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Non-Federal Climate Leadership Can Sustain U.S. Emissions Reductions Under Federal Policy Uncertainty

Manuscript

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Authors: Alicia Zhao[1,2], Kiara Ordonez-Olazabal[1], Claire V. Squire[1], Kowan T.V. O'Keefe[1], Matthew Binsted[1], Adriana Bryant[1], Stephanie Vo[1], Dhruv Modi[1], Steven J. Smith[1], Ryna Cui[1], Nate Hultman[1]

Affiliations:

[1]Center for Global Sustainability, University of Maryland, College Park, Maryland, USA

[2]Corresponding author: aszhao@umd.edu, https://orcid.org/0000-0002-6054-8671

Abstract

Recent federal climate policy rollbacks in the United States have slowed progress toward high-ambition climate targets under the Paris Agreement. In the absence of federal climate leadership, there is a growing need to better understand the potential impacts of non-federal climate action. We assess the impacts of recent changes in federal policy, non-federal climate leadership, and potential federal re-engagement on U.S. greenhouse gas (GHG) emissions through 2035 using an integrated assessment model with state-level detail. We find that if all states adopt high-ambition policies and the next federal government re-orients on climate policy, a 56% reduction in GHG emissions can be delivered by 2035, relative to 2005 levels. A 45% reduction can be achieved with high-ambition actions from climate-leading states only, under existing federal policies. This compares to a 35% reduction under existing federal and subnational policies. Total electricity demand could increase by 24% to 34% from 2021 levels due to electrification policies and data center growth, with more than 90% of new capacity additions coming from renewables across scenarios. These findings highlight the potential impacts of non-federal leadership on near-term targets, and offer specific policy actions that can support electricity demand growth and domestic climate action.

Introduction

As the largest economy and the second largest greenhouse gas (GHG) emitter in the world, the United States plays a key role in limiting global warming to 1.5℃ above pre-industrial levels under the Paris Agreement.[1] Strong climate ambition from the United States is critical for both driving emissions reductions domestically and catalyzing ambitious targets in other countries. In 2024, the United States articulated ambitious short-term targets, including a 61-66% reduction below 2005 levels by 2035[2], and a long-term strategy for net zero GHG emissions by 2050.[3]

Changes to federal priorities, beginning in 2025, have created substantial challenges toward meeting these targets. Internationally, a second U.S. withdrawal from the Paris Agreement was later followed by a withdrawal from the United Nations Framework Convention on Climate Change.[4] Domestically, wide-ranging policy rollbacks that favor fossil fuel expansion and constrain the use of renewable energy and other low-emissions technologies have been enacted, including funding freezes for major climate mitigation projects (e.g. $20 billion for clean energy projects under the Greenhouse Gas Reduction Fund), phasedown of clean energy tax credits and investments originally enacted under the Inflation Reduction Act (IRA) of 2022 and Bipartisan Infrastructure Law of 2021, redefined energy goals, repeal of climate regulations, and more.[5–7] Many of these policies were expected to substantially reduce GHG emissions and help the United States move toward its climate targets.[8–11] Attempts have also been made to restrict subnational authorities over climate policy, including removal of the California waiver under the Clean Air Act, which allowed the state to set its own emissions standards for vehicles,[12,13] though some of these changes face legal challenges and their long-term impacts are unclear.[14–16] Recent literature has assessed the potential impacts of federal policy rollbacks on GHG emissions reductions, with estimates ranging from 25% to 35% below 2005 levels in 2035, compared to reductions of 38-56% prior to the rollbacks.[17,18]

However, fully understanding the U.S. climate policy landscape in modeling studies also requires explicit consideration of non-federal action. Literature has shown that high-ambition actions from subnational actors have the potential to deliver substantial economy-wide GHG emissions reductions.[9,19–21] Within the U.S. federal system, subnational governments, including states, cities, and counties, have numerous policy authorities over sectors related to climate.[22,23] Yet, significant variation in climate ambition exists across states. Historically, states such as California and New York have led on climate action through setting aggressive mitigation targets and proposing pioneering policies,[22] including an all-electric building standards[24] and EV sales mandates for light-duty vehicles.[25] On the other end of the spectrum are states with few or no climate policies, due to factors including politics, public opinion, and industry opposition.[26,27] Within these lagging states, federal climate policy, including regulations, incentives, and more, can play an important role in driving emissions reductions.[28]

In the absence of federal climate leadership, there is a growing need to better understand the potential of subnational climate action, particularly in lagging states. While lagging states are unlikely to enact climate policies similar to those in the leading states, other approaches can be used to drive emission reductions. Previous studies find that cities and other local actors can go beyond state commitments and contribute significant emissions reductions.[20,29] Other mechanisms include highlighting economic development benefits of clean energy policies,[30,31] policy spillover effects from more ambitious neighboring regions,[32,33] private sector commitments,[34] and market forces that favor clean energy technologies.[35,36] The variable nature of political cycles also brings about the possibility that a future federal government may choose to re-engage in climate policy.

Additionally, recent federal efforts to curtail renewable energy come at a time where there is growing concern around rapid electricity demand growth, raising questions about impacts on U.S. decarbonization efforts and energy affordability.[17,37–40] In particular, data centers are expected to exert pressure on the grid and raise emissions from the electricity sector in the near-term. While climate policy can mitigate emissions associated with data center load growth by accelerating the buildout of clean electricity, it also introduces additional sources of electricity demand through electrifying end uses. Modeling studies have projected national electricity demand from data centers under federal policy rollbacks[17] and net-zero targets.[40] However, since data center load growth is highly concentrated in specific regions, it becomes important to understand their interactions with climate policy at a finer scale.

This paper fills these gaps by modeling alternative U.S. energy and emissions pathways to 2035, taking into account the latest policies at both federal and non-federal levels as of July 2025. We use an integrated modeling framework with state-level resolution to assess these pathways under 1) recent federal policy rollbacks and existing state policies, 2) high-ambition actions from the leading states and less ambitious actions from the other states, and 3) expanded high-ambition actions from leading and lagging states combined with new actions from a re-engaged federal administration after 2028. We also assess the impacts of data center demand growth on emissions outcomes across scenarios.

We model specific policies at the state level across all economic sectors and gases using the integrated assessment model GCAM-USA.[41] We find that the United States can achieve up to a 56% reduction in GHG emissions by 2035 (relative to 2005 levels) under widespread high-ambition actions from subnational actors and future federal climate action, assuming a central scenario for data center load growth. Under a scenario that relies on the climate-leading states to enact high-ambition actions and no federal engagement, we find that these emissions reductions fall to 45% by 2035. In comparison, the United States achieves a 35% GHG emissions reduction in 2035 in a scenario with current policies.

Results

This analysis assesses GHG emissions and energy impacts under three distinct scenarios. The *Current Policies* scenario includes recent rollbacks of federal policies including the Inflation Reduction Act, Bipartisan Infrastructure Law, and Environmental Protection Agency (EPA) regulations. Existing state-level policies, including renewable portfolio standards and building energy efficiency standards, are assumed to be implemented.

