

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)

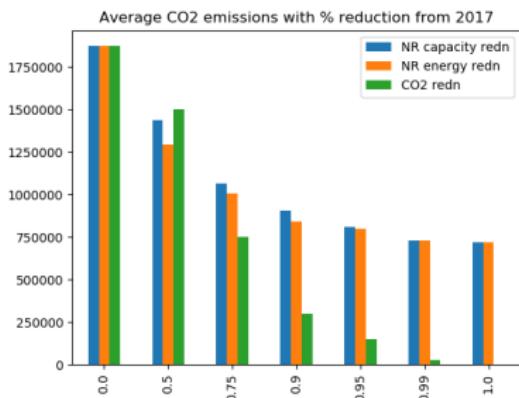
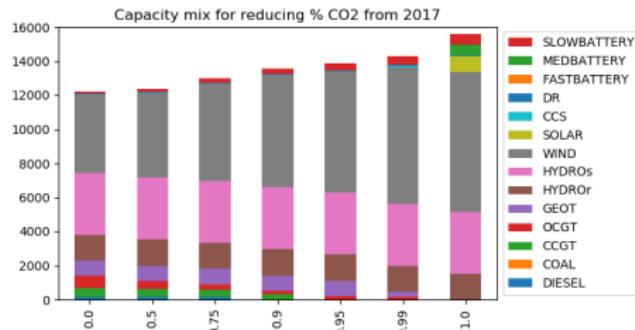
Jacques-Louis Lions Chair, and Stephen Kleene Professor of Computer Science
Computer Sciences Department and
Wisconsin Institute for Discovery, University of Wisconsin, Madison

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

Supported by Tommy G. Thompson Center on Public Leadership

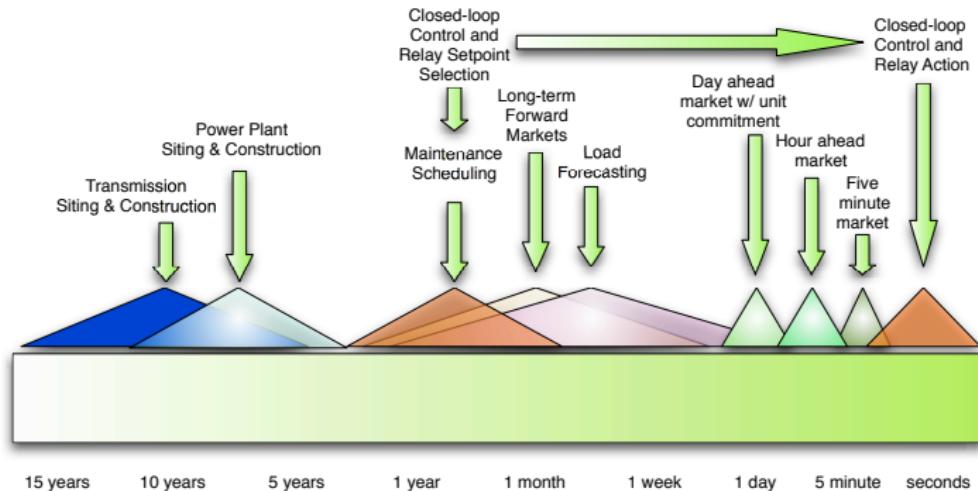
New Zealand's Zero Carbon Act

- 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)

