Rhodium Group

State climate ambition with the Inflation Reduction Act

Energy system, emissions, and fiscal outcomes

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About this analysis

The Environmental Defense Fund (EDF) commissioned Rhodium Group to demonstrate the emissions and energy systems impacts of achieving state GHG targets consistent with the US Nationally Determined Contribution (NDC) in climate-leader states, including the effects and consequential federal investments of achieving these targets driven by the Inflation Reduction Act (IRA). Rhodium Group performed this analysis independently and maintained full analytical and editorial control of this deliverable. The results presented reflect the views of the authors and not necessarily those of the supporting organization.

Rhodium Group is an independent research provider combining economic data and policy insight to analyze global trends. Rhodium's Energy & Climate team analyzes the market impact of energy and climate policy and the economic risks of global climate change. This interdisciplinary group of policy experts, economic analysts, energy modelers, data engineers, and climate scientists supports decision-makers in the public, financial services, corporate, philanthropic and non-profit sectors. More information is available at www.rhg.com.

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SECTION 1

Project introduction and modeling approach

Project overview

Passage of the Inflation Reduction Act (IRA) in August 2022 marked the single largest action ever taken by the federal government to address climate change and represents an inflection point in greenhouse gas (GHG) emission trajectories in a wide range of modeling scenarios. Rhodium Group estimates current policy, including the IRA and binding state policies with specific targets and timelines, will drive economywide emissions to 29-42% below 2005 levels in 2030.

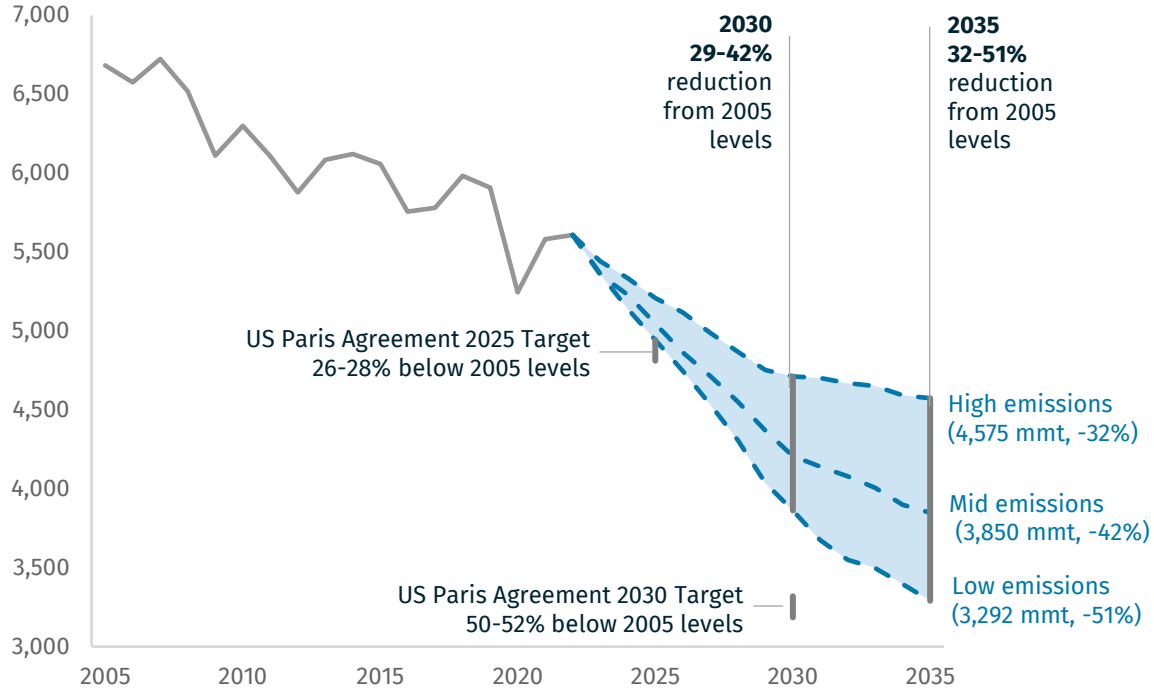
While this reflects an acceleration of the rate of decarbonization over historical levels, it is still not sufficiently fast for the US to achieve its 2030 Nationally Determined Contribution (NDC) under the Paris Agreement of a 50-52% reduction below 2005 levels.

State action has been a key historic driver of climate ambition, and additional policy action by states can help further close the gap between current emissions projections and the 2030 NDC target. In addition, states can leverage investments made by the IRA to achieve these emissions goals at a lower cost.

Project goal: Demonstrate the emissions and energy systems effects and consequential federal investments of setting and achieving state GHG targets consistent with the US NDC in climate-leader states.

US greenhouse gas emissions from Taking Stock 2023

Net million metric tons (MMT) of CO2-equivalent



Modeling approach overview

1. Starting from Rhodium Group's Taking Stock 2023 baseline, model the effects of a national gross energy CO2 cap using RHG-NEMS

2. Establish sectoral targets in climate leader states that reflect the outcomes in the national cap

3. Estimate non-energy CO2 abatement opportunities using RHG-ICAP and other tools

Modeling approach: Taking Stock 2023 baseline

We begin this analysis from Rhodium Group's Taking Stock 2023 "mid emissions" scenario estimates. Every year, Rhodium Group produces an independent projection of future emissions under current policy and expectations for economic growth, future fossil fuel prices, and clean energy cost and performance trends.

- We use RHG-NEMS to quantify the energy sector and emissions outcomes. RHG-NEMS is a modified version of the National Energy Modeling System (NEMS), a model developed by the US Energy Information Administration (EIA) to produce their Annual Energy Outlooks. Rhodium Group maintains a version of NEMS that we modify from the EIA base version.
- Key mid emissions scenario assumptions include continued cost declines for clean energy technologies consistent with NREL's Annual Technology Baseline moderate case (for most electric power technologies), Rhodium Group's own analysis (for carbon capture in industry and power), and EIA projections for battery prices (for electric power storage and transportation). Fossil fuel and macroeconomic projections are generally consistent with EIA's Annual Energy Outlook 2023 reference case.
- Taking Stock scenarios quantify the impacts of all actionable and quantifiable existing federal and state policies as of June 2023, including the IRA and Infrastructure Investment and Jobs Act (IIJA) as well as state carbon pricing policies, clean energy and renewable portfolio standards (CES and RPS), and zero-emitting vehicle (ZEV) targets.
- Additional detail on inputs and assumptions to the baseline are available in the Taking Stock 2023 technical appendix and on ClimateDeck.
- We adjust this baseline to reallocate historic iron and steel production emissions to the state level based on a new methodology that better captures emissions trends.

Modeling approach: national cap and climate leader states

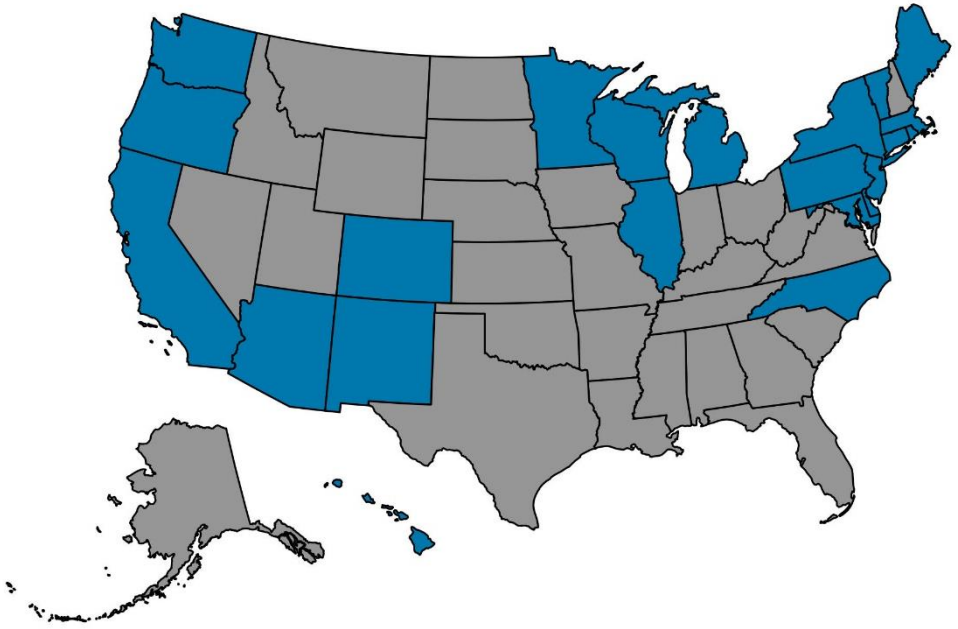
National cap

- NEMS operates on a variety of geographic scales including 25 electricity market regions, nine census divisions representing energy demand, and nine continental US oil and gas supply regions, among others. Rhodium Group had developed downscaling methodologies to refine these regional outcomes to the state level, but NEMS cannot natively establish emissions caps for individual states.
- To demonstrate the energy system response to an emissions target, we first modeled a national emissions cap targeting a 45% energy sector CO2 reduction, to be consistent with an overall target of a 50% net reduction in GHGs compliant with the US 2030 NDC.

Targets for climate-leader states

- We model a set of climate-leader states establishing and achieving state emissions caps that jointly reduce gross economywide GHG emissions by 45% over 2005 levels.[1] We define climate-leader states as the members of the US Climate Alliance (USCA) (shown at right).[2]

Modeled US Climate Alliance states[2] (highlighted)



[1] Given projected carbon removals in 2030, EDF has determined a 45% reduction in gross emissions between 2004 and 2030 is consistent with achieving a 50% net reduction over the same period. For more information, see Appendix 5 from EDF's Turning Climate Commitments into Results: Evaluating Updated 2023 Projections vs. State Climate Targets. Rhodium Group therefore models a 45% gross emissions reduction target.

[2] Puerto Rico and Guam are also members of the USCA but are not fully represented in RHG-NEMS; they are omitted from this analysis.

Modeling approach: state sectoral targets and non-CO2 abatement

State-level targets

- We establish sectoral-level targets on a state-by-state basis that reflect how the energy system responds to a national cap in NEMS. Some targets are binding within the model and provide an exogenous method to drive states to achieve sectoral and emissions outcomes; other targets are not binding at the state level and are subject to optimization at the relevant geographic level in the model.
  - Power sector emission reduction targets (for in-state generation)
  - Light, medium, and heavy-duty vehicle zero-emitting vehicle targets
  - Reduced carbon intensity of liquid transportation fuels
  - Reduced LDV vehicle miles traveled
  - Increased electrification and reduced fuel consumption in residential and commercial buildings
- We expand these target beyond energy sector CO2 in a number of ways, including:
  - Additional industrial decarbonization technology adoption using Rhodium Group's Industrial Carbon Abatement Platform (RHG-ICAP)
  - Adoption of EPA's finalized oil and gas methane regulations
    (Note: Final EPA O&G regulations are not included in our baselines, since they were finalized after the publication of Taking Stock 2023.)
  - Methane and nitrous oxide reduction targets

Modeling approach: state sectoral targets and non-CO2 abatement

- We do not account for natural carbon removal when establishing a 45% gross reduction target. There is limited uptake of technological carbon removal in the baseline as well as limited increased deployment of ethanol production with CCS in the state target case.
- Variation in state-level outcomes is largely driven by the availability of cost-effective decarbonization opportunities. Some states may have better or worse wind or solar resources for power generation, other states may or may not have industrial facilities suitable for carbon capture retrofits. By replicating the dynamics we see in the national cap run, we roughly proxy the availability of these cost-effective opportunities in our sectoral-level inputs.
- We use consistent sectoral interventions across the IRA and no IRA scenarios. In the no IRA scenario, this input consistency leads to the USCA states slightly underachieving the 45% gross reduction target. The model yields differentiated responses to the target given meaningfully different economics with IRA financial support and without (e.g., more ZEV or heat pump sales in earlier years of the analysis window)
- Additional detail on state targets is available in the appendix to this report.

SECTION 2

Scenario descriptions

Scenario descriptions

- Taking Stock 2023: Rhodium Group's mid emissions current policy baseline.
- **Taking Stock 2023 (No IRA):** Rhodium Group's mid emissions current policy baseline, reversing any policies enacted by the Inflation Reduction Act. Where appropriate, these policies revert back to pre-IRA levels (e.g., tax credits).
- **USCA Action:** Beginning with the Taking Stock 2023 baseline, US Climate Alliance (USCA) states establish and meet GHG emissions targets that achieve a collective 45% gross reduction in emissions over 2005 levels.
- **USCA Action (No IRA):** Beginning with the Taking Stock 2023 (No IRA) baseline, USCA states establish and meet GHG emissions targets that achieve a collective 45% gross reduction in emissions over 2005 levels.
- **Sensitivities:**
  - USCA Action + CA Scoping Plan: USCA Action results for all USCA states except California, which achieves the percentage levels of reductions in each sector from 2022-2030 as identified in the CARB 2022 Scoping Plan.
  - USCA Action (No IRA) + CA Scoping Plan: USCA Action (No IRA) results for all USCA states except California, which achieves the percentage levels of reductions in each sector from 2022-2030 as identified in the CARB 2022 Scoping Plan.

