Ongoing Evolution of the Electricity Industry:

Effects of Market Conditions and the Clean Power Plan on States

Presenter: Martin T. Ross

8/16/16

Nicholas Institute for Environmental Policy Solutions
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- Current Paper: https://nicholasinstitute.duke.edu/climate/publications/ongoing-evolution-electricity-industry-effects-market-conditions-and-clean-power-plan
- Analyses of Original CPP Proposal: https://nicholasinstitute.duke.edu/climate/publications/clean-power-plan-implications-three-compliance-decisions-us-states; https://nicholasinstitute.duke.edu/climate/publications/assessing-impacts-clean-power-plan-southeast-states
- *Energy Policy* Paper: http://www.sciencedirect.com/science/article/pii/S0301421515001421

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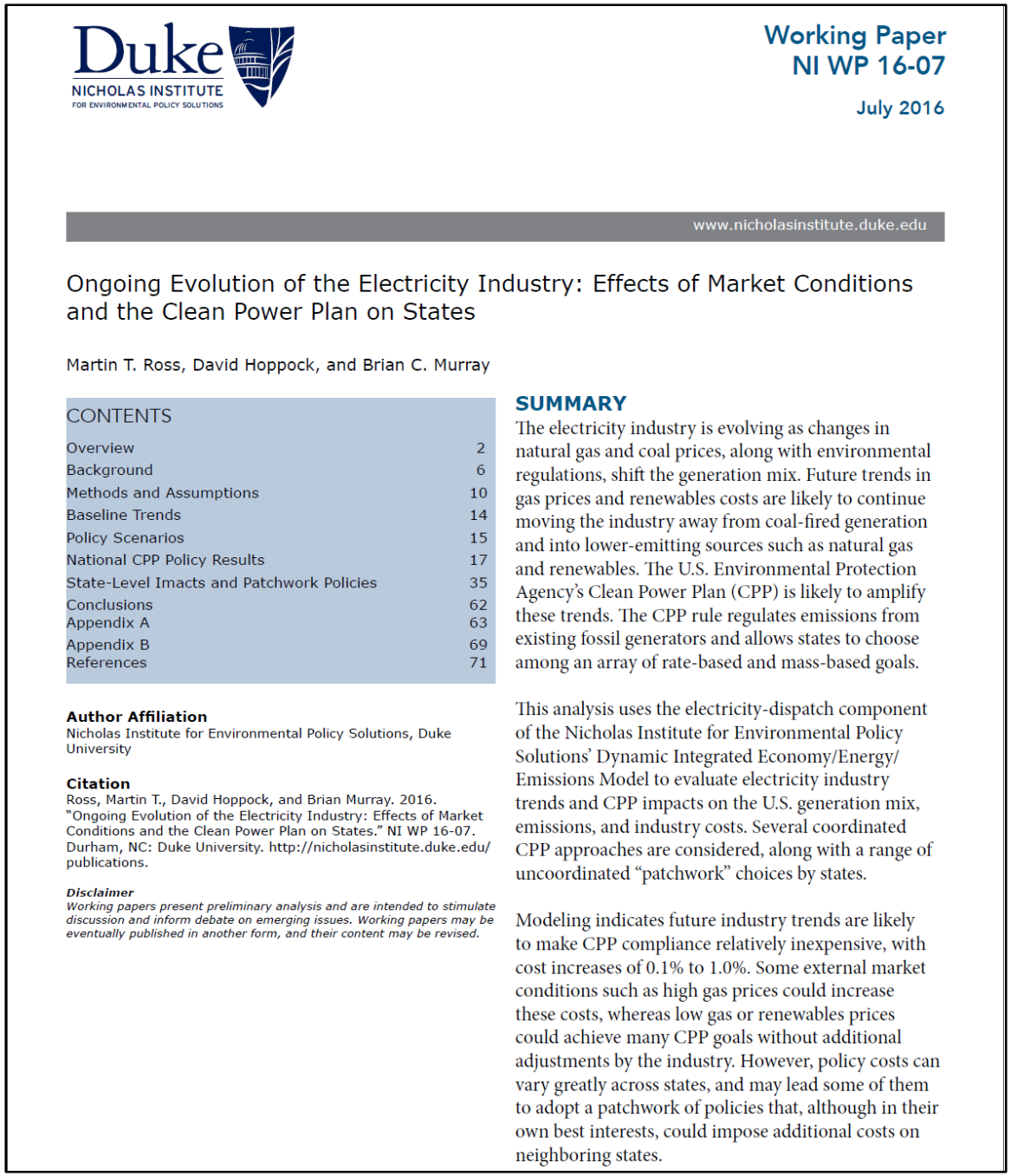

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Ongoing Evolution of the Electricity Industry: Effects of Market Conditions and the Clean Power Plan on States

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SUMMARY

The electricity industry is evolving as changes in natural gas and coal prices, along with environmental regulations, shift the generation mix. Future trends in gas prices and renewables costs are likely to continue moving the industry away from coal-fired generation and into lower-emitting sources such as natural gas and renewables. The U.S. Environmental Protection Agency's Clean Power Plan (CPP) is likely to amplify these trends. The CPP rule regulates emissions from existing fossil generators and allows states to choose among an array of rate-based and mass-based goals.

This analysis uses the electricity-dispatch component of the Nicholas Institute for Environmental Policy Solutions' Dynamic Integrated Economy/Energy/Emissions Model to evaluate electricity industry trends and CPP impacts on the U.S. generation mix, emissions, and industry costs. Several coordinated CPP approaches are considered, along with a range of uncoordinated "patchwork" choices by states.

Modeling indicates future industry trends are likely to make CPP compliance relatively inexpensive, with cost increases of 0.1% to 1.0%. Some external market conditions such as high gas prices could increase these costs, whereas low gas or renewables prices could achieve many CPP goals without additional adjustments by the industry. However, policy costs can vary greatly across states, and may lead some of them to adopt a patchwork of policies that, although in their own best interests, could impose additional costs on neighboring states.

Overview

- Summary of the Analysis Highlights
- Brief description of the *DIEM-Electricity* Model
  - Important assumptions and sensitivities
- DIEM Model Results
  - Baseline trends in the industry without the CPP
  - CPP policy results for coordinated national responses
    - Mass cap over existing, mass cap with NSC, dual rate
  - CPP policy results for state “patchwork” approaches
- Thoughts on sensitivities and conclusions

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Highlights of the Analysis

- Gas prices are very important for both baseline emissions and CPP policy costs and emissions
  - Renewable costs and energy efficiency availability are also important
- Costs of CPP are relatively low, nationally
  - Mass cap over existing units is the cheapest option
  - Mass with New Source Complement and Dual Rate have similar costs
- There is no single answer for most states
  - Some states are clearly better off under one approach
  - For most states, what your neighbors do will matter a lot
  - Use caution when interpreting results at the state level…
- Costs can vary significantly by state
  - Some states may benefit from selling ERCs/allowances or electricity
  - ERC/allowance values depend on the breadth of the markets
  - Mass-based options have a narrower range of cost outcomes than Rate

DIEM Model Summary

"Dynamic Integrated Economy/Energy/Emissions Model"

- Electricity Dispatch Component
  - Linear programming model with foresight
    - ➢ Minimize costs of generation subject to meeting demand and policies
  - U.S. regional markets (10-60 regions, 40 used in this analysis)
  - Historical data on existing units from IPM NEEDS v.5.15
    - Added announced retirements and new additions
  - Coal efficiency retrofits, redispatch of existing NGCC, energy efficiency, and construction of new renewables are choices
- Model Assumptions Affecting Findings:
  - Federal extension of renewables PTC/ITC
  - AEO 2015 – electricity demands, some capital costs, some fuel prices
    - Adjustments to AEO assumptions shown on next slide
  - EPA assumptions on cost and availability of energy efficiency (EE)
  - In the long term, assume a 2nd 20-year nuclear life extension
  - Banking of ERCs/allowances over 2022-2029 (annual goal after 2030)

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DIEM Model Assumptions

- Natural Gas Prices
  - Midpoint of AEO 2015 Reference and AEO low gas price cases (similar to AEO 2016)

U.S. Delivered Natural Gas Price ($/MMBtu)	2020	2025	2030	2035	2040	2016-2037 average
High Gas Price (AEO 2015 Reference Case)	$5.07	$5.79	$5.67	$6.57	$7.82	$5.38
Medium Gas Price (standard assumption)	$4.34	$4.78	$4.70	$5.36	$6.14	$4.57
Low Gas Price (AEO High Resource Case)	$3.60	$3.76	$3.74	$4.14	$4.46	$3.76

- Renewables Costs
  - EPA RIA for CPP Final Rule (standard assumption)
  - NREL Annual Technology Baseline – Low case

$ per kW	Source	2020	2025	2030	2035	2040
Wind	EPA	$1,682	$1,672	$1,668	$1,668	$1,667
	NREL ATB - Low	$1,570	$1,550	$1,540	$1,536	$1,536
Solar PV	EPA	$1,552	$1,423	$1,294	$1,165	$1,035
	NREL ATB - Low	$1,069	$1,069	$1,069	$1,069	$1,069

- Electricity Demand Growth
  - AEO 2015 Reference Case has ~0.7%/year for the U.S. as a whole (regional rates can vary)
    - "Standard Assumption" – at this growth rate, including energy efficiency leaves demand growth at basically zero
  - "Low Growth": electricity growth of 0.4%/year (excluding EE measures)
  - "Medium-High Growth": electricity growth of 1.2%/year (excluding EE measures)
  - "High Growth": electricity growth of 1.7%/year (excluding EE measures)

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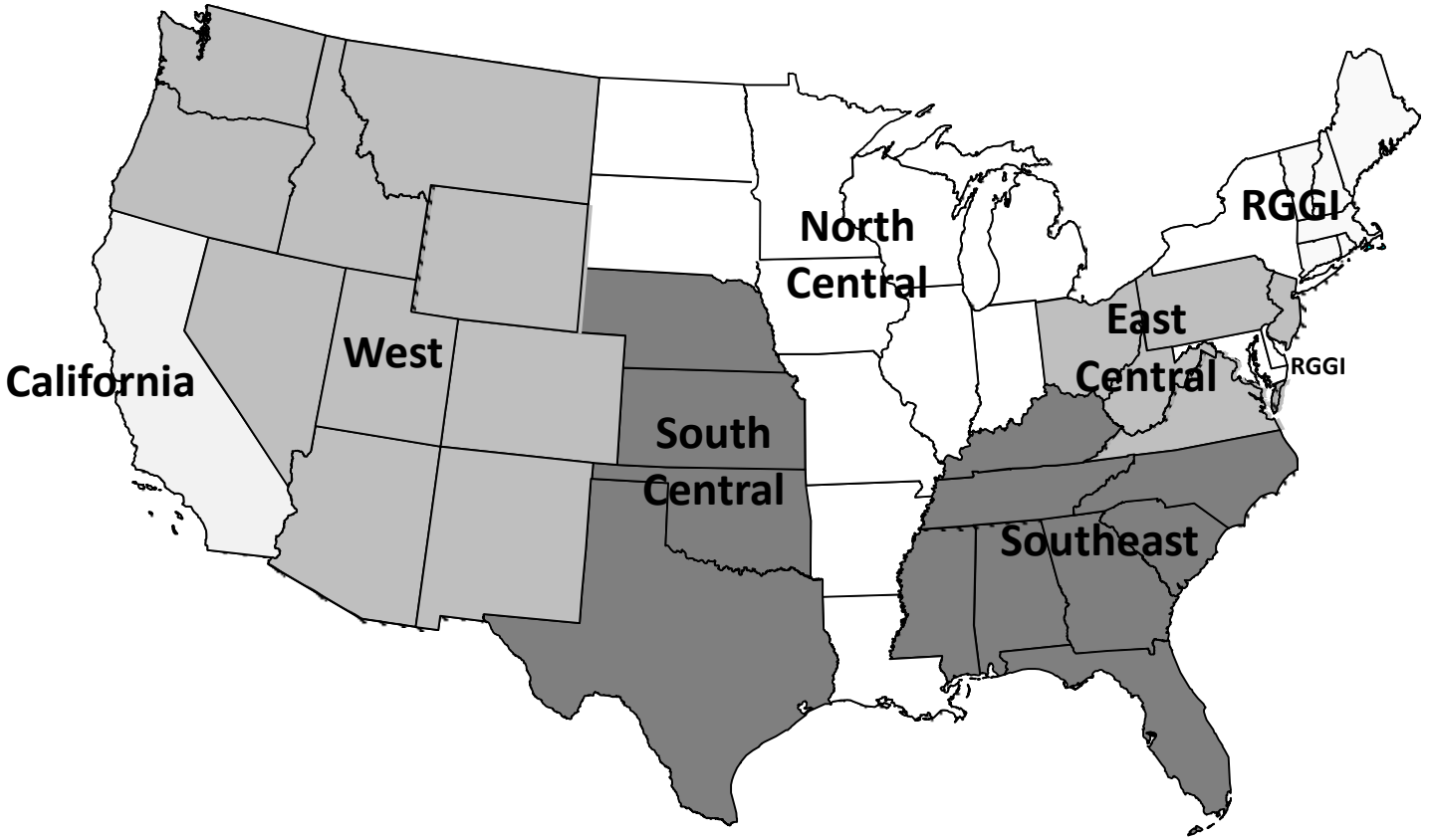
Definitions of State Groupings for Reporting
(only used as trading regions in a few policy runs)



