Werewolf and NetZero: the interactions between operations, planning, investments and policies

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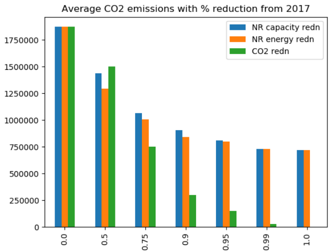
Jacinda's 2017 election deal

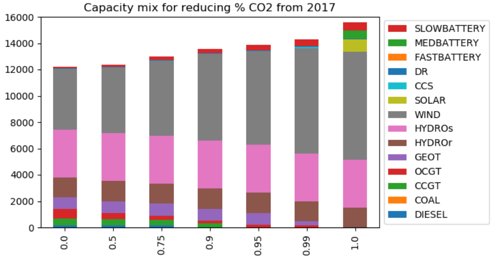
- Introduce a Zero Carbon Act and establish an independent Climate Commission.
- Request the Climate Commission to plan the transition to 100% renewable electricity by 2035 (which includes geothermal) in a normal hydrological year.
- Stimulate up to $1 billion of new investment in low carbon industries by 2020, kick-started by a Government-backed Green Investment fund of $100M.

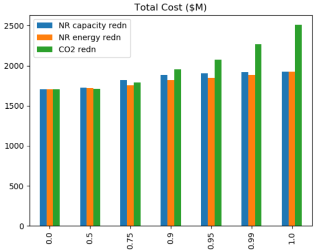
(Confidence and Supply Agreement between the New Zealand Labour Party and the Green Party of Aoteoroa)

Built model GEMSTONE that was used by New Zealand Climate Commission to help inform this policy

New Zealand (NetZero)

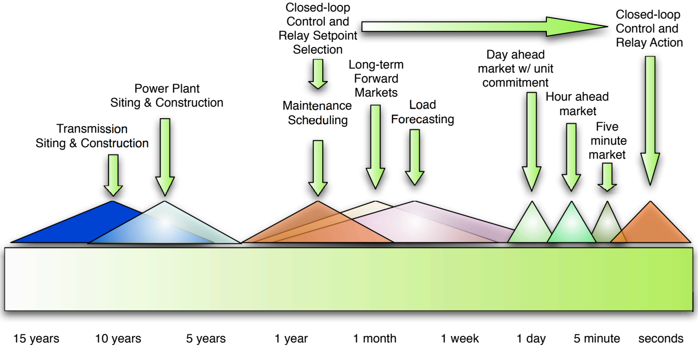






- Policies matter: affects reduction amounts and cost
- Portfolio of required technologies becomes complex as reduction increases
- Uncertainties and incentives key
- November 2019 climate act provides framework

Werewolf (Wisconsin Expansion of Renewable Electricity with Optimization under Long-term Forecasts)



- Design/policy decisions affecting operations/reliability and vice-versa
- Goal: to help policy and decision makers ...
  - to distinguish between objectives and actions;
  - to understand effects of uncertainty;
  - to understand effects of incentives;
  - to explore larger design space.

Simplified two-stage stochastic optimization model

- Capacity decisions are z at cost $K(z)$
- Operating decisions: generation y at cost $C(y)$, loadshedding q at cost Vq.
- Scenarios (futures) ω, demand (load curve) is $d(\omega)$.
- Minimize capital cost plus expected operating cost:

$$
\begin{array}{lrcl}
\min & K(z) & + & \mathbb{E}_\omega[C(y(\omega)) + Vq(\omega)] \\
\\
\text{s.t.} & y(\omega) & \leq & z \\
& y(\omega) + q(\omega) & \geq & d(\omega) \\
& (z, y, q) & \in & X
\end{array}
$$

- WEREWOLF populated using data from Wisconsin: develop the model for MISO and look at Wisconsin policies in particular
- Data and structure facilitate any US regional model

The data

Some figures that represent different facets of the data. Solar/wind etc.

Carbon leakage

Look at spatial effects when allow imports of non-renewable energy unlimited or flat.

Increased demand

Cost effects (and possible changes in portfolio of generation) when have increased demand. Flat imports.

Environmental constraints: Capacity or CO_2 reduction

Reduce capacity of plants compared to reduction in CO_2 emissions. Flat imports.

1. Reduce CO_2 emissions compared with 2017:
2. Reduce non-renewable capacity compared with 2017:
3. Reduce non-renewable generation compared with 2017:

Limits on technology expansion

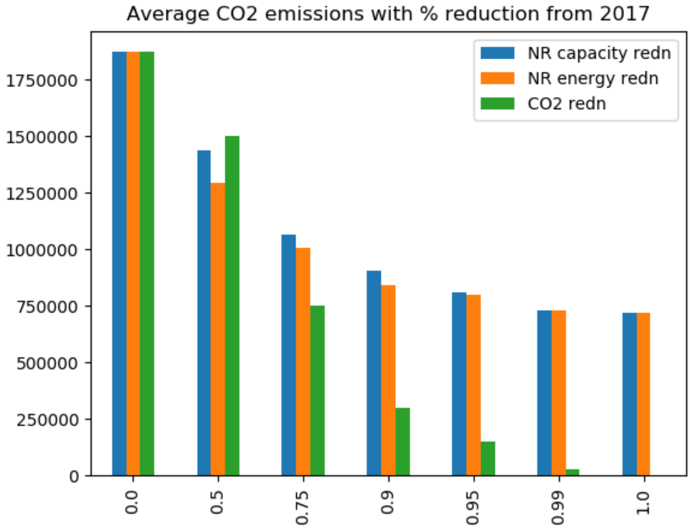
Could limit capacity expansion on certain technologies, or could have flat imports on non-renewable generation and different limits on non-renewable imports. Or could just limit wind and see what takes up the slack (with flat imports).