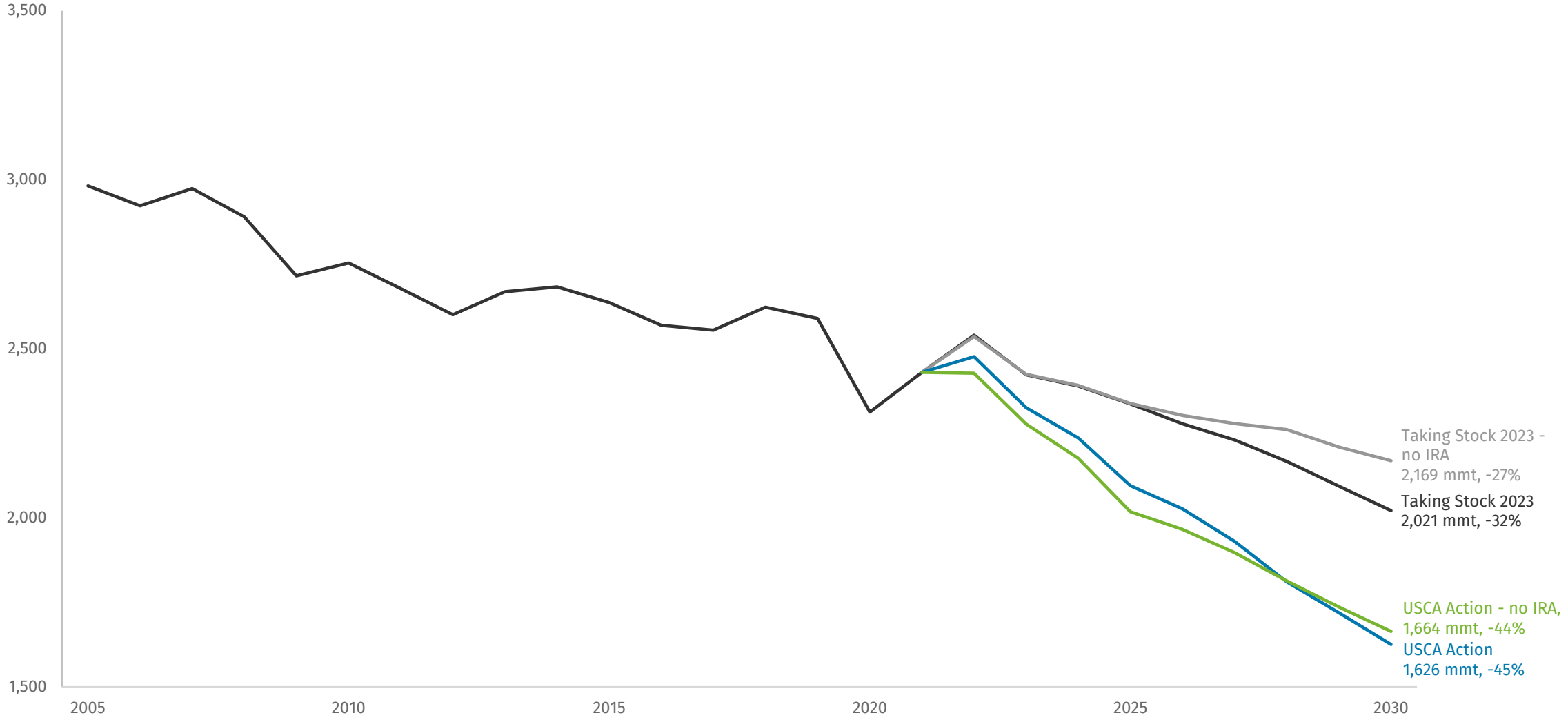
SECTION 3

Results

Overall emission reductions

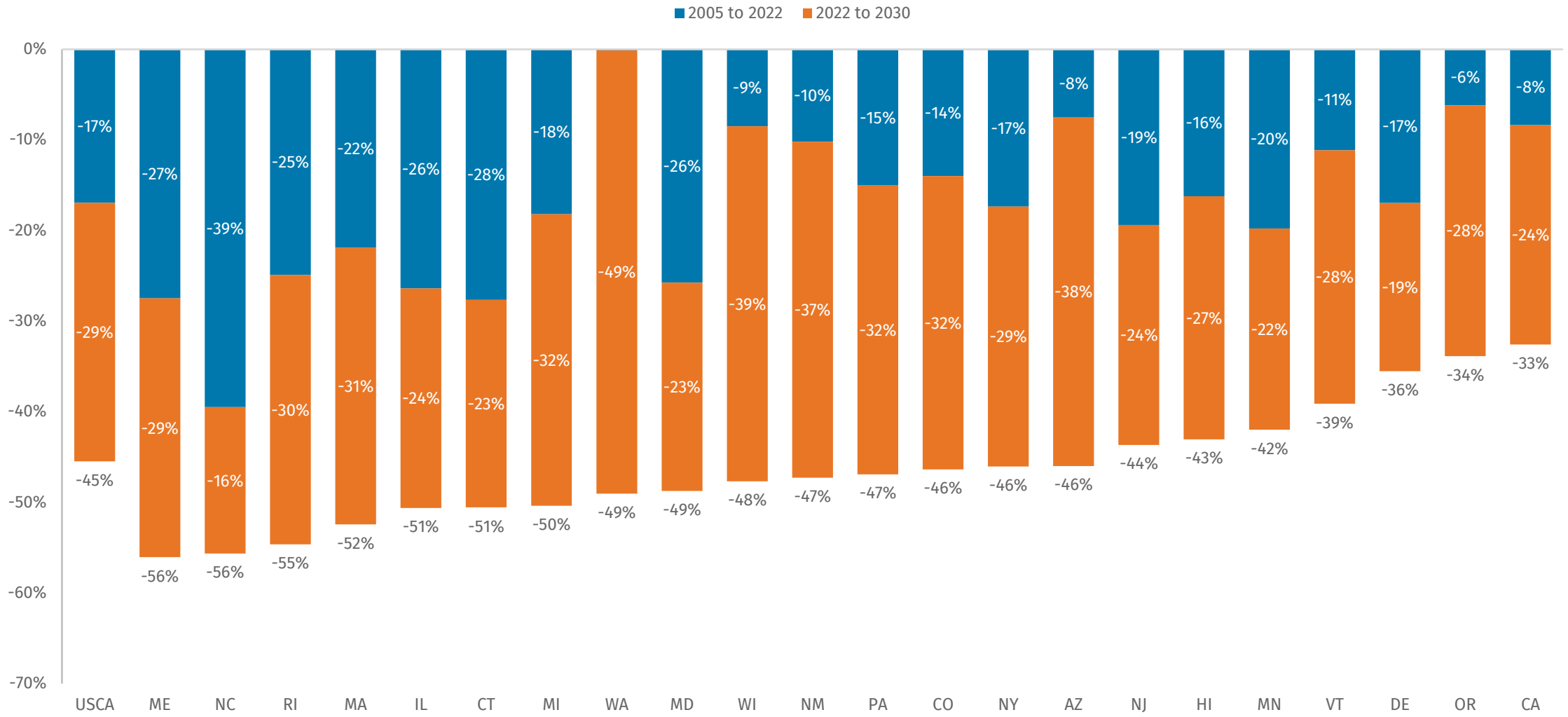
Gross greenhouse gas emissions

MMT CO_2e in USCA states, percent reduction from 2005 level



GHG reductions in USCA Action scenario in 2030

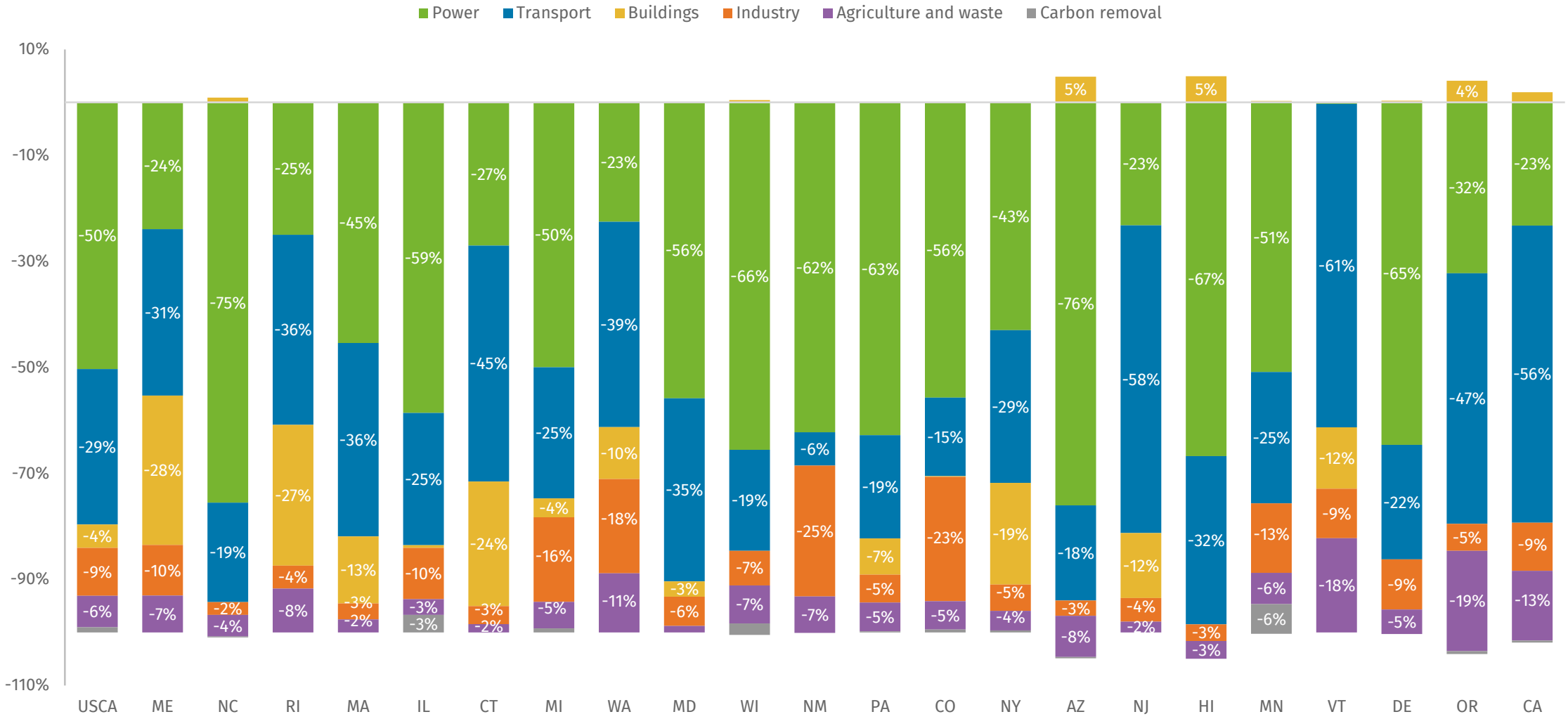
Percent reduction in gross GHG emissions from 2005 level



Note: USCA Action scenario includes impacts of the IRA. See Section 4 for sensitivities that include CA achieving its Scoping Plan targets.

GHG reductions by sector in USCA Action scenario from 2005 to 2030

Share of total GHG reduction from 2005 level from sector



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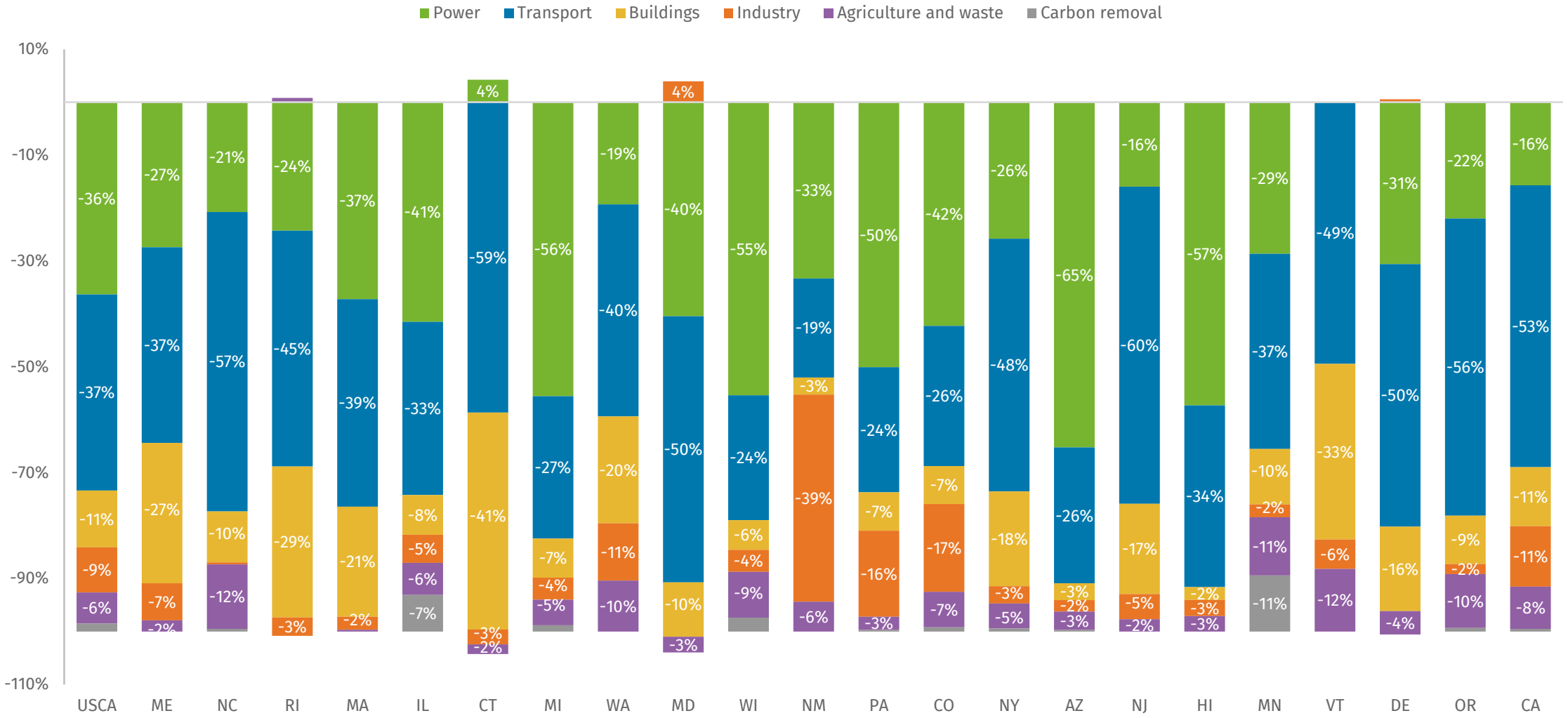
GHG reductions by sector in USCA Action scenario from 2022 to 2030

Share of total GHG reduction from 2022 level from sector



Note: USCA Action scenario includes impacts of the IRA.