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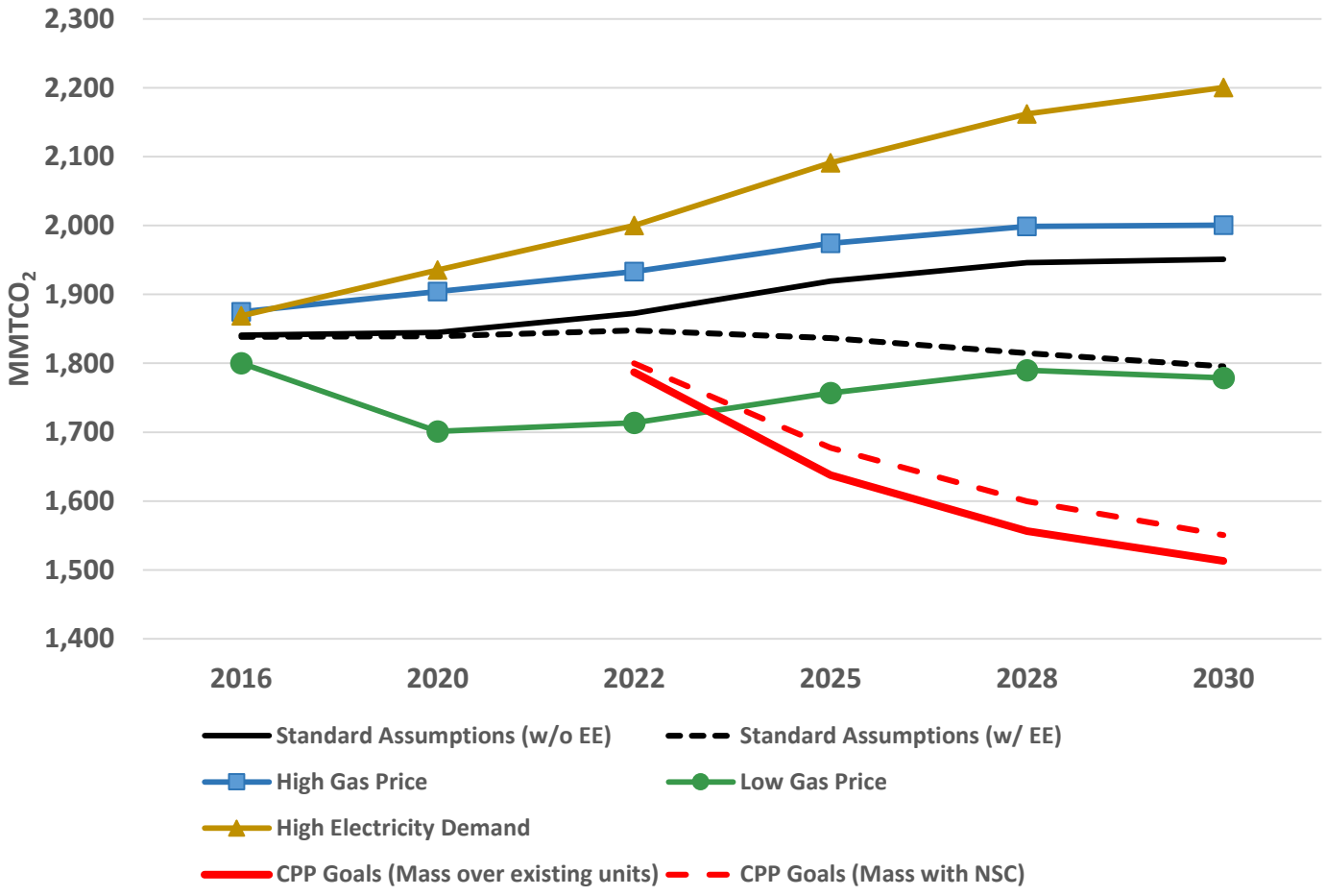
Highlights: Baseline Trends in the Industry (without the CPP)

- CO_2 emissions depend critically on future natural gas prices
  - Moderate gas prices leave future emissions near today's levels
  - Lower gas prices can result in significant declines in emissions
- Low gas prices (below $4/MMBtu) will shift the generation mix
  - Compared with gas prices above $4, gas generation could be 30% higher and coal generation 20% lower by 2030
  - High gas prices would reverse this and also lead to more renewables
- Clean Power Plan may not be binding in some regions initially
  - This effect does not extend beyond the first few years of the policy (unless gas prices are lower than forecasted)
- Renewables penetration depends on future construction costs
  - Extension of federal PTC/ITC leads to extra 15-40 GW by early 2020s
  - Impacts of the PTC/ITC fade out without additional extensions
  - Wind generation increases as costs decline and effectiveness increases
  - Utility solar PV costs need to be close to $1/watt to be cost competitive

Baseline Emissions under Alternative Assumptions (compared to CPP)



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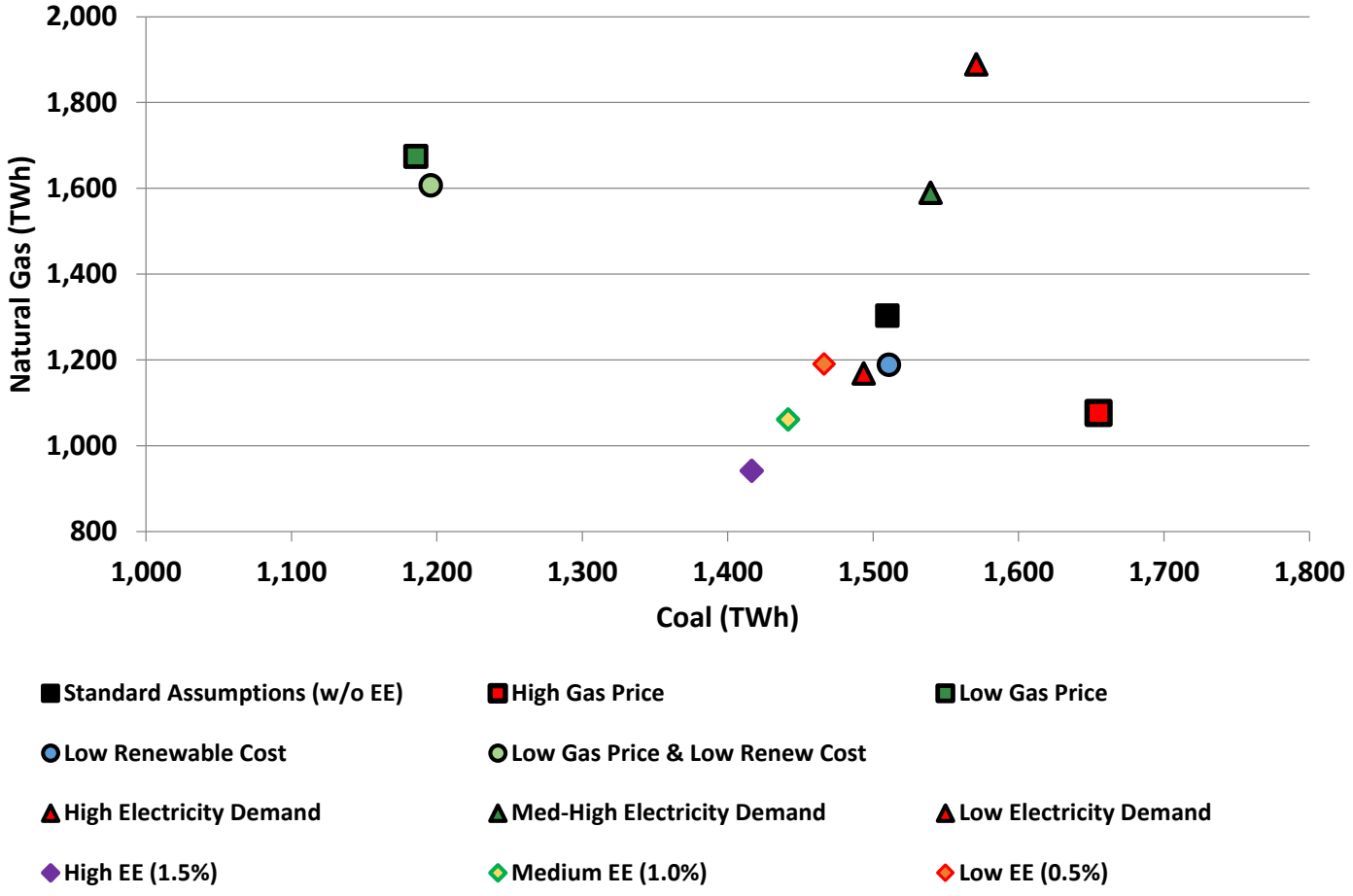
2030 Baseline Fossil Generation under Alternative Assumptions



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Future CPP Policy Options

- Focus on three policy options:
  1) Rate-based with dual rates (subcategorized coal/natural gas targets)
     - ERCs from fossil-steam, gas-shift, renewables, EE, under-construction nuclear
  2) Mass-based over existing units
     - Mass states do not sell ERCs into Rate states
     - Includes leakage provisions (output-based allocations, renewables set-asides)
  3) Mass-based including new units (New Source Complement)
     - Mass states do not sell ERCs into Rate states
- Start with national coordinated approaches to the CPP
  - California always adopts NSC by itself, RGGI states adopt NSC as a group
- Examine patchwork outcomes of states' CPP choices
  - States/regions are assumed to make different choices
  - Based on desire to export/import ERCs & allowances, overall policy costs
- Alternative assumptions about:
  - Natural gas prices, renewables costs, electricity demand growth, etc.

