TOWARD 2035:

Forging a High-Ambition U.S. Climate Pathway

SCHOOL OF PUBLIC POLICY
CENTER FOR GLOBAL SUSTAINABILITY

SEPTEMBER 2024

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List Of Acronyms And Abbreviations

ACC: Advanced Clean Cars

ACT: Advanced Clean Trucks

ACF: Advanced Clean Fleets

BEV: Battery Electric Vehicle

BIL: Bipartisan Infrastructure Law

BRT: Bus Rapid Transit

CAFE: Corporate Average Fuel Economy

CCS: Carbon Capture and Storage

CDR: Carbon Dioxide Removal

CES: Clean Electricity Standard

CGS: Center for Global Sustainability

CH4: Methane

CO2: Carbon Dioxide

COP: Conference of the Parties (United Nations Climate Change Conference)

CSP: Concentrated Solar Power

DAC: Direct Air Capture

DER: Distributed Energy Resource

DOT: United States Department of Transportation

EERS: Energy Efficiency Resource Standards

EIR: Energy Infrastructure Reinvestment Program

EJ: Exajoules

EPA: United States Environmental Protection Agency

EUI: Energy Use Intensity

EV: Electric Vehicle

FERC: Federal Energy Regulatory Commission

GET: Grid Enhancing Technologies

GHG: Greenhouse Gas

GW: Gigawatt

GWP: Global Warming Potential

HFC: Hydrofluorocarbon

HUD: United States Department of Housing and Urban Development

ICE: Internal Combustion Engine

IEA: International Energy Agency

IRA: Inflation Reduction Act

IRP: Integrated Resource Planning

J40: Justice40

kW: Kilowatt

LCFFES: Low-Carbon Fuels, Feedstocks, and Energy Sources

LDV: Light-Duty Vehicle

LMI: Low- and Moderate-Income

LNG: Liquefied Natural Gas

LULUCF: Land Use, Land-Use Change, and Forestry

MtCO2e: Million Metric Tons of CO2 Equivalent

MW: Megawatt

NDC: Nationally Determined Contribution

ODS: Ozone-depleting substances

POC: People of Color

PPA: Power Purchase Agreement

R&D: Research and Development

RD&D: Research, Development and Demonstration

RE: Renewable Energy

RGGI: Regional Greenhouse Gas Initiative

RMP: Refrigerant Management Program

RPS: Renewable Portfolio Standards

SNAP: Significant New Alternatives Policy program

TW: Terawatt

TWH: Terawatt-hours

USDA: United States Department of Agriculture

VMT: Vehicle Miles Traveled

VPP: Virtual Power Plant

V2G: Vehicle-to-Grid

ZEB: Zero-emission Building

ZEV: Zero-emission Vehicle

Executive Summary

Globally, the window of opportunity to limit the warming of the Earth's atmosphere to 1.5°C is closing, creating increased urgency to deliver rapid emissions reductions across all sectors and all greenhouse gases (GHGs) in the coming decade. Under the Paris Agreement, all countries must submit new climate targets for 2035 by the beginning of next year as part of the next round of nationally determined contributions (NDCs). In order to keep warming under 1.5°C, the 2035 NDCs must demonstrate substantially enhanced ambition for further emissions reductions, reflecting maximized outcomes using all available tools and leveraging different strengths from all actors. Leadership from key emitting countries is critical in setting expectations and raising ambition worldwide. In particular, other countries are looking to the United States, the world's largest economy and second-largest GHG emitter, to announce a high-ambition target for 2035.

The United States has made significant progress, buoyed by climate legislation and regulation, but existing policies alone are not enough to achieve the U.S. 2030 NDC of 50-52% GHG emissions reductions below 2005 levels and the 2050 net-zero target. However, economically attractive and scalable emission reduction strategies exist which, if adopted on a society-wide basis, can avoid the greatest dangers of a high-temperature overshoot and keep the United States on track toward its climate targets. By implementing robust climate policies across all levels of society, we find that the United States could meet its 2030 NDC and achieve a 65% emissions reduction by 2035.

An effective target should be high-ambition and 1.5°C-aligned; at the same time, it should be plausible and embedded in robust domestic policies with clear implementation mechanisms.[1,2] The United States is well positioned to strengthen domestic action and lead this round of ambition enhancement internationally with strong climate policies, market momentum, and growing subnational leadership–from states, cities, businesses, Tribes, Healthcare organizations, and more. In the past few years, the United States has rolled out new climate and energy policies at a high and sustained pace, including the largest federal climate investments in history through the Inflation Reduction Act and the Bipartisan Infrastructure Law, as well as increased leadership from various non-state actors on policy development and implementation. This all-of-society approach can mobilize and integrate action across diverse federal and non-federal (e.g. states, cities, businesses, and others) actors to make the best use of available resources and tools to set and deliver ambitious climate targets.

This analysis takes an innovative, integrated approach to develop plausible, high-ambition pathways through 2035 to inform the third U.S. NDC target setting. This approach combines: (1) an extensive consultation and engagement process with a broad set of federal and subnational stakeholders to build a robust U.S. policy platform; (2) an open-source, field-leading integrated assessment model focused on the United States with state-level detail; and 3) an analysis of both the short-term impact and urgency of rapid reductions in methane emissions alongside the necessity of reducing the long-term build-up of CO_2 and other GHGs.

The modeling tool assesses existing as well as new and expanded policies from both federal and non-federal levels to identify the overall emissions reduction potential in 2035 and concrete policy pathways to deliver on this potential while keeping the United States on a path toward net zero. In addition, this report identifies the challenges associated with the transition in each sector and showcases implementation pathways for a broad suite of actors across all of society.

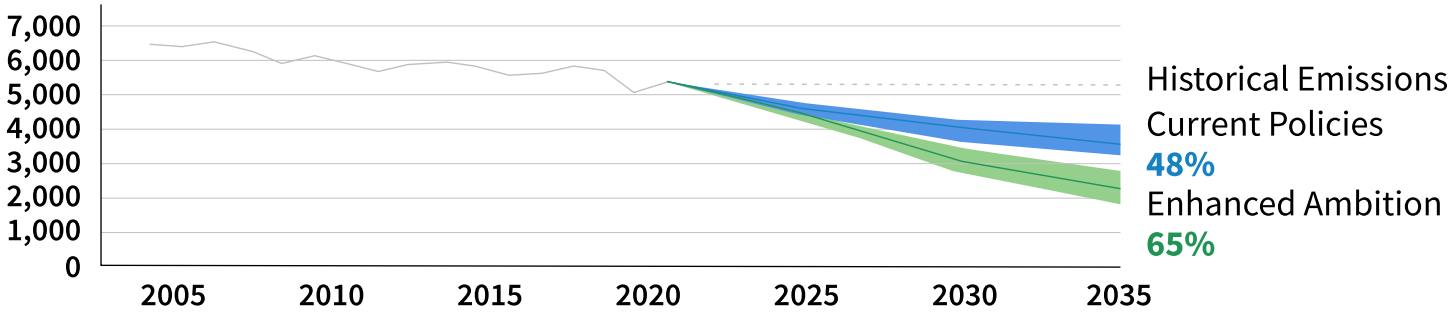

Figure 1. U.S. GHG emissions from 2005 - 2035. *Historical emissions through 2021 are taken from the 2021 U.S. Environmental Protection Agency (EPA) inventory.[3] The Current Policies scenario achieves 48% emissions reductions below 2005 levels by 2035 in the central case, with a sensitivity range of 42% to 54% based on assumptions around socioeconomic pathways, energy prices, and the size of the land sink. The Enhanced Ambition scenario achieves 65% reductions in the central case, with a sensitivity range of 59% to 70% based on assumptions around socioeconomic pathways, energy prices, and the size of the land sink. Achieving additional electricity and methane targets can increase the central case reduction to 67%.*

SUMMARY OF FINDINGS

In our analysis of plausible, all-of-society actions to deliver a high-ambition 2035 NDC, we find that the United States can achieve a 65% GHG emissions reduction by 2035, down from 2005 levels, under our core scenario.

Achieving additional sectoral targets, including 100% clean electricity and 0.2% oil and gas methane intensity, requires additional efforts beyond the specific policies modeled in the core scenario, and can further drive overall emissions reductions to 67% by 2035.

The average annual decarbonization rate from 2020 to 2035 increases by nearly 70% from 2.2% per year with current policies to 3.7% in the core scenario. Delivering this ambitious 2035 NDC, which also achieves the current U.S. 2030 NDC, will require specific actions from all of society – federal, state, city, businesses, and other actors – with guidance for implementation that is supported by robust analysis. This approach is critical to setting and achieving an ambitious U.S. national climate target in line with Paris Agreement goals, keeping a 1.5-degree pathway within reach.

Methane has a critical role to play in reducing near-term warming. Using the EPA baseline which will govern the NDC process, methane emissions decrease by 35% from 2020 levels by 2035 through an extended methane fee that covers oil and gas, coal, and waste sectors, and incentives for reducing agricultural methane in the core scenario. With the use of an alternative baseline for oil and gas methane and the addition of an internationally agreed upon standard to achieve a 0.2% methane emissions intensity for oil and gas production and transmission – a measure of how much methane is released into the atmosphere relative to the amount of oil and gas production – and a 50% reduction target for landfill methane, methane emissions can be reduced by 48% by 2035.

In the electricity sector, a generation mix that is 91% powered by clean technologies is achieved under the core scenario, with unabated coal power phased out by 2030, solar generation increasing ninefold, and wind generation nearly sixfold between 2020 and 2035. By achieving the 100% clean electricity target, unabated gas power is phased down and replaced by additional solar and wind deployment.

In the transport sector, 82% of light-duty vehicle sales and 42% of freight truck sales under our core scenario are electric by 2035. Passenger vehicle miles traveled fall by 65% compared to current policies as a result of switching from single-occupancy vehicles to alternative modes of transportation.

In the buildings sector, 38% of water and space heating are electrified by 2035, and overall energy demand decreases by 16% compared to 2020 levels as a result of energy efficiency measures and increased electrification.

In the industrial sector, progress is made in carbon capture and storage (CCS), with annual industrial carbon sequestration increasing to 154 $MtCO_2e$ by 2035.

Land sink carbon sequestration increases by 96 $MtCO_2$ from 2021 levels through enhanced carbon sequestration from forests and climate-smart livestock management.

Critical to achieving emissions reductions is the full implementation and expansion of key federal policies, including over $1 trillion in investments under the Inflation Reduction Act and Bipartisan Infrastructure Law and the recently finalized EPA rules on vehicle emissions and fossil fuel power plants, underscoring the importance of supporting actions from non-federal actors.

In addition to implementing federal policies, non-federal actors also play a key role in driving emissions reductions through expanding and delivering on their own policies. State and local leadership can unlock federal and industry decarbonization with initiatives in accelerating renewable energy targets, methane intensity standards, EV sales mandates, vehicle miles traveled reduction policies, building appliance electrification targets, and more.

An initial analysis shows that even without federal support, continued, high-ambition actions from non-federal actors can achieve a 48–60% reduction by 2035. This highlights the impact that non-federal actors can still have despite uncertainties at the federal level.

Introduction

SETTING AND ACHIEVING AN AMBITIOUS NATIONAL CLIMATE TARGET UNDER THE PARIS AGREEMENT

Since re-entering the Paris Agreement in 2021, the United States has re-established itself as a climate leader. The Biden-Harris Administration has committed to an ambitious national climate target, or nationally determined contribution (NDC), of a 50-52% greenhouse gas (GHG) emissions reduction below 2005 levels by 2030 and a long-term strategy of achieving a net-zero emissions economy by 2050. Recent federal and non-federal climate actions have contributed significantly to U.S. emissions reductions, including the Inflation Reduction Act (IRA) of 2022 and the Bipartisan Infrastructure Law (BIL) of 2021, recent changes in EPA regulations, and increased ambition from states, cities, businesses, and other entities. Still, a gap remains and additional actions will be needed to meet U.S. climate targets, including strengthened renewable energy targets, accelerated permitting and siting of electricity transmission and renewables, additional incentives and sales targets for EVs, stronger building codes, and more stringent regulations on oil and gas sector methane.[4-7]

In the coming months, countries will be undertaking the planning and target-setting phase for the next round of NDCs, which are due by early 2025. The 2035 NDCs will be critical for ratcheting up near-term actions and keeping a path to remaining below 1.5°C within reach. The United States has the opportunity to set the stage and catalyze enhanced ambition by key partners and other major economies by submitting a new 2035 NDC that is viewed broadly as being ambitious and in line with the global 1.5°C goal.

Furthermore, the United States can root its 2035 NDC in a plausible and attainable set of all-of-society policy actions and subnational leadership. Through the NDC and global stocktake processes, the Paris Agreement has placed emphasis on domestic strategic planning in the international target-setting process. The openness and transparency of these processes have also led to increased engagement of stakeholders from all of society in the design and implementation of international climate targets. A robust and ambitious U.S. climate target requires a broad stakeholder engagement approach, including states, cities, businesses, and more, to understand emissions opportunities for reductions at all levels of society. The Center for Global Sustainability, with assistance from *America Is All In*, has facilitated this kind of robust stakeholder engagement to support sub-federal input into the NDC development process and further strengthen the final NDC.

CURRENT POLICY LANDSCAPE IN THE UNITED STATES

Recent federal actions have set a new precedent for federal support of non-federal climate action. The Inflation Reduction Act (IRA) of 2022 and the Bipartisan Infrastructure Law (BIL) of 2021 are projected to contribute significantly to U.S. emissions reductions.[4-6,8,9] Additionally, finalized EPA rules on power plants, methane, and internal combustion engine (ICE) vehicles can further strengthen U.S. emissions reductions.[10-12] At the same time, non-federal actors have been stepping up their climate ambition by adopting robust policies such as California's Advanced Clean Cars II regulations, clean energy targets, zero-emission appliance standards, private sector net-zero goals, and mandates for more stringent management of fugitive methane and hydrofluorocarbon (HFC) emissions.[13-17]

Collectively, these actions have catalyzed the clean energy transition. Investments in clean energy development have been accelerating, with $239 billion in new investments in the past year, up 38% from the previous year.[18] These investments span manufacturing, energy, industry, and retail, including technologies like utility-scale solar and battery storage technologies, heat pumps, zero-emission vehicles, and more. Public support for the clean energy transition has also continued to increase. Recent data released by the Treasury Department shows that public response to the IRA's household tax credit program has exceeded projections significantly, with 3.4 million American households having already invested $8 billion in clean energy technologies such as rooftop solar and heat pumps in a single year.[19,20]

Trends for vehicle electrification have also been largely positive. Electric light-duty vehicle (LDV) sales encompassed 9% of national vehicle sales in 2023, reaching 1.4 million electric vehicles (EVs) compared to one million in the previous year, though U.S. EV sales are still below the global average.[21] The market shows a strong consumer preference for battery electric vehicles (BEVs) over plug-in hybrid electric vehicles (PHEVs).[22] Efforts to reduce total vehicle miles traveled (VMT), which have risen by 40% in the last three decades,[23] can further support emissions reductions and yield benefits in public health, community connectivity, and public safety through reduced congestion and air pollution.[24-26]

Yet, even with advances in the energy transition and emissions reductions, challenges remain in effectively implementing these policies and overcoming various political, social, and technical barriers. Although IRA investments have flowed to both red and blue states,[27] the uptake of these investments continues to unfold. Many IRA investments for consumers are not automatically dispersed and are dependent on the capacity of state and local governments and community organizations to spread information and educate consumers. At the same time, states are struggling to meet the climate targets they have set, highlighting the critical need for effective implementation strategies.[28] Renewable energy (RE) deployment remains hindered by delays in permitting processes and lack of transmission infrastructure, slowing the progress needed to transition to a sustainable energy future.[29] In addition, while the EPA has recently finalized regulations on coal and new gas-fired power plants, presenting opportunities to further reduce emissions from unabated fossil fuel generation, uncertainty remains around the future of existing gas-fired power plants, which make up more than 40% of the current generation mix.[30] The durability of the rule has also been called into question, with 25 states having sued the EPA over the rule.[31]

Despite these uncertainties, the United States has an opportunity to leverage the current momentum in climate action and build on the groundswell of efforts from all levels of society to achieve its climate targets. This report explores the key challenges and barriers for each sector and provides examples of concrete actions in all sectors from different actor levels that can help achieve an ambitious 2035 NDC.

AN INNOVATIVE APPROACH IN THIS ANALYSIS

This report presents an in-depth analysis of an all-of-society, economy-wide strategy designed to achieve a high-ambition 2035 NDC. Previous analyses led by the Center for Global Sustainability at the University of Maryland have demonstrated that an all-of-society strategy effectively delivers ambitious national climate action targets more quickly and comprehensively than approaches that only rely on actions from the federal government.[4,32-34] Building on this prior work, this report presents an innovative approach to deliver on a U.S. 2035 NDC target, combining a robust modeling analysis[35] with stakeholder engagement.

This study uses an open-source, global integrated assessment model to project emissions reductions resulting from a suite of federal and non-federal actions. To increase the engagement of stakeholders from all of society, this analysis is paired with a stakeholder input process to help inform the feasibility of its assumptions and results and to provide additional context around the opportunities and challenges associated with ambitious climate actions across different sectors.

Society-wide Pathways Toward 2035

Stakeholder Input Process and General Observations

Including a stakeholder element into the NDC target-setting process is paramount not only for garnering broad buy-in but also for leveraging diverse expertise and resources. This inclusive approach fosters innovation, ensures policy relevance, and enhances the resilience of climate strategies in the face of evolving challenges.[36,37] By examining the input processes that shape a society-wide NDC with the practitioners who work in each of the major sectors, we aim to demonstrate how collaborative efforts can strengthen national climate ambitions and contribute to a sustainable and equitable future.

Over the course of March through July 2024, the Center for Global Sustainability, with assistance from ***America Is All In,*** held 12 stakeholder listening sessions across multiple sectors, including participants from federal, state and municipal government, industry, civil society, and academia. In some instances, in response to the feedback received, the researchers modified modeling assumptions. Additionally, the feedback was integrated throughout this report, from identifying the challenges and barriers in each sector to recommending implementation pathways for different actors. Some common themes that surfaced during these sessions are listed below. More detailed information on the stakeholder engagement process is included in the Listening Session Appendix.

OBSERVATIONS FROM STAKEHOLDER ENGAGEMENT SESSIONS:

- **Clear definitions and standardization of targets, especially for emerging technologies and training, will aid sectors in reaching ambitious climate goals.**
- **Workforce development is needed across sectors to train and prepare workers for the technical changes associated with an accelerated clean energy transition.**
- **Disseminating accurate, accessible, and community-specific information about climate action will be critical in keeping the public well-informed and motivated to participate in meeting climate targets.**
- **Opportunities for cross-sectoral engagement, such as building codes and standards, tax credits, energy efficiency resource standards, and industrial decarbonization incentives, represent areas where industry, state governments, and local governments can collaborate to meet climate goals.**

Emissions Reductions under Current Policies and Enhanced Ambition

This analysis focuses on specific, bottom-up policies that can help achieve GHG emissions reductions in the United States. Using a globally recognized and transparent modeling framework, this analysis assesses all major climate-related policies across each sector at both the federal and non-federal levels. The analysis models two distinct scenarios to represent the impacts of existing, on-the-books policies and the additional effects from a suite of high-ambition policies.

The ***Current Policies*** scenario represents on-the-books policies, including provisions from the IRA and BIL, the recently finalized EPA regulations for power plants and vehicle emissions, as well as state-level renewable energy targets, and zero-emission vehicle sales targets, among other existing policy actions. In this scenario, we estimate that the full achievement of existing policies can reduce U.S. GHG emissions by 48% from 2005 levels by 2035 (Figure 1).

In the ***Enhanced Ambition*** scenario, we layer on new and expanded policies at the federal and non-federal levels, including strenghtened regulations for existing gas-fired power plants, coal phaseout policies, a methane program for all sectors of the economy, enhanced renewable energy targets, widespread adoption of zero-emission vehicle targets and appliance standards, direct air capture technology, increased investments in land sector mitigation activities, and more. **This suite of policies achieves the 2030 NDC, and delivers a 65% reduction in GHG emissions below 2005 levels by 2035 (Figure 1); additional sectoral targets in electricity and methane can deliver a 67% reduction (Box 1).** For comparison, a recent Princeton ZERO study finds that a straight-line reduction in emissions from 2023 historical levels to net-zero by 2050 delivers 60% emissions reductions by 2035.[38] Additionally, Energy Innovation's "Continued Climate Leadership" scenario achieves emissions reductions of 70% by 2035.[39] See the Technical Appendix for more information on modeling assumptions and a comparison with other studies.

Major contributions toward the 65% reductions in our core scenario come from the electricity and transport sectors, which make up 41% (or 1,203 $MtCO_2e$) and 27% (or 790 $MtCO_2e$) of overall emissions reductions from 2020 to 2035 (Figure 2). However, the results also place an increased emphasis on other sectors like buildings (7%, or 211 $MtCO_2e$), industry (8%, or 243 $MtCO_2e$), and methane (10%, or 285 $MtCO_2e$). Other sectors, including direct air capture, land use, and hydrofluorocarbons, contribute the remaining 7% of overall emissions reductions collectively. Based on the EPA's GHG emissions inventory[3] and marginal abatement cost curves,[40] methane mitigation contributes only 10% to overall emissions reductions; however, by assessing its immediate climate impacts over a shorter time frame and by taking into account the potential underestimated emissions, methane abatement can be as important as CO_2 reductions in the electricity sector through 2035 (See Box 1). These results show that beyond measures in the electricity and transport sectors, methane mitigation, electrification, and efficiency improvements in the buildings and industry sectors, sequestration from CCS technologies, and enhanced land sink sequestration are also important for achieving an ambitious 2035 NDC.

New policies that are explicitly modeled under the ***Enhanced Ambition*** scenario are shown in Table 1, and detailed results for each sector can be found in the following sections. **Additionally, this report identifies barriers and provides implementation pathways for federal and non-federal actors to achieve the emissions reductions modeled.** The "Implementation Pathway" and "Implementation Spotlight" sections in each sector provide examples of key supportive policies and actions, some of which are not explicitly modeled in this analysis, for different types of actors.

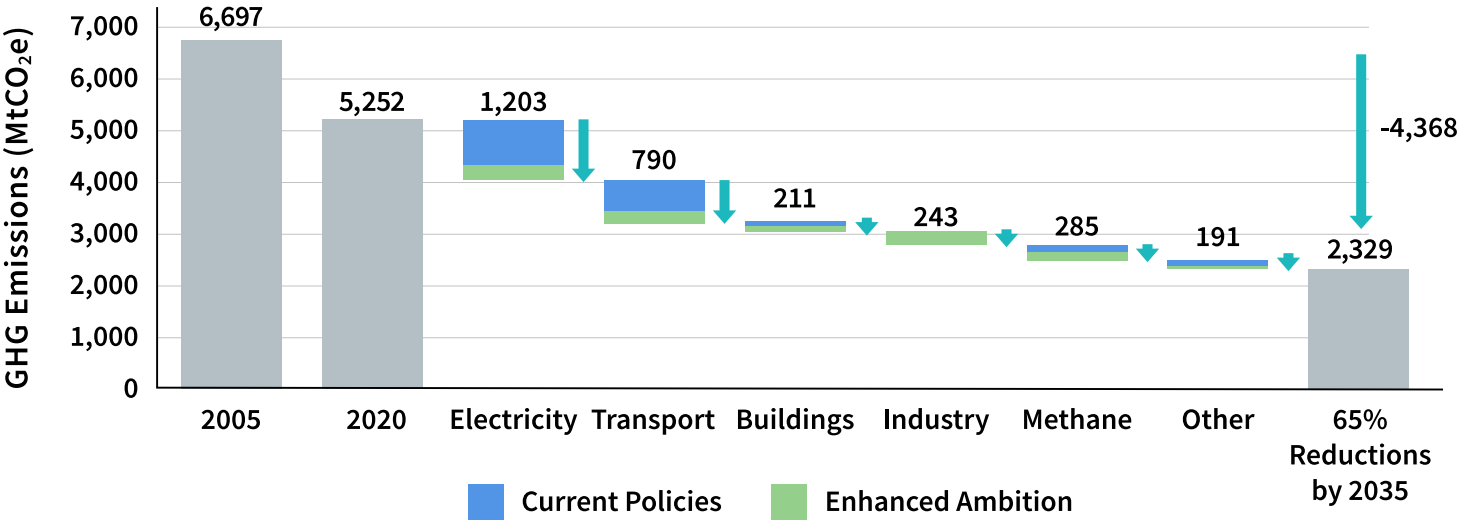

Figure 2. A suite of federal and non-federal actions across the economy allows the United States to achieve a 65% GHG emissions reduction by 2035. *Historical emissions data are taken from EPA's 2021 inventory, which uses the 100-year global warming potential to convert non-CO_2 gases into CO_2 equivalents.[41] Bars show GHG emissions in CO_2 equivalents, with reductions across the power, transport, buildings, industry, methane, and other sectors under Current Policies and Enhanced Ambition scenarios. Gray bars represent total emissions in 2005, 2020, and 2035 with 2020 being the last historical model year. The blue and green bars represent emissions reductions needed from each sector between 2020 and 2035, with reductions from the Current Policies scenario in blue, and the additional reductions from the Enhanced Ambition scenario in green. Methane emissions from all sectors are accounted for in the methane sector.*

NEW POLICIES TO ACHIEVE 65% EMISSIONS REDUCTIONS BY 2035			ADDITIONAL TARGETS TO ACHIEVE 67% REDUCTIONS
SECTOR	**FEDERAL POLICIES**	**NON-FEDERAL POLICIES**	
ELECTRICITY	• Extension of IRA provisions, siting and permitting reform, and other actions to promote renewable deployment • Strengthened regulations on gas plants • Coal phaseout by 2030	• Enhanced Renewable Portfolio Standards, siting and permitting reform, and other actions to promote renewable deployment • Coal phaseout by 2030	100% clean electricity by 2035
TRANSPORT	• Extension of IRA tax credits • Enhanced Corporate Average Fuel Economy (CAFE) standards for cars and trucks	• Widespread adoption of California's Advanced Clean Cars II and Advanced Clean Trucks • Vehicle miles traveled reduction policies • Low carbon fuel standards	
BUILDINGS	• Extension of IRA tax credits	• Enhanced energy efficiency standards • Zero-emission appliance standards for hot water and space heating • Zero-emission construction standards	
INDUSTRY	• Extension of IRA provisions • Standards for industry CCS • Direct Air Capture	• Cement CCS targets	
METHANE	• Methane fee/incentive for all sectors	• Enhanced waste diversion efforts	0.2% intensity target for oil and gas methane by 2035 50% landfill methane reduction target by 2035
OTHER NON-CO2 AND LANDS	• Expanded funding for climate-smart agricultural programs and land conservation, wildfire mitigation	• HFC regulations • Economy-wide GHG targets for leading states • Expanded funding for wildfire mitigation, tree planting, conservation, and healthy soils	

Table 1. New and enhanced policies modeled in the Enhanced Ambition scenario to achieve 65% emissions reductions, and additional targets that achieve 67% reductions by 2035.
All on-the-books policies, including recently finalized EPA regulations on power plants and vehicle tailpipe emissions, are already included in this scenario.

