WEREWOLF in London: Minding the Gap with User-Friendly Energy Optimization Tools Informing Policy Makers through the Energy Transition

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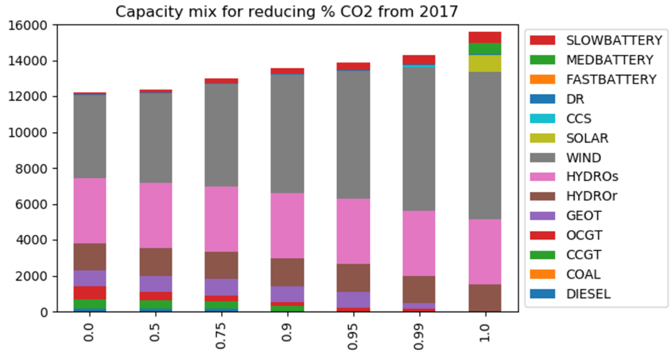
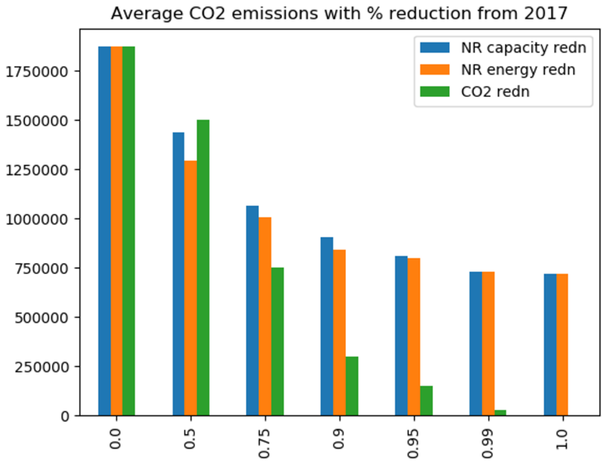
GEMSTONE model was used to inform New Zealand's Zero Carbon Act

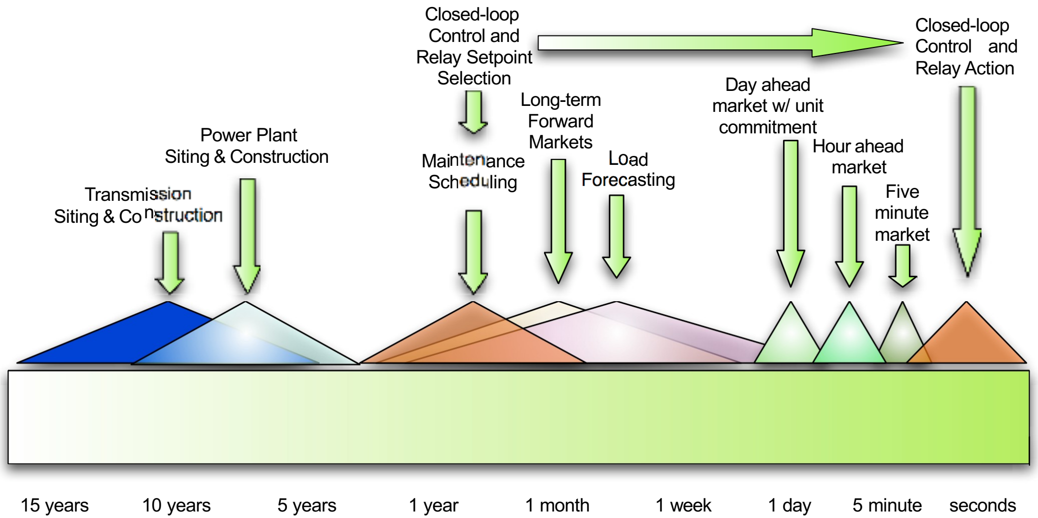
- Zero Carbon Act and new Climate Commission
- Transition to 100% renewable electricity by 2035
- Stimulate new investment