Highlights: National Approaches to CPP

- CPP policy costs are relatively low for the United States*
  - Regardless of the policy options chosen by states, costs are quite low (i.e., cost increases in the 0.1%–1.0% range, compared to industry costs in the baseline) across most assumptions about future trends in the industry
  - The mass-based approach with the New Source Complement has policy costs roughly equivalent to those of the dual-rate approach
  - Mass cap over existing units has the lowest policy costs
  - Prices for mass allowances and ERCs are quite low
- Mass-based options are less sensitive to future conditions
- Gas prices will affect policy costs
  - Low prices can reduce costs to almost zero
  - High prices could result in industry cost increases of 3.0%-3.5%
- Energy efficiency measures are important for containing costs
- Leakage of emissions through generation shifts is important
  - Mass cap over only existing sources has 7% higher emissions than mass w/NSC (output-based allocations and renewables set-asides don't affect leakage much)
  - Dual rate can also lead to emissions significantly higher (or lower) than NSC, depending on future market conditions

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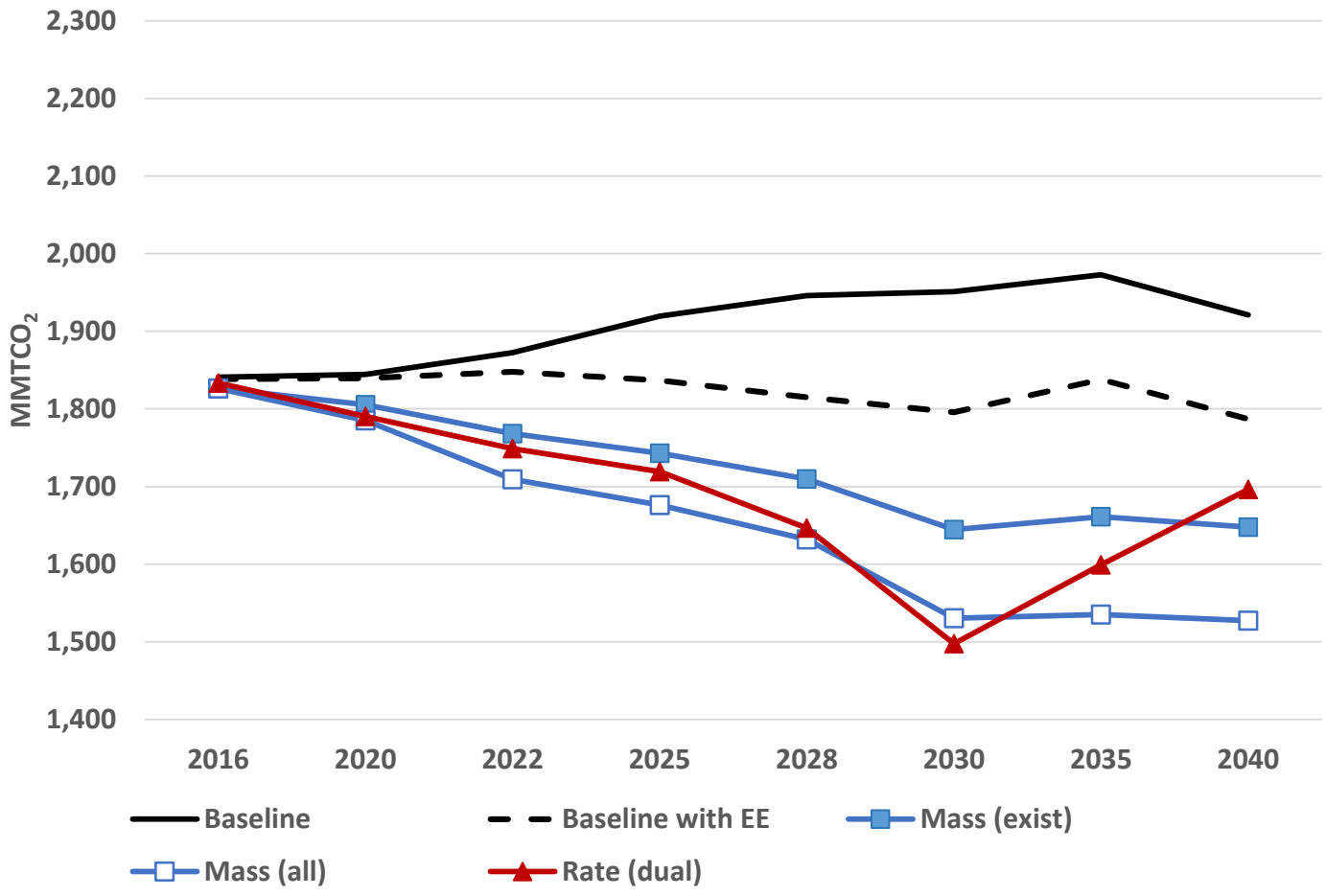
* Note: any cost savings from energy efficiency measures are not counted as policy savings when calculating CPP costs

CPP Emissions under Alternative Assumptions



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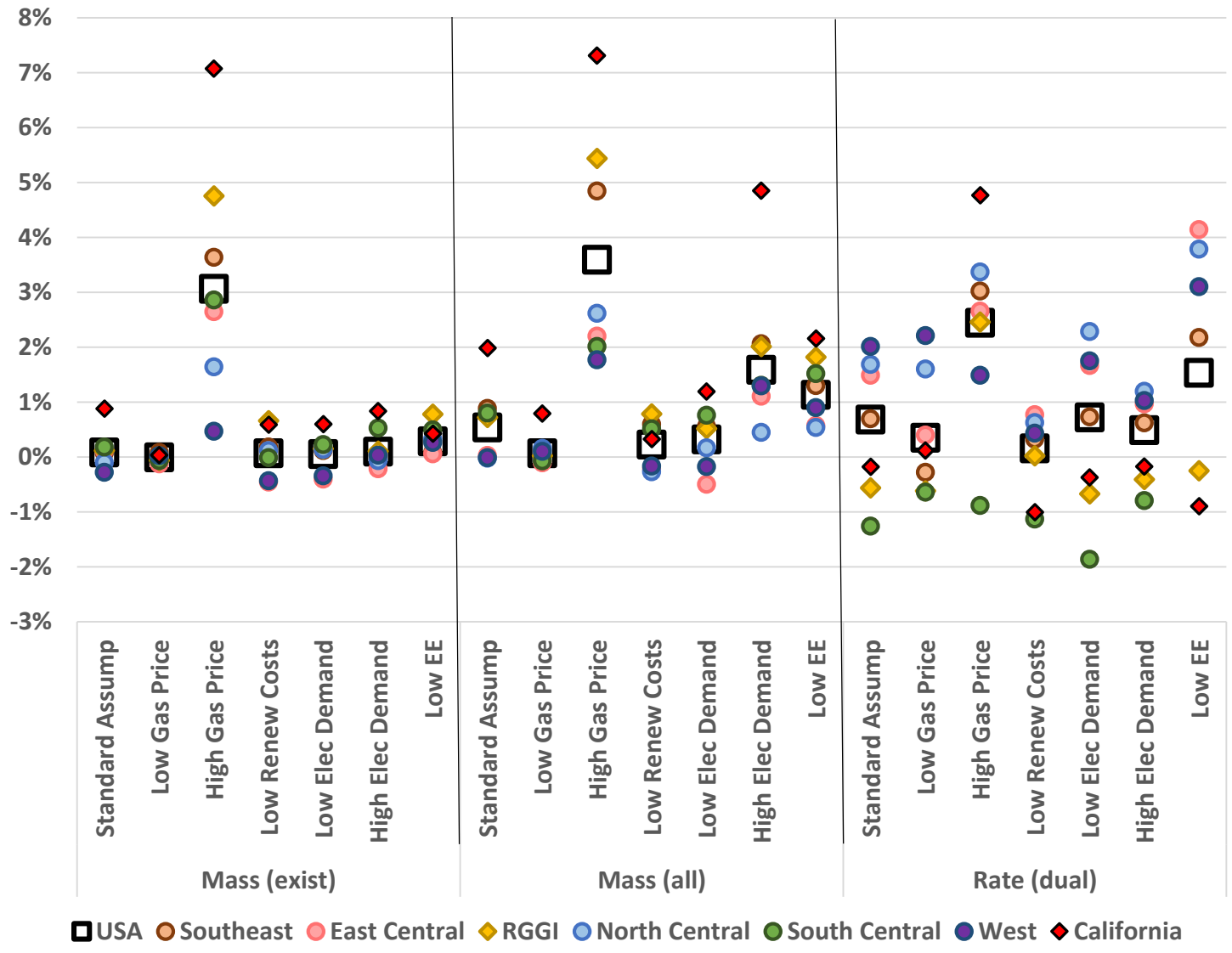
National Approach to CPP (ΔPV to 2040)

(Change in capital, operating, fuel costs plus ERC/allowance trade value)



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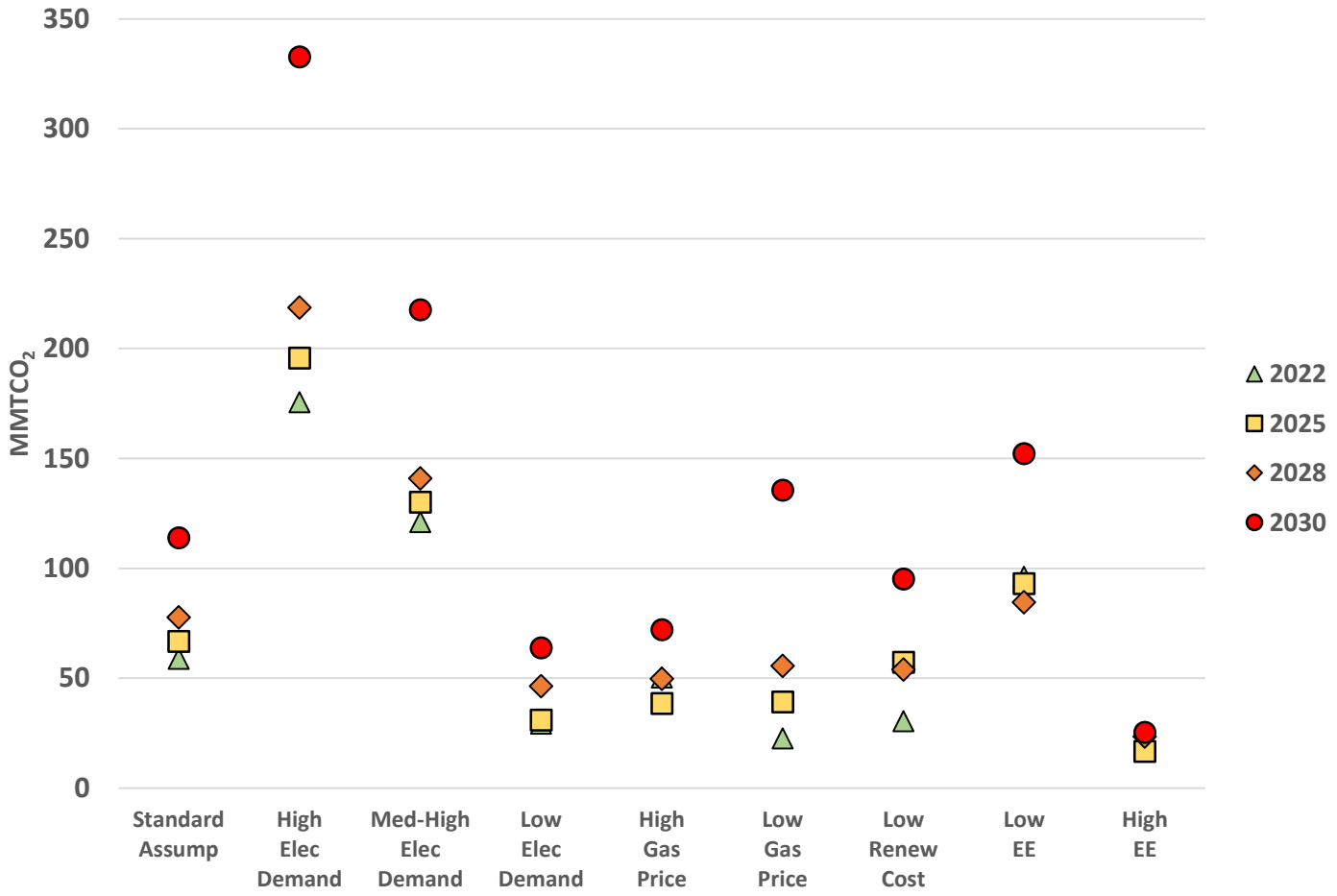
Leakage of National Mass Cap over Existing Units

(emissions difference compared to Mass with NSC – in $MMTCO_2$)



