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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Wisconsin Public Utility Institute, Board Meeting,
Madison, March 10, 2020
Supported by Tommy G. Thompson Center on Public Leadership

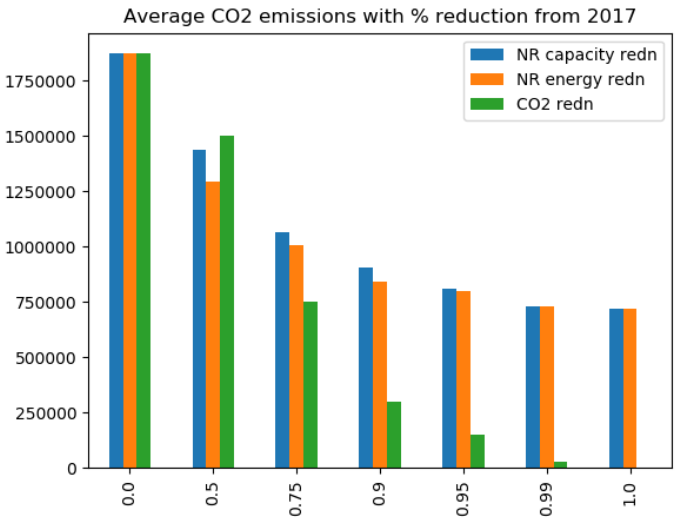
Jacinda's 2017 election deal

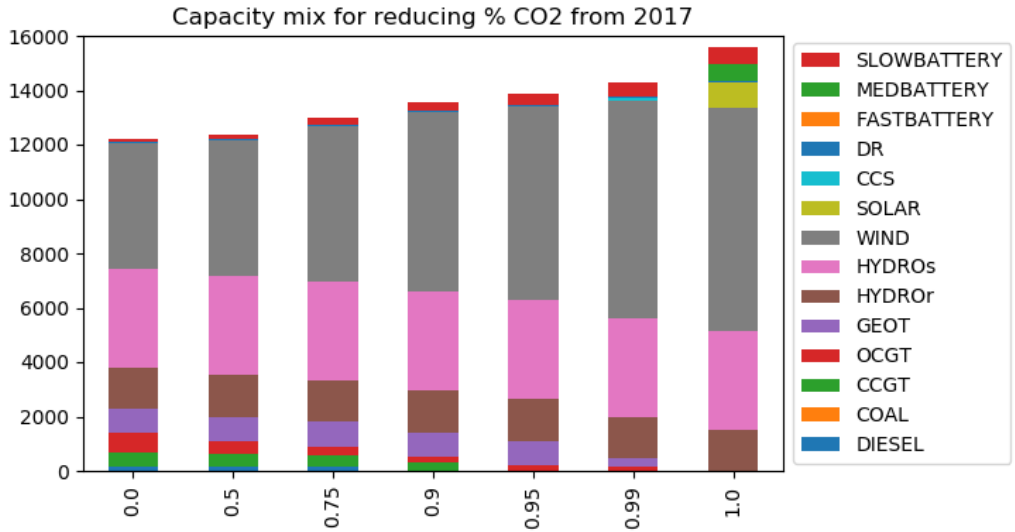
- Introduce a Zero Carbon Act and establish an independent Climate Commission.
- Request the Climate Commission to plan the transition to 100% renewable electricity by 2035 (which includes geothermal) in a normal hydrological year.
- Stimulate up to $1 billion of new investment in low carbon industries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

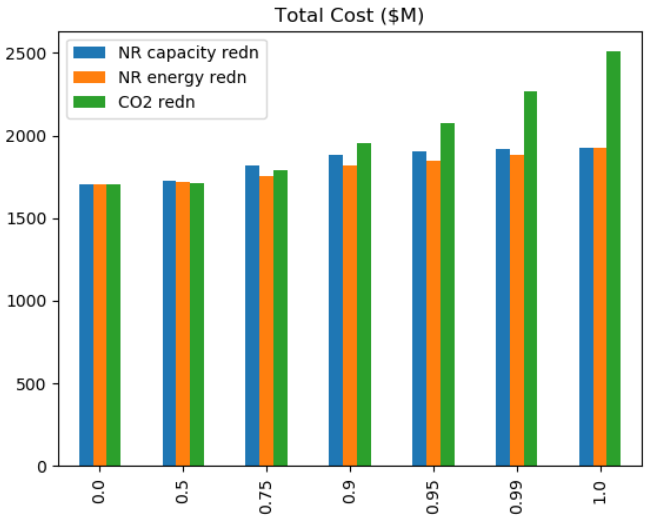
(Confidence and Supply Agreement between the New Zealand Labour Party and the Green Party of Aoteoroa)

