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

Manuscript

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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 $MtCO_2e$/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 $MtCO_2e$/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 $MtCO_2e$/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 $MtCO_2e$/year between 2021 and 2035. To reach net zero in 2050, the emissions reduction rate would need to increase to 237 $MtCO_2e$/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 $MtCO_2e$/year. This accelerates to 204 $MtCO_2e$/year between 2030-2035 as the federal government steps in to support state action. Reductions would need to continue at about this rate (191 $MtCO_2e$/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 $MtCO_2e$/year from 2021 levels.

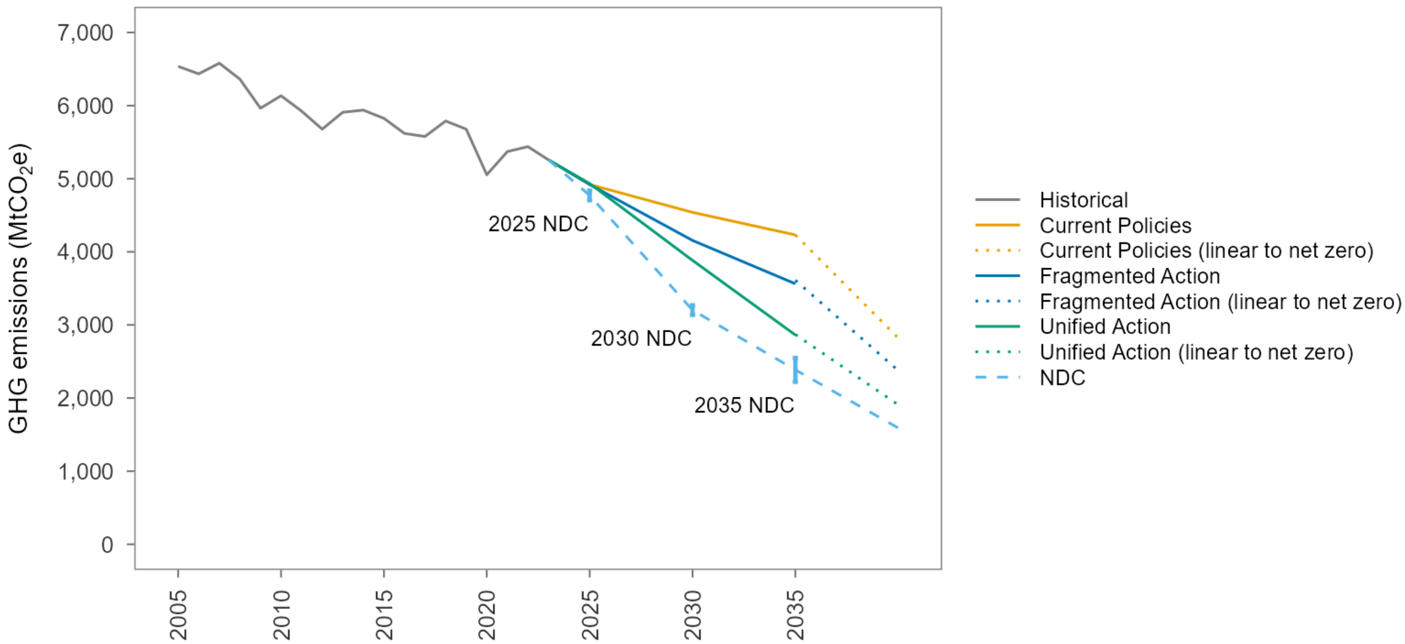

Figure 1. GHG emissions through 2035 under modeled scenarios. Historical emissions through 2023 are taken from the latest EPA inventory.[45] Modeled scenarios through 2035 are shown in the solid lines, differentiated by color. The previously communicated 2025, 2030 and 2035 NDCs are also shown by the 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.

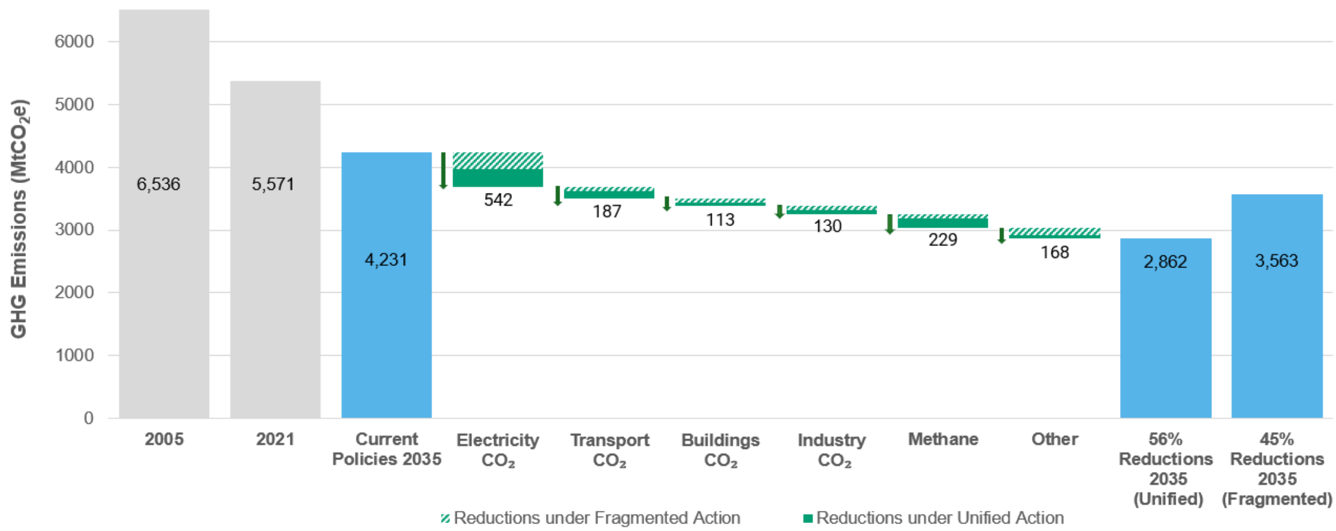

Figure 2. GHG emissions reductions across sectors needed to achieve the 56% and 45% overall reduction in 2035 under the *Unified Action* and *Fragmented Action* scenario, respectively. Bars show net GHG emissions in million tonnes of CO_2 equivalent, with reductions across electricity, transport, buildings, 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 $MtCO_2e$ 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 $MtCO_2e$), 17% (229 $MtCO_2e$), and 14% (187 $MtCO_2e$) 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 $MtCO_2e$) of emissions reductions needed.

The *Fragmented Action* scenario achieves a lower level of mitigation of 668 $MtCO_2e$ 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]

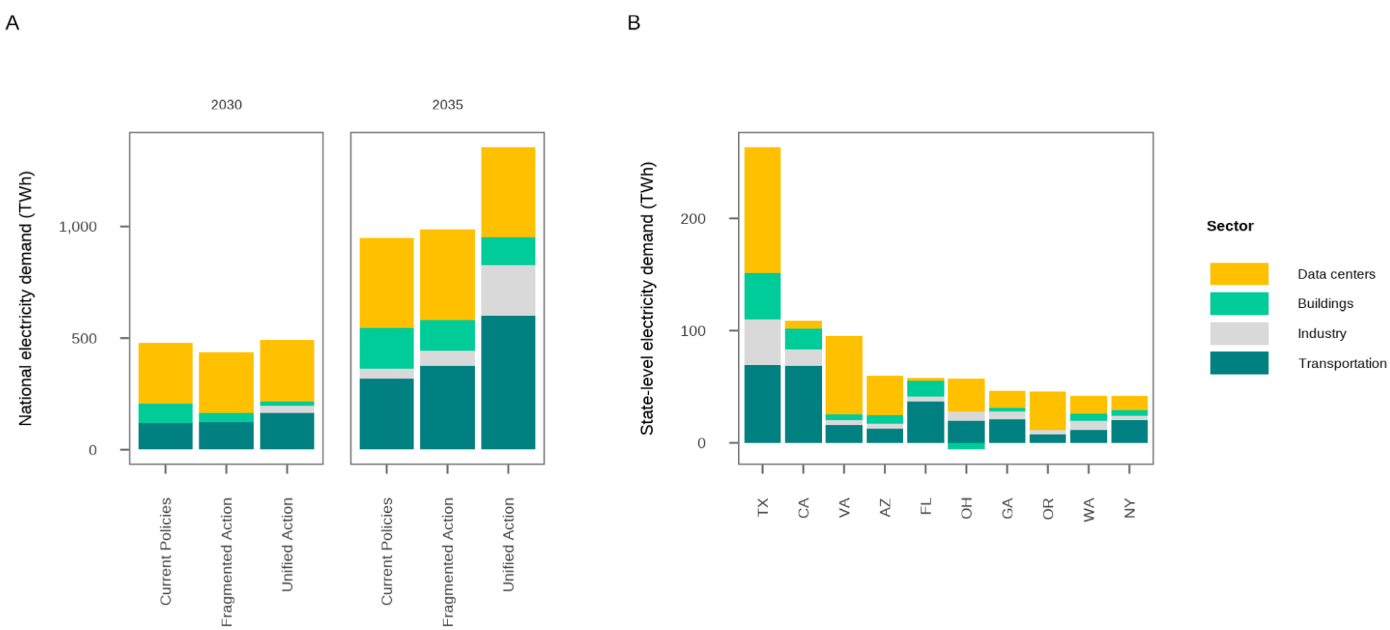

Figure 3. Electricity demand growth, relative to 2021 levels. Panel a) shows national electricity demand growth in 2030 and 2035 broken out by sector across scenarios, in TWh. Panel b) shows the top 10 states with the most electricity demand growth by sector in 2035 under the *Unified Action* scenario,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

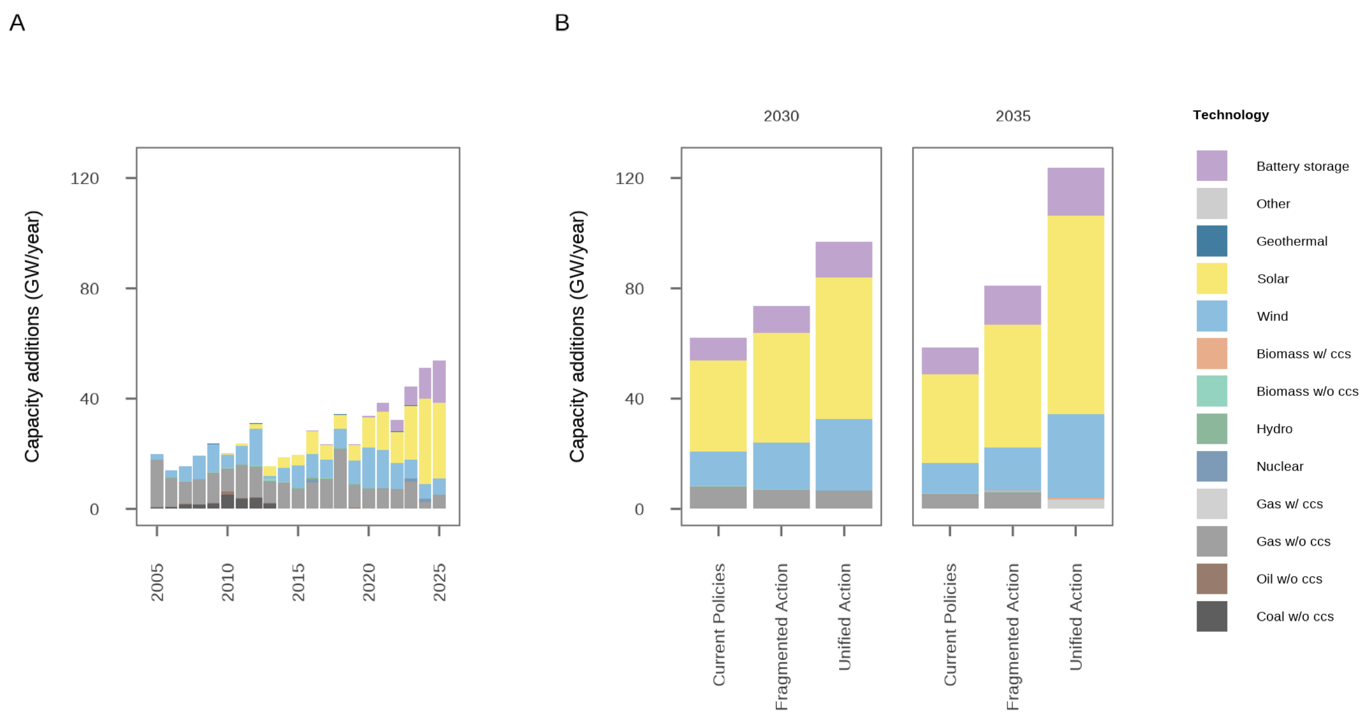

Figure 4. Annual electricity capacity additions by technology. Panel a) shows historical electricity capacity additions by technology through 2025, in GW/year.[51] Panel b) shows projected annual average capacity additions in 2030 and 2035 across the three modeled scenarios, in units of GW/year.

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.

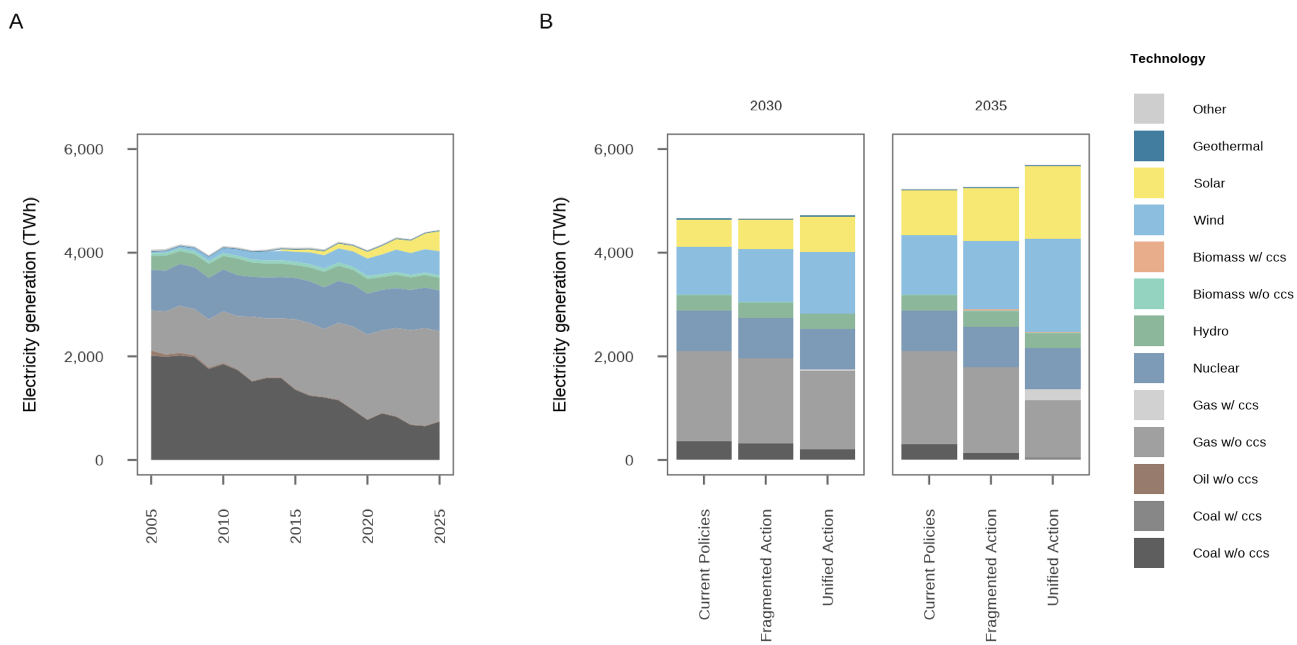

Figure 5. Electricity generation by technology. Panel a) shows historical electricity generation by technology through 2025 in TWh.[54] Panel b) shows projected generation in 2030 and 2035 across the three modeled scenarios, in units of TWh.

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.