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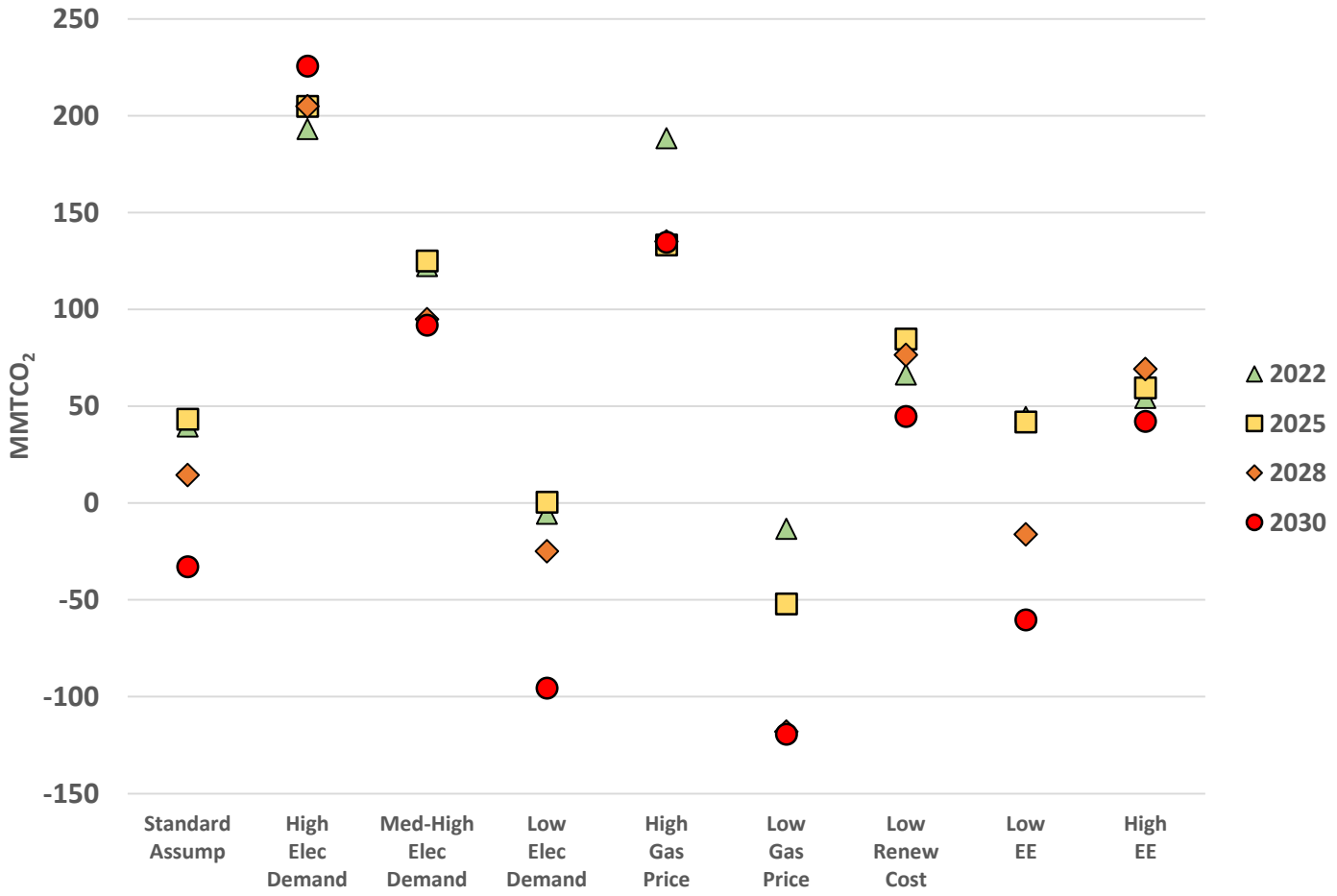
Leakage of National Dual Rate

(emissions difference compared to Mass with NSC – in $MMTCO_2$)



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Highlights: State-Level Impacts of CPP

- State-level cost estimates depend on (among other things):
  - Emissions goals
  - Existing generation fleet
  - Capacity to construct new renewables
- Caveats…
  - Use caution when interpreting state-level estimates of policy costs
  - To estimate impacts at the state level, the DIEM model:
    - has the capability to reflect data on existing and new units within a state
    - assigns new generating units to a specific state, rather than broader utility region
    - forecasts electricity demand at the state level
    - estimates electricity flows between states and values it at wholesale prices
    - assigns ERCs to the state in which the ERC generating unit operates
  - Note that dispatch models are trying to minimize overall costs over a long time horizon, not those to any specific state or region for a limited number of years
  - ❖ I do not have off-the-cuff answers for every state cost estimate and sensitivity…
- In general, policy costs can vary significantly across states
  - Some states are clearly better off with one approach over another
  - Some states can even be better off than they were without the CPP (largely through exporting ERCs, allowances, or electricity)
  - For other states, answers are less clear and can depend on future conditions

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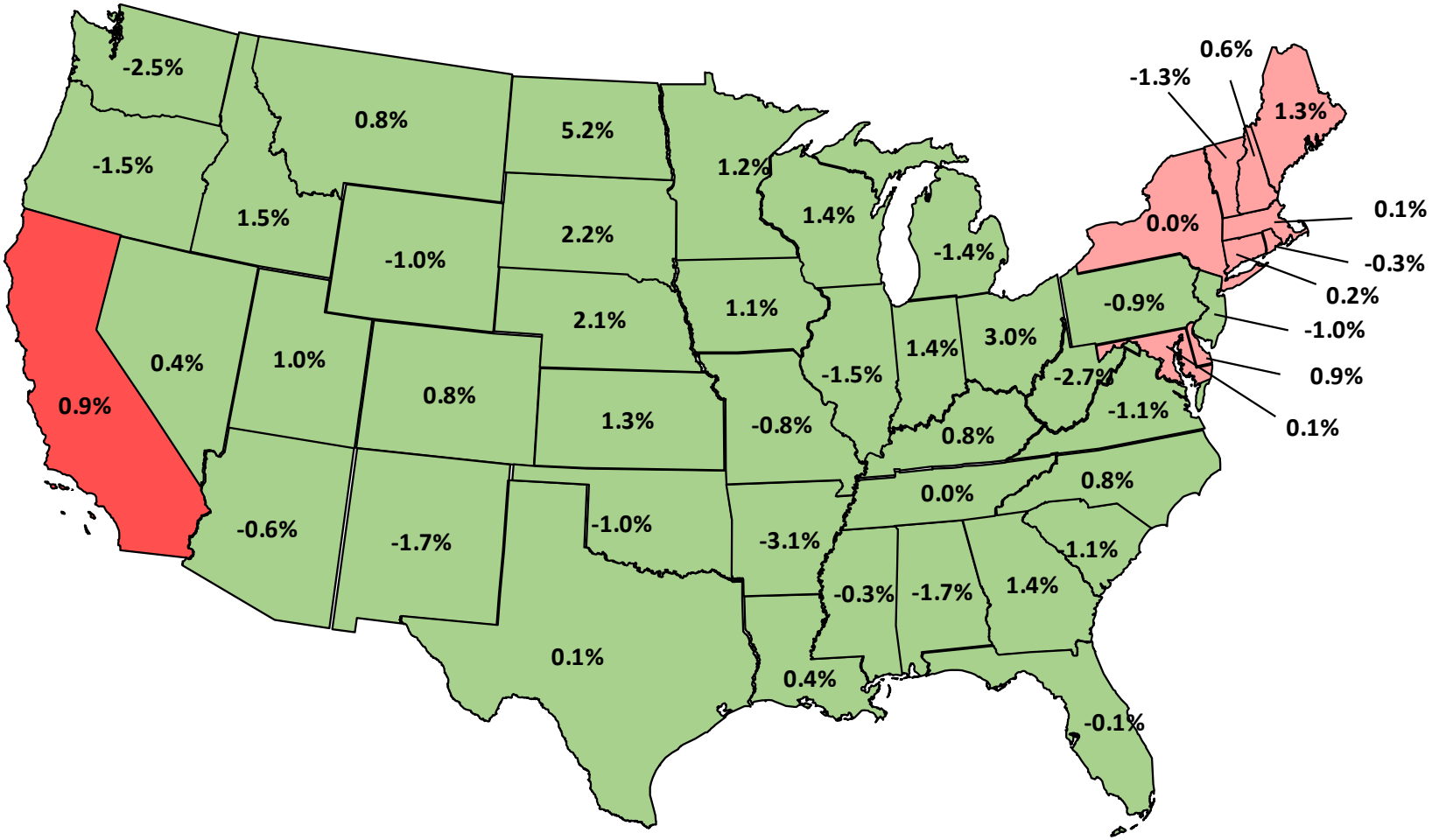
Policy Costs – mass cap over existing (ΔPV to 2040)

(Change in capital, operating, fuel costs plus ERC/allowance trade value)



- States with Rate
- States with Mass (existing units)
- States with Mass (including new units)
- RGGI

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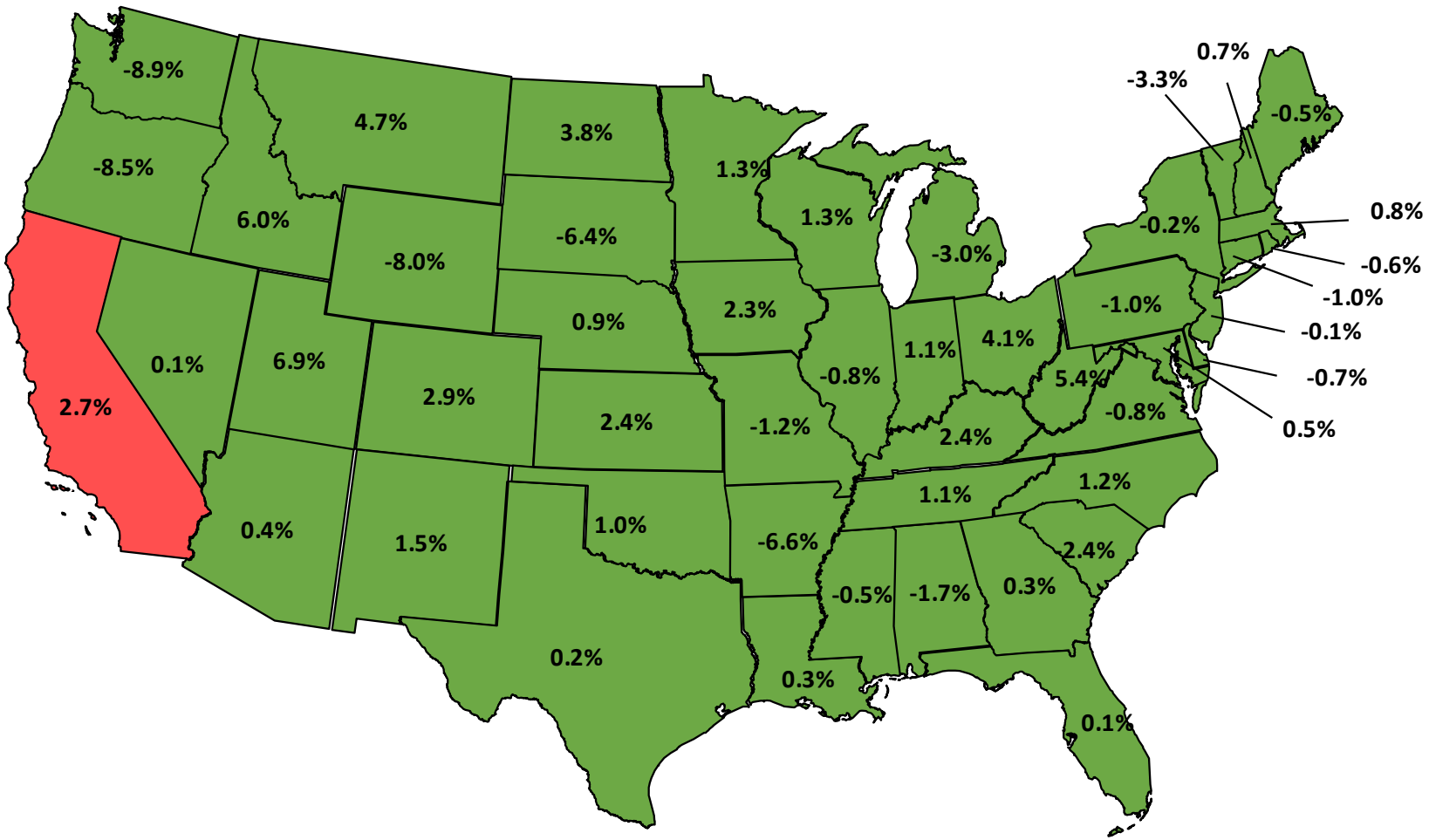
Policy Costs – mass cap over all units (ΔPV to 2040)

(Change in capital, operating, fuel costs plus ERC/allowance trade value)



States with Rate

States with Mass (existing units)

States with Mass (including new units)

