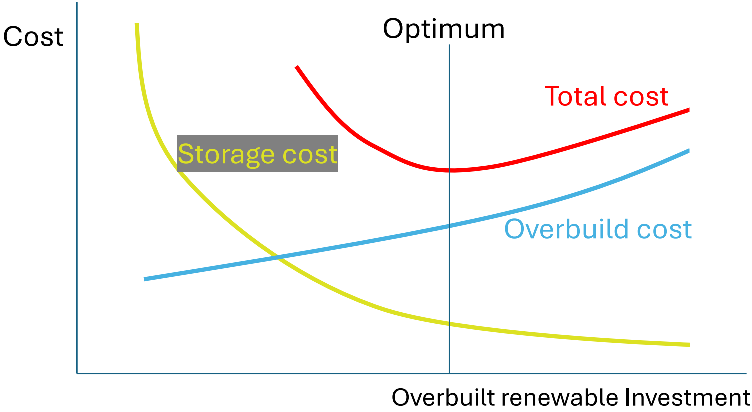


Figure: Storage technology mix (from Ferris & Philpott, 2024).

Optimizing renewable overbuild



Optimal wind investment

Investments and costs	*Onslow*	*Peakers*	*Wind only*
Wind - North Island [MW]	1315	1458	1997
Wind - South Island [MW]	0	0	0
HVDC capacity [MW]	643	0	379
Green peaker [MW]	-	837	-
CAPEX [MNZD]	4633	3671	5047
OPEX [MNZD]	2128	2219	3775
Total [MNZD]	6761	5890	8822

Table: Wind/peaker/HVDC investment from extended SDDP model. (From Hole, Philpott, Dowson, 2024)

Reservoir operation for different renewable builds

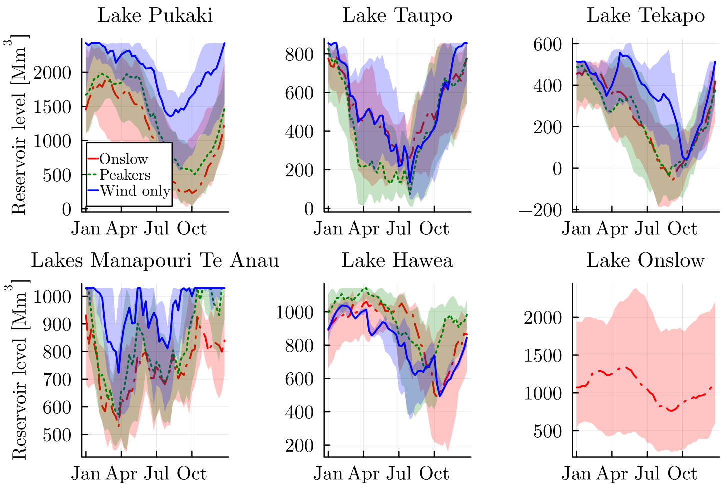


Figure: Hydro reservoir levels relative to consented minimum operating levels simulated over 1990–2020. (From Hole, Philpott, Dowson, 2024)

HVDC operation for different renewable builds

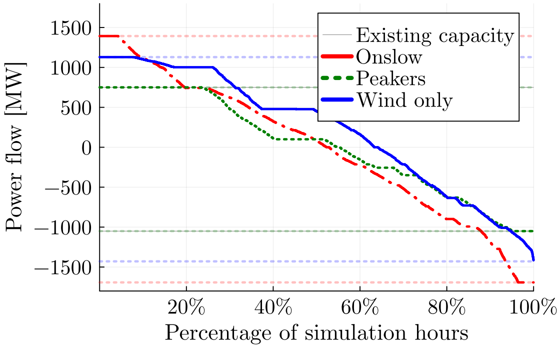


Figure: Flow-duration curve for HVDC from HAY-BEN for inflow years 1990–2020. Dotted lines are capacities.(From Hole, Philpott, Dowson, 2024)

Conclusions

- Optimization models expose the tradeoffs.
- It's complicated. There's no silver bullet.
- If market designs get the price signals right then in theory the commercial sector should build the optimal technology mix . . .
  - . . . if the future is uncertain and they are risk averse?
  - . . . in time to meet targets?
  - . . . with large economies of scale?
- Stochastic dynamic equilibrium models needed for this - see my next seminar.