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

New Zealand (NetZero)

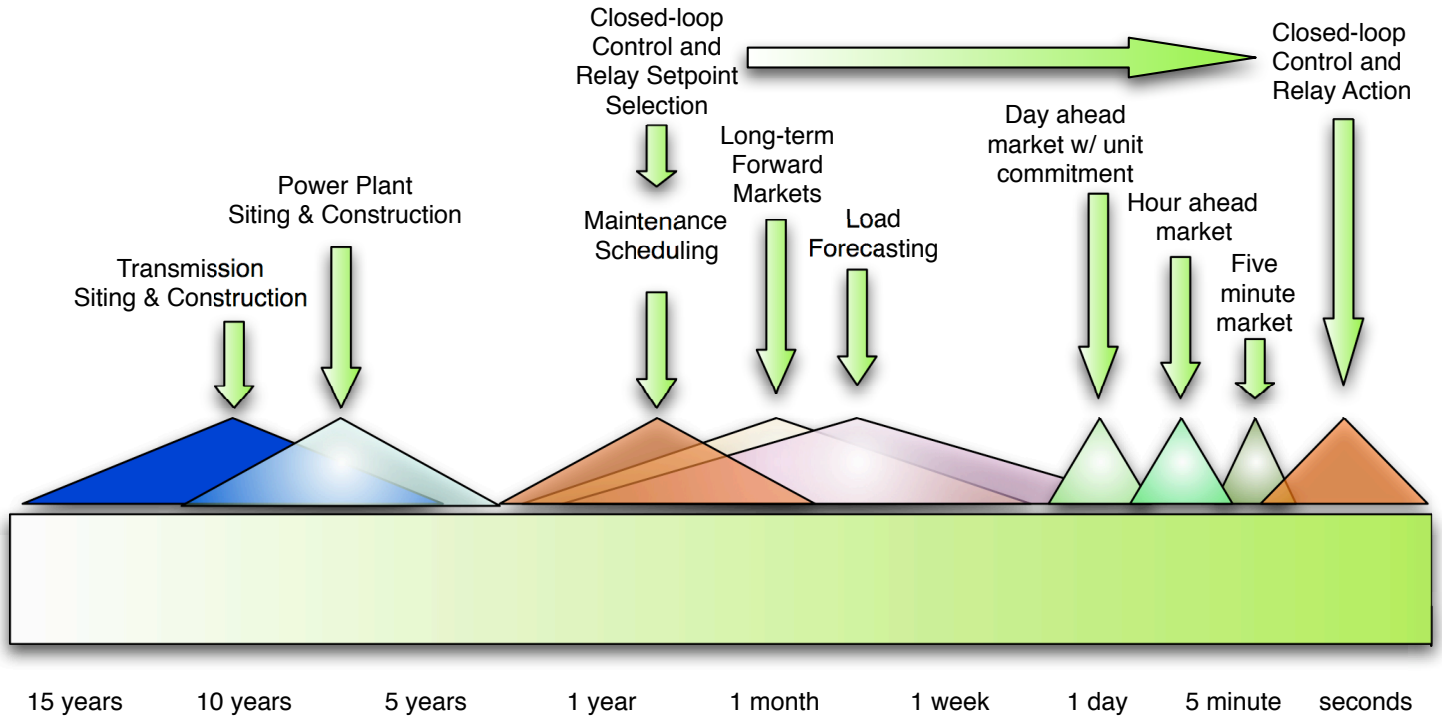






- Policies matter: affects reduction amounts and cost
- Portfolio of required technologies becomes complex as reduction increases
- Uncertainties and incentives key
- November 2019 climate act provides framework

