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Consortium for Electric Reliability Technology Solutions

PSERC

Modeling Long-Run Demand Response in Electricity Markets with Carbon Markets

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- New York ISO
- Marija Ilic, Richard Schuler, Robert Thomas, Doug Mitarotonda, and Ray Zimmerman

Purpose

- Model the effects of proposed national carbon cap and trade laws using a reduced-network AC model on:
  - Carbon Prices
  - Carbon Emissions
  - Electricity Prices
  - Electricity Consumption
  - SOX, NOX emissions

Model of the Northeast

	Generation of States, Provinces in Model	Generation of US
Coal	29%	49%
Hydro	10%	6%
Natural Gas	20%	21%
Nuclear	37%	20%

PJM-East

New York

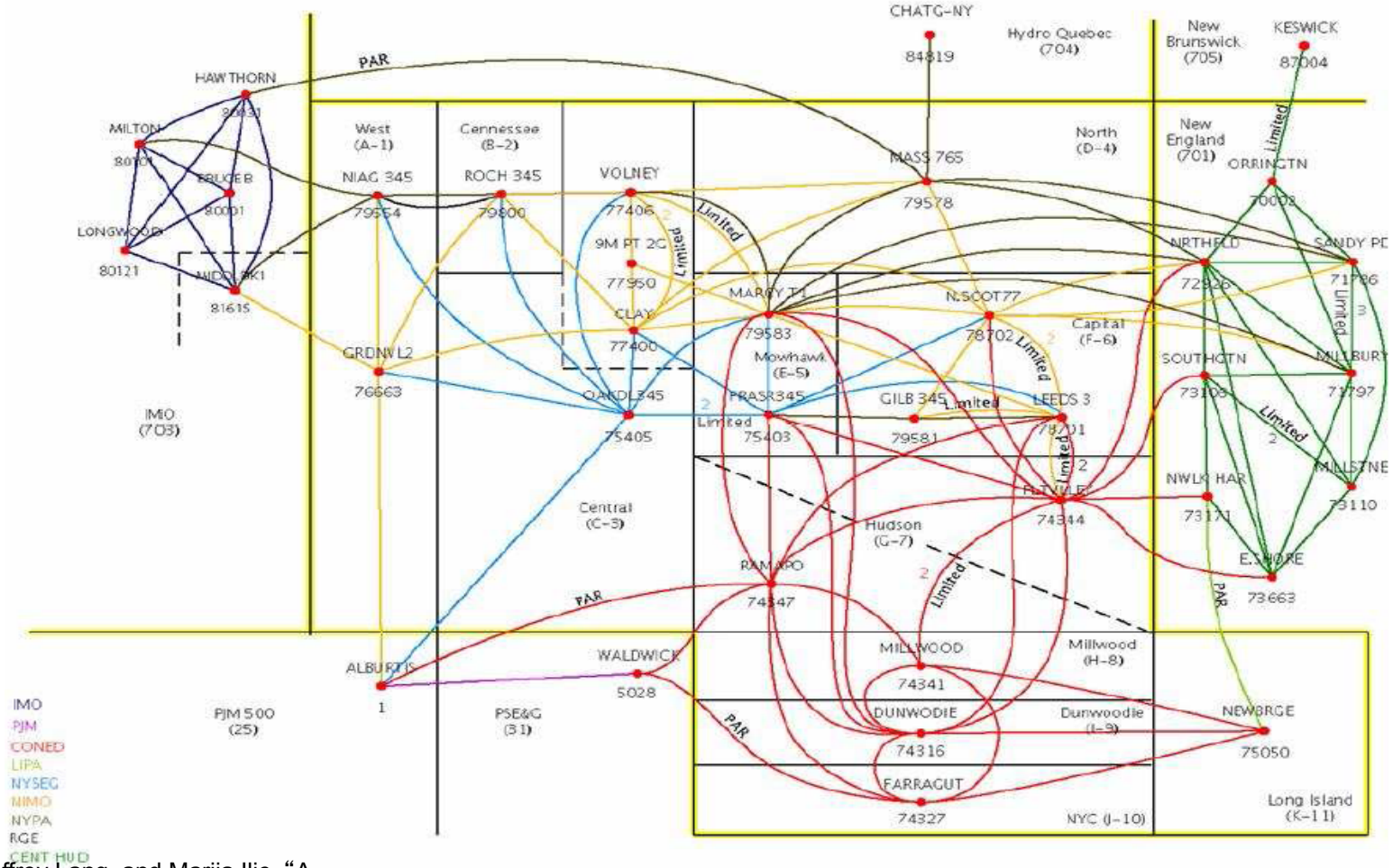
New England

Ontario

Quebec

Maritime Provinces

Model of the Northeast



Eric Allen, Jeffrey Lang, and Marija Ilic, "A Combined Equivalenced-Electric, Economic & Market Representation of the Northeastern Power Coordinating Council (NPCC) US Electric Power System," IEEE Transactions on Power Systems, Vol. 3, Issue 3, 2008