BOX 1. ACHIEVING AN EVEN HIGHER CLIMATE TARGET BY 2035

Our core ***Enhanced Ambition*** scenario includes a policy platform with specific, bottom-up policies from federal and non-federal actors. To further evaluate enhanced ambition, we constructed an alternative scenario that achieves critical targets beyond the concrete policies modeled in the platform. In this scenario, we assume that the electricity sector achieves 100% clean generation, oil and gas methane achieves a 0.2% intensity target – a measure of how much methane is released into the atmosphere relative to the amount of oil and gas production – and that landfill methane achieves a 50% reduction target by 2035. While these are critical targets, they are not achieved with the specific policies modeled in the core scenario and are thus assessed separately to show additional areas for enhanced action. With these targets in place, the United States achieves 67% emissions reductions by 2035.

Methane

Methane has a critical role to play in slowing near-term warming and has emerged as a new focal point for climate mitigation. On a 100-year time horizon, methane has a global warming potential (GWP) of 28, which means that it is 28 times more potent of a GHG than CO_2. While the 100-year GWP is used in country-level emissions accounting by convention, methane is much more potent in the near term, with a 20-year GWP of 84, meaning that it is 84 times more potent than CO_2 on a 20-year time horizon. Given methane's high greenhouse warming impact per molecule and short atmospheric lifetime compared with CO_2 emissions, methane mitigation can contribute substantially to near-term GHG emissions reductions.

At COP 26 in Glasgow, the United States and more than 100 countries signed the Global Methane Pledge (GMP), aiming to cut global methane emissions by 30% by 2030 compared with 2020 levels.[42] This was followed by the launch of the Oil and Gas Decarbonization Charter (OGDC), an industry-led effort focused on climate action in the oil and gas sector, at COP 28 in Dubai. The 52 companies in the initiative have pledged to reduce the methane intensity of their oil and gas production to 0.2% by 2030.[43] Additionally, at the 2023 North American Leaders' Summit, the United States agreed to reduce waste methane emissions by 15% and halve food waste by 2030.[44] Actions in this sector also have the potential to improve public health and deliver sharp near-term emissions reductions.[45] The largest share of U.S. methane emissions comes from energy and agriculture, followed by waste.[46]

1. Methane's Critical Near-Term Role

With the IRA methane fee that covers oil and gas sources and the EPA's recently finalized oil and gas methane regulations, ***Current Policies*** achieves methane emissions reductions of 15% between 2020 and 2035 (124 $MtCO_2e$). Under the ***Enhanced Ambition*** scenario shown in Figure 2, methane mitigation policies expand to include agriculture, waste, and coal sectors, reducing emissions by 35% between 2020 and 2035 (285 $MtCO_2e$). This more than double the rate of methane abatement under *Current Policies,* emphasizing the opportunities not yet realized. For consistency with U.S. NDC planning, this methane analysis uses historical emissions from EPA's GHG inventory along with a 100-year GWP and calculates reduced methane emissions based on the EPA's marginal abatement cost curves.[41] However, this likely undervalues the role of methane, as quantified in Box 2. In an alternative methane scenario, the more inclusive International Energy Agency inventory is applied along with a 20-year GWP (see Box 2).

Much of the methane emissions associated with the extraction of oil and gas can be mitigated at relatively low cost, or sometimes at a net profit.[40] Technologies for both abatement and leak detection and repair are also rapidly developing and being deployed. Yet, despite the potential for sale or utilization of captured gas, methane is still routinely vented or flared.[47] Though the new methane fee will shift these financial incentives, continued monitoring will be required to achieve compliance given that current market incentives are not sufficient to motivate capture and use.

A key strategy to reduce methane emissions intensity across the board is for all oil and gas consumers, including businesses, cities, states and the federal government to set methane intensity standards of 0.2% leakage for gas shipped by pipeline across state or national boundaries, as mandated by the Oil and Gas Decarbonization Charter launched at COP28 in Dubai.[43] The European Union has declared its intentions to set methane intensity standards for imported gas.[48]

Alongside implementation uncertainty, future challenges faced by this sector may impact the range of emissions reductions achieved. Some agricultural methane abatement tools require further research and development, particularly for methane produced by enteric fermentation. The dispersed nature of waste methane generation means coordinated actions across households, states, businesses, and local governments. Future methane emissions from fossil fuel production and delivery will vary substantially depending upon the role that these fuels play in fulfilling energy demand domestically and internationally in upcoming years; reduction in domestic consumption of coal, oil, and gas will also reduce volumes of associated methane leakage in the United States.

BOX 2. METHANE'S CONTRIBUTION TO NEAR-TERM U.S. REDUCTIONS

According to the EPA's GHG inventory, methane emissions have been falling. However, there is abundant evidence in the scientific literature that U.S. methane emissions, particularly from the oil and gas sector, are underestimated.[49–53] Given that U.S. oil and gas production has doubled between 2010 and 2023,[54] methane emissions may have increased rather than decreased over this period.

To consider the importance of methane in reducing near-term climate change, we have constructed an alternative scenario to quantify the near-term role of methane under the ***Enhanced Ambition*** scenario.

Alternative scenario showcases the full range of methane reductions:

Different emissions baseline: In this alternative scenario, we use data from the International Energy Agency's (IEA) Methane Tracker for historical oil and gas emissions to better reflect current emissions levels. The IEA data has a higher baseline for oil and gas methane emissions with around twice the emissions from oil and gas production compared to the EPA inventory. In this inventory, 2020 oil and gas sector emissions are 12.3 $MtCH_4$, which is nearly 40% higher than EPA's value of 8.8 $MtCH_4$. This increases total U.S. anthropogenic methane emissions to 32.3 $MtCH_4$, compared to 28.8 $MtCH_4$ using the EPA inventory.

20-year GWP: Additionally, this scenario uses methane's 20-year GWP to calculate emissions in terms of CO_2e. Methane emissions account for 35% of U.S. GHG emissions using GWP20 (compared to 15% using GWP100) in 2020 – highlighting how using GWP100 obscures the critical role that methane mitigation can play in limiting near-term global warming.

CONTINUED: BOX 2. METHANE'S CONTRIBUTION TO NEAR-TERM U.S. REDUCTIONS

Critical policy targets: This scenario further assumes that two additional policy targets are achieved:

The U.S. oil and gas industry meets a methane intensity target of 0.2%, from production through transmission, of total oil and gas production (which we evaluate on a net energy basis). Given limited low-cost mitigation opportunities for natural gas distribution and a lack of detailed mitigation data by segment, we assume that emissions from distribution scale with total natural gas consumption.

Landfill methane emissions achieve a 50% reduction by 2035.

We find that under this alternative scenario, the United States can achieve a 76% reduction in oil and gas methane emissions between 2020 and 2035, and an even larger 82% reduction in methane emissions ascribed to U.S. consumption.[1] This highlights the combined role of reduced fossil consumption and cleaner production. These emissions reductions translate into a 48% reduction in overall methane emissions, compared to a 35% reduction in the core scenario.

With higher initial emissions, the use of GWP20, and the addition of two critical methane targets, the alternative scenario has a larger overall fractional reduction of methane emissions (Figure 3). Overall GHG emission reductions are lower, given that methane still has a slower rate of decarbonization compared to CO_2 at 48% and 65% from 2020 to 2035, respectively.

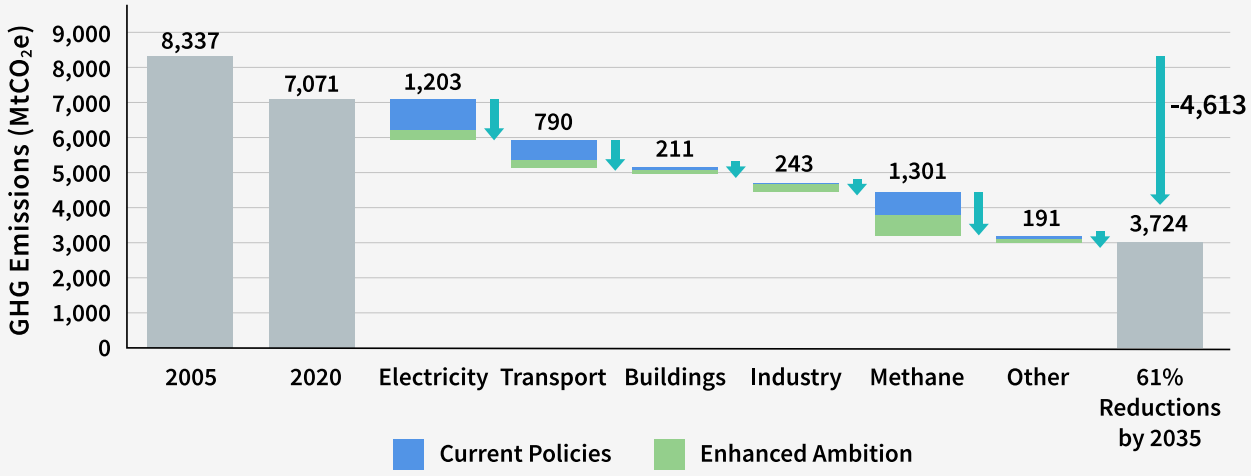

Figure 3. When considering the short-term impact of methane and including the full range of methane reductions, methane becomes the largest contributor toward GHG emissions reductions between 2020 and 2035. *Historical oil and gas emissions data are taken from IEA inventory[55] and the Community Emissions Data System,[56] and all other historical data are taken from EPA's 2021 inventory.[41] To account for methane's short-term impact, GWP20 is used to convert methane emissions into units of CO_2e. Additionally, the achievement of a 0.2% methane intensity target in the oil and gas sector and a 50% reduction in landfill methane emissions by 2035 is assumed. Methane emissions from all sectors are accounted for in the methane sector.*

1 We split upstream methane emissions in proportion to net exports and domestic consumption. We assume that net natural gas exports increase according to the U.S. EIA Annual Energy Outlook 2023, representing currently planned and anticipated LNG export infrastructure.

2. Challenges and Barriers

Financial and technological barriers. Most agriculture methane funding is currently directed toward manure management, and some states have mandated methane reductions through manure management. Tools to reduce methane emissions from enteric fermentation, a digestive process that occurs in ruminant animals like cows, are typically expensive and only modestly effective.[57,58]

Regulatory barriers. Regulatory challenges at state and city levels can hinder methane mitigation. In the waste sector, for example, variability in regulations across states and cities creates a patchwork of requirements that businesses must navigate, impacting compliance and operational consistency. Obtaining permits for waste management facilities and emissions control technologies is often hindered by lengthy approval processes, delaying the adoption of emissions-reducing measures. Additionally, loopholes allowing venting or flaring during "emergencies" exist in current oil and gas regulations. For example, New Mexico's landmark law prohibits routine venting and flaring but allows operators to vent or flare during emergencies or equipment failures.[59] Under this loophole, in the first two months of 2024, the pipeline company Targa Northern Delaware was able to vent 250% more natural gas from its operations in New Mexico than all other oil and gas producers in the state combined.[60] Stringently tracking flaring and venting where it is prohibited can ensure governments successfully prevent the release of avoidable methane emissions.

Data limitations. Given the cross-sectoral nature of these emissions, which include both point and nonpoint sources and are scattered across the country, obtaining accurate, reliable data is a challenge. In previous years, difficulty tracking methane emissions has led to an underestimation of total emissions, especially in the oil and gas sector.[54,61,62] At landfills, substantial differences between bottom-up landfill emissions estimates and top-down atmospheric emissions estimates make detection of point source hotspots difficult, limiting regulators' ability to address them.[47] Overall, the lack of robust methane data can limit the development and evaluation of methane mitigation policies.[49,50,58]

Consumer behavior. Another factor impeding the success of methane mitigation policies is consumer behavior and knowledge. While openness towards composting is increasing, many Americans still lack the proper knowledge on what can be recycled, trashed, or composted.[63] Additionally, reducing meat consumption could help achieve significant emissions reductions in the agriculture sector. However, meat is a central component of the American diet and culture, and shifting away from this will require significant changes in public attitudes and social norms.[64]

3. Implementation Pathway

Key policy #1: Increase methane mitigation across the energy sector, including among coal, oil, and gas. *New federal fees, and state and federal intensity standards for methane from the energy sector, alongside more stringent monitoring of leaks and prevention of venting and flaring have the potential to save money and drive down emissions.*

SUPPORTING POLICIES AND ACTIONS

Federal

Methane pricing programs: The federal government can implement a methane fee or offer incentives for mitigation. Under the Methane Emissions Reduction Program established by the IRA, a subset of oil and gas facilities are charged per ton of methane emissions, reaching $1,500 per ton of methane in 2026, if they are not in compliance with the EPA's oil and gas methane regulations. However, a more comprehensive pricing program could cover all oil and gas facilities, as well as other sectors like agriculture and waste.

Financial and technical assistance: The Methane Emissions Reduction Program also provides more than $1 billion in funding for financial and technical assistance activities to monitor and reduce emissions, with a focus on efforts in low-income communities to improve local air quality and environmental restoration.[65] The Biden-Harris Administration has invested $196 million in 37 projects to modernize municipal- and community-owned natural gas distribution pipelines, which are expected to improve safety and generate new jobs.[66]

Regulations on oil and gas methane: In 2023, the EPA finalized a new rule to reduce methane emissions and other harmful air pollutants from oil and gas operations, including existing sources, by requiring that facilities reduce emissions from high-emitting equipment, monitor and repair leaks, and limit flaring.[12] The Department of Transportation (DOT)'s Pipeline and Hazardous Materials Safety Administration has also proposed a new rule to significantly improve the detection and repair of leaks from gas pipelines.[67] The federal government should further set an emissions intensity standard of 0.2% for both domestic and globally traded U.S. gas.

Funding for abandoned mines: Funding to reclaim abandoned coal mines can help mitigate fugitive methane emissions. BIL has administered over $11 billion in funding for the Abandoned Mine Land Reclamation Program Fund, which aims to address hazards resulting from legacy mining.[68]

State

Methane intensity standards: States can take the lead in setting 0.2% methane intensity standards for oil and gas they produce or combust.

Bans on routine flaring and venting: Routine flaring and venting are controlled processes used by oil field operators to manage the gas that accompanies oil production by releasing it into the atmosphere. Several states including Alaska, Colorado, New Mexico, North Dakota, Pennsylvania, and Wyoming have taken steps to limit venting and flaring from oil and gas operations.[69] In Colorado, flaring is only permitted during disruption, maintenance, and production evaluation.[70]

Operator-financed shutdown of idled wells: Most oil- and gas-producing states require operators to pay the costs of shutting down their wells when they are no longer producing. However, there are at least 120,000 orphaned wells across the United States that have not been properly decommissioned by the original operators.[71] More state enforcement of closure obligations is essential to eliminate fugitive oil and gas from idled wells.

Plugging orphaned wells: Under the BIL, 26 states are eligible to plug orphaned oil and gas wells. Louisiana, for example, plans to utilize a $25 million grant to train and employ displaced energy workers to plug more than 250 documented orphaned wells, halting emissions from leaks and investing in communities affected by the energy transition.[72]

Leak detection and repair programs: To curb avoidable emissions from leaky infrastructure, states such as California, Pennsylvania, Colorado, and New Mexico have implemented programs that require operators to regularly inspect their facilities and repair any leaks. New Mexico has strict rules that require operators to detect leaks, isolate them within 48 hours, and repair them within 15 days.[72,73] North Dakota launched an initiative that will use AI to monitor and predict methane leaks in real time.[74]

Other

Tribal orphaned wells program: To address the legacy pollution and leaks from wells on Tribal lands, the BIL provides $150 million for Tribal well plugging and repairing.[75]

Commitments from businesses: Buy-in from the oil and gas industry is critical for methane mitigation. Since 2016, Chevron has reduced its methane intensity by more than 50% by using vapor recovery units and pneumatic controllers to avoid continuous venting and flaring, reducing methane and working towards its goal of zero routine flaring by 2030.[76]

Research and development: Research on new technologies to reduce methane emissions will be critical for additional abatement. The University of Texas is leading Project Astra, a first-of-its-kind sensor network project that will monitor emissions across oil and gas facilities in the Permian Basin.[77]

Key policy #2: Increase methane mitigation across the agriculture and waste sectors. *Given the diffuse nature of the agriculture and waste sectors, coordinated actions will be required across all of society. Non-federal actors can set mandates and targets, create strategic partnerships, and provide technical assistance, while higher-level funds from the federal government are needed to address the costly and technologically difficult aspects of abatement.*

SUPPORTING POLICIES AND ACTIONS

Federal

Funding for implementation: Non-IRA funds such as the USDA's Partnerships for Climate Smart Commodities, Conservation Innovation Grants, and the Regional Conservation Partnership Program provide funding for states to implement agricultural methane reduction tools, most of which apply to manure management but some of which also cover enteric fermentation and rice production.[78-80]

R&D Investment: To address the need for better enteric methane mitigation technologies, the USDA's National Institute of Food and Agriculture invested in projects to assist in meeting national methane targets.[81]

State

Landfill monitoring mandates: Municipal solid waste is the third-largest source of methane emissions from human activities in the United States.[82] In Oregon, state regulations require that large landfills monitor their methane emissions and install a gas collection and control system if they exceed allowable levels.[83,84]

Organics recycling mandate: To address food waste, the state of Maryland's Organics Recycling Law made food residuals collection and diversion mandatory for businesses, organizations, and schools that generate at least two tons of food residuals per week and are located within 30 miles of an organics recycling facility.[85]

Livestock activities and methane mitigation: Livestock is one of the largest sources of methane emissions, as cows and other ruminant animals naturally produce methane in their digestive tract. California's Alternative Manure Management Program provides funding for non-digester manure management practices with free technical assistance, such as one-on-one assistance from designated providers.[86]

Local

Residential composting mandates: A key tactic for reducing waste methane emissions is through composting, and many local governments are responsible for municipal waste management. Laurel, Maryland is working to provide infrastructure and educational campaigns to enable compliance with its first-in-the-state composting mandate.[87]

Zero-waste targets: By implementing zero-waste targets, governments can divert the amount of organic waste sent to landfills that will break down and emit methane. In 2023, New York City Council passed the Zero Waste Act which mandated recycling, introduced curbside organics collections and drop-off points, and established new community recycling centers as part of their goal of becoming a zero-waste city by 2030.[88]

Other

Repurposing solid waste: Businesses have been using innovative methods to reuse the solid waste that they generate. The Sierra Nevada Brewing Company, for instance, sends part of its spent yeast to be used as feed in dairy farms. The remainder of their spent waste is anaerobically digested at an on-site wastewater treatment plant, producing electricity that covers 8% of the total electricity needs at the facility.[89]

R&D and Public Partnerships: To address the need for better enteric fermentation abatement solutions, the company Cargill issued a $1 million dollar grant to Colorado State University to support research on sustainable beef production.[90]

4. Implementation Spotlights

Local actions to reduce waste methane emissions. City and state governments are often in charge of waste diversion efforts and thus play a key role in reducing methane emissions from the waste sector. One of the leading zero-waste cities, Fort Collins, Colorado has a Road to Zero Waste Plan that aims to achieve a 90% waste diversion rate by 2025 and reach zero waste by 2030.[91] To facilitate the implementation of these goals, Fort Collins adopted the Good Samaritan Act that eliminates liability for food donations, covering a range of providers from backyard gardeners to farmers to educational institutions, food banks, and specially designated kitchens.[91,92] Fort Collins also partners with several companies to increase curbside organics collection, providing key composting information on their website to reduce food waste.[93] Another city leading the charge on waste diversion efforts is Washington, D.C., which set a goal to divert 80% of solid waste from landfills and incinerators by 2040.[94] A key strategy to achieve this goal is increasing recycling and composting participation and accessibility. In 2023, D.C. launched a curbside composting pilot program administered by the company Compost Crew, which currently serves 9,000 households.[95] The 2024 Zero Waste DC Plan aims to expand composting efforts to all single-family residential households, as well as expand education and outreach efforts to increase recycling and composting participation.

Improvements in tracking and understanding methane emissions. To help abate methane emissions, better monitoring and tabulation of emissions is needed. Studies have found that oil and gas methane emissions are often underestimated and much higher than government or industry reports.[50,54] Understanding agricultural emissions is also difficult given their range of sources and the complex processes that drive them. Satellites, among other new technologies, are key tools to enable global detection and monitoring of methane emissions while identifying super-emitters to better inform policies and regulations. Recently, the MethaneSat satellite was launched into orbit, a joint U.S.-New Zealand venture to better track methane emissions from oil and gas operations, as well as agricultural facilities, and pinpoint leaks.[96] While the satellite is largely focused on oil and gas emissions, it will eventually record emissions from waste facilities as well. In Utah, the utilization of infrared cameras helped compliance staff discover that 80% of fugitive emissions from its Uinta Basin come from leaky lid openings, or thief hatches on storage tanks.[6] As a result of this discovery, the Utah Department of Air Quality plans to fund thief hatch replacements at 800 facilities.[97]

Electricity Sector

The electricity sector has historically been the largest emitting sector in the United States. Despite increased electricity demand, emissions have fallen over the past few decades due to a combination of market and regulatory forces. Notably, coal generation dropped from 55% of the U.S. electricity mix in 1990 to less than 20% in 2024, replaced by renewable and natural gas generation.[98] Even so, the electricity sector is still the second largest source of U.S. GHG emissions, and work remains to decarbonize the sector and achieve a 100% clean grid. Furthermore, as demand for electricity rises in other sectors, like transportation and buildings, the electricity sector faces the dual challenge of reducing its carbon intensity and providing greater quantities of clean electricity to end-use sectors. Renewable technologies have become significantly cheaper over the years[99], and replacing fossil fuels with low-cost renewables will be key to decarbonization.

Decarbonizing this sector has many benefits beyond emissions reductions, including improved air quality and reduced premature deaths attributable to generation from fossil fuel.[100] With oil and gas electricity plants disproportionately concentrated in disadvantaged communities, phasing out fossil fuels provides a critical opportunity to address historical inequities in energy production and associated pollution.[101] Switching to clean energy sources also brings economic stability and benefits through job creation, innovation, and increased domestic energy production, making the United States less vulnerable to global fossil fuel price volatility.[102]

1. Sector Pathway

The electricity sector delivers the largest share of emissions reductions between 2020 and 2035 under our core ***Enhanced Ambition*** scenario. However, contributions from the electricity sector and methane sector are roughly equal in importance when methane's climate impacts are assessed over a shorter time frame (See Box 2).

Under the ***Current Policies*** scenario, the IRA's tax credits and Energy Infrastructure Reinvestment provision, recent EPA regulations on power plants, and state-level renewable portfolio standards drive up clean generation while phasing down coal and gas generation, reducing emissions by 61% (887 $MtCO_2e$) between 2020 and 2035. By 2035, clean technologies make up 75% of the electricity generation mix. Unabated coal generation is nearly phased out by 2035, while unabated gas generation still makes up a 24% of the generation mix.

Under the ***Enhanced Ambition*** scenario, emissions fall by 83% (1,203 $MtCO_2e$) between 2020 and 2035. All coal-fired power plants are retired by 2030 as a result of strengthened regulations, coal exit policies, and increasing costs. Additionally, unabated gas generation is reduced as a result of expanded EPA regulations on existing gas plants that have a capacity factor greater than 20% and makes up only 9% of the generation mix by 2035. Meanwhile, a combination of federal action to promote the accelerated deployment of clean electricity sources, including permitting and siting reform, extended IRA tax credits, and increased state ambition accelerate the transition to clean technologies. Solar and wind technologies increase ninefold and nearly sixfold, respectively, enabling a power grid that is 91% clean by 2035. Overall electricity demand increases by 33% in 2035 compared to 2020 levels.

To fully achieve 100% clean electricity by 2035, additional efforts beyond the policies modeled here are needed to retire all unabated gas plants and increase deployment from solar and wind (see Figure S3 in Technical Appendix).

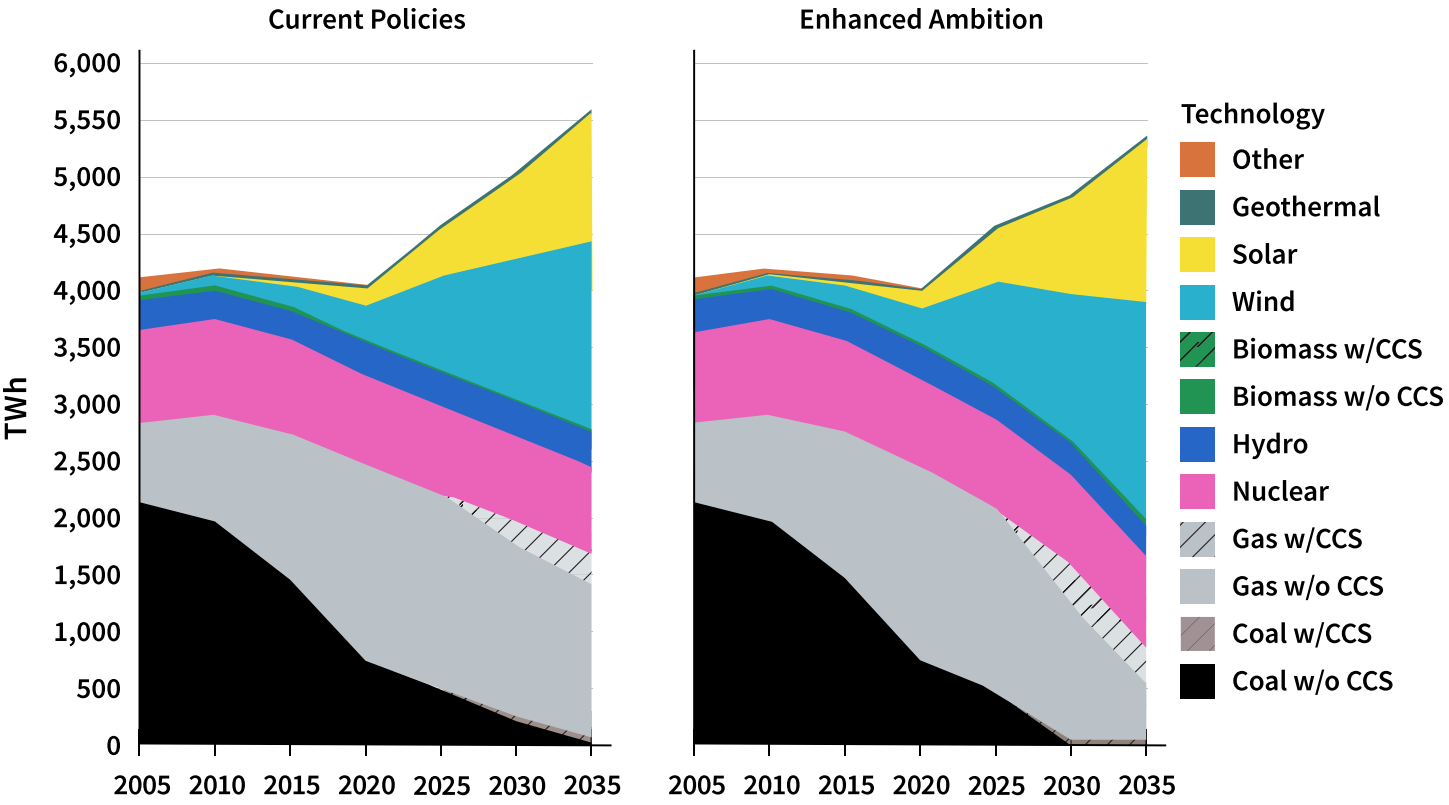

Figure 4. Electricity generation by technology, in terawatt hours (TWh), under Current Policies and Enhanced Ambition scenarios. *By 2035, electricity generation reaches 50% renewable and 75% clean under the Current Policies scenario, and 63% renewable and 91% clean under the Enhanced Ambition scenario. Renewable sources include solar and wind technologies. Clean sources include solar, wind, geothermal, nuclear, hydropower, and biomass and CCS technologies.*

2. Challenges and Barriers

Though the costs of renewables have been decreasing over time and are now competitive with fossil fuel technologies, fully deploying renewables to the levels modeled will be challenging. Obstacles include rising electricity demand, concerns about grid reliability, inadequate transmission infrastructure, slow permitting processes, and cost considerations. Achieving the level of decarbonization in the *Enhanced Ambition* scenario would require overcoming these challenges.

