

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

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(Joint work with Josh Arnold, Adam Christensen and Andy Philpott)

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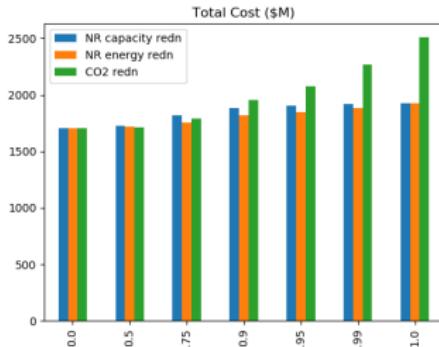
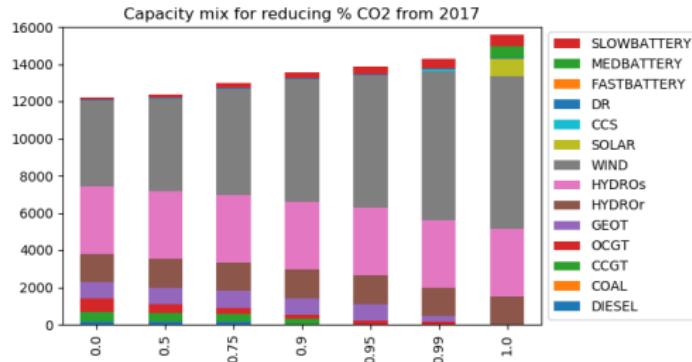
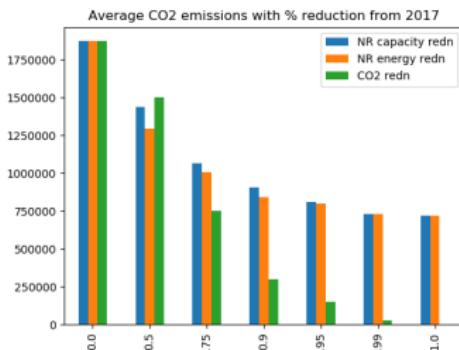
Jacinda's 2017 election deal

- 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 Aotearoa)

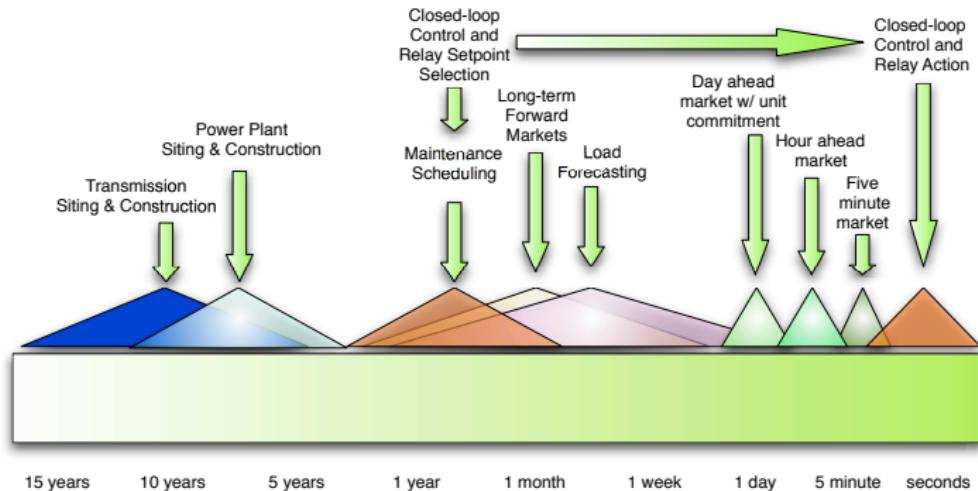
Built model GEMSTONE that was used by New Zealand Climate Commission to help inform this policy

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:

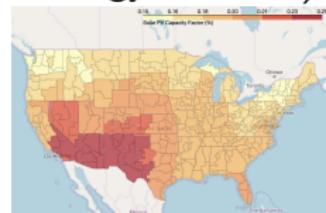
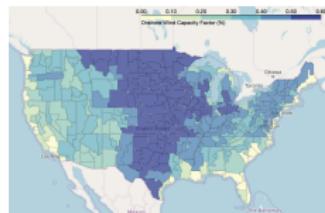
$$\min \quad K(z) + \mathbb{E}_\omega [C(y(\omega)) + Vq(\omega)]$$

$$\begin{aligned} \text{s.t.} \quad & y(\omega) \leq z \\ & y(\omega) + q(\omega) \geq d(\omega) \\ & (z, y, q) \in X \end{aligned}$$

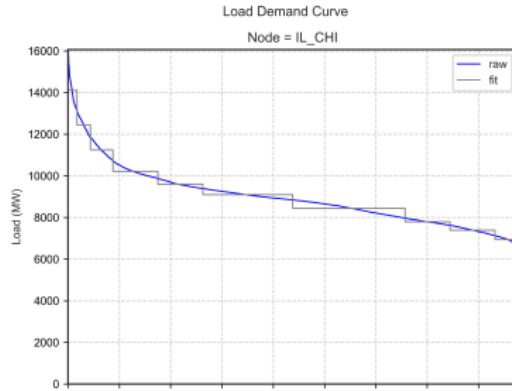
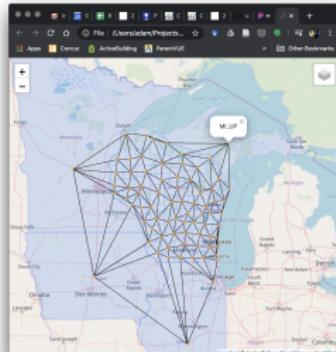
- WEREWOLF populated using data from Wisconsin: develop the model for MISO and look at Wisconsin policies in particular
- Data and structure facilitate any US regional model