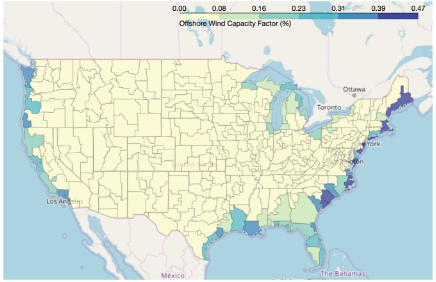
- Policies matter: affects reduction amounts and cost
- Portfolio of required technologies becomes complex as reduction increases
- Uncertainties and incentives key
- November 2019 climate act provides framework for adoption

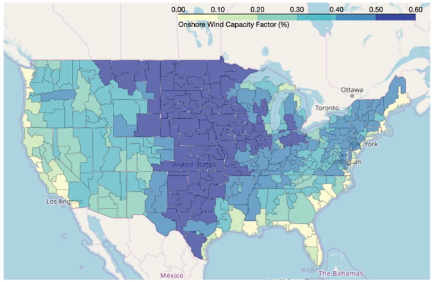
WEREWOLF (Wisconsin Expansion of Renewable Electricity with Optimization under Long-term Forecasts) informs policy....quickly

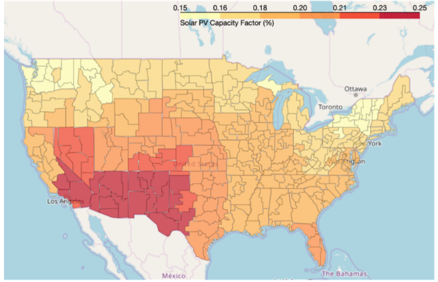


- Design/policy decisions affect operations/reliability and vice-versa
- Goal: to help policy and decision makers ...
  - to distinguish between objectives and actions;
  - to understand effects of uncertainty;
  - to understand effects of incentives;
  - to explore larger design space, with quick turnaround

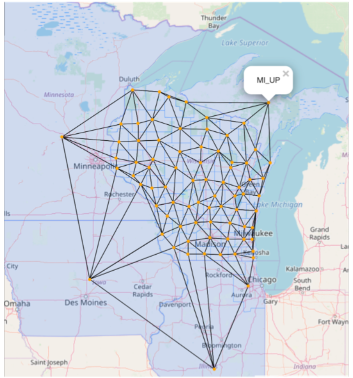
WEREWOLF uses up to date industry-leading data sources

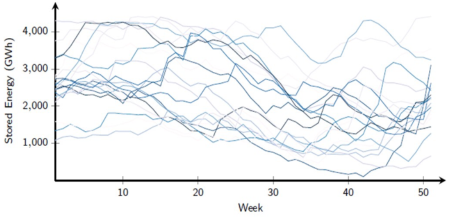


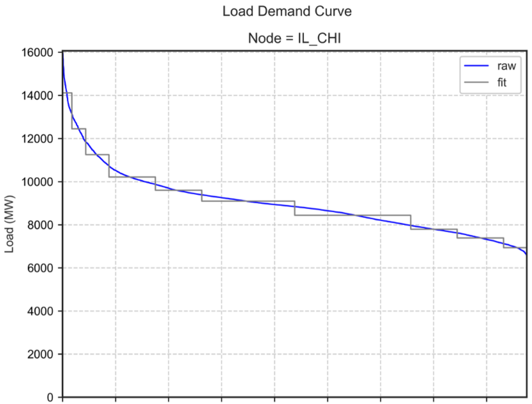




- (EPA NEEDS/Integrated Planning Model, NREL ReEDS data, NREL Annual Technology Baseline) can be updated regularly as needed
- Data is downscaled to county level - user can customize regions as aggregations of these counties
- Spatial impacts are captured in visualizations



