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

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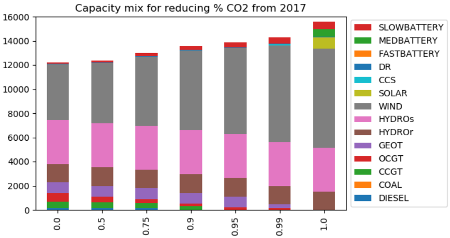
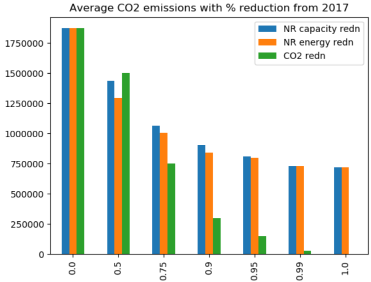
Public Services Commission Strategic Energy Assessment Group,
Madison, May 20, 2020

Supported by Tommy G. Thompson Center on Public Leadership

New Zealand's Zero Carbon Act

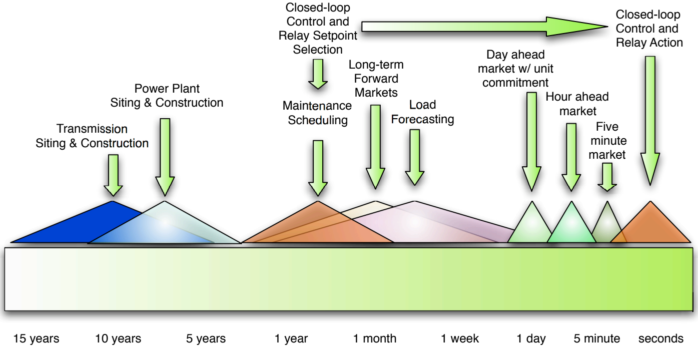
- Zero Carbon Act and new Climate Commission
- Transition to 100% renewable electricity by 2035
- Stimulate new investment
- Our model GEMSTONE helped inform this policy





- 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 for adoption

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



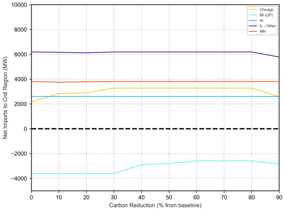
- Design/policy decisions affect operations/reliability and vice-versa
- Goal: to help policy and decision makers ...
  - to distinguish between objectives and actions;
  - to understand effects of uncertainty;
  - to understand effects of incentives;
  - to explore larger design space, with quick turnaround

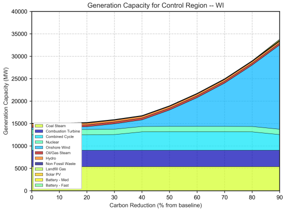
Werewolf code

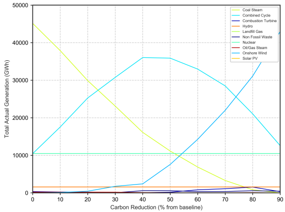
- Code is on github
- Data is adapted from EPA NEEDS/Integrated Planning Model, NREL ReEDS model data, NREL Annual Technology Baseline and other sources
- After data initialization, each run takes $\approx$ 30 mins to generate the following results
- Show effects of strategies driving towards 100% carbon free energy by 2050, coal plant closures, rapid deployment of renewables, increase in electric vehicle (EV) uptake, for example
- How could this help with SEA?

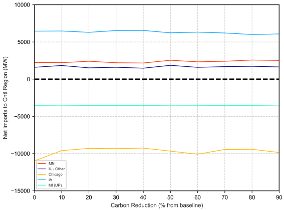
Carbon reductions (with/without shutdowns)

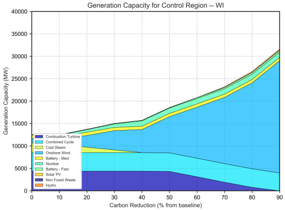
- Demand in 2030 is a data input, what generation portfolio needed for this new demand under increasing carbon reduction requirement
- Costs, capacity mix, generation

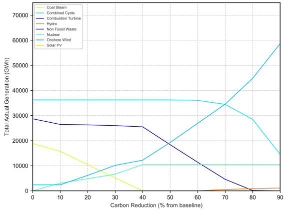






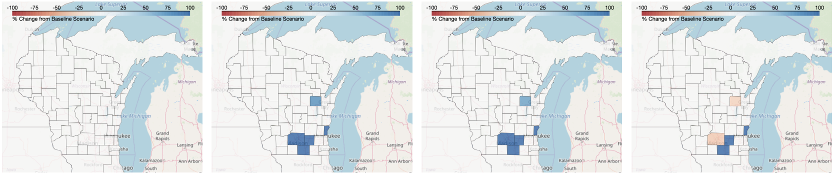




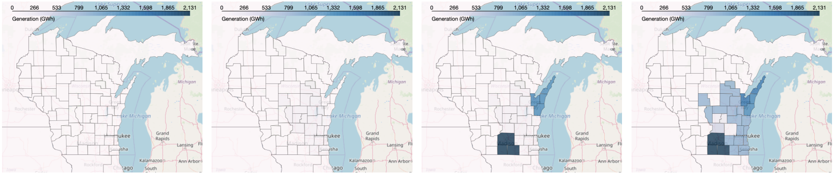


Carbon reductions – No Plant Shutdowns

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

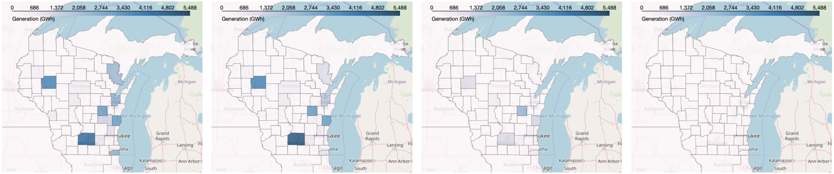


Onshore wind ramps up.