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

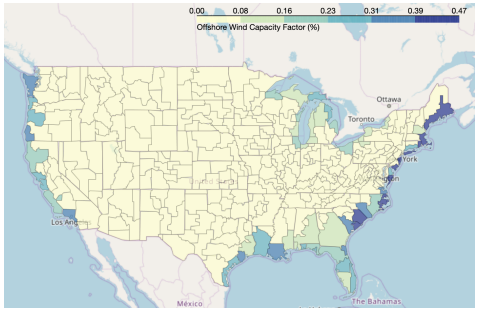
- Capacity decisions are z at cost $K(z)$
- Operating decisions: generation y at cost $C(y)$, loadshedding q at cost Vq.
- Scenarios (futures) ω, demand (load curve) is $d(\omega)$.
- Minimize capital cost plus expected operating cost:

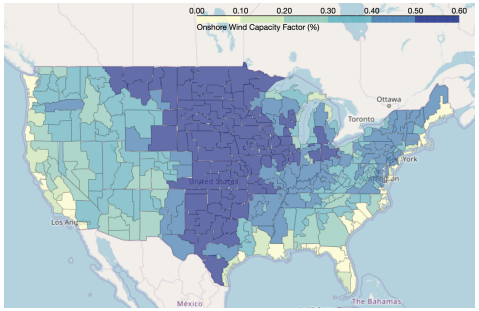
$$\begin{array}{lrcl} \min & K(z) & + & \mathbb{E}_\omega[C(y(\omega)) + Vq(\omega)] \\ \\ \text{s.t.} & y(\omega) & \leq & z \\ & y(\omega) + q(\omega) & \geq & d(\omega) \\ & (z, y, q) & \in & X \end{array}$$

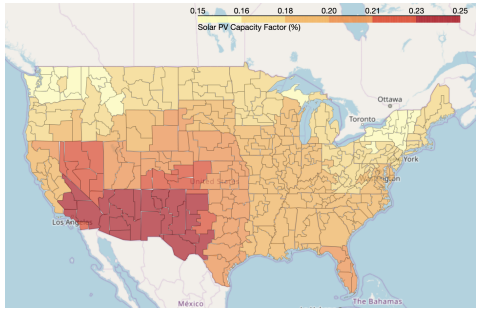
- WEREWOLF populated using data from Wisconsin: develop the model for MISO and look at Wisconsin policies in particular
- Data and structure facilitate any US regional model

The data

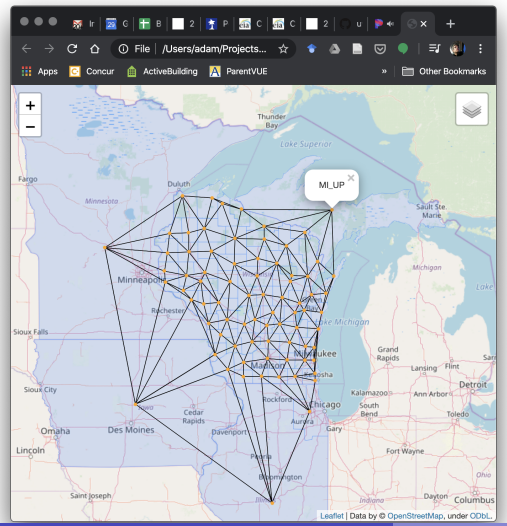
- WEREWOLF is data rich (EPA NEEDS/Integrated Planning Model, NREL ReEDS model data, NREL Annual Technology Baseline)