In the *Fragmented Action* scenario, state-level climate policy is enhanced, but there is considerable heterogeneity in state-level climate ambition. This heterogeneity is represented using a tiering system, which is described further in the Methods section. Only climate-leading states, or the Tier 1 states, adopt the high-ambition actions, while Tier 2 and 3 states adopt fewer and less ambitious policies. See Supplementary Information for additional details.

In the *Unified Action* scenario, all states adopt high-ambition climate policies, with some level of differentiation in terms of timing and ambition level based on state tiers. It also assumes that the federal government re-introduces climate policies under a new administration after 2028, including clean energy tax credits similar to the IRA, standards on fossil fuel power plants and tailpipe emissions similar to previous EPA regulations, and new regulations on oil refineries. Table 1 lists the non-federal policies and new federal policies modeled, with associated ambition levels and timelines. See Supplementary Information for additional details.

Table 1. Non-federal and new federal policies modeled under *Unified Action*. Policies are categorized by sector, implementing actor, and policy type. In the fourth column, the ambition levels and timelines assumed are listed. Ambition levels for federal policies are applied nationally. For non-federal policies, the ambition levels assumed under each tier are listed. If no policy is explicitly assumed for a certain tier, “Not applicable” is listed.

Sector	Actor	Policy Type	Ambition Level
Electricity	Federal	Tax credits and investments	Tax credits and rebates similar to those under the IRA are reinstated by 2030.
	Federal	Clean Air Act (CAA) Section 111(b) Standards for New Stationary Combustion Turbines	Reinstated by 2030, requiring at least 90% CCS for any new natural gas turbines with a capacity factor higher than 40%
	Non-federal	Renewable portfolio standards	**Tier 1 and 2:** 50% by 2030, 65% by 2035 **Tier 3:** 40% by 2030, 50% by 2035
	Non-federal	Clean electricity standards	**Tier 1 and 2:** 80% by 2035 **Tier 3:** Not applicable
	Non-federal	Coal phaseout policies	**Tier 1 and 2:** 2030 phaseout **Tier 3:** 2035 phaseout
Transport	Federal	Tax credits and investments	Tax credits and rebates similar to those under the IRA are reinstated by 2030.
	Federal	Tailpipe emissions standards for LDVs	Reinstated by 2030 to help states achieve 100% EV sales by 2038
	Federal	CAFE standards and GHG standards for LDVs	Reinstated by 2030 such that new vehicles achieve the same internal combustion engine efficiency improvement from 2030-2035 as they would have under 2025-2030
	Federal	GHG emissions standards for freight trucks	Reinstated by 2030 such that new vehicles achieve the same internal combustion engine efficiency improvement from 2030-2035 as they would have under 2025-2030
	Non-federal	LDV electrification policies	All states achieve 100% EV sales by 2038, with the support of federal policies
	Non-federal	M/HDV electrification policies	All states achieve EV sales equivalent to California's Advanced Clean Trucks targets with a 3-year delay, with the support of federal policies
	Non-federal	Bus electrification targets	**Tier 1 and 2:** 100% electrification of new bus sales in 2035. **Tier 3:** 100% electrification of new bus sales in 2040.
	Non-federal	Vehicle miles traveled reduction policies	**Tier 1 and 2:** 1% by 2030 and 1.25% by 2035 annual VMT per capita reductions by 2035 **Tier 3:** 0.5% by 2030 and 0.75% by 2035 annual VMT per

			capita reductions by 2035
	Non-federal	Low carbon fuel standards	**Tier 1 and 2:** 20% in 2030, 25% in 2035 **Tier 3:** Not applicable
Buildings	Federal	Tax credits and investments	Tax credits and rebates similar to those under the IRA are reinstated by 2030.
	Non-federal	Enhanced energy efficiency resource standards	All states achieve 4% annual efficiency savings by 2030
	Non-federal	Zero-emission appliance standards	**Tier 1 and 2:** 100% electric heating and water heating sales by 2035 **Tier 3:** 100% electric heating and water heating sales by 2040
	Non-federal	Zero-emission construction standards	All states achieve 100% new electric construction by 2035
Industry	Federal	Tax credits and investments	Tax credits and rebates similar to those under the IRA are reinstated by 2030.
	Federal	Standards on oil refineries	Introduced after 2030, requiring CCS capabilities for 25% of oil by 2035
	Federal	Direct air carbon capture and storage (DACCS) incentives	Results in 12 MtCO$_2$ removals by 2035. This level of removal is consistent with announced DACCS facilities in the United States[42,43]
	Non-federal	Cement CCS targets	**Tier 1 and 2:** CCS capability for 40% of cement produced by 2035 **Tier 3:** CCS capability for 20% of cement produced by 2035.
Methane	Federal	Coal methane regulations	Implement reductions achievable at a cost of $60/tCO2e or below on the EPA's MAC curves by 2035.
	Federal	Agricultural methane regulations and incentives	Implement reductions achievable at a cost of achievable at a cost of $30/tCO2e or below on the EPA's MAC curves by 2035
	Federal	Oil and gas methane regulations	Regulations are reinstated by 2030, achieving reductions at a cost of $60/tCO2e or below on the EPA's MAC curves by 2035. A methane intensity standard of 0.2% is also achieved by 2035.
	Non-federal	Oil and gas methane regulations	All states achieve reductions at a cost of $60/tCO2e or below on the EPA's MAC curves by 2035, with the support of federal policies. A methane intensity standard of 0.2% is also achieved by 2035.

	Non-federal	Landfill methane capture regulations	**Tier 1 and 2:** Implement reductions achievable at a cost of \$60/tCO2e or below on the EPA's MAC curves by 2035 **Tier 3:** Implement reductions achievable at a cost of \$40/tCO2e or below on the EPA's MAC curves by 2035
	Non-federal	Enhanced waste diversion efforts	**Tier 1 and 2:** 60% reduction in landfill waste by 2035 **Tier 3:** 40% reduction in landfill waste by 2035
Other	Non-federal	HFC regulations	**Tier 1 and 2:** Adopt Significant New Alternatives Policy (SNAP) and Refrigerant Management Programs (RMP) programs.
Lands	Federal + Non-federal	Expanded funding for wildfire mitigation, tree planting, conservation and healthy soils	Assume \$160 billion in investments in climate-smart policies resulting from enhanced federal and state-level action, based on the 'Enhanced Ambition' scenario from a previous CGS report on lands[44]

Overall emissions trends

GHG emissions in the United States have generally declined over the last 20 years, reaching 19% below 2005 levels in 2023 (averaging 71 MtCO$_2$e/year).[45] Under the *Current Policies* scenario, GHG emissions further drop by 30% in 2030 and 35% in 2035, relative to 2005 levels. This is aligned with previous studies, though on the high end of the reduction range.[17,18,46] The average rate of emissions reduction between 2021 and 2035 is 81 MtCO$_2$e/year. To reach net zero in 2050, assuming a linear trend, the average rate of emissions reduction between 2035 and 2050 would need to accelerate to 282 MtCO$_2$e/year (Figure 1).

The *Fragmented Action* scenario achieves GHG emissions reductions of 36% in 2030 and 45% in 2035. This scenario reduces emissions at an average rate of 129 MtCO$_2$e/year between 2021 and 2035. To reach net zero in 2050, the emissions reduction rate would need to increase to 237 MtCO$_2$e/year after 2035.