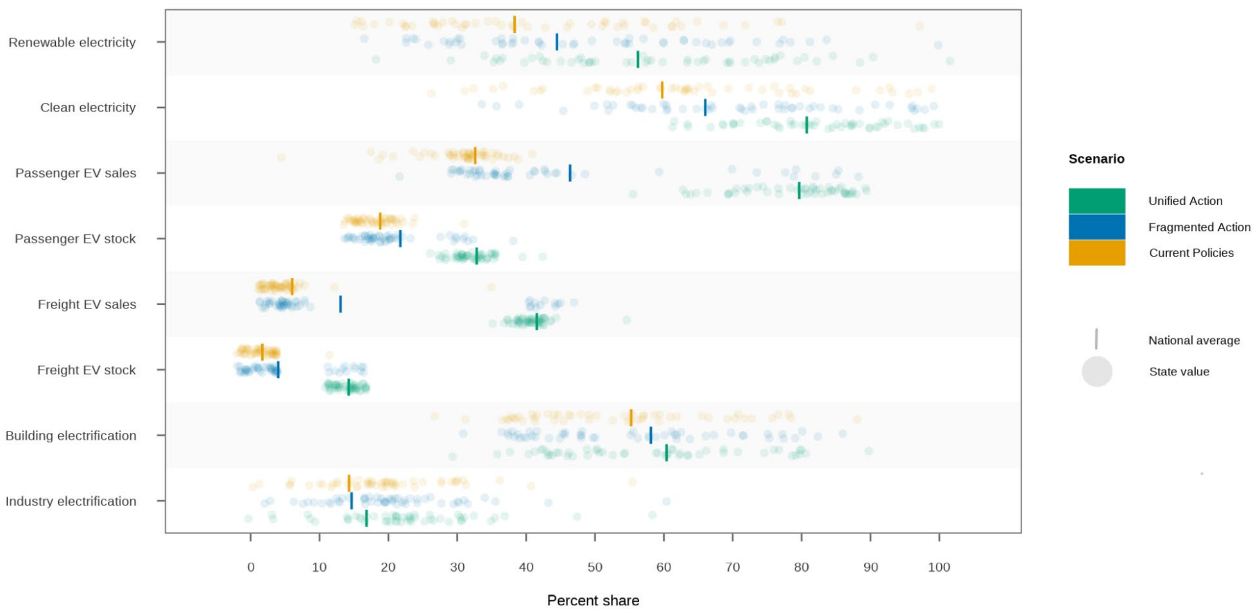

Figure 6. Sectoral metrics in 2035 across scenarios. Each metric has a national value, represented by the bars, and state-level values, represented by the transparent circles, across all three scenarios. Scenarios are differentiated by color. The renewable electricity metric indicates the percentage 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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Non-Federal Climate Leadership Can Sustain U.S. Emissions Reductions Under Federal Policy Uncertainty

Supplementary Information

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1 Introduction

In this study, we use a bottom-up aggregation framework paired with GCAM-USA-CGS, an integrated assessment model with 50-state resolution, to assess economy-wide greenhouse gas emissions reductions and associated energy system changes in the United States through 2035. This analysis reflects recent changes to the federal climate policy landscape and the potential of subnational climate action. We model three scenarios: 1) the *Current Policies* scenario, which includes recent federal policy rollbacks and existing state-level policies; 2) the *Fragmented Action* scenario, which has the same federal assumptions as *Current Policies*, and assumes that climate-leading states adopt high-ambition climate actions; 3) the *Unified Action* scenario, which assumes that all states adopt high-ambition climate action and the federal government re-introduces climate policies after 2028.

Bottom-up policy representation in these scenarios builds on previously developed methodology for aggregating non-federal actions to the state-level for implementation in GCAM-USA.[1–6] We provide a detailed description of our methodology in the following sections.

2 Scenario Overview

2.1 Current Policies scenario

The *Current Policies* scenario includes recent updates to federal policy as of July 2025. These include provisions from the Inflation Reduction Act (IRA) and the Bipartisan Infrastructure Law (BIL) that were rolled back through the One Big Beautiful Bill Act, as well as federal regulations that have been or are in the process of being repealed, such as tailpipe emissions and fuel economy standards, fossil fuel power plant regulations, oil and gas methane standards, and more. Other federal key rollbacks, including the repeal of the endangerment finding and funding freezes related to the Greenhouse Gas Reduction Fund (a $27 billion grant for clean energy projects under the IRA), were not explicitly modeled due to modeling limitations and/or uncertainty related to the outcomes. Many of the recent repeals are going through litigation, and the long-term impacts remain to be seen.

States and other non-federal actors continue to implement key existing policies, such as renewable portfolio standards (RPS), energy efficiency resource standards (EERS), and carbon pricing programs. For example, Maryland's RPS mandates that electricity suppliers must procure 50% of their electricity from renewable sources by 2030,[7] and its EERS covers all sales within the state with a goal to increase energy savings by 2.5% by 2027.[8] Over 20 other states also have RPS and EERS policies. California and Washington have cap and trade programs that set a limit on GHG emissions for major polluters and require them to buy allowances to offset them.[9,10] Existing state-level GHG reduction targets are not assumed to be met in this scenario. Due to the recent federal repeal of the California waiver, states are not assumed to have any mandates for EV sales in place, including legislation on Advanced Clean Cars and Advanced Clean Trucks.

2.2 Fragmented Action scenario

The *Fragmented Action* scenario uses the same federal assumptions as *Current Policies*, and models enhanced state-level policies. Using the state tiering system described in Section 2.4, states are grouped into three tiers based on their propensity to adopt ambitious climate policy. Tier 1 states, or climate-leading states, are assumed to adopt high-ambition climate actions that are in line with the most ambitious existing policies. While other states (Tier 2 and 3 states) also increase their ambition level relative to current policies, the policies adopted are either less ambitious or have slower uptake.

2.3 Unified Action scenario

In the *Unified Action* scenario, all states shift to high-ambition climate policies. This scenario uses the same modeling assumptions as the *Fragmented Action* scenario for Tier 1 states, but further increases climate ambition for Tier 2 and 3 states. In general, ambition for Tier 2 states is raised to Tier 1 levels, and ambition for Tier 3 states is raised to Tier 2 levels. Additionally, the next federal administration is assumed to re-orient toward climate policy, introducing legislation similar to the IRA and implementing regulations on fossil fuel power plants, tailpipe emissions, and more, starting in 2029.

2.4 State tiering

State-level climate action in the United States varies considerably. For example, some states aim to achieve 100% clean energy generation by 2040, while others have less ambitious targets, and some lack these targets altogether.[11,12] To account for the varying levels of policy adoption, we used a new methodology to categorize states into three tiers based on their propensity to adopt high-ambition climate action. The methodology is further described in Ordonez-Olazabal et al. (2026)[13], which classifies states into three ambition tiers on a sectoral and multidimensional index of historical climate mitigation performance.

In each sector, state tiers are determined based on the strength of current state climate policy, progress in emissions reductions, local climate policies, and climate commitments. These components are normalized and weighted at 60% for current state climate policy, 20% for progress in emissions reductions, 10% for the local climate policy, and 10% for climate commitment, emphasizing enacted policy strength while also incorporating realized emissions performance and institutional context. States are then assigned to Tier 1, Tier 2, or Tier 3 within each sector using k-means clustering applied to the resulting index values, allowing tier boundaries to emerge endogenously from the distribution of state performance rather than from predetermined thresholds. This approach captures state heterogeneity in policy ambition across sectors in a transparent and reproducible process.

Tier 1 states have been leading the way on climate action, and are assumed to adopt a full range of climate policies under high-ambition policy scenarios. Tier 2 states have some policies in place but tend to move more slowly than Tier 1 states. Thus, they are assumed to adopt some level of climate ambition in high ambition scenarios, though not at the same level or on the same timeline as Tier 1 states. Tier 3 states have taken limited steps to advance climate action and are thus assumed to take few additional policy actions.

Across tiers, our policy assumptions differ by the stringency of the policy target or the speed of policy uptake. For example, EV sales targets vary in the speed of uptake: Tier 1 states achieve 100% EV sales by 2038 (representing a 3-year delay of the Advanced Clean Cars II targets), while Tier 2 states achieve this target by 2041, and Tier 3 states achieve it by 2044. On the other hand, RPS implementation is based on differences in the target itself: Tier 1 states set an RPS of 65% in 2035, which falls to 50% for Tier 2 states, and 20% for Tier 3 states. Targets for the different tiers are estimated based on high-achieving states in each tier.

A full list of states categorized into Tier 1, Tier 2, and Tier 3 by sector is described in Table S1. Within each sector, it is important to note that states with strong policies in one area but not other areas (e.g. strong VMT policies but not EV policies in transportation) may be categorized in lower tiers because states are evaluated comprehensively on policies within each sector in this index. Additionally, states that are advancing the clean energy transition as a result of market forces and other non-policy drivers (e.g. high shares of renewable energy in Texas) are not likely to be ranked highly in this index given the current weighting structure.

Table S1. State tiers by sector

Sector	States by tier
Electricity	**Tier 1 states:** California, Colorado, the District of Columbia, Hawaii, Illinois, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nevada, New Jersey, New Mexico, New York, Oregon, and Washington **Tier 2 states:** Arizona, Connecticut, Delaware, New Hampshire, North Carolina, Ohio, Pennsylvania, Rhode Island, South Carolina, Vermont, Virginia, Wisconsin **Tier 3 states:** Alabama, Alaska, Arkansas, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Montana, Nebraska, North Dakota, Oklahoma, South Dakota, Tennessee, Texas, Utah, West Virginia, and Wyoming
Buildings	**Tier 1 states:** California, Colorado, Connecticut, the District of Columbia, Illinois, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont, and Washington **Tier 2 states:** Delaware, Hawaii, Louisiana, Michigan, Minnesota, Nevada, New Hampshire, New Mexico, North Carolina, Pennsylvania, Texas, Virginia, Wisconsin **Tier 3 states:** Alabama, Alaska, Arizona, Arkansas, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Mississippi, Missouri, Montana, Nebraska, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Utah, West Virginia, and Wyoming
Transportation	**Tier 1 states:** California, Colorado, Connecticut, the District of Columbia, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Washington **Tier 2 states:** Delaware, Hawaii, Illinois, Maine, Michigan, Minnesota, Nevada, New Mexico, Pennsylvania, Vermont, and Virginia **Tier 3 states:** Alabama, Alaska, Arizona, Arkansas, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Montana, Nebraska, New Hampshire, North Carolina, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, West Virginia, Wisconsin, and Wyoming
Industry	**Tier 1 states:** California, Colorado, Maryland, Massachusetts, New York, Oregon, Washington **Tier 2 states:** Connecticut, Hawaii, Illinois, Maine, Nevada, New Jersey, New Mexico, North Caroline, Pennsylvania, Rhode Island, Vermont, and Virginia **Tier 3 states:** Alabama, Alaska, Arizona, Arkansas, Delaware, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Hampshire, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, West Virginia, Wisconsin, and Wyoming

Land Use	**Tier 1 states:** California, Colorado, Maryland, New Mexico, New York, Washington **Tier 2 states:** Connecticut, the District of Columbia, Delaware, Hawaii, Illinois, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Nevada, New Jersey, North Carolina, Oregon, Pennsylvania, Rhode Island, Texas, Utah, Vermont, and Wisconsin **Tier 3 states:** Alabama, Alaska, Arizona, Arkansas, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Mississippi, Missouri, Montana, Nebraska, New Hampshire, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Virginia, West Virginia, and Wyoming
Economy-wide	**Tier 1 states:** California, Colorado, the District of Columbia, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Washington **Tier 2 states:** Connecticut, Delaware, Hawaii, Illinois, Maine, Michigan, Minnesota, Nevada, New Mexico, North Carolina, Pennsylvania, Vermont, and Virginia **Tier 3 states:** Alabama, Alaska, Arizona, Arkansas, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Montana, Nebraska, New Hampshire, North Dakota, Ohio, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, West Virginia, Wisconsin, and Wyoming

2.5 GHG emissions reductions

Table S2 presents GHG emissions reductions achieved under the three scenarios described above.

Table S2. Emissions results by sector. The AR5 100-year GWP is used to convert non-CO_2 emissions into CO_2 equivalents .

Sector/GHG	Emissions 2005 ($MMTCO_2e$)	Emissions 2021 ($MMTCO_2e$)	Emissions 2035 ($MMTCO_2e$)			Change relative from 2005 to 2035 (%)		
			Current Policies	*Fragmented Action*	*Unified Action*	*Current Policies*	*Fragmented Action*	*Unified Action*
Electricity CO_2	2,413	1,553	917	653	376	-62%	-73%	-84%
Transport CO_2	1,869	1,762	1,369	1,302	1,182	-27%	-30%	-36%
Industry CO_2	1,188	1,111	1,107	1,035	977	-7%	-13%	-18%
Buildings CO_2	586	556	501	431	388	-15%	-26%	-33%
Other CO_2	71	38	31	28	25	-56%	-60%	-65%
CH_4	858	783	756	674	526	-12%	-21%	-39%
N_2O	436	412	408	407	406	-6%	-7%	-7%
F-Gases	156	200	117	109	111	-25%	-30%	-29%
Direct Air Capture	0	0	0	0	-12	0%	0%	N/A
Land sink	-1,041	-1,044	-974	-1,081	-1,115	-6%	4%	7%
Net GHG Total	**6,536**	**5,371**	**4,231**	**3,558**	**2,862**	**35%**	**45%**	**56%**

3 Economy-Wide Analysis

3.1 GCAM-USA-CGS

Our analysis uses a version of the open-source Global Change Analysis Model (GCAM) to estimate the aggregate impact of federal and non-federal climate policies and actions on economy-wide emissions reductions in the United States. Specifically, we use GCAM-USA, a state-level version of GCAM. We refer to the version of GCAM-USA used in this study as GCAM-USA-CGS.

GCAM is an integrated assessment model (IAM) of the energy, land, water, climate, and socioeconomic systems. The global version of GCAM groups the world's countries into 32 geopolitical regions with representation of the energy and socioeconomic systems for each region. The United States is one of the 32 regions. GCAM represents the global climate system and uses 235 water basins and 384 land regions to represent global water and land systems. GCAM tracks emissions and sinks of carbon dioxide (CO_2), 16 other GHGs, and several air pollutants.

The state-level version of GCAM used in this analysis, GCAM-USA, disaggregates the U.S. energy and economy components into 50 states and the District of Columbia while maintaining the same level of detail as GCAM for water and land sectors. The energy system in GCAM-USA 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. Energy transformation processes like oil refining and electricity generation are represented at the state-level in GCAM-USA. These energy carriers, in turn, are used to deliver services to state-level end users in the buildings, transportation, and industrial sectors. The electric power sector includes representation of a range of electricity generation technologies, including those fueled by fossil fuels and bioenergy (with and without CCS), renewables, and nuclear.

GCAM-USA is a market equilibrium model. The model solves for equilibrium in each period by finding a set of market prices such that supplies and demands are equal in all markets as model actors adjust the quantities of the commodities they provide and consume. GCAM operates in 5-year time-increments, with each new period starting from the conditions that emerged in the previous period, and with most technologies being vintaged such that existing capital stocks in each period carry over into future time periods (subject to technical or economically-driven retirement).

GCAM-USA-CGS is based on the open-source release of GCAM-USA 8.2,[14] which is calibrated to historical outcomes through 2021 (the first simulation period is 2025). GCAM-USA-CGS has been updated for the purposes of this study to reflect changes such as the most recent estimates of future renewable energy costs.[15] The model is also calibrated to the latest non-CO_2 marginal abatement cost curves from the U.S. Environmental Protection Agency (EPA).[16]

3.2 Modeling approach

Policy representation in our modeled scenarios utilizes bottom-up aggregation tools and data analysis to evaluate the impacts of policies and climate actions in isolation and within specific sectors. Throughout, we took care to avoid potential double counting of potential emissions reduction drivers from nested governance levels. We then used this information in GCAM-USA-CGS to estimate the economy-wide implications of associated policies. This modeling approach is consistent with previous analyses.[1–6]

All modeled policies in GCAM-USA-CGS are implemented at the state and/or national levels. Policies and actions from city governments, businesses, and institutions are not explicitly modeled, but are assumed to be embedded within or supportive of the state and/or national level policy representation in the model. Descriptions of policy representation in GCAM-USA-CGS can be found in Tables S4-S8.

Model parameters in GCAM-USA-CGS were varied according to information from our bottom-up aggregation analysis or changed directly for policy drivers where bottom-up aggregation was either not feasible or not necessary in the case of small-scale potential impacts. The purpose of this analysis is to assess the national emissions reduction potential in the United States for the policies modeled in our scenarios. Accordingly, non-federal policies and actions are only modeled to the extent that doing so would have a meaningful impact on the national-level emissions outcome.

3.3 Core modeling assumptions

The results of this study rely on a set of core assumptions for drivers including economic growth, population growth, fossil fuel prices, technology costs, and data center electricity demand (Table S3). These assumptions draw from a set of data sources, including U.S. Energy Information Agency's (EIA) Annual Energy Outlook (AEO) 2023,[17] National Renewable Energy Lab's Annual Technology Baseline 2024,[15] and the Electric Power Research Institute (EPRI)'s data center load growth projections from October 2024.[18]

The EPRI data used on data center load growth rates are based on public estimates of historical and current load levels, as well as varying assumptions about future industry growth, such as the extent of efficiency breakthroughs and saturation of service demand.[13,14] The data do not take into account transmission constraints and assume that future data center load growth is concentrated in emerging and already established markets. These extrapolated projections rely heavily on current assumptions about data center technology and demand. However, uncertainty remains around current data center load and how technology and efficiency rates may improve in the future.