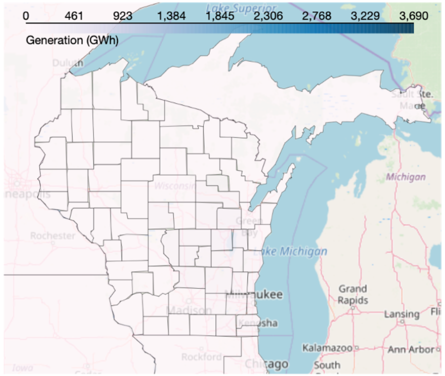


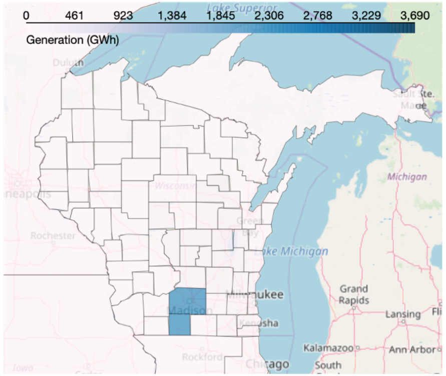


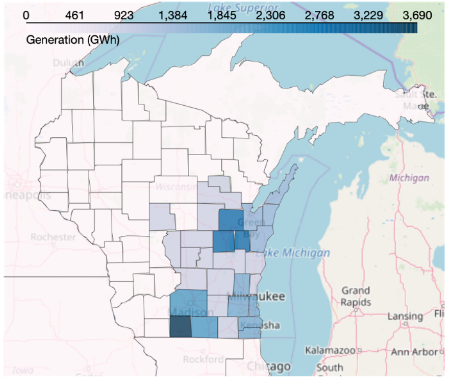
WEREWOLF uses open source code available on github

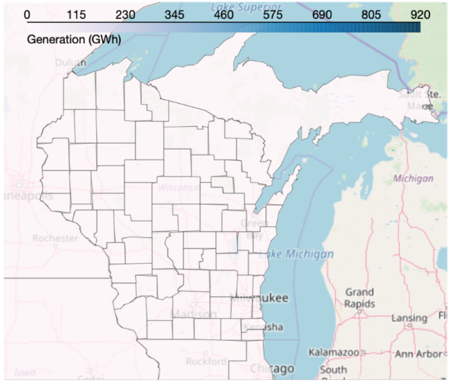
- Transparency - open source code is on github
- Data is adapted from EPA NEEDS/Integrated Planning Model, NREL ReEDS model data, NREL Annual Technology Baseline and other sources
- After data initialization, each run takes ≈ 5 mins to generate the following results
- Show effects of strategies driving towards 100% carbon free energy by 2050, coal plant closures, rapid deployment of renewables, increase in electric vehicle (EV) uptake, for example
- Demand in 2030 is a data input, what generation portfolio needed for this new demand?
- Model and app exercised with utility executives and state regulators (Wisconsin Public Utility Institute, Public Service Commission of Wisconsin, and WI Office of Sustainability and Clean Energy)

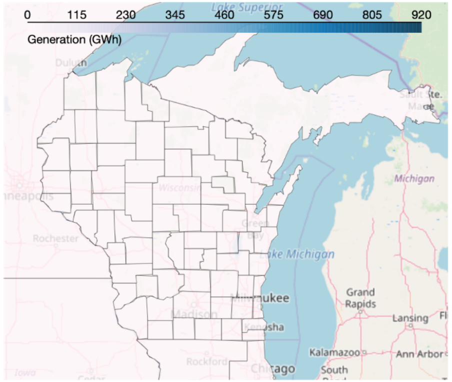
WEREWOLF model outputs: Renewable increases (wind and solar) for 0%, 40%, 80% carbon reduction policy scenarios in State of Wisconsin, USA