RGGI

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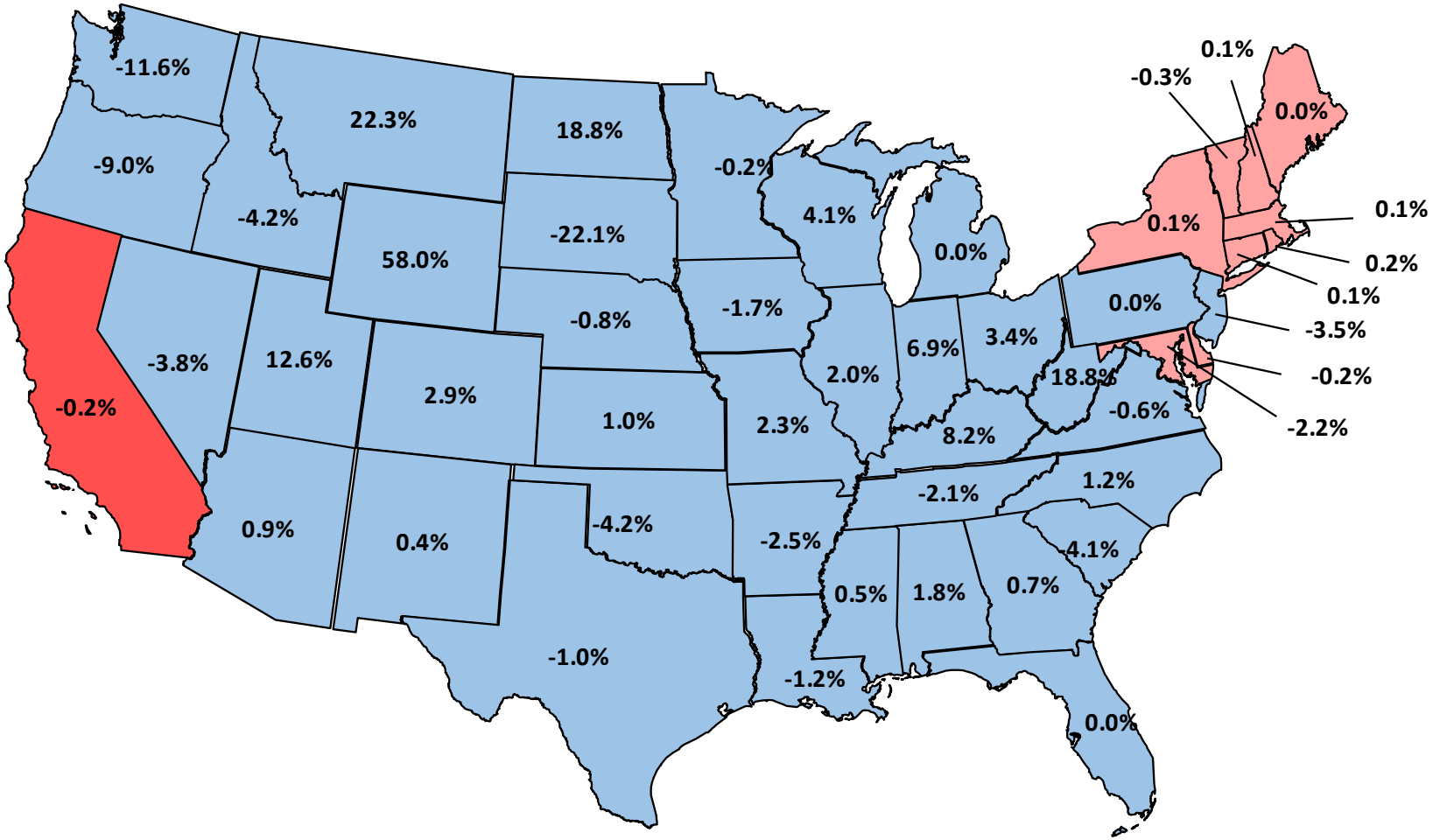
Policy Costs – dual rate (ΔPV to 2040)

(Change in capital, operating, fuel costs plus ERC/allowance trade value)



- States with Rate
- States with Mass (existing units)
- States with Mass (including new units)
- RGGI

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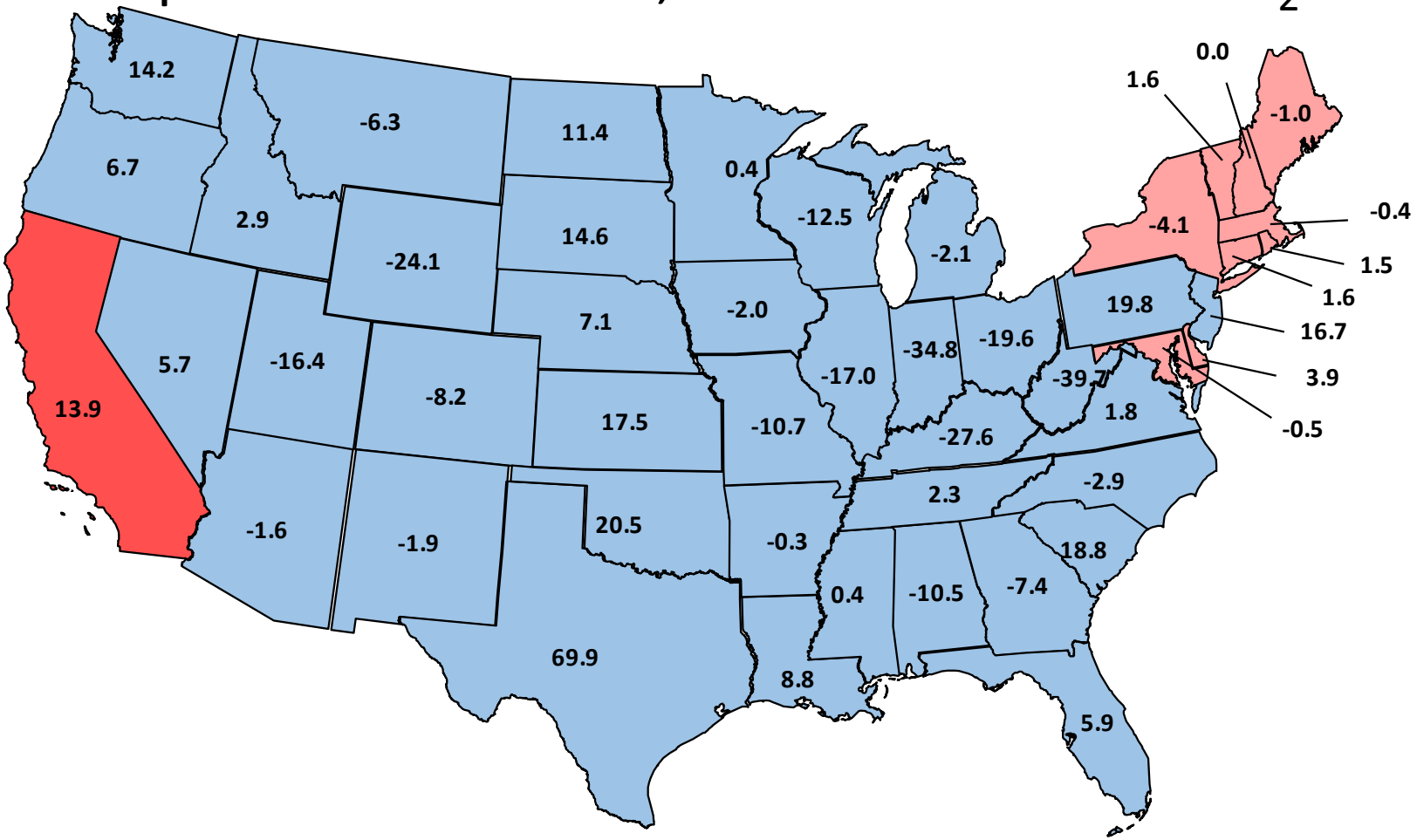
Highlights: State CPP Policy Choices

- Patchwork options – who may go rate?
  - Who has excess ERCs or relatively cheap methods of generating them?
  - Who has lower policy costs under rate-based trading?
- Under uncoordinated "patchwork" outcomes, actions of neighboring states can have large impacts on a state
- Patchwork outcomes depend on size of ERC/allowance markets
  - States experiencing difficulties meeting their emissions goals will benefit from trading markets that allow them to purchase ERCs/allowances
  - States in position to sell ERCs or allowances will have to evaluate market prices
- The ability to sell, or need to purchase, ERCs and allowances is a good measure of a state's benefits (costs) from the policy
- ERC and mass allowance prices
  - Prices are generally low (zero in some years), but depend on scope of expected markets
  - However, low ERC prices may encourage additional states to go with dual rate
  - Low ERC prices provide little incentive to renewables, mass options also have few incentives
  - Low allowance prices limit the effectiveness of leakage provisions in mass over existing units

ERC and Mass Allowance Trade (2030)

Net Exports: ERCs in TWh, allowances in $MMTCO_2$



States with Rate
States with Mass (existing units)
States with Mass (including new units)
RGGI

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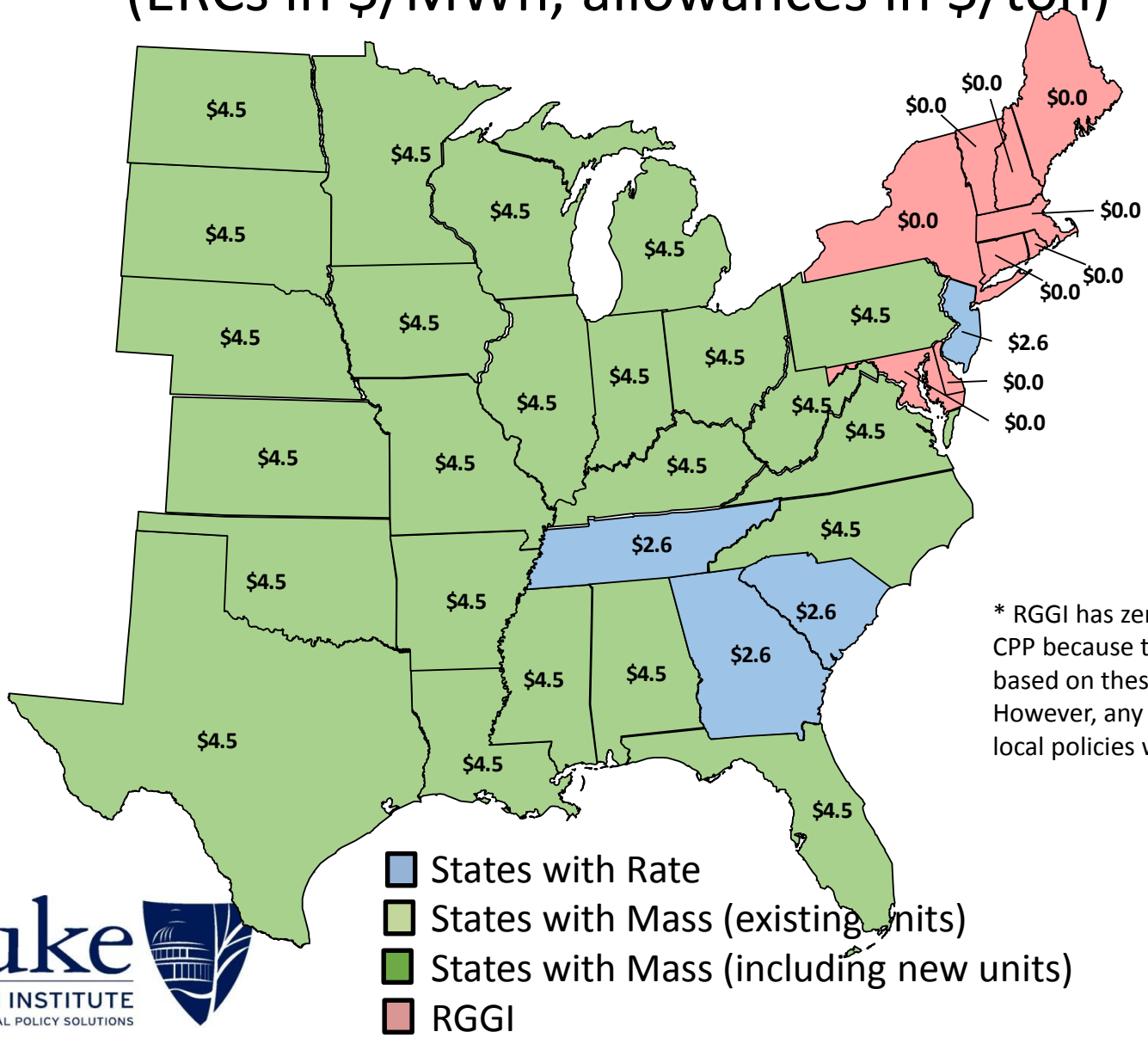
ERC and Mass Allowance Prices (2030)

(ERCs in $/MWh, allowances in $/ton)



* RGGI has zero allowance prices for CPP because the cap is non-binding, based on these market assumptions. However, any CO_2 price floors from local policies would still apply.