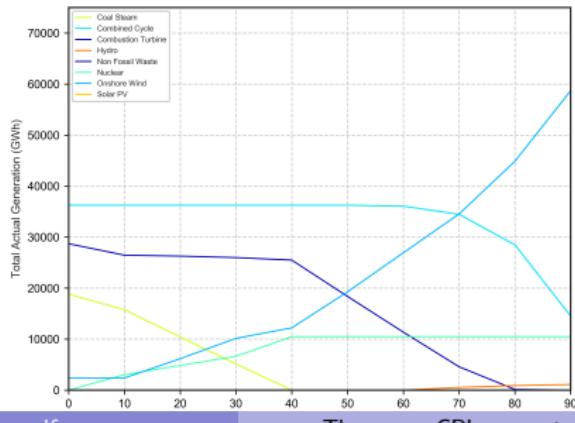
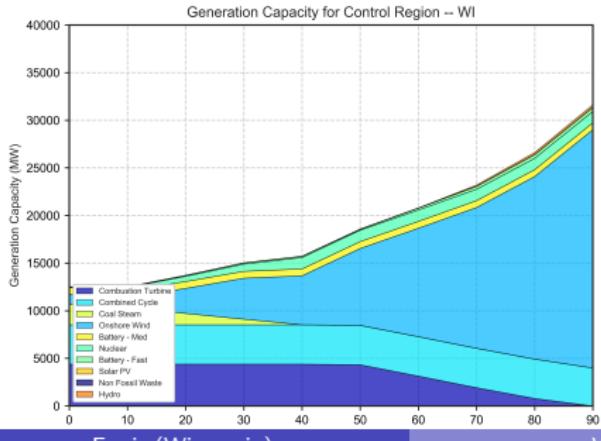
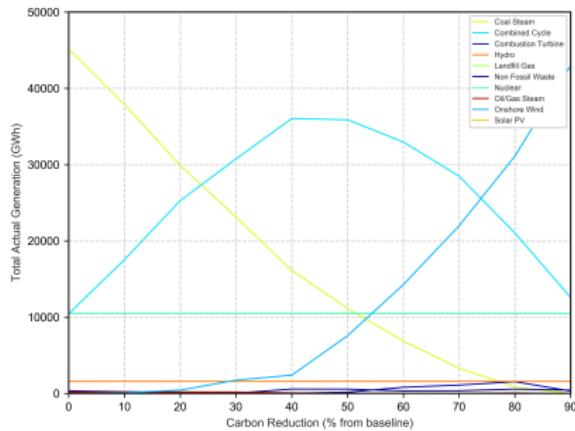
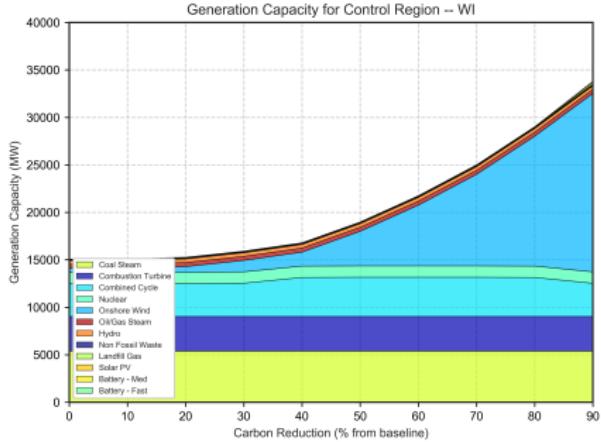


- Design/policy decisions affect operations/reliability and vice-versa
- Goal: to help policy and decision makers ...
 - ▶ to distinguish between objectives and actions;
 - ▶ to understand effects of uncertainty;
 - ▶ to understand effects of incentives;
 - ▶ to explore larger design space, **with quick 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 ≈ 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?
- Demand in 2030 is a data input, what generation portfolio needed for this new demand?

Increasing carbon reductions (without/with shutdowns)



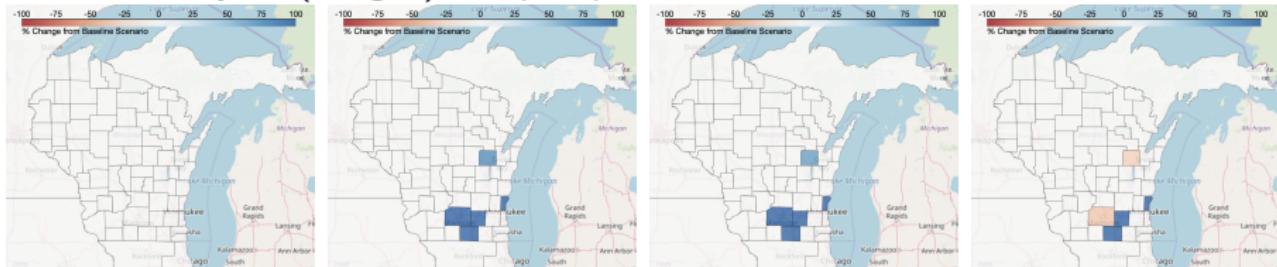
Ferris (Wisconsin)