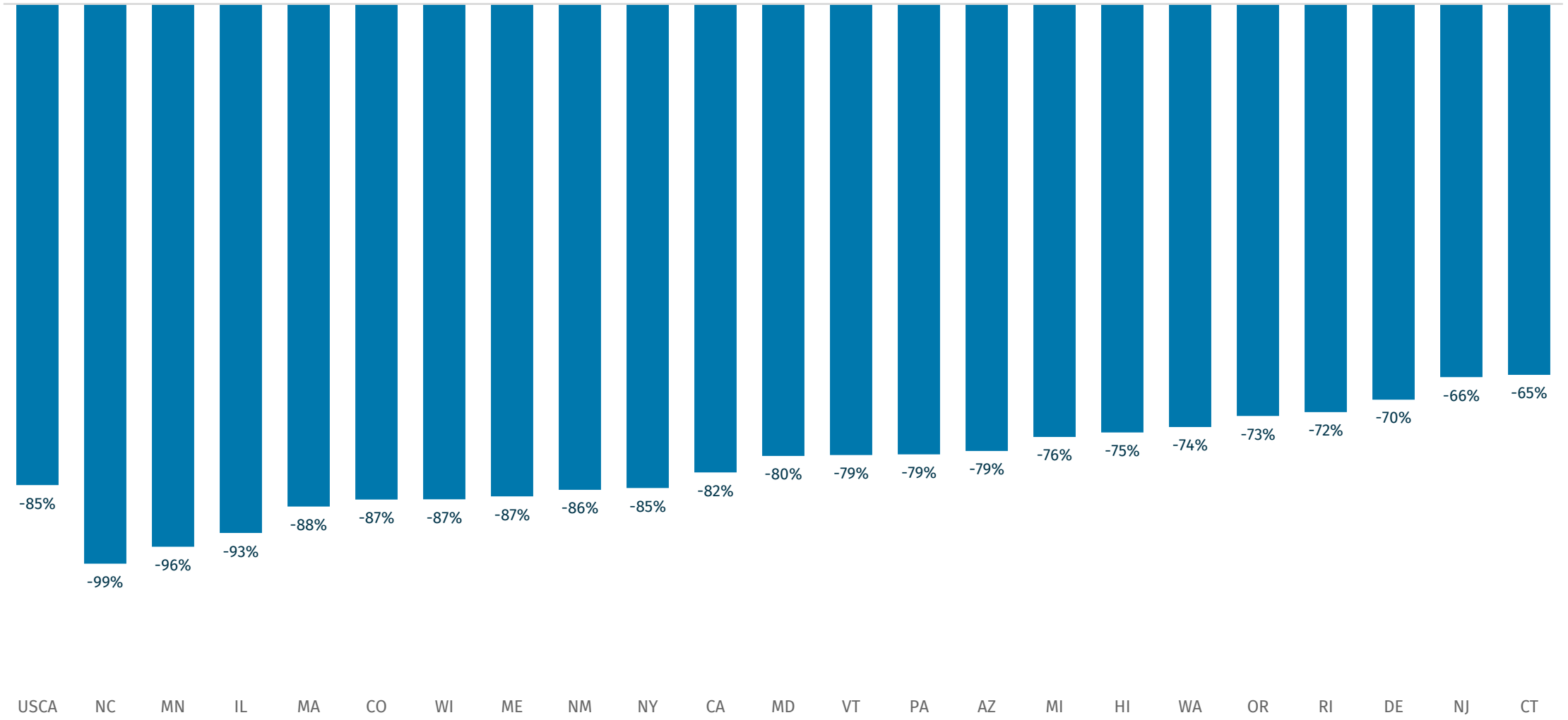
SECTION 3

Results

Sectoral technology changes

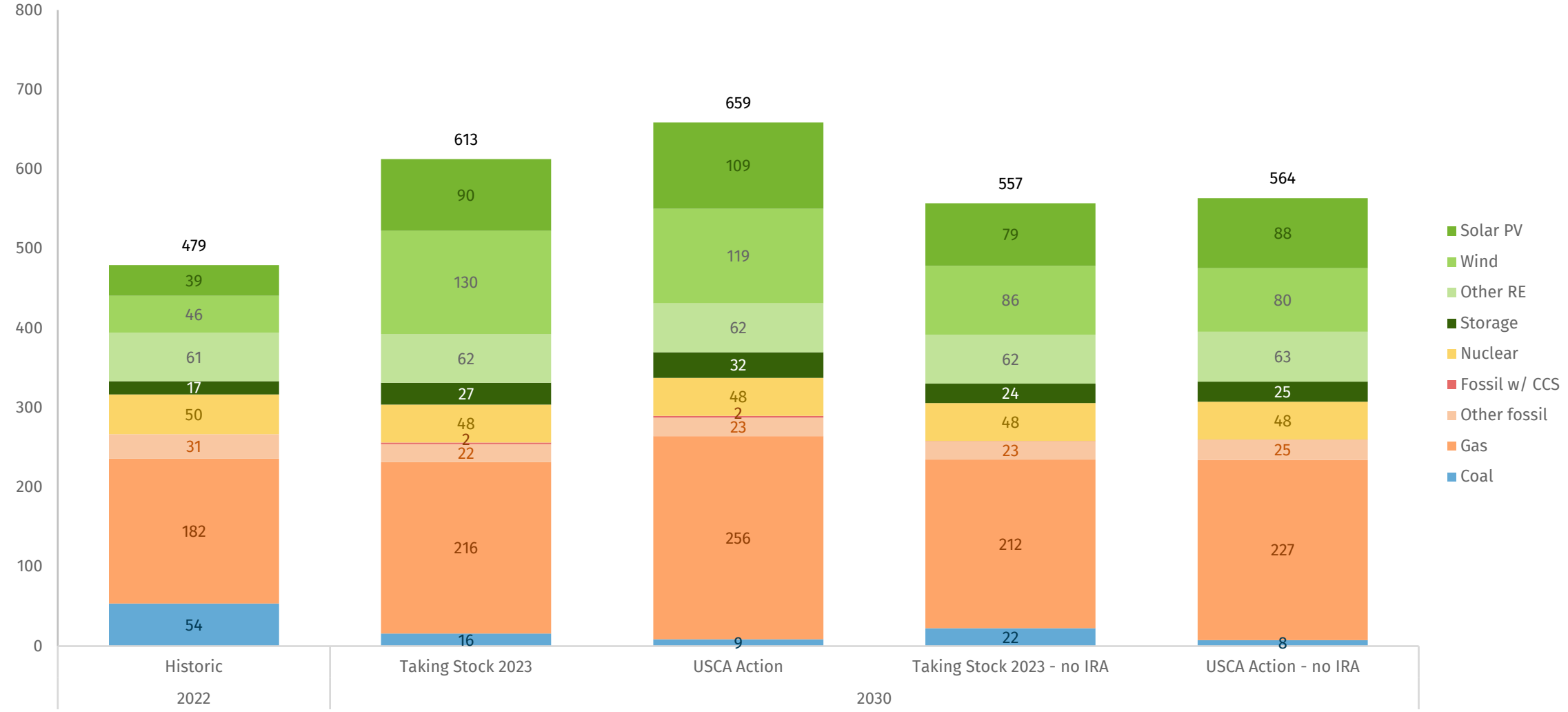
Power sector GHG reductions in 2030

Percent reduction in gross GHG emissions from 2005 level in **USCA Action** scenario



Power sector capacity

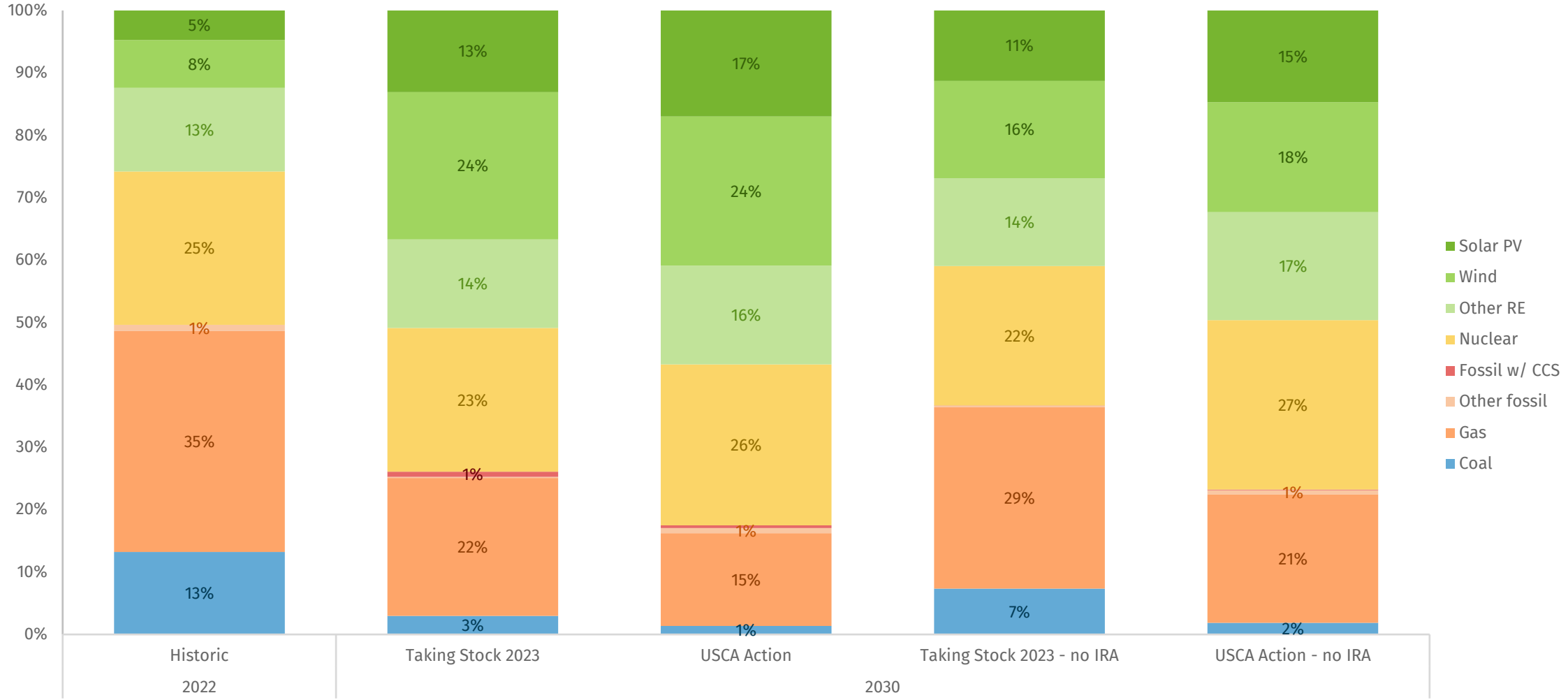
GW in USCA states



Note: Other RE category includes hydropower, biomass, geothermal, fuel cell, waste, and solar thermal.