Table S3. Core modeling assumptions in GCAM-USA-CGS

Drivers	**Scenario assumptions**
Economic Growth	Overall gross domestic product (GDP) increases by 1.68% per year on average from 2022 through 2035, based on EIA's AEO 2023 Reference case.
Population Growth	Population grows by 0.46% per year on average from 2022 through 2035, based on EIA's AEO 2023 Reference case.
Fuel Prices	Gas price is assumed to increase at an average rate of 1.3% per year from 2022 through 2035, which is consistent with EIA's AEO 2023 Reference case. Oil price is assumed to increase at an average rate of 2.5% per year from 2022 through 2035, which is consistent with EIA's AEO 2023 Reference case.
Technology Costs	Technology costs are updated with the National Renewable Energy Laboratory (NREL) Annual Technology Baseline 2024 Moderate Scenario assumptions.
Data Center Electricity Demand	The medium scenario is based on a 2024 EPRI study, which assumes an average 12% annual growth rate from 2023 to 2030. Projections from 2030-2035 are linearly extrapolated from the medium scenario.

In addition to these core model assumptions, we also adjusted parameters related to offshore wind and natural gas generation to reflect major barriers related to deploying these technologies. We constrain the amount of offshore wind coming online by 2035 to reflect pauses on project leasing, increased regulatory uncertainty, and market volatility.[19] New offshore wind capacity is limited to fully permitted projects, assuming that those without permits would not be able to complete construction by 2035.[20] Additionally, major companies have announced delivery backlogs for natural gas turbines, with GE and GE Vernova stating that gas turbines would not be delivered until late 2028 at the earliest.[21] To account for limitations related to the natural gas turbines supply chain, we constrain new natural gas capacity between model years 2025 and 2030 to roughly reflect only planned additions as of August 2025 from the U.S. Energy Information Administration.[22] 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.

3.4 Policy modeling assumptions

3.4.1 Current Policies

Federal Assumptions

The federal assumptions used in this scenario are described in Table S4.

Table S4. Federal policy assumptions under *Current Policies*

Sector	Policy Type	Provision/Policy	Modeling Adjustment
Electricity	IRA	Sections 13701 & 13702: New clean electricity PTC and ITC	Rolled back after 2025
		Section 13302: Residential clean energy credit	Rolled back after 2025
		Section 13015: PTC for existing nuclear	No change, continues through 2033
		Section 50144: Energy infrastructure reinvestment financing	Rolled back after 2025
		Section 13104 – 45Q: Extension of credits for captured CO_2	Rolled back after 2025 due to termination of the greenhouse gas reporting program, which would make this credit difficult to claim.[23]
	Regulations	CAA section 111(b) Standards for New Stationary Combustion Turbines	Rolled back after 2025
		CAA section 111(d) Emission Guidelines for Existing Fossil Fuel-Fired Sources	Rolled back after 2025
Transportation	IRA	Section 13401 – 30D: Clean vehicle credit	Rolled back after 2025
		Section 13404: Alternative refueling property credit	Rolled back after 2026
		Section 13403 – 45W: Commercial clean vehicle credit	Rolled back after 2025
		Sections 45Z: Clean fuel production credit	Extended through 2030
	BIL	Section 11401 and 11403: Grants from charging and fueling infrastructure, Carbon reduction program, and National Electric Vehicle Formula Program	Rolled back after 2025
		Section 11115 and 11403: Congestion mitigation and air quality improvement program, and Carbon reduction program	Rolled back after 2025
		Sections 71101 and 30018: Clean school bus program and Grants for buses and bus facilities	Rolled back after 2025
	Regulations	CAFE standards for LDVs	Rolled back after 2025
		GHG emissions standards for freight trucks	Rolled back 2025
Buildings	IRA	Section 13303: Energy efficient commercial building deduction	Rolled back after 2026
		Sections 13301 – 25C, 13304, and 50121: Energy efficient home improvement credit, Energy efficient home credit, and Home energy efficiency credit	Rolled back after 2025
		Section 51022: High-efficiency home rebate program	No change, continues through 2031
Industry	IRA	Section 13104 – 45Q: Extension of credits for captured CO_2	Rolled back after 2025 due to termination of the greenhouse gas reporting program, which would make this credit difficult to claim.[23]

		Section 13204 – 45V: Production credit for clean hydrogen	Rolled back after 2027
		Section 13501 – 48C: Manufacturing investment tax credit for advanced energy projects	Rolled back after 2025
		Section 50161: Advanced industrial facilities deployment program	Rolled back after 2025
Methane	IRA	Section 60113: Methane emissions reduction program	Rolled back after 2025
	Regulations	EPA standards for oil and gas methane	Rolled back after 2025
Other	AIM Act	HFC phasedown	National HFC phasedown is implemented consistent with the American Innovation and Manufacturing (AIM) Act.
	IRA and BIL	Land use, land-use change and forestry (LULUCF)	Rolled back after 2025, using the 'Absent Climate-Smart Policies' scenario from Kennedy et al. 2024.[24]

Non-federal Assumptions

The non-federal assumptions used in this scenario are described in Table S5.

Table S5. Non-federal modeling assumptions under *Current Policies*

Sector	Policy	Modeling Assumption
Electricity	Renewable portfolio standards	Current state-level RPS targets are modeled.
	Cap and trade	The Regional Greenhouse Gas Initiative (RGGI) is modeled as a 50% reduction in power sector emissions below 2020 levels by 2035 in participating states. Additionally, cap and trade targets for California and Washington are modeled.

	Coal phase-out	Scheduled retirements of coal-fired capacity are modeled through 2035.
Transportation	LDV ZEV sales mandates and targets	Rolled back after 2025
	Freight truck ZEV sales mandates and targets	Rolled back after 2025
	LDV ZEV incentives	Major existing incentives for LDV ZEVs at the state-, utility-, and district levels from the Alternative Fuels Data Center are modeled at the state level as reductions in per-vehicle capital cost. Altogether, these are equivalent to a national average capital cost reduction for LDV EVs of $826 per vehicle.
Buildings	Energy efficiency standards (EERS)	Current state-level EERS were modeled by reducing state-level building service demands.
Methane	Methane incentives and regulations	Non-federal actors are incentivized to reduce methane emissions reductions achievable at a cost of $0/tCO2e or below on the EPA's MAC curves.

3.4.2 Fragmented Action

Federal Assumptions

Fragmented Action uses the same federal assumptions as *Current Policies.* Detailed assumptions are described in Table S4.

Non-federal Assumptions

In the *Fragmented Action* scenario, Tier 1 states adopt the most ambitious climate actions across sectors based upon existing or proposed policies. Tier 2 states adopt similar policies but with a less stringent target or at a slower pace. Tier 3 states have limited policy uptake, but increase their ambition in some areas. Modeled policies include clean electricity standards, LDV electrification policies, vehicle miles traveled reduction policies, zero-emission appliance standards, cement CCS targets, oil and gas methane regulations, and more. Detailed assumptions are described in Table S6.

In place of EV sales mandates, we assume that a combination of other non-federal actions, including clean car coalitions, transport emissions reduction targets, low carbon fuel standards, and automaker commitments collectively helps states achieve what is equivalent to a delayed implementation of the targets under Advanced Clean Cars II (ACC II) and Advanced Clean Trucks (ACT). These specific policies are not modeled explicitly but instead modeled through delayed implementation of the ACC II and ACT targets. See Section 4.3.1 for additional information.

Table S6. Non-federal modeling assumptions under *Fragmented Action*

Sector	Policy	Tier 1 Ambition Level	Tier 2 Ambition Level	Tier 3 Ambition Level
Electricity	Renewable portfolio standards	50% by 2030, 65% by 2035	40% by 2030, 50% by 2035	15% by 2030, 20% by 2035
	Clean electricity standards	80% by 2035	-	-
	Coal phaseout policies	2030 phaseout	2035 phaseout	2040 phaseout
Transportation	LDV electrification policies (e.g. clean car coalitions, emissions reduction targets, low carbon fuel standards, automaker commitments, and more)	100% EV sales by 2038	100% EV sales by 2041	100% EV sales by 2044
	M/HDV electrification policies (e.g. clean car coalitions, emissions reduction targets, low carbon fuel standards, automaker commitments, and more)	EV sales equivalent to California's Advanced Clean Trucks targets with a 3-year delay	-	-
	Bus electrification targets	100% electrification of new bus sales in 2030	100% electrification of new bus sales in 2035	100% electrification of new bus sales in 2040
	Vehicle miles traveled reduction policies	1% by 2030 and 1.25% by 2035 annual VMT per capita reductions	0.5% by 2030 and 0.75% by 2035 annual VMT per capita reductions	-
	Low carbon fuel standards	20% in 2030, 25% in 2035	-	-
Buildings	Enhanced energy efficiency resource standards	4% annual efficiency savings by 2030		
	Zero-emission appliance standards	100% electric heating and water heating sales by 2035	100% electric heating and water heating sales by 2040	
	Zero-emission construction standards	100% new electric construction by 2035		
Industry	Cement CCS targets	CCS capability for 40% of cement produced by 2035	CCS capability for 20% of cement produced by 2035	CCS capability for 10% of cement produced by 2035

Methane	Oil and gas methane regulations	Reductions achievable at a cost of $60/tCO2e or below on the EPA's MAC curves by 2035	Reductions achievable at a cost of $30/tCO2e or below on the EPA's MAC curves by 2035	Reductions achievable at a cost of $0/tCO2e or below on the EPA's MAC curves
	Agricultural methane policies	Reductions achievable at a cost of $0/tCO2e or below on the EPA's MAC curves by 2035		
	Landfill waste methane regulations	Reductions achievable at a cost of $60/tCO2e or below on the EPA's MAC curves by 2035	Reductions achievable at a cost of $40/tCO2e or below on the EPA's MAC curves by 2035	Reductions achievable at a cost of $20/tCO2e or below on the EPA's MAC curves by 2035
	Enhanced waste diversion efforts	60% reduction in landfill waste by 2035	40% reduction in landfill waste by 2035	20% reduction in landfill waste by 2035
Other	HFC regulations	Adopt Significant New Alternatives Policy (SNAP) and Refrigerant Management Programs (RMP) programs[1]		
	Expanded funding for wildfire mitigation, tree planting, conservation and health soils	Assume $42 billion in investments in climate-smart policies resulting from enhanced state-level action, based on the 'Current Policies' scenario from Kennedy et al. 2024.[24]		

3.4.2 Unified Action

Federal Assumptions

In the *Unified Action* scenario, we assume that the next federal administration re-engages on climate policy after 2028. Federal assumptions for this scenario include the rollbacks specified in the previous section (Table S4), in addition to new policies in Table S7 below. The policies assumed under re-engagement are largely in line with what already existed under policies like the IRA and EPA regulations but with adjusted timelines and requirements to reflect delayed action, as well as some additional policies on refineries and direct air capture. These policies are also expected to be supportive of the state-level policies modeled in this scenario. Some of the regulations, for instance, may instead be approached as incentives instead of requirements due to political feasibility.

Non-federal Assumptions

All states accelerate their actions and adopt high-ambition policies: Tier 1 states continue to implement the policies under *Fragmented Action*. Tier 2 states accelerate their actions and implement Tier 1 policies. Tier 3 states also ramp up their ambition, implementing Tier 2 policies. Certain policies, such as EV sales targets and oil and gas methane regulations, are further boosted by federal incentives and regulations. Detailed assumptions are described in Table S8.

[1] Emissions impacts from national and state-level HFC regulations were derived from a short-lived climate pollutant tool developed by CARB and extrapolated to additional states. We used the tool's Kigali phasedown scenario as a proxy for the impact of the AIM Act.

Table S7. Federal modeling assumptions under *Unified Action*

Sector	Policy	Modeling Assumption
Electricity, Transportation, Buildings, Industry, Lands	Tax credits and investments	Tax credits and rebates similar to those under the IRA are reinstated by 2030.
Electricity	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%
Transportation	Tailpipe emissions standards for LDVs	Reinstated by 2030 to help states achieve 100% EV sales by 2038
	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
	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
Methane	Oil and gas methane regulations	Reinstated by 2030 such that reductions identified on the EPA's MAC curves as achievable at a cost of $60/tCO2e or below are achieved by 2035
	Coal methane regulations	Introduced by 2030, delivering emissions reductions achievable at a cost of $60/tCO2e or below on the EPA's MAC curves by 2035
	Agricultural methane regulations and incentives	Introduced by 2030, delivering emissions reductions achievable at a cost of achievable at a cost of $30/tCO2e or below on the EPA's MAC curves by 2035
Industry	Standards on oil refineries	Introduced after 2030, requiring CCS capabilities for 25% of oil by 2035
	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 as of March 2026.[25,26]
Lands	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 Kennedy et al. 2024.[24]

Table S8. Non-federal modeling assumptions under *Unified Action*

Sector	Policy Type	Tier 1 Ambition Level	Tier 2 Ambition Level	Tier 3 Ambition Level
Electricity	Renewable portfolio standards	50% by 2030, 65% by 2035		40% by 2030, 50% by 2035

	Clean electricity standards	80% by 2035	-
	Coal phaseout policies	2030 phaseout	2035 phaseout
Transport	LDV electrification policies to help achieve targets under Advanced Clean Cars II, including federal tax credits + regulations	100% EV sales by 2038	
	M/HDV electrification policies to help achieve targets under Advanced Clean Trucks, including federal tax credits + regulations	EV sales equivalent to California's Advanced Clean Trucks targets with a 3-year delay	
	Bus electrification targets	100% electrification of new bus sales in 2035.	100% electrification of new bus sales in 2040.
	Vehicle miles traveled reduction policies	1% by 2030 and 1.25% by 2035 annual VMT per capita reductions	0.5% by 2030 and 0.75% annual VMT per capita reductions
	Low carbon fuel standards	20% in 2030, 25% in 2035	-
Buildings	Enhanced energy efficiency resource standards	4% annual efficiency savings by 2030	
	Zero-emission appliance standards	100% electric heating and water heating sales by 2035	100% electric heating and water heating sales by 2040
	Zero-emission construction standards	100% new electric construction by 2035	
Industry	Cement CCS targets	CCS capability for 40% of cement produced by 2035	CCS capability for 20% of cement produced by 2035.
Methane	Oil and gas methane regulations	Deliver emissions reductions achievable 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.	
	Landfill methane capture regulations	Deliver emissions reductions achievable at a cost of $60/tCO2e or below on the EPA's MAC curves by 2035	Deliver emissions reductions achievable at a cost of $40/tCO2e or below on the EPA's MAC curves by 2035
	Enhanced waste diversion efforts	60% reduction in landfill waste by 2035	40% reduction in landfill waste by 2035

Other	HFC regulations	Adopt Significant New Alternatives Policy (SNAP) and Refrigerant Management Programs (RMP) programs.	-

3.6 Calibrating emissions to EPA inventory

Emission results through the year 2021 were calibrated to historical GHG emissions from the 1990-2023 EPA inventory report.[27] GCAM-USA-CGS is calibrated through 2021, with the first simulation period being 2025. Net GHG emissions fell by 114 $MtCO_2e$ between 2021 and 2023, from 17.8% to 19.6% below 2005 levels.

3.7 Comparison with near-term trends

While our scenarios have incorporated recent policy developments and projections of core drivers, the last calibrated model year in GCAM-USA-CGS is 2021. Thus, projections in model year 2025 may diverge from historical outcomes in that year. In this section, we compare the latest historical trends with projections from our modeled scenarios, noting areas of alignment and divergence.

3.7.1 GHG emissions

Although EPA data on 2025 has not been released, preliminary estimates from Rhodium Group were published after the modeling for this study was conducted. They find that emissions increased in 2025, reversing two years of decline and returning to an 18% GHG emissions reduction relative to 2005 levels.[28] The report attributes much of the increase to buildings and the power sector, driven by colder winter temperatures that raised heating demand and by higher electricity demand alongside a rebound in coal generation.

GCAM-USA-CGS's 2025 model year was parameterized based on earlier coal power plant retirement and other emissions and energy trends, resulting in modeled 2025 emissions (24.7% below 2005 levels) that are below the Rhodium estimate. While this difference could be perpetuated into lower modeled emissions in subsequent periods under our main scenarios (see section 3.7.2 as an example), it is possible that the recent change in trends is short lived and longer-term trends align more closely with our projections for 2035. We also run additional sensitivities in Section 3.9 to account for potential changes to core drivers related to socioeconomic changes, technology costs, data center demand load, and more.

3.7.2 Coal generation

National coal generation has been declining steadily from its peak in the mid-2010s due to a combination of economics and environmental regulations. However, newly available data shows that this trend reversed over the last year, with coal generation increasing 13% in 2025 year-on-year (Figure S1) . This increase is primarily driven by additional generation from existing coal plants (increasing capacity factors) due to higher natural gas prices, growing electricity demand, and federal policy changes.[28,29] While it's unclear whether the uptick in coal generation will continue in the coming years, there is likely a limit to the amount of demand growth coal can accommodate due to retirement schedules and to the economics of operating aging coal plants compared to newer and more efficient energy sources, like renewable energy and natural gas.