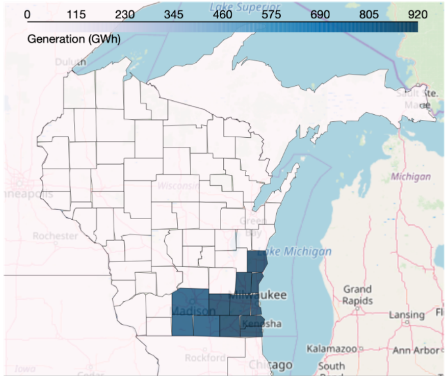




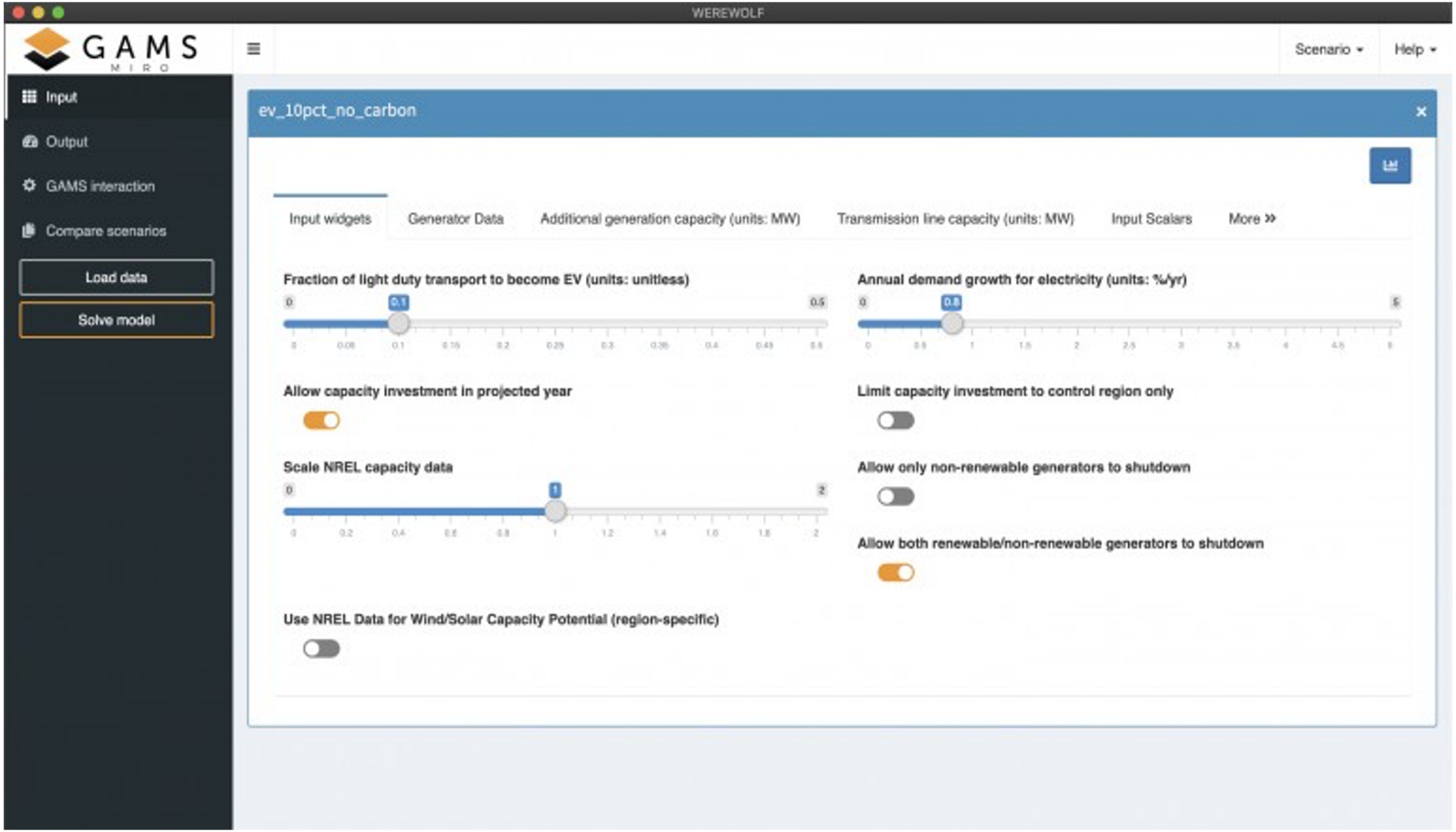




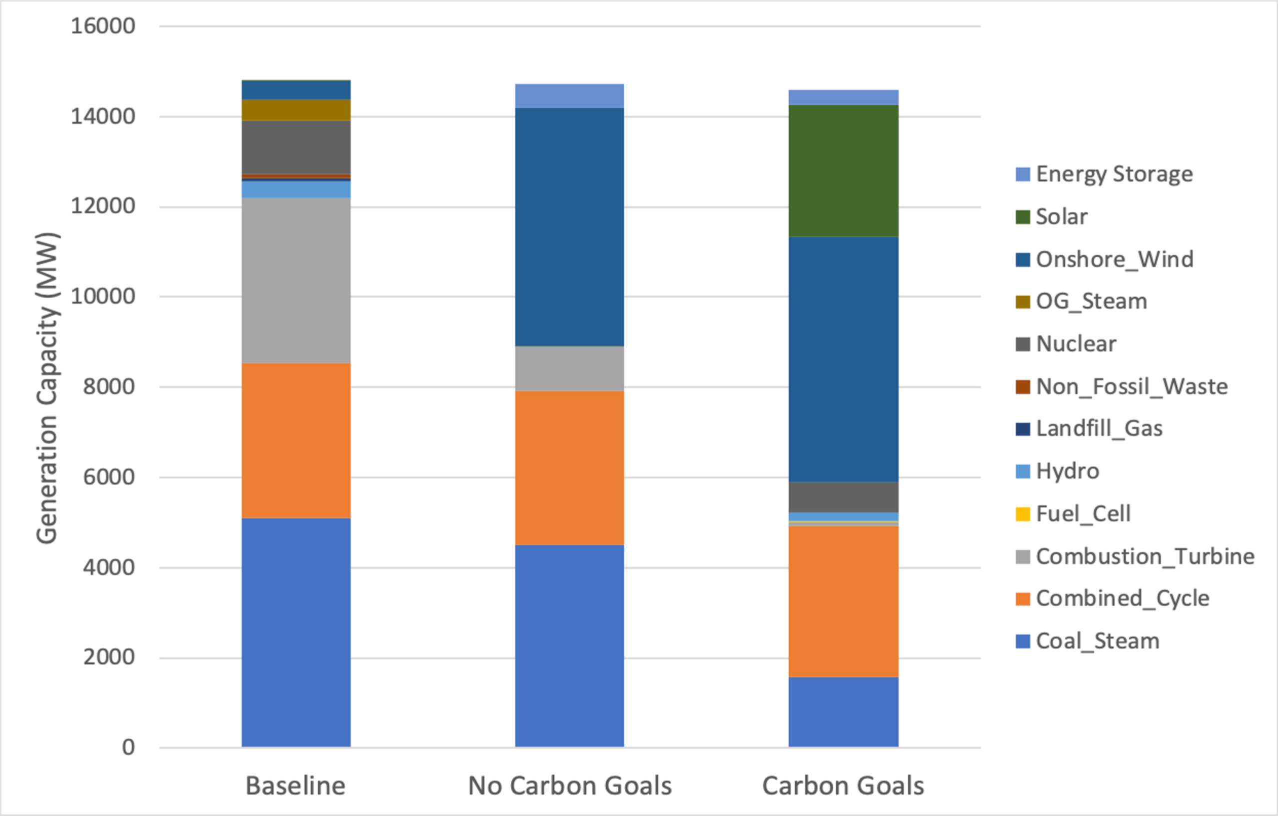




WEREWOLF: User-friendly configuration using interactive GAMS MIRO app

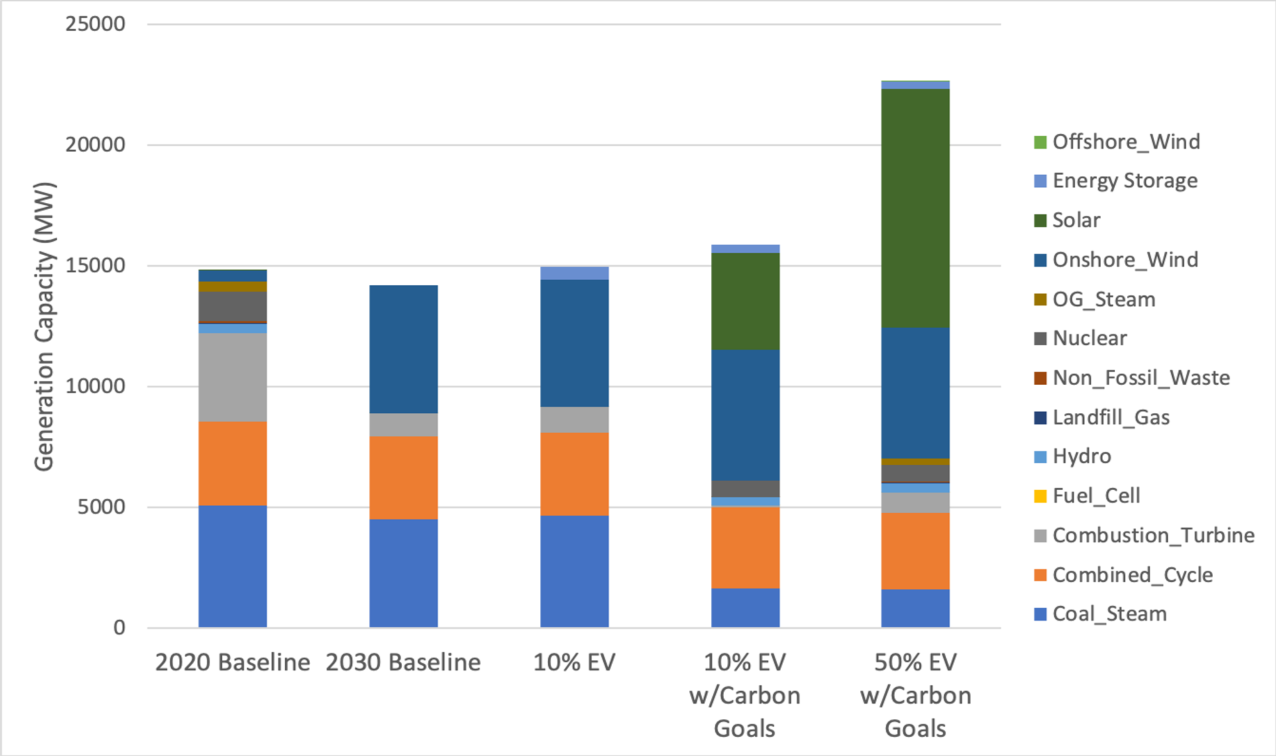


Generation capacity mix in 2020/2030 for different policy scenarios



- No Carbon Goals: overall system costs are minimized, without a carbon constraint
- Carbon Goals: 60% reduction on in-state carbon emissions by 2030
- Nuclear (low-carbon) used when deep carbon reductions are necessary
- Coal steam generators are shut down, supplanted by renewables
- Storage to arbitrage across time slices
- Caps on investment are modifiable

Impact of Electric Vehicle Deployment on Generator Investments



- Model widespread adoption of light duty electric vehicles (EVs)
- Additional 180,000 MWh demand per year
- Storage investment needed
- No significant CO2 reduction
- Additional demand and/or imposing carbon goals necessary for more dramatic effects

How can WEREWOLF add value to your next energy decision?

- Models can and should inform policy
- Models demonstrate effects and costs of constraints
- Investment is coupled to reliability
- Run high level scenarios in close to real-time – quick and interactive
- We are interested to get feedback from utility and policy experts about how this model/app would be useful in your utility and regulatory planning and evaluation efforts
- One-on-one demonstrations of model, suggestions of possible policy interventions
- Contact at: ferris@cs.wisc.edu or see https://werewolf.discovery.wisc.edu

WEREWOLF: two-stage stochastic optimization model (simplified)

- 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:

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

- 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 or EU model