In the *Unified Action* scenario, GHG emissions reductions reach 40% in 2030 and 56% in 2035. The average rate of reduction between 2021-2035 is 179 MtCO$_2$e/year. This accelerates to 204 MtCO$_2$e/year between 2030-2035 as the federal government steps in to support state action. Reductions would need to continue at about this rate (191 MtCO$_2$e/year) after 2035 to reach net zero. For comparison, a linear trajectory to reach the 2035 U.S. NDC (61-66%), which was set in 2024 under the Biden administration,[2] requires an average reduction rate of 201-224 MtCO$_2$e/year from 2021 levels.

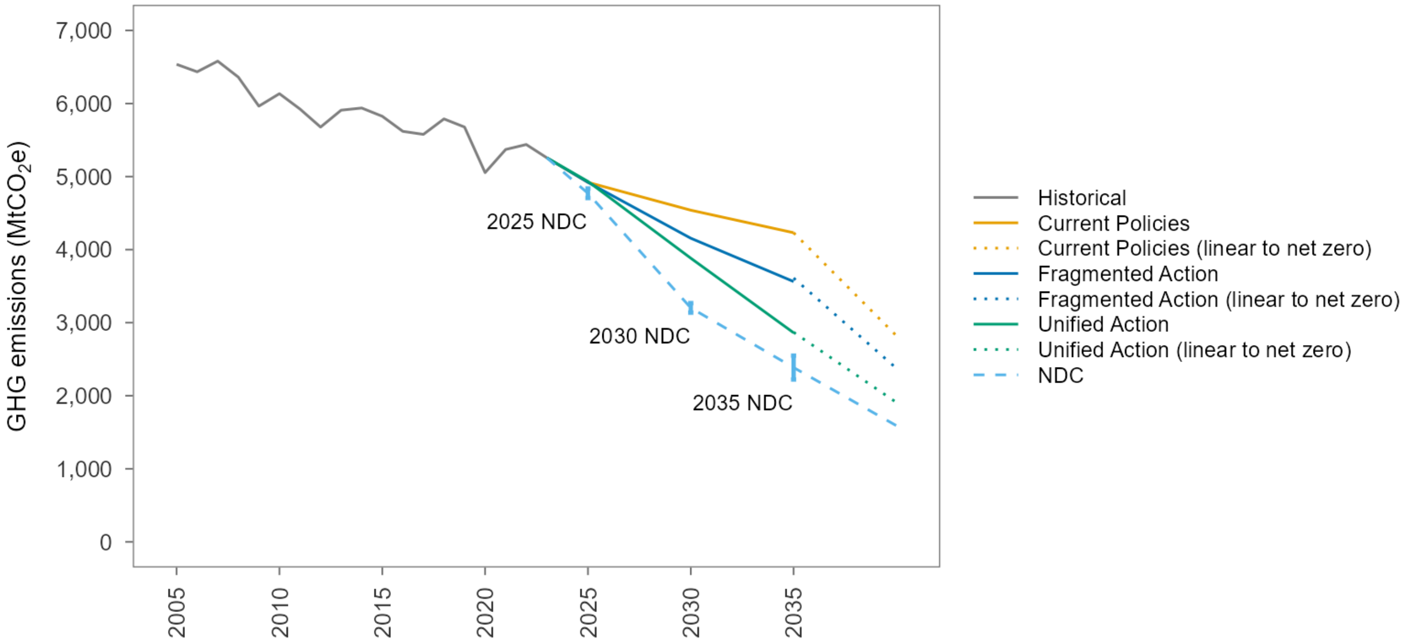

Figure 1. GHG emissions through 2035 under modeled scenarios. Historical emissions through 2023 are taken from the latest EPA inventory.[45] Modeled scenarios through 2035 are shown in the solid lines, differentiated by color. The previously communicated 2025, 2030 and 2035 NDCs are also shown by the dashed line for reference, with the range under each NDC shown with the error bars. Dotted lines after 2035 represent the linear trajectory under each scenario to reach net zero by 2050.

While all scenarios fall short of meeting the most recent US NDC, high-ambition actions from states and a re-engaged federal government could significantly close this gap, missing the lower bound of the 2035 NDC (61% reductions) by five percentage points. In comparison, the United States would miss this bound by 16 percentage points if only leading states enact ambitious climate policies under the *Fragmented Action* scenario, and by 26 percentage points under *Current Policies*.

In terms of reaching the previously communicated U.S. net zero target by mid-century, substantially accelerated rates of reductions would be needed under the *Current Policies* and *Fragmented Action* scenarios, suggesting potential difficulties in achieving this goal. However, shifting toward the pathway identified under *Unified Action* would meaningfully reduce difficulties of reaching net zero and keeping the world on a 1.5℃ trajectory.

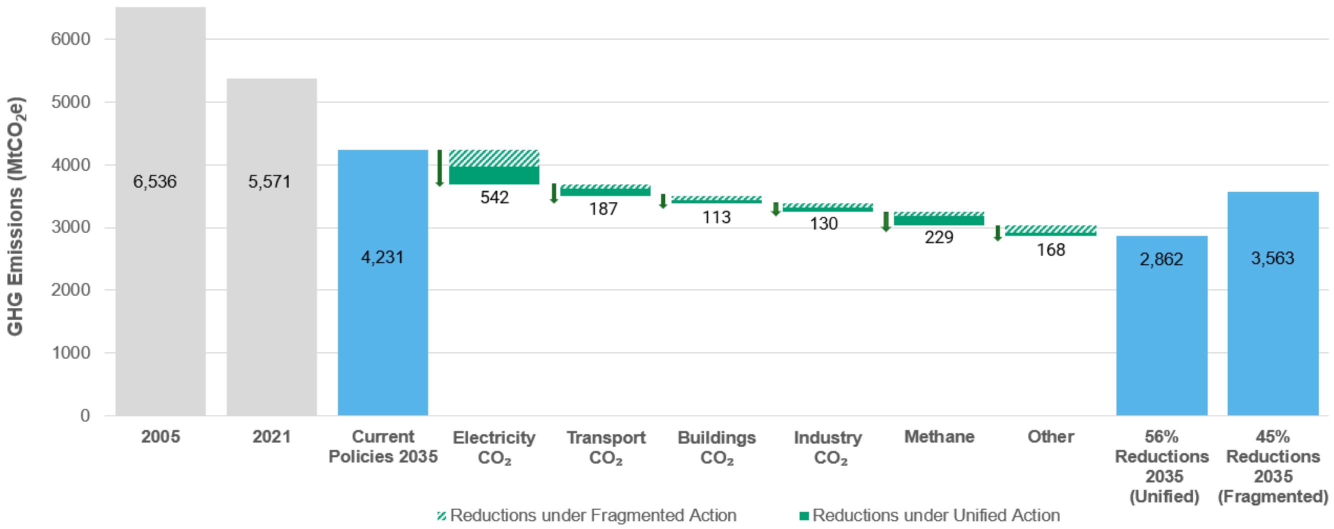

Figure 2. GHG emissions reductions across sectors needed to achieve the 56% and 45% overall reduction in 2035 under the *Unified Action* and *Fragmented Action* scenario, respectively. Bars show net GHG emissions in million tonnes of CO$_2$ equivalent, with reductions across electricity, transport, buildings, industry, and other sectors. The gray bars on the left show residual emissions in 2005 and 2021. The blue bar on the left shows residual emissions in 2035 under the *Current Policies* scenario. Green bars represent additional progress needed from each sector by 2035. Emissions reductions achieved by the *Fragmented Action* scenario are represented by the green bars with hashed lines, and additional emissions reductions under the *Unified Action* scenario are represented by the solid green bars. The first blue bar on the right shows residual emissions in 2035 under *Unified Action*, and the second blue bar shows residual emissions under *Fragmented Action*.