Modeled coal generation in 2025 is in line with historical 2024 levels but lower than 2025 levels (Figure S1). The additional emissions from coal generation in 2025 would be equivalent to 4-6% of the 2035 overall GHG emissions across scenarios. However, high-ambition clean energy policies in the *Fragmented Action* and *Unified Action* scenarios would mandate coal phaseout regardless of the shifting trends, and thus the longer-term impacts associated with the increase in coal generation under these scenarios would be minimal. Post 2025, coal generation is projected to continue to decline across scenarios, with *Unified Action* driving the steepest reduction toward near-zero levels by 2035, and *Current Policies* showing a slower downward trend, particularly after 2030.

Across tiers, coal generation in 2025 deviates particularly for Tier 2 and 3 states (Figures S2). Post 2025, Tier 1 states are well positioned to phase out coal generation by 2030, whereas Tier 2 and 3 states would require some acceleration in the rate of coal decline compared to historical trends (Figure S2).

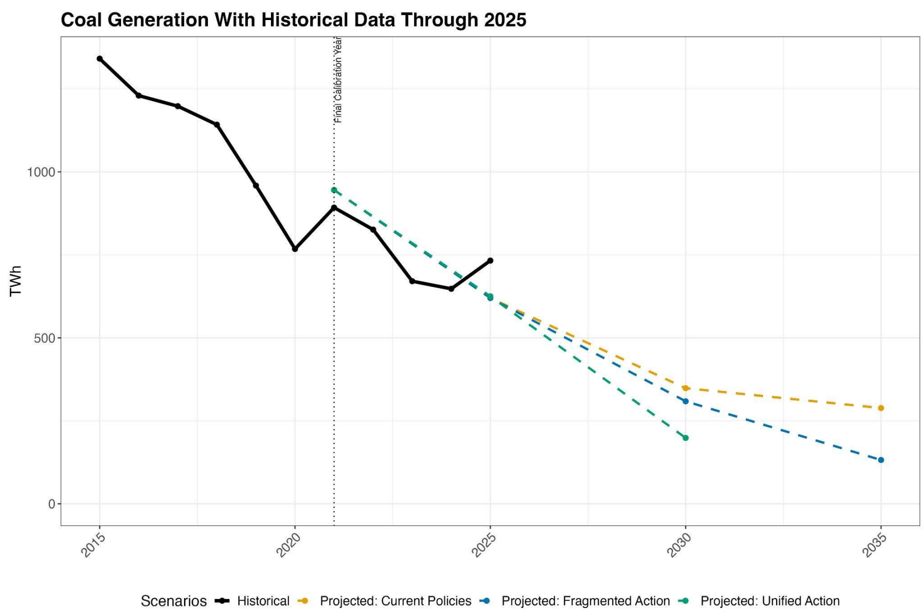


Fig. S1. U.S. coal generation, with historical data through 2025 from the U.S. Energy Information Administration[30] and projections from 2025 through 2035 under the *Current Policies*, *Fragmented Action*, and *Unified Action* scenarios, in units of TWh. Markers indicate the model years; values for the years between model years are estimated using a linear interpolation.

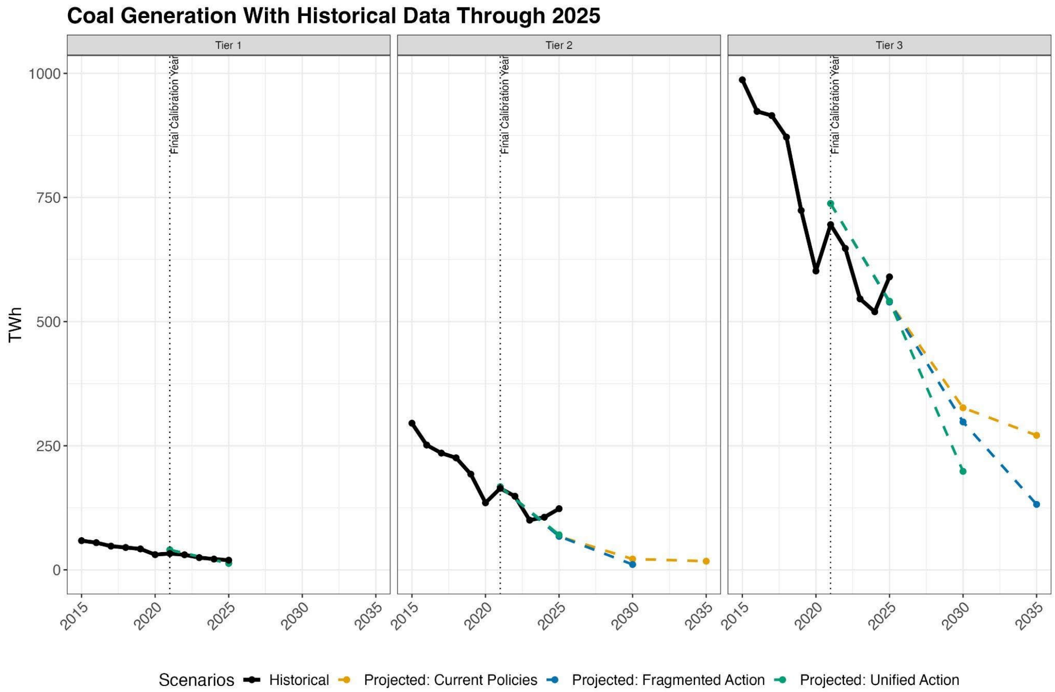


Fig. S2. Coal generation by state tier, with historical data through 2025 from the U.S. Energy Information Administration[30] and projections from 2025 through 2035 under the *Current Policies*, *Fragmented Action*, and *Unified Action* scenarios, in units of TWh. Markers indicate the model years; values for the years between model years are estimated using a linear interpolation.

3.7.3 Natural gas generation

Natural gas generation has increased over the last decade, playing a key role in replacing coal generation. Historical data for natural gas generation is well aligned with model projections in 2025. Post 2025, *Current Policies* and *Fragmented Action* project a slow increase from 2025 levels, while *Unified Action* shows declining generation (Figure S3).

In Tier 1 states, projected gas generation declines from 2025 levels across scenarios (Figure S4). In Tier 2 states, gas generation stays flat under *Current Policies,* but decreases under *Fragmented Action* and *Unified Action*. In Tier 3 states, gas generation continues to increase from 2025 levels under *Current Policies* and *Fragmented Action*, and increases in 2030 followed by a decrease in 2035 under *Unified Action*.

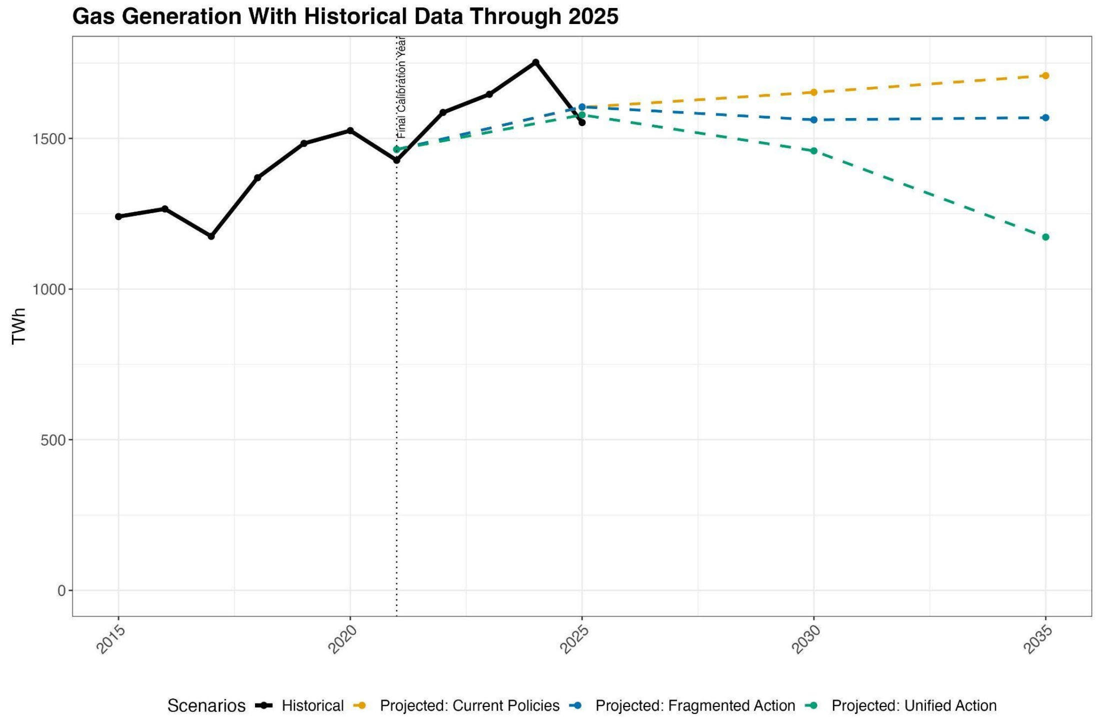


Fig. S3. U.S. natural gas generation, with historical data through 2025 from the U.S. Energy Information Administration[30] and projections from 2025 through 2035 under the *Current Policies*, *Fragmented Action*, and *Unified Action* scenarios, in units of TWh. Markers indicate the model years; values for the years between model years are estimated using a linear interpolation.

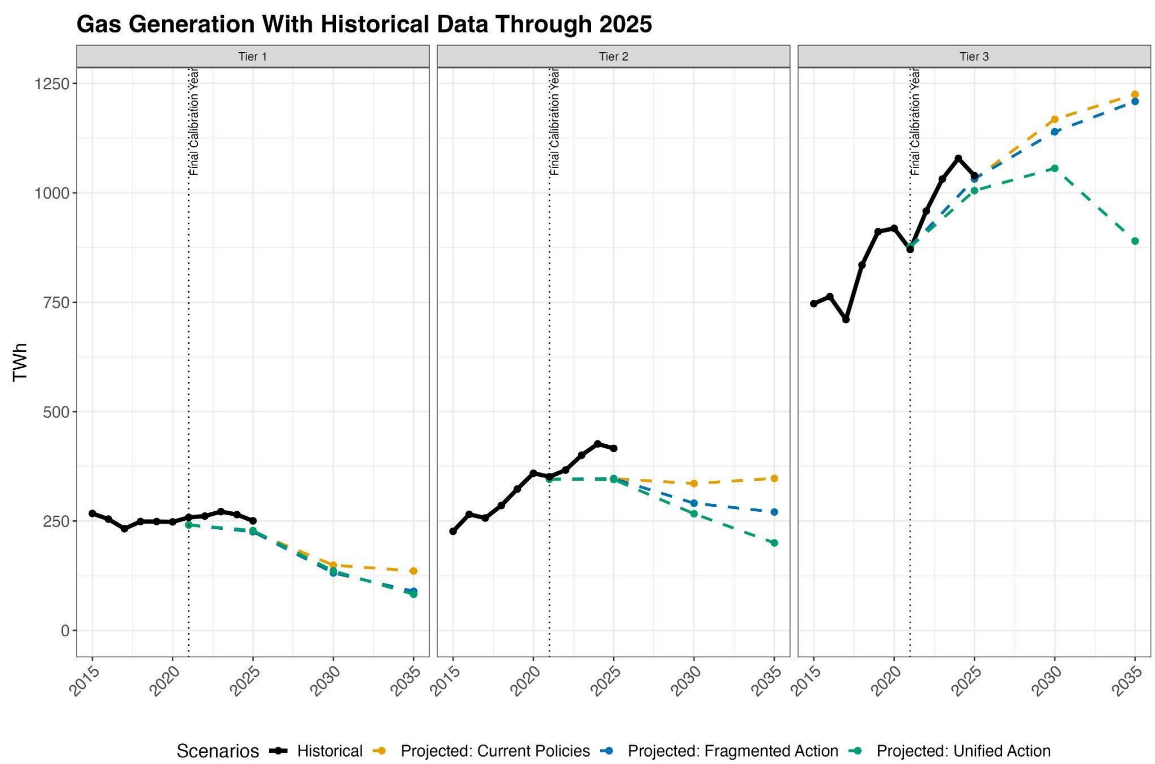


Fig. S4. Natural gas generation by state tier, with historical data through 2025 from the U.S. Energy Information Administration[30] and projections from 2025 through 2035 under the *Current Policies*, *Fragmented Action*, and *Unified Action* scenarios, in units of TWh. Markers indicate the model years; values for the years between model years are estimated using a linear interpolation.

3.7.4 Renewable generation

Solar and wind generation has been increasing steadily over the last decade due to falling costs and clean energy policies. In 2025, solar and wind made up over 20% of the generation mix, surpassing coal.[22] Renewable capacity has more than tripled since 2015, with annual capacity additions from solar, wind, and battery storage reaching 48 GW/year and making up 90% of total capacity additions in 2025.[22]

National model projections follow historical trends closely (Figure S5). Post 2025, solar and wind generation continues growing in all scenarios, with *Unified Action* showing the steepest acceleration and exceeding the historical trajectory. *Current Policies* and *Fragmented Action* increase at a slower place, roughly following a linear path relative to history.

Across tiers, historical 2025 generation is higher than projected levels in Tier 1 states, and slightly lower than projected levels in Tier 3 states (Figure S6). Post 2025, all tiers project growth in solar and wind: while Tier 1 states follow a roughly linear path relative to history for all scenarios, Tier 2 states require an accelerated rate of increase. Tier 3 states show the highest rate of increase historically, and achieve the generation levels under *Current Policies* and *Fragmented Action* on a roughly linear path relative to history. The trajectory under *Unified Action* would still require additional acceleration.

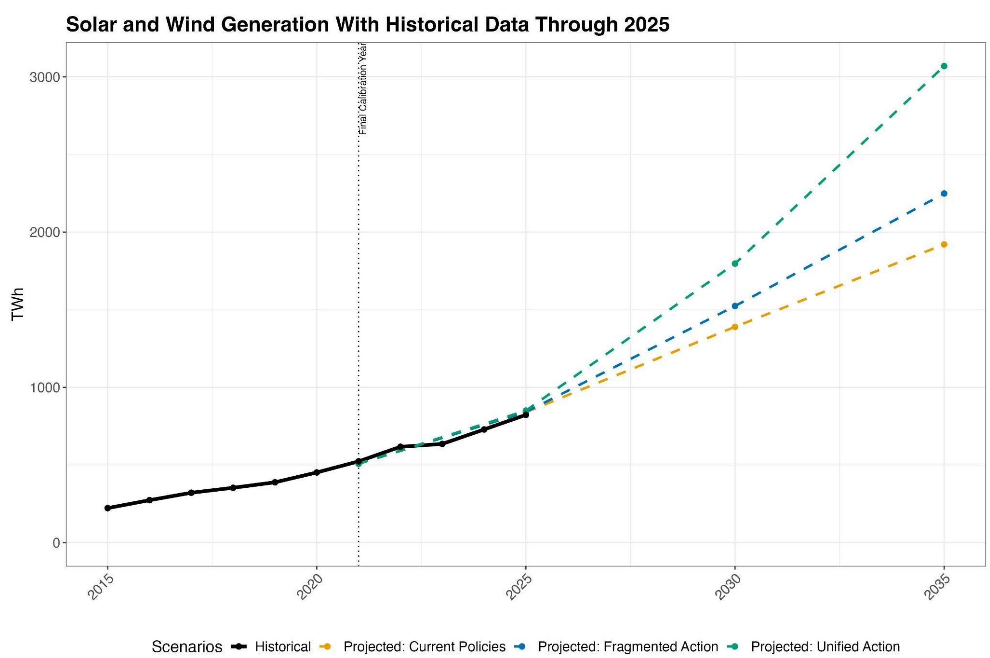


Fig. S5. Renewable generation (solar and wind), with historical data through 2025 from the U.S. Energy Information Administration[30] and projections from 2025 through 2035 under the *Current Policies*, *Fragmented Action*, and *Unified Action* scenarios, in units of TWh. Markers indicate the model years; values for the years between model years are estimated using a linear interpolation.