Power sector generation

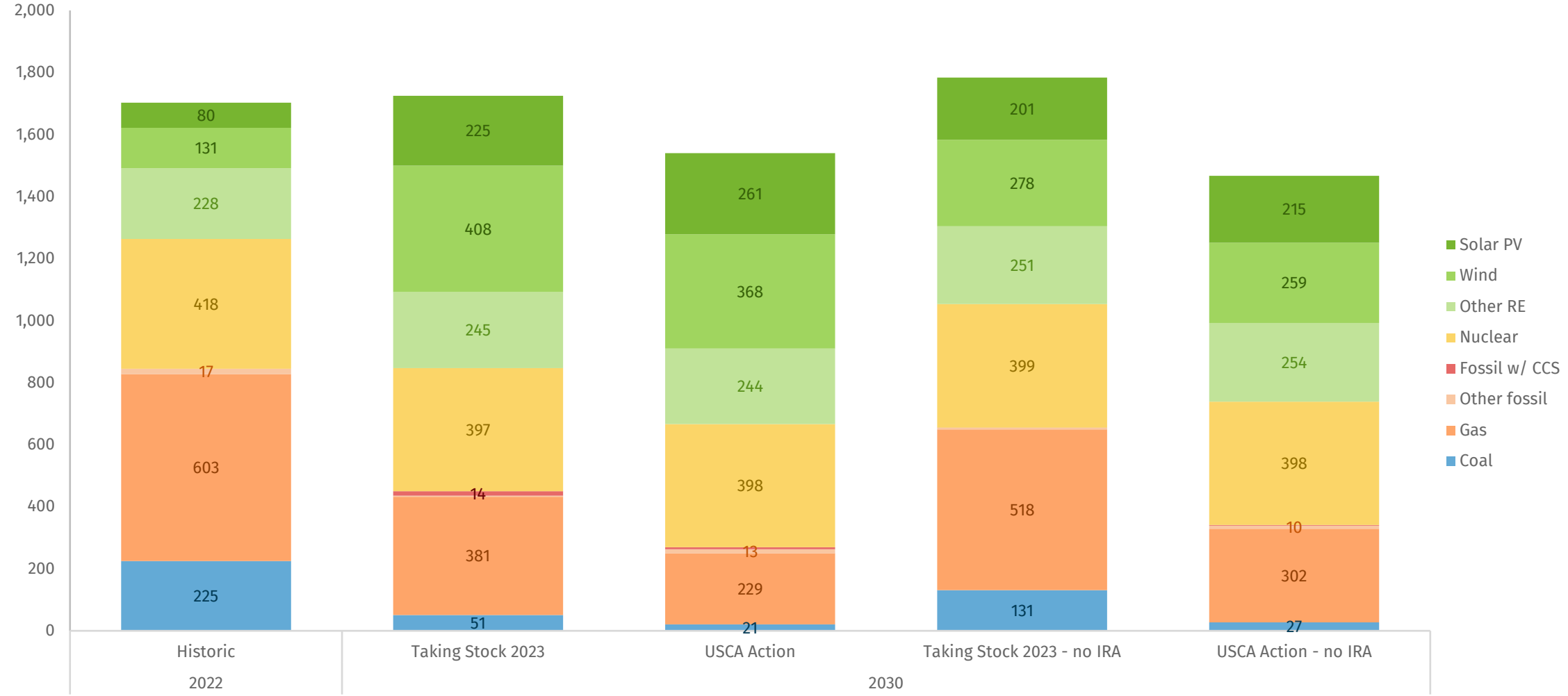
Percent of total power sector generation in USCA states



Note: Other RE category includes hydropower, biomass, geothermal, fuel cell, waste, and solar thermal.

Power sector generation

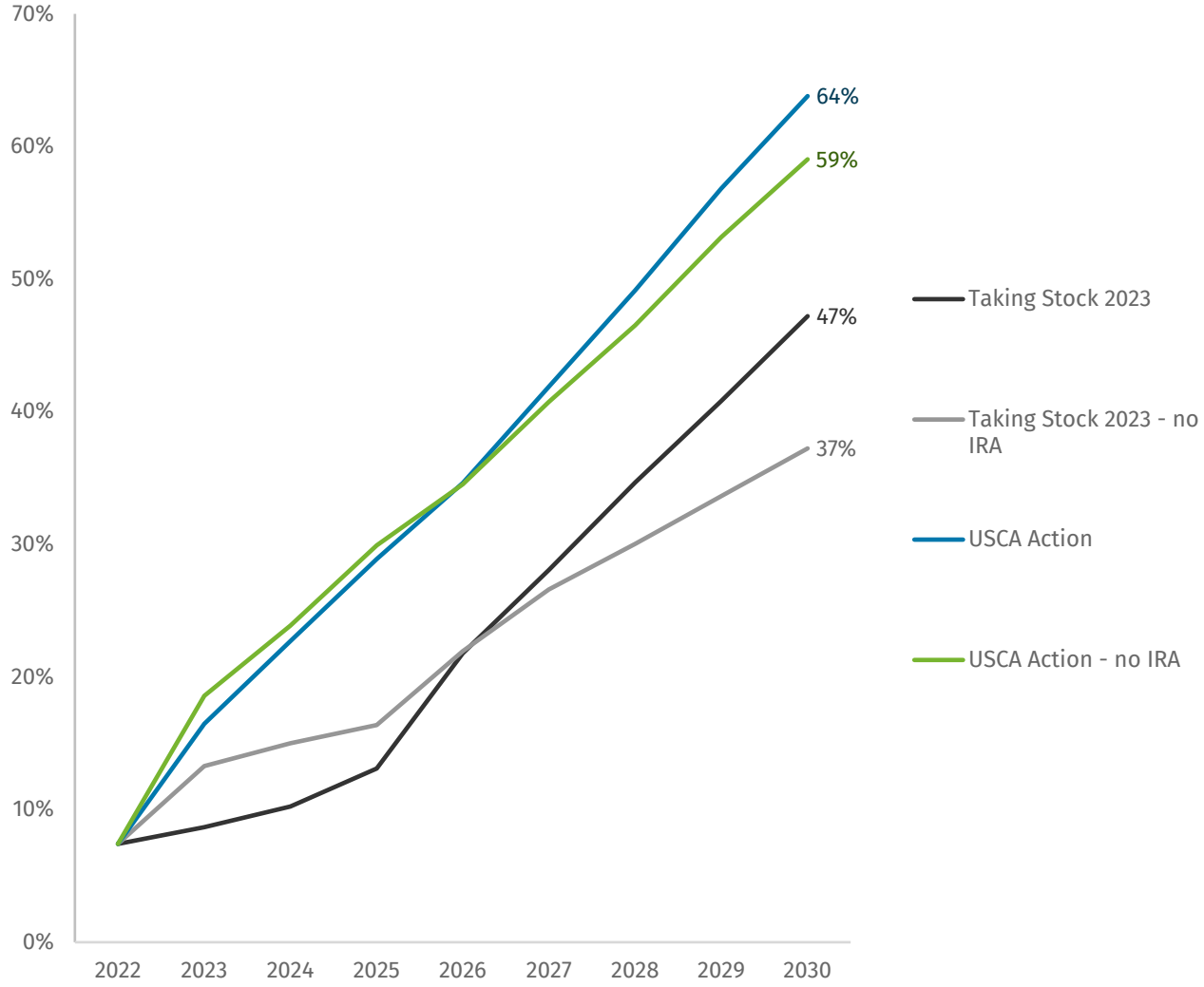
TWh of total power sector generation in USCA states



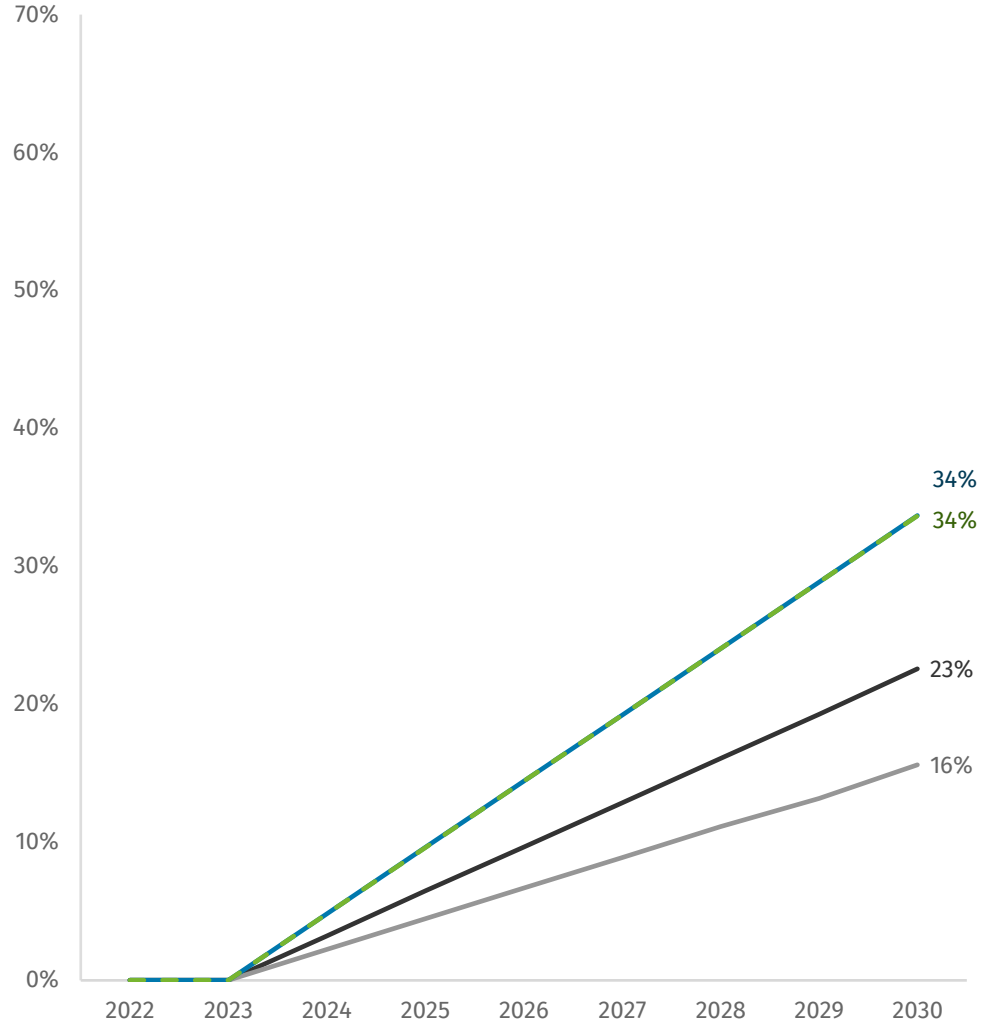
Note: Other RE category includes hydropower, biomass, geothermal, fuel cell, waste, and solar thermal.