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Proposed Legislation

- Waxman-Markey American Clean Energy and Security Act of 2009 (ACESA)
- Cap relative to 2005 CO2 levels
  - 3% reduction in 2012
  - 17% reduction in 2020
- $10 CO2 price floor, plus 5% annually

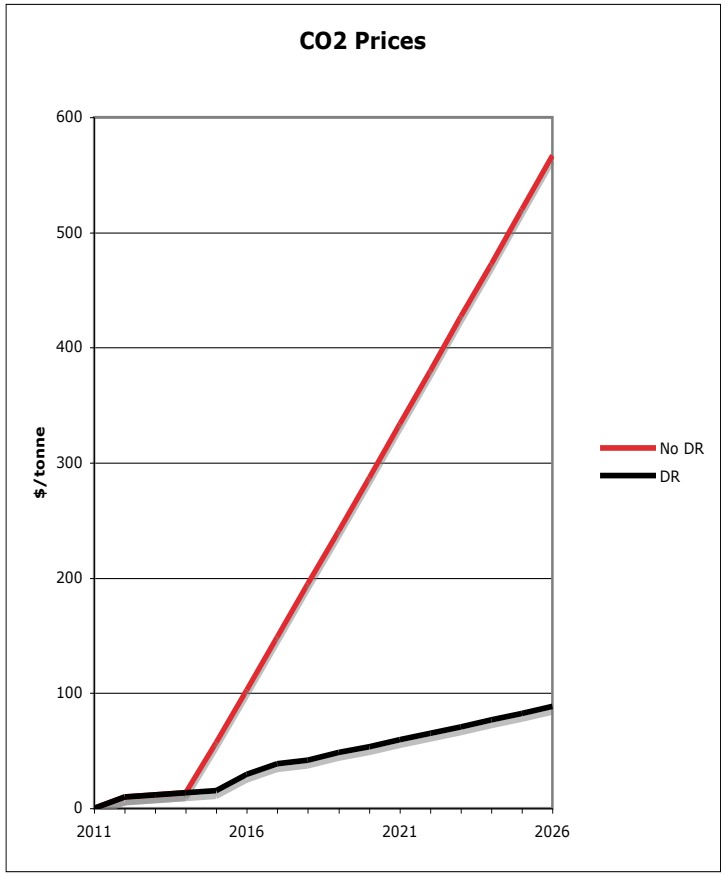
Proposed Legislation

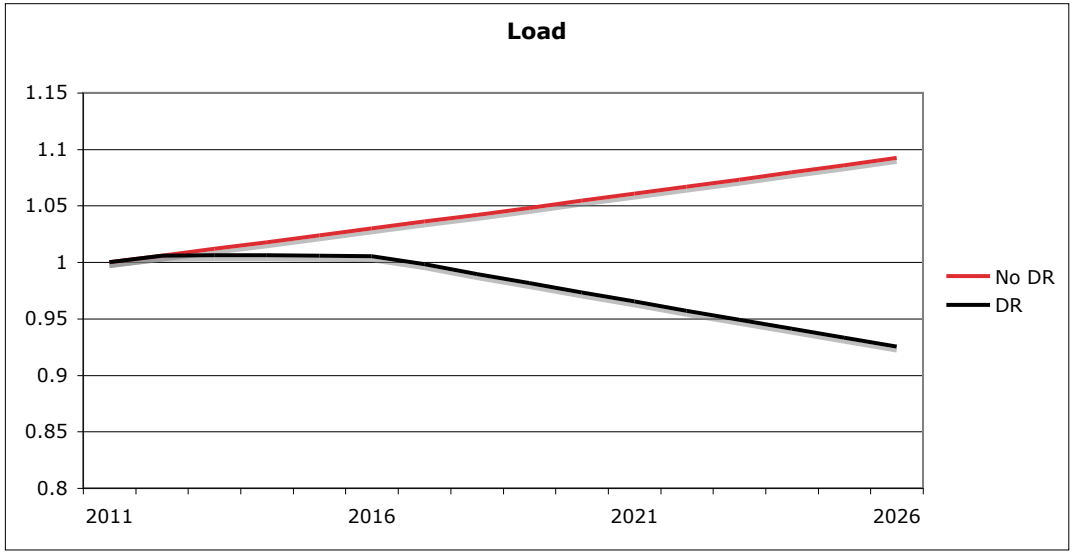
- Kerry-Lieberman American Power Act (APA)
- Cap relative to 2010 levels
  - 1.8% reduction in 2012
  - 17% reduction in 2020
- Price collar
  - $12/tonne floor, plus 3% annually
  - $25/tonne ceiling, plus 5% annually