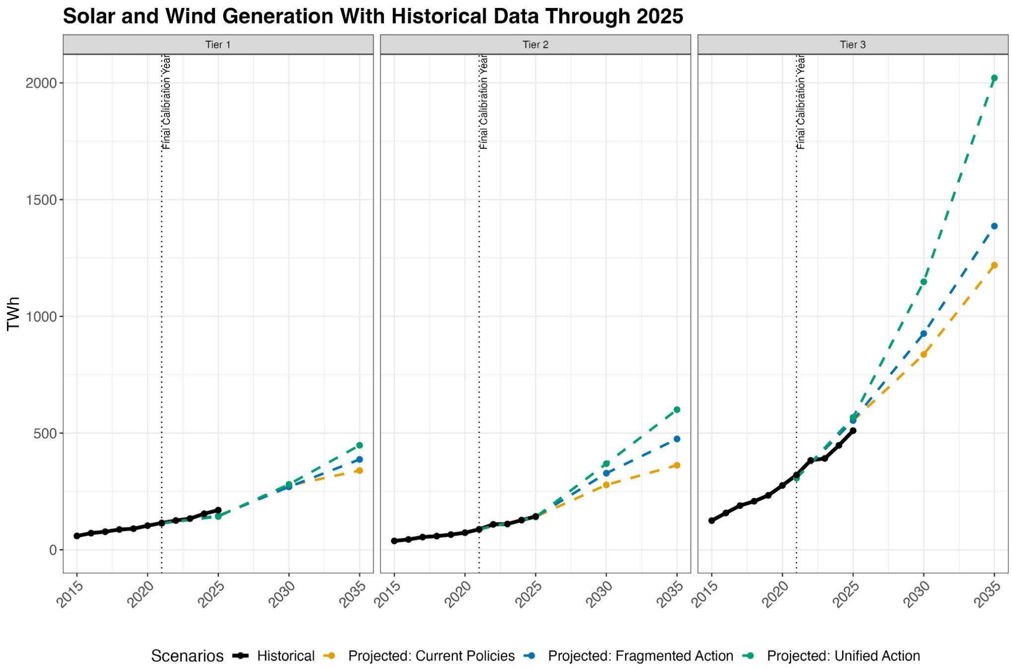


Fig. S6. Renewables generation by state tier, with historical data through 2025 from the U.S. Energy Information Administration[30] and projections from 2025 through 2035 under the *Current Policies*, *Fragmented Action*, and *Unified Action* scenarios, in units of TWh. Markers indicate the model years; values for the years between model years are estimated using a linear interpolation.

3.7.5 EV sales

EV sales reached 7.5% for battery electric vehicles (BEVs) and 1.6% for plug-in hybrid electric vehicles (PHEVs) in 2025, though progress has stalled in the last two years (Figure S7). National model projections for 2025 are in line with historical EV sales in 2025. Post-2025 projections would require an accelerated rate of sales compared to recent years, especially in the *Unified Action* scenario.

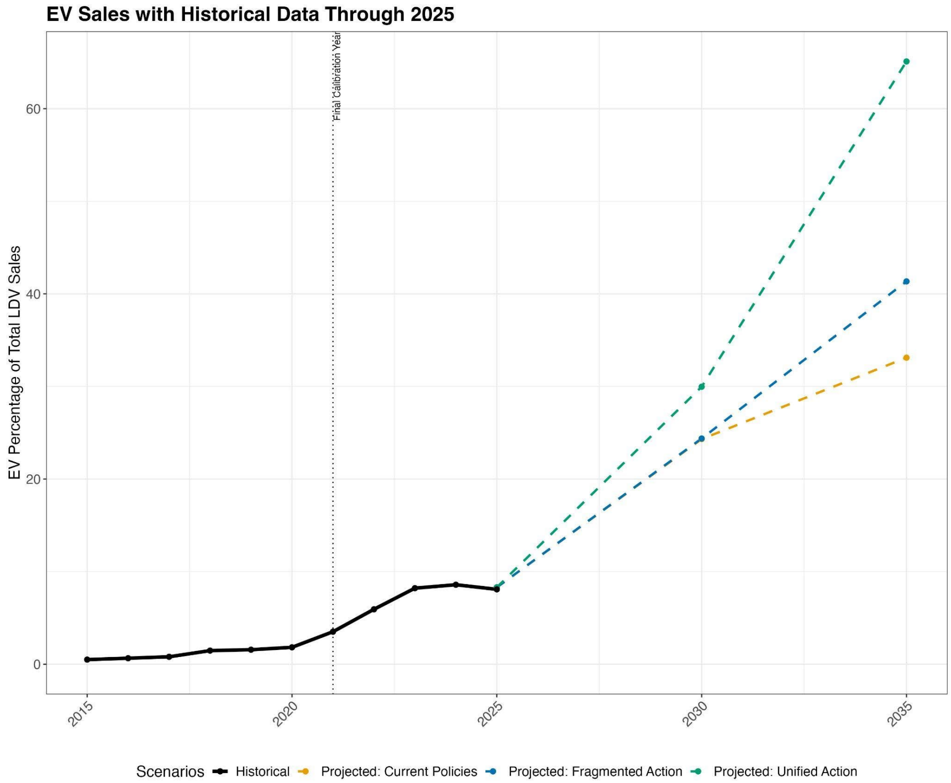


Fig. S7. Light-duty vehicle EV sales, with historical data through 2025 from Argonne National Laboratory[31] and projections from 2025 through 2035 under the *Current Policies*, *Fragmented Action*, and *Unified Action* scenarios. Markers indicate the model years; values for the years between model years are estimated using a linear interpolation. EVs include all-electric vehicles and plug-in hybrid electric vehicles, assuming an average utility factor of 37%.

3.7.6 Electricity demand

Electricity demand has been stagnant over the past decade, though it has started to increase in recent years (Figure S8). All three scenarios project increasing demand through 2035, at a faster rate than recent history, due to new data centers as well as end-use electrification. Across tiers, Tier 3 states are expected to experience the highest levels of electricity demand increase (Figure S9).

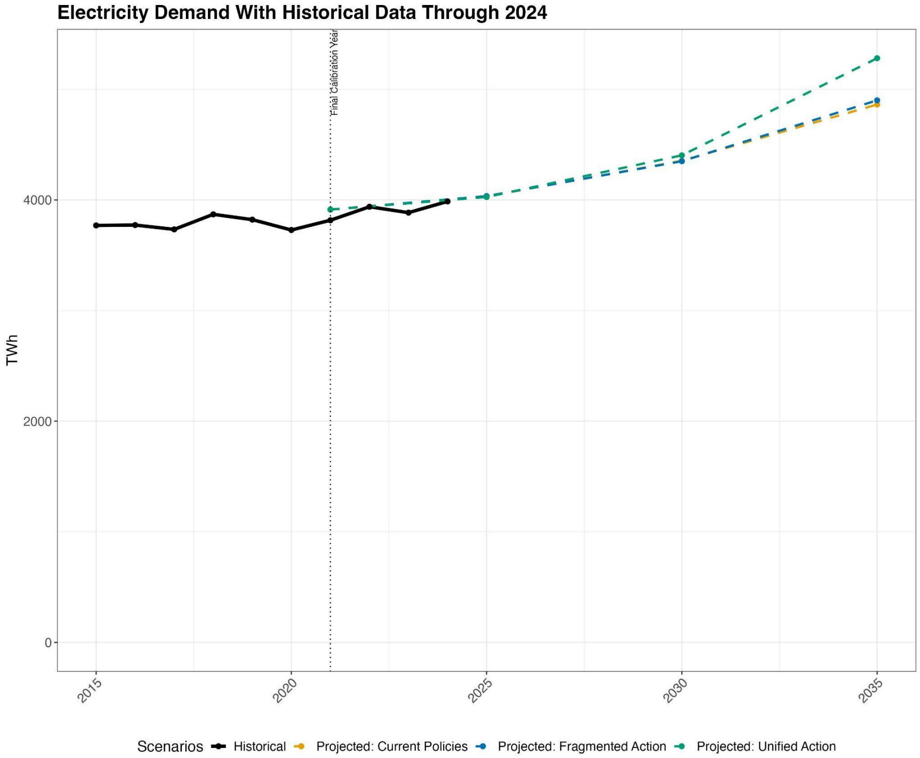


Fig. S8. U.S. electricity demand, with historical data through 2024 from the U.S. Energy Information Administration[32], and projections from 2025 through 2035 under the *Current Policies*, *Fragmented Action*, and *Unified Action* scenarios, in units of TWh. Markers indicate the model years; values for the years between model years are estimated using a linear interpolation.

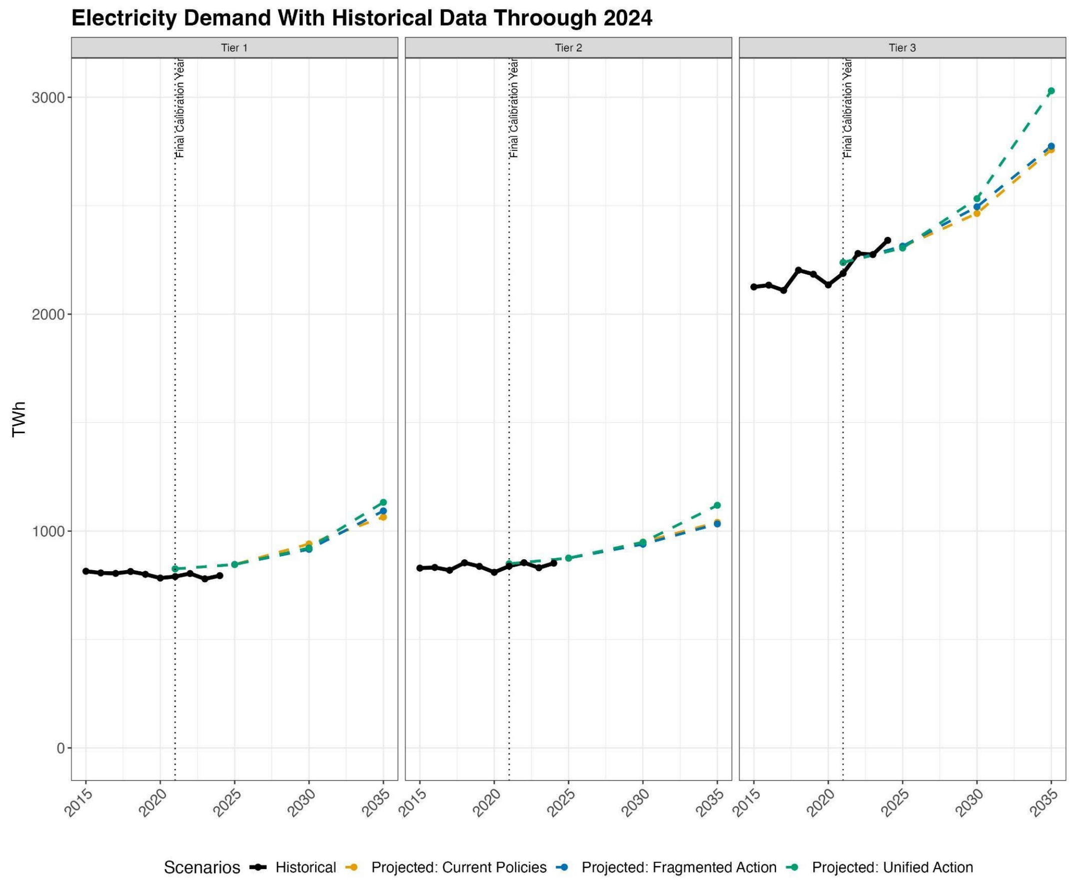
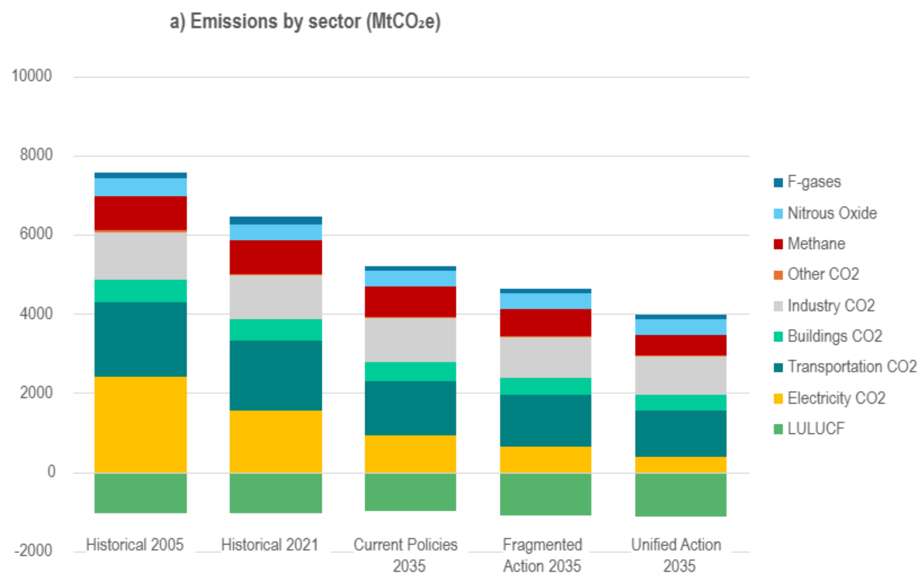


Fig. S9. U.S. electricity demand by state tier with historical data through 2023 from the U.S. Energy Information Administration[32], and projections from 2025 through 2035 under the *Current Policies*, *Fragmented Action*, and *Unified Action* scenarios, in units of TWh. Markers indicate the model years; values for the years between model years are estimated using a linear interpolation.

3.8 Global Warming Potential for Methane

In our scenarios, we use the 100-year global warming potential (GWP) from the IPCC Fifth Assessment Report (AR5) to convert non-CO_2 GHGs into CO_2 equivalents, which is aligned with the latest EPA inventory.[33] The 100-year GWP for methane is 28. However, methane is much more potent over a shorter time frame, given its high greenhouse warming impact per molecule and short atmospheric lifetime compared with CO_2 emission. When methane's GWP is evaluated over a 20-year time frame (using a GWP of 84), methane surpasses the transportation sector and becomes the second largest contributor (after the electricity sector) towards emission differences between *Current Policies* and *Unified Action*.



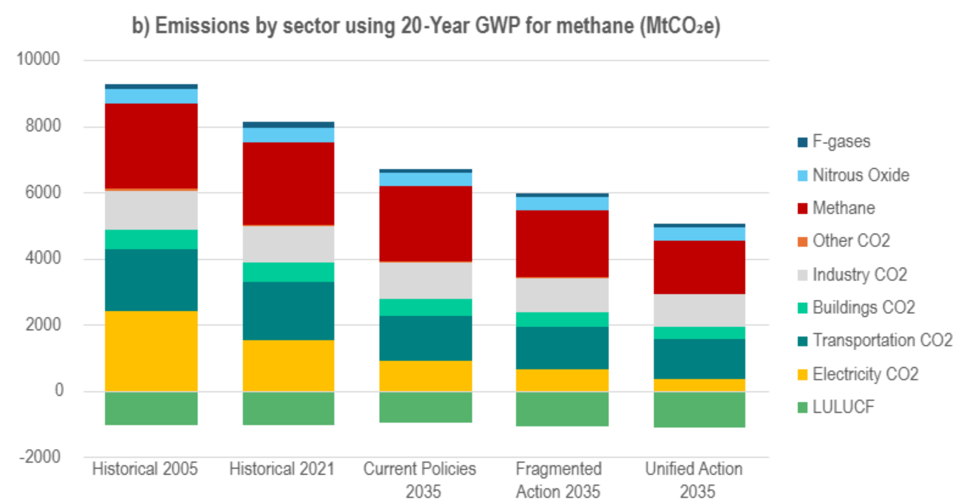


Fig. S10. GHG emissions by sector across scenarios. Panel a) shows historical GHG emissions in 2005 and 2021 and projected emissions in 2035 under *Current Policies*, *Fragmented Action*, and *Unified Action*, using the 100-year GWP to convert non-CO_2 GHGs into CO_2 equivalents. Panel b) shows these results when the 20-year GWP is used to convert methane emissions into CO_2 equivalents.

3.9 Sensitivity analysis

3.9.1 Data centers

Significant uncertainty exists around the growth of electricity demand from data centers in the coming years. The EPRI data used on data center load growth rates are based on public estimates of historical and current load levels, as well as varying assumptions about future industry growth, such as the extent of efficiency breakthroughs and saturation of service demand.[13,14] While the central estimate is used in our analysis, the low and high estimates (documented in Table S8) could alter projected levels of electricity demand, and, correspondingly, GHG emissions.

Under the central estimate used in our scenarios, overall electricity demand increases by 24%-34% (949-1,356 TWh) from 2021 levels in 2035, and data centers account for 30%-42% of this growth.
Under the low estimate, overall electricity demand growth increases by 19-30% (764-1,171 TWh) in 2035, relative to 2021 levels, across scenarios. Data centers are responsible for 17-27% of the growth. Under the high estimate, overall electricity demand growth increases by 31-41% in 2035, with data centers responsible for 42-56%. of the growth. Figure S11 shows the change in electricity demand growth under the *Unified Action* scenario, comparing the default assumption to the low and high variations.