Zero-emitting vehicle (ZEV) sales shares

Percent of LDV ZEV sales in USCA states

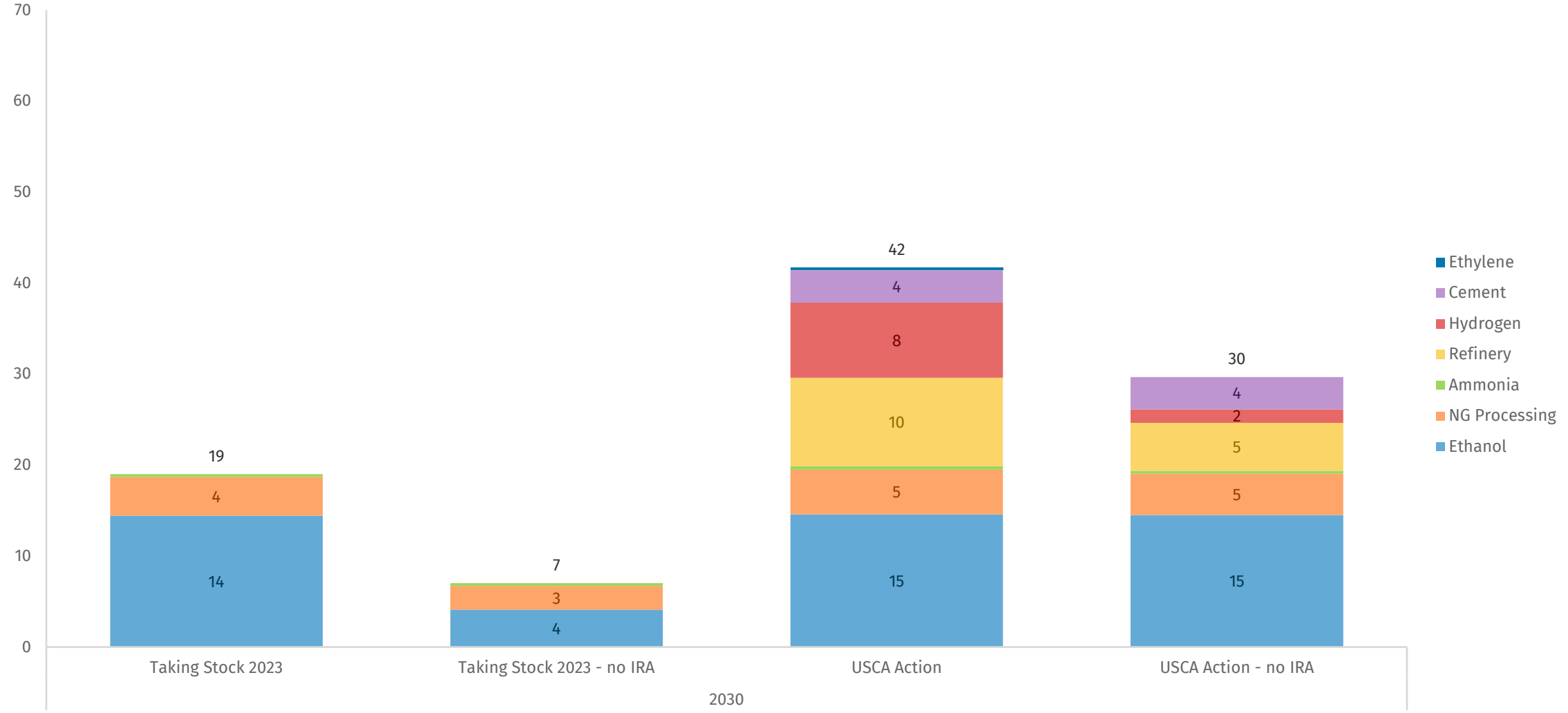


Percent of MDV/HDV ZEV sales in USCA states



Industrial carbon capture capacity in 2030

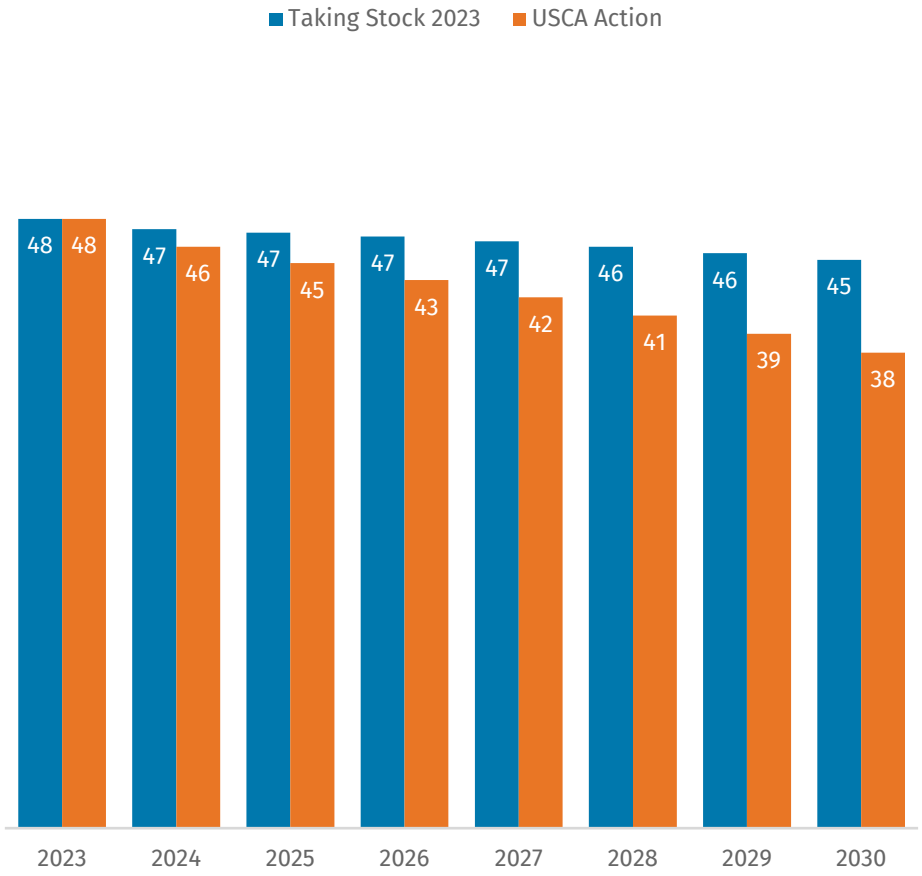
Million metric ton per year of CO_2 capture capacity in USCA states



Building stock energy use intensity

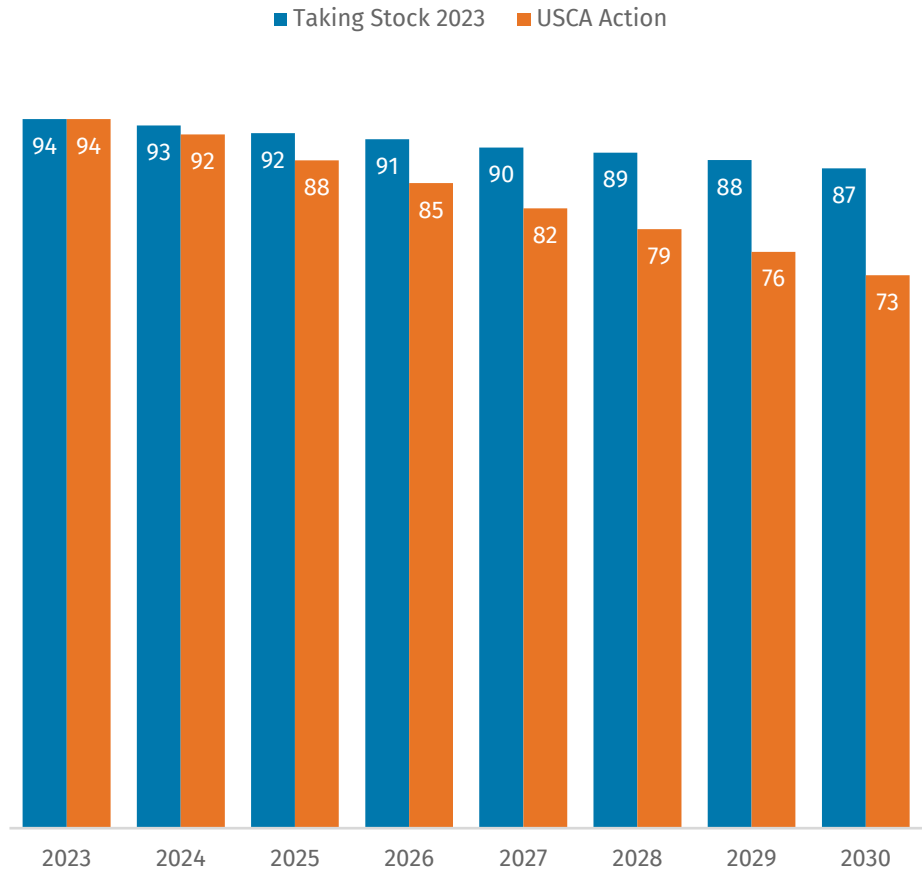
Residential building energy use intensity

Thousand BTU of delivered energy per square foot in USCA states



Commercial building energy use intensity

Thousand BTU of delivered energy per square foot in USCA states



Note: Decreasing energy use intensity (EUI) reflects efficiency gains from electrification as well as traditional efficiency measures.

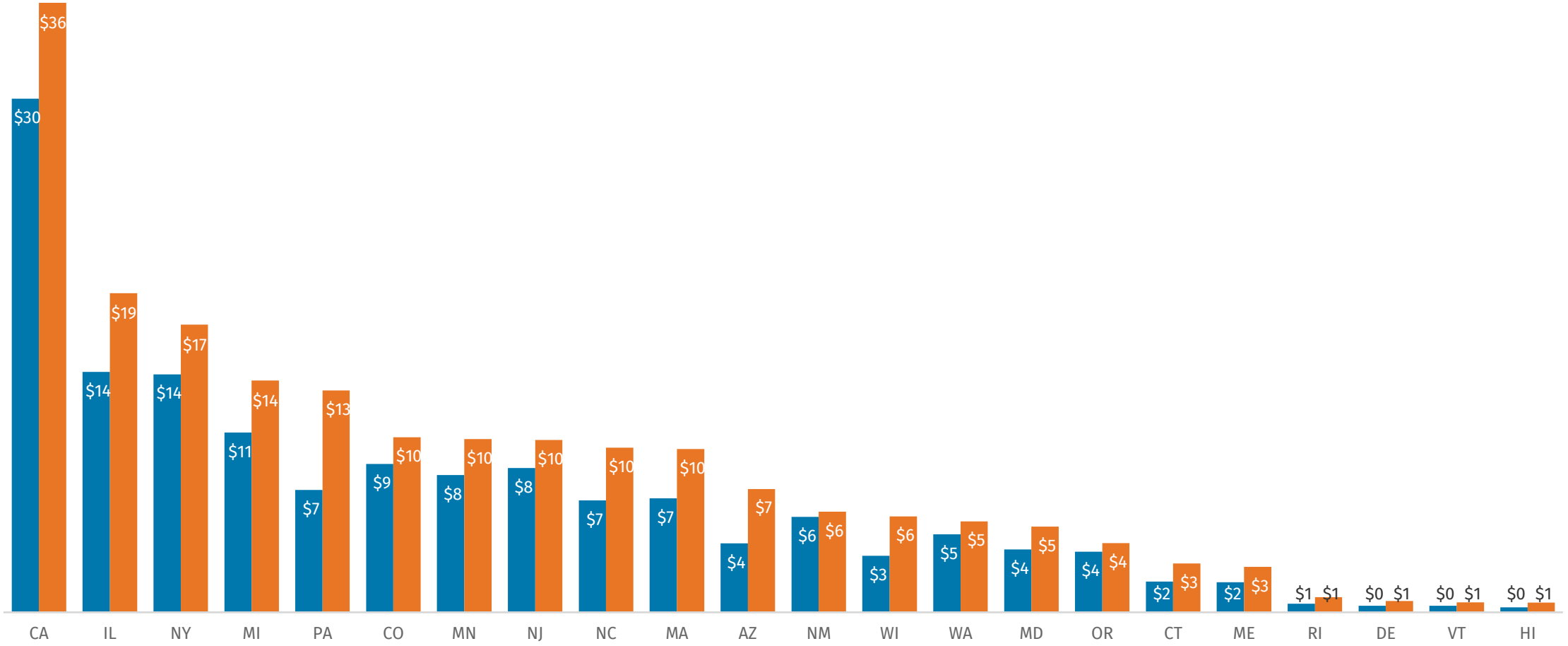
SECTION 3

Results

Economic impacts

Cumulative total federal tax expenditures for clean energy credits

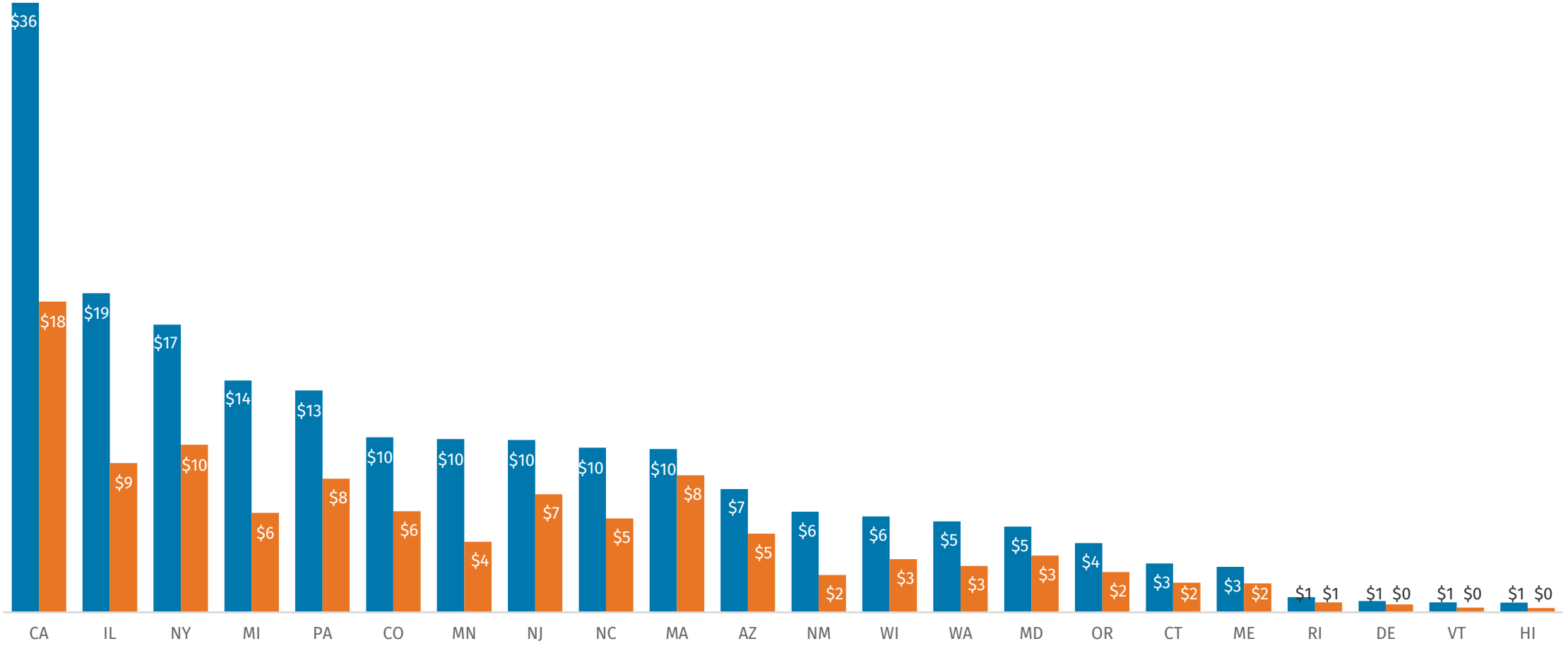
Billions of USD (2022), 2023-2030 in **Taking Stock 2023** and **USCA Action** scenarios



Note: Federal tax expenditures represent the value of tax credits that accrue to a state from clean electricity tax credits, clean vehicle tax credits, carbon capture and hydrogen tax credits, and building efficiency tax credits.