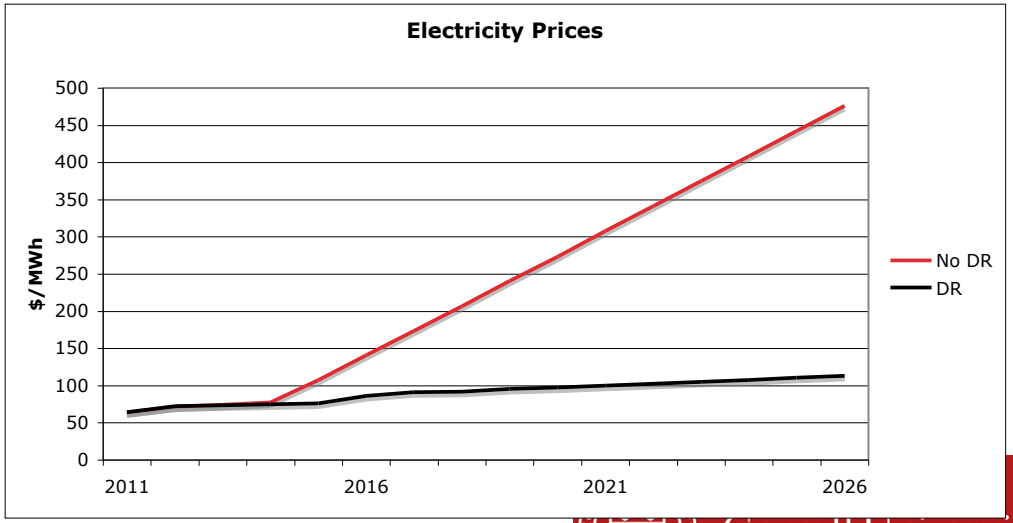
Long-Run Demand Response Model

- MATPOWER predicts reduced-model AC system
- Linear regressions fitted to output
- CO2, SO2, NOX emissions, Average electricity prices predicted by emission prices, system-wide load
- R^2 between 0.93 - 0.99

Importance of Demand Response







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Long-Run Demand Response Model

- $W_t = ([1-\alpha] \times W_{t-1}) + (\alpha \times (75+P_{t-1}))$
- $L_t = \eta \times (\% \Delta W) \times L_{t-1} + (1.0059 \times L_{t-1})$
  - W: Infinitely distributed lag of "effective retail prices"
  - P: Average wholesale electricity prices
  - L: Load
  - Vary α and η to vary speed of demand response and elasticity