The data

- WEREWOLF is data rich (EPA NEEDS/Integrated Planning Model, NREL ReEDS model data, NREL Annual Technology Baseline)

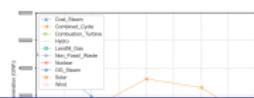
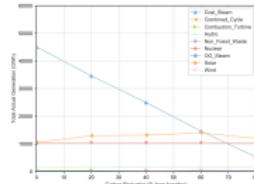
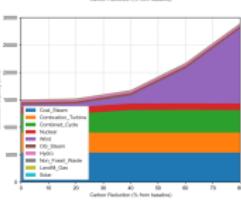
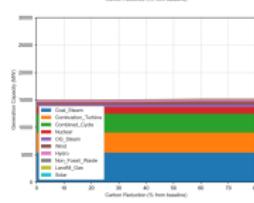
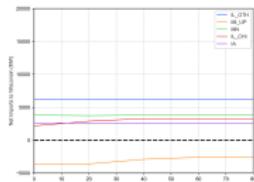
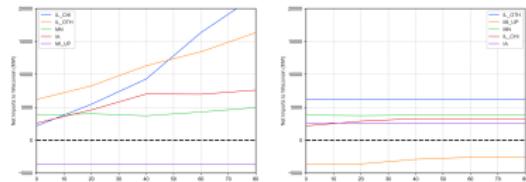


- Data is downscaled to county level - *user can customize regions as aggregations of these counties*
- Spatial impacts are captured in visualizations



Carbon leakage (increasing or flat imports)

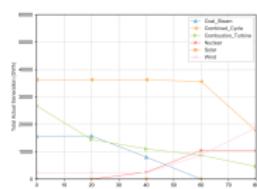
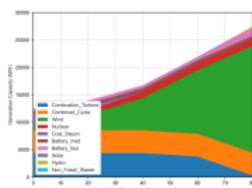
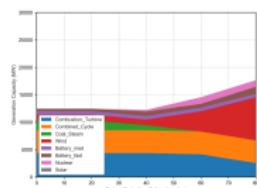
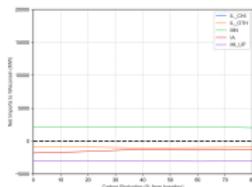
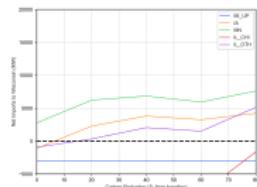
- Demand in 2030 is a data input, but what is the right investment now for this new demand?
- What is the right action (shutdown/investment) for this new demand + additional policies?



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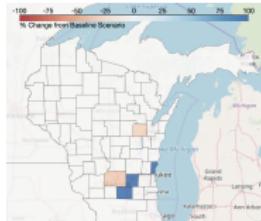
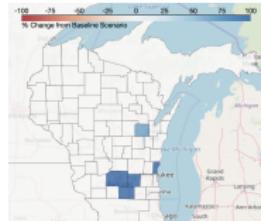
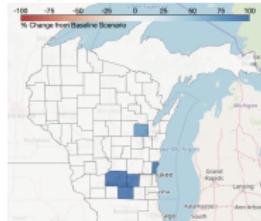
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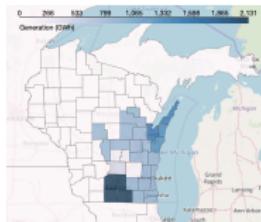
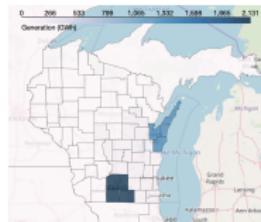
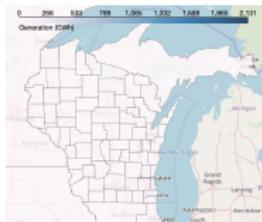


Carbon leakage

Combined Cycle (natgas) ramps up and then down while...

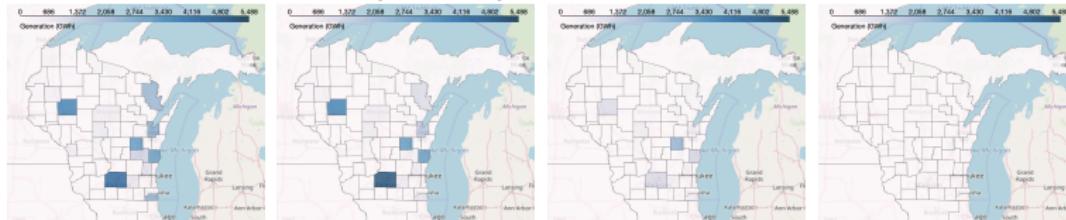


Onshore wind ramps up.



Carbon leakage

Combustion Turbine (natgas) ramps down while...



Onshore wind ramps up.