Achieving a 56% overall reduction from 2005 levels in 2035 under the *Unified Action* scenario requires an additional 1,369 MtCO$_2$e emissions reductions relative to the *Current Policies* scenario in 2035 (Figure 2). While mitigation efforts are needed across all sectors, electricity, methane and transport have the largest opportunities for emissions reductions, composing 39% (542 MtCO$_2$e), 17% (229 MtCO$_2$e), and 14% (187 MtCO$_2$e) of the additional reductions needed. The buildings, industrial, and other (including direct air capture; land-use, land-use change and forestry (LULUCF) CO$_2$; other CO$_2$; nitrous oxide; and fluorinated gases) sectors contribute the remaining 30% (411 MtCO$_2$e) of emissions reductions needed.

The *Fragmented Action* scenario achieves a lower level of mitigation of 668 MtCO$_2$e relative to *Current Policies*. The higher reductions under *Unified Action* are due to enhanced policies that significantly expand mitigation across all sectors, with emphasis on the industry, methane, transportation, and electricity sectors.

Electricity demand growth

Across the three scenarios, electricity demand increases by 24%-34%, or 949-1,356 TWh, from 2021 levels in 2035 (Figure 3a). Demand growth is significantly higher in the *Unified Action* scenario due to strengthened electrification policies, particularly in the transportation sector. The buildings sector sees less growth due to expanded energy efficiency measures, which help offset demand growth from additional building electrification.

A central assumption for data center growth is used in all scenarios. Data center expansion accounts for 30-42% of the total demand growth from 2021 to 2035 across scenarios (Figure 3a). Varying assumptions around data center growth shifts overall electricity demand trajectories, where data centers make up 17-27% of the new growth in 2035 under a low data center growth assumption, and 42-56% under a high growth assumption, across scenarios. SI Section 3.9.1 contains additional information on varying assumptions around data centers. These rates of data center growth compare to 25-65% projected across a number of industry and literature studies over similar time horizons.[17,47–49]

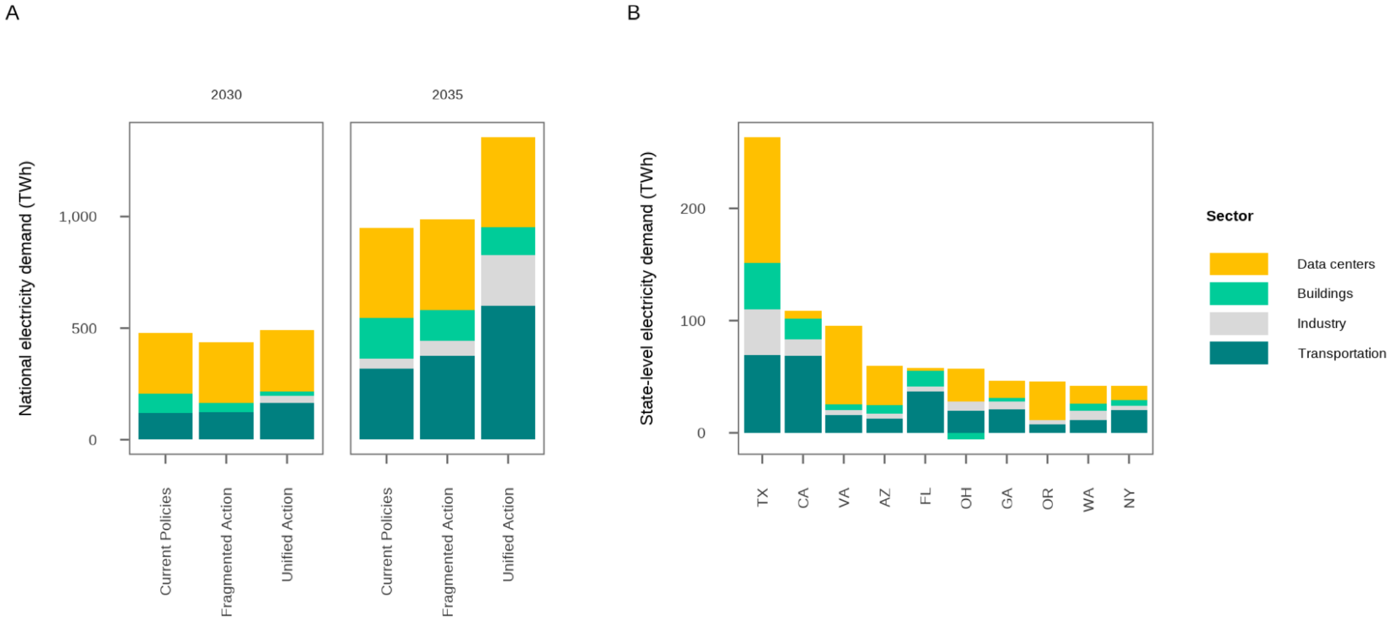

Figure 3. Electricity demand growth, relative to 2021 levels. Panel a) shows national electricity demand growth in 2030 and 2035 broken out by sector across scenarios, in TWh. Panel b) shows the top 10 states with the most electricity demand growth by sector in 2035 under the *Unified Action* scenario, in TWh.

The impacts of data centers vary regionally. Texas, Virginia, Arizona, Oregon, and Ohio account for nearly 70% of the electricity demand growth from data centers across scenarios (Figure 3b). In contrast, data centers account for less than 5% of growth in states such as North Carolina, Florida, and Wisconsin. California and Virginia are examples of two states that have similar levels of overall electricity demand growth in 2035 (108 TWh and 95 TWh, respectively) with divergent sources for this growth: California's demand growth is driven largely by the transportation sector, while Virginia's is driven by data centers.

Meeting the projected electricity demand growth would entail investments in new generation capacity. To reflect announced gas turbine backlogs from major companies,[50] we constrain new natural gas capacity between model years 2025 and 2030 to roughly reflect only the 35 GW of planned additions as reported to the U.S. Energy Information Administration as of August 2025.[51] We assume that manufacturers are able to increase new capacity from natural gas by up to that same amount between model years 2030 and 2035. Additionally, offshore wind deployment is currently facing substantial challenges in the United

States, including pauses on project leasing, increased regulatory uncertainty, and market volatility.[52] As such, new offshore wind capacity was explicitly constrained to only fully permitted projects, assuming that those without permits would not be able to complete construction by 2035.[53]

Across scenarios, more than 90% of new capacity additions come from solar, wind, and battery storage in 2035, adding 53 GW/year and 74 GW/year of new capacity under *Current Policies* and *Fragmented Action*, respectively, and 120 GW/year under *Unified Action* (Figure 4). For reference, while renewables already make up 90% of capacity additions in 2025 at 48 GW/year, [51] the *Unified Action* scenario would require more than doubling current levels of additions by 2035. Due to supply chain bottlenecks and clean energy policies, natural gas plays a relatively smaller role in meeting new demand, adding 5-7 GW of new capacity in 2035 in *Current Policies* and *Fragmented Action*. There are no new unabated natural gas additions in 2035 under the *Unified Action* scenario due to new federal standards that phase out new gas without CCS after 2030 assumed in this scenario (SI Table S7); instead, 3 GW of natural gas with carbon capture and storage comes online by 2035.