Rising electricity demand. With increasing levels of end-use electrification, as well as heightened peak demand under climate change, electricity demand is expected to increase beyond historical levels in the near term. Furthermore, there is growing interest in artificial intelligence and cryptocurrency, which may rapidly increase data center electricity usage. Data centers, which house computer systems and components for running critical applications and storing data, are projected to consume between 4.6-9.1% of U.S. electricity generation annually by 2030.[103] If clean electricity buildout is unable to keep pace with surging power demand, then data center growth could lead to increased fossil fuel generation. See Box 4 for additional information.

Delays with siting and permitting processes. Despite rising electricity demand, renewable generation growth is not currently on track to reach levels necessary to achieve significant emissions reductions by 2035. This is largely due to delays in connecting renewable energy (RE) projects to the grid, with nearly 1.5 TW of clean generation capacity stuck in the interconnection queue at the end of 2023.[29]

The overlapping regulatory powers among state and local governments significantly slow down the siting and permitting processes needed for multi-state RE transmission projects.[104] Additionally, opposition from local residents due to concerns over their landscape, local biodiversity, soil quality, and land status has resulted in further project delays and cancellations.[105]

Lack of transmission infrastructure. The lack of high-capacity, long-distance transmission, which is important for RE expansion, has also contributed to the interconnection backlogs. The United States only had a 1% annual increase in transmission capacity between 2013 and 2020.[106] Without accelerated transmission growth, U.S. states, counties, and cities will only be able to reach a fraction of their RE deployment targets, and 80% of IRA's emissions reduction potential could be lost.[107,108]

CCS scalability. The use of carbon capture and storage (CCS) will be needed to replace some of the firm capacity provided by unabated gas and achieve the 91% clean grid in our ***Enhanced Ambition*** scenario. While the United States has large-scale CCS facilities and investments for all stages of CCS development, CCS projects need to come online faster to achieve deployment consistent with our Enhanced Ambition scenario.[109]

Costs and equity. Though clean energy has accelerated in recent years, not every household has equal access. The electricity costs associated with transitioning to clean energy can pose a major barrier for historically disadvantaged communities, with nearly a quarter of U.S. households struggling to pay their energy bills in 2023.[110] Lower-income households are less likely to adopt solar panels due to associated short-term financial challenges.[111] In New York, offshore wind project developers such as Orsted, Eversource, and Equinox are facing cost increases due to global inflation and supply chain challenges related to material shortages. As a response, developers are requesting price adjustments, which will likely translate into higher electricity prices for consumers.[112]

3. Implementation Pathway

Key policy #1: Ramp up of clean energy deployment. *Meeting U.S. climate targets and reducing fossil fuel dependence requires increasing the use of clean energy. Supportive policies to ramp up deployment include various standards, incentives and procurement policies for clean energy, the promotion of grid-enhancing technologies and distributed energy resources, and transmission and distribution system upgrades.*

SUPPORTING POLICIES AND ACTIONS

Federal

Incentives for clean electricity: IRA's provisions related to electricity, including production and investment tax credits for clean electricity production, help incentivize the deployment of renewables and can be further extended through 2035.

Identifying high-priority transmission corridors: The Department of Energy's (DOE) National Interest Electric Transmission Corridor designations are eligible for public-private partnerships under federal funds through IRA and BIL and enable the Federal Energy Regulatory Commission (FERC) to issue permits for the siting of transmission lines within the corridor. This can expedite permitting and provide additional financial support for building out transmission infrastructure.

One-stop permitting offices: Centralizing permitting processes can increase efficiencies and accelerate the process of connecting clean energy projects to the grid. The Department of Energy's (DOE) Coordinated Interagency Transmission Authorization and Permits (CITAP) was created to centralize the permit application process and reduce the number of offices.[113]

Promotion of grid-enhancing technologies: The proposed Advancing Grid Enhancing Technologies (GETs) Act would create a shared savings incentive program, splitting the savings for GETs installations between installers and ratepayers. This can promote greater investment in GETs, which have the potential to increase transmission capacity by over 6 GW in the next three years, to help meet growing electricity demand.[114,115]

Clean energy technology deployment on tribal lands: Tribal communities face high utility costs and lack reliable electricity access. Recently, the DOE announced $25 million to fund clean energy technology development on Tribal lands, which will help tribes strengthen their energy sovereignty and increase their energy access and reliability.[117] Continued funding of these clean energy projects will reduce the barriers to clean energy adoption for tribes.

State

Renewable/clean energy standard: To accelerate clean energy production and deployment, a number of states have mandated that utilities achieve 100% clean electricity. New York is targeting 70% RE by 2030 and 100% carbon-free electricity by 2040, while Michigan targets 65% RE by 2035 and 100% clean electricity by 2040.[118,119]

Investment in innovative transmission, storage, and distribution projects: States can leverage federal funding to invest in cutting-edge technologies. Using funding from DOE's Grid Resilience and Innovation Partnerships Program, the Virginia Department of Energy plans to deploy battery energy storage systems at the Iron Mountain data center, and the California Energy Commission plans to deploy advanced conductor technologies and dynamic line ratings along transmission lines to ramp up renewable energy integration.[120]

Permitting reform: Permitting reform is necessary to prevent bottlenecks in the approval process that delay connecting clean energy to the grid. New York passed the Accelerated Renewable Energy Growth and Community Benefit Act in 2020 which incorporated procedures and provisions to expedite the permitting process and established the Office of Renewable Energy Siting to consolidate the review of major renewable energy projects.[121] Washington passed a clean energy siting reform bill to make the siting and permitting processes for clean energy projects more effective and efficient, establishing an Interagency Clean Energy Coordinating Siting Council to assist with improvement efforts and make recommendations to lawmakers.[122]

Clean energy workforce: Maryland Offshore Wind Workforce Training & Education Program offers over $6 million in grant funding to new or existing workforce training centers and academic institutions across Maryland to support the state's offshore wind workforce education, training, and internships.[123]

Local

Clean energy procurement: Many cities and municipalities have set 100% clean energy targets, including Phoenix, Arizona; Kansas City, Missouri; and Miami, Florida. Austin Energy, a city-owned public electric utility, has goals of 93% carbon-free energy by 2030 and 100% carbon-free energy by 2035.[124]

Strategic partnerships: Cities and municipalities have collaborated with energy developers to accelerate clean energy deployment. Wayne County, West Virginia has partnered with a solar developer, Solar Holler, on a 25-year Power Purchase Agreement (PPA) to install up to 10,000 solar panels annually, saving nearly $6.5 million in energy costs.[125,126]

Investment in distributed energy resources (DERs), microgrids, and virtual power plants (VPPs): DERs are small-scale energy generation units that are connected to the grid but located close to sites of energy use, including rooftop solar panels, EVs, heat pumps, and batteries.[127] Microgrids, which are interconnected networks of DERs, can provide electricity even when the larger grid experiences disruptions, while VPPs can help balance the grid by combining capacity from many different DERs to form a virtual source.[128] The Eastern Band of Cherokee Indians and the Hopi Tribe are planning to implement solar-powered microgrids up to 10 MW in capacity using funding from EPA's Climate Pollution Reduction Grants. Along with reducing GHG emissions, these projects can help achieve greater energy sovereignty and provide significant cost savings with lower electric bills for tribal community members.[129]

Other

Long-term clean energy planning: Large electric utilities have set goals to achieve 100% clean energy with defined timelines and plans to invest in RE generation. However, corresponding investment decisions and plans are needed to follow through on these commitments.[130]

Clean energy workforce training: Across the country, universities and organizations provide hands-on training for clean energy careers. In Illinois, the Danville Area Community College offers a Wind Energy Technician Associate Degree Program, providing strong partnerships with industry employers.[131] The Energy Innovation Center, a Pittsburgh-based not-for-profit organization, provides programs to equip displaced coal workers with skills in clean energy technologies such as solar power and energy efficiency.[132]

Requirements for Integrated Resource Planning (IRP) filings: IRPs are long-term roadmaps used by utilities to forecast future energy needs and ensure that transmission infrastructure aligns with regulatory requirements and policy goals.[133] Many utilities have not updated their IRPs since the passing of the IRA and BIL. The Washington Utilities and Transportation Commission has directed utilities to include IRA tax credits in their IRP assumptions and to consider transmission needs that qualify for various IRA programs when developing their plans.[134]

Key policy #2: Phasedown of generation from unabated coal and gas. *Federal and non-federal actors can regulate fossil fuels and provide funding to transition away from these fuels. Supportive policies include coal and gas-fired power plant regulations, carbon pricing programs, CCS funding and development, and funding for coal communities.*

SUPPORTING POLICIES AND ACTIONS

Federal

Power plant regulations: The EPA can reduce fossil fuel generation by regulating power plants under the Clean Air Act. Recently finalized power plant regulations set stringent standards for coal and new gas plants, but they should be further strengthened with standards for existing gas plants.[10]

Repurposing energy infrastructure: Repurposing old fossil-fuel infrastructure can also support the clean energy transition. The IRA's Energy Infrastructure Reinvestment provision provides up to $250 billion in loan guarantees for old energy infrastructure, which can help retire coal plants and replace them with renewable energy. Another example is the DOE's Capacity Building for Repurposing Energy Assets Initiative, which provides $2.7 million to help local energy communities repurpose existing energy assets.[135]

Funding for coal communities: The Department of Commerce's Coal Communities Commitment Program allocated $552 million to support job creation and economic development in communities affected by coal mine closures.[136] Additionally, DOE's Office of Fossil Energy and Carbon Management announced $1.4 million in funding for 14 projects aimed at building the technical capacity and workforce necessary to retire existing coal assets and replace them with renewable energy infrastructure.[135]

Ending new federal coal leases: Halting the expansion of coal leases and infrastructure can reduce U.S. coal dependence and shift market dynamics in favor of clean energy. In May, the Biden-Harris Administration proposed ending new coal leasing within federal lands in the Powder River Basin area of Wyoming and Montana.[137]

State

Coal securitization policies: Securitization allows utilities to take out low-interest bonds to pay off remaining coal investments, which can result in lower electricity rates for consumers and support coal communities. States such as Colorado, New Mexico, Michigan, and Wisconsin have passed legislation to authorize the use of securitization.[138]

Carbon pricing programs: The Regional Greenhouse Gas Initiative (RGGI) is a cooperative effort among 11 states to reduce power sector emissions through CO2 allowances. At the state level, California and Washington both have cap and trade programs that set a limit on GHG emissions for major polluters and require them to buy allowances to offset them.[139,140]

Tax incentives for CCS: Texas provides a clean energy credit for projects sequestering at least 70% of CO2 emissions resulting from or associated with electricity generation by the facility, and Illinois' Clean Coal Portfolio Standard provides tax credits for facilities that capture at least 50% of total CO2 emissions.

Fossil fuel subsidy and tax break reform: Ending subsidies and tax breaks for oil and gas industries can divert additional money to fund clean energy initiatives in states. California Governor Gavin Newsom proposed eliminating oil and gas subsidies, including deductions for drilling costs and credits for enhanced oil recovery. The proposal is expected to increase state revenues by $22 million in 2024-2025 and $17 million annually thereafter.[141]

Local

Community engagement: In some cases, CCS projects have been canceled due to public opposition. To support CCS projects moving forward, local policymakers can focus on community engagement and public education campaigns to build local support and reduce delays in permitting and approval processes.[142]

Strategic CCS siting: To ensure benefits are delivered to the host community, local governments and their residents should work with energy companies to pick CCS storage sites that reduce negative impacts and risks.[143]

Other

Utility-scale battery storage and CCS demonstration projects: In Becker, Minnesota, Xcel Energy is in the process of building three solar projects and piloting a long-duration battery storage project to replace the Sherco coal plant by 2025.[144] Additionally, in Baytown, Texas, Calpine's Baytown Carbon Capture and Storage Project was awarded $12.5 million in federal funding for a carbon capture demonstration facility that will capture CO2 from a natural gas power plant. The project plans to capture up to two million MtCO2e annually and sequester the CO2 in saline storage sites on the Gulf Coast.[145]

4. Implementation Spotlight

Providing incentives for utilities. Without a profit incentive for innovative solutions to enhance resource efficiency and adequacy, utility companies will continue to benefit from investing in new infrastructure and base their utility decisions accordingly. Utilities typically receive a regulated return on investments and collect higher profits with large capital investments on projects. This incentivizes the construction of new transmission lines to grow electricity sales over measures that reduce electricity demand and improve the efficiency of existing transmission lines. The recently introduced Advancing Grid Enhancing Technologies Act aims to address this barrier by requiring the FERC to create a shared savings incentive for GETs between utilities and ratepayers.[146] Several states including Minnesota, Virginia, and Illinois have implemented their own GETs policies to improve statewide transmission.[147-149]

Permitting reform. Barriers in the permitting process delay utility-scale clean energy projects, with renewable projects often waiting over four years and transmission lines up to a decade.[29] A recent study by the U.S. Department of Energy's Lawrence Berkeley National Laboratory surveyed large-scale wind and solar project developers and found that approximately one-third of wind and solar siting applications submitted in the last five years were canceled.[150] The study also found that local ordinances or zoning, grid interconnection, and community opposition were the three leading causes of project cancellations for both wind and solar energy applications. The DOE's CITAP program aims to streamline federal permitting by requiring a single environmental impact statement and setting fixed application response deadlines. Additionally, states and local governments play crucial roles in siting and permitting, with authority varying between state and local levels. States can maximize the use of existing rights-of-way and adopt "one-stop" permitting offices, such as Maryland's OneStop Portal.[151] Legislation on permitting and siting reform, such as those in Washington and New York, can further streamline siting and permitting processes by requiring completed environmental impact statements within a specified time frame and soliciting early input from stakeholders.[152,153] Streamlining the permitting process will help rapidly build out clean energy projects, remove unnecessary barriers, and encourage investment by reducing the costs developers face awaiting permitting decisions.

Regional cooperation. Transmission buildout and large-scale grid upgrades often require input and approval from multiple states and other regional actors. Regional collaboration is critical to ensuring grid stability and progressing renewable energy deployment. Recognizing this need, the Midwestern Governors Association has facilitated inter-state collaboration on issues related to the power grid, often interacting with the Midwest Independent Transmission System Operator. The association also started MID-GRID 2035, a regional transmission education and planning initiative meant to improve the Midwest's future of transmission buildout.[154] The inability of states and other regional actors to work together on grid and transmission issues can impede a region's progress toward reliable and clean energy deployment. For example, National Grid canceled a proposed 1,200 MW bi-directional transmission project that would have brought hydropower from Canada into the New England region, citing differing levels of commitment from states as one of the main difficulties leading to the project's cancellation.[155]

BOX 3. PHASING OUT COAL POWER BY 2030: A KEY LEVER FOR ACHIEVING U.S. CLIMATE GOALS.

Coal-fired generation capacity in the United States has been on the decline since 2011 as a result of shifting market dynamics, clean energy policies, and environmental regulations.[156] Aging infrastructure and rising maintenance costs, combined with increased outages and competition from renewable energy and natural gas have made coal plants less reliable and financially viable compared to alternative energy sources. Recent EPA power plant rules and U.S. commitments to no new unabated coal plants through the Power Past Coal Alliance have further contributed to coal's decline.[157] However, utilities are delaying planned power plant retirements due to concerns about grid reliability in the face of growing electricity demand and supply chain issues, and many are not considering the clean energy incentives from IRA and BIL in their energy plans, which may delay coal retirement.[158,159]

Retiring the remaining coal-fired power plants in the United States can both reduce GHG emissions and offer co-benefits in improved health and air quality. In 2022, coal-related CO_2 emissions accounted for about 55% of total power sector emissions.[98] Coal combustion also emits other toxic pollutants, including sulfur dioxide, nitrogen oxides, and particulate matter, which can cause a variety of adverse respiratory and cognitive impacts and contribute to thousands of deaths annually.[160,161] Furthermore, adverse health impacts from these pollutants disproportionately affect minority and low-income communities, highlighting important environmental justice considerations associated with coal plants.[162,163]

Nearly one-fifth of Americans reside in fossil fuel energy communities, which will be vulnerable to the economic consequences of a coal phase-out.[164] Federal, state, and local governments can support coal workers and energy communities by implementing comprehensive transition plans including job retraining programs, economic diversification initiatives, and financial assistance.[165-167] Policy packages such as the Department of Commerce's Coal Communities Commitment program, which contributes $552 million toward supporting job creation and economic development in communities affected by coal mine closure, can aid energy communities in the transition away from coal.[136]

Transportation Sector

The transportation sector, currently the largest source of U.S. GHG emissions, will be critical for near-term emissions reductions. A low-carbon transport sector can also help reduce oil dependence, save consumers money, and improve public health through reduced air pollution and land-use changes.[24,26,168] Furthermore, decarbonizing this sector offers an opportunity for governments to address historical inequities in disadvantaged communities that suffer from higher rates of air pollution and inadequate public transit access.[169]

A growing number of states have started adopting California's Advanced Clean Cars (ACC) II regulations, and 9% of national light-duty vehicle (LDV) sales were electric in 2023. On the medium- and heavy-duty vehicle side, 15 states signed a 2020 Memorandum of Understanding to accelerate freight electrification, aiming for 30% of new medium and heavy-duty sales to be zero-emission by 2030 and 100% by 2050, and 11 states have officially adopted California's Advanced Clean Trucks (ACT) rules.[170]

However, successful implementation of these sales targets will hinge on supportive state policies and initiatives. Additionally, national vehicle miles traveled (VMT) is projected to increase by 0.6% annually through 2040.[171] As such, plans that incorporate sustainable modes of transportation and discourage the use of single-occupancy vehicles will also be important for decarbonizing the sector.

1. Sector Pathway

Following the electricity sector, the transportation sector is the second largest source of emissions reductions in both scenarios, primarily driven by road vehicle electrification. Under ***Current Policies***, existing actions including IRA tax credits for electric vehicles (EVs), Corporate Average Fuel Economy (CAFE) standards, and state-level incentives and zero-emission vehicle (ZEV) mandates achieve GHG emissions reductions of 36% between 2020 and 2035 (573 $MtCO_2e$). New LDV electric sales reach 68% in 2035, while electric sales for freight trucks reach 16%. Overall road passenger demand increases by 23% between 2020 and 2035.

Under ***Enhanced Ambition***, a combination of extended IRA tax credits for EVs, and enhanced state-level EV sales targets, low-carbon fuel standards, and VMT reduction targets drive emissions reductions of 50% between 2020 and 2035 (790 $MtCO_2e$). New LDV electric sales reach 82% in 2035, with the share of LDV electric stock growing to 44%. Electric truck sales reach 42% by 2035. Beyond electrification, states increase the use of biofuels through low-carbon fuel standards and implement VMT reduction policies that reduce the use of single-occupancy vehicles while increasing the use of sustainable modes of transportation. This leads to an increase in road passenger service of only 8% from 2020 levels by 2035, which is a 65% decrease compared to ***Current Policies***.

Our results show that the transportation sector has the largest opportunity for electrification and can be a key source of emissions reductions. However, while recent trends have been positive for passenger vehicle electrification, continued progress, especially for freight vehicles, will be needed to achieve the levels modeled in our results. Recent lawsuits on state-mandated ZEV sales targets may pose significant roadblocks as well. Additionally, only a few states currently have VMT reduction targets, and associated implementation pathways still need to be finalized.

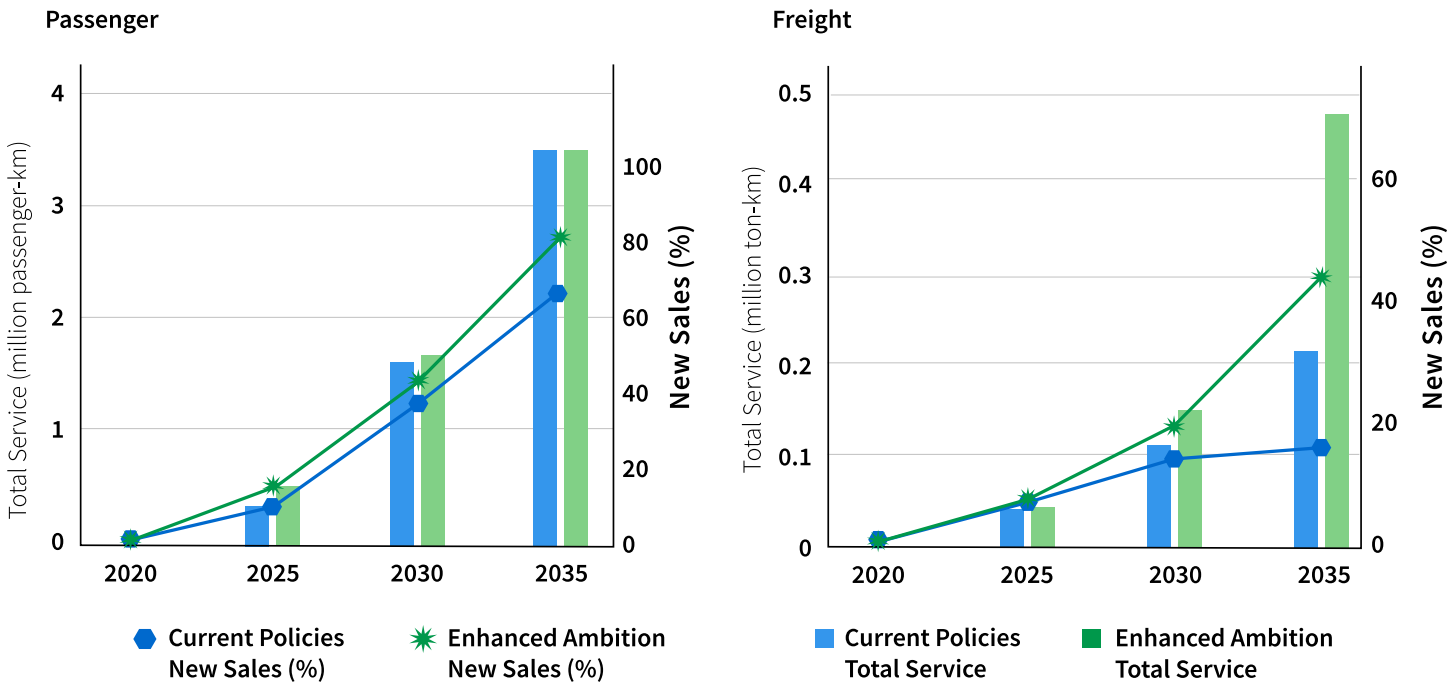

Figure 5. New sales and total service for road passenger and freight vehicles. *The bars show total EV service in units of million passenger-km for passenger vehicles and million ton-km for freight vehicles, and the lines represent new EV sales. By 2035, EV sales for passenger cars and SUVs increase to 68% under Current Policies and 82% under Enhanced Ambition. EV sales for freight trucks increase to 16% under Current Policies and 42% under Enhanced Ambition.*

2. Challenges and Barriers

Barriers to decarbonizing the transport sector include issues related to accessing EV infrastructure, the high upfront costs of EVs, potential shortages of critical resources and clean electricity, difficulties associated with implementing VMT reduction policies, and the limited scalability of technologies to decarbonize freight. Achieving the level of decarbonization in the ***Enhanced Ambition*** scenario would require overcoming these challenges.

Political roadblocks. While a growing number of states have adopted ZEV sales targets, there has also been significant pushback. Kentucky and Louisiana have passed laws prohibiting state-mandated targets, and a handful of other states are in various stages of the legislative process.[172-177] Additionally, two ongoing lawsuits from many states are suing the EPA's heavy-duty vehicle emissions standards and California's Advanced Clean Fleets.[178]

Access to EV infrastructure. Research has shown that access to both home charging and public fast charging is vital for the adoption of electric vehicles.[179] Though the National Renewable Energy Laboratory estimates that the United States will need 28 million EV charging ports by 2030,[180] there are only 189,000 charging ports currently in operation,[181] underscoring the need to accelerate deployment of charging infrastructure. It is also crucial to improve the efficiency and maintenance of current and future EV infrastructure, as built EV infrastructure has low functionality rates in certain regions, like the Greater Bay Area in California.[182] Moreover, there are disparities in access to charging across income, racial, and ethnic groups, as well as between urban and rural areas. Black, Hispanic, low median-income, and rural households are less likely to have access to chargers, especially in multifamily unit dwellings.[183] As EVs are deployed through 2035, it will be important to ensure that supporting infrastructure is widely available in all types of communities, public and private.

High upfront costs of EVs with a nascent used market. Despite the significant savings from reduced fuel and maintenance costs,[184] the current upfront cost of EVs makes them inaccessible to most consumers in middle and low-income groups. The EV market is primarily composed of luxury cars; the majority of EVs cost over $30,000.[185] This price point is unaffordable for most families, even after taking into consideration federal tax credits, as the median U.S. household income is just over $70,000.[186] Additional subsidized options and lower-cost EVs can help ensure all income groups are able to obtain an EV at an affordable price. Furthermore, the used EV market remains nascent, with EVs comprising less than 1% of the used car market.[187] Limited availability of affordable, pre-owned EVs further restricts access for low- and middle-income consumers.

Supply of critical resources. Many resources needed to electrify transport, such as lithium, cobalt, nickel, and platinum, have been classified as having a critical or near-critical supply risk.[188] Extraction of these materials has also raised significant environmental justice concerns, as they predominantly come from countries vulnerable to political instability or from highly energy-intensive processes.[189] As demand for EVs increases, so will the demand for these minerals, accentuating the need for material usage efficiency, ethical sourcing, and safe recycling practices. This presents a multifaceted challenge, balancing the urgency of transitioning to electric vehicles with the imperative of ensuring sustainable and equitable resource extraction.