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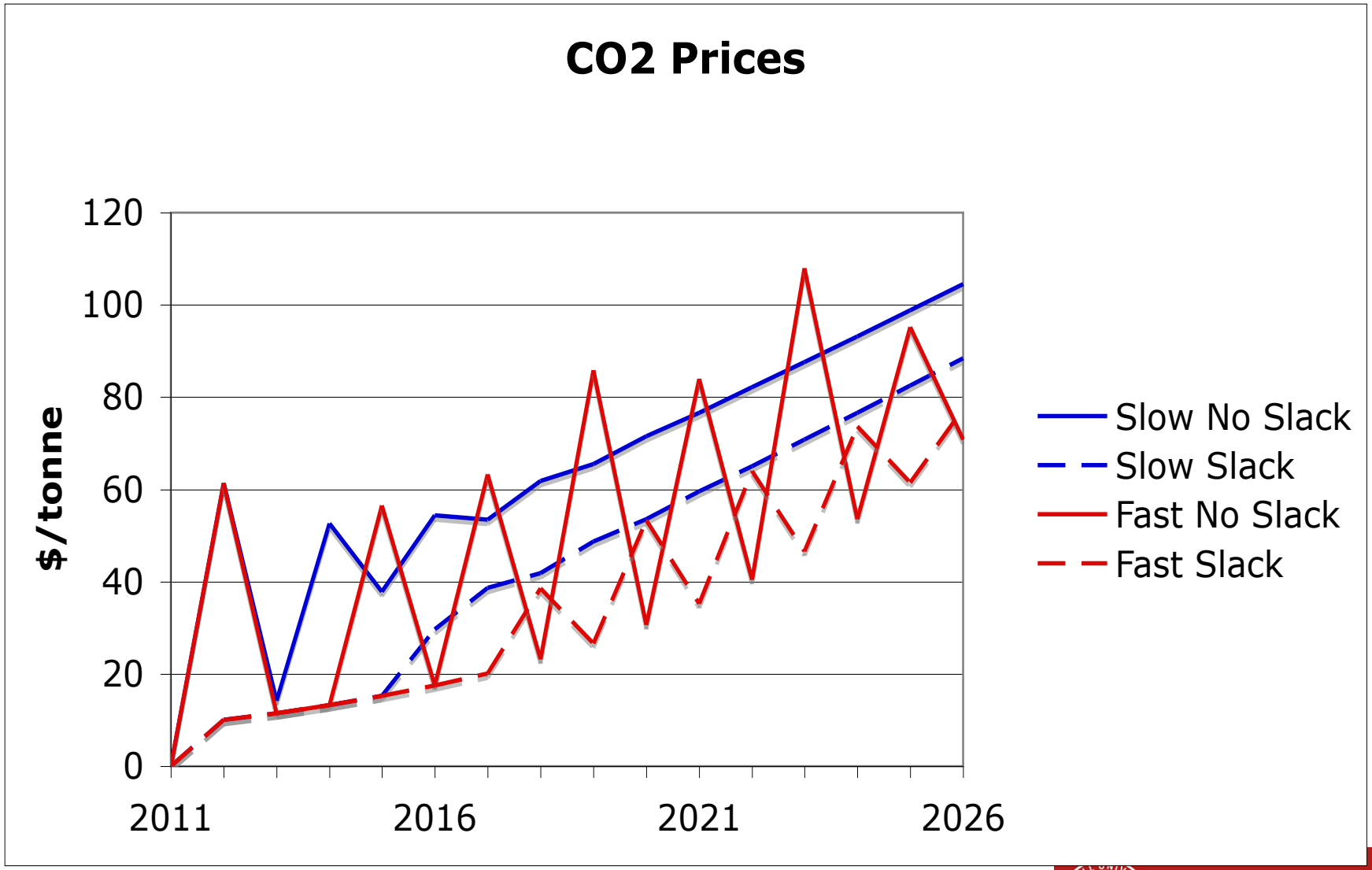
Long-Run Demand Response Model

- 1) Given W_{t-1}, L is calculated for year t
- 2) Emission prices are chosen to comply with cap
- 3) P is calculated for year t
- 4) W is calculated for year t
- 5) Back to step 1 for year t+1

