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

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Werewolf

Who are we, what are we doing.

This talk is about

- Operations research: helping government policy ...
  - to distinguish between objectives and actions;
  - to understand effects of uncertainty;
  - to understand effects of incentives.

Simplified two-stage stochastic optimization model

- Capacity decisions are z at cost $K(z)$
- Operating decisions are: generation y at cost $C(y)$, loadshedding r at cost Vr.
- Random demand is $d(\omega)$.
- Minimize capital cost plus expected operating cost:

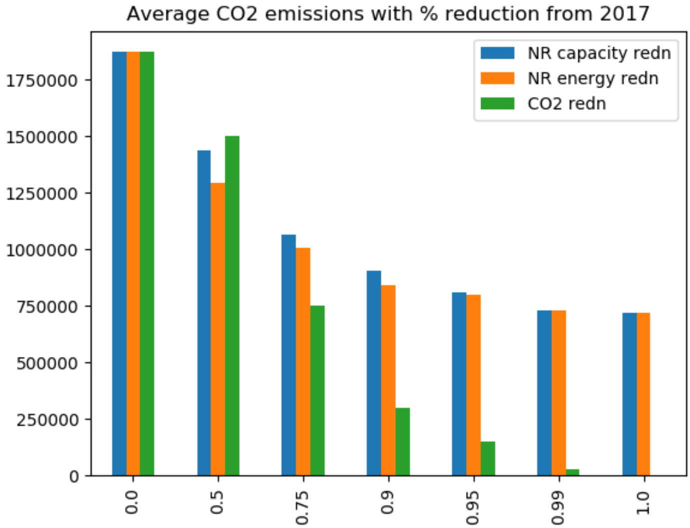
$$
\begin{array}{llrcl}
\text{P:} & \min\limits_{(z,y,r)\in X} & K(z) & + & \mathbb{E}_{\omega}[C(y(\omega)) + Vr(\omega)] \\
& \text{s.t.} & y(\omega) & \leq & z \\
& & y(\omega) + r(\omega) & \geq & d(\omega)
\end{array}
$$

- Model populated using data from Wisconsin

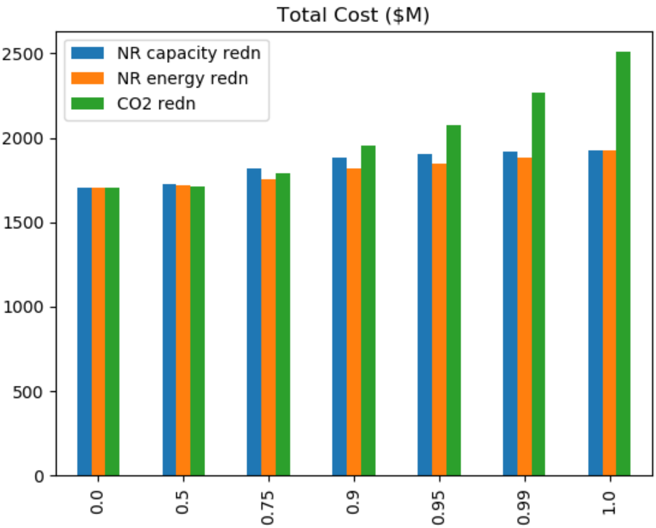
Environmental constraints

Some capacity z_k, $k \in \mathcal{N}$, is "non renewable". Some generation $y_k(\omega)$, $k \in \mathcal{E}$ emits $\beta_k y_k(\omega)$ tonnes of CO2. For a choice of $\theta \in [0, 1]$ constraint is either:

1. Reduce CO2 emissions compared with 2017:
2. Reduce non-renewable capacity compared with 2017:
3. Reduce non-renewable generation compared with 2017:

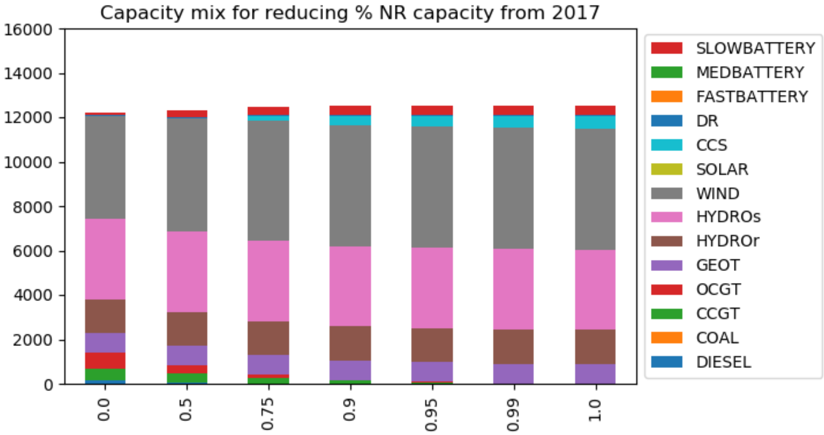


Since (renewable) geothermal and CCS emit some CO2 100% renewable yields modest reductions in CO2 emissions.



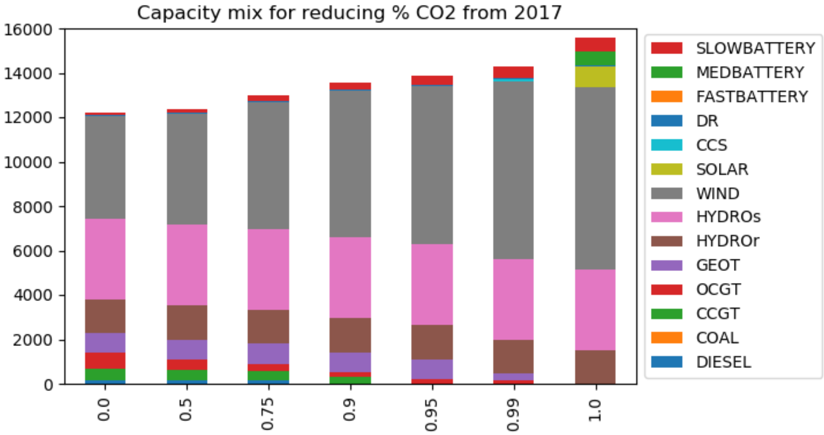
Cost of actually reaching zero CO2 emissions (without geothermal or CCS) increases as we approach the limit.

Technology choices as θ increases (NR capacity redn)



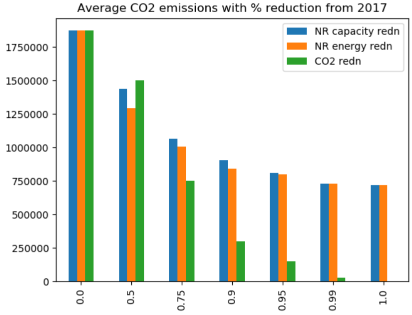
- Use geothermal, CCS, wind, batteries
- Fairly constant capacity

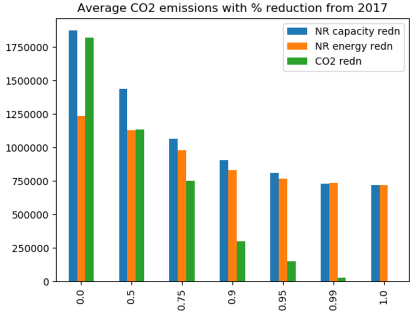
Technology choices as θ increases (% CO2 redn)



- Rich portfolio of renewable technologies used
- More capacity needed as more uncertain generation

Carbon emissions (almost sure)





- Average reduction, vs reduction *in every scenario*
- Significant differences only at relatively low levels of CO_2 reduction
- Single year, 2005, in which the emissions are significantly higher than all the others in the average case, but is compensated for by reduced emissions in other years.

Conclusions

- Models can inform policy
- Models can show effects and costs of constraints
- Investment is coupled to reliability
- Very large scale models (many agents with many instruments acting strategically) with risk are hard
- New algorithms enable solution of more detailed, authentic problems and address underlying policy questions
- Evaluation via simulation computations and out-of-sample testing