Challenges with reducing vehicle miles traveled (VMT). While electrification plays a big role in decarbonizing the transport sector, reducing the use of single-occupancy vehicles and shifting to active and sustainable modes of transportation through VMT reduction policies is also important. However, applying effective VMT reduction policies in the U.S. context can be particularly challenging. Around 20% of the population lives in rural areas, which have limited or no access to public transportation and rely on private vehicles.[190] Suburbs, which house a substantial share of the U.S. population, are likewise largely reliant on private vehicle use. In urban areas, the development of public transit is costly, and other measures like congestion pricing can be politically unpopular.[191] Governments have historically prioritized building infrastructure for cars, which amplifies the challenge of decreasing car reliance.[192] Consumers may be hesitant to support VMT policies given the convenience of driving, easy access to economic opportunities, and potential safety concerns over alternative options such as public transit.

Scalability of technologies in hard-to-decarbonize sectors. Scaling up truck electrification is particularly difficult due to the limited supply of electric trucks, cross-border charging requirements, and high costs, especially for long-haul routes.[193] Long-term options like green hydrogen and ammonia may help electrify hard-to-decarbonize freight transport but require additional research and development.[194] In aviation, battery- and hydrogen-powered aircraft are currently under development, but these technologies are still in the early stages and will not replace liquid fuels in the near future. The use of sustainable aviation fuel, derived from renewable feedstocks like biomass, offers a potential 80% reduction in carbon intensity in the sector but currently accounts for less than 0.1% of global aviation fuel due to supply limitations and cost barriers.[195]

Current Policies
Electric LDV Stock Share in 2035

Enhanced Ambition
Electric LDV Stock Share 2035

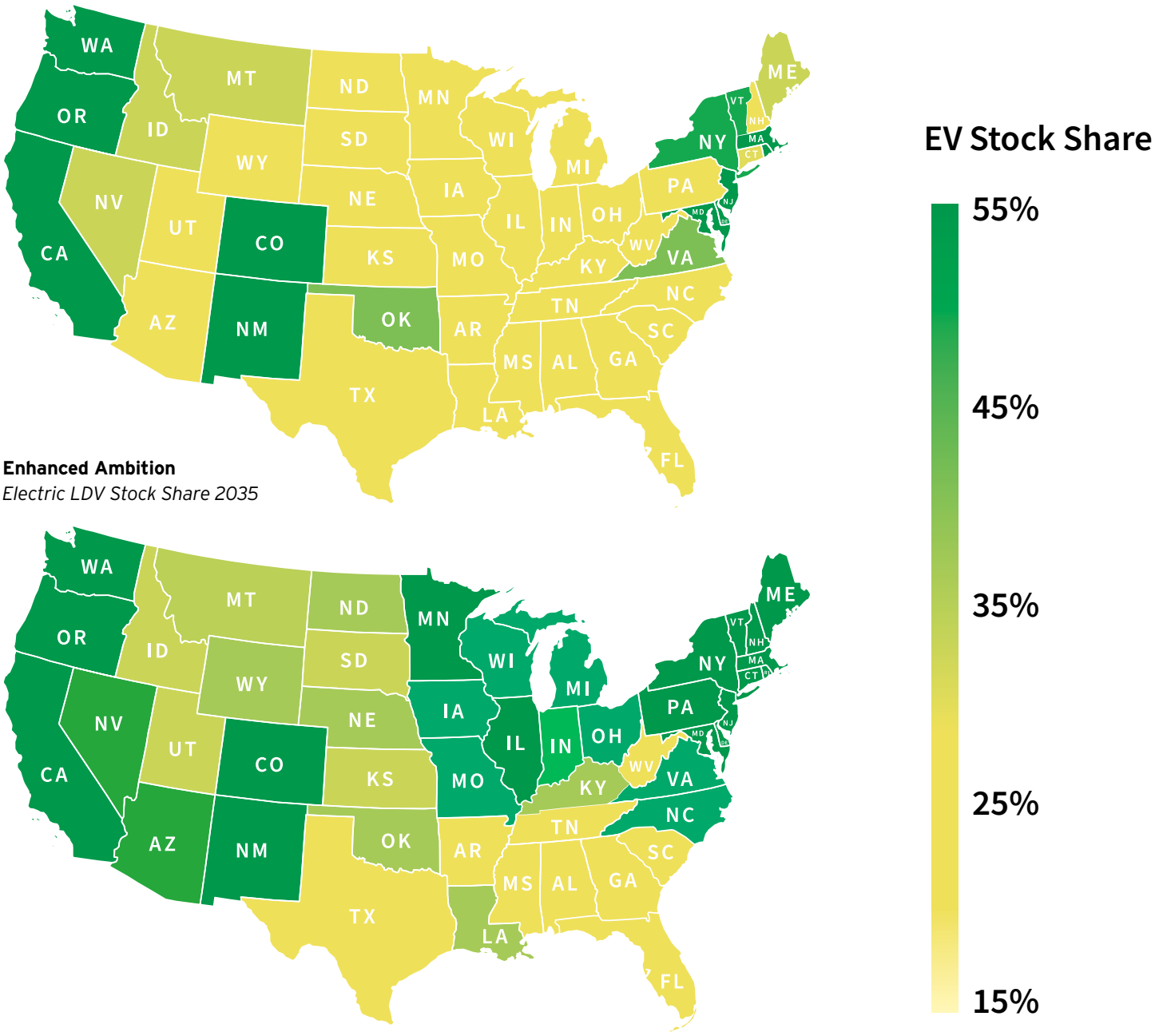

Figure 6. State-level share of electric LDV stock under Current Policies and Enhanced Ambition in 2035.

3. Implementation Pathway

Key policy #1: Widespread adoption of EVs. *Supportive policies include tax credits and rebates, sufficient EV infrastructure buildout, a reliable supply chain, and fleet commitments from governments, coalitions, and businesses.*

SUPPORTING POLICIES AND ACTIONS

Federal

Tax credits: Offering financial incentives for purchasing EVs through tax credits or rebates is one of the best ways for governments to increase EV adoption. The IRA established a federal EV tax credit of up to $7,500 for the purchase of new EVS and $4,000 for used EVs. With varying state-level incentives, a federal program is crucial for addressing disparities in EV adoption. Extending the IRA's tax credits for purchasing new and used EVs can continue to incentivize EV deployment.

Fuel efficiency and air quality standards: By passing stringent standards on both fuel efficiency and air quality, the federal government can shift the market toward EVs. CAFE standards, combined with the EPA's recently updated tailpipe emissions standards, require auto manufacturers to increase the average fuel economy of their fleets, which would increase new EV sales. These standards are anticipated to have an annualized savings of $46 billion in fuel costs, $16 billion in maintenance costs, and $13 billion from reduced health impacts.[11]

Charging and fueling infrastructure grants: DOE offers grants of up to $2 million for large-scale renewable energy planning and siting projects, including EV charging infrastructure.

Guidance on infrastructure buildout: The National Zero-Emission Freight Corridor Strategy from the Joint Office of Energy and Transportation lays out an all-of-government approach to align investments and accelerate the deployment of a zero-emission freight network with ubiquitous and convenient charging infrastructure access.

State

Point-of-sale tax credits and rebate programs: Several states, including California, Delaware, Maryland, and New York, offer rebates and tax credits for purchasing or leasing a new or used EV, ranging from $1,000 - $12,000. In Maryland, these tax credits helped increase EV sales by more than 59% in 2023.[196] To reduce barriers for low- and moderate- income (LMI) individuals and households, states can provide an instant rebate or tax credit at the point-of-sale, as seen in Washington's new EV rebate program for low-income drivers.[197]

Infrastructure investments: To support accelerated EV deployment, states can provide monetary incentives for EV charging infrastructure, as well as improve their own infrastructure through programs and partnerships. California's Electric Vehicle Infrastructure Project provides incentives for EV charger installations and works with local partners to support regional EV needs. This program has also set aside $29.8 million for installing charging connections in low-income and disadvantaged communities.[198]

School bus electrification programs and mandates: School bus electrification can help decarbonize transportation while also reducing pollution and adverse health impacts for children across the country. Electric school bus commitments exist in nearly all states, and seven states have legislation mandating a zero-emission school bus transition.[199] It will also be important to ensure that electric school buses are allocated to low-income and minority households, who historically have suffered the most from air pollution.[200,201]

Non-monetary incentives: In addition to subsidizing the cost of EVs, states can increase EV adoption through policies that provide additional benefits to EV owners. Maryland exempts qualified EVs from emissions testing and inspections, while New York allows eligible energy-efficient vehicles to use carpool lanes regardless of the number of passengers.[202]

Freight truck ZEV sales mandates and targets: Establishing state-level EV sales targets sends signals to auto manufacturers and moves the market toward EVs. A growing number of states have adopted or announced the adoption of California's Advanced Clean Trucks (ACT), which requires an increased share of medium- and heavy-duty EV sales between 2024 and 2035.[170,203] Adopting ACT is expected to lead to health benefits ranging from $18.8 - $49.9 billion between 2020 and 2050 in states including North Carolina, Maryland, New York, and Pennsylvania.[204,205] Additionally, California has passed Advanced Clean Fleets (ACF), which requires private and public fleets to phase in the use of ZEVs starting in 2024; this is estimated to save owners over $48 billion in operating costs through 2050.[206]

Local

Infrastructure planning and investments: Local governments play an integral role in expanding EV charging infrastructure. Cities like Orlando,[207] Boston,[208] and Columbus[209] have implemented EV readiness ordinances, requiring new buildings and major remodel projects to integrate EV charging infrastructure.

Consumer awareness: Local governments can create education and outreach programs to increase understanding of the benefits of EVs and available incentives, targeting consumers from historically disadvantaged communities to address current gaps in EV accessibility. Austin, Texas has a partnership with Austin Energy to ramp up EV adoption and awareness through an EVs for Schools program that offers EV education to economically disadvantaged schools.[210]

Interregional coordination: The Climate Mayors Electric Vehicle Purchasing Collaborative leverages the buying power of Climate Mayors, a bipartisan network of U.S. mayors who demonstrate climate leadership, to accelerate fleet transitions by reducing the costs of EVs and charging infrastructure.[211] The Collaborative also provides training, best practices, educational resources, and analysis support, creating a one-stop shop to support EV transitions for public fleets.[212]

Other

Utility incentives: Many utilities offer resources for consumers to maximize savings when making the switch to an EV. Alabama Power, for instance, offers eligible residential customers a $500 rebate for the purchase and installation of a Level 2 charger,[213] while Alaska Electric Light and Power offers discount charging rates during off-peak hours.[214]

EV production commitments: Commitments from the auto manufacturing industry will be important for complementing EV mandates and incentives. For example, Stellantis has partnered with California to comply with its mandated sales targets, even if the state is unable to enforce its standards in the future.[215]

Collaboration, education, and advocacy for electric freight trucks: Electrifying medium- and heavy-duty vehicles comes with unique challenges and will require additional education and support. The Powering America's Commercial Transformation coalition unites truck manufacturers, commercial fleets, charging infrastructure developers, technology providers, and utilities in a collaborative effort to support the transition to commercial ZEVs.[216]

Business commitments: Businesses, companies, and organizations can each take part in reducing emissions in their supply chain by committing to switching over to EVs to transport their goods and services. Amazon plans to incorporate 100,000 EV delivery vehicles by 2030, and FedEx aims for an all-electric global pickup and delivery fleet by 2040.[217]

Key policy #2: Reduce VMT. *With VMT on the rise, policies are needed to shift away from single-occupancy vehicle use and toward more sustainable modes of transportation. Careful local planning and decisions to not expand highways can help achieve this key policy.*

SUPPORTING POLICIES AND ACTIONS

Federal

Public transit funding: To expand state and local public transit options, the federal government can provide critical funding and grant programs to build out current infrastructure. Programs like the Capital Investment Grants and Expedited Project Delivery Pilot programs include investments in new and expanded subway systems, commuter rail, light rail, streetcars, and bus rapid transit.[218]

State

VMT reduction targets: State-level VMT reduction targets can help states achieve their climate targets and bring co-benefits, i.e. air pollution reduction. California, Connecticut, and Minnesota have on-the-books VMT reduction targets with short-term goals as early as 2030 and long-term goals to 2050.[219-221] While establishing targets is a key first step, more work is needed to design and implement policies that can successfully reduce VMT.

Highway funding reconsiderations: States can opt to use federal transportation funding for public transit projects rather than expand highways.[222] Colorado adopted a 2021 rule that requires planning organizations to demonstrate how new highway projects can reduce greenhouse gas emissions to keep their funding. This led to the cancellation of two major highway expansions.[223]

Expansion of public transit programs: Reducing VMT requires offering high-quality, affordable transportation alternatives. Michigan, for instance, received over $72 million in BIL funding to deploy zero- or low-emission transit buses and related infrastructure. The state can use this funding to help its cities expand their clean transit fleets.[224]

Local

Sustainable planning practices: Local government implementation of sustainable planning practices can make cities more walkable and increase safety while reducing VMT. In Houston, Texas, major multimodal plans and policies aim to encourage easy access to transit and decrease average VMT.[225] Additionally, the regional government for the Portland, Oregon metropolitan area established an enforceable urban growth perimeter to ensure efficient land use and transportation systems.[226]

Congestion pricing: Congestion pricing can be used to make driving single-occupancy vehicles more expensive and less convenient, pushing commuters toward less carbon-intensive modes of transit. Though postponed, New York City's congestion pricing initiative would charge a toll to vehicles entering the Congestion Relief Zone in Manhattan.[227]

Expansion of bus rapid transit (BRT): BRT offers a low-cost transportation option while reducing emissions. Several jurisdictions across the country are investing in BRT systems to make public transportation a reliable alternative to car use, including Wake County, North Carolina, which plans to dedicate 20 miles of transit lanes to BRT routes by 2035,[228] and Omaha, Nebraska, which launched a city-wide BRT network with an estimated impact of $450 million.[229]

4. Implementation Spotlight

Promoting micro-mobility. A key component for enabling widespread VMT reduction is increasing access to alternative transportation methods, including micro-mobility options such as bicycles and scooters, both traditional and electric. Colorado, for instance, has implemented a statewide e-bike rebate program that provides a $450 point-of-sale rebate on e-bikes.[230] Bike share programs, which allow individuals to rent out a bicycle at a public docking station for a fee, are becoming more common across the country as well. To make micro-mobility a more reliable, equitable, and accessible alternative to car use, the City of Madison, Wisconsin launched the Community Pass Program, operated through its public library system.[231] The program allows library cardholders to check out a bike helmet and a week-long pass to the city's bike share program at no cost, providing access to more than 50 bike share stations located across the city.

Equitable allocation of EV incentives. Ensuring that LMI households have access to EV incentives will be critical for policy uptake. Updates to the federal clean vehicle tax credit expand access for LMI households by employing point-of-sale rebates, which allows consumers to take full advantage of the credit upfront at the point-of-sale and regardless of tax eligibility.[232] States can adopt similar measures. For example, Washington's EV Instant Rebate Program offers $2,500-$9,000 off the sticker price or lease price at the point of sale, exclusively for households making 300% or below the national poverty level.[197] Beyond ensuring an equitable distribution of tax credits, governments must ensure adequate financing for the tax credit and rebate programs. Some programs are oversubscribed,[233] discouraging consumers from purchasing EVs if they are unable to afford the upfront cost without the incentive programs.

BOX 4. ADDRESSING A RISE IN ELECTRICITY DEMAND

In the last two decades, energy efficiency improvements – through utility efficiency programs, federal and state building efficiency standards, and more – have helped to curb electricity demand from population and economic growth.[234-236] However, with rising demand from EVs and electric appliances, heightened peak demand under climate change, and the proliferation of data centers across the country, electricity demand is expected to increase beyond historical levels in the near term. Recent studies have projected electricity demand to grow by 15% to 20% in the next decade after decades of remaining flat.[237,238] A heightened load would challenge the grid's capacity to deliver reliable and consistent electricity to businesses and residences. Addressing the unprecedented growth in electricity demand necessitates a combination of expanding transmission capacity, enhancing existing infrastructure, and investing in innovative energy efficiency technologies.

Despite enhanced incentives and market structures favoring clean energy projects, utilities are increasingly turning to new natural gas generation, including Georgia Power, Entergy Mississippi LLC, Dominion Energy, and more.[239] Natural gas-fired power plants can be started up quickly and meet sudden spikes in demand, while wind and solar are intermittently available and dependent on weather conditions. However, new natural gas plants are large investments that can hinder the clean energy transition and if retired early, incur additional costs to consumers. Several communities have formally gathered to express concerns over the environmental implications of proposed natural gas-fired power plants, the lack of pursuit of clean energy options by utilities, and the desire for more local involvement in the decision-making process.[240,241]

However, solutions other than adding new natural gas plants exist, and should be leveraged by policymakers. The ***Enhanced Ambition*** scenario in this analysis contains VMT reduction policies in the transport sector and energy efficiency measures in the buildings and industry sectors. Other key solutions include:

Strengthening the existing power grid: Grid-enhancing technologies (GETs) enable existing power infrastructure to better respond to fluctuations in power supply and demand with integrated automated controls, advanced sensors, and real-time monitoring systems.[242] Demand response technologies, energy storage systems, distributed energy resources (DERs), and microgrids also reduce the need for new transmission infrastructure by effectively managing peak loads and enabling variable renewable energy sources to interconnect onto the grid.[243-245]

Building renewables and storage with existing infrastructure: Additional solar and wind projects can be connected to the grid by reusing existing interconnection infrastructure, such as sites of retired coal plants. A recent Rocky Mountain Institute study identified 250 GW of potential capacity available for these projects.[246] These projects are likely eligible for IRA incentives and funding for energy communities, such as the energy community tax credit bonus and the Energy Infrastructure Reinvestment program.

Shifting electric usage with demand-response programs: Demand-response programs like flexible vehicle charging can help taper demand during peak hours. CPS Energy in San Antonio, Texas, for example, offers residential customers a $125 credit for EV charging during off-peak hours.[247] Additionally, vehicle-to-grid (V2G) charging technology sends power back to the electric grid when needed through bidirectional charging.[248] In 2022, New York City deployed the first V2G charging station that exports energy back to the grid during times of peak demand.[249]

Buildings Sector

The buildings sector accounts for 13% of economy-wide GHG emissions. Overall buildings sector emissions have increased by nearly 9% from 2010 levels.[250] This sector includes buildings that serve a range of purposes, including residential and commercial buildings. Buildings have a cross-sectoral impact on emissions, including emissions from the production and transport of building materials, land-use decisions for building development, and the growing power sector demands from electrifying buildings. Building decarbonization is dependent on effective carbon abatement in other sectors, and has the potential to not only deliver climate goals but also provide consumer savings, improve public health, and spur local economic growth.[251]

1. Sector Pathway

The buildings sector in our model accounts for residential and commercial buildings; industrial buildings are accounted for in the industrial sector.

In the buildings sector, ***Current Policies*** including IRA tax credits for building electrification and efficiency and state energy efficiency resource standards (EERS) drive emissions reductions of 14% between 2020 and 2035 (77 $MtCO_2e$). As a result of these policies, the electric share of hot water and space heaters increases from 20% in 2020 to 29% by 2035, and building electrification increases from 54% in 2020 to 59% in 2035. Energy demand stays relatively stagnant (a 2% decrease in 2035, relative to 2020 levels).

Under ***Enhanced Ambition***, the extension of IRA incentives alongside the expansion of state-level efficiency and electrification initiatives and standards reduces building sector emissions by 39% between 2020 and 2035 (211 $MtCO_2e$). Final energy demand falls by 16% between 2020 and 2035 due to additional efficiency gains. Building electrification expands under Enhanced Ambition, rising to 65% of the final energy share in 2035. As most electrification standards target hot water and space heating appliances, the electricity share for these specific appliances will increase to 38% by 2035.

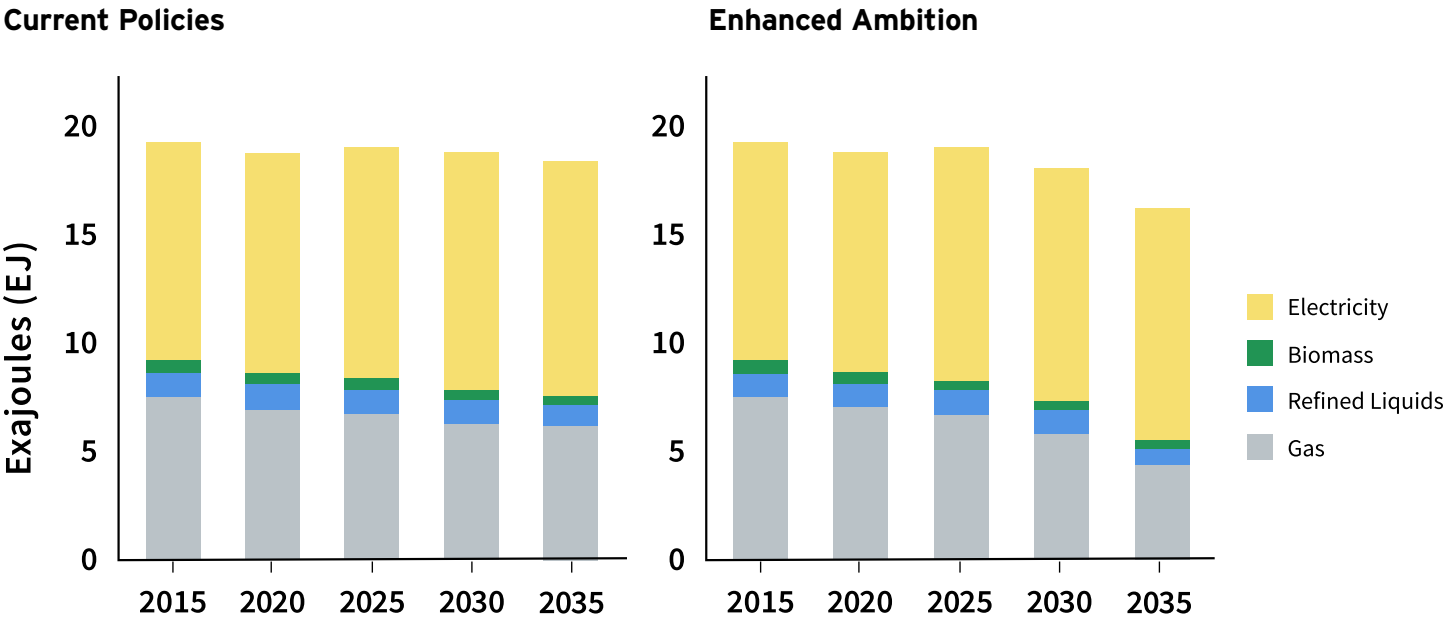

Figure 7. Buildings final energy by fuel under Current Policies and Enhanced Ambition, in units of exajoules (EJ). *Under the Enhanced Ambition scenario, the share of electricity increases from 54% in 2020 to 65% by 2035 as a result of electrification incentives and mandates, compared to 59% under the* ***Current Policies*** *scenario. Additionally, total energy demand decreases in the* ***Enhanced Ambition*** *scenario as a result of enhanced energy efficiency measures as well as a higher share of electricity, which is more energy efficient than other fuels.*

2. Challenges and Barriers

Successful building sector decarbonization faces a range of challenges including characteristics of existing building stock, cost, consumer perception and information access, state and local-level political and legal constraints, and reliance on other sectors. Achieving the level of decarbonization in the ***Enhanced Ambition*** scenario would require overcoming these challenges.

Characteristics of existing building stock. The varied nature of U.S. buildings presents both barriers and opportunities for decarbonization. In some regions, a substantial fraction of buildings are older, which makes retrofits more expensive and heat pumps incompatible in some contexts.[252] New construction poses opportunities for all-electric or electric-ready construction but is largely concentrated in states with limited climate ambition.[253] Among residential buildings, multi-unit dwellings and rentals have additional barriers to uptake compared to single-family homes and those occupied by their owner.[254] Additionally, LMI communities often have outdated building infrastructure that requires renovation before the installation of zero-emissions building (ZEB) technologies, which increases overall cost.[255] Commercial buildings sometimes have unique energy needs. As a result, segments of this sector such as commercial kitchens, laundromats, and hospitals are often excluded from state or city-level electrification mandates due to difficulty electrifying end uses.[256]

Appliance cost. ZEB technologies are generally more accessible to wealthier households due to appliance cost. While appliance retrofits in existing buildings yield savings over time, the delayed cost-savings may disincentivize uptake by consumers.[257] In residential buildings, split incentives exist in rental properties, where the owners are not incentivized to pay for building upgrades that would save tenants on their energy bills.[257,258] In cases where the owner pays for the upgrades, the tenant may end up having a higher rent burden. However, all-electric new construction is cheaper compared with fossil-based construction and yields savings on operating costs both one year out and fifteen years out.[259]

Consumer perception of ZEB technologies. Concerns about reliability and lack of visible ZEB deployment among neighbors have slowed adoption.[260] Further, companies operating in LMI communities often do not offer ZEB technologies due to the assumed lack of potential demand and the need to train specialists, limiting installation opportunities in some communities.[257]

Political and legal constraints. Tensions between state and city policy goals and ongoing legal challenges further hinder building decarbonization, particularly electrification. As of June 2023, 24 states have adopted laws preempting natural gas bans, preventing local governments from preventing new installations of gas appliances. In response to ongoing legal challenges, in March 2024 Berkeley, California repealed a law that would have banned natural gas hookups in new homes, spurring a wave of gas ban withdrawals across the ninth circuit, including in Eugene, Oregon, and Santa Cruz, California.[261,262]

3. Implementation Pathway

Key policy #1: Zero-emissions heating, hot water, and construction. *Electrifying current and new building stock enables emissions reductions, health improvements, and cost savings among both residential and commercial buildings, but expanding fossil-free appliance buildout at the speed required to meet climate targets necessitates further action.*

SUPPORTING POLICIES AND ACTIONS

Federal

Federal green buildings: Federal buildings make up a substantial share of national building stock. Under Executive Order 14057 on Federal Sustainability, the Biden-Harris Administration directed federal agencies to achieve net-zero building emissions by 2045, with a mid-term goal of 50% reductions by 2032.[263]

Equitable retrofit financing: Many low-income renters in the United States live in housing operated by the Department of Housing and Urban Development (HUD). HUD's Green and Resilient Retrofit Program, established under the IRA, provides loans and grants for renovations and has been used to replace gas heating and cooling with heat pumps in public apartments.[264]

State

Zero-emission appliance sales: Expansion of policies requiring zero-emission new appliance sales, particularly for space heating and water heating, can help mitigate emissions from this sector. Proposed rulemaking in California would ban sales of fossil-fuel-powered space heaters and water heaters beginning in 2030,[265] while in Washington, D.C., a similar policy applies to residential buildings under 3 stories.[266]

Zero-emission buildings: Some states go further, requiring zero-emission new buildings. New York's building electrification policy bans all fossil fuel hookups in new residential and commercial buildings beginning in 2026, expanding beyond heating to include cooling, cooking, clothes dryers, and other uses. Exceptions apply to commercial buildings that are more difficult to fully decarbonize, such as hospitals and restaurants.[267]

Electrification incentives: States can also provide incentives for upgrading to electric appliances, which often have high upfront costs. Iowa's geothermal heat pump tax and geothermal tax credit credit provide homeowners with incentives upon installation.[268]

Local

Zero-emission appliance sales: New York City's gas hookup ban phases fossil fuels out of new buildings beginning in 2024 for low-rise buildings, expanding to taller buildings in 2027.[269]

Zero-emission buildings: Given that many appliances have long lifetimes of 30 years or more, some entities favor the electrification of both new and existing appliances. Ithaca, New York has a target for all-electric buildings by 2030, covering all buildings, requiring that both new buildings and existing buildings decarbonize rapidly.[270]

Electrification incentives: Water heating accounts for a substantial share of residential building emissions, but high retrofit costs limit uptake. Residents of Orleans Parish in New Orleans, Louisiana, are eligible for rebates on heat pump water heater purchases.[271]

Other

Real estate organizations: Under the Better Climate Challenge, organizations including major real estate portfolio owners partnered with the DOE to reduce emissions.[272]

Green schools: Encourage clean new construction across public facilities owned by state or local governments. In Maryland, the Decarbonizing Public Schools Program uses funds from the Maryland Energy Administration to build net-zero energy schools.[273]

Utility planning: Broader electrification will shift demand from gas and other fuels towards electricity. Utilities need to plan for expanded electrification within this sector.