Werewolf

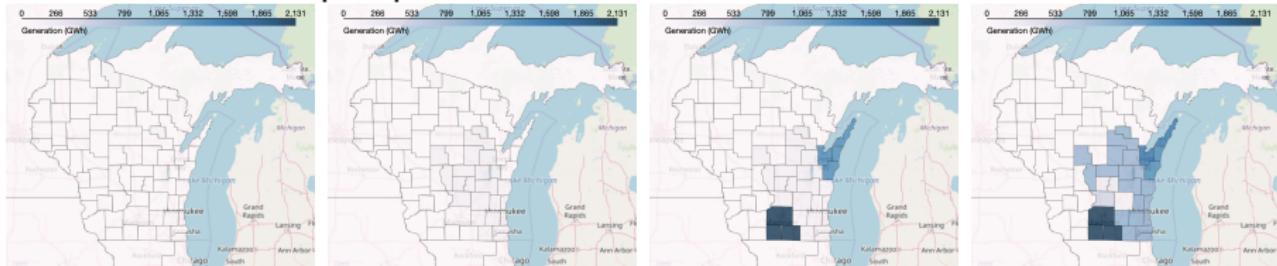
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Carbon reductions – No Plant Shutdowns

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

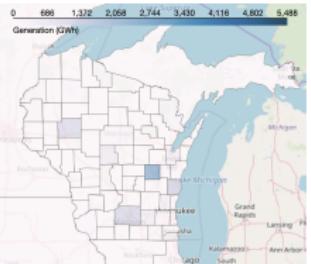
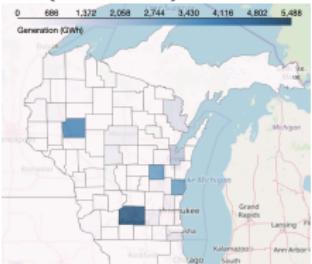
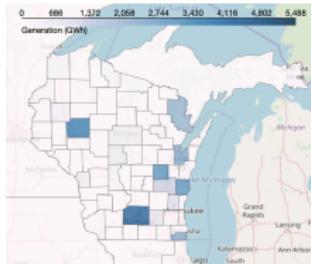


Onshore wind ramps up.

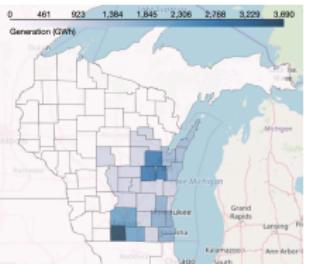
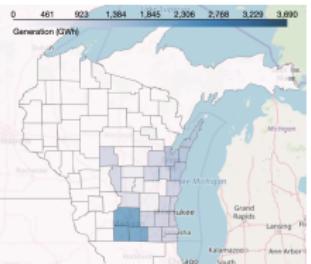
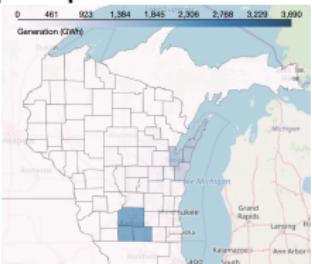


Carbon reductions – Shutdowns Allowed

Combustion Turbine (natgas) ramps down while...

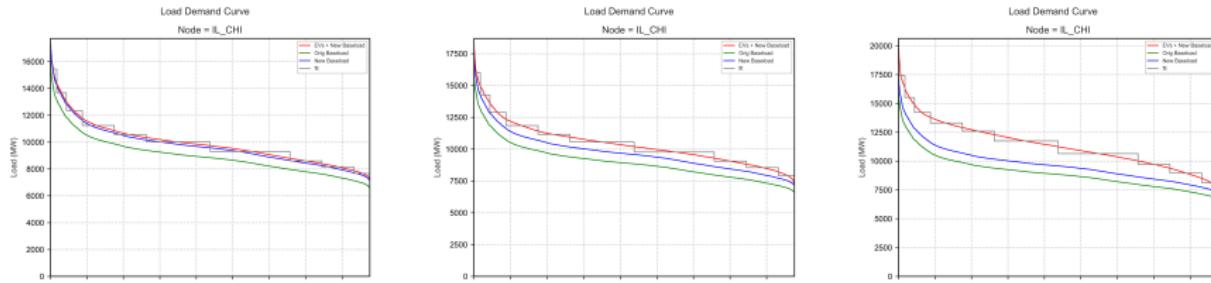


Onshore wind ramps up.