Cumulative total federal tax expenditures for clean energy credits

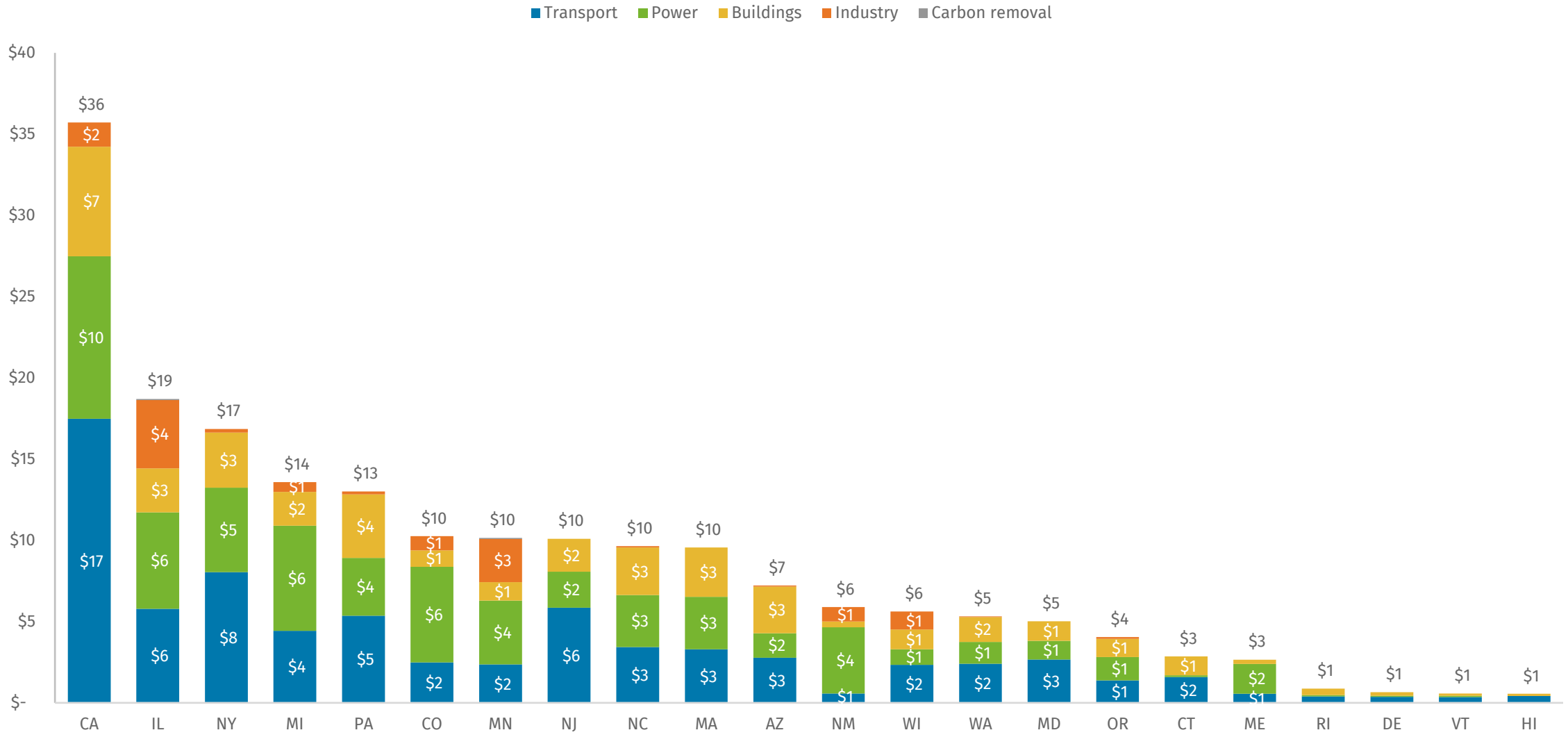
Billions of USD (2022), 2023-2030 in **USCA Action** and **USCA Action – No IRA** scenarios



Note: Federal tax expenditures represent the value of tax credits that accrue to a state from clean electricity tax credits, clean vehicle tax credits, carbon capture and hydrogen tax credits, and building efficiency tax credits.

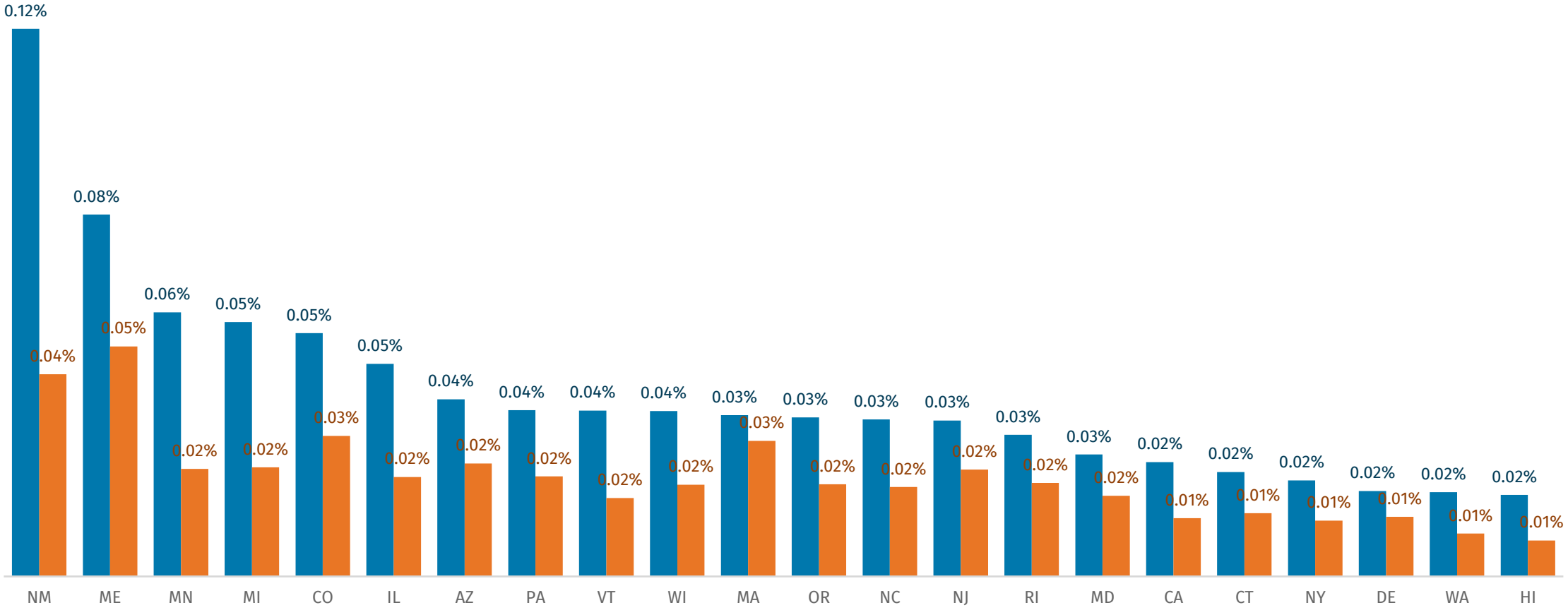
Cumulative clean energy tax expenditures by sector in USCA Action scenario

Billions of USD (2022). 2023-2030



Federal tax expenditures relative to the size of state economy

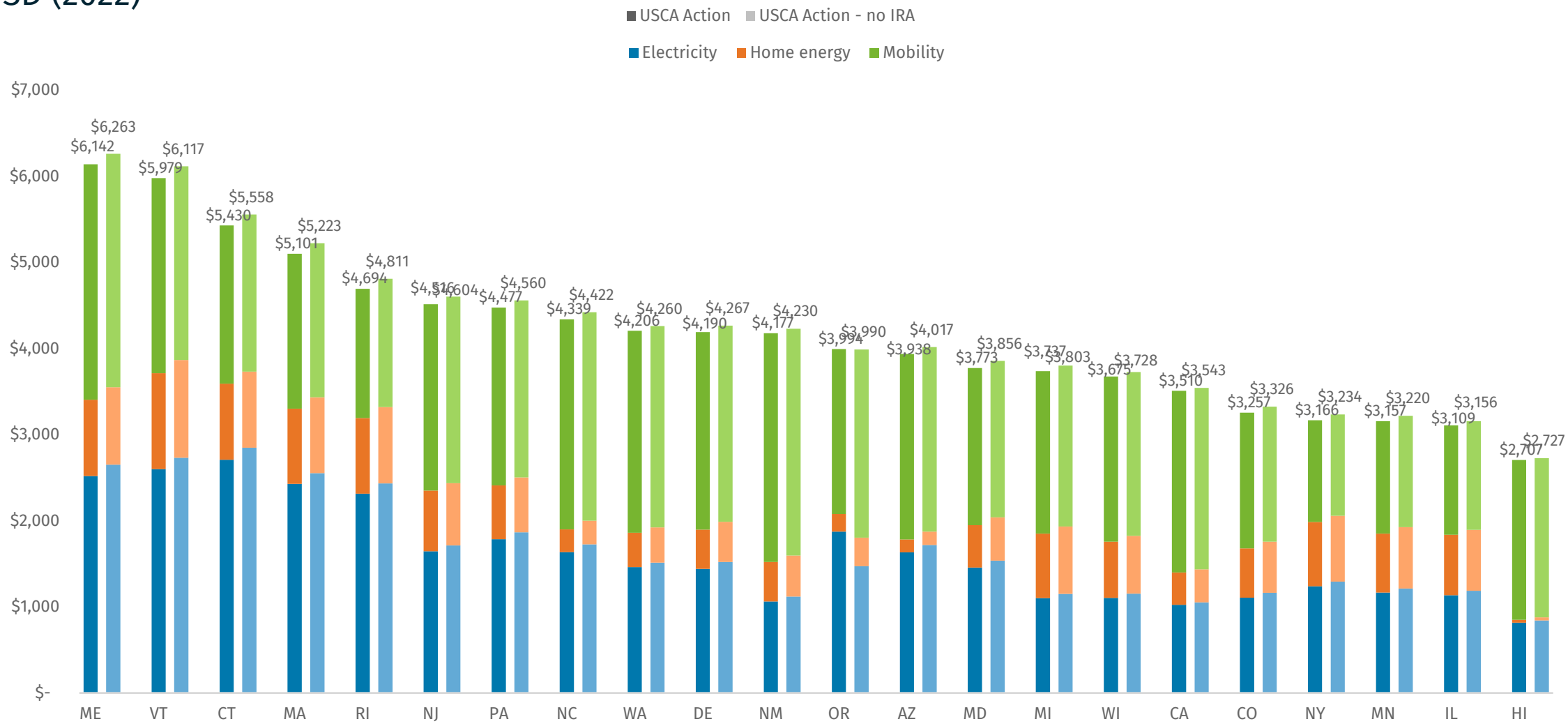
Average 2023-2030 tax expenditures as percentage of state 2022 total GDP
in **USCA Action** and **USCA Action – No IRA** scenarios



Note: State GDP from BEA

Average household energy expenditures in 2030

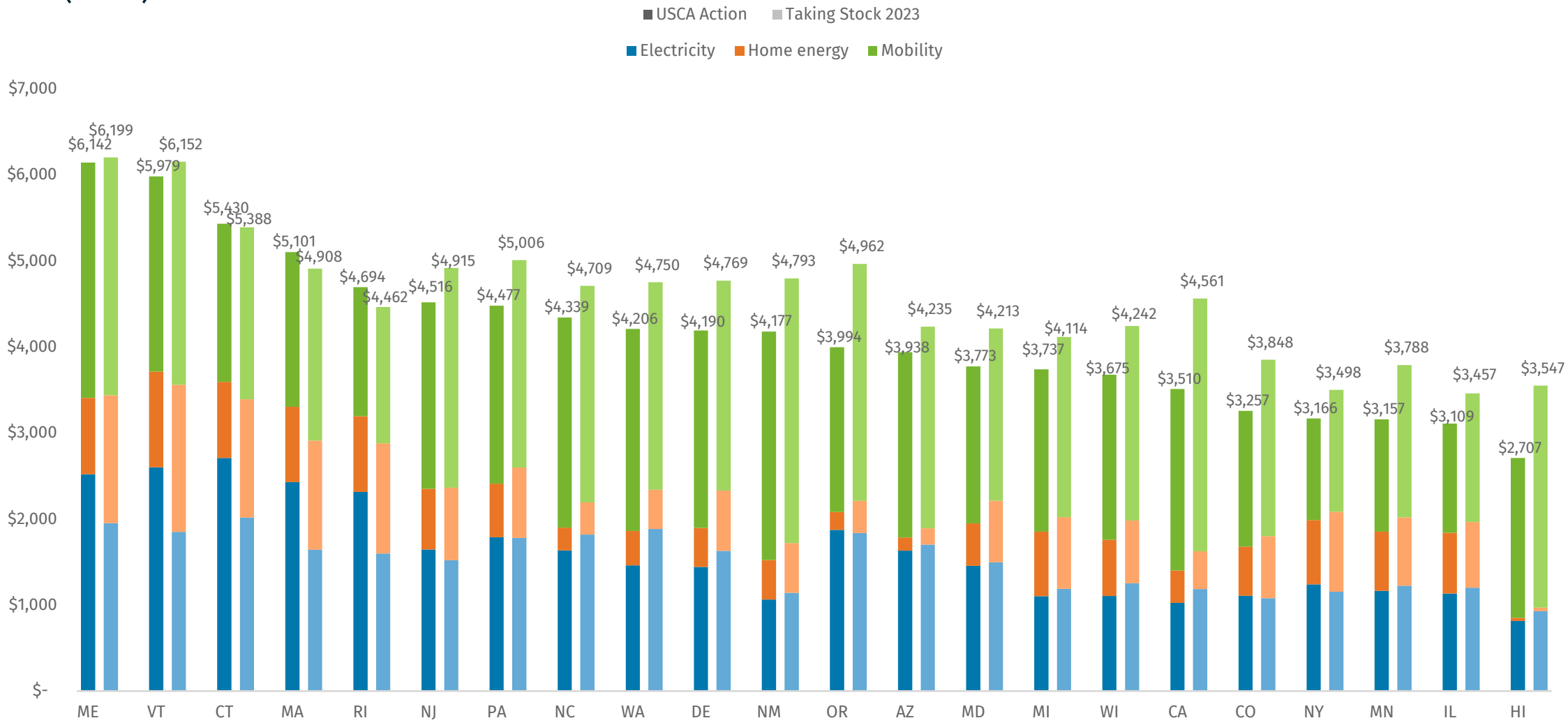
USD (2022)



Note: Household energy expenditures represent average household spending on electricity bills, home energy bills (e.g., natural gas, propane, fuel oil, etc.), and vehicle fuel (gasoline and diesel). Number of households in a state assumes consistent state share of national population from 2022-2030.