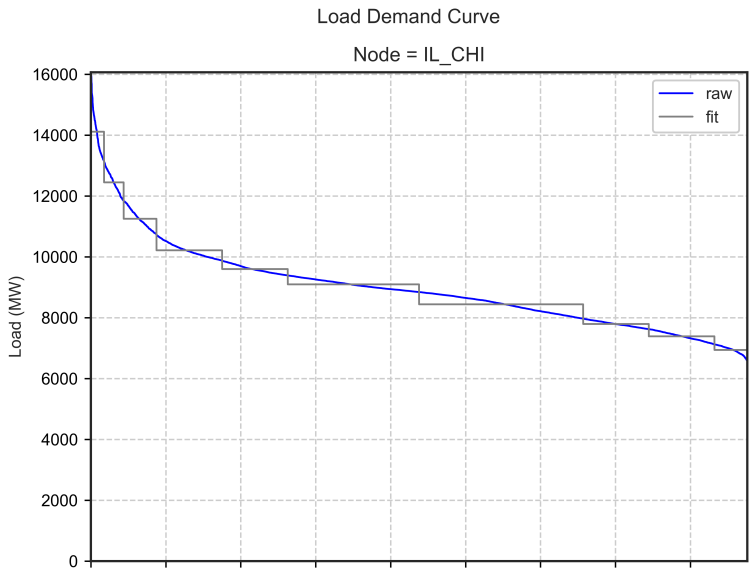






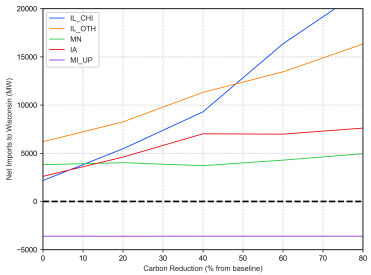
- Data is downscaled to county level - *user can customize regions as aggregations of these counties*
- Spatial impacts are captured in visualizations

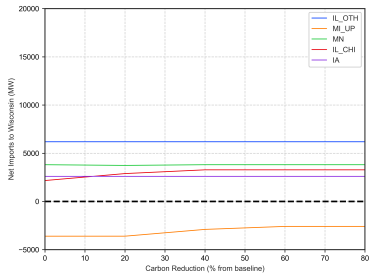


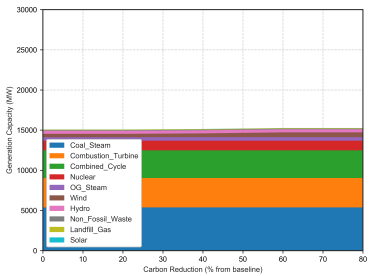


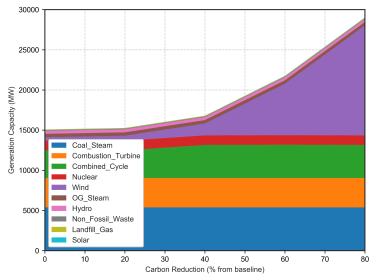
Carbon leakage (increasing or flat imports) – No Plant Shutdowns

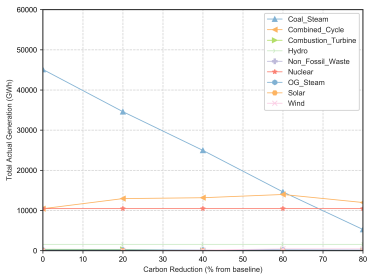
- Demand in 2030 is a data input, but what is the right investment now for this new demand?
- What is the right action (shutdown/investment) for this new demand + additional policies?











Carbon leakage (increasing or flat imports) – Shutdowns Allowed

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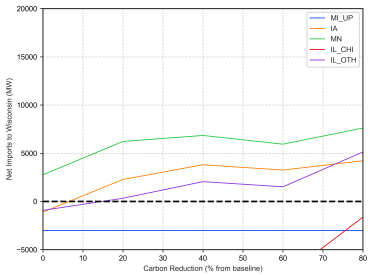
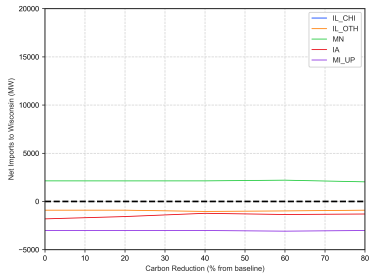
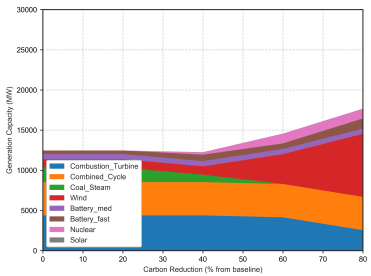
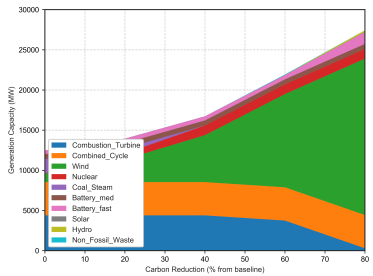
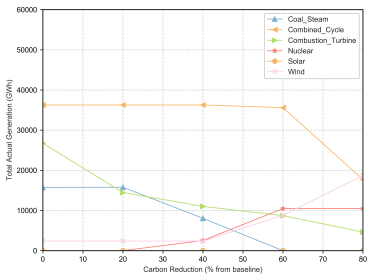