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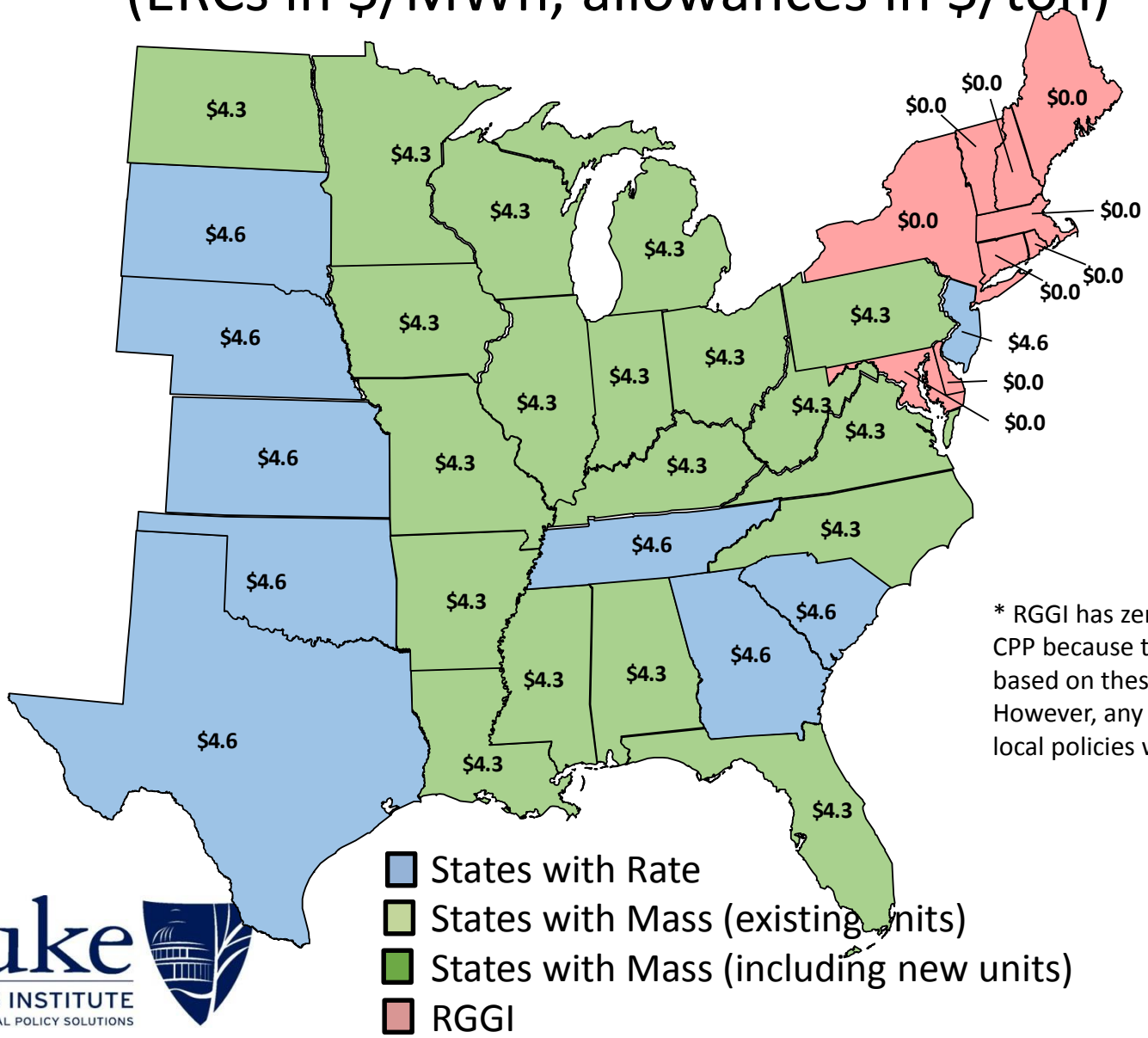
ERC and Mass Allowance Prices (2030)

(ERCs in $/MWh, allowances in $/ton)



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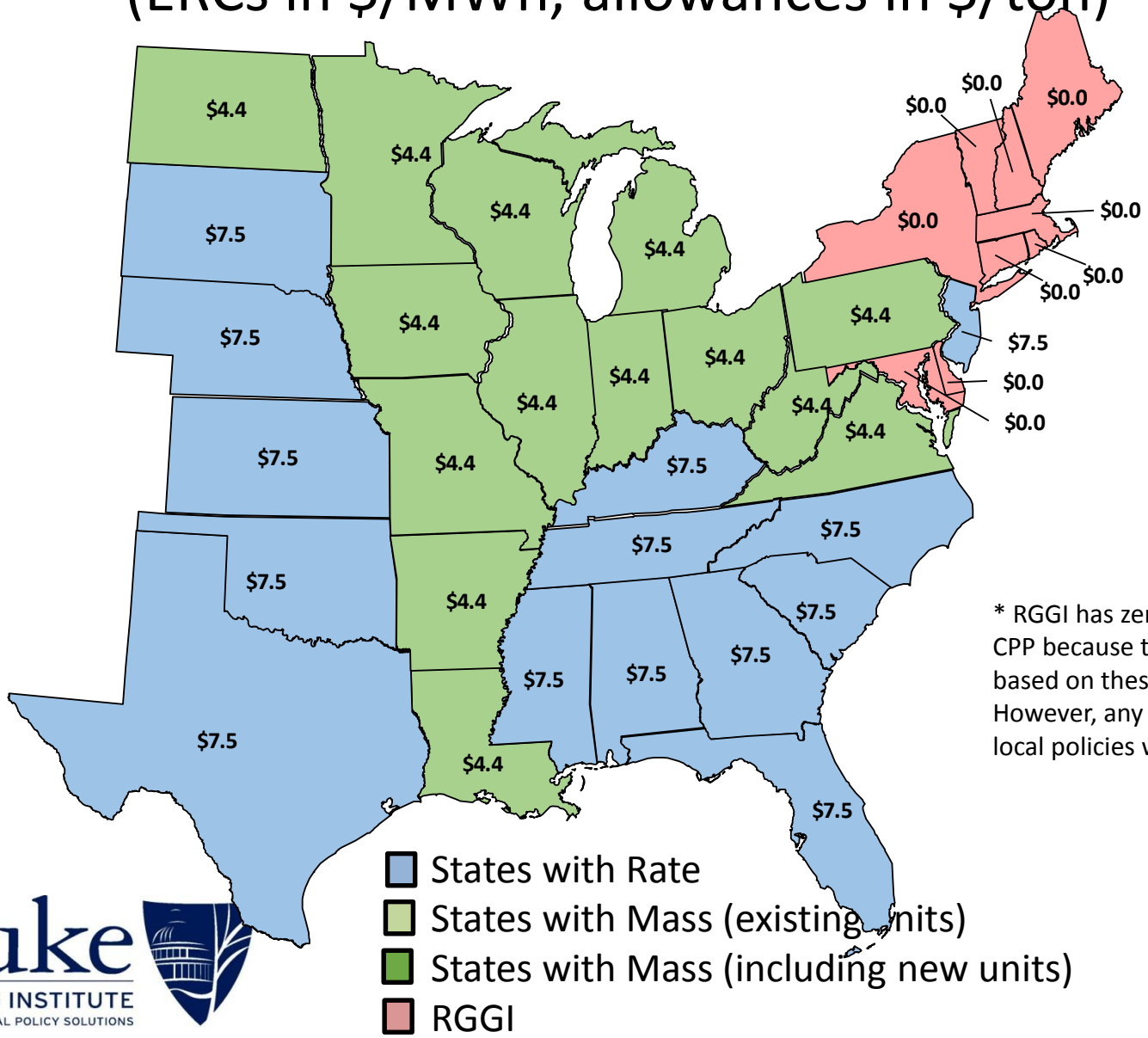

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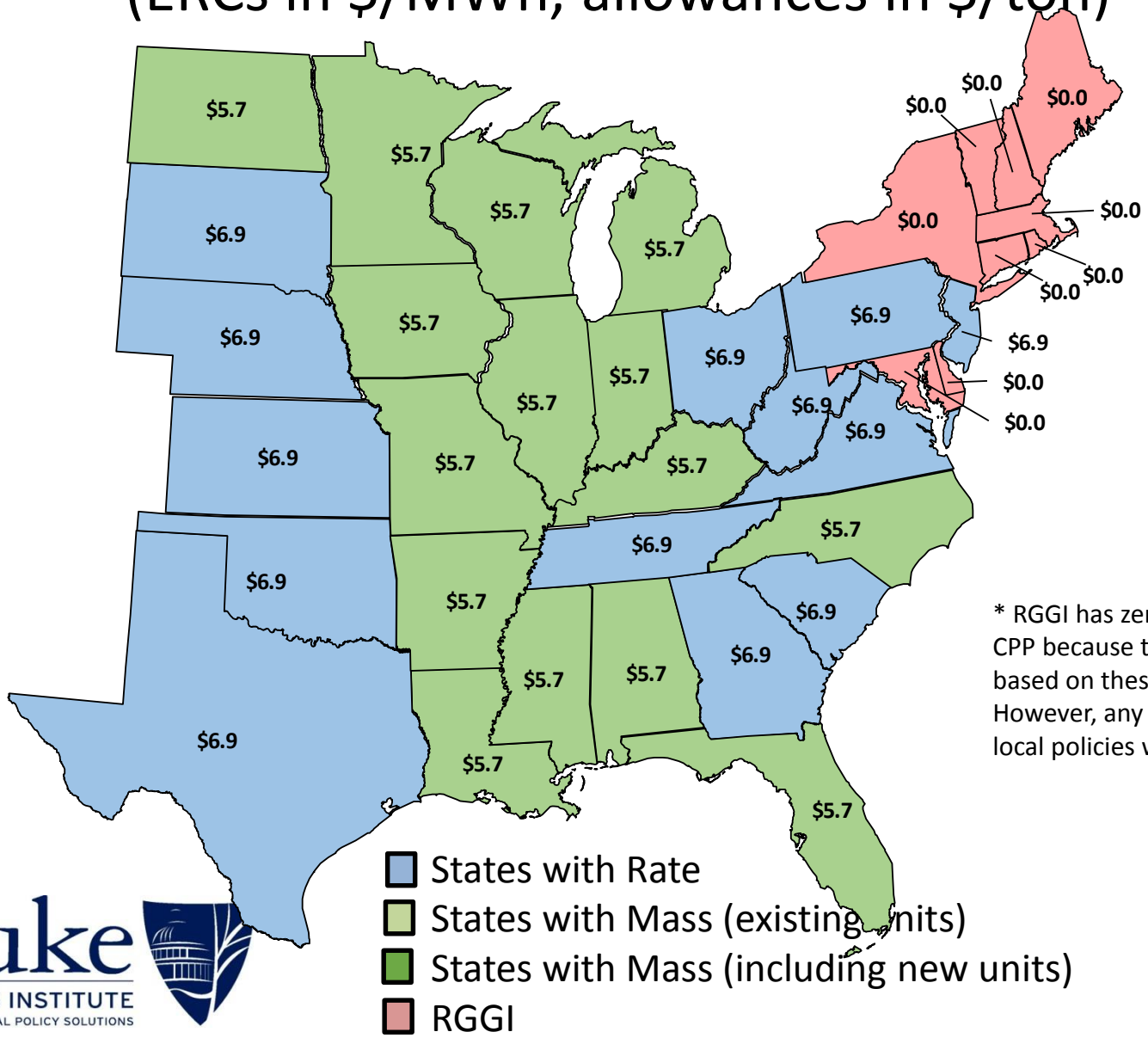