Average household energy expenditures in 2030

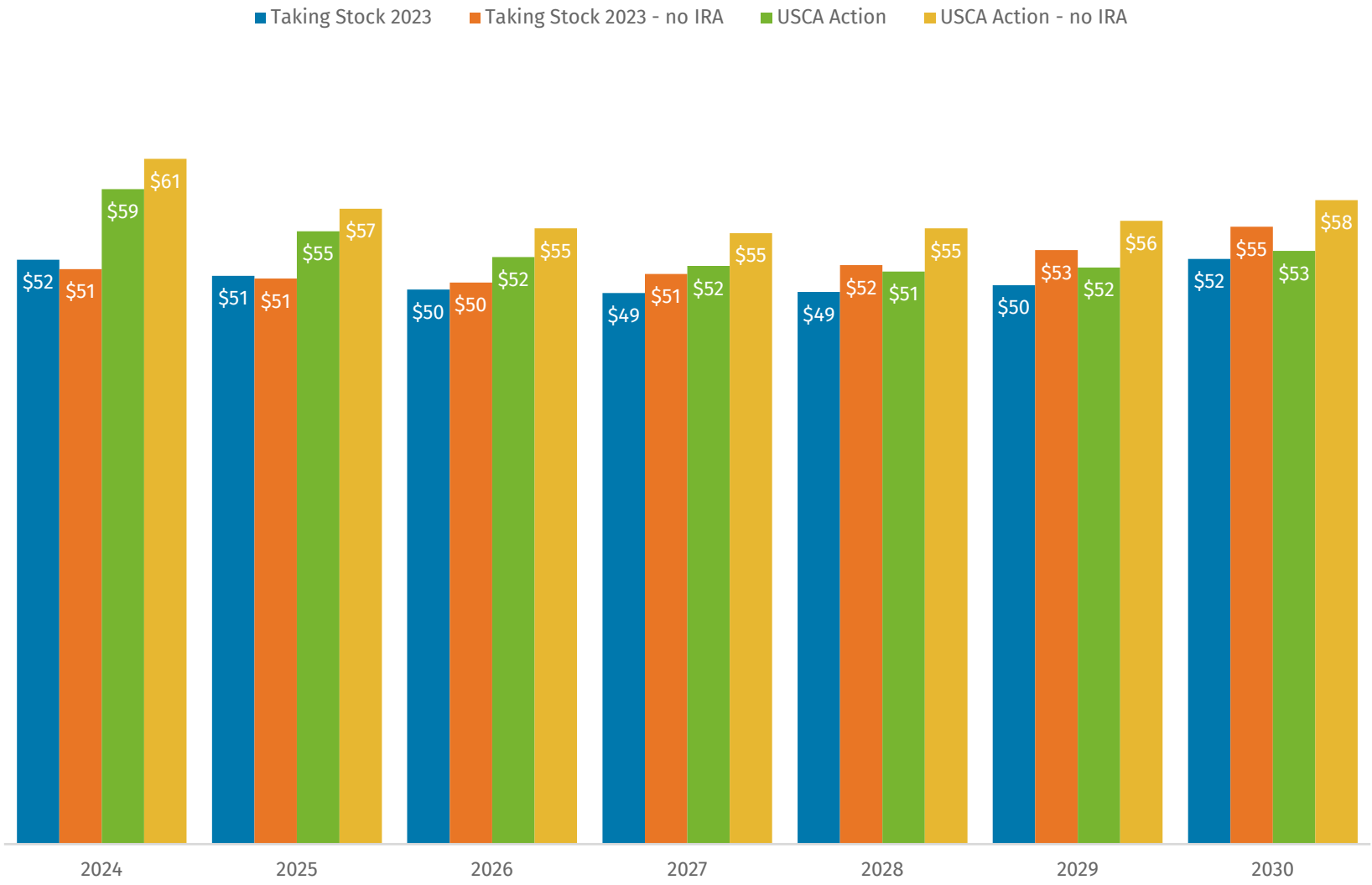
USD (2022)



Note: Household energy expenditures represent average household spending on electricity bills, home energy bills (e.g., natural gas, propane, fuel oil, etc.), and vehicle fuel (gasoline and diesel). Number of households in a state assumes consistent state share of national population from 2022-2030.

Total annual power sector system costs

Billion USD (2022) for select electricity regions



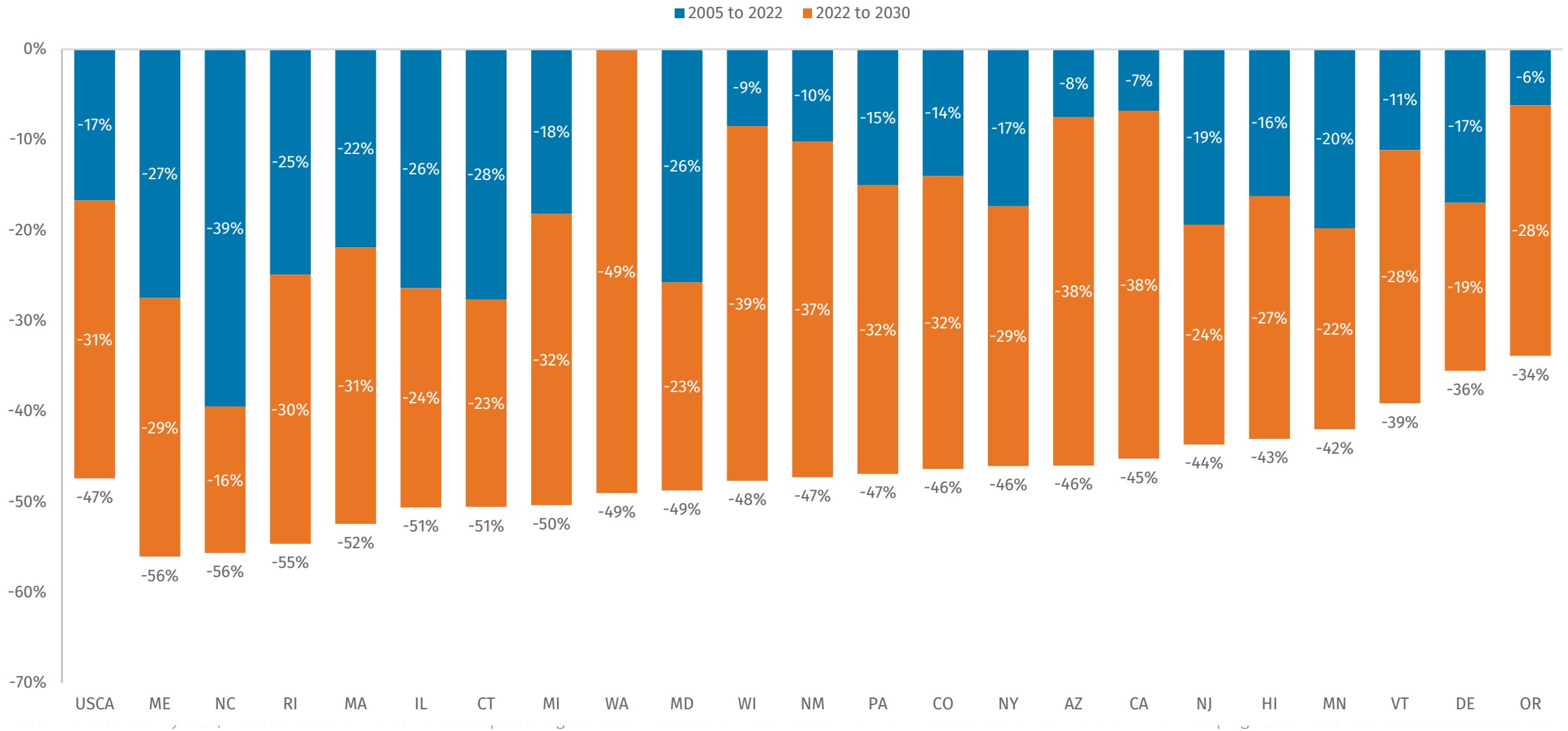
- Power sector costs include annual generating capacity costs, fuel and non-fuel O&M, transmission capacity costs, and other capital expenses.
- These results reflect total resource costs in 12 of 25 electricity market regions that roughly align with the majority of the USCA state footprint. Some portions of non-USCA states are included in these regions, and some portions of USCA states are not included in these regions, so this analysis should be taken as directional rather than a precise estimate of total system cost in USCA states.

SECTION 4

Sensitivity results

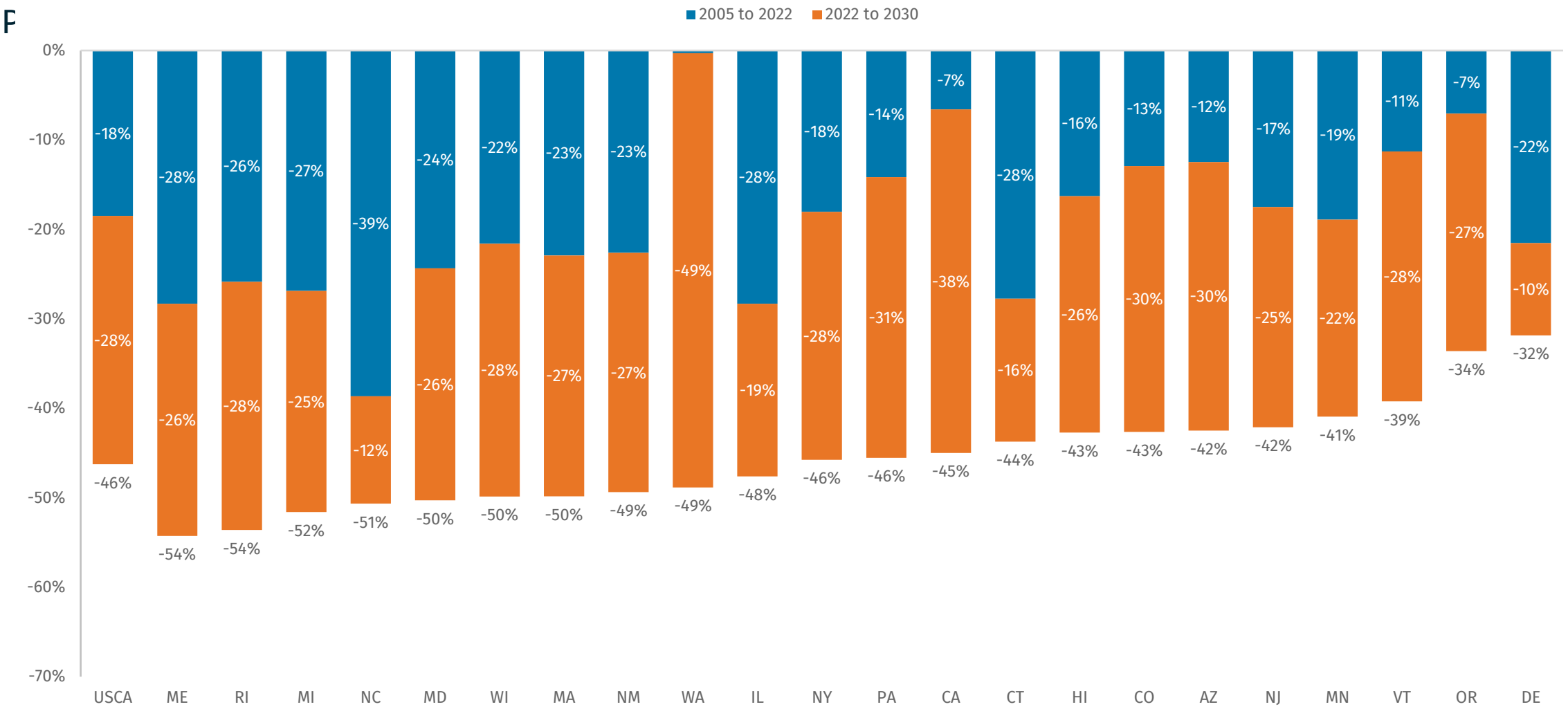
GHG reductions in USCA Action + CA Scoping Sensitivity in 2030

Percent reduction in gross GHG emissions from 2005 level



HG-
NEMS, but rather apply those reduction levels to our 2022 baseline. Note that the CARB Scoping Plan includes emission reductions from sourcing cleaner out-of-state power; we only model power emissions coming from in-state generators.

GHG reductions in USCA Action (No IRA) + CA Scoping Sensitivity scenario in 2030



Note: In this sensitivity case, we assume California achieves the percentage levels of reductions in each sector from 2022-2030 as identified in the CARB 2022 Scoping Plan. We do not model these outcomes in RHG-NEMS, but rather apply those reduction levels to our 2022 baseline. Note that the CARB Scoping Plan includes emission reductions from sourcing cleaner out-of-state power; we only model power emissions coming from in-state generators.