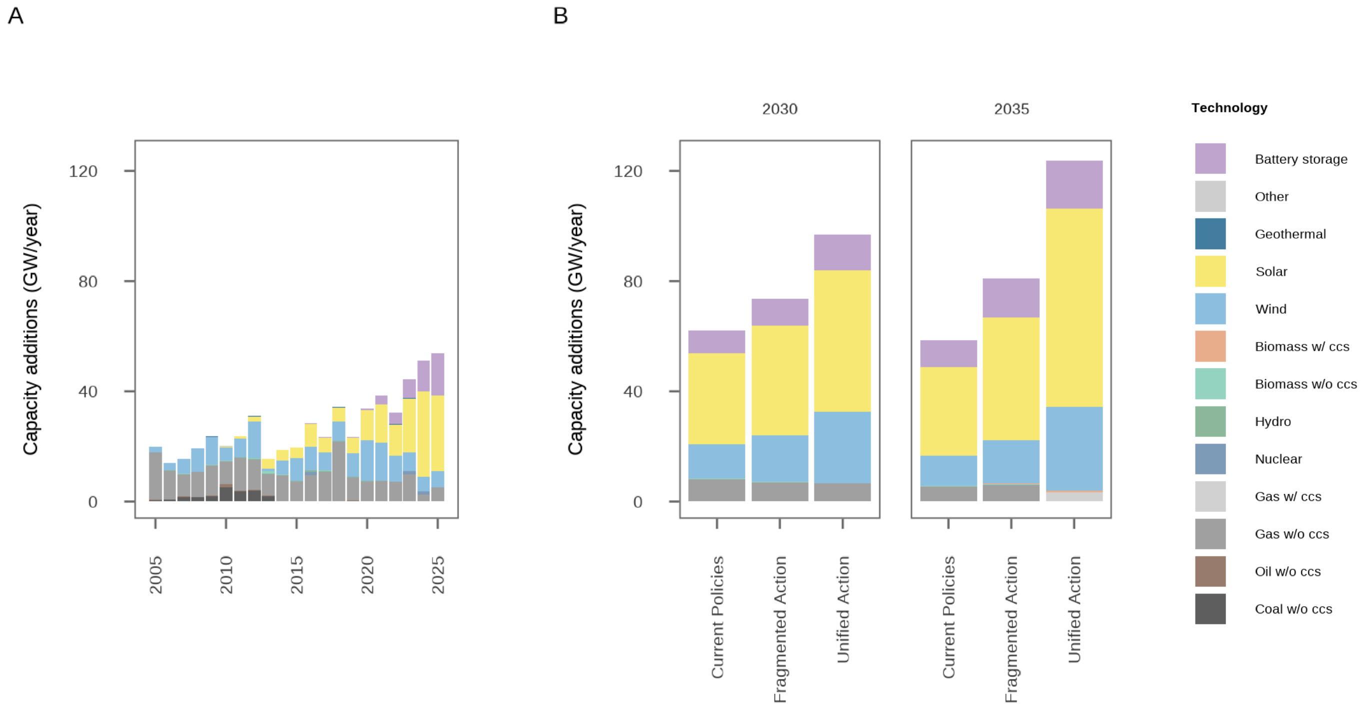

Figure 4. Annual electricity capacity additions by technology. Panel a) shows historical electricity capacity additions by technology through 2025, in GW/year.[51] Panel b) shows projected annual average capacity additions in 2030 and 2035 across the three modeled scenarios, in units of GW/year.

With the gradual phase down of coal power, electricity CO_2 emissions decline by 41% (636 $MtCO_2e$) by 2035 from 2021 levels under *Current Policies* (Figure 5). The share of wind and solar generation increases from 12% of the electricity mix in 2021 to 38% in 2035 (Figure 7). Coal plants are retired in accordance with announced retirement schedules and existing state-level clean energy policies as of

2025, and coal generation makes up 5% of the electricity mix in 2035, down from 23% in 2021. The share of natural gas is 34%, similar to 2021 levels.

Fragmented Action has a lower share of natural gas generation (31% in 2035) as compared to *Current Policies*, a lower share of coal generation (2% in 2035), and higher generation from renewables (44% in 2035) due to ambitious clean energy policies from leading states.

With accelerated decarbonization policies, including expanded renewable portfolio standards and clean energy standards, along with policies to phase out coal and new natural gas, in the *Unified Action* scenario, electricity sector emissions fall by 75% (1,177 $MtCO_2e$) in 2035. Renewable generation rises to 56% of the electricity mix in 2035, with natural gas accounting for 23%. Unabated coal is phased out by 2035 in this scenario.

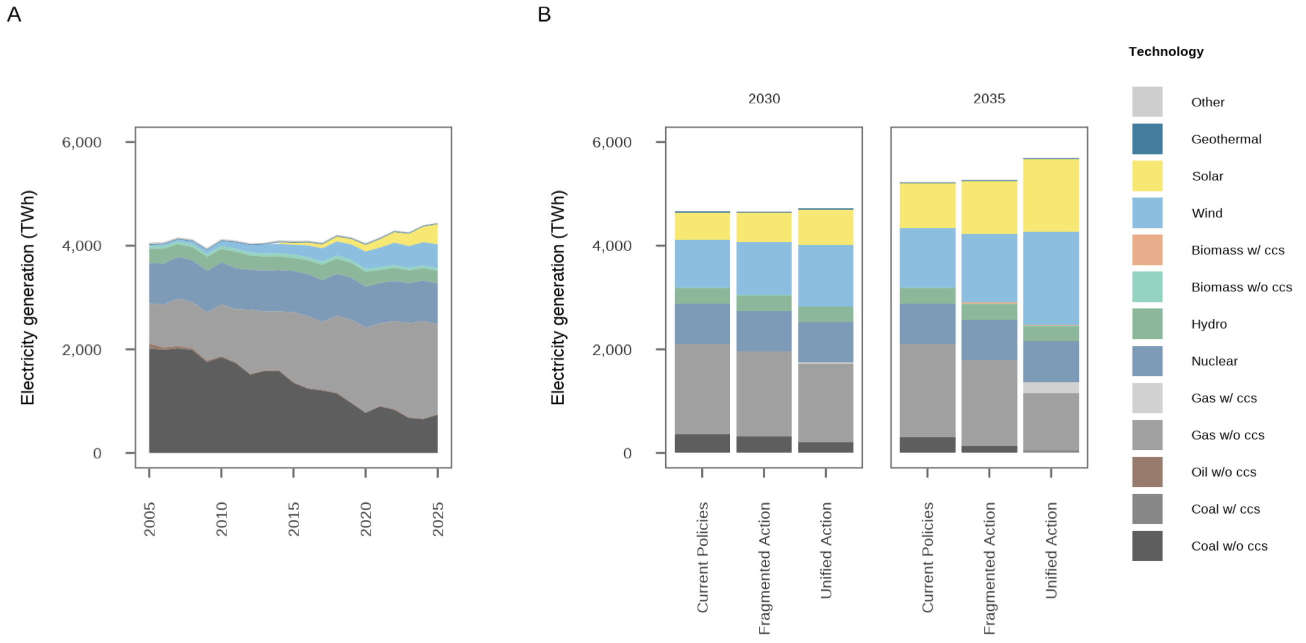

Figure 5. Electricity generation by technology. Panel a) shows historical electricity generation by technology through 2025 in TWh.[54] Panel b) shows projected generation in 2030 and 2035 across the three modeled scenarios, in units of TWh.