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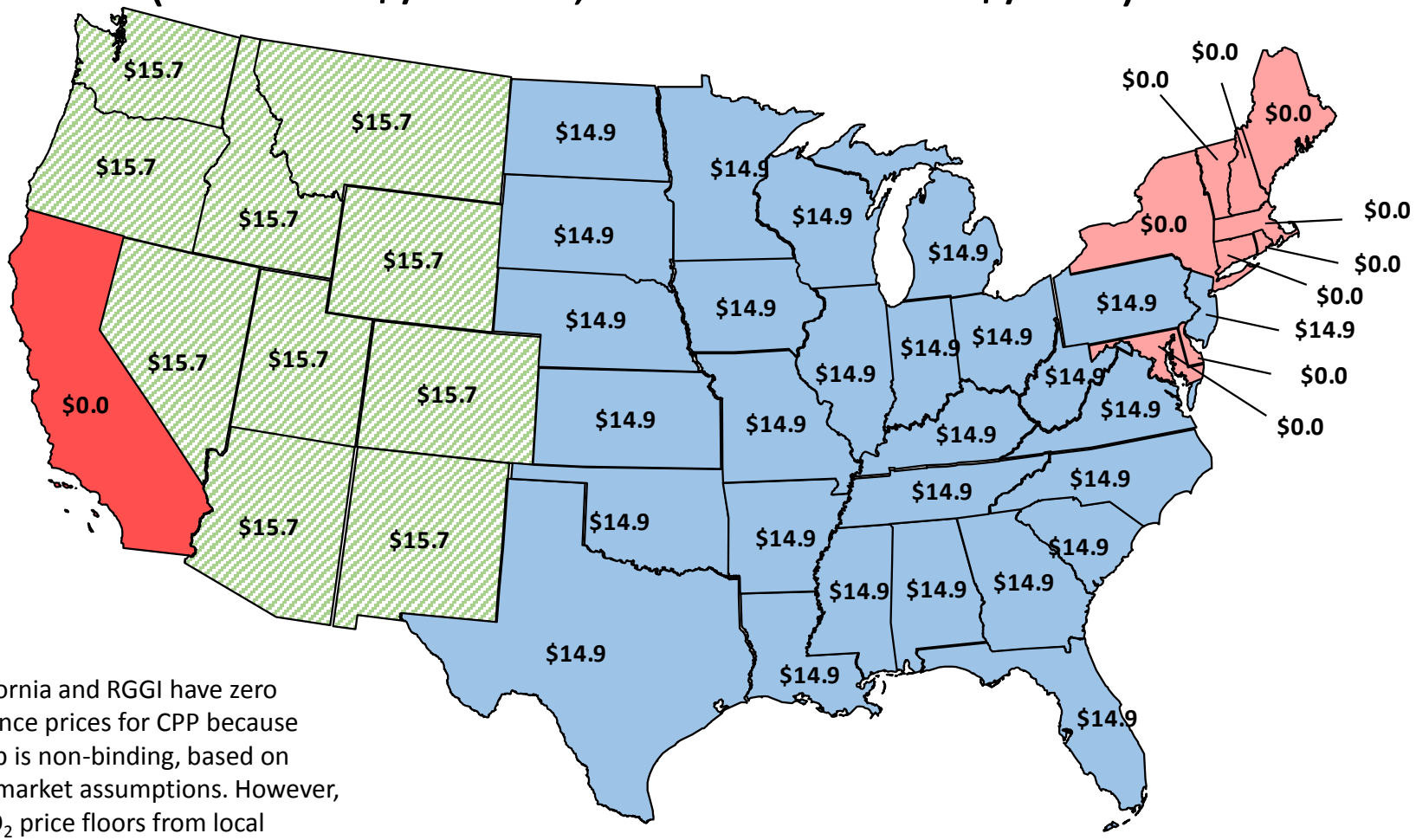
ERC and Mass Allowance Prices (2030)

(ERCs in $/MWh, allowances in $/ton)



* California and RGGI have zero allowance prices for CPP because the cap is non-binding, based on these market assumptions. However, any CO_2 price floors from local policies would still apply.

States with Rate
States with Mass (existing units)
States with Mass (including new units)
RGGI

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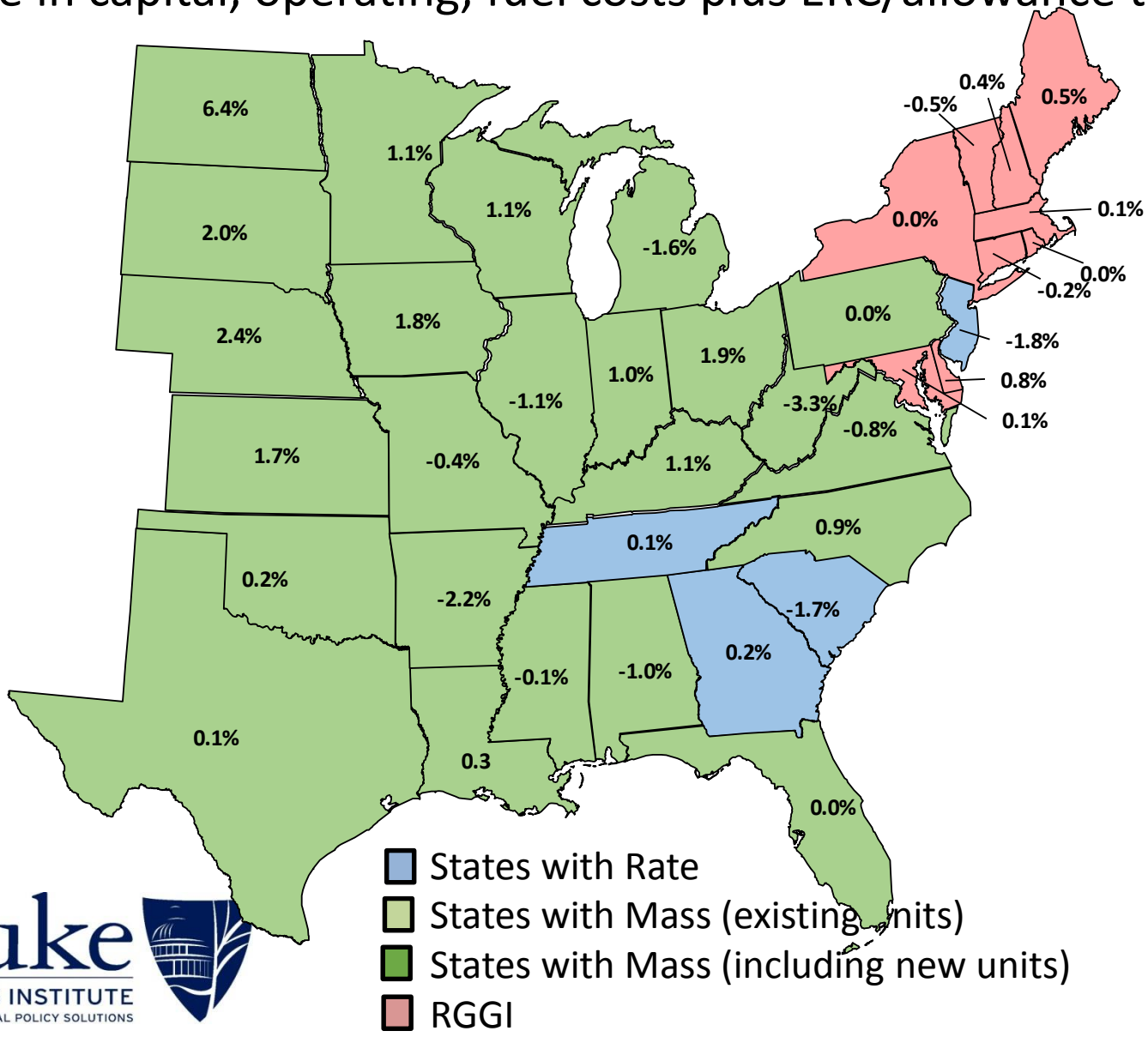
Policy Costs (ΔPV to 2040)

(Change in capital, operating, fuel costs plus ERC/allowance trade value)



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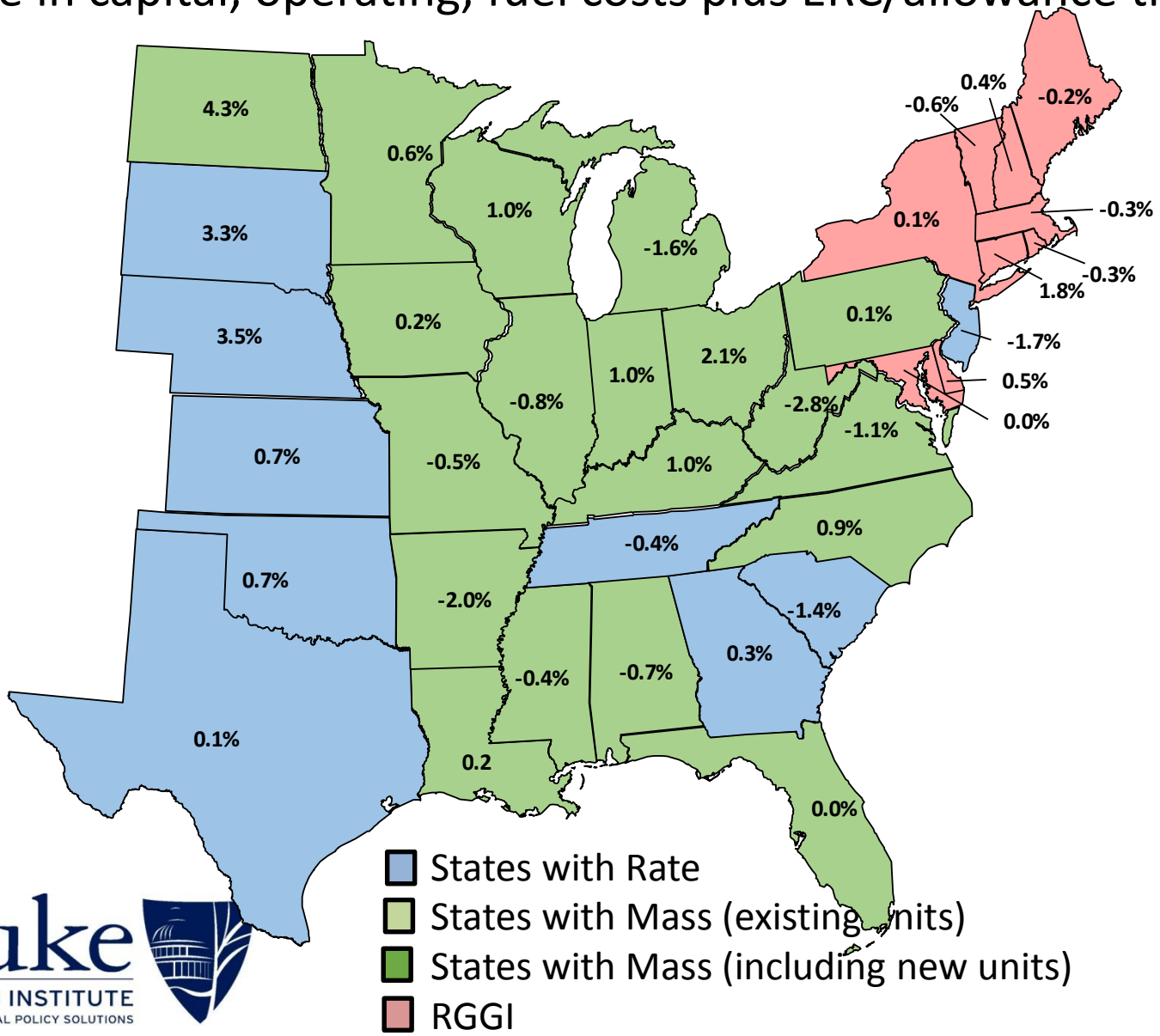