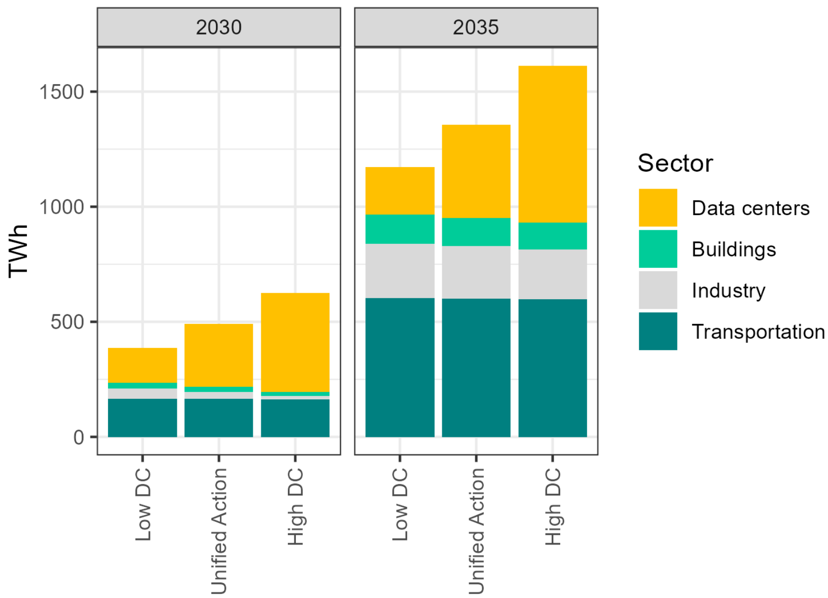


Fig. S11. Electricity demand growth by sector under different data center assumptions in the *Unified Action* scenario.

Impacts of different data center assumptions on GHG emissions are minimal. GHG emissions reductions in 2035 relative to 2005 range from 34.6-35.7% for *Current Policies* (35.3% in the central scenario), 46.1-44.8% for *Fragmented Action* (45.6% in the central scenario), and 56-56.4% for *Unified Action* (56.2% in the central scenario) under different data center load growth assumptions (Fig S12). In scenarios with high data center demand, constraints on fossil fuel buildout (based on observed supply chain limitations for new gas turbines) and clean energy policies in the electricity sector mean that renewables are meeting a significant portion of the new demand across scenarios, and therefore significant increases in emissions are not observed. Additionally, other sectors decrease their use of electricity in response to the higher electricity prices associated with higher demand, reducing additional emissions from the sector. In scenarios with low data center demand, given that renewables are the primary source of new generation, decreasing demand does not substantially impact fossil fuel generation and emissions. Additionally, other end-use sectors increase their use of electricity due to lower prices.

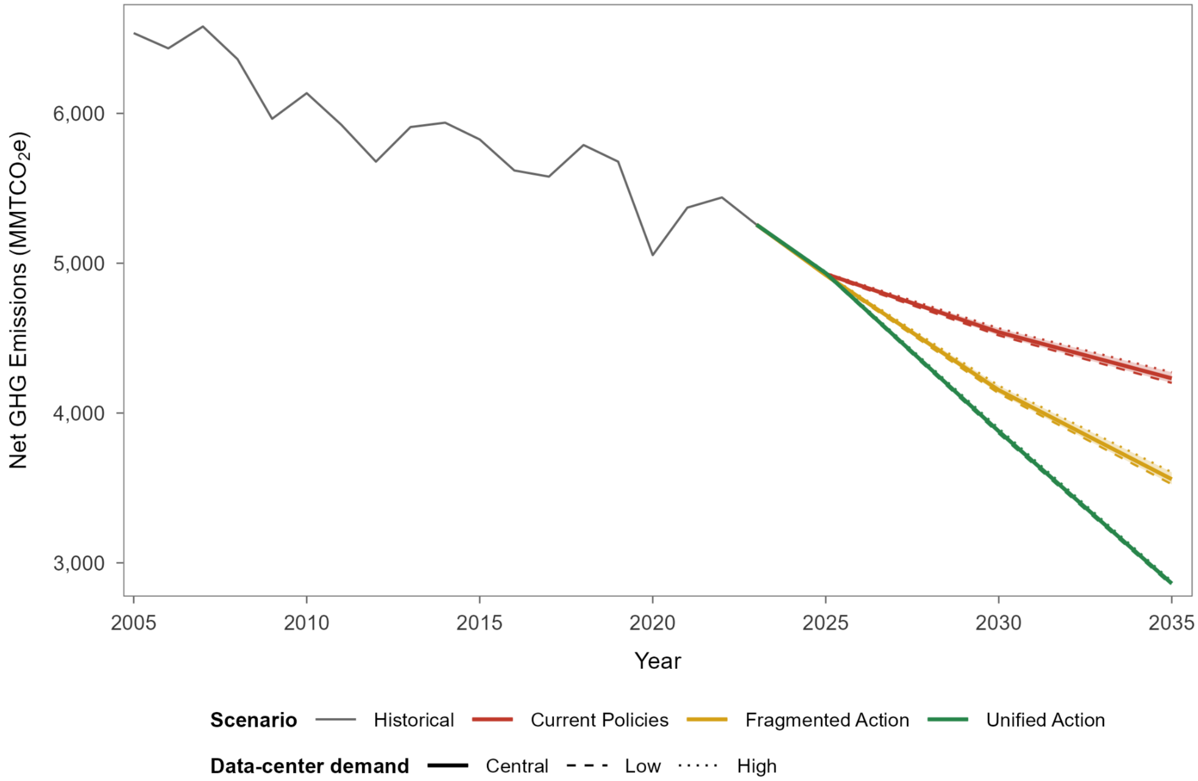


Fig. S12. GHG emissions under different data center assumptions across scenarios.

3.9.2 Other sensitivities

Beyond data center expansion, there are other sources of uncertainty that could impact emissions trajectories. In this study, we accounted for variations in future projections of Gross Domestic Product (GDP), population growth, oil and gas prices, and solar and wind capital costs, as documented in Table S9. We developed the high and low variations for each parameter.

Table S9. Assumptions under sensitivity scenarios

Driver	Core Assumptions	Sensitivities
GDP	GDP is assumed to grow by 1.68% per year on average from 2022 through 2035.	**High**: GDP is assumed to grow by 2.12% per year on average through 2035. **Low:** GDP grows by 1.08% per year on average through 2035.
Population	Population is assumed to grow by 0.46% per year on average from 2022 through 2035.	**High**: Grows by 0.66% per year on average through 2035. **Low:** Grows by 0.34% per year on average through 2035.
Fuel prices	Gas prices are assumed to increase at an average rate of 1.3% per year from 2021 through 2035.	**High:** Gas prices are assumed to increase at an average rate of 4.3% per year from 2021 through 2035. **Low:** Gas prices are assumed to decrease at an average rate of 0.01% per year from 2021 through 2035.
	Oil prices are assumed to increase at an average rate of 2.5% per year between 2021 and 2035.	**High:** Oil prices are assumed to increase at an average rate of 8.4% per year through 2035. **Low:** Oil prices are assumed to decrease at an average rate of 0.3% per year through 2035.
Solar power	Utility solar PV capital costs are assumed to decrease by 44% from 2022 to 2035.	**High:** Utility solar PV capital costs are assumed to decrease by 55% in 2035. **Low:** Utility solar PV capital costs are assumed to decrease by 27% in 2035.
Wind power	Land-based wind and offshore wind capital costs are assumed to decrease by 21% and 45%, respectively, from 2022 to 2035	**High:** Land-based wind and offshore wind capital costs are assumed to decrease by 26% and 47%, respectively, in 2035. **Low:** Land-based wind and offshore wind capital costs are assumed to decrease by 9% and 47%, respectively, in 2035.
Data centers	Data center load is assumed to grow at an average 12% annual growth rate from 2023 to 2030, based on a 2024 EPRI study. Projections from 2030-2035 are linearly extrapolated.	**Low:** Data center load is assumed to grow at an average 6% annual growth rate from 2023 to 2030, based on a 2024 EPRI study. Projections from 2030-2035 are linearly extrapolated. **High:** Data center load is assumed to grow at an average 18% annual growth rate from 2023 to 2030, based on a 2024 EPRI study. Projections from 2030-2035 are linearly extrapolated.

We also combined these sensitivities to represent a low-emissions trajectory—with low GDP and population growth, high oil and gas prices, low solar and wind capital costs, and low data center demand growth— and a high-emissions trajectory—with high GDP and population growth, low oil and gas prices, high solar and wind capital costs, and high data center demand growth—for each of our main scenarios (Fig. S13).

Accounting for the low- and high-emissions trajectories, we find that 2035 emissions reductions in 2035, relative to 2005, range from 29-45% in *Current Policies*, 40-53% in *Fragmented Action*, and 52-64% in *Unified Action*. These scenarios represent the substantial cumulative effects of these uncertainties on the final emissions outcomes

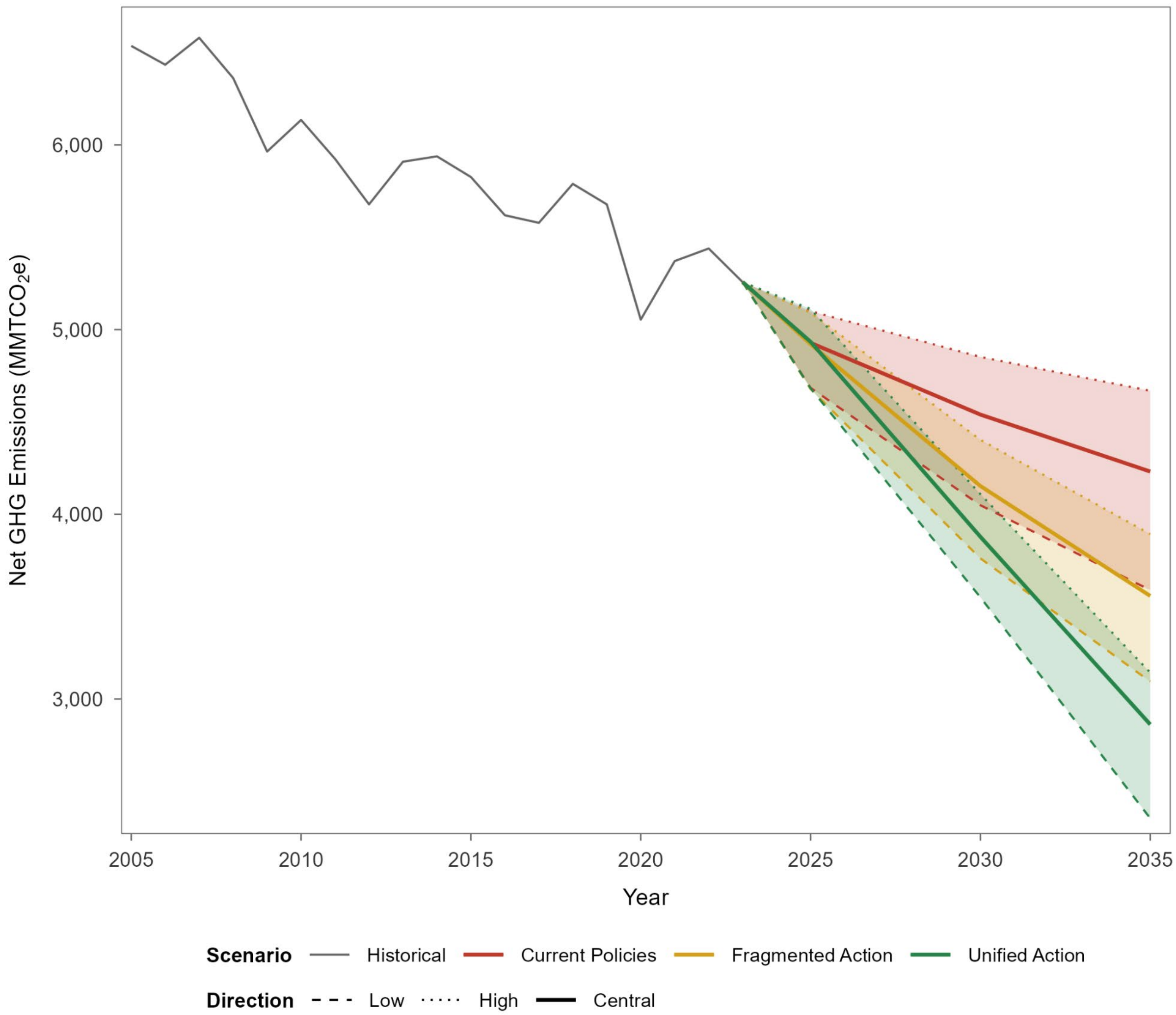


Fig. S13. GHG emissions under high and low emissions variations of aggregated drivers across scenarios.

Figure S14 further illustrates the independent effects of each of these parameters on emissions trajectories using the *Current Policies* scenario. Under the central assumptions for these drivers, this scenario achieves a 35% reduction in 2035, relative to 2005 levels. Varying oil and gas prices drives the largest change in future emissions, with 2035 emissions reductions ranging from 32% to 43%. Variations around other parameters are more modest by comparison. 2035 emissions reductions range from 33-37% across different GDP and population assumptions; 35-36% across wind and solar capital cost assumptions; 35-36% across data center electricity demand assumptions.

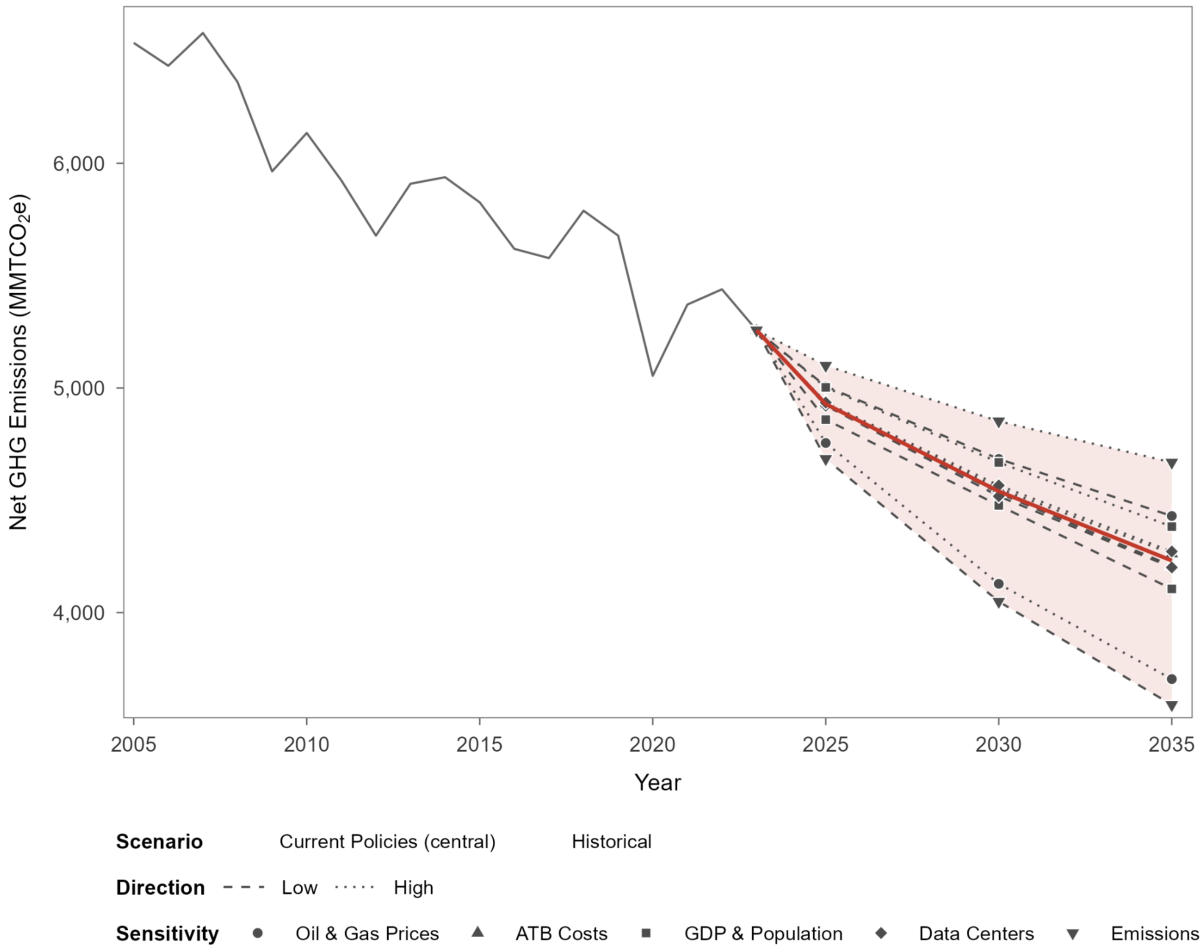


Fig. S14. GHG emissions under high and low variations of disaggregated drivers in the *Current Policies* scenario.

4 Bottom-up Aggregation Analysis

4.1 Overview of approach

The goal of the bottom-up aggregation analysis is to estimate the overall economy-wide emissions reductions resulting from a combination of climate actions by non-federal actors. In this analysis, we build upon a previously developed methodology, including the Accelerating America's Pledge Technical Appendix (2019),[1] Hultman, et al. (2020)[2] , and Zhao et al. (2024)[6].

