REGIONAL VARIATION IN POWER PLANT TURNOVER RESULTING FROM THE TIMING OF CLIMATE CHANGE POLICY

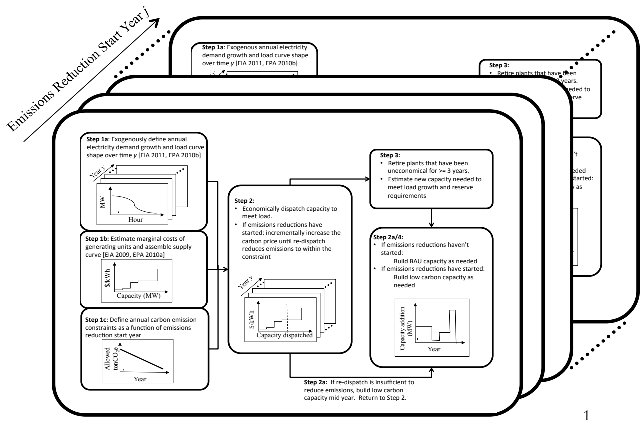
Catherine F. Izard,[1,2] Inês Lima Azevedo,[2] Constantine Samaras,[3] H. Scott Matthews,[1,2] and Chris T. Hendrickson[1]

[1] Dept. Civil & Environmental Engineering, Carnegie Mellon University; [2]Dept. Engineering & Public Policy, Carnegie Mellon University; [3]The RAND Corporation, Pittsburgh

MOTIVATION

Achieving significant emissions reductions of the electricity grid will require a radical change in the technology mix of the U.S. electricity sector (Johnson and Keith, 2004). The inertia in the electricity sector makes such rapid change difficult. Morgan et al. (2005) estimate that building an average of 25 GW of zero-carbon capacity a year between 2010-2050 can meet 100% of projected demand with carbon-free electricity. Given that the historical single-year maximum construction of carbon-free energy was 10GW (1986; primarily nuclear), this represents an enormous undertaking. Delaying the transition to low-carbon electricity compounds this problem: construction must proceed more rapidly in order to meet cumulative emissions targets. It has been suggested that as decarbonization is delayed the electricity sector is likely to build new carbon-intensive fossil fuel plants to meet demand, increasing the amount of capacity that must be replaced. A rapid increase in the rate of construction may lead to increased costs and/or short-term labor and material shortages. Delay also risks the forced early retirement of newly built plants (e.g. Morgan et al., 2005). If the delay in emissions reductions does cause new plants to be retired before their capital costs are recovered, it would drastically increase the cost of emissions reductions and create a significant stranded capital problem. The potential cost of either increased construction rates or the prospect of prematurely retired capital are likely to increase political opposition to climate change abatement policy. We investigate two questions: 1. How much extra capacity must be built as a result of delaying the imposition of emissions-reduction policy? and 2. Whether delay is likely to cause large numbers of newly built plants to be forced into early retirement.

METHODS



1

Fig. 1 shows our methodology for estimating capacity turnover resulting from climate change policy. We build a dispatch-based model of the electricity sector in each NERC region. Every year in the model period (2012-2050), the grid is constrained to meet both demand and an emissions cap (if an emissions reduction policy is in place). At the end of each year, plants that have had negative profits for two consecutive years are retired. New capacity (either low carbon or the business-as-usual (BAU), depending on whether emissions reductions have started yet) is then built to meet both projected new demand and a specified reserve margin. The emissions cap is calculated annually such that cumulative emissions over the period 2012-2050 are 20% less than BAU scenario. The model is iterated over every possible emissions reduction starting year between 2014-2050. Here we present preliminary results for emissions reduction scenarios of 20%, 30% and 40% below BAU for ERCOT (Texas) as well as nationwide results at a NERC region level for the 20% below BAU scenario. In all cases, new low carbon capacity construction is a mix of 50% wind and 50% nuclear.