Results for ACESA



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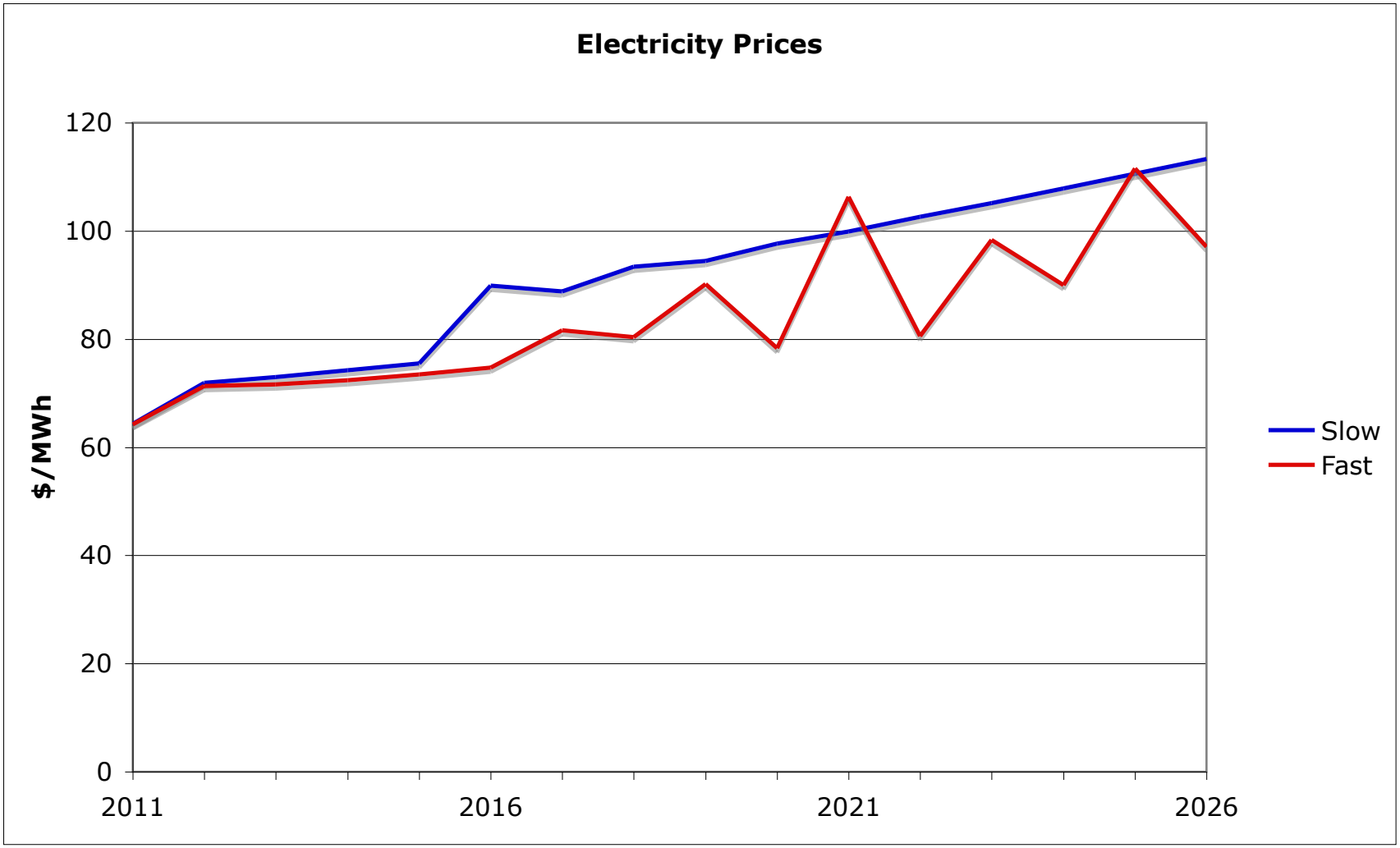