Key policy #2: Enhanced energy efficiency measures. *At COP28, the United States and dozens of other countries pledged to reach 4% annual efficiency savings by 2030.[274] To achieve this target, all levels of society must implement new efficiency measures and enhance those that currently exist.*

SUPPORTING POLICIES AND ACTIONS

Federal

Tax credits and rebates: Extension of IRA provisions that finance residential and commercial energy efficiency retrofits can bring about additional financial and energy savings for consumers.

Energy efficiency standards for new homes: The federal government can help ensure that new homes have embedded energy savings in their construction. HUD and USDA updates to energy efficiency standards, for example, would impact affordable housing apartments and starter homes insured by the USDA, which is nearly a quarter of all new homes.[275]

Appliance standards: The federal government has the authority to set appliance standards, which have historically been crucial in driving down emissions and providing consumers with energy savings. Federal regulations mandating efficient appliances, including light bulbs, furnaces, and clothes dryers, will drive down energy use in buildings.[276]

Equitable retrofit financing: HUD's Green and Resilient Retrofit Program, established under the IRA, provides loans and grants for renovating public housing and has been used to improve energy efficiency and climate resilience.[264]

State

Energy efficiency standards: Historically, states' largest lever in boosting efficiency has been the enactment and gradual enhancement of Energy Efficiency Resource Standards (EERS). Strengthened EERS for electricity and gas can drive down emissions and mandate that utilities invest in efficiency programs to attain annual final energy reductions.[277]

Data center policies: Data center growth could considerably increase energy demand from commercial buildings over the next decade. Among data centers, enhanced standards are needed to incentivize improvements in computational efficiency and cooling technology to reduce overall electricity demand.[278]

Local

Outreach and education: Cambridge, Massachusetts had a week-long partnership with Eversource to offer small businesses no-cost energy audits, and provide information on efficiency improvements and upgrades.[279]

Other

Tightened building codes: The International Energy Conservation Code, which sets model codes with minimum energy efficiency requirements for new and renovated buildings, can enhance efficiency baselines used by governments.

Utility efficiency improvement: In some states, utilities must periodically update regulators on the status of efficiency attainment and their plans for future efficiency programs. In Massachusetts, utilities must collect and report overall savings and track savings by income group, to ensure programs are being delivered successfully in underserved communities.

4. Implementation Spotlight

Expanding consumer education. Broader education is needed to support building decarbonization, especially in the residential sector. Many residents are unaware of efficiency and electrification incentives and need help navigating these programs. Misconceptions about the safety and climate impact of natural gas, along with concerns about electrification reliability, highlight the need for better education on resiliency, health, and comfort. In the commercial sector, a lack of education among building managers and occupants can hinder efficiency gains. Beyond understanding financial incentives, they need training in using new technologies to maximize building performance. Tying rebate rates to recorded performance, as with the IRA's Home Owner Managing Energy Savings (HOMES) rebate could incentivize optimal use of green technologies. Additionally, energy audit programs such as Miami Dade County's free scalable energy assessments offer building operators insights on current energy use and provide a roadmap for improvement.

Leverage existing institutional infrastructure. Utilities have significant power to reduce emissions through efficiency measures, but efficiency programs vary widely, and some utilities lacking them altogether. Expanding incentives for energy-efficient equipment has helped, but utilities can further improve by enhancing building-grid interactions and reducing peak demand. Mandatory training for realtors and contractors on green building strategies could also promote wider adoption of these technologies. Home purchases and unexpected appliance replacements offer key opportunities for energy assessments and efficient upgrades, but consumers need to be informed of their options. However, efforts to mandate realtor and contractor training on efficiency measures have faced resistance from industry groups, making it difficult to pass such requirements in state legislatures.

Removing cost barriers. Efficiency and electrification efforts are often hindered by costs and split incentives. With low electricity and gas prices, switching to electric or investing in efficiency is a low priority, especially given the high upfront costs. The split-utility incentive in residential buildings further discourages both owners and tenants from making efficiency investments. Cost challenges may be addressed through broader use of cash rebates at the point of purchase, as exists in the IRA's High-Efficiency Electric Home Rebate Program, expansion of low- or no-interest financing, and inclusion of energy efficiency loans when refinancing. Existing programs in several cities and states enable green technology proliferation in low-income households, including the city of Austin's waiver on permitting fees for affordable housing projects in Austin and the Oregon Community Heat Pump Program, which subsidizes heat pump installations for priority households, both rentals and privately owned.

Industry Sector

Industry emissions represent 30% of U.S. GHG emissions.[98] These emissions come from energy consumption, chemical reactions, and the burning of fossil fuels necessary for manufacturing. Five carbon-intensive subsectors – iron and steel, cement, chemicals, petroleum refining, and food and beverage – contribute over 50% of the energy-related CO_2 emissions in the U.S. industrial sector.[280]

Industry has lagged behind other sectors in terms of decarbonization. The sector's diversity and reliance on high-temperature processes, like cement production, create challenges for decarbonization. While the IRA and BIL provide substantial funding and tax credits for clean fuels, carbon capture, and technology demonstrations, further efforts are needed to continue decarbonizing the sector.

1. Sector Pathway

In the ***Current Policies*** scenario, industrial GHG emissions remain flat from 2020 to 2035, with the expansion of industrial production outweighing reductions achieved through IRA's credits for captured CO_2, production of clean hydrogen, and manufacturing investment.

Under ***Enhanced Ambition***, additional policies reduce industrial emissions by 22% (243 $MtCO_2$) in 2035. While the electricity share of final energy hovers around 25% in 2035, which is similar to ***Current Policies***, CCS plays a larger role in this scenario. We assume enhanced uptake of IRA's 45Q tax credit for CCS, complemented by regulations that require CCS installation and state-level CCS targets, achieve 154 $MtCO_2$ sequestered in cement, ethanol, oil refining, hydrogen, and pulp and paper sectors, compared to just 15 $MtCO_2$ under Current Policies. Moreover, the introduction of direct air capture technology after 2030 sequesters 20 $MtCO_2$ annually by 2035.

To achieve the level of reductions in our scenario, the industrial sector will require acceleration in technological advancements and deployment of low-carbon fuels, feedstocks, and energy sources (LCFFES) and carbon capture and storage (CCS). However, these technologies need further development and demonstration to be commercially scaled, with supportive policies that promote their deployment.

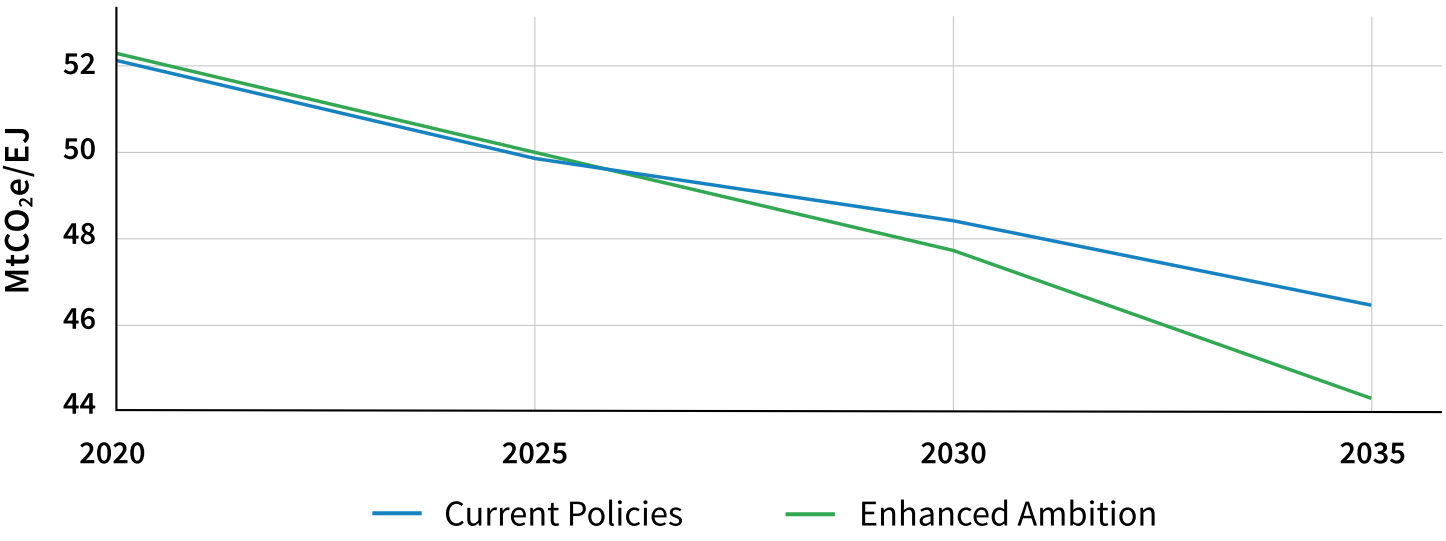

Figure 8. Industry energy intensity under Current Policies and Enhanced Ambition, in units of $MtCO_2e$/EJ (exajoules). *Industry energy intensity is measured by emissions ($MtCO_2e$) per unit of energy consumed (EJ). Under the Enhanced Ambition scenario, energy intensity decreases by 35% from 2020 levels by 2035, showing that the industrial sector becomes less emission-intensive over time with policies in electrification, efficiency, and CCS.*

2. Challenges and Barriers

Although significant advancements have been made in industrial decarbonization, achieving net zero emissions will be challenging. Key obstacles include the lack of technological maturity and commercial demonstration of low-carbon fuels, feedstocks, and energy sources (LCFFES), high retrofitting costs, and the hard-to-decarbonize nature of certain industrial processes. Additionally, scaling up carbon capture and storage (CCS) and ensuring the availability of clean electricity present challenges related to cost, infrastructure, and storage. Achieving the level of decarbonization in the ***Enhanced Ambition*** scenario would require overcoming these challenges.

Lack of technological maturity and commercial demonstration of LCFFES. Many LCFFES are first-of-a-kind technologies that have been proven to work at a small scale but have not been tested commercially, including the applications of hydrogen and less emissions-intensive clinker in cement. Concentrated Solar Power (CSP), which converts sunlight power into heat and electricity, can be used for many industrial processes, like food processing and chemical production. While significant progress has been made in reducing the cost of its application, the technology still needs to go through large-scale demonstrations before it can be adopted more widely in the industry.[281]

High retrofitting costs. The costs of installing low-carbon industrial equipment can be very high, especially if it has not become an industry standard. For example, in Ohio, the cost of replacing Cleveland Cliffs' existing blast furnace with a hydrogen-ready direct reduced iron plant and two electric melting furnaces totals $1.3 billion.[282] A $500 million DOE grant will help partially cover this cost, highlighting the need for external incentives to implement these technologies. Technology cost is particularly important for the industry sector, as it is a highly competitive environment with often narrow profit margins.[283]

Hard-to-decarbonize processes. Certain industrial sectors release emissions as a part of their production processes. Petrochemical-based products like clothing, tires, plastics, and detergents use oil as a fundamental component, making it intrinsically carbon-intensive.[284] Decarbonizing this sector would require an alternative feedstock to replace oil or the application of CCS technologies to capture carbon emissions. For similar reasons, other hard-to-decarbonize sectors include iron and steel, aluminum, cement, and food processing.

Scale-up of CCS technologies. The scale-up of CCS technologies will be important for capturing emissions that cannot be eliminated through other methods, though they come with their own set of challenges that impede their commercial viability in the near future. The cost of CCS technologies, particularly direct air capture technologies, can be a barrier for industries with high carbon emissions even with government subsidies.[285] Another challenge is the availability of pipeline networks to transport the carbon captured and the storage capacity.[286] Additionally, while the United States has robust policies and investments for different stages of CCS development and a growing number of large-scale CCS facilities, higher rates of project realization are necessary for successful scale-up.[287,288]

Limited availability of clean electricity. LCFFES and CCS require ample sources of clean electricity from renewable energy to operate and truly reduce emissions. Using gray hydrogen or fossil-fuel-generated electricity to power CCS and industrial equipment could counteract or even increase emissions. There is a need for large-scale deployment of renewable energy that can power industrial decarbonization while meeting other electricity demands, which is a significant challenge in itself.[289] This demand for renewable energy could be met in part by co-siting industrial facilities with renewable sources, which would reduce the need for additional transmission grid infrastructure. Similarly, on-site production of electrolytic hydrogen for applicable industries could avoid the need for hydrogen transportation infrastructure.

3. Implementation Pathway

Key policy #1: Promoting energy efficiency measures across all industry sectors. *Energy efficiency is a solution that has a high potential for emissions reductions in the near term by providing immediate results with no major change in infrastructure.*

SUPPORTING POLICIES AND ACTIONS

Federal

Promotion of industrial efficiency programs: Funding and technical assistance are crucial to bypassing the upfront costs of retrofitting infrastructure. Through its Better Plants Program, DOE partners with manufacturers and wastewater treatment agencies and provides them with technical assistance and resources to reduce energy consumption, water use, and waste.

Increase funding for research and development (R&D): Many technologies under development have the potential to significantly increase energy efficiency but are in need of funding to reach maturity. The DOE has allocated $38.3 million in R&D funding for nine pilot programs to increase energy efficiency and reduce the carbon intensity of high-volume chemical production for consumer and industrial products.[46]

Funding for demonstration programs: Reducing the risk of new technologies requires demonstrating their commercial viability. The IRA's Advanced Industrial Facilities Deployment Program provides financial support for energy-intensive facilities to complete demonstration projects, including advanced technology installation and early-stage engineering studies.[291]

State

Funding for energy efficiency projects: Several states have established funding programs to support industrial retrofitting. California's Food Production Investment Program provides grants to help food processors accelerate the adoption of advanced energy and decarbonization technologies to support grid reliability and reduce emissions.[292] Kentucky's Industrial Revenue Bonds program provides state and local government-issued bonds to industrial buildings to cover the cost of energy efficiency projects.[293]

Education and training: States have an important role to play in closing the knowledge gap regarding energy efficiency applications. Alabama's Industrial Energy Efficiency Program provides education and training on the use of alternative energy sources to help promote energy efficiency opportunities for small and medium-sized manufacturers.[294]

Local

Energy efficiency incentives: New York City's Con Edison Commercial and Industrial Energy Efficiency Program provides cash rebates and incentives for commercial and industrial energy efficiency projects, including the installation of energy-efficient equipment.[295] Education and outreach: The City of Palo Alto Utilities Commercial and Industrial Energy Efficiency Program provides consultations on energy usage and recommendations for energy saving.[296]

Key policy #2: Promoting the usage of LCFFES. *Deploying LCFFES at a commercial scale will require additional R&D funding, new equipment and feedstock standards, and shared standards to validate low-carbon products.*

SUPPORTING POLICIES AND ACTIONS

Federal

Funding for Research, Development, & Demonstration (RD&D): The DOE's Industrial Demonstrations Program has allocated $6 billion for 33 projects across 20 states to test emerging technologies at a commercial scale. Extending this program will be key to verifying the viability of future decarbonization technologies and decreasing implementation risks.[297] Approving the Concrete and Asphalt Innovation Act and the Innovative Mitigation Partnerships Act would fund and support research and demonstration of low-carbon technologies for asphalt and cement production.

Tax credits: Extending IRA tax credits for hydrogen production will further encourage the deployment and commercialization of these technologies.

Building supply chain capacity: Funding through the BIL, IRA, CHIPS and Science Act of 2022, and the Defense Production Act are helping build a domestic supply chain capacity for electrified heating technologies.[298]

Establish shared standards and data infrastructure: A clear set of criteria to distinguish low-carbon products will be key for setting new industry standards and providing information to buyers. For example, the EPA's Label Program for Low Embodied Carbon Construction Materials is aimed at creating a central registry of certified low-carbon construction materials and products.

Federal procurement policies: The federal government's purchase of low-carbon products can help create demand for these emerging technologies and encourage the implementation of low-carbon processes at all levels. The Federal Buy Clean Initiative mandates the federal government to prioritize the purchase of low-carbon steel, concrete, asphalt, and flat glass.

State

Procurement policies: State-level procurement policies would help create demand for low-carbon products. California is a leader in this area, having enacted the Buy Clean California Act, which establishes a Global Warming Potential limit for structural steel, concrete reinforcing steel, flat glass, and mineral wool board insulation that can be purchased by the state government.

Mandates for low-carbon technologies: States can also reduce emissions from their operations by updating the standards for industrial products to require the use of low-carbon materials, for example, cement with lower levels of clinker.

Funding for RD&D: Arizona State University will receive $70 million in federal funding until 2028 for RD&D projects to electrify process heating and decarbonize the industrial sector, which will both advance the national task to promote industrial electrification and will provide the State of Arizona with new opportunities in the sector.[299]

Local

Energy Use Intensity (EUI) Standards: Cities can promote decarbonized process heating by updating the respective requirements for commercial and industrial buildings in local building codes. For example, Denver requires industrial buildings that are 25,000 square feet or larger to meet EUI and to electrify when replacing space and water heating equipment.[300]

Key policy #3: Deployment of carbon capture and storage (CCS). *CCS will be key to removing the emissions that cannot be reduced from the previously mentioned solutions. In order to deploy CCS at the level needed for carbon neutrality, there are multiple policies federal, state, and local actors can undertake to ensure the appropriate conditions and infrastructure.*

SUPPORTING POLICIES AND ACTIONS

Federal

Permitting for CO_2 pipelines: Expansion of CCS technologies requires adequate buildout of CO_2 pipelines for transportation. To this end, the Consolidated Appropriations Act of 2021 established expedited federal permitting eligibility for CO_2 pipelines.[301]

Tax credits: Extension of IRA's tax credit for CCS technologies can further ramp up the deployment and commercialization of these technologies.

Funding for RD&D: RD&D funding can help reduce costs and increase the efficiency of CCS technologies. BIL provides $8.2 billion in advance allocations for CCS programs and research through 2026. DOE's Carbon Capture Demonstration Projects program provides $2.5 billion to accelerate the demonstration and deployment of CCS technologies.

Financing: BIL's Carbon Dioxide Transportation Infrastructure Finance and Innovation Program provides low-interest loans to realize economies of scale for commercial CCS.[302]

Guidance on best practices: CCS Guidelines by the Council on Environmental Quality aim to ensure that the CCS deployment is conducted in a responsible manner, with community input and a reflection of the best available CCS technologies.

State

CCS and CDR Targets: Several states are now at the forefront of CCS implementation, having established carbon dioxide removal (CDR) targets, including California's 40% cement CCS target by 2035 and a 15% emissions target for CDR by 2045. Other states with these types of targets include New York, New Jersey, Massachusetts, Maryland, and Colorado.[303]

Energy Financial Incentives for CCS: To encourage the development of and investment into CCS projects, several states have established financial incentive programs, including North Dakota, Wyoming, Montana, Kansas, New Mexico, Texas, Louisiana, Mississippi, Kentucky, and Illinois.[304] The incentives often used include direct financial assistance, tax incentives, state assumption of long-term liability, utility cost recovery mechanism, etc.

Local

Community engagement: In some cases, CCS projects have been canceled due to public opposition. Moving forward, local policymakers can focus on community engagement and education to build local support and reduce delays in permitting and approval processes, including working with the public to pick a low-impact storage site with few risks.[142]

Investment in CDR technologies: Cincinnati, Ohio, one of the leading cities in Biochar Carbon Removal policy, has invested in a biochar production facility to produce wood debris that can become a special carbon-capturing charcoal added into soil to store carbon.[305]

Other

Innovation with CDR: New technological approaches to CDR may enable more rapid deployment at scale. For instance, the startup Heirloom recently launched the first direct air capture (DAC) facility in the United States in Tracy, California. This facility uses limestone to extract carbon dioxide from the atmosphere and then injects it into concrete.[306]

Leveraging existing CO_2 pipeline networks: Transporting captured CO_2 through pipeline networks is necessary for underground storage. Currently, ExxonMobil owns and operates the largest network of CO_2 pipelines, with access to 15 onshore CCS facilities and the potential for more than 100 $MtCO_2$ transport per year.[307]

4. Implementation Spotlight

Promoting a circular economy. A circular economy focuses on extending product lifetimes and reusing materials and products already in circulation, thereby reducing the need for virgin material production.[308] This approach helps maximize the value obtained from resources, reduce waste and energy consumption, and lower emissions from industrial processes. The EPA has been developing national strategies to promote circularity, such as the National Strategy for Reducing Food Loss and Waste and the Recycling Organics program.[309] There has also been progress at the state and local levels. For example, the Austin Circular Economy Program provides resources and guidance to businesses interested in integrating circularity into their production processes.[310] However, more work is needed to develop a cohesive national plan that involves all industrial sectors and actively engages manufacturers and other stakeholders.

Establishing shared standards and data infrastructure to define and validate low-carbon products. Defining a clear low-carbon standard across industry sectors and manufacturing products will allow for consistent measurement and validation of emissions performance throughout the industry. For example, the California Air Resources Board's Low Carbon Fuel Standard sets benchmarks for reducing the carbon intensity of fuels.[311] This and similar initiatives promote transparency and accountability by making emissions data publicly available, informing stakeholders, and empowering potential buyers while fostering a culture of environmental responsibility.

BOX 4. HYDROFLUOROCARBONS (HFCS) PHASEDOWN

HFCs are widely used in products and industrial processes as cooling agents, solvents, aerosol propellants, and for other applications. Their consumption increased significantly in the past two decades due to their use as a replacement for ozone-depleting substances (ODS), which were phased out under the Montreal Protocol.[312] Despite being less damaging than ODS, HFCs are potent GHGs with a global warming potential that can be hundreds to thousands of times greater than that of CO_2.[313] The phasedown of HFCs can be challenging due to the significant costs associated with adopting new technologies and the risk of stranded assets in industries reliant on existing HFC-based equipment.

The Kigali Amendment establishes an international agreement to phase down the production and consumption of HFCs by 80-85% by 2047. State policies and commitments, as well as pressure from industry and environmental groups, led to the enactment of the American Innovation and Manufacturing (AIM) Act of 2020, a bipartisan bill that authorized the EPA to address HFC emissions by phasing down their production and consumption, reclaiming and minimizing HFC releases from equipment, and establishing sector-based restrictions.[314] Ensuring the effective application and enforcement of this ruling will be key for phasing down HFCs, through collaboration with industry stakeholders and reinforced with state and local actions.

States have the potential to lead in the phasedown of HFCs by enacting their own legislation to phasedown HFCs and supporting the industry in the transition toward alternative technologies. Colorado, Virginia, Maine, and a handful of other states have laws consistent with the HFCs restrictions developed under EPA's Significant New Alternatives Policy (SNAP) program.[315-317] Washington, California, and New York have also passed SNAP restrictions and produced rulings to limit further HFC usage in sectors like the food industry.[17] Some states also have Refrigerant Management Programs, which require facilities to conduct leak inspections and repair leaks from refrigerants, as well as use best practices to minimize refrigerant emissions.[318]

Land Use

The U.S. land sector, encompassing agriculture, forestry, and other land uses, is a critical yet often overlooked component of the nation's emissions profile. With enhanced policies, it has the potential to significantly reduce emissions and help the United States achieve its climate goals. In 2021, the U.S. land carbon sink sequestered 832 $MtCO_2e$ per year–highlighting the vital role of the national carbon sink in achieving an ambitious 2035 climate target.[319]

However, the land carbon sink is increasingly threatened by climate change, land use change, invasive species, and other disturbances. Land loss from wildfires and extreme weather events challenge efforts to preserve and expand the sink and wreak havoc on homes, businesses, food supply, and more.[319] Enhancing the land carbon sink is critical to not only achieve an ambitious 2035 NDC, but also to provide substantial local economic, health, and community benefits, including ecosystem resilience, biodiversity conservation, water and air purification, and disturbance regulation.[320]

1. Sector Pathway

In this analysis, land use, land-use change, and forestry (LULUCF) emissions for CO_2 and N_2O are adapted from ***America Is All In's*** previous analysis, "Harnessing the Land Sector to Achieve U.S. Climate Goals."[319] ***Current Policies*** assumes full implementation of federal and state policies already in place, which includes approximately $42 billion of planned investments in climate-smart agricultural practices, conservation policies, wildfire mitigation, and afforestation and reforestation efforts. Under the ***Current Policies*** scenario, the land sector increases carbon sequestration by 52 $MtCO_2$/yr compared to 2021 levels, reaching -884 $MtCO_2$ in 2035.

Under the ***Enhanced Ambition*** scenario, expanded climate-smart policies in the forestry and agricultural sectors and additional implementation policies including urban land use reform and wildfire mitigation total $160 billion in investments. With these expanded actions, the Enhanced Ambition scenario increases carbon sequestration by 96 $MtCO_2$/yr from 2021 levels, reaching -928 $MtCO_2$ in 2035.

2. Challenges and Barriers

Expanding the carbon sequestration potential of the land sector is complex. Several challenges threaten efforts to conserve and restore U.S. lands while safeguarding farmers, businesses, and communities, and ensuring sustainable food production. These barriers include natural disturbances, urban expansion pressures, threats to agricultural productivity, and political obstacles to securing funding and implementing climate-smart policies.

Natural disturbances such as wildfire, pests, flooding, drought, and more. As climate change worsens, the U.S. land sector faces increasing vulnerability to climate-related hazards such as storms, wildfires, and invasive species. These threats jeopardize the health, vitality, and carbon sequestration potential of U.S. lands. Wildfires, in particular, demand significant attention as they increase in frequency, extent, and severity. In the Western United States, home and structure loss due to wildfires has increased by 246% over the past two decades.[321] Effective wildfire mitigation and prevention policies are essential to protect forests from degradation and maintain carbon sinks.

Differing regional priorities for land use management. Maximizing the land carbon sink involves land use trade-offs. While it is critical to expand U.S. forests to increase carbon sequestration potential, converting large areas of agricultural land into new forests could interrupt food production. Effective land use management requires adequately addressing potential drawbacks while combating larger threats. Urban sprawl threatens to convert vital forests and agricultural lands, exacerbating the loss of cropland to commercial and residential development on productive soils.[322] This urban expansion displaces efficient agricultural production, requiring the conversion of less productive areas to compensate, and also threatens already vulnerable U.S. forestland.[323] Therefore, curbing land conversion is critical to protecting existing lands while protecting food production, biodiversity, and more.