RESULTS: ERCOT

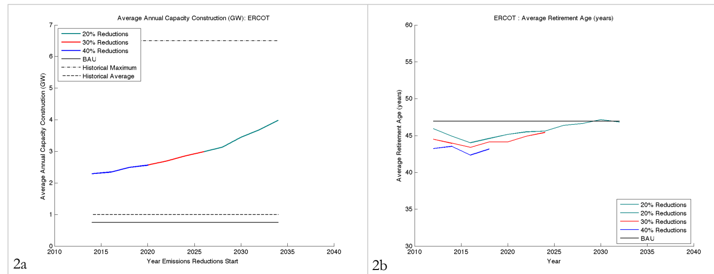
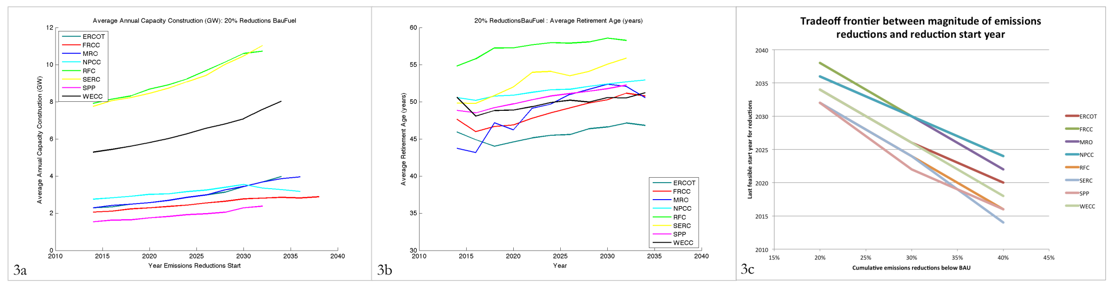


Fig. 2a shows the average annual new capacity construction in ERCOT after emissions reductions commence as a function of when emissions reductions begin, for emissions reduction scenarios of 20%, 30% and 40% below BAU. Waiting 20 years approximately doubles the rate of construction needed to meet reduction targets. All three scenarios have the same construction requirements; this is because the entire fossil fleet is replaced in all three scenarios. However, more aggressive scenarios become impossible to achieve at later starting dates.

Fig. 2b shows the average age of retired capacity after emissions reductions starts. All scenarios retire plants slightly younger than BAU, and aggressive emissions targets increase this effect. Delaying the implementation of climate change policy has little effect on the average age of retired plants

RESULTS: NATIONWIDE



Figs. 3a-3c show the effects of a 20% emissions reduction below BAU scenario for all eight NERC regions. Fig. 3a shows average annual construction rates after emissions reductions start as a function of when reductions start. The variation in the rate of new construction across regions is roughly proportional to the size of the regions. The penalty for waiting 20 years to start emissions reductions varies from 25-50%. Fig. 3b shows the average age of retired capacity in each region. The average retirement age varies by about 10 years across regions. Most regions see a slight increase—up to about 8 years (MRO)--in the age of retired capacity from waiting to begin emissions reductions. Fig. 3c shows the trade-off frontier between the aggressiveness of emissions reductions and delaying their implementation—the figure shows the point at which achieving the target becomes impossible without pulling carbon out of the air. There is about a 10 year difference across regions, with SERC needing to act the soonest and NPCC/FRCC able to delay the longest. Increasing the emissions reduction target to 40% requires starting 12-18 years earlier than a 20% reduction target.

CONCLUSIONS

Preliminary results suggest that for emissions reductions targets of 20% below BAU, waiting to implement reductions can increase the rate of capacity turnover in the electricity sector by 25-50%, depending on the region. Despite the increase in turnover, delaying the start of emissions reduction policy does not seem to cause large numbers of very young plant retirements. There is moderate regional variation in capacity turnover, mostly due to the characteristics (age and carbon intensity) of existing stock. Regional variation is the strongest when considering the last possible start date for emissions reductions, which vary by about 10 years. These results suggest that issues related to inter-regional equity should be considered when implementing a climate change mitigation policy.

REFERENCES

EIA, Annual Energy Outlook 2011 with Projections to 2035 DOE/EIA-0383. Energy Information Administration: Washington, D.C. , **2011**.
EIA, Costs and Quality of Fuels for Electric Plants DOE/EIA-0191(2009). Energy Information Administration: Washington, D.C. , **2010**.
EPA, National Electric Energy Data System (NEEDS), v. 4.10. Environmental Protection Agency: Washington, D.C., **2010a**.
EPA, Integrated Planning Model Documentation, v. 4.10. Environmental Protection Agency: Washington, D.C., **2010b**.
Johnson, T. L., Keith, D.W., Fossil electricity and CO2 sequestration: how natural gas costs, initial conditions, and retrofits determine the costs of controlling CO2 emissions. *Energy Policy* **2004,** *32*, 367-382.
Morgan, G.M., Apt, J. , Lave, L. *The U.S. Electric Power Sector and Climate Change Mitigation*. Pew Center on Global Climate Change: Arlington VA. **2005**.

This work was funded in part by the EPA STAR Fellowship.