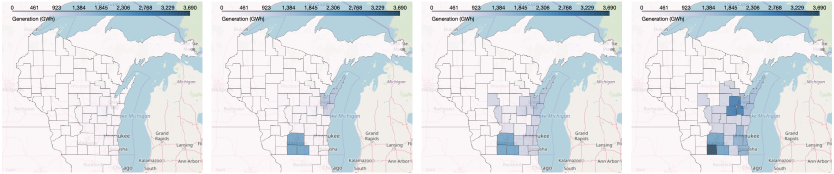


Carbon reductions – Shutdowns Allowed

Combustion Turbine (natgas) ramps down while...

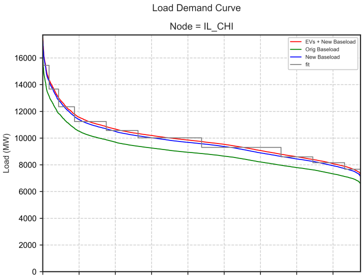


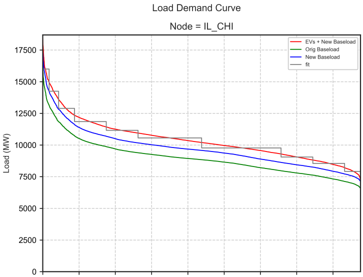
Onshore wind ramps up.



Increased demand from EVs – Shutdowns Allowed

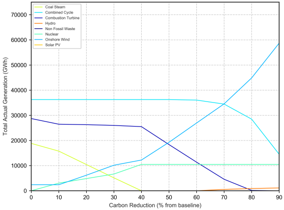
- What if EV penetration was 5% or even 20%?
- EV charging is modeled as a periodic function
- Single daily peak occurs at 5:30pm (charging occurs primarily after work)

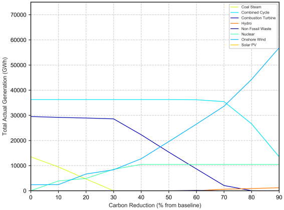


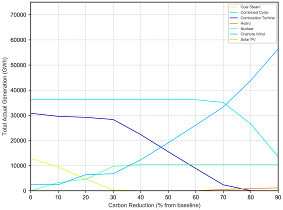


Increased demand from EVs – Shutdowns Allowed

- Wind still dominates the low carbon fuel
- Only subtle impacts from 5% EV penetration
- 20% incentivizes nuclear to come in back in earlier

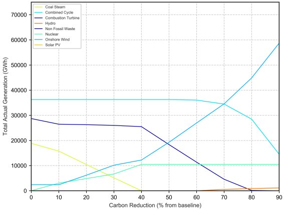


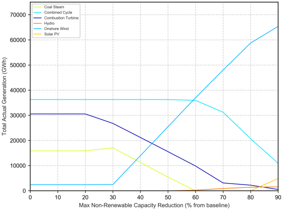


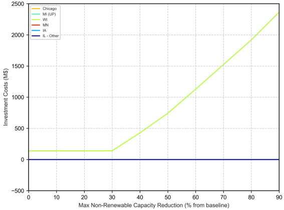


Limit non-renewable capacity

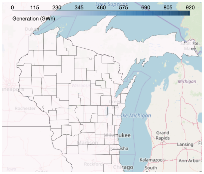
Expansion of combustion turbines for 2030, but then they ramp down as nonrenewable capacity allowed shrinks, cost increase significant

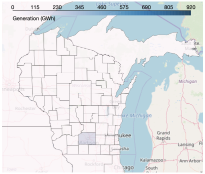


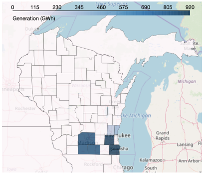


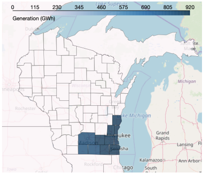


Solar deployment ramps up is specific locations...









Questions?

- Models are strategic: can show effects and costs of constraints
- Investment is closely coupled to reliability
- Run high level scenarios in close to real-time
- What futures are you interested in? Could we implement these in Werewolf?
- Is there data that you need to use but are not able to share?

Simplified two-stage stochastic optimization model

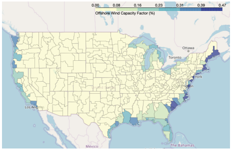
- Capacity decisions are z at cost $K(z)$
- Operating decisions: generation y at cost $C(y)$, loadshedding q at cost Vq.
- Scenarios (futures) ω, demand (load curve) is $d(\omega)$.
- Minimize capital cost plus expected operating cost:

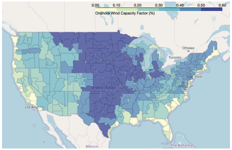
$$\begin{array}{lrcl} \min & K(z) & + & \mathbb{E}_\omega[C(y(\omega)) + Vq(\omega)] \\ \text{s.t.} & y(\omega) & \leq & z \\ & y(\omega) + q(\omega) & \geq & d(\omega) \\ & (z, y, q) & \in & X \end{array}$$

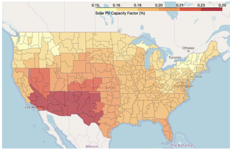
- WEREWOLF populated using data from Wisconsin: develop the model for MISO and look at Wisconsin policies in particular
- Data and structure facilitate any US regional model

The data

- 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