Wind and solar generation in 2035 under *Unified Action* are significantly accelerated relative to recent trends (Figure S6). Reaching this level of renewable generation would require removal of key barriers, including those related to permitting, siting, and transmission. While Tier 1 states are on track with modeled levels of renewable growth, Tier 3 states would require the most acceleration in the near term (Figure S7). Renewable energy buildout has been increasing steadily across all tiers in recent years, demonstrating that the economics of renewables can play a key role in their deployment.

Recent federal efforts to halt solar and wind generation, rely on fossil fuels, and keep coal plants open past their scheduled retirement dates,[55] have created additional obstacles to achieving the levels of renewable buildout modeled in our high-ambition scenarios. While coal generation has steadily declined over the past decade, it increased in 2025 due to a combination of federal policy changes, higher natural gas prices and growing electricity demand. If this trend continues for another decade, it could entail different outcomes for our modeled scenarios (see SI Section 3.7.2 for additional detail).

Transformations in other sectors

To achieve the emissions pathways under *Unified Action*, transformations across other sectors are also necessary. Methane mitigation is a key area for near-term emissions reductions, given methane's ability to trap more than 80 times as much heat over a 20-year period than CO_2. Energy sector methane emissions drop 63% from 2021 levels by 2035 under *Unified Action* as a result of oil and gas methane regulations and incentives at the state and federal levels. *Fragmented Action* includes oil and gas methane regulations from leading states only, which results in a 19% reduction in 2035. In contrast, *Current Policies* assumes only cost-effective abatement strategies, yielding a 13% reduction by 2035. The *Unified Action* scenario also sees significant reductions in methane emissions from the waste sector (37% reduction from 2021 levels) due to state and local-level policies on waste management.

In the transportation sector, EV sales rise to 80% in 2035 for passenger road vehicles under *Unified Action* (Figure 6). This is due to a combination of expanded state-level policies and incentives as well as new federal EV incentives and standards for tailpipe emissions after 2028. With only leading states adopting EV policies, passenger EV sales reach 46% in 2035 under *Fragmented Action*. This compares to 32% sales in 2035 under *Current Policies*. Freight truck electrification is also accelerated under *Unified Action* through a combination of state-level policies and new federal incentives, with EV sales in 2035 increasing to 41%. Freight EV sales are much lower under *Fragmented Action* and *Current Policies*, at 13% and 6%, respectively. Projected levels of both passenger and freight EV sales under *Unified Action* would require significant acceleration relative to current trends (see SI Section 3.7.5), with potential challenges pertaining to critical mineral availability further discussed below.

Additionally, the buildings sector is further electrified in these scenarios. Under *Unified Action*, electricity accounts for 60% of all building final energy consumption in 2035, up from 51% in 2021, as a result of state-level electrification and efficiency measures and renewed measures from the federal government (Figure 6). This compares to 58% and 55% under *Fragmented Action* and *Current Policies*, respectively.

Industry electrification (not including industrial feedstocks) under *Unified Action* increases modestly, from 15% in 2021 to 17% in 2035 (Figure 6). In contrast, electrification remains roughly the same at 14% in 2035 under *Fragmented Action* and *Current Policies*. The *Unified Action* scenario also sees additional deployment of cement and refining CCS technologies relative to the other scenarios, mitigating 14 and 19 $MtCO_2$, respectively. Compared to other sectors, relatively less progress is observed in the industrial sector due to limited federal and state-level policies and technical challenges related to electrifying industrial processes that require high temperatures.

Overall, substantial state-level variation exists across sectoral metrics. This is particularly noticeable in the shares of renewable and clean electricity, which range from 16% to 78% and 29% to 97%, respectively, in 2035 under *Current Policies* (Figure 6), with DC being an outlier in both scenarios at 100%. These examples reflect the different situations of states across the country, influenced by factors including availability of renewable resources, reliance on fossil fuels, and political dynamics, which can create opportunities or challenges for enhancing policy actions. Under the *Unified Action* scenario, states start to converge to higher levels of renewable and clean energy; however, variation still exists as a result of electricity trade. Model dynamics are more straightforward for passenger and freight EV sales. States are clustered closely together under *Current Policies* and *Unified Action* due to similar policy assumptions across states, but diverge more in the *Fragmented Action*, where only the leading states adopt transport electrification policies. Passenger and freight EV stock see even higher convergence across states due to the long timelines associated with fleet turnover.

Negative emissions from carbon dioxide removal (CDR) technologies also play a role in these emissions pathways. In 2035, 93 $MtCO_2$/year is sequestered by CDR technologies in the power and industrial sectors under *Unified Action,* with 12 $MtCO_2$/year from direct air capture with carbon capture and storage (DACCS) and 81 $MtCO_2$/year from biomass energy with carbon capture and storage (BECCS) technologies. The U.S. land sink is exogenously specified and contributes an additional 1,115 $MtCO_2$/year in natural carbon sequestration. For comparison, under *Current Policies*, 46 $MtCO_2$/year is sequestered from BECCS and 974 $MtCO_2$/year from the land sink in 2035.