Uncertainty in key federal legislation and funding for climate-smart land use policy. The 2018 Farm Bill expanded conservation, sustainable agriculture, and forestry-related initiatives that can further emissions reductions. However, due to congressional gridlock as of September 2024, the 2023 Farm Bill has yet to be finalized, and many key policies may be significantly weakened or removed. This delay and uncertainty hinder efforts to enhance carbon sequestration programs. States across the nation have already benefited from Farm Bill funds and many eligible projects nationwide are still awaiting funding.

3. Implementation Pathway

Key policy #1: Protecting and expanding U.S. lands. *Protecting forests through wildfire mitigation, conservation, and sustainable management is crucial for maintaining carbon sinks. Sequestration efforts can be expanded through reforestation and afforestation policies, research and development, and increasing seedling inventories to strengthen the defense against climate change.*

SUPPORTING POLICIES AND ACTIONS

Federal

Sustainable forest management: Forest management policies can optimize carbon storage in current stocks. The U.S. Forest Service's Forest Stewardship Program provides landowners with the necessary information and tools to sustainably manage their land.[324]

Land easements: Conservation easements can convert agricultural land back into forests or grasslands, thereby enhancing sequestration efforts. The Agricultural Conservation Easement Program assists landowners, land trusts, and other entities in protecting, restoring, and enhancing wetlands, as well as conserving working farms and ranches.[325]

Expanded funding for wildfire mitigation: The BIL provided a $3.5 billion investment in programs to reduce wildfire risks, detect wildfires, institute firefighter workforce reforms, increase pay for federal wildland firefighters, and establish the Community Wildfire Defense Grant Program.[326] Additionally, the Landscape Scale Restoration Program provides funding for prescribed fire burns that can reduce wildfire risk by reducing fuel loads.[327]

State

Wildfire mitigation funding: As wildfires become more severe and frequent, it's crucial to both mitigate their impacts and equip vulnerable communities with the knowledge to prepare. Many high-risk states have implemented their own programs to mitigate wildfires and build resilience. Colorado's Wildfire Mitigation Outreach Grant Program funds efforts that conduct outreach on wildfire mitigation to landowners in high wildfire-risk areas.[328]

Financial assistance for forest regeneration: New York's Regenerate New York Forestry Cost Share Grant Program supports forest regeneration by providing financial assistance for landowners to implement projects that promote healthy forest establishment and renewal.

Investment in forest nurseries: The United States currently faces a significant shortage of seeds and seedlings, making it increasingly difficult to meet reforestation goals.[329] In Colorado, the Updates to State Forest Service Tree Nursery Act provides funding to upgrade and improve its seedling tree nursery.[330]

Local

Promotion of community forests: The Forest Service's Community Forest and Open Space Conservation Program allows local governments, tribal governments, and qualified nonprofit entities to establish community forests with public access.[331]

Implementation of funding for tribes: California's Tribal Wildfire Resilience Grants fund projects for cultural burns, fuel breaks, native vegetation planting, biodiversity, traditional food access, and fire and forestry workforce training.[332] The Forest Service and Bureau of Land Management provide funds and collaborate with tribes to plan and execute restoration projects on federal lands.[333]

Equitable urban tree investments: Addressing the current inequitable distribution of urban tree cover will be crucial, with tree cover 12% lower in neighborhoods with predominantly people of color (POC) than in white neighborhoods.[334] Pittsburgh's Equitable Street Tree Investment Strategy targets ten low-income, low-canopy neighborhoods for focused tree maintenance, plantings, and urban forest education.[335]

Other

Tree planting nonprofit organizations: The Arbor Day Foundation is one of the largest organizations dedicated to planting trees and is working to plant 500 million trees by 2027.[336] In the United States, the foundation works with the U.S. Forest Service and the National Association of State Foresters to plant trees in both national and state forests.

University programs and research: Universities play a vital role in forest management research and education. Michigan State University's Forest Carbon and Climate Program aims to increase understanding and implementation of climate-smart forest management through education, research, stakeholder engagement, and partnerships.[337]

Key policy #2: Climate-smart agricultural practices: *Sustainable agricultural practices that can reduce emissions include land conservation, efficient land use, crop production policies, and livestock management policies. To improve their efficacy, federal and non-federal actors must expand funding and can incorporate strategic partnerships to expand knowledge of incentives.*

SUPPORTING POLICIES AND ACTIONS

Federal

Expanded Farm Bill provisions: The 2018 Farm Bill funds crucial conservation and climate-smart agriculture programs. A renewed Farm Bill is key to not only retaining existing programs but also enhancing future reductions by focusing on sequestration efforts.

Climate-smart agricultural projects: With a $11.7 billion funding expansion by the IRA, the Environmental Quality Incentives Program and Conservation Stewardship Program offer financial and technical assistance to help agricultural producers and landowners integrate conservation practices into their lands.[338,339]

Strategic partnerships: Strategic partnerships are crucial for raising awareness among farmers and landowners and providing technical assistance. The USDA's Partnerships for Climate-Smart Commodities funds projects that offer support to producers, encouraging voluntary adoption of climate-smart practices on working lands.[78]

State

Healthy soil grant programs: Several states have implemented soil health programs including New Mexico's Healthy Soil Program which provides grants to projects that promote healthy soil practices such as minimizing soil disturbance, maximizing biodiversity, maintaining a living root, and integrating animals into land management.[340]

Climate-smart food systems: Recently, Minnesota announced a $200 million grant to reduce emissions in their food system through the EPA's Climate Pollution Reduction Grants program. The Minnesota Climate-Smart Food Systems project aims to create a sustainable food system by restoring 10,000 acres of peatlands to absorb and store carbon, expanding farmer support through water quality certification and soil health programs, and adopting innovative technologies at waste processing sites.[341]

Local

Outreach and assistance: To raise awareness of voluntary programs and the benefits of sustainable agriculture, local governments can compile resources on funding opportunities and provide technical assistance for farmers and landowners.

Incentives to plant native trees and shrubs: Local governments can implement programs that incentivize growing native trees and plants. North Hempstead, New York received $15,000 in a partnership with the Nassau County Soil and Water Conservation District to offer rebates to residents to encourage planting of native plants in their landscapes.[342]

Other

Soil health partnerships and research: Oklahoma State University partners with agriculture producers for field trials to evaluate cover crops and no-till cropping systems and research new potential practices.[343]

Regenerative farming practices: Several U.S. companies are prioritizing regenerative farming in their supply chains, including General Mills, which has committed to advancing regenerative agriculture across one million acres by 2030. To accelerate this effort, the company has launched initiatives such as multi-day workshops, one-on-one technical support, and personalized coaching on regenerative farming principles.[344]

Climate-smart grazing practices: Supported by the USDA's Partnerships for Climate-Smart Commodities initiative, the Farm Journal Foundation and the Intertribal Agriculture Council launched a program to promote climate-smart grazing among Native American cattle farmers. The program offers incentive payments, technical assistance, and education to producers adopting conservation practices on grazing lands.[345]

4. Implementation Spotlight

Education and outreach. Government officials can help effective implementation of policies through outreach, education, technical assistance, and support for competitive grant programs.[346] These efforts can alleviate capacity constraints and raise program awareness. States can play a crucial role in directing federal funding toward eligible groups and state agencies. The USDA website compiles state-specific information on sustainable land use policies, as well as information on local service providers to help eligible individual groups apply for federal funding.[347] New Mexico's Agricultural Land Easement Program helps landowners limit non-agricultural land use through conservation easements and utilizes IRA funds to support strategic partnerships and conduct outreach to underserved producers, and the website includes factsheets with application and program details.[348]

Tribal forest management. Incorporating the perspectives, traditions, and knowledge of U.S. tribes, as well as recognizing the historical impact of land loss on tribes, is crucial to improving land management. Tribes currently possess over 100 million acres of land in the United States, and many tribal nations have land bases larger than some states. Through the BIL, the Forest Service is investing $18 million in 23 projects that help the Forest Services and tribes reduce hazardous fuels, including through prescribed burns, and restore watersheds to ensure clean drinking water.[349] These projects also incorporate Indigenous knowledge for sustainable land use and align with the Justice40 Initiative. The projects promote co-stewardship, restore culturally significant plants, create job opportunities for Tribal crews, and engage youth.

BOX 5. REALIZING JUSTICE40 GOALS.

To effectively implement an ambitious 2035 climate target, the impact of emissions reduction policies on existing inequities should be considered. The Justice40 (J40) initiative aims to address inequities in the nation's energy infrastructure by directing at least 40% of the benefits from federal investments in climate, clean energy, and the environment to disadvantaged communities.[350] These communities represent about 109 million people, including many communities of color, tribal communities, and working-class neighborhoods.[351] In support of this mission, the Biden-Harris Administration has announced $2 billion in Environmental and Climate Justice Community Change Grants, marking the largest direct investment in EJ in U.S. history.[352] With the influx in federal investments to tackle the climate crisis, J40 can help ensure that resources are delivered to communities most impacted by climate change, pollution, and environmental hazards.

To facilitate the adoption of J40, federal agencies collaborate with state and local governments, communities, and nonprofits. The EPA, for example, hosts public meetings, conducts statewide tours with environmental justice communities, appoints environmental justice coordinators in every region, and has established technical assistance centers to ease access to Justice40 funding.[353] State and local governments also play a key role in positioning J40 for success.[354] The mayor of Albuquerque, New Mexico, signed an Executive Order for Equitable and Just Implementation of J40, creating an oversight committee to ensure the program's benefits reach frontline communities.[355]

J40's mission is further amplified through strategic partnerships that offer technical and financial assistance to these communities. The Justice40 Accelerator (J40A), a nonprofit organization, helps community-based organizations secure Justice40 funding by providing participation grants, technology stipends, and comprehensive support.[356] Since 2021, J40A participants have secured $43 million in federal and state funding. Notable successes include the West Georgia Farmers' Cooperative, which received $1.1 million in USDA grants to improve access to nutritious food in underserved areas, and the Power52 Foundation, which secured a $1.5 million DOE grant to train at-risk adults in Baltimore for careers in solar energy and other green jobs.[357,358]

Despite these successes, implementing Justice40 presents challenges, such as defining disadvantaged communities and ensuring that benefits reach them directly.[359] Effective accountability, collaboration, and direct community engagement are crucial for overcoming these challenges and achieving meaningful impact.

Conclusion

The United States has made significant progress toward achieving its near-term climate target, with historic climate legislation, more stringent regulations, as well as increased ambition from non-federal actors and promising market signals for renewable energy deployment, vehicle electrification, electric heat pumps, and more. Building upon this progress and ensuring that the next U.S. NDC is both ambitious and achievable will be critical for setting the stage for deeper reductions in the long term and staying on a 1.5°C-compatible pathway.

Our analysis shows how the United States can deliver an ambitious 2035 NDC of reducing emissions to 65% below 2005 levels, rooted in new and expanded policy actions from a broad suite of actors, including federal, state, and local governments, and more; additional sectoral targets in electricity and methane can deliver a 67% reduction. This would represent a nearly 70% acceleration of the pace of decarbonization over current policies between 2020 and 2035. Major transformations will be required across all sectors (Figure 8),

including driving down methane emissions in the oil and gas, coal, agriculture, and waste sectors; the transition to a grid that is powered by clean technologies; the acceleration of EV adoption and EV infrastructure buildout while reducing vehicle miles traveled; electrification and efficiency improvements in the buildings and industry sectors; sequestration from CCS technologies; and additional investments in wildfire mitigation programs, afforestation programs, and more to enhance our land sink.

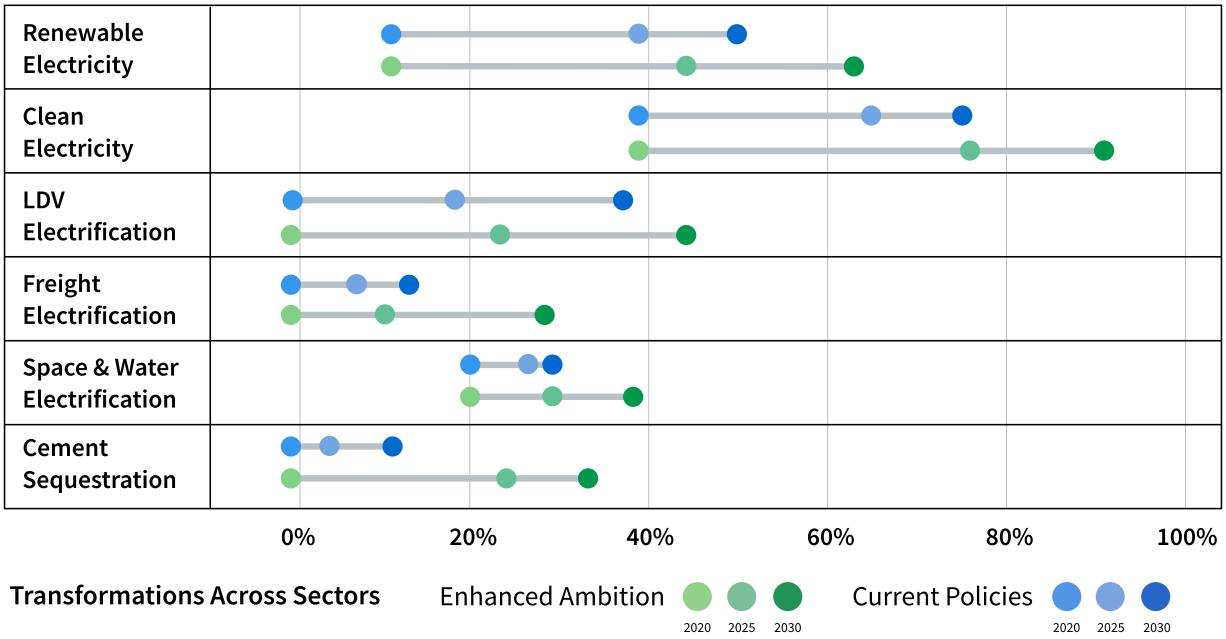

Figure 8. Key metrics in Current Policies and Enhanced Ambition, showing the change between 2020, 2030, and 2035. *Renewable electricity is measured by the share of electricity generation from solar and wind technologies. Clean electricity is measured by the share of electricity generation from solar, wind, geothermal, biomass, nuclear, hydro, and CCS technologies. LDV electrification is measured by the share of electricity in passenger car transport services. Freight electrification is measured by the share of electricity in freight truck transport service. Space and water heating electrification is measured by the share of electricity in total final energy from commercial and residential heating. Cement sequestration is measured by the percentage of cement sector process emissions that are captured by cement CCS.*

Nevertheless, these transformations will require policy foresight at the state and federal levels, and the ability to overcome various political, social, and technological barriers, which can create uncertainties around policy uptake and durability. The upcoming election as well as ongoing lawsuits around current regulations present significant market uncertainty and potential additional hurdles to overcome. The impact of the Bipartisan Infrastructure Law and the Inflation Reduction Act coupled with strong regulatory action implemented by the executive branch have the potential to reduce economy-wide emissions at scale. While these actions have been impactful, some of these policies, laws, and regulations are at risk of being rolled back under a less climate-friendly federal government – either in the executive or legislative branches. There is no replacement for strong federal climate leadership but our approach supports ambitious climate action at multiple levels of government and society, helping to support a more durable climate strategy and mitigate potential political backsliding. Even with rollbacks at the federal level, accelerated leadership from non-federal actors can pick up some of the slack and contribute significantly toward our climate pledge and global climate goals.

To quantify the impact of non-federal ambition, we conducted an initial analysis with two scenarios in which federal policies are cut back but non-federal actors continue to enhance their ambition. We find that if the federal government keeps its current policies but does not enact any new policies as of today, continued non-federal action, as modeled in the core Enhanced Ambition scenario, can achieve 60% reductions by 2035. In addition, as a simple proxy for maximum federal rollbacks, we modeled a scenario in which recent legislation and regulations from the federal government, including the IRA, BIL, and recently finalized EPA regulations, are removed. Under this scenario, continued non-federal action can achieve a 48% reduction by 2035. These two scenarios highlight the impact that non-federal actors can still have despite uncertainties at the federal level. A forthcoming analysis will further explore different levels of federal rollbacks and the impacts of non-federal climate action.

References

1. Tørstad, V. H. Participation, ambition and compliance: can the Paris Agreement solve the effectiveness trilemma? *Environ. Polit.* **29**, 761–780 (2020).
2. Kuyper, J. W. & Tørstad, V. Mobilizing non-state actors for climate action through the global stocktake. *Nat. Clim. Change* **13**, 1000–1001 (2023).
3. US Environmental Protection Agency. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021. *Greenhouse Gas Emissions* https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021 (2023).
4. Zhao, A. *et al. An All-In Pathway To 2030: The Beyond 50 Scenario*. 16 https://cgs.umd.edu/sites/default/files/2022-11/All%20In-The%20Beyond%2050%20Scenario-Report-Nov%202022.pdf (2022).
5. Bistline, J. *et al.* Emissions and energy impacts of the Inflation Reduction Act. *Science* **380**, 1324–1327 (2023).
6. King, B. *et al. Pathways to Paris: Post-IRA Policy Action to Drive US Decarbonization*. https://rhg.com/research/ira-us-climate-policy-2030/ (2023).
7. Orvis, R. *et al. Closing The Emissions Gap Between The IRA And 2030 NDC: Policies To Meet The Moment*. https://energyinnovation.org/publication/closing-the-emissions-gap-between-the-ira-and-ndc-policies-to-meet-the-moment/ (2022).
8. Mahajan, M., Ashmoore, O., Orvis, R. & Gopal, A. *Updated Inflation Reduction Act Modeling Using the Energy Policy Simulator*. https://energyinnovation.org/wp-content/uploads/2022/08/Updated-Inflation-Reduction-Act-Modeling-Using-the-Energy-Policy-Simulator.pdf (2022).
9. Jenkins, J. D. *et al. Climate Progress and the 117th Congress: The Impacts of the Inflation Reduction Act and Infrastructure Investment and Jobs Act*. https://zenodo.org/records/8148188 (2023).
10. Biden-Harris Administration Finalizes Suite of Standards to Reduce Pollution from Fossil Fuel-Fired Power Plants. *U.S. Environmental Protection Agency Office of the Administrator* https://www.epa.gov/newsreleases/biden-harris-administration-finalizes-suite-standards-reduce-pollution-fossil-fuel (2024).
11. *Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light- Duty and Medium-Duty Vehicles: Final Rule*. https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1019VP5.pdf (2024).
12. US Environmental Protection Agency., O. EPA's Final Rule for Oil and Natural Gas Operations Will Sharply Reduce Methane and Other Harmful Pollution. https://www.epa.gov/controlling-air-pollution-oil-and-natural-gas-operations/epas-final-rule-oil-and-natural-gas (2023).
13. ZEV Transition Council. Phase-out targets: LDV. https://zevtc.org/tracking-progress/light-duty-vehicle-map/ (2023).
14. American Council for an Energy-Efficient Economy. Renewable Energy Efforts. *ACEEE.org* https://database.aceee.org/city/renewable-energy-efforts (2021).
15. American Council for an Energy-Efficient Economy. Energy Efficiency Resource Standards. https://database.aceee.org/state/energy-efficiency-resource-standards.
16. Maez, M. New Mexico adopts nationally leading oil and gas emissions rule. *New Mexico Environment Department* https://www.env.nm.gov/wp-content/uploads/2022/04/2022-04-14-COMMS-New-Mexico-adopts-nationally-leading-oil-and-gas-emissions-rule-Final.pdf (2022).
17. HFC Policy Tracker. *North American Sustainable Refrigeration Council* https://nasrc.org/hfc-policy-tracker/.
18. Lily Bermel *et al. Clean Investment Monitor: Q4 2023 Update*. https://cdn.prod.website-files.com/64e31ae6c5fd44b10ff405a7/65dfcaebd76fc56445fd7375_Clean%20Investment%20Monitor%20-%20Q4%202023%20Update.pdf (2024).
19. Feiveson, L. & Ashenfarb, M. The Inflation Reduction Act: Saving American Households Money While Reducing Climate Change and Air Pollution. *U.S. Department of the Treasury* https://home.treasury.gov/news/featured-stories/the-inflation-reduction-act-saving-american-households-money-while-reducing-climate-change-and-air-pollution (2024).
20. Weil, J. Americans tapped $8 billion in tax credits on home energy upgrades. *The Washington Post* (2024).
21. McKerracher, C. *et al. Electric Vehicle Outlook 2024*. https://about.bnef.com/electric-vehicle-outlook/ (2024).
22. Anh Bui. *Electric Vehicle Market and Policy Development in the U.S. States, 2023*. https://theicct.org/wp-content/uploads/2024/05/ID-154-–-U.S.-EVs_final.pdf (2024).
23. Annual Vehicle Miles Traveled in the United States. *Alternative Fuels Data Center* https://afdc.energy.gov/data/10315 (2024).

24. Maizlish, N., Rudolph, L. & Jiang, C. Health Benefits of Strategies for Carbon Mitigation in US Transportation, 2017–2050. *Am. J. Public Health* **112**, 426–433 (2022).
25. Rodriguez, M. A. & Leinberger, C. B. *Foot Traffic AHEAD: Ranking Walkable Urbanism in America's Largest Metros 2023*. 72 https://smartgrowthamerica.org/wp-content/uploads/2023/01/Foot-Traffic-Ahead-2023.pdf (2023).
26. Mills, R. Drive Less, Live More: How States Can Lead the Way in Climate-Smart Transportation. *RMI* https://rmi.org/drive-less-live-more-how-states-can-lead-the-way-in-climate-smart-transportation/ (2024).
27. Sobczyk, N. The climate law will help red states. Can it change minds? *E&E News by POLITICO* https://www.eenews.net/articles/the-climate-law-will-help-red-states-can-it-change-minds/ (2022).
28. Cao, L., Brindle, T., Schneer, K. & DeGolia, A. *Turning Climate Commitments into Results: Evaluating Updated 2023 Projections vs. State Climate Targets*. https://www.edf.org/report/turning-climate-commitments-results (2023).
29. Rand, J. *et al. Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection*. https://emp.lbl.gov/queues (2024).
30. What is U.S. electricity generation by energy source? *U.S. Energy Information Administration (EIA)* https://www.eia.gov/tools/faqs/faq.php (2024).
31. Frazin, R. Republican-led states ask court to overturn EPA power plant rule. *The Hill* https://thehill.com/policy/energy-environment/4653791-republican-led-states-epa-power-plant-rule-legal-challenge/ (2024).
32. Hultman, N. E. *et al.* Fusing subnational with national climate action is central to decarbonization: the case of the United States. *Nat. Commun.* **11**, 5255 (2020).
33. Kennedy, K. *et al. Blueprint 2030: An All-In Climate Strategy for Faster, More Durable Emissions Reductions*. https://www.americaisallin.com/blueprint-2030 (2022).
34. Hultman, N. *et al. Accelerating America's Pledge: Going All-In to Build a Prosperous, Low-Carbon Economy for the United States*. 86 https://assets.bbhub.io/dotorg/sites/28/2019/12/Accelerating-Americas-Pledge.pdf (2019).
35. Zhao, A. *et al.* High-ambition climate action in all sectors can achieve a 65% greenhouse gas emissions reduction in the United States by 2035. *Npj Clim. Action* **3**, 1–11 (2024).
36. *Whole-of-Society Approaches to Inclusive Stakeholder Engagement*. https://ndcpartnership.org/sites/default/files/2024-03/whole-society-approaches-inclusive-stakeholder-engagement-best-practice-brief.pdf (2024).
37. *Insights for Designing Mitigation Elements in the next Round of Nationally Determined Contributions (NDCs)*. vol. 2024/01 https://www.oecd-ilibrary.org/environment/insights-for-designing-mitigation-elements-in-the-next-round-of-nationally-determined-contributions-ndcs_b70a88ef-en (2024).
38. Jenkins, J. D., Farbes, J. & Jones, R. Climate Progress 2024: REPEAT Project's Annual U.S. Emissions Pathways Update. (2024) doi:10.5281/zenodo.13345138.
39. Mahajan, M., Orvis, R., Gopal, A., O'Brien, D. & Goldstein, R. The Second half of the decisive decade. 27 (2024).
40. US Environmental Protection Agency. U.S. State-level Non-CO2 GHG Mitigation Report. *Global Mitigation of Non-CO2 Greenhouse Gases* https://www.epa.gov/global-mitigation-non-co2-greenhouse-gases/us-state-level-non-co2-ghg-mitigation-report (2022).
41. US EPA, O. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2021 (2023).
42. Global Methane Pledge. https://www.globalmethanepledge.org/.
43. What did COP28 mean for methane? – Global Methane Tracker 2024. *IEA* https://www.iea.org/reports/global-methane-tracker-2024/what-did-cop28-mean-for-methane (2024).
44. FACT SHEET: Key Deliverables for the 2023 North American Leaders' Summit. *The White House* https://www.whitehouse.gov/briefing-room/statements-releases/2023/01/10/fact-sheet-key-deliverables-for-the-2023-north-american-leaders-summit/ (2023).
45. Mar, K. A., Unger, C., Walderdorff, L. & Butler, T. Beyond CO2 equivalence: The impacts of methane on climate, ecosystems, and health. *Environ. Sci. Policy* **134**, 127–136 (2022).
46. Zhao, A. *et al. An "All-In" Pathway To 2030: U.S. Methane Emissions Reduction Potential*. https://cgs.umd.edu/research-impact/publications/all-pathway-2030-us-methane-emissions-reduction-potential (2022).

47. Quantifying methane emissions from the largest oil-producing basin in the United States from space. *Sci. Adv.* **6**, (2020).

48. EU Methane Regulations. *IEA* https://www.iea.org/policies/18209-eu-methane-regulations (2023).

49. Caulton, D. R. *et al.* Toward a better understanding and quantification of methane emissions from shale gas development. *Proc. Natl. Acad. Sci.* **111**, 6237–6242 (2014).

50. Nesser, H. *et al.* High-resolution US methane emissions inferred from an inversion of 2019 TROPOMI satellite data: contributions from individual states, urban areas, and landfills. *Atmospheric Chem. Phys.* **24**, 5069–5091 (2024).

51. Rutherford, J. S. *et al.* Closing the methane gap in US oil and natural gas production emissions inventories. *Nat. Commun.* **12**, 4715 (2021).

52. Re-imagining how methane emissions from the oil and gas industry are tracked and analyzed to drive large-scale emission reductions. *Project Astra* https://www.projectastra.energy/.

53. Wang, Y. *et al.* Underestimated Methane Emissions from Solid Waste Disposal Sites Reveal Missed Greenhouse Gas Mitigation Opportunities. *Engineering*. **11**, 12-15 (2024)

54. Sherwin, E. D. *et al.* US oil and gas system emissions from nearly one million aerial site measurements. *Nature* **627**, 328–334 (2024).

55. Global Methane Tracker 2024. *IEA* https://www.iea.org/reports/global-methane-tracker-2024 (2024).

56. Hoesly, R. *et al.* CEDS v_2024_07_08 Release Emission Data. Zenodo https://doi.org/10.5281/zenodo.12803197 (2024).

57. Searchinger, T. *et al. Opportunities to Reduce Methane Emissions from Global Agriculture*. 40 https://searchinger.princeton.edu/sites/g/files/toruqf4701/files/methane_discussion_paper_nov_2021.pdf (2021).