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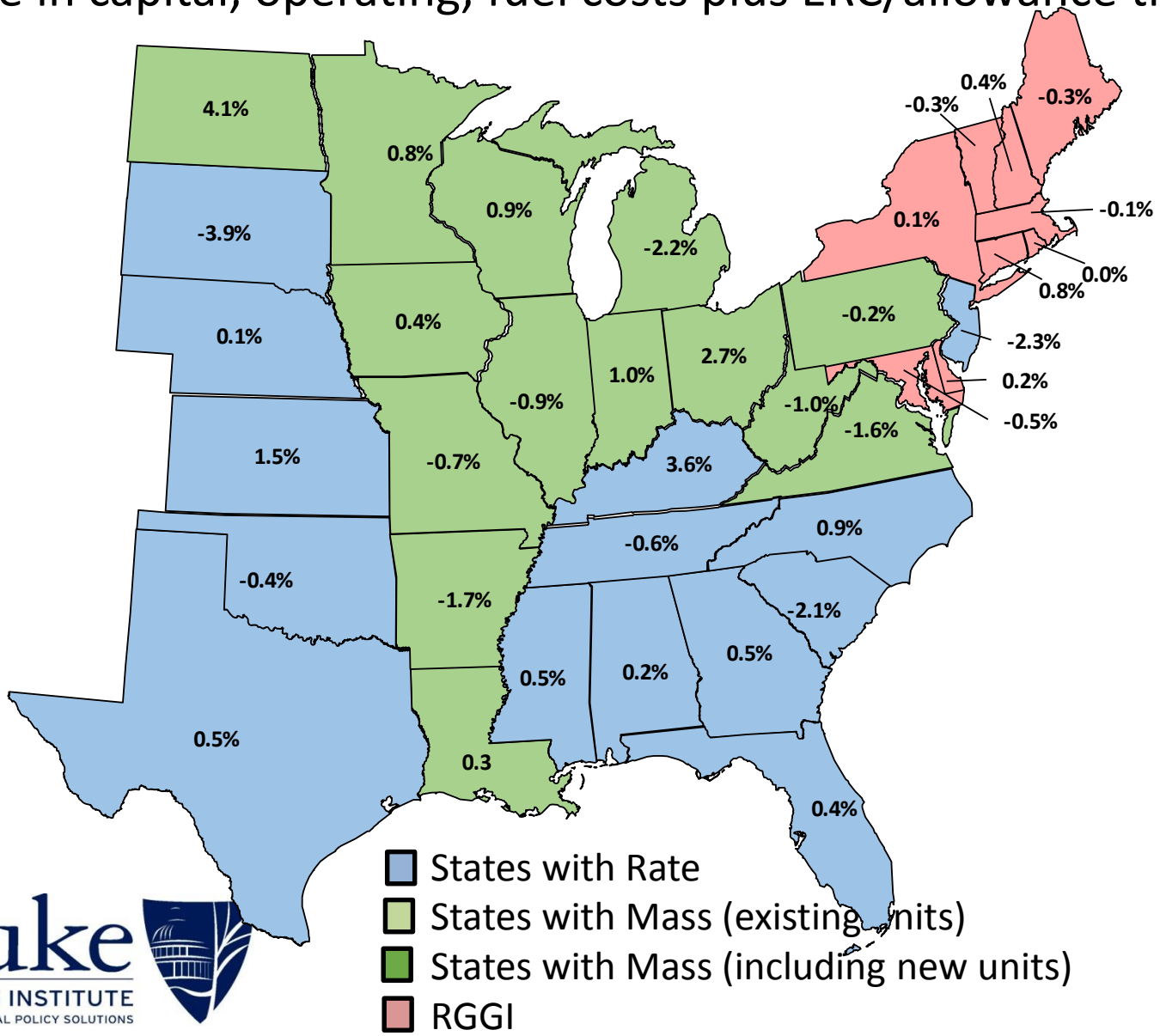

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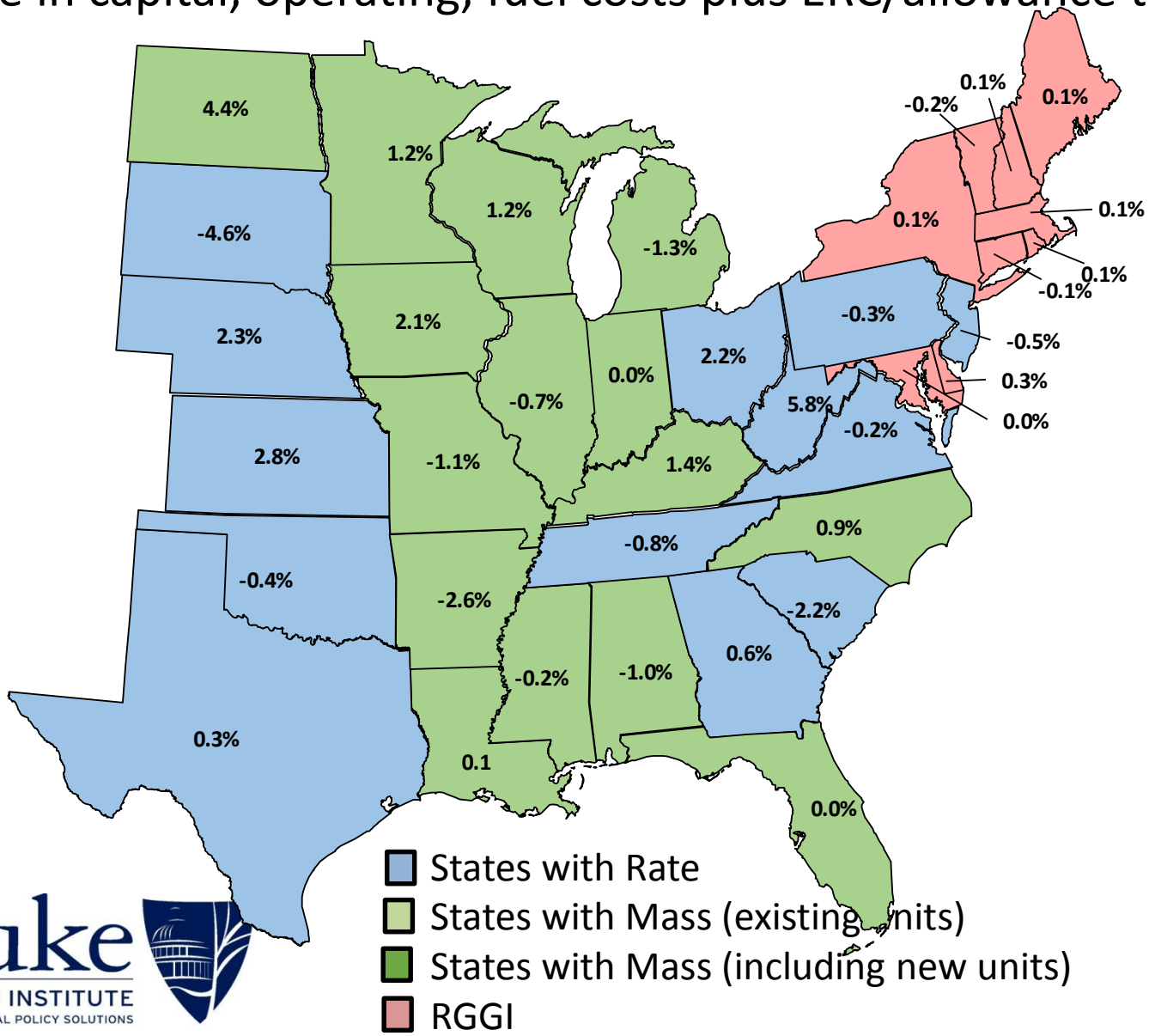

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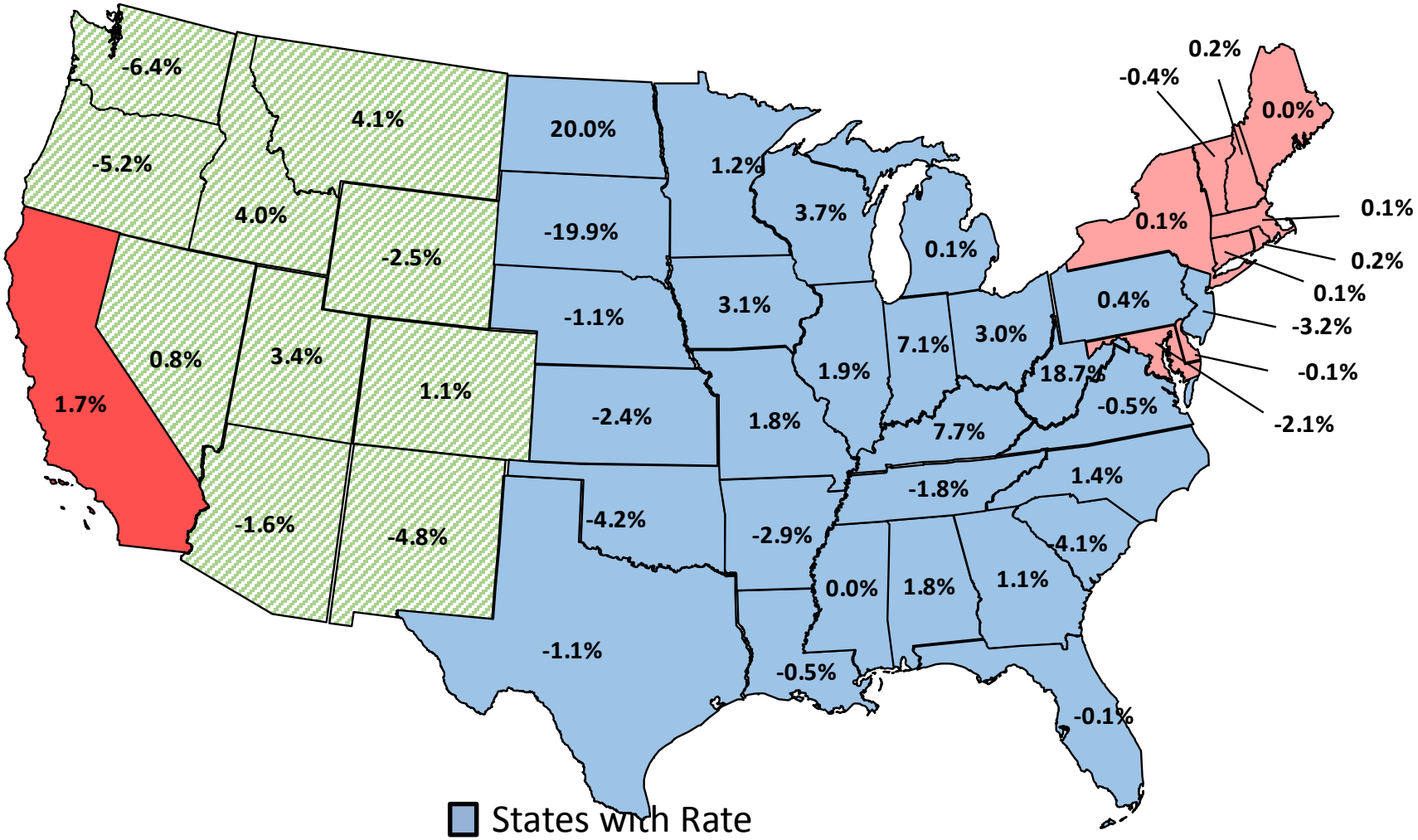

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Sensitivities & Final Thoughts

- Natural gas
  - Low prices encourage gas at the expense of coal, and also replaces renewables
  - Reduced demand from energy efficiency comes out of gas generation, not coal
  - A rate-based policy with low gas prices greatly encourages gas generation
  - High gas prices have the largest CPP costs, while low prices eliminate most costs
- Electricity demand
  - Higher than expected electricity demand growth is supplied by gas
  - High demand makes mass with New Source Complement more expensive
- Renewables and energy efficiency
  - Low renewable costs make dual rate cheaper but lead to higher emissions
  - Limited EE makes dual rate more expensive
- Policy Costs (assuming patchwork approach)
  - Even if policy costs for a region are close to zero, individual states may be sensitive to variations in gas & renewables costs, or electricity demand
  - Things will not always move in the direction you expect, depending on what happens with your neighbors

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Thank You

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