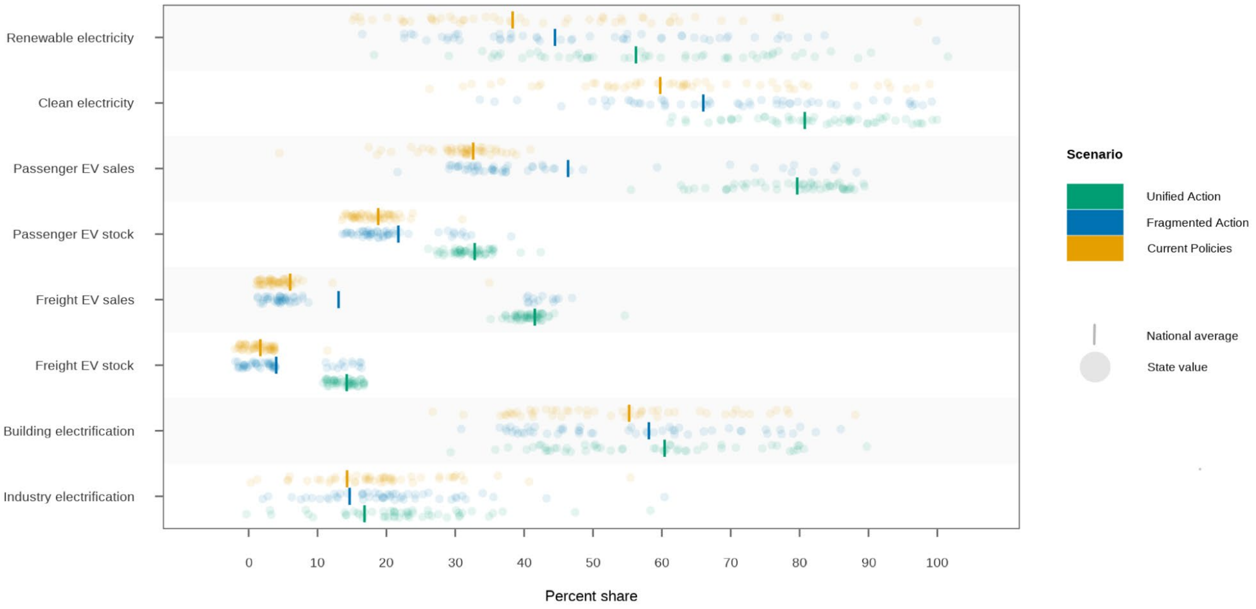

Figure 6. Sectoral metrics in 2035 across scenarios. Each metric has a national value, represented by the bars, and state-level values, represented by the transparent circles, across all three scenarios. Scenarios are differentiated by color. The renewable electricity metric indicates the percentage of the generation mix that comes from solar and wind resources. The clean electricity metric indicates the percentage of generation from clean sources, which include solar, wind, biomass, nuclear, hydropower, and fossil fuels with CCS. The passenger EV stock metric indicates the percentage of total road passenger vehicles that are electric. The freight EV stock metric indicates the percentage of total road freight vehicles that are electric. The building electrification metric indicates the percentage of building energy consumption that is from electricity. The industry electrification indicates the percentage of industry energy consumption that is from electricity.

Discussion

Though recent federal policy rollbacks have created roadblocks for reaching previously communicated U.S. NDCs, we show that expanded actions from subnational governments, especially with support from a future climate-aligned federal government, have the potential to make up ground. Critically, a high-ambition pathway requires not only accelerated actions from states that are already leading on climate, but also new and enhanced policies from non-leading states. Enhancing ambition within these states through emphasis on climate co-benefits, bold local actions, clean energy investments, and other mechanisms, can help offset some of the federal rollbacks. Electricity, transportation, and methane are poised to be key drivers of emission reductions, supported by policies such as renewable portfolio standards, clean energy standards, EV incentives and mandates, mode shift policies, oil and gas methane regulations, and waste reduction targets. Transformations will also be needed from the buildings and industry sectors, through energy efficiency and electrification measures, and from CDR scale-up, including both CCS technologies and expansion of natural land sinks.

This analysis models specific federal policy rollbacks (e.g. IRA, CAFE) with the assumption that subnational policies are unaffected and able to proceed as normal. In reality, ongoing uncertainties associated with rollbacks could impact subnational ambition. For example, major funding cuts and pauses have meant fewer dollars for states to implement their climate policies — the cancellation of a $4.9 billion federal loan guarantee for a major transmission line across the Midwest would likely impede efforts to deliver on clean energy targets.[56] Further, the federal government has superseded state energy planning in some areas, including attempting to pause leases and construction on five fully-permitted offshore wind projects[57] and using emergency orders to keep five coal plants open past planned retirement.[58] The 2025 repeal of California's waivers for its EV sales mandates prevents states from setting more stringent vehicle emissions standards than the federal government; this change in the state policymaking landscape and the resulting lawsuit led by eleven states[59] has created ongoing uncertainty among state policymakers and automakers regarding emissions standards and the pace of future EV adoption.

State climate ambition is also being shaped by expected increases in electricity demand. While our modeling shows that building out renewable energy will be key for meeting the oncoming demand, the federal government has substantially limited policy efforts to support renewable deployment. Some states have turned to fossil fuels to support their data centers, citing the dispatchable, consistent generation from natural gas and coal.[60–62] Yet, the economics of renewable energy may outweigh such policies. Renewable energy, including battery storage, has been growing quickly due to decreasing costs and has less price volatility compared to fossil fuels.[63,64] These characteristics have become especially relevant as energy affordability rises to the forefront of U.S. economic and policy debates.[65] Not only would meeting new demand with fossil fuel generation mean risking state clean energy and emissions goals; it could also mean higher electricity prices.

Our results show that sources for electricity demand growth vary widely across states, suggesting different strategies and solutions to manage demand growth. For example, in states with high expected levels of transport electrification, flexible vehicle charging initiatives and vehicle-to-grid technologies could reduce strain on the grid during peak hours, especially if financial incentives are offered.[66,67] In states that expect high demand from data centers, policymakers may proactively control demand growth by requiring large loads to adopt flexibility measures (e.g. shifting non-critical tasks to off-peak periods) and provide their own generation.[68,69] Nonetheless, the evolving nature of technologies related to artificial intelligence (AI) inherently creates difficulty around predicting electricity demand from data centers, as AI applications and potential efficiency improvements are still uncertain. Additionally, speculation of an AI bubble and an imminent market collapse could also result in an overestimation of future demand from data centers.[70]

Upcoming electoral cycles, shifting political priorities, geopolitical dynamics, and macroeconomic trends introduce additional sources of uncertainty. The 2026 U.S. mid-term elections could reshape congressional dynamics, affecting budgetary authority, oversight of federal agencies, and the likelihood of new climate legislation or regulatory action. Furthermore, it is uncertain whether the next administration would be willing to pursue climate action; even under a climate friendly administration, they may not be willing to deliver legislation as comprehensive as the Inflation Reduction Act, and could approach some of the regulations modeled in this study as incentives instead of requirements to gain bipartisan support. Geopolitical tensions and changing trade policies can affect supply chains for key resources underpinning the energy transition, such as critical minerals, solar technologies, and battery storage.[71–73] Critical minerals are particularly vulnerable to geopolitical risks, such as export restrictions, resource nationalism, mineral cartels, political instability, social unrest, and other external shocks (e.g., natural disasters, pandemics, wars).[73] These risks can translate into uncertainties around resource availability and cost trajectories, and discourage long-term capital investment in clean energy. Additionally, periods of economic recession or expansion can alter trajectories for energy demand and associated emissions.

This analysis can be improved by using different types of modeling tools in addition to GCAM-USA to better represent some of the real-world energy interactions. With its dynamic feedbacks across economy-wide sectors and its ability to represent emissions, energy, and trade at the state level with linkages to the rest of the world, GCAM-USA is well-suited for analyzing economy-wide decarbonization scenarios with state-level detail. However, GCAM-USA currently lacks representation of delays related to permitting processes and transmission and distribution infrastructure buildout, which have become key bottlenecks for renewable energy expansion.[74,75] Additionally, though the model includes comprehensive electricity generation technologies across different load segments at the state level, it does not presently represent load shifting from peak demand to off-peak times, which could inform future electricity demand planning. Further building on this analysis and assessing detailed electricity sector outcomes with sub-annual resolution (seasonal or diurnal) would be a valuable next step.