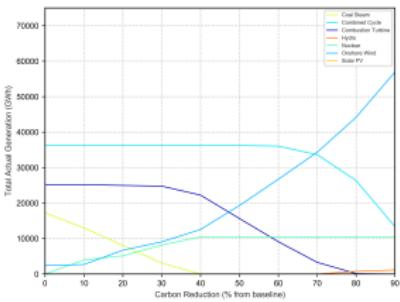
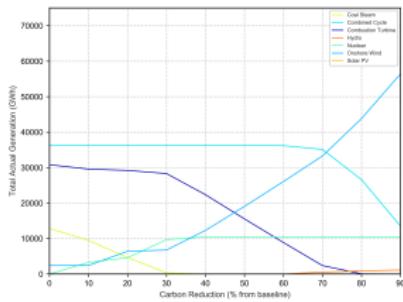
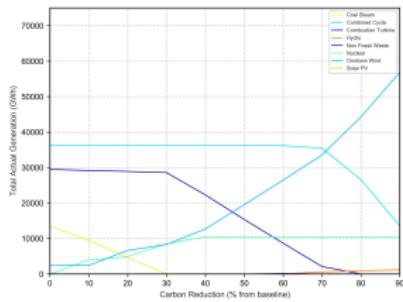
Increased demand from EVs – Shutdowns Allowed

- What if EV penetration was 5%, 20% or even 50%?
- EV charging is modeled as a periodic function
- Single daily peak occurs at 5:30pm (charging occurs primarily after work)



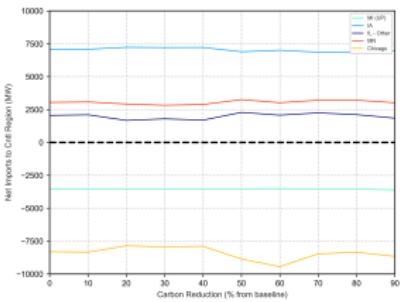
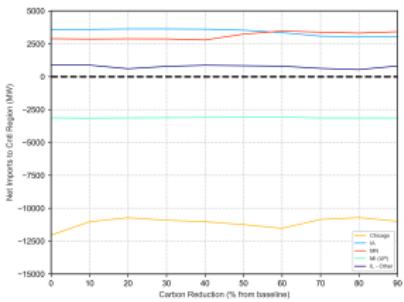
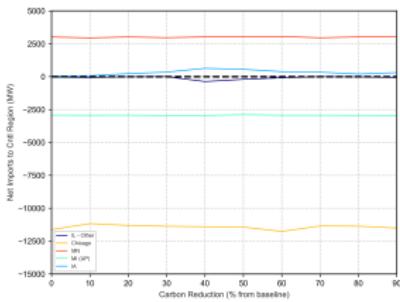
Increased demand from EVs – Shutdowns Allowed

- Wind still dominates in WI as the low carbon fuel
- Only subtle impacts from EV penetration on WI generation profile



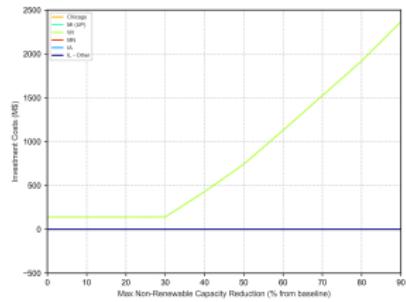
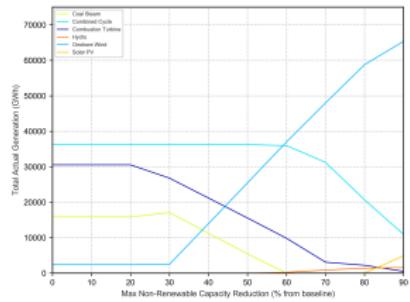
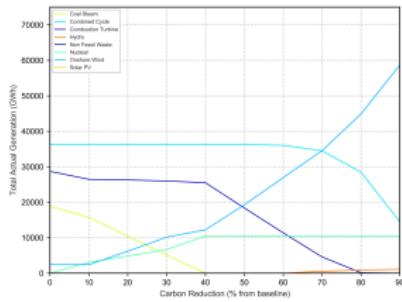
Increased demand from EVs – Shutdowns Allowed