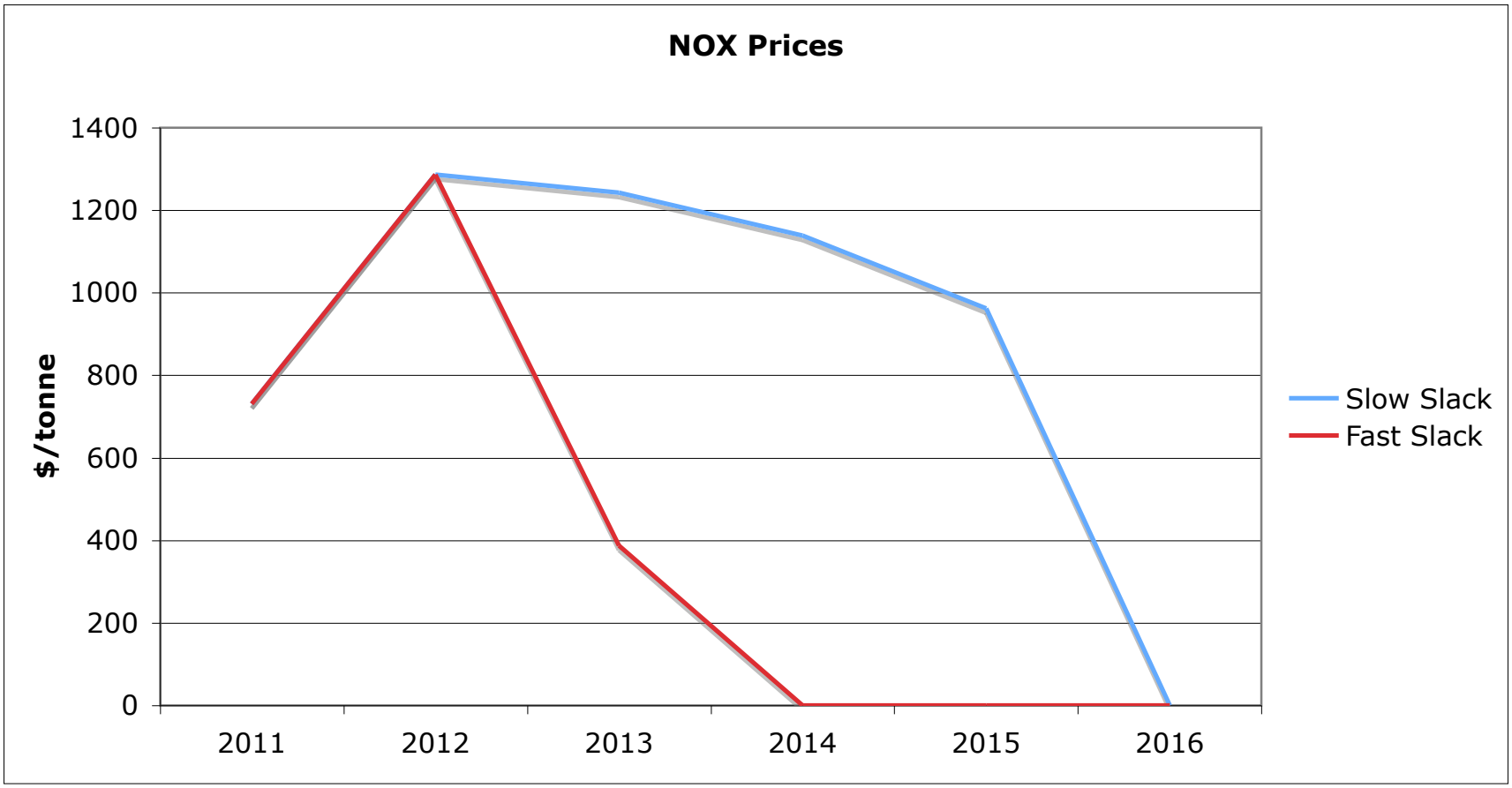
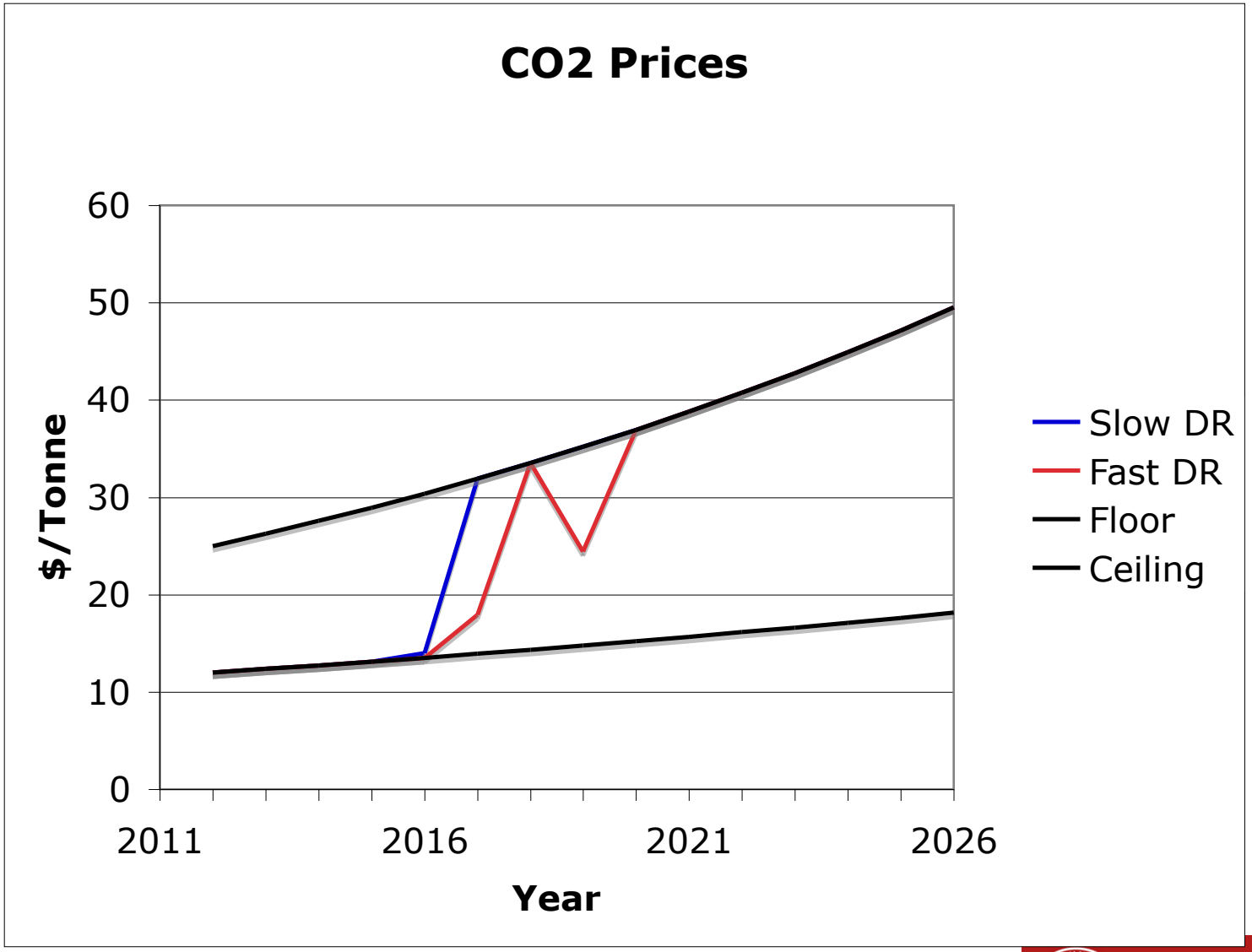
Results for ACESA