Conclusions

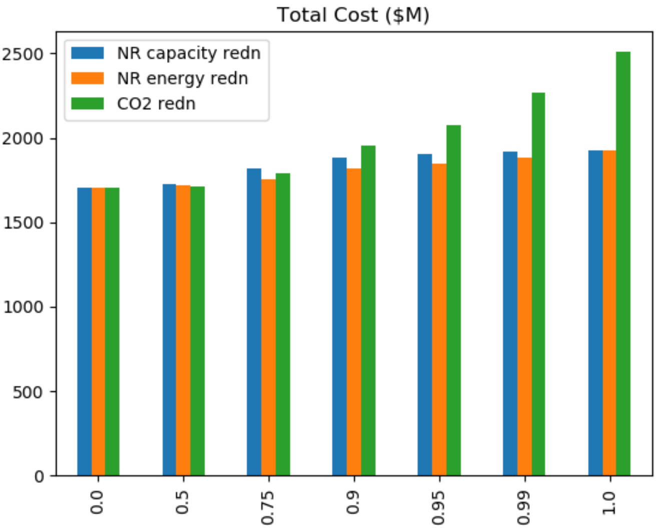
- Models can inform policy
- Models can show effects and costs of constraints
- Investment is coupled to reliability
- The model is currently being refined, and we are interested to get feedback from utility and policy experts about how this model would be useful in your utility and regulatory planning efforts (by April-May)
- here's how to get in touch with us if you should be interested in a one-on-one demonstration of the model and/or a brief interview to discuss possible policy interventions - we would anticipate after this first round of WEREWOLF (funded by TT Center) that we will be exploring additional opportunities to partner with stakeholders to further evolve the model with the goal of making it as useful as possible to policy stakeholders (such as through ARPA-E or other funding sources down the road).

In the Appendix, you could include information about the model (the current slides 4, 5) for example.

- Very large scale models (many agents with many instruments acting strategically) with risk are hard
- New algorithms enable solution of more detailed, authentic problems and address underlying policy questions
- Evaluation via simulation computations and out-of-sample testing

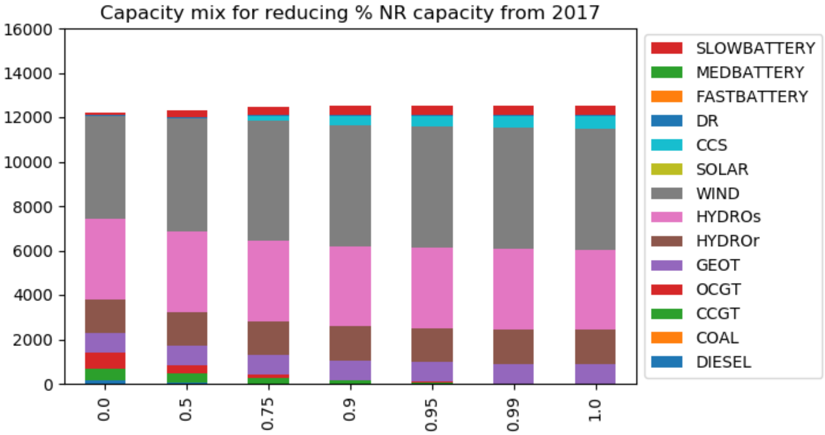


Since (renewable) geothermal and CCS emit some CO2 100% renewable yields modest reductions in CO2 emissions.



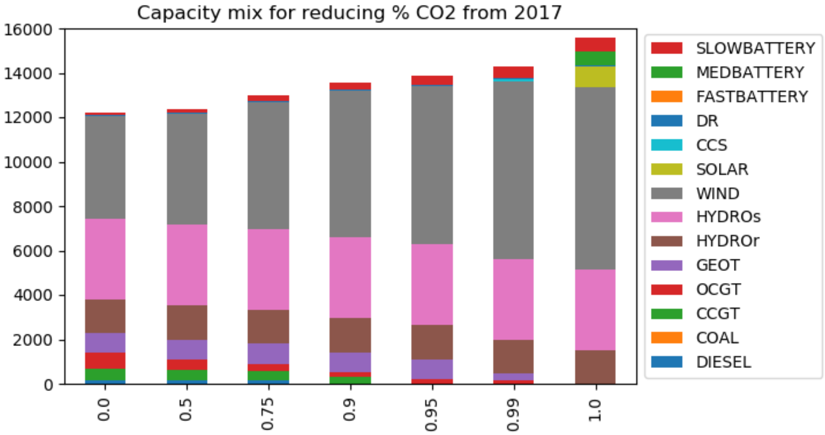
Cost of actually reaching zero CO2 emissions (without geothermal or CCS) increases as we approach the limit.

Technology choices as θ increases (NR capacity redn)



- Use geothermal, CCS, wind, batteries
- Fairly constant capacity

Technology choices as θ increases (% CO2 redn)



- Rich portfolio of renewable technologies used
- More capacity needed as more uncertain generation