- Larger impacts on imports/exports from other regions
- More fossil generation comes online outside of WI



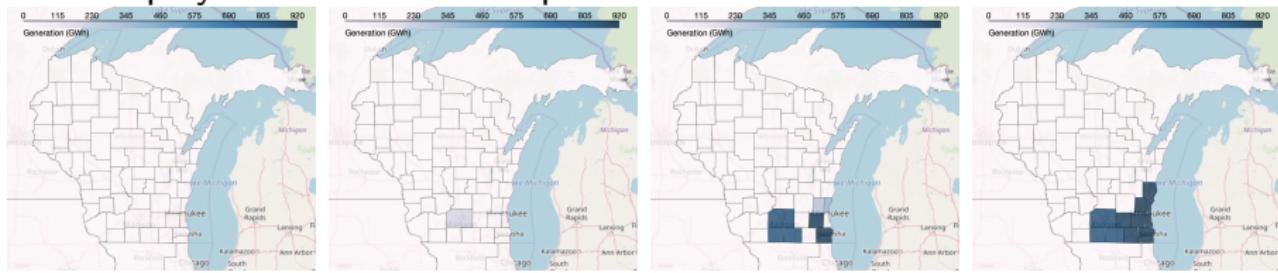
Limit non-renewable capacity

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



Limit non-renewable capacity

Solar deployment increases in 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:

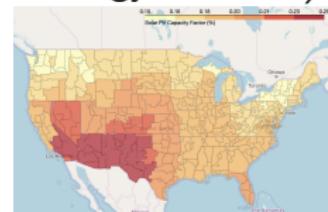
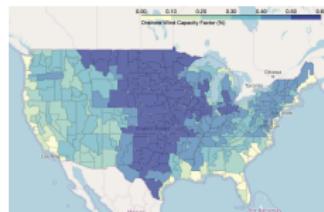
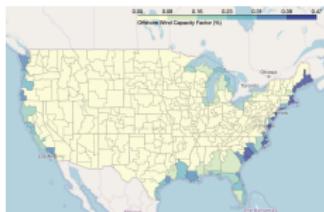
$$\min \quad K(z) + \mathbb{E}_\omega [C(y(\omega)) + Vq(\omega)]$$

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

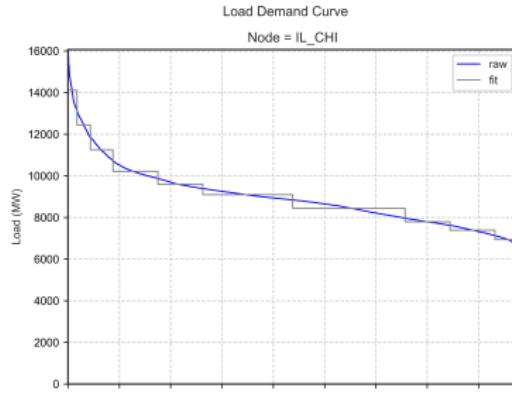
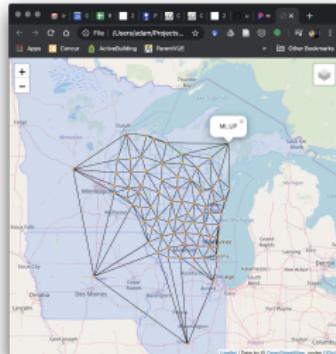
- WEREWOLF populated using data from Wisconsin: develop the model for MISO and look at Wisconsin policies in particular
- Data and structure facilitate any US regional model

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



Ferris (Wisconsin)

Werewolf

Thompson CPL support