Results for ACESA



Results for APA



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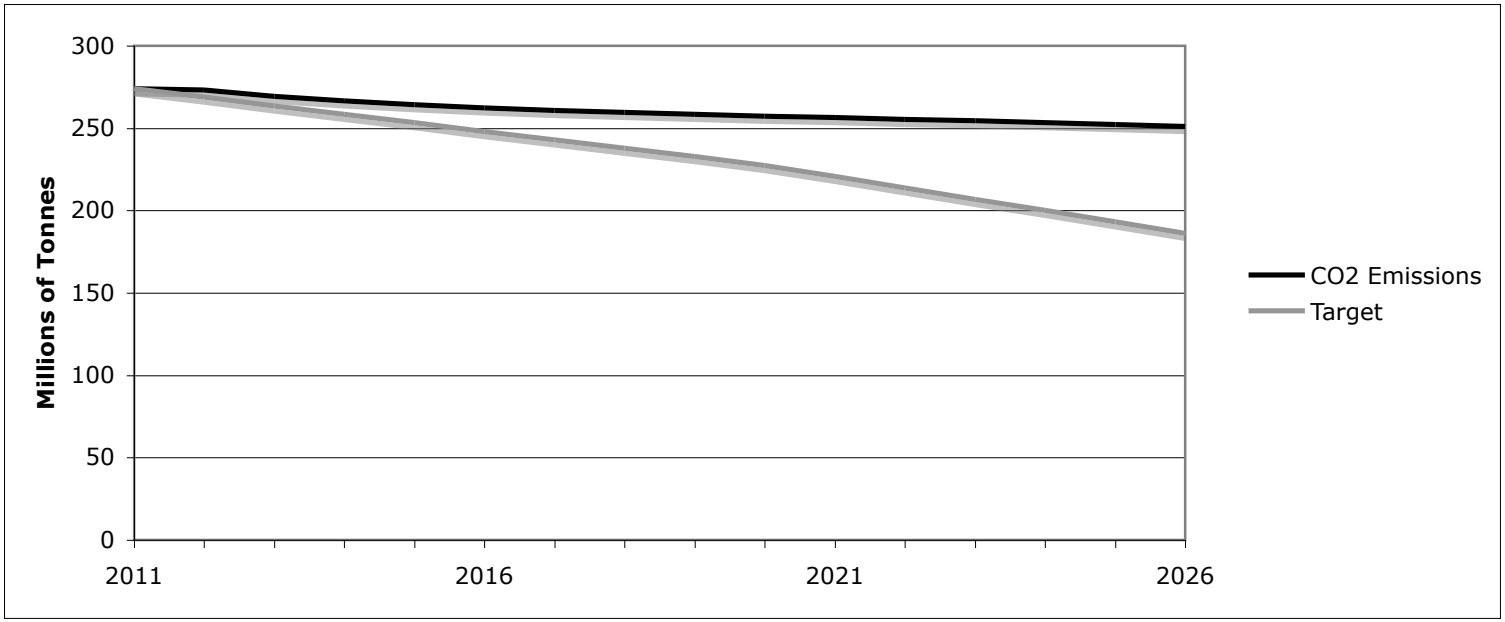
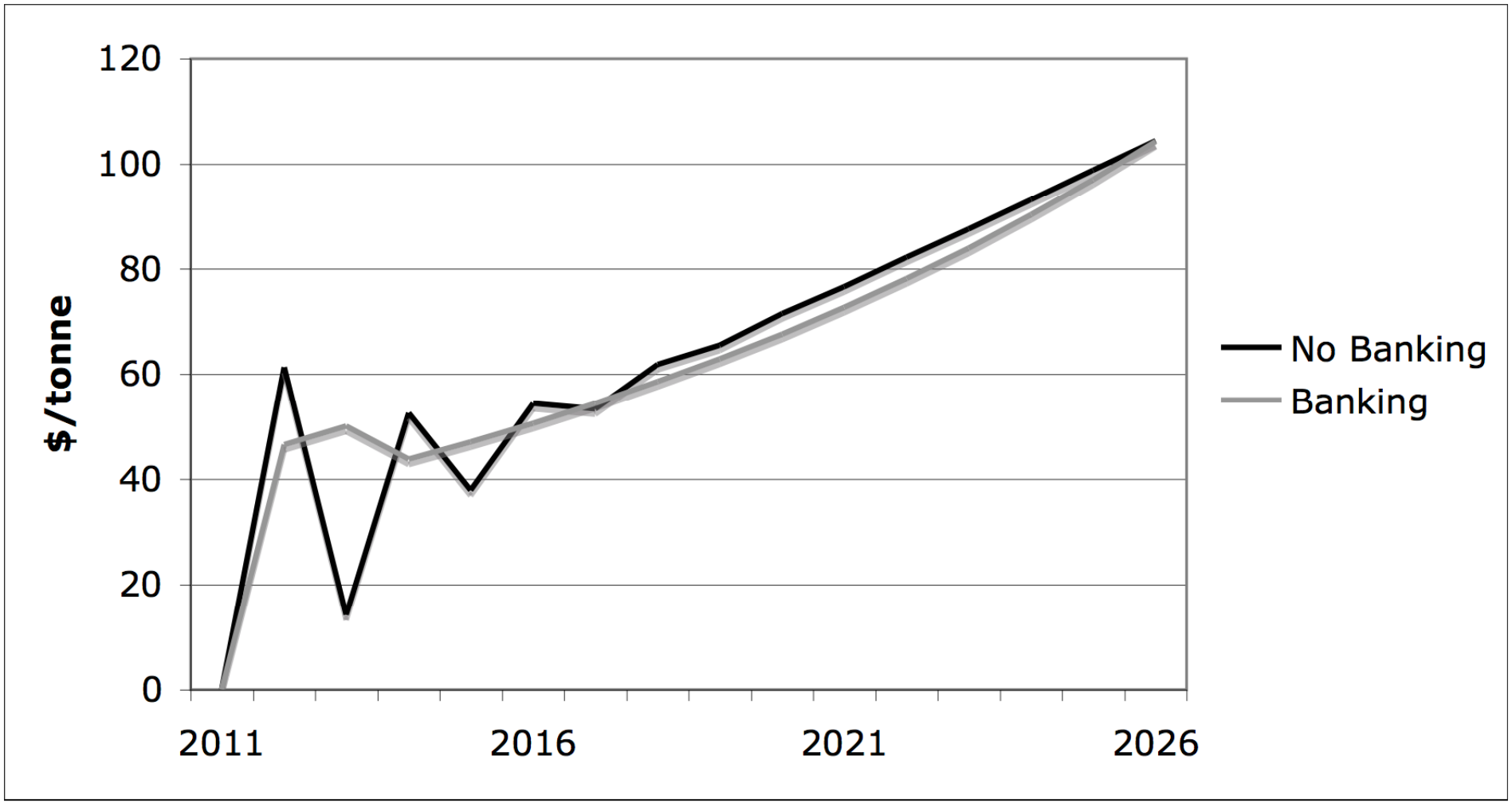
Results for APA



Banking


120
100
80
60
40
20
0
$/tonne
2011
2016
2021
2026
No Banking
Banking

Future Work

- Expand geographic scope
  - Expand northeast to include entire Eastern Interconnection
  - Model WECC and ERCOT
- Allow investment and retirement

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Thank you!

Comments?

Questions?

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