State climate ambition with the Inflation Reduction Act

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APPENDIX

Additional detail

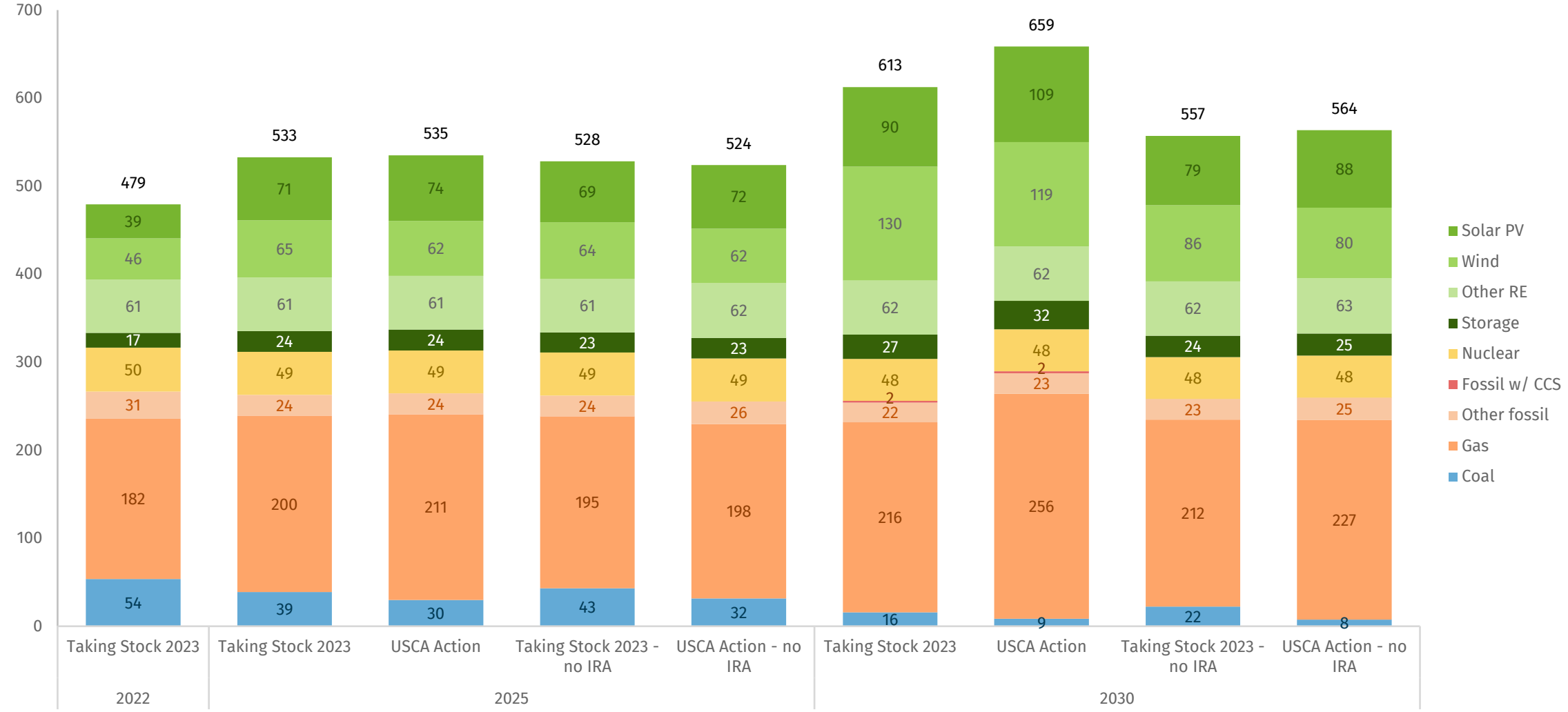
Appendix: sectoral target inputs

We establish sectoral-level targets on a state-by-state basis that reflect how the energy system responds to a national cap in NEMS, reflected in the table below. In some cases, like the power sector, we cannot input state-level reductions directly into the model, so the model doesn't always solve precisely to these levels.

Sector	Target input	Level
Power	Reduction in GHG emissions from 2005 levels	80% by 2030
Transportation	Light-duty ZEV sales	100% sales by 2035
	Medium- and heavy-duty ZEV sales	100% sales by 2045
	Carbon intensity of fuel	20% reduction over 2010 levels by 2030
	VMT reduction	• 10-15% reduction by 2030 • California achieves 25% VMT reduction in line with their 2022 Scoping Plan
Buildings	Fuel consumption reductions	2.5-4% annual incremental reductions from 2024-2030
	Electricity consumption reductions	2.5% annual incremental reductions from 2024-2030
	Increased appliance electrification	Loosening of non-cost barriers to electrification of space and water heating
Industry	Industrial point-source carbon capture and clean hydrogen deployment	• Additional $50/t incentive beyond current policy • California further adds carbon capture to refineries consistent with their 2022 Scoping Plan
	Oil and gas methane reduction	Reductions consistent with finalized EPA oil and gas methane regulations
Agriculture and waste	Reduction in methane emissions	40% reduction over 2013 levels by 2030
	Reduction in N20 emissions	Adoption of <$100/t crop management strategies

Power sector capacity

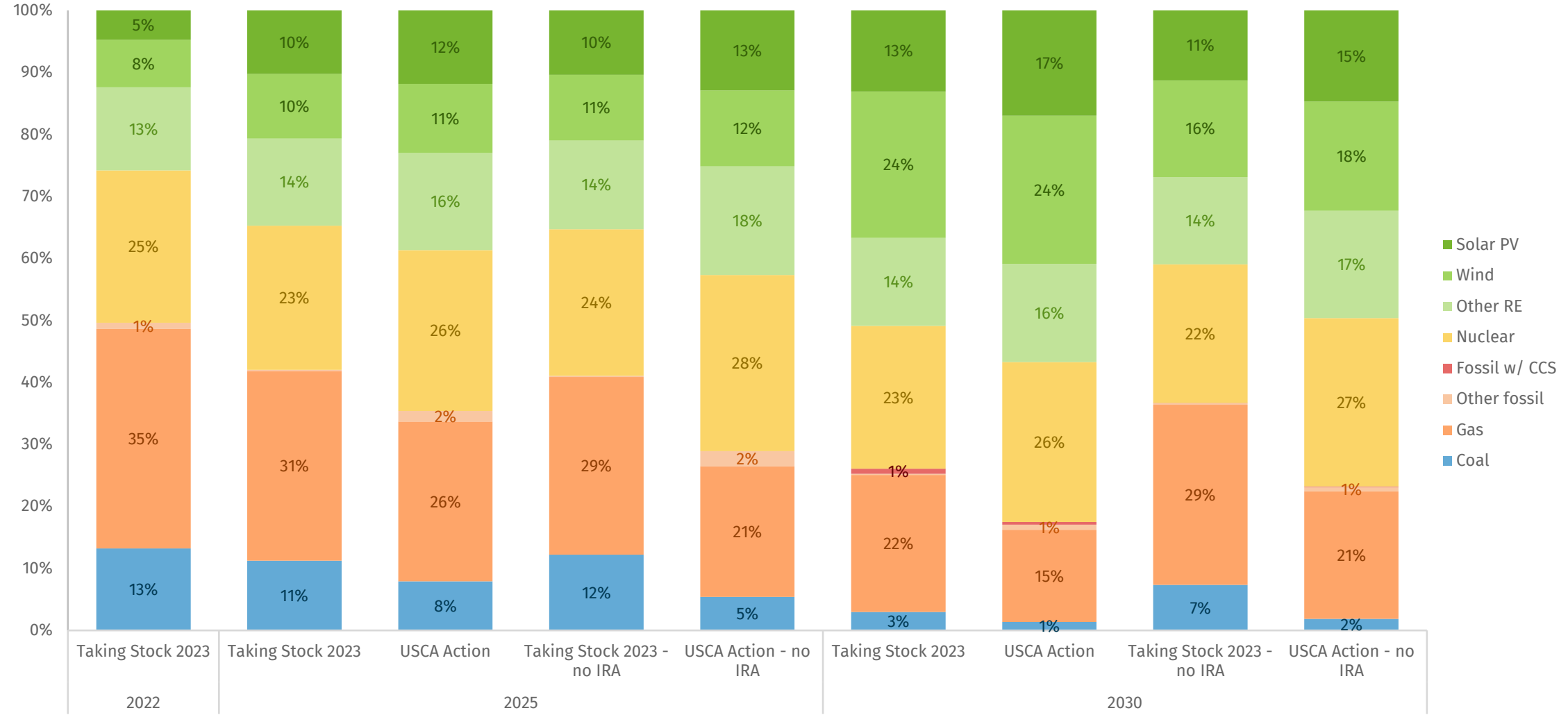
GW in USCA states



Note: Other RE category includes hydropower, biomass, geothermal, fuel cell, waste, and solar thermal.

Power sector generation

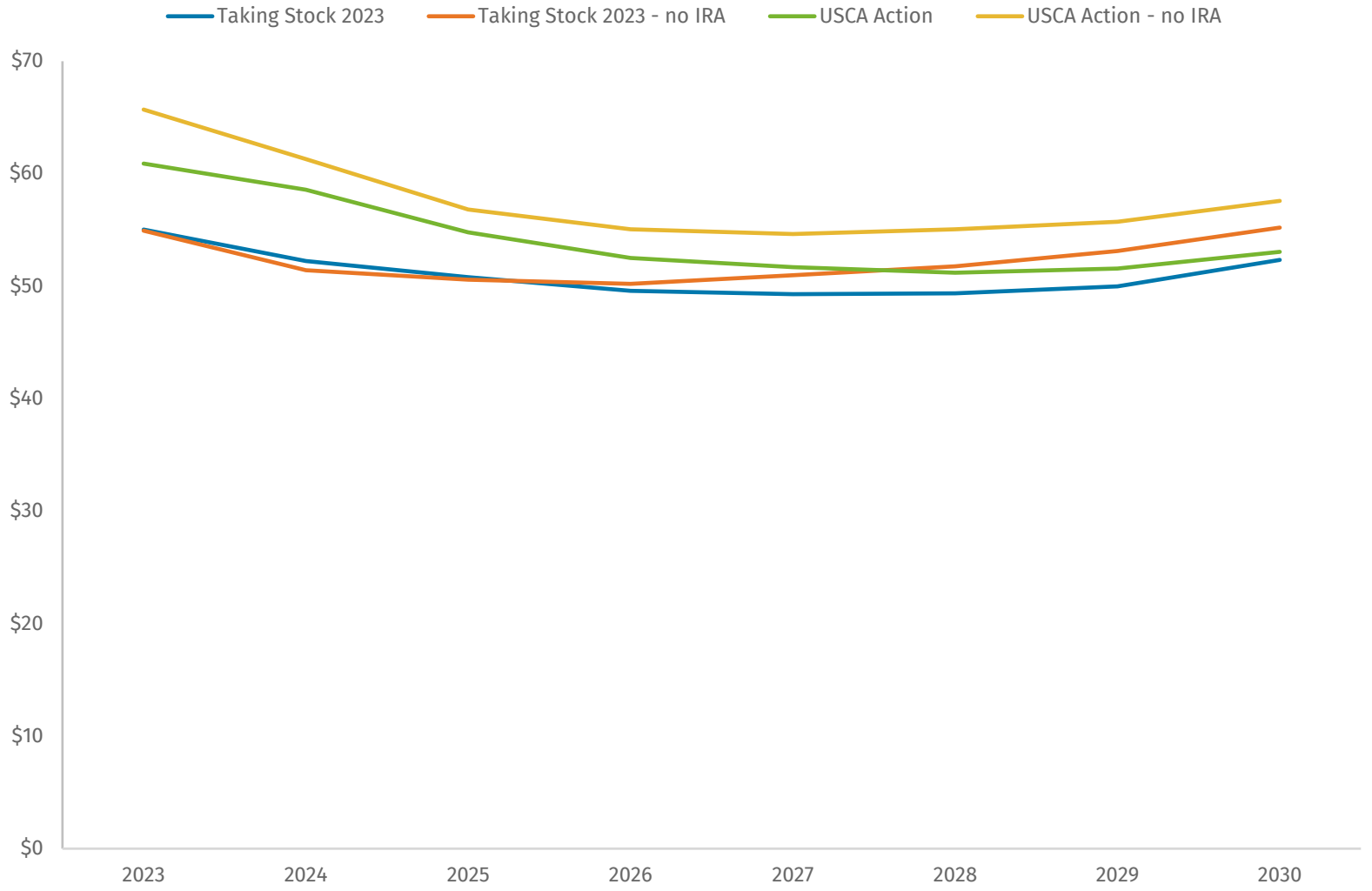
Percent of total power sector generation in USCA states



Note: Other RE category includes hydropower, biomass, geothermal, fuel cell, waste, and solar thermal.

Total annual power sector system costs

Billion USD (2022) for select electricity regions[1]



- Power sector costs include annual generating capacity costs, fuel and non-fuel O&M, transmission capacity costs, and other capital expenses.
- These results reflect total resource costs in 12 of 25 electricity market[1] regions that roughly align with the majority of the USCA state footprint. Some portions of non-USCA states are included in these regions, and some portions of USCA states are not included in these regions, so this analysis should be taken as directional rather than a precise estimate of total system cost in USCA states.

[1] EMM regions represented: Midcontinent ISO/West, Midcontinent ISO/East, all NPCC regions, PJM/East, PJM/Commonwealth, all WECC regions except Basin