58. Cahill, B. & Swanson, K. Cross-Industry Methane Challenges. (2023).

59. New Mexico Natural Gas Flaring and Venting Regulations. *U.S. Department of Energy Office of Fossil Energy and Carbon Management* https://www.energy.gov/sites/default/files/2022-06/NewMexico-state-profile.pdf.

60. Redfern, J. New Mexico Loophole May Allow Record Methane Releases. *KRWG Public Media* https://www.krwg.org/regional/2024-05-19/new-mexico-loophole-may-allow-record-methane-releases (2024).

61. Alvarez, R. A. *et al.* Assessment of methane emissions from the U.S. oil and gas supply chain. *Science* **361**, 186–188 (2018).

62. Zhang, Y. *et al.* Quantifying methane emissions from the largest oil-producing basin in the United States from space. *Sci. Adv.* **6**, eaaz5120 (2020).

63. Unpacking Labeling and Design: U.S. Consumer Perception of Compostable Packaging. *Closed Loop Partners* https://www.closedlooppartners.com/research/us-consumer-perception-of-compostable-packaging/ (2023).

64. Kwasny, T., Dobernig & Riefler, P. Towards reduced meat consumption: A systematic literature review of intervention effectiveness, 2001–2019. *Appetite* **168**, (2022).

65. US EPA, O. Methane Emissions Reduction Program. https://www.epa.gov/inflation-reduction-act/methane-emissions-reduction-program (2023).

66. Biden-Harris Administration Announces Historic Funding for 37 Projects to Improve Safety, Fix Old, Leaky Gas Pipes and Create Jobs. *U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration* https://www.phmsa.dot.gov/news/biden-harris-administration-announces-historic-funding-37-projects-improve-safety-fix-old (2023).

67. USDOT Announces Bipartisan PIPES Act Proposal to Modernize Decades-Old Pipeline Leak Detection Rules, Invests in Critical American Infrastructure, Create Good-Paying Jobs, and Improve Safety. *U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration* https://www.phmsa.dot.gov/news/usdot-announces-bipartisan-pipes-act-proposal-modernize-decades-old-pipeline-leak-detection (2023).

68. Grants and Funding Opportunities. *U.S. Department of the Interior Office of Surface Mining Reclamation and Enforcement* https://www.osmre.gov/resources/grants-resources.

69. Interior Department Takes Action to Reduce Methane Releases on Public and Tribal Lands. *U.S. Department of the Interior* https://www.doi.gov/pressreleases/interior-department-takes-action-reduce-methane-releases-public-and-tribal-lands (2022).

70. Office of Fossil Energy and Carbon Management. *Colorado Natural Gas Flaring and Venting Regulation*. https://www.energy.gov/sites/default/files/2022-06/Colorado-state-profile-2022.pdf (2022).

71. Fassler, J. Colorado oil and gas wells can't fund their own cleanup. Taxpayers may foot the bill. *The Guardian* (2024).

72. U.S. Department of the Interior. Louisiana to Begin Work Plugging More Than 250 Orphaned Wells Through President Biden's Bipartisan Infrastructure Law. https://www.doi.gov/pressreleases/louisiana-begin-work-plugging-more-250-orphaned-wells-through-president-bidens (2022).

73. Office of Fossil Energy and Carbon Management. *Colorado Natural Gas Flaring and Venting Regulation*. https://www.energy.gov/sites/default/files/2022-06/Colorado-state-profile-2022.pdf (2022).

74. Schmidt, D. iPIPE 1.0, 2.0 and Next Phase 3.0 iNTELLIGENT PIPELINE INTEGRITY PROGRAM. *Energy Environ. Res. Cent. EERC* (2023).

75. Tribal Orphaned Wells Program. *U.S. Department of the Interior* https://www.doi.gov/tribal-orphaned-wells-program (2023).

76. *2022 Methane Report*. 26 https://www.chevron.com/-/media/shared-media/documents/chevron-methane-report.pdf (2022).

77. Sensor Network Could Change How Methane Emissions Are Detected. *The University of Texas at Austin Center for Energy and Environmental Resources* https://dept.ceer.utexas.edu/ceer/astra/presskit.cfm (2020).

78. Partnerships for Climate-Smart Commodities. *U.S. Department of Agriculture* https://www.usda.gov/climate-solutions/climate-smart-commodities.

79. Conservation Innovation Grants. *Natural Resources Conservation Service* https://www.nrcs.usda.gov/programs-initiatives/cig-conservation-innovation-grants (2024).

80. Regional Conservation Partnership Program. *Natural Resources Conservation Service* https://www.nrcs.usda.gov/programs-initiatives/rcpp-regional-conservation-partnership-program (2024).

81. NIFA Invests $10M to Reduce Methane Emission from Ruminants. *National Institute of Food and Agriculture* https://www.nifa.usda.gov/about-nifa/announcements/nifa-invests-10m-reduce-methane-emission-ruminants (2023).

82. Quantifying Methane Emissions from Landfilled Food Waste. *United States Environmental Protection Agency* https://www.epa.gov/land-research/quantifying-methane-emissions-landfilled-food-waste#.

83. *Methane Measurement and Monitoring*. 9 https://mde.maryland.gov/programs/air/ClimateChange/Maryland%20Climate%20Reduction%20Plan/Methane%20Measurement%20and%20Monitoring.pdf.

84. Oregon Secretary of State Administrative Rules. https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=6533.

85. Laws - Statute Text. *Maryland General Assembly* https://mgaleg.maryland.gov/mgawebsite/Laws/StatuteText?article=gen&section=9-1724.1.

86. Alternative Manure Management Program (AMMP). *cdfa* https://www.cdfa.ca.gov/oefi/AMMP/.

87. Organics Composting to Become Mandatory in the City of Laurel in 2025. *City of Laurel Maryland* https://www.laurelmd.gov/CivicAlerts.aspx?AID=168&ARC=379.

88. Council Votes on Legislative Package to Create Citywide Residential Curbside Organics Collection Program, Advance NYC's Zero Waste Efforts. *New York City Council* https://council.nyc.gov/press/2023/06/08/2421/ (2023).

89. Slanger, D. Your trash deserves better. These three cases show what's possible. *RMI* https://rmi.org/your-trash-deserves-better-these-three-cases-show-whats-possible/ (2023).

90. Cargill Invests $1 Million in Research on Methane Reduction in Cattle. *Cargill* https://www.cargill.com/2024/cargill-invests-1-million-in-research-on-methane-reduction (2024).

91. *Road to Zero Waste Plan*. https://www.fcgov.com/recycling/pdf/RoadtoZeroWasteReport_FINAL.pdf?1395151623 (2013).

92. Jean, B. Good Samaritan Act Provides Liability Protection For Food Donations | USDA. https://www.usda.gov/media/blog/2020/08/13/good-samaritan-act-provides-liability-protection-food-donations (2020).

93. Food Waste. *City of Fort Collins* https://www.fcgov.com/recycling/atoz/items/?item=122.

94. Zero Waste DC Plan. *Zero Waste DC* https://zerowaste.dc.gov/zwdcplan#.

95. DC's Determination to Reduce Food Waste Will Reach More Local Businesses in 2024. *Compost Crew* https://compostcrew.com/dc-reduce-food-waste-2024/.

96. MethaneSAT | Solving a crucial climate challenge. *MethaneSAT* https://www.methanesat.org/.

97. Beehive Emission Reduction Plan: Priority Plan. (2024).

98. Sources of Greenhouse Gas Emissions. https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions.

99. *The Renewable Revolution*. https://rmi.org/wp-content/uploads/dlm_uploads/2023/06/rmi_renewable_revolution.pdf (2023).

100. Peng, W. *et al. All-In Climate Action for Improved U.S. Air Quality & Health Benefits*. https://cgs.umd.edu/sites/default/files/2023-12/All-In%20Air%20Quality_Report_Dec.%203%202023%20%281%29.pdf (2023).

101. Historic redlining and the siting of oil and gas wells in the United States. *J. Expo. Sci. Environ. Epidemiol.* **33**, 76–83 (2023).

102. *On The Path to 100% Clean Electricity*. https://www.energy.gov/sites/default/files/2023-05/DOE%20-%20100%25%20Clean%20Electricity%20-%20Final.pdf (2023).

103. *Powering Intelligence: Analyzing Artificial Intelligence and Data Center Energy Consumption*. https://www.epri.com/research/products/3002028905 (2024).

104. Susskind, L. *et al.* Sources of opposition to renewable energy projects in the United States. *Energy Policy* **165**, (2022).

105. Congressional Research Service. Electricity Transmission Permitting Reform Proposals. (2024).

106. Clifford, C. Why it's so hard to add electrical transmission lines in the U.S. *CNBC* (2023).

107. Garrett, K. P., McManamay, R. A. & DeRolph, C. R. When energy doesn't add up: use of an energyshed framework in assessing progress towards renewable energy transitions. *Environ. Res. Infrastruct. Sustain.* **4**, 015004 (2024).

108. Jenkins, J. D., Farbes, J., Jones, R., Patankar, N. & Schivley, G. *Electricity Transmission Is Key to Unlock the Full Potential of the Inflation Reduction Act*. https://zenodo.org/record/7106176 (2022) doi:10.5281/ZENODO.7106176.

109. Zhang, Y., Jackson, C., Darraj, N. & Krevor, S. Feasibility of Carbon Dioxide Storage Resource Use within Climate Change Mitigation Scenarios for the United States. *Environ. Sci. Technol.* **57**, 14938–14949 (2023).

110. Summer Shutoff Protections and Bill Support Fail to Adapt to a Warming World. (2024).

111. Gonzalez, D. J. X., Nardone, A., Nguyen, A. V., Morello-Frosch, R. & Casey, J. A. Said, E., Neuberger, J. & Walker, C. The US Clean Energy Transition Isn't Equitable – But it Could Be. (2021).

112. Hanley, J. E. New Wind Energy Costs Blow the Doors Off Projections. *Empire Center for Public Policy* https://www.empirecenter.org/publications/new-wind-energy-blows-doors-off-projections/ (2023).

113. Garden, L. Biden administration creates new rule to speed up clean energy transmission. *Trellis* (2024).

114. Rep. Castor, K. [D-F.-14. H.R.7624 - Advancing GETs Act of 2024. https://www.congress.gov/bill/118th-congress/house-bill/7624/text (2024).

115. *GETting Interconnected in PJM: Grid-Enhancing Technologies (GETs) Can Increase the Speed and Scale of New Entry from PJM's Queue*. https://rmi.org/insight/analyzing-gets-as-a-tool-for-increasing-interconnection-throughput-from-pjms-queue/ (2024).

116. Welton, S. Governing the grid for the future: The case for a Federal Grid Planning Authority. (2024).

117. DOE Announces Funding for Tribal Clean Energy Projects. *Energy.gov* https://www.energy.gov/articles/doe-announces-funding-tribal-clean-energy-projects (2024).

118. Michigan Compiled Laws Complete Through PA 122 of 2024. *Michigan Legislature* https://legislature.mi.gov/Search/ExecuteSearch?paNumber=235&paYear=2023&docTypes=MCLs (2023).

119. Sherman, L. Michigan's new clean energy package is historic for the country, not just the Midwest. *Utility Dive* https://www.utilitydive.com/news/michigan-clean-energy-wind-solar-efficiency-storage-fossil-fuel-transition/702521/ (2023).

120. Grid Resilience and Innovation Partnerships (GRIP) Program Projects. *United States Department of Energy Grid Deployment Office* https://www.energy.gov/gdo/grid-resilience-and-innovation-partnerships-grip-program-projects.

121. Governor Cuomo Announces New Regulations Adopted to Accelerate Renewable Energy Projects Across New York State. *NY Power Authority* (2021).

122. *Clean Energy Project Siting*. *E2SHB* (2023).

123. Maryland Offshore Wind Workforce Training & Education Program. *Maryland Energy Administration* https://energy.maryland.gov/Pages/default.aspx.

124. Austin Energy Resource, Generation and Climate Protection Plan to 2030. (2020).

125. Schneiderman, R. Solar Holler to Save Wayne County Schools Nearly $6.5 Million Through State's Largest Power Purchase Agreement to Date. *Solar Holler* https://www.solarholler.com/2023/11/29/solar-holler-to-save-wayne-county-schools-nearly-6-5-million-through-states-largest-power-purchase-agreement-to-date/ (2023).

126. Coal-producing West Virginia is converting an entire school system to solar power. *AP News* https://apnews.com/article/west-virginia-wayne-county-solar-power-manchin-8b2bb5544b4943006dc48d48cf9929ee (2023).

127. Unlocking the Potential of Distributed Energy Resources. *IEA* https://www.iea.org/reports/unlocking-the-potential-of-distributed-energy-resources (2022).

128. The Benefits and Challenges of Microgrids. *TRC* https://www.trccompanies.com/insights/benefits-and-challenges-of-microgrids/.

129. Tribes and Territories Competition Selected Applications Table. *U.S. Environmental Protection Agency* https://www.epa.gov/inflation-reduction-act/tribes-and-territories-competition-selected-applications-table.

130. Romankiewicz, J., Bottorff, C. & Stokes, L. C. *The Dirty Truth About Utility Climate Pledges*. https://www.sierraclub.org/sites/www.sierraclub.org/files/blog/Final%20Greenwashing%20Report%20%281.22.2021%29.pdf (2021).

131. St. John, A. & Walling, M. Community colleges offer clean energy training as climate-related jobs expand across America. *AP News* (2024).

132. Energy Innovation Center Pittsburgh. *Energy Innovation Center Pittsburgh* https://www.eicpittsburgh.org/.

133. Girouard, C. Understanding IRPs: How Utilities Plan for the Future. *Advanced Energy United* https://blog.advancedenergyunited.org/understanding-irps-how-utilities-plan-for-the-future (2015).

134. Slanger, D. How Regulators Can Direct Utilities to Leverage IRA Savings. *RMI* https://rmi.org/how-regulators-can-direct-utilities-to-leverage-ira-savings/ (2024).

135. Funding Notice: Capacity Building for Repurposing Energy Assets. *U.S. Department of Energy Office of Fossil Energy and Carbon Management* https://www.energy.gov/fecm/funding-notice-capacity-building-repurposing-energy-assets.

136. Coal Communities Commitment. *U.S. Economic Development Administration* https://www.eda.gov/arpa/coal-communities.

137. Brown, M. US proposes ending new federal leases in nation's biggest coal region. *AP News* (2024).

138. Fong, C. & Mardell, S. Securitization in Action: How US States Are Shaping an Equitable Coal Transition. *RMI* https://rmi.org/securitization-in-action-how-us-states-are-shaping-an-equitable-coal-transition/ (2021).

139. Cap-and-Trade Program. *California Air Resources Board* https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program.

140. Washington's Cap-and-Invest Program. *State of Washington Department of Ecology* https://ecology.wa.gov/air-climate/climate-commitment-act/cap-and-invest.

141. California Budget and Policy Center. First Look: Understanding the Governor's 2024-25 State Budget Proposal. *California Budget and Policy Center* https://calbudgetcenter.org/resources/first-look-understanding-the-governors-2024-25-state-budget-proposal/ (2024).

142. *Decarbonization: Status, Challenges, and Policy Options for Carbon Capture, Utilization, and Storage*. 78 https://www.gao.gov/assets/730/723198.pdf (2022).

143. Bonham, S. *et al. Local Community Benefit Sharing Mechanisms for CCS Projects*. 8177–8184 https://www.co2captureproject.org/xt457PuN/report/Local_community_benefit_sharing_mechanisms_for_CCS_projects_2013.pdf (2014).

144. Sherco Solar Project. *Xcel Energy* https://mn.my.xcelenergy.com/s/renewable/developers/sherco-solar-project.

145. Carbon Capture Demonstration Projects Program – Baytown Carbon Capture and Storage Project. *U.S. Department of Energy Office of Clean Energy Demonstrations* https://www.energy.gov/sites/default/files/2024-07/Baytown%20CC%20and%20Storage%20Factsheet_072324.pdf.

146. Sen. Welch, P. [D-V. S.3918 - Advancing GETs Act of 2024. https://www.congress.gov/bill/118th-congress/senate-bill/3918/text (2024).

147. Hortman, M. & Champion, B. J. *Conference Committee Report on H. F. No. 5247*. https://www.revisor.mn.gov/bills/text.php?number=HF5247&version=0&session=ls93&session_year=2024&session_number=0&type=ccr&format=pdf (2024).

148. *An Act to Amend and Reenact §§ 56-597 and 56-599 of the Code of Virginia, Relating to Electric Utilities; Integrated Resource Plans; Grid-Enhancing Technologies and Advanced Conductors*. (2024).

149. *Illinois Renewable Energy Access Plan*. https://www.icc.illinois.gov/docket/P2022-0749/documents/351191/files/614348.pdf (2024).

150. Large-scale wind and solar developers concerned about social factors affecting deployment. *Energy Markets & Policy* https://emp.lbl.gov/news/larg-e-scale-wind-and-solar (2024).

151. OneStop Maryland Portal. *Maryland OneStop* https://onestop.md.gov/.

152. HB 1216 - 2023-24. *Washington State Legislature* https://app.leg.wa.gov/billsummary?BillNumber=1216&Year=2023.

153. Office of Renewable Energy Siting and Electric Transmission. *New York State Department of Public Service* https://dps.ny.gov/ores.

154. MID-GRID 2035. *Midwestern Governors Association* https://midwesterngovernors.org/mid-grid/.

155. Tracy, P. National Grid Pulls Plug On Twin States Energy Project Disappointing Sununu. *InDepthNH.org* https://indepthnh.org/2024/03/04/national-grid-pulls-plug-on-twin-states-energy-project-disappointing-sununu/ (2024).

156. What's Driving the Decline of Coal in the United States. *Climatenexus* https://climatenexus.org/climate-issues/energy/whats-driving-the-decline-of-coal-in-the-united-states/ (2019).

157. The United States heads a group of countries making new commitments to phasing out coal. *Powering Past Coal Alliance* (2023).

158. Fogler, C. & Beek, N. V. *The Dirty Truth About Utility Climate Pledges*. https://coal.sierraclub.org/sites/nat-coal/files/dirty_truth_report_2023.pdf?utm_source=sierraclub&utm_medium=web&utm_id=dirty-truth&utm_content=popup (2023).

159. AI is forcing a delay in coal plant retirement plans. *Finimize* https://finimize.com/content/the-back-burner (2024).

160. Deaths associated with pollution from coal power plants. *National Institutes of Health (NIH)* https://www.nih.gov/news-events/nih-research-matters/deaths-associated-pollution-coal-power-plants (2023).

161. Prull, D., Beek, N. V. & Saraswati, M. *Out of Control: The Deadly Impact of Coal Pollution*. https://coal.sierraclub.org/sites/nat-coal/files/Out%20of%20Control%20coal%20mortality%20report%20FINAL.pdf (2023).

162. Tessum, C. W. *et al.* PM2.5 polluters disproportionately and systemically affect people of color in the United States. *Sci. Adv.* **7**, (2021).

163. Spiller, E., Proville, J., Roy, A. & Muller, N. Z. Mortality Risk from PM2.5: A Comparison of Modeling Approaches to Identify Disparities across Racial/Ethnic Groups in Policy Outcomes. *Environ. Health Perspect.* (2021)

164. Shrestha, R., Rajpurohit, S. & Saha, D. Redefining America's 'Energy Communities' Can Boost Clean Energy Investments Where It's Needed Most. *World Resources Institute* https://www.wri.org/insights/redefining-americas-energy-communities (2023).

165. Forster, O. & Stevens, L. Supporting Frontline Leadership and Pursuing a Just Energy Transition in Portland. *Sierra Club* https://www.sierraclub.org/articles/2019/12/supporting-frontline-leadership-and-pursuing-just-energy-transition-portland (2019).

166. Just Transitions: Economic Diversification for Coal Dependent regions. *Climate Investment Funds* https://www.cif.org/news/just-transitions-economic-diversification-coal-dependent-regions (2021).

167. Interior Department Announces $130 Million to Help Create Jobs and Revitalize Land in Coal Communities. *U.S. Department of the Interior* https://www.doi.gov/pressreleases/interior-department-announces-130-million-help-create-jobs-and-revitalize-land-coal (2024).

168. Nanayakkara, S. *et al. Just and Sustainable Mobility Transition in the Transport Sector: A Conceptual Framework and Gender-Mainstreaming Case Studies*. NREL/TP--7A40-87449, 2204834, MainId:88224 https://www.osti.gov/servlets/purl/2204834/ (2023) doi:10.2172/2204834.

169. *DOT Report to Congress: Decarbonizing U.S. Transportation*. https://www.transportation.gov/sites/dot.gov/files/2024-07/Decarbonizing%20U.S.%20Transportation_July%202024.pdf (2024).

170. Maryland becomes 10th state to adopt life-saving clean trucks standards. *Maryland Sierra Club* https://www.sierraclub.org/maryland/blog/2023/12/maryland-becomes-10th-state-adopt-life-saving-clean-trucks-standards (2023).

171. 2024 FHWA Forecasts of Vehicle Miles Traveled (VMT). *Federal Highway Administration Office of Highway Policy Information* https://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_forecast_sum.cfm# (2024).

172. HB 1183: Prohibiting Washington from adopting California vehicle emission standards. *Washington State Legislature* https://app.leg.wa.gov/billsummary?BillNumber=1183&Year=2023&Initiative=false (2023).

173. HB515: Prohibits government restriction of choice regarding vehicles. *Louisiana State Legislature* https://www.legis.la.gov/legis/BillInfo.aspx?i=246273 (2024).

174. HB1247: Environment – Advanced Clean Cars II Program – Application and Enforcement. *Maryland General Assembly* https://mgaleg.maryland.gov/mgawebsite/Legislation/Details/hb1247.

175. HF 1373: Consumer choice of fuel provided, rulemaking authority modified, and Clean Car rules eliminated. *Minnesota Legislature Office of the Revisor of Statutes* https://www.revisor.mn.gov/bills/bill.php?f=HF1373&b=house&y=2023&ssn=0 (2023).

176. *House Bill 76: An Act Relating to the Environment; Prohibiting the Adoption of Certain Rules Relating to the Production and Delivery for Sale of Zero-Emission Vehicles*. (2024).

177. Senate Bill 215: An Act relating to motor vehicles. *Kentucky General Assembly* https://apps.legislature.ky.gov/record/24rs/sb215.html.

178. Attorney General Hilgers Leads Multi-State Coalitions in Two Lawsuits to Stop Electric-Truck Mandates. *Nebraska Attorney General* https://ago.nebraska.gov (2024).

179. Wood, E. *et al.* The 2030 National Charging Network: Estimating U.S. Light-Duty Demand for Electric Vehicle Charging Infrastructure. (2023).

180. FOTW #1334, March 18, 2024: By 2030, the US Will Need 28 million EV Charging Ports to Support 33 million EVs. *Energy.gov* https://www.energy.gov/eere/vehicles/articles/fotw-1334-march-18-2024-2030-us-will-need-28-million-ev-charging-ports (2024).

181. Electric Vehicle Charging Stations. *Joint Office of Energy and Transportation* https://driveelectric.gov/stations.

182. Rempel, D., Cullen, C., Bryan, M. M. & Cezar, G. V. Reliability of Open Public Electric Vehicle Direct Current Fast Chargers. *Human Factors (2022)*

183. Hsu, C.-W. & Fingerman, K. Public electric vehicle charger access disparities across race and income in California. *Transp. Policy* **100**, 59–67 (2021).

184. Electric Vehicles: An Economic and Environmental Win for Developing Countries. *World Bank Group* https://www.worldbank.org/en/news/feature/2022/11/17/electric-vehicles-an-economic-and-environmental-win-for-developing-countries (2022).

185. Lee, D.-Y., McDermott, M. H., Sovacool, B. K. & Isaac, R. Toward just and equitable mobility: Socioeconomic and perceptual barriers for electric vehicles and charging infrastructure in the United States. *Energy Clim. Change* **5**, 100146 (2024).

186. Real Median Household Income in the United States. *Fred* https://fred.stlouisfed.org/series/MEHOINUSA672N (2023).

187. The EV. Used EV Market Sees Strong Growth. *The EV Report* https://theevreport.com/used-ev-market-sees-strong-growth (2024).

188. U.S. Department of Energy Issues Request for Information to Provide Feedback on Critical Materials Assessment. *Energy.gov* https://www.energy.gov/eere/articles/us-department-energy-issues-request-information-provide-feedback-critical-materials (2023).

189. Ballinger, B. *et al.* The vulnerability of electric vehicle deployment to critical mineral supply. *Appl. Energy* **255**, 113844 (2019).

190. Nation's Urban and Rural Populations Shift Following 2020 Census. *United States Census Bureau* (2022).

191. Altschuler, G. C. Why NYC's congestion pricing plan is stuck in traffic. *The Hill* (2024).

192. Mattioli, G., Roberts, C., Steinberger, J. K. & Brown, A. The political economy of car dependence: A systems of provision approach. *Energy Res. Soc. Sci.* **66**, (2020).

193. Fleming, K. L., Brown, A. L., Fulton, L. & Miller, M. Electrification of Medium- and Heavy-Duty Ground Transportation: Status Report. *Curr. Sustain. Energy Rep.* **8**, 180–188 (2021).

194. Kennedy, K. & Feldmann, J. Decarbonizing Freight: Opportunities and Obstacles for Clean Fuels. *World Resour. Inst.* (2023).

195. Decarbonizing Aviation. *RMI* https://rmi.org/decarbonizing-aviation/.

196. Electric Vehicle Registrations Pass Record-Breaking 100,000 Mark in Maryland. *Maryland Department of Transportation (MDOT)* https://www.mdot.maryland.gov/tso/pages/newsroomdetails.aspx?newsId=779&PageId=38 (2024).

197. Washington EV Instant Rebate Program. *Washington State Department of Commerce* https://www.commerce.wa.gov/growing-the-economy/energy/electric-vehicles/ev-instant-rebate-program/.

198. Commission, C. E. California Energy Commission Launches $38 Million Project for EV Charging in Low-Income and Disadvantaged Communities. *California Energy Commission* (2023).

199. The State of Electric School Bus Adoption in the US. *Electric School Bus Initiative* https://electricschoolbusinitiative.org/state-electric-school-bus-adoption-us (2024).

200. Samuels, G. & Freemark, Y. The Polluted Life Near the Highway. *Urban Inst. Metrop. Housing Communities Policy Cent.* (2022).

201. Rowangould, G. M. A census of the US near-roadway population: Public health and environmental justice considerations. *Transp. Res. Part Transp. Environ.* **25**, 59–67 (2013).

202. Md. Code, Transp. § 23-206.4. https://casetext.com/statute/code-of-maryland/article-transportation/title-23-vehicle-laws-inspection-of-used-vehicles-and-warnings-for-defective-equipment/subtitle-2-emissions-control/section-23-2064-zero-emission-vehicles (2019).

203. California Air Resources Board. Advanced Clean Trucks Fact Sheet. *ca.gov* https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-trucks-fact-sheet (2021).

204. California Air Resources Board. Advanced Clean Cars II. https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii.