We focus on state-level climate action, with the assumption that additional policies from cities and businesses will also be needed to support the state-level actions modeled. We consider non-federal climate actions with the potential to drive greenhouse gas emissions reductions, which are inclusive of actions taken to induce cost savings, promote economic growth, and deliver health impacts, among others.

This bottom-up aggregation framework involves collecting data on climate actions across sectors at the state level from official planning documents and policy databases. We then quantified the relative impacts of these climate actions against a no policy baseline in terms of technology deployment, electricity generation, energy use, costs, and more. The resulting state-level impacts of these non-federal climate actions were then represented in GCAM-USA-CGS to estimate potential emissions reductions across the entire economy.

4.2 Electricity

4.2.1 Renewable Portfolio Standards

Legally binding state-level renewable portfolio standards (RPS) in 29 U.S. states and the District of Columbia were included in our assessment of existing policies. We differentiated between policies that include hydroelectric and non-hydroelectric sources, and assumed that all future renewable energy demand driven by the goals is satisfied by non-hydroelectric generation. In states with RPS that include hydroelectric sources where hydroelectric generation already meets or surpasses the RPS target, we will assume a 0% of demand is satisfied by renewable energy.

To estimate future renewable electricity generation driven by RPS legislation, we used effective RPS demand rates (representing the actual percentage of a state's electricity load needed to meet RPS requirements for a specific year) from the Lawrence Berkeley National Lab.[34] We then projected state-level electricity load by coupling historical state-level electricity sales data from the EIA[35] with the projected annual growth rates sourced from GCAM-USA-CGS's state-level electricity demand outputs.

We assumed that all legally binding state-level RPS would be achieved in the *Current Policies* scenario. In the *Fragmented Action* and *Unified Action* scenarios, we make assumptions for enhanced action according to state tiers specified in Table S1. Under *Fragmented Action,* Tier 1 states are assumed to reach 65% renewable energy generation by 2035, while Tier 2 states achieve 55% renewable by 2035, and Tier 3 states achieve 20% renewable energy generation by 2035. Under *Unified Action,* Tier 1 and Tier 2 states are assumed to reach 65% renewable energy generation by 2035, and Tier 3 states achieve 50% renewable energy generation by 2035.

After calculating the appropriate ambition levels for state-level RPS, the RPS are aggregated at the grid level, weighted by the share of electricity consumed by each state.

Table S9. Modeled state-level RPS under *Current Policies*

State	2030	2035
AK	0%	0%
AL	0%	0%
AR	0%	0%
AZ	0%	0%
CA	55%	56%
CO	19%	19%
CT	45%	45%
DC	87%	100%
DE	21%	32%
FL	0%	0%
GA	0%	0%
HI	48%	64%
IA	0%	0%
ID	0%	0%
IL	37%	42%
IN	0%	0%
KS	0%	0%
KY	0%	0%
LA	0%	0%
MA	39%	43%
MD	46%	46%
ME	61%	62%
MI	12%	12%
MN	50%	76%
MO	9%	9%
MS	0%	0%
MS	0%	0%
MT	0%	0%
NC	0%	0%
ND	0%	0%
NE	0%	0%
NH	17%	17%
NJ	53%	51%
NM	45%	58%
NV	43%	44%
NY	70%	70%
OH	0%	0%
OK	0%	0%
OR	25%	32%
PA	14%	14%
RI	67%	95%
SC	0%	0%
SD	0%	0%
TN	0%	0%
TX	0%	0%
UT	0%	0%
VA	21%	31%
VT	39%	44%
WA	12%	12%
WI	0%	0%
WV	0%	0%
WY	0%	0%

4.2.2 Clean Electricity Standards

Clean electricity standards (CES) were implemented in the *Fragmented Action* and *Unified Action* scenarios, with assumptions for enhanced action according to state tiers specified in Table S1. Under *Fragmented Action*, Tier 1 states are assumed to reach 80% clean energy generation by 2035, while Tier 2 and Tier 3 states are assumed to not have an explicit clean energy generation target. Under *Unified Action*, Tier 1 and Tier 2 states are assumed to reach 80% clean energy generation by 2035, while Tier 3 states are assumed to not have an explicit clean energy generation target.

The CES encompasses all low-emitting sources, including hydroelectric power, nuclear, biomass, solar, wind, and fossil fuels equipped with carbon capture and storage.

4.2.3 Coal

It is assumed that no new unabated coal-fired power plants are constructed in the United States across all modeled scenarios, consistent with existing EPA new source performance standards under section 111 of the Clean Air Act.[36] For electricity generation from existing coal-fired power plants, we estimate an upper limit based on announced retirement dates at the plant-level based reported in three data sources: EIA-860 (March 2024)[22], Global Energy Monitor's Global Coal Plant Tracker (January 2024)[37], and the EPA National Electric Energy Data System (NEEDS) database (January 2024).[38] For plants with an announced retirement date reported only in the EPA NEEDS database, that retirement date was used.

For plants with an announced retirement date in either EIA-860 or the Global Energy Monitor's Global Coal Plant Tracker, we used the earliest of the two, regardless of what was contained in the EPA NEEDS database for a given coal plant. We then applied the retirement trajectories for each generating unit to historical generation levels in 2020 and assumed that that amount of generation goes offline in each unit's retirement year.

The resulting electricity generation from all generating units in each model year was then aggregated to the state level and was used to represent the upper bound on electricity generation from unabated coal in each state. Additionally, federal and state-level policies in each scenario – for example, state-level renewable portfolio standards – may drive further reductions in electricity generation from coal in each state. In the *Fragmented Action* scenario, it is further assumed that Tier 1 states fully phase out unabated coal by 2030, Tier 2 states by 2035, and Tier 3 states by 2040. In the *Unified Action* scenario, coal phase-out in Tier 2 states is assumed to occur by 2030 as modeled in Tier 1 states, while Tier 3 states are assumed to phase out unabated coal by 2035.

4.2.4 Nuclear

In all scenarios, a combination of federal and state policy actions are assumed to keep any nuclear power plants at risk of retiring by 2035 to continue operating. Additionally, Vogtle units 3&4 in Georgia are assumed to be operating at full capacity by the end of 2025 model period and no additional new nuclear capacity is assumed to come online in the United States by 2035. The resulting level of nuclear generation in each state is exogenously specified in GCAM-USA-CGS for each model period.

4.3 Transportation

4.3.1 Zero Emission Vehicle Standards

California has become a model state for electric vehicle adoption by passing emission reduction regulations and setting ZEV sales targets. California's Advanced Clean Cars (ACC) I requires vehicle manufacturers to sell increased shares of zero-emission passenger cars and light-duty trucks starting in model year 2017 and ending in model year 2025. Under 2012 amendments, state manufacturers can opt to comply with California's enhanced standards over the EPA's GHG regulations.[39] In 2022, California passed ACC II, which extends light-duty vehicle (LDV) sales targets after 2025 with an ultimate goal of 100% sales of ZEVs by 2035.[40] Since then, thirteen states have announced their adoption of ACC II over the less stringent EPA regulations. As states adopt regulations targeted toward LDVs, there has been concurrent movement towards the electrification of medium and heavy-duty vehicles. California's Advanced Clean Trucks (ACT) program sets ZEV sales targets for medium and heavy-duty vehicles through 2035, which was adopted by eleven states as well.[41]

However, with the recent removal of the California Waiver under the Clean Air Act, the trajectory for ZEV deployment in the United States has become uncertain. In response to the waiver removal, the U.S. Climate Alliance Governors launched the Affordable Clean Cars Coalition (ACCC), with eleven states signing on. Still, many states have halted their enforcement of EV sales targets or issued delayed achievement announcements.[42–44] To represent these ongoing developments and uncertainty around the waiver repeal, we assume that no EV sales mandates are enforced under the *Current Policies* scenario as a conservative assumption.

In the *Fragmented Action* scenario, we assume that various state-level initiatives, including clean car coalitions, transport emissions reduction targets, low carbon fuel standards, paired with momentum in the electric vehicle market, continues the sales of electric vehicles consistent with ACC II and ACT, but on a delayed trajectory. For LDV electrification, Tier 1 states follow California and achieve ZEV sales targets consistent with ACC II lagged three years, with ZEVs making up 25% of LDV sales by 2028, increasing to 68% in 2033, and maxing out at 100% in 2038. We assumed a six-year time lag for Tier 2 states and a nine-year time lag for Tier 3 states for achieving ACC II targets. For medium and heavy-duty vehicle electrification, ACT stipulates the following ZEV sales targets between 2024 to 2035: 55% for Class 2b-3 trucks, 75% for Class 4-8 straight truck sales, and 40% for truck tractor sales. Under *Fragmented Action*, Tier 1 states follow California and achieve ZEV sales targets consistent with ACT lagged three years. In light of federal rollbacks, we do not implement ACT sales targets for Tier 2 and Tier 3 states.

In the *Unified Action* scenario, we assume that a re-engaged federal government passes ambitious tailpipe emissions standards that further supports the state-level EV policies and the market momentum. In this scenario, all states are assumed to achieve ZEV sales targets consistent with ACC II with a 3-year lag, reaching 100% of sales in 2038. For medium and heavy-duty electrification, all states are assumed to achieve ZEV sales consistent with ACT targets with a 3-year lag.

Table S10. States that have implemented or have announced plans to implement ACC I, ACC II, ACT and signed on to ACCC. This table does not reflect states' delayed implementation announcements.

ACC I	ACC II	ACT	ACCC
Minnesota	California	California	California
Nevada	Colorado	Colorado	Colorado
Virginia	Delaware	Maryland	Delaware
	District of Columbia	Massachusetts	Maryland
	Maryland	New Jersey	Massachusetts
	Massachusetts	New Mexico	New Jersey
	New Jersey	New York	New Mexico
	New Mexico	Rhode Island	New York
	New York	Oregon	Oregon
	Oregon	Vermont	Rhode Island
	Rhode Island	Washington	Washington
	Vermont		
	Washington		

4.3.2 Vehicle Miles Traveled

VMT per capita measures the total annual miles of vehicle travel divided by the total population in a state or urbanized area.[45] VMT can be reduced by shifting away from single-occupancy vehicles and toward car shares, public transit, micromobility, and other active modes of transportation.

An increasing number of states and other local actors have turned to vehicle miles traveled (VMT) reduction policies, in addition to vehicle electrification policies, as a strategy for achieving GHG reduction goals. California's 2022 Scoping Plan for Achieving Carbon Neutrality proposed a statewide VMT per capita reduction of 25% below 2019 levels by 2030 and 30% by 2045.[46] This target is in line with California goals to "reduce demand for fossil transportation fuels and GHGs, and improve air quality."[46] Five other states - Connecticut, Minnesota, Oregon, Colorado, and Washington - varying VMT reduction targets spanning both near- and long-term policy implementation. Massachusetts has proposed a Senate Bill which would require VMT reduction targets for 2030, 2035, 2040, 2045, and 2050. Additionally, New York City has proposed a Senate Bill with the goal of reducing total VMT by 20% by 2050 and implemented a congestion pricing program that has reduced traffic while generating revenue and improving air quality.[47]

VMT targets for LDVs were modeled in the *Fragmented Action* and *Unified Action* scenarios. To create a baseline case, we collected 2015 LDV VMT data from the FHWA Highway Statistics Series Publications for each state and applied VMT growth rates for future years through 2035 from GCAM-USA-CGS.[48] We then applied an annualized reduction target specific to each tier between 2026 and 2035 on top of the baseline. California's VMT target was estimated to have an annual per capita reduction of 1.75% between 2026 and 2030.[46] Our scenarios use a more conservative annualized per capita reduction rate of 1.25% for Tier 1 states and 0.75% for Tier 2 states under *Fragmented Action*, and 1.25% for both Tier 1 and Tier 2 states and 0.75% for Tier 3 states under *Unified Action*.

VMT reductions are implemented as a percentage reduction in total passenger service demand in the model. The resulting decline in passenger service was predominantly from road vehicles, but a small amount was from rail and short-haul aircraft.

4.4 Buildings

4.4.1 Efficiency

Energy Efficiency Resources Standards (EERS) are a policy lever at the state level to improve efficiency in the delivery of residential, commercial, and industrial electricity and gas by setting energy savings targets for utilities. The scope and ambition can vary across states: Maryland's EERS covers all sales within the state, while Iowa's only covers major utilities; targets range from 0-3% of sales; and electricity standards are more common than than gas targets (data collection found 28 state-level EERS policies for electricity efficiency, and 21 policies for gas).

To calculate EERS savings under *Current Policies*, we first collected current state-level efficiency standards using American Council for an Energy-Efficient Economy's documentation,[49] and then cross-checked these with individual state websites. Then, to calculate future demand projections, we used historical state-level demand by sector from the EIA for the years 1990-2019[50,51] and layered on projections of future demand obtained from GCAM-USA-CGS's state-level electricity and natural gas demand outputs through 2035. To avoid double counting, we removed the expected efficiency gains by state in the absence of binding policies, from the calculated EERS savings. This approach allows us to implement only the additional savings that would be achieved from EERS policies. We derived embedded energy efficiency using projections of future demand from a GCAM-USA-CGS baseline scenario along with projected energy efficiency savings reported by EIA's Annual Electric Power Industry Report.[52]

Under the *Fragmented Action* scenario, states begin to adopt more ambitious standards starting in 2025 (Table S11). Tier 1 states' electricity and gas savings rates were linearly interpolated as if the state was on track to reach 4% in 2030, allowing states time to gradually reach higher efficiency levels. For Tier 2 states, we implemented electricity efficiency gains of 1.2% annually, based upon a previous version of Virginia's policy.[53] We used annual natural gas savings of 0.75%, following efficiency policies currently enacted in Michigan.[54] Across sectors, by 2030 all Tier 1 and Tier 2 states reach a 4% annual electricity savings, in alignment with the Global Renewables and Energy Efficiency Pledge.[55] We assumed that Tier 3 states implement no additional efficiency targets. For states lacking an efficiency standard, we enacted the corresponding *Enhanced Ambition* target at 50% ambition in 2025. For example, North Carolina, a Tier 2 state, has no gas EERS policy, so we applied a gas target of 0.38% from 2025-2029. Additionally, across all tiers and scenarios, if the *Current Policies* EERS savings in a state is more ambitious than what is assumed under the enhanced scenario, we maintained the former savings levels.

Table S11. Implementation of EERS in the *Fragmented Action* scenario

Fuel	Tier 1	Tier 2	Tier 3
Electricity	Linearly interpolate between 2024 savings rate and 2030 4% savings beginning in 2030	1.2% beginning in 2025 If no existing EERS: .6% beginning in 2025 4% savings beginning in 2030	n/a
Natural Gas	1.3% beginning in 2025 If no existing EERS: .65% beginning in 2025, 4% savings beginning in 2030	.75% beginning in 2025 If no existing EERS: 0.38% beginning in 2030 4% savings beginning in 2030	n/a
For both technologies and all Tiers, if the *Current Policies* savings target is higher than the *Fragmented Action* target, maintain the *Current Policies* target until surpassed by *Fragmented Action* in ambition			

Under the *Unified Action* scenario, states begin to adopt more ambitious standards starting in 2025 (Table S12). Within building electricity, Tier 1 and Tier 2 states' electricity and gas savings rates were linearly interpolated as if the state was on track to reach 4% in 2030, allowing states time to gradually reach higher efficiency levels. We assume that Tier 3 states reach .6% savings annually from 2025-2029, in line with savings assumed for TIer 2 states without previous targets under the *Fragmented Action* scenario. For natural gas use in buildings, Tier 1 states follow New York's gas efficiency policy, which mandates annual savings of 1.3% beginning in 2025.[56] We assume that Tier 2 states can achieve half of these savings, at .65% per year, and that Tier 3 states are capable of savings of .38% annually. Across tiers and sectors, by 2030 all states reach a 4% annual energy savings, in alignment with the Global Renewables and Energy Efficiency Pledge formulated at COP28, which targets global average energy efficiency improvements of 4% by 2030.[55]

Table S12. Implementation of EERS in the *Unified Action* scenario

Fuel	Tier 1	Tier 2	Tier 3

Electricity	Linearly interpolate between 2024 savings rate and a 4% savings rate in 2030 4% savings beginning in 2030	Linearly interpolate between 2024 savings rate and a 4% savings rate in 2030 4% savings beginning in 2030	.6% savings from 2025-2029 4% savings beginning in 2030
Natural Gas	1.3% savings from 2025-2029 4% savings beginning in 2030	0.65% savings from 2025-2029 4% savings beginning in 2030	.38% savings from 2025-2029 4% savings beginning in 2030
For both technologies and all Tiers, if the *Current Policies* savings target is higher than the *Unified Action* target, maintain the *Current Policies* target until surpassed by *Unified Action* in ambition			

4.4.2 Electrification

In addition to efficiency standards, some states have also enacted policies banning use of combustion-powered appliances or otherwise encouraging electrification. Appliance bans in California[57] and New York[58] prohibit installation of fossil-fuel hookups in new construction or, in California beginning in 2030, all new fossil appliance sales. California's ban includes fossil-fuel powered space heaters and water heaters, while New York's policy mandates all-of-building electrification. Other state policies include electrification targets (e.g. New Jersey)[59], mandated reductions in emissions or energy use in the building sector (e.g. Maryland and Minnesota)[60,61], and electric-ready hookup requirements (e.g. Colorado and Delaware).[62,63] Electrification mandates, particularly for cookstoves, have encountered fierce opposition: since 2020, 26 states have passed preemption laws prohibiting cities from banning natural gas.[64] However, 21 of these states with preemptive bans are listed as Tier 3 in our analysis, and not predicted to enact ambitious electrification policies.