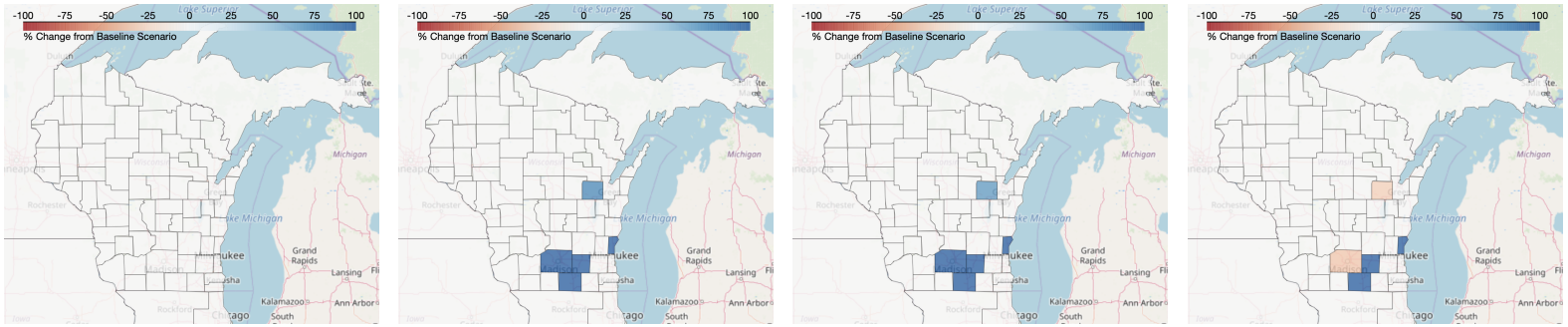




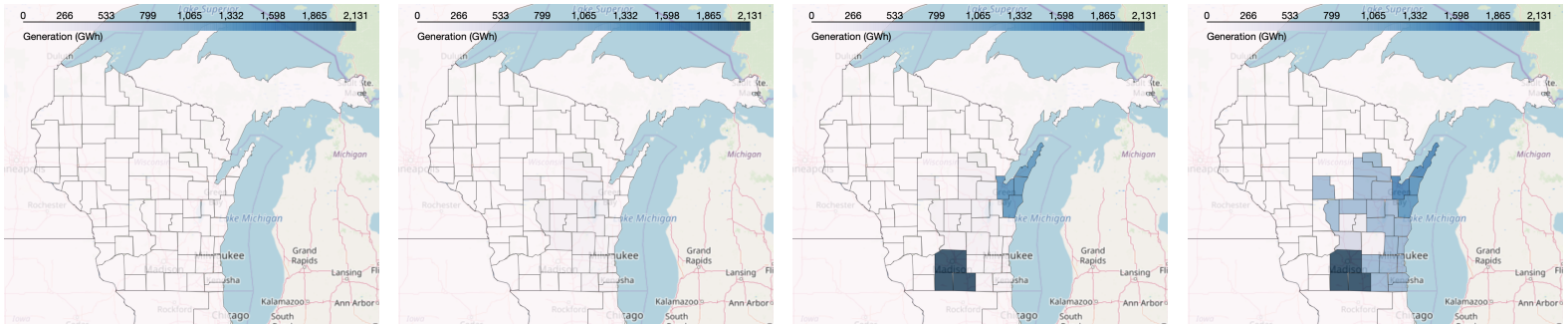


Carbon leakage – No Plant Shutdowns

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

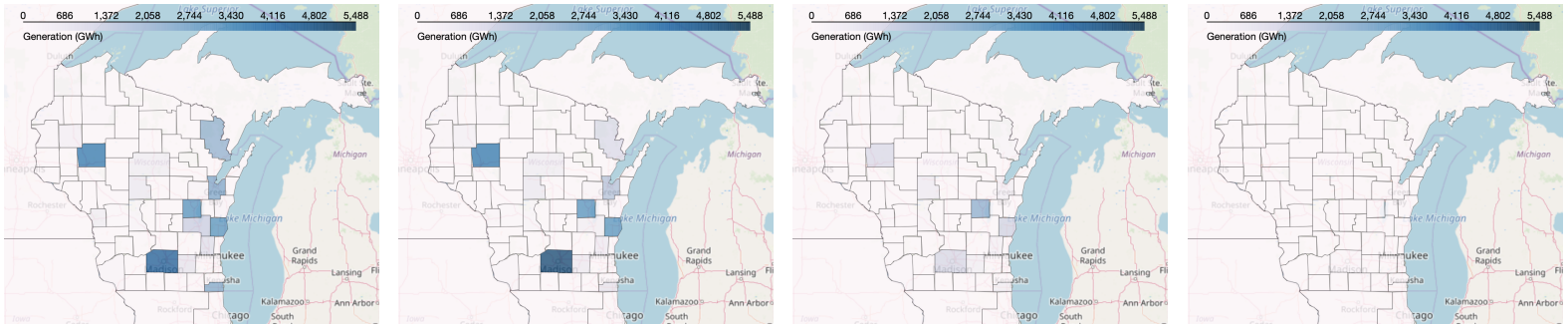


- Onshore wind ramps up.



Carbon leakage – Shutdowns Allowed

- Combustion Turbine (natgas) ramps down while...



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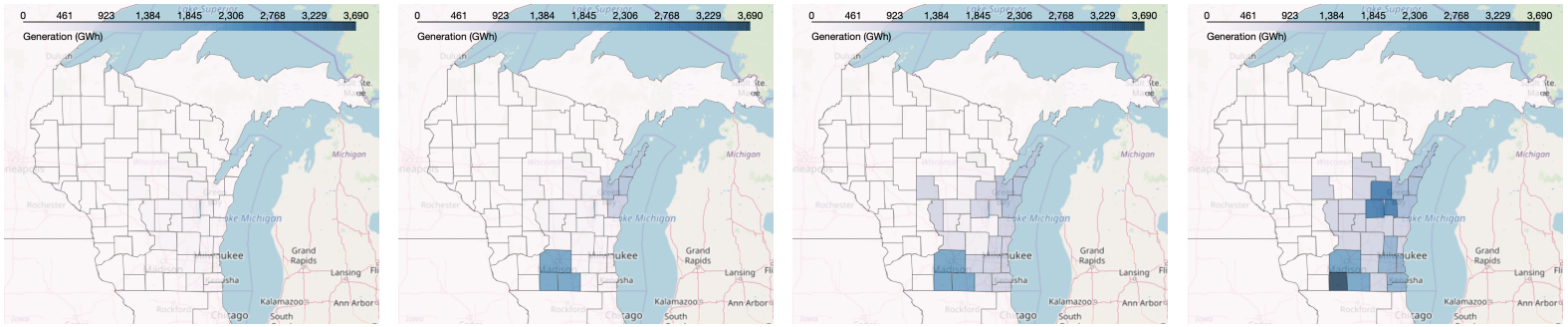
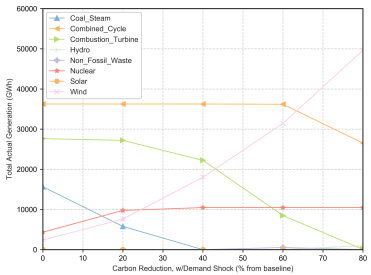


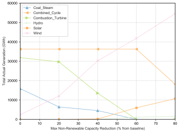
Increased demand – Shutdowns Allowed

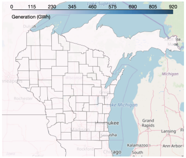
- Cost effects (and possible changes in portfolio of generation) when have increased demand. Flat imports. Shutdowns allowed
- 5% increase in demand for WI only (beyond the growth factor for 2030)
- Wind still dominates the low carbon fuel, but the demand shock incentivizes nuclear to come in back in earlier ($> 20\%$)
- Carbon emissions policy baseline is set in 2020 – more demand but same emissions cap necessitates lots of clean electricity

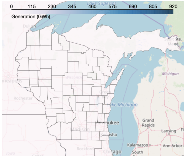


Limits on technology expansion – Shutdowns Allowed

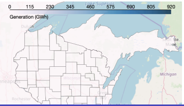
- Policy Experiment - limit capacity expansion on all non-renewable technologies.
- Can expect huge increases in solar and wind, but where?
- Model does not consider nuclear as a renewable technology in this experiment
- Expansion of combustion turbines for 2030, but then they ramp down as capacity limit grows

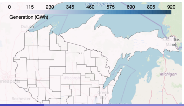


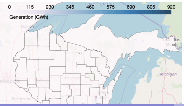




- Solar deployment ramps up...







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).