205. Advanced Clean Trucks. *California Air Resources Board* https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks.

206. California approves groundbreaking regulation that accelerates the deployment of heavy-duty ZEVs to protect public health. *California Air Resources Board* https://ww2.arb.ca.gov/news/california-approves-groundbreaking-regulation-accelerates-deployment-heavy-duty-zevs-protect (2023).

207. Larsen, D. Orlando City Council Passes EV Make-Ready Code. *SACE | Southern Alliance for Clean Energy* https://www.cleanenergy.org/blog/orlando-city-council-passes-ev-make-ready-code/ (2021).

208. EV Readiness Policy For New Developments.

209. EV Ready Parking Ordinance - Passed at Council. *The City of Columbus* https://www.columbus.gov/Services/Public-Utilities/About-Public-Utilities/Office-of-Sustainability/Equitable-Electric-Vehicle-Parking.

210. Leading the Charge: City of Austin Accelerates Commitment to Electric Vehicle Adoption. *City of Austin* https://www.austintexas.gov/article/leading-charge-city-austin-accelerates-commitment-electric-vehicle-adoption (2022).

211. Climate Mayors: We are mayors working together to demonstrate leadership on climate change. *Climate Mayors* https://www.climatemayors.org/who-we-are.

212. Climate Mayors Electric Vehicle Purchasing Collaborative. *Climate Mayors* https://driveevfleets.org/ (2015).

213. EV Home Charger Rebate. *Alabama Power* https://www.alabamapower.com/residential/save-money-and-energy/energy-saving-products/electric-vehicles/ev-home-charger-rebate.html.

214. Electric Vehicles. *Alaska Electric Light & Power Co.* https://www.aelp.com/Energy-Conservation/Electric-Vehicles.

215. California announces partnership with Stellantis to further emissions reductions. *California Air Resources Board* https://ww2.arb.ca.gov/news/california-announces-partnership-stellantis-further-emissions-reductions (2024).

216. Our Members. *PACT - Powering America's Commercial Transportation* https://www.pactcoalition.org/our-members.

217. Transportation. *Amazon Sustainability* https://sustainability.aboutamazon.com/climate-solutions/transportation.

218. Capital Investment Grants Program. *Federal Transit Administration* https://www.transit.dot.gov/CIG.

219. SB-743. https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140SB743 (2013).

220. Connecticut Department of Transportation. 2030 VMT Goal and Strategies. (2021).

221. Szczpanski, C. A Milestone for Statewide VMT Reduction. *Move Minnesota* https://www.movemn.org/a-milestone-for-statewide-vmt-reduction/ (2023).

222. Flexible Funding for Transit and Highway Improvements. *Federal Transit Administration* https://www.transit.dot.gov/funding/grants/grant-programs/flexible-funding-transit-and-highway-improvements.

223. Kimble, M. Colorado's Bold New Approach to Highways – Not Building Them. *The New York Times* (2024).

224. Michigan Transit Authorities Receive Over 72 Million in Federal Funding to Modernize Bus Fleets and Deploy Clean Transit Buses. *Michigan Infrastructure Office* https://www.michigan.gov/whitmer/issues/michigan-infrastructure-office/mio-press-release/2024/07/10/michigan-transit-authorities-receive-over-72-million-in-federal-funding (2024).

225. Southeast Mobility Plan. *City of Houston* https://www.houstontx.gov/planning/transportation/CMP/Southeast-Mobility-Plan/index.html.

226. Urban growth boundary. *Metro* https://www.oregonmetro.gov/urban-growth-boundary (2014).

227. Congestion Pricing Program in New York. *MTA* https://congestionreliefzone.mta.info.

228. Bus Rapid Transit (BRT) Projects. *Raleigh NC* https://raleighnc.gov/bus-rapid-transit (2024).

229. Transit Oriented Development. *City of Omaha Urban Planning* https://urbanplanning.cityofomaha.org/transit-oriented-development.

230. Community Access to Electric Bicycles Rebate Program. *Colorado Energy Office* https://energyoffice.colorado.gov/ebike-rebates.

231. Herbert, K. Have a Library Card? Check Out a Bike. *Better Bike Share* https://betterbikeshare.org/2022/04/08/have-a-library-card-check-out-a-bike/ (2022).

232. U.S. Department of the Treasury, IRS Release Guidance to Expand Access to Clean Vehicle Tax Credits, Help Car Dealers Grow Businesses. *U.S. Department of the Treasury* https://home.treasury.gov/news/press-releases/jy1783 (2024).

233. Lopez, N. Can Californians afford electric cars? Wait lists for rebates are long and some programs have shut down. *CalMatters* (2022).

234. Shehabi, A. *et al. United States Data Center Energy Usage Report*. https://doi.org/10.2172/1372902 (2016) doi:10.2172/1372902.

235. deLaski, A. & Mauer, J. *Energy-Saving States of America: How Every State Benefits from National Appliance Standards*. https://appliance-standards.org/sites/default/files/Appliances%20standards%20white%20paper%202%202-14-17.pdf (2017).

236. Subramanian, S. *et al. 2022 State Energy Efficiency Scorecard*. https://www.aceee.org/sites/default/files/pdfs/u2206.pdf (2022).

237. Clean Energy Resources to Meet Data Center Electricity Demand. *U.S. Department of Energy Office of Policy* https://www.energy.gov/policy/articles/clean-energy-resources-meet-data-center-electricity-demand (2024).

238. Chandramowli, S., Cook, P., Mackovyak, J., Parmar, H. & Scheller, M. The impact of rapid demand growth: Affordable, clean energy under threat. *ICF* https://www.icf.com/insights/energy/impact-rapid-demand-growth-us (2024).

239. Plumer, B. & Popovich, N. A New Surge in Power Use Is Threatening U.S. Climate Goals. *The New York Times* (2024).

240. Davis, S. Dominion hosts open house for new gas plant: 'We need natural gas'. *12 On Your Side* (2024).

241. Lumpkins, B. Tensions flare at Sugar Land community meeting over proposed natural gas plant. *Houston Landing* https://houstonlanding.org/tensions-flare-at-sugar-land-community-meeting-over-proposed-natural-gas-plant/ (2024).

242. What are Grid Enhancing Technologies? *Working for Advanced Transmission Technologies* https://watt-transmission.org/.

243. Distributed Energy Resource Management Systems. *NREL* https://www.nrel.gov/grid/distributed-energy-resource-management-systems.html.

244. Long-duration Energy Storage. *ESS Inc.* https://essinc.com/ (2021).

245. Microgrids. *Center for Climate and Energy Solutions* https://www.c2es.org/content/microgrids/.

246. Mills, R. Clean Repowering: A Near-Term, IRA-Powered Energy Transition Accelerant. *RMI* https://rmi.org/clean-repowering-a-near-term-ira-powered-energy-transition-accelerant/ (2024).

247. Electric Vehicles - EV Charging Solutions. *cps Energy* https://www.cpsenergy.com/en/about-us/programs-services/electric-vehicles/ev-charging-solutions.html#.

248. Bidirectional Charging and Electric Vehicles for Mobile Storage. *U.S. Department of Energy Federal Energy Management Program* https://www.energy.gov/femp/bidirectional-charging-and-electric-vehicles-mobile-storage.

249. Zukowski, D. New York City's first vehicle-to-grid charging installation is live in Brooklyn. *Smart Cities Dive* https://www.smartcitiesdive.com/news/new-york-first-vehicle-to-grid-charging-installation-V2G-Revel-Fermata-NineDot/631459/ (2022).

250. US EPA, O. Inventory of U.S. Greenhouse Gas Emissions and Sinks. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks (2017).

251. U.S. Department of Energy. Decarbonizing the U.S. Economy by 2050: A National Blueprint for the Buildings Sector. *Energy.gov* https://www.energy.gov/eere/decarbonizing-us-economy-2050-national-blueprint-buildings-sector.

252. Nadel, S. Electrification in the Transportation, Buildings, and Industrial Sectors: a Review of Opportunities, Barriers, and Policies. *Curr. Sustain. Energy Rep.* **6**, 158–168 (2019).

253. Goldstein, B., Gounaridis, D. & Newell, J. P. The carbon footprint of household energy use in the United States. *Proc. Natl. Acad. Sci. U. S. A.* **117**, 19122–19130 (2020).

254. Zhao, D. & Mo, Y. Construction Cost Decomposition of Residential Building Energy Retrofit. *Buildings* **13**, 1363 (2023).

255. Heeter, J., Sekar, A., Fekete, E., Shah, M. & Cook, J. *Affordable and Accessible Solar for All: Barriers, Solutions, and On-Site Adoption Potential*. NREL/TP--6A20-80532, 1820098, MainId:43734 https://doi.org/10.2172/1820098 (2021) doi:10.2172/1820098.

256. NYC Buildings. Building Electrification. https://www.nyc.gov/site/buildings/codes/building-electrification.page (2024).

257. Azhgaliyeva, D. Promoting Green Buildings: Barriers, Solutions, and Policies. (2022).

258. von Platten, J., Mangold, M., Johansson, T. & Mjörnell, K. Energy efficiency at what cost? Unjust burden-sharing of rent increases in extensive energy retrofitting projects in Sweden. *Energy Res. Soc. Sci.* **92**, 102791 (2022).

259. The Economics of Electrifying Buildings: Residential New Construction. *RMI* https://rmi.org/insight/the-economics-of-electrifying-buildings-residential-new-construction/.

260. Deason, J. & Borgeson, M. Electrification of Buildings: Potential, Challenges, and Outlook. *Curr. Sustain. Energy Rep.* **6**, 131–139 (2019).

261. Hu, A. Berkeley's gas ban is all but dead. What does that mean for other cities? *Grist* https://grist.org/buildings/berkeleys-gas-ban-is-all-but-dead-what-does-that-mean-for-other-cities/ (2024).

262. Plumer, B. Berkeley Will Repeal Its Landmark Ban on Natural Gas in New Homes. *The New York Times* (2024).

263. House, T. W. Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability. *The White House* https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability/ (2021).

264. Green and Resilient Retrofit Program (GRRP). *HUD.gov / U.S. Department of Housing and Urban Development (HUD)* https://www.hud.gov/GRRP.

265. Hicks. 2022 State Strategy for the State Implementation Plan. (2022).

266. B24-0785 - Greener Government Buildings Amendment Act of 2022. https://lims.dccouncil.gov/Legislation/B24-0785.

267. State of New York. FY 2024 Enacted Budget Financial Plan. (2023).

268. Geothermal Heat Pump Tax Credit. *Iowa Department of Revenue* https://revenue.iowa.gov/taxes/tax-guidance/tax-credits-deductions-exemption/geothermal-heat-pump-tax-credit.

269. Local Laws of the City of New York For the Year 2021: No.154. (2021).

270. Green New Deal | Ithaca, NY. https://www.cityofithaca.org/642/Green-New-Deal.

271. Heat Pump Water Heater Rebates. *Energy Smart NOLA* https://www.energysmartnola.info/heat-pump-water-heater-rebates/ (2018).

272. Better Climate Challenge | Better Buildings Initiative. https://betterbuildingssolutioncenter.energy.gov/climate-challenge.

273. Maryland Energy Administration Debuts Ambitious Program to Help Public Schools Reduce Carbon Emissions. https://news.maryland.gov/mea/2024/01/03/maryland-energy-administration-debuts-ambitious-program-to-help-public-schools-reduce-carbon-emissions/ (2024).

274. COP28: Global Renewables And Energy Efficiency Pledge. https://www.cop28.com/en/global-renewables-and-energy-efficiency-pledge.

275. Minimum Energy Standards. *HUD.gov / U.S. Department of Housing and Urban Development (HUD)* https://www.hud.gov/program_offices/comm_planning/environment_energy/mes_notice (2024).

276. House, T. W. FACT SHEET: Biden-Harris Administration Takes More Than 100 Actions in 2022 to Strengthen Energy Efficiency Standards and Save Families Money. *The White House* https://www.whitehouse.gov/briefing-room/statements-releases/2022/12/19/fact-sheet-biden-harris-administration-takes-more-than-100-actions-in-2022-to-strengthen-energy-efficiency-standards-and-save-families-money/ (2022).

277. Energy Efficiency Resource Standards (EERS) | ACEEE. https://www.aceee.org/topic/eers.

278. Powering Intelligence: Analyzing Artificial Intelligence and Data Center Energy Consumption. https://www.epri.com/research/products/3002028905.

279. Cambridge Launches Week-Long Energy Efficiency Initiative for Small Businesses. *Community Development Department* (2024).

280. U.S. Energy Information Administration. Annual Energy Outlook 2021. https://www.eia.gov/outlooks/archive/aeo21/ (2021).

281. Solar Energy Technologies Office. Concentrating Solar-Thermal Power | Department of Energy. https://www.energy.gov/eere/solar/concentrating-solar-thermal-power.

282. Cleveland-Cliffs Selected to Receive $575 Million in US Department of Energy Investments for Two Projects to Accelerate Industrial Decarbonization Technologies. *Cleveland-Cliffs Inc.* (2024).

283. Gross, S. *The Challenge of Decarbonizing Heavy Industry*. https://www.brookings.edu/wp-content/uploads/2021/06/FP_20210623_industrial_gross_v2.pdf (2021).

284. *The Future of Petrochemicals*. https://www.iea.org/reports/the-future-of-petrochemicals (2018).

285. IEA. *The Role of CCUS in Low-Carbon Power Systems*. https://www.iea.org/reports/the-role-of-ccus-in-low-carbon-power-systems (2020).

286. CO2 storage resources and their development. *IEA* https://www.iea.org/reports/co2-storage-resources-and-their-development (2022).

287. Carbon capture and storage in the USA: the role of US innovation leadership in climate-technology commercialization. *Global CCS Institute* (2020).

288. Beck, L. Carbon capture and storage in the USA: the role of US innovation leadership in climate-technology commercialization. *Clean Energy* **4**, 2–11 (2020).

289. Mission Possible: Reaching Net-Zero Carbon Emissions - ETC. *Energy Transitions Commission* https://www.energy-transitions.org/publications/mission-possible/.

290. Biden-Harris Administration Announces $135 Million to Reduce Emissions Across America's Industrial Sector. *Energy.gov* https://www.energy.gov/articles/biden-harris-administration-announces-135-million-reduce-emissions-across-americas (2023).

291. Inflation Reduction Act Guidebook | Clean Energy. *The White House* https://www.whitehouse.gov/cleanenergy/inflation-reduction-act-guidebook/.

292. California Energy Commission, C. E. Food Production Investment Program. https://www.energy.ca.gov/programs-and-topics/programs/food-production-program (current-date).

293. Kentucky Industrial Revenue Bonds. *Development District Association of Appalachia* https://www.appalachiandevelopment.org/rural-broadband-programs/industrial-revenue-bonds/.

294. Knight, J. Act-2009-722. https://adeca.alabama.gov/wp-content/uploads/Act-2009-722.pdf (2009).

295. Commercial and Industrial Energy Efficiency Program | City of New York. https://nyc-business.nyc.gov/nycbusiness/description/commercial-and-industrial-energy-efficiency-program.

296. Commercial & Industrial Energy Efficiency Program. https://www.cityofpaloalto.org/Departments/Utilities/Business/Ways-to-Save/Commercial-Industrial-Energy-Efficiency-Program.

297. 42 USC 17113b: Advanced industrial facilities deployment program. https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title42-section17113b&num=0&edition=prelim (2024).

298. Esram, N., Johnson, A. & Elliott, N. *How to Decarbonize Industrial Process Heat While Building American Manufacturing Competitiveness*. https://www.aceee.org/sites/default/files/pdfs/how_to_decarbonize_industrial_process_heat_while_building_american_manufacturing_competitiveness.pdf (2024).

299. DOE Selects Arizona State University to Lead New Institute to Drive Industrial Decarbonization through Electrification of Process Heat. *Energy.gov* https://www.energy.gov/eere/articles/doe-selects-arizona-state-university-lead-new-institute-drive-industrial (2023).

300. Buildings 25,000 sq. ft. or Larger. https://denvergov.org/Government/Agencies-Departments-Offices/Agencies-Departments-Offices-Directory/Climate-Action-Sustainability-and-Resiliency/Cutting-Denvers-Carbon-Pollution/High-Performance-Buildings-and-Homes/Energize-Denver-Hub/Buildings-25000-sq-ft-or-Larger.

301. *Carbon Capture and Sequestration (CCS) in the United States*. https://sgp.fas.org/crs/misc/R44902.pdf (2022).

302. *DOE's Carbon Capture and Storage (CCS) and Carbon Removal Programs*. https://crsreports.congress.gov/product/pdf/IF/IF11861 (2024).

303. Manhart, S. Understanding Carbon Removal Policy Across All 50 US States: An Exclusive Analysis. https://www.carbonfuture.earth/magazine/exclusive-analysis-carbon-dioxide-removal-policy-across-all-50-us-states (2023).

304. U.S. State Energy Financial Incentives for CCS. (2021).

305. Biochar. https://www.cincinnati-oh.gov/cincyparks/natural-resources/biochar/.

306. Chase, M. A Look at America's First Direct Air Capture Facility. *Earth.Org* https://earth.org/americas-first-direct-air-capture-facility-opens-in-california/ (2024).

307. Carbon capture and storage | ExxonMobil. https://corporate.exxonmobil.com/what-we-do/delivering-industrial-solutions/carbon-capture-and-storage?utm_source=google&utm_medium=cpc&utm_campaign=1ECX_GAD_TRAF_OT_Non-Brand_Carbon+Capture&utm_content=OT_Non-Brand_Carbon+Solutions+%26+Control&utm_term=direct+air+capture&gad_source=1&gclid=CjwKCAjwnqK1BhBvEiwAi7o0X1_uzy30V06NIQzTdW7xjw0MVTN91pacBdakAn2E4pZAf7G7mB04lxoCop0QAvD_BwE&gclsrc=aw.ds#Denbury.

308. US EPA, O. What is a Circular Economy? *United States Environmental Protection Agency* https://www.epa.gov/circulareconomy/what-circular-economy (2021).

309. US EPA, O. National Strategy for Reducing Food Loss and Waste and Recycling Organics. *United States Environmental Protection Agency* https://www.epa.gov/circulareconomy/national-strategy-reducing-food-loss-and-waste-and-recycling-organics (2023).

310. Circular Economy Program. *City of Austin* https://www.austintexas.gov/circulareconomy.

311. Low Carbon Fuel Standard. *California Air Resources Board* https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard.

312. Velders, G. J. M. *et al.* Projections of hydrofluorocarbon (HFC) emissions and the resulting global warming based on recent trends in observed abundances and current policies. *Atmospheric Chem. Phys.* **22**, 6087–6101 (2022).

313. Intergovernmental Panel on Climate Change (IPCC). *Climate Change 2021 – The Physical Science Basis: Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. (Cambridge University Press, Cambridge, 2023). doi:10.1017/9781009157896.

314. Background on HFCs and the AIM Act. *U.S. Environmental Protection Agency* https://www.epa.gov/climate-hfcs-reduction/background-hfcs-and-aim-act (2021).

315. Code of Colorado Regulations. *Colorado Secretary of State Jena Griswold* https://www.sos.state.co.us/CCR/DisplayRule.do?action=ruleinfo&ruleId=3325.

316. An Act to Limit the Use of Hydrofluorocarbons To Fight Climate Change. *130 Maine Legislature* https://www.legislature.maine.gov/legis/bills/display_ps.asp?PID=1456&snum=130&paper=&paperId=l&Id=226 (2021).

317. 9VAC5 Chapter 145. Regulations For Control of Greenhouse Gases. (2022).

318. Refrigerant Management Program. *California Air Resources Board* https://ww2.arb.ca.gov/our-work/programs/refrigerant-management-program/about.

319. Kennedy, S. *et al. Harnessing the Land Sector to Achieve U.S. Climate Goals: An All-Ofsociety Approach to Meeting Our Climate Goals and Bolstering the Carbon Sink by 2035*. 22 https://www.americaisallin.com/harnessing-the-land-sector (2024).

320. *Opportunities to Accelerate Nature Based Solutions: A Roadmap for Climate Progress, Thriving Nature, Equity, & Prosperity*. https://www.whitehouse.gov/wp-content/uploads/2022/11/Nature-Based-Solutions-Roadmap.pdf (2022).

321. Higuera, P. E. *et al.* Shifting social-ecological fire regimes explain increasing structure loss from Western wildfires. *PNAS Nexus* **2**, (2023).

322. Gao, J. & O'Neill, B. C. Mapping global urban land for the 21st century with data-driven simulations and Shared Socioeconomic Pathways. *Nat. Commun.* **11**, 2302 (2020).

323. Dadi, W., Mulugeta, M. & Semie, N. Impact of urbanization on the welfare of farm households: Evidence from Adama Rural District in Oromia regional state, Ethiopia. *PubMed Cent.* (2024)

324. Forest Stewardship. *US Forest Service* https://www.fs.usda.gov/managing-land/private-land/forest-stewardship (2017).

325. Agricultural Conservation Easement Program. *Natural Resources Conservation Service* https://www.nrcs.usda.gov/programs-initiatives/acep-agricultural-conservation-easement-program (2024).

326. Community Wildfire Defense Grant Program. *US Forest Service* https://www.fs.usda.gov/managing-land/fire/grants/cwdg (2024).

327. Miller, R. K., Field, C. B. & Mach, K. J. Barriers and enablers for prescribed burns for wildfire management in California. *Nat. Sustain.* **3**, 101–109 (2020).

328. Lee, P., Simpson, C., Lynch, M. & Valdez, D. *Assistance Landowner Wildfire Mitigation*. (2022).

329. Fargione, J. *et al.* Challenges to the Reforestation Pipeline in the United States. *Front. For. Glob. Change* **4**, (2021).

330. Ginal, J., Rankin, B., Froelich, M. & Snyder, M. *Updates To State Forest Service Tree Nursery*. (2022).

331. How the Community Forest Program Works. *US Forest Service* https://www.fs.usda.gov/managing-land/private-land/community-forest/program (2017).

332. Tribal Wildfire Resilience Grants. *Cal Fire* https://www.fire.ca.gov/what-we-do/grants/tribal-wildfire-resilience.

333. Good Neighbor Authority. *US Forest Service* https://www.fs.usda.gov/managing-land/farm-bill/gna (2016).

334. McDonald, R. I. *et al.* Current inequality and future potential of US urban tree cover for reducing heat-related health impacts. *Npj Urban Sustain.* **4**, 1–16 (2024).

335. Mayor Peduto's Shade Tree Commission Introduce Equitable Street Tree Investment Strategy. *City of Pittsburgh* https://pittsburghpa.gov/press-releases/press-releases/4734 (2021).

336. Arbor Day Foundation. *Arbor Day Foundation* https://www.arborday.org.

337. Michigan State University Department of Forestry Forest Carbon and Climate Program. *Michigan State University Department of Forestry* https://www.canr.msu.edu/fccp/.

338. Conservation Stewardship Program. *U.S. Department of Agriculture Natural Resources Conservation Service* https://www.nrcs.usda.gov/programs-initiatives/csp-conservation-stewardship-program.

339. Environmental Quality Incentives Program. *U.S. Department of Agriculture Natural Resources Conservation Service* https://www.nrcs.usda.gov/programs-initiatives/eqip-environmental-quality-incentives (2024).

340. Healthy Soil Program. *NMDA* https://nmdeptag.nmsu.edu/healthy-soil-program.html.

341. Governor Walz Announces $200 Million for Climate-Smart Food Systems in Minnesota. *Office of Governor Tim Walz and Lt. Governor Peggy Flanagan* https://mn.gov/governor/newsroom/press-releases/?id=1055-638440 (2024).

342. North Hempstead to Host Native Plant Rebates for Residents. *Town of North Hempstead* (2023).

343. Soil Health Partnerships. *Oklahoma Conservation Commission* https://conservation.ok.gov/wq-soil-health-soil-health-partnerships/.

344. Biden-Harris Administration Issues Financial Assistance to More than 43,000 Farmers, Ranchers, and Forest Landowners through the Inflation Reduction Act's Discrimination Financial Assistance Program. *U.S. Department of Agriculture* https://www.usda.gov/media/press-releases/2024/07/31/biden-harris-administration-issues-financial-assistance-more-43000 (2024).

345. New Program to Support Native American Farmers With Climate-Smart Grazing. *Intertribal Agriculture Council* https://www.indianag.org/post/new-program-to-support-native-american-farmers-with-climate-smart-grazing (2023).

346. Resilient Lands and Agriculture Measures in U.S. Climate Policy. *World Resources Institute U.S. Climate Policy Resource Center* https://www.wri.org/us-climate-policy-implementation/sectors/resilient-lands.

347. Conservation By State. *U.S. Department of Agriculture Natural Resources Conservation Service* https://www.nrcs.usda.gov/conservation-basics/conservation-by-state.

348. Agricultural Land Easement Program - New Mexico. *U.S. Department of Agriculture Natural Resources Conservation Service* https://www.nrcs.usda.gov/programs-initiatives/ale-agricultural-land-easements/new-mexico/agricultural-land-easement-program (2023).

349. Biden-Harris Administration Announces Actions to Strengthen Tribal Food Sovereignty, Co-Stewardship, and Knowledge of Tribal Agriculture Policy. *U.S. Department of Agriculture* https://www.usda.gov/media/press-releases/2024/06/05/biden-harris-administration-announces-actions-strengthen-tribal (2024).

350. Justice40: A Whole-of-government Initiative.

351. Shrestha, R., Rajpurohit, S. & Saha, D. CEQ's Climate and Economic Justice Screening Tool Needs to Consider How Burdens Add Up. *World Resources Institute* https://www.wri.org/technical-perspectives/ceq-climate-and-economic-justice-screening-tool-cumulative-burdens# (2023).

352. Biden-Harris Administration Announces $2 Billion to Fund Environmental and Climate Justice Community Change Grants as Part of Investing in America Agenda. *U.S. Environmental Protection Agency Office of Environmental Justice and External Civil Rights* https://www.epa.gov/newsreleases/biden-harris-administration-announces-2-billion-fund-environmental-and-climate-justice (2023).

353. US Environmental Protection Agency. Justice40 at EPA. *U.S. Environmental Protection Agency* https://www.epa.gov/environmentaljustice/justice40-epa (2022).

354. C40 Cities Climate Leadership Group, City Scale & Climate Mayors. Climate action and the Inflation Reduction Act: A guide for local government leaders. *C40 Knowledge Hub* https://www.c40knowledgehub.org/s/article/Climate-action-and-the-Inflation-Reduction-Act-A-guide-for-local-government-leaders?language=en_US.

355. Albuquerque Becomes First City in Nation to Advance Justice40. *City of Albuquerque* https://www.cabq.gov/mayor/news/albuquerque-becomes-first-city-in-nation-to-advance-justice40.

356. Justice40 Accelerator. *Justice40 Accelerator* https://justice40accelerator.org/.

357. West Georgia Farmers Cooperative. *West Georgia Farmers* https://www.westgeorgiafarmerscoop.com.

358. Power52 Foundation. *Power52* https://power52.org/.

359. Sotolongo, M. Defining environmental justice communities: Evaluating digital infrastructure in Southeastern states for Justice40 benefits allocation. *Appl. Geogr.* **158**, (2023).

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