Building electrification under our enhanced scenarios is broadly based on California's zero-emissions appliance standard, which requires that all new sales of space heaters and gas heaters comply with a zero-NO_x standard beginning in 2030.[57] Under our *Fragmented Action* scenario, Tier 1 states reach 100% electric heating and water sales by 2035, with Tier 2 states following their lead in 2040. The pace of electrification is faster under the *Unified Action* scenario, in which both Tier 1 and Tier 2 states reach 100% electric heating and water sales by 2035, with Tier 3 states joining to electrify in 2040. Building upon this target, under *Fragmented Action*, all Tier 1 and Tier 2 states commit to all-electric new construction by 2035, while under *Unified Action*, all states regardless of tier commit to 100% electric construction by 2035.

4.5 Land Use, Land-use Change, and Forestry

Projected CH_4 emissions in the land use, land-use change, and forestry (LULUCF) sector are estimated based on the EPA's MAC curves, as described in Table S6. CO_2 and N_2O emissions are estimated based on results from the *America Is All In* lands sector report as described in Table S6.[65] In this 2024 report, the Forest and Agricultural Sector Optimization Model with Greenhouse Gases (FASOMGHG) is used to assess the cost-effective combination of different land-based activities to maximize the greenhouse gas mitigation potential of federal and non-federal policies.[66] The model accounts for opportunity costs as agriculture and forestry commodity markets adjust in response to GHG reduction investments, and projects subnational land sector dynamics for 11 regions in the United States.

This report examines three scenarios under alternative policy assumptions: an Absent Climate-Smart Policies scenario, an Existing Policies scenario, and an Enhanced Ambition scenario. The Existing Policies scenario assumes full implementation of current federal and state policies, including $42 billion in investments in climate-smart agricultural practices, conservation policies across the forestry and agriculture sectors, wildfire mitigation, and afforestation and reforestation efforts. The Enhanced Ambition scenario assumes heightened ambition from climate-leading, fast-mover states, leading to an increase of $160 billion in climate-smart policies and incentives for the agriculture and forestry sectors.

While these scenarios do not match the assumptions in our scenarios precisely given recent changes on the federal side, we assume that the agriculture and forestry emissions projections under the baseline scenario are achieved in this paper's *Current Policies* scenario; the projections under the Existing Policies scenario are achieved in this paper's and *Fragmented Action* scenario; and the projections under the Enhanced Ambition scenario are achieved in this paper's *Unified Action* scenario.

5 Supplementary Figures

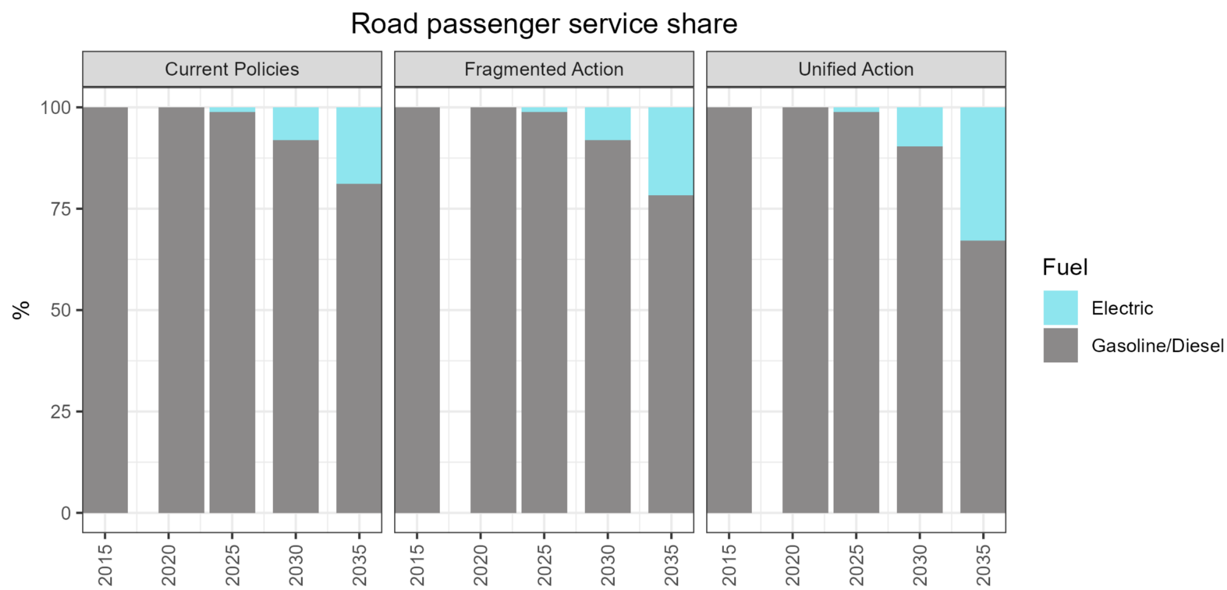


Fig. S15. Road passenger service share in the *Current Policies, Fragmented Action* and *Unified Action* scenarios, in units of percentages. The percentage of total service from electric vehicles is in blue, and the percentage from gasoline is in gray. Under the *Unified Action* scenario, the share of EV sales increases to 33% in 2035 as a result of additional EV incentives and mandates, compared to 22% under the *Fragmented Action* scenario and 19% under the *Current Policies* scenario.

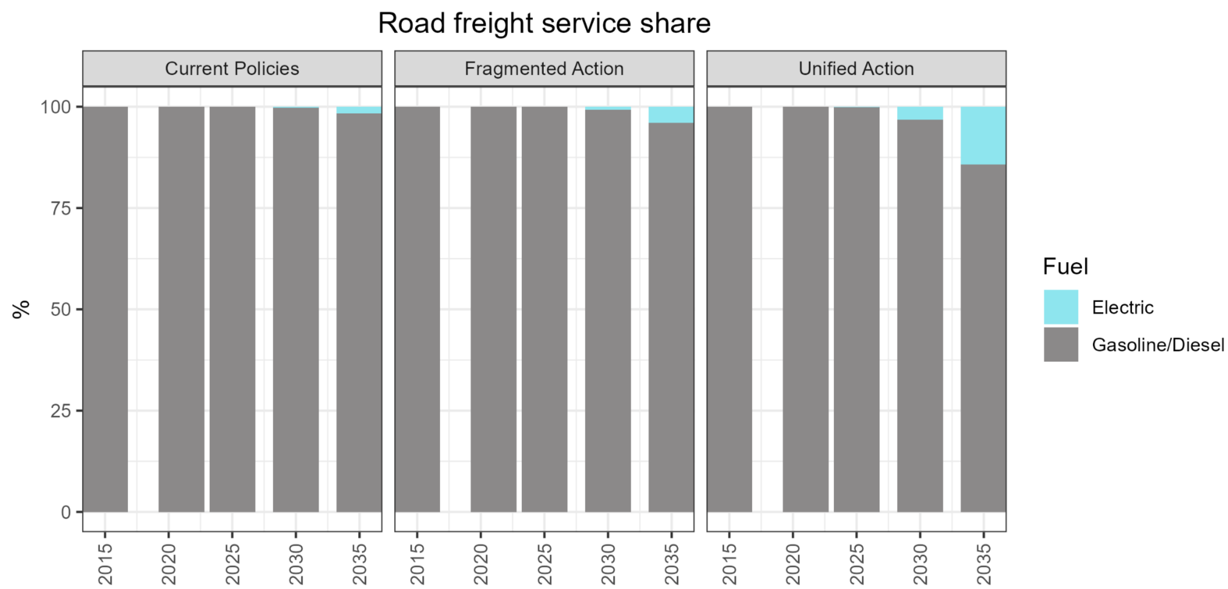


Fig. S16. Road freight service share in the *Current Policies, Fragmented Action* and *Unified Action* scenarios, in units of percentages. The percentage of total service from electric vehicles is in blue, and the percentage from diesel is in gray. Under the *Unified Action* scenario, the share of EV sales increases to 14% in 2035 as a result of additional EV incentives and mandates, compared to 4% under the *Fragmented Action* scenario and 1% under the *Current Policies* scenario.

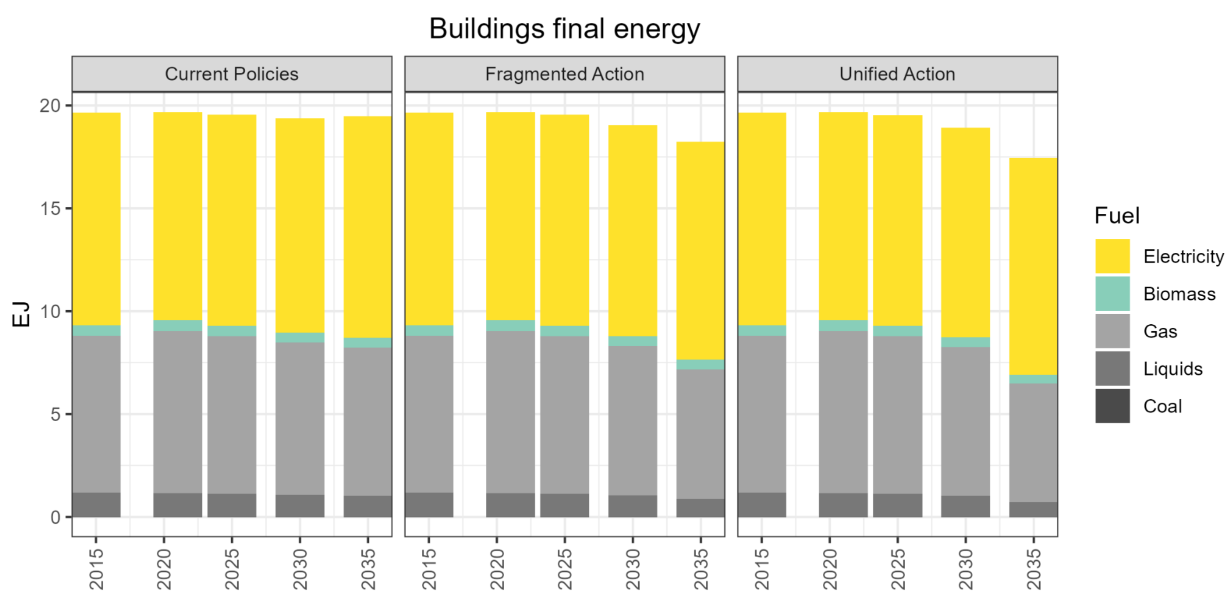


Fig. S17. Buildings sector final energy demand in the the *Current Policies, Fragmented Action* and *Unified Action* scenarios, in units of exajoules (EJ). Under the *Unified Action* scenario, the share of electricity increases from 51% in 2021 to 60% by 2035 as a result of electrification incentives and mandates, compared to 58% under *Fragmented Action* and 55% under the *Current Policies* scenario. Additionally, total demand decreases in the *Unified Action* scenario as a result of enhanced energy efficiency measures as well the higher share of electricity, which is more energy efficient than other fuels.

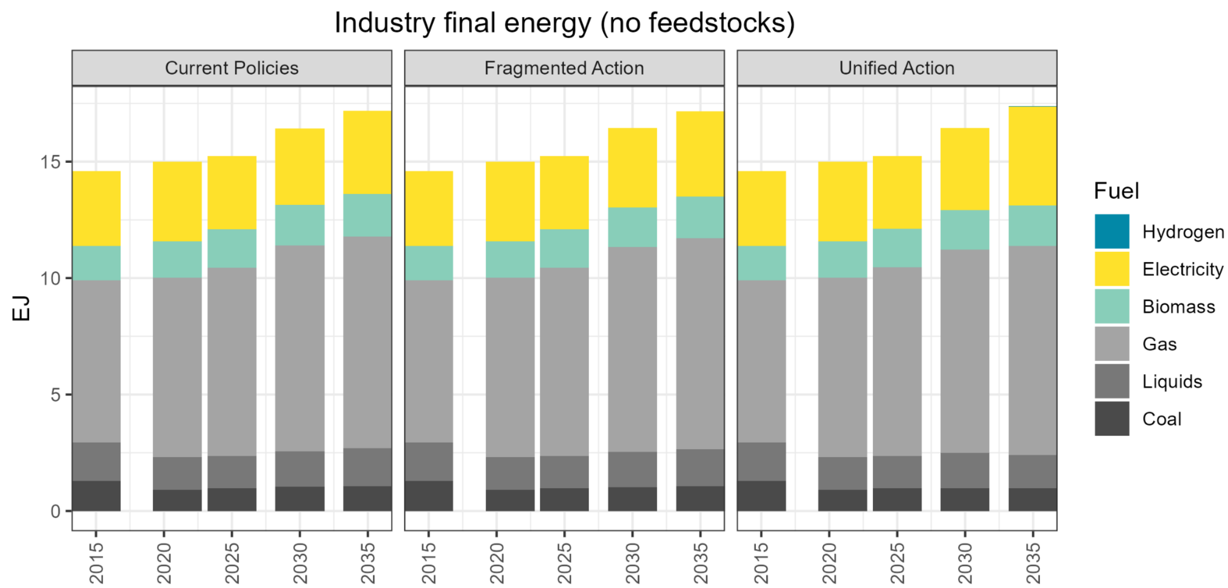


Fig. S18 Industrial sector final energy under the *Current Policies, Fragmented Action* and *Unified Action* scenarios, in units of exajoules (EJ). Under the *Unified Action* scenario, the share of electricity increases from 22% in 2021 to 24% by 2035 as a result of electrification incentives and lower electricity prices, compared to 21% under *Fragmented Action* and 20% under the *Current Policies* scenario.

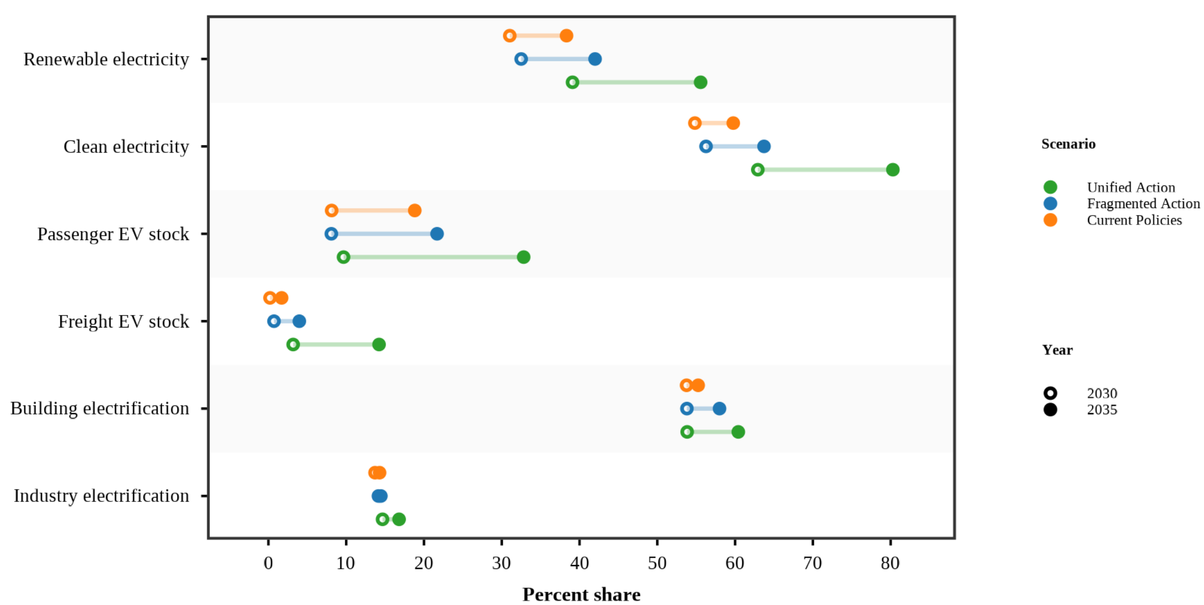


Fig. S19. National sectoral metrics in 2030 and 2035 across scenarios. Scenarios are differentiated by color. The renewable electricity metric indicates the percentage of the generation mix that comes from solar and wind resources. The clean electricity metric indicates the percentage of generation from 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.

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