While near-term challenges remain, compounded by rapidly changing geopolitical and economic circumstances, this analysis demonstrates that non-federal actors can serve as the backbone of a high-ambition U.S. climate trajectory and sustain progress toward net zero. We outline a suite of concrete policy actions and ambition levels for non-federal actors, accounting for existing variation in climate ambition across states. These levers, together with the broader policy implications from this study, can guide state and local decisionmakers in identifying appropriate sectoral targets and policies to support both electricity demand growth and domestic climate action. In parallel, the federal policies identified here highlight opportunities for a future climate-aligned federal leadership to support and amplify subnational efforts in pursuit of long-term national goals. More broadly, this study provides a framework for narrowing the gap toward national climate targets under Paris Agreement during periods of federal policy uncertainty.

Materials and Methods

Overview of Modeling Approach

Applying a sector-specific bottom-up aggregation framework and data analysis, we integrate the impacts of federal- and state-level climate policy instruments into an economy-wide assessment using GCAM-USA-CGS, a customized version of the open-source Global Change Analysis Model with 50-state resolution in the United States. The bottom-up aggregation framework synthesizes state-level climate policies and actions from official planning documents and policy collection databases, and quantifies their expected changes in terms of technology deployment, electricity generation, energy use, costs, and more. These impacts are then modeled as concrete state-level policy levers in GCAM-USA-CGS. The overall modeling approach follows those in previous analyses, including Hultman et al. (2020) and Zhao et al. (2024).[9,19,76–78] GHG emissions are reported in terms of CO_2 equivalents using IPCC AR5 100-year

GWP values, which is consistent with 2023 UNFCCC reporting guidance (see SI Section 3.8). SI Section 3 contains more detailed information on the overall modeling approach.

GCAM-USA-CGS is an integrated assessment model (IAM) examining linkages between the energy, land, water, climate, and socioeconomic systems. The global version of GCAM disaggregates the world into 32 geopolitical regions, one of which is the United States. GCAM-USA is the state-level version of GCAM, with resolution for 50 states and the District of Columbia for the energy and economy components in the U.S., and using the same level of detail as GCAM for water and land sectors. GCAM-USA-CGS is based on the open-source release of GCAM-USA v8.2, which is calibrated to historical outcomes through 2021 (the first simulation period is 2025).[41] GCAM-USA-CGS has been updated for the purposes of this study, including updated renewable energy costs and socioeconomic trajectories, calibrations to better match recent sectoral outcomes, and more.

Emissions of different GHGs and air pollutants across the energy, agriculture, land use, and other systems, are tracked in GCAM-USA-CGS. The energy system in GCAM-USA-CGS has representation of depletable primary energy sources, including coal, gas, oil, and uranium, in addition to renewable resources, including biomass, hydropower, solar, wind, and geothermal. Additionally, GCAM-USA-CGS represents the transformation processes that turn these resources into final energy carriers, including electricity generation and oil refining. These carriers provide services to end users in the buildings, transportation, and industrial sectors at the state level. In the electricity sector, a range of generation technologies are represented, including technologies using fossil fuels and bioenergy (with and without CCS), renewables, and nuclear. SI Section 3.1 contains more detailed information on GCAM-USA-CGS.

U.S. climate policies in GCAM-USA-CGS are modeled at the state and/or national levels. To represent state-level policy drivers, model parameters were adjusted based on information from the bottom-up aggregation analysis. In cases where it was either not feasible or not necessary to use bottom-up aggregation, model parameters were changed at the national level. We note that policies and actions from cities, businesses, and other non-federal actors are not explicitly modeled, though they are assumed to support the state and national-level policies modeled. Regions in the rest of the world are assumed to follow emissions pathways consistent with their NDCs.

Construction of Policy Scenarios

We model three distinct scenarios to evaluate U.S. greenhouse gas emissions trajectories and energy impacts through 2035. We carefully reviewed official policy documents, legislative texts, news articles, and state policy databases to model the updated federal and non-federal policies (as of July 2025) represented in these scenarios.

The *Current Policies* scenario reflects federal policy rollbacks, including repeals to different provisions of the Inflation Reduction Act and Bipartisan Infrastructure Law, and EPA regulations on fossil fuel power plants, tailpipe emissions, and oil and gas methane. Coal-fired power plants are assumed to phase down according to announced retirements. State-level EV sales mandates for cars and freight trucks are assumed to be repealed, in line with the recent removal of the California waiver. Existing state policies, including renewable portfolio standards and building energy efficiency resource standards, are modeled. In this scenario, planned coal retirements, and existing state-level policies are the key policy drivers.

The *Fragmented Action* scenario enhances state-level policy but with heterogeneity in ambition levels and timelines across states. This heterogeneity in state-level ambition is represented using a tiering system.

States are grouped into three tiers based on their propensity to adopt high-ambition climate actions, based on their existing state and local policies, emissions trends, and climate commitments. We then create policy assumptions based on the state tiers. Tier 1 states, or the climate leading states, adopt the high-ambition policies that exist or have been proposed in the most climate-forward states like California and New York; Tier 2 states adopt fewer policies at less ambitious levels in line with existing policies in the most ambitious Tier 2 states; and Tier 3 states adopt few to no policies. This tiering system is further described in SI Section 2.4 and in Ordonez-Olazabal et al. (2026), who also conduct further analysis of the implications of different state tiering methodological assumptions.

The *Unified Action* scenario assumes that all states adopt high-ambition policies. To add a layer of plausibility, there is some level of differentiation in terms of timing and ambition level based on state tiers. While we increase the ambition levels of Tier 2 states to those in line with Tier 1 states, we only increase the ambition level of Tier 3 states to be consistent with Tier 2 states. We also assume that the federal government re-introduces climate policies under a new administration after 2028, including clean energy tax credits similar to the IRA, standards on fossil fuel power plants and tailpipe emissions similar to the previous EPA regulations, and new regulations on oil refineries.

These scenarios were also assessed by varying the assumptions around a few key drivers, including data center growth, GDP and population, clean energy costs, and fossil fuel prices. While this is not a comprehensive sensitivity analysis, the selected drivers provide a reasonable range of emissions projects that vary the technical and economic parameters of our scenarios. We find that varying fossil fuel prices has the largest impact on emissions, followed by varying GDP and population. SI Section 3.9 contains more information on the sensitivity analysis. Further details regarding the methods can be found in the supplemental information.

Data and code availability

GCAM is an open source community model available at http://github.com/JGCRI/gcam-core/releases (DOI: 10.5281/zenodo.5093192). Comprehensive output data summaries and Input files used for this study will be available upon publication at DOI: 10.5281/zenodo.19739221. Detailed model results can be obtained running this input file set using the release version of GCAM 8.2 available at the above website. Results presented in this paper may differ in some minor aspects from those obtained using the release version of the model. Additionally, as noted in Supplementary Information Section 3.6, GHG emissions results were post processed to harmonize with the EPA inventory, and will differ from raw model results.

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Author contributions

A.Z., R.C., and N.H. conceptualized the study. A.Z., K.O.O., C.V.S., K.T.V.O., M.B., A.B., S.V. and D.M. conducted the data collection and modeling for this project. A.Z., M.B., and S.J.S. interpreted the results.

A.Z. created the visualizations for the manuscript. A.Z. wrote the first draft of this manuscript, with support from K.O.O., C.V.S., S.V., and D.M. All authors reviewed and/or edited the manuscript.

Declaration of interests

All authors declare no financial or non-financial competing interests.

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