2023 Voluntary Supplement to the U.S. Fifth Biennial Report

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Executive Summary

The United States is advancing a range of actions to reduce greenhouse gas emissions across sectors, and recent legislation will help drive significantly lower emissions in 2030. The Inflation Reduction Act of 2022 (IRA) and Bipartisan Infrastructure Law of 2021 (BIL) represent historic investments in climate action. This report presents analysis of the emissions impacts of IRA and BIL, both signed into law by President Biden after the cutoff date for analysis in prior U.S. reporting to the UN Framework Convention on Climate Change.

The IRA and BIL will contribute to achievement of the U.S. Nationally Determined Contribution (NDC) of reducing economy-wide net greenhouse gas emissions 50-52% below 2005 levels in 2030, building on a range of other ambitious climate policies and measures advanced by the Biden-Harris Administration. With IRA and BIL now in place, the latest U.S. modeling shows:

- **Net greenhouse gas emissions decreasing to 33-41% below 2005 levels in 2030**. This represents a near doubling in emissions reductions compared to the pre-IRA/BIL policy baseline and puts the United States in a strong position to achieve its NDC through additional action, including new federal and subnational policies and private sector investment that IRA/BIL will catalyze through powerful incentives and cost reductions spanning all major carbon-reducing technologies and solutions.
- **Clean electricity increasing from 43% of power generation in 2022 to up to 80% in 2030**, putting the United States in a strong position to achieve 100% clean electricity in 2035 through additional action.
- **Significant emissions reductions across sectors,** with CO_2 emissions reductions in 2030 of 49-83% in the electricity sector, 12-25% in the transportation sector, 49-63% in the buildings sectors, and 17-43% in the industrial sector, relative to 2005 levels. IRA and BIL will also support U.S. efforts to reduce methane and other non-CO_2 emissions across sectors.

The IRA and BIL will drive significant emissions reductions by accelerating deployment of clean electricity, including rapid growth of wind, solar, and storage; advancing electrification across the transportation sector, buildings, and industry, along with energy efficiency improvements; and supporting innovation and cost reductions across a range of clean technologies. This report focuses mainly on these energy-related emissions, though it also considers emissions from other sectors.

This report builds on the U.S. Department of Energy's August 2023 report on "Investing in American Energy: Significant Impacts of the Inflation Reduction Act and Bipartisan Infrastructure Law on the U.S. Energy Economy and Emissions Reductions and the U.S. Environmental Protection Agency's September 2023 report on "Electricity Sector Emissions Impacts of the Inflation Reduction Act." It incorporates results from nine models, robustly showing how IRA and BIL help position the United States to achieve ambitious climate goals.

IRA and BIL will also propel additional climate action by the federal government as well as states, territories, Tribal Nations, local governments, and the private sector by driving down the costs of key carbon-reducing solutions and providing sustained, uncapped deployment incentives. This report contextualizes how with IRA and BIL in place, the United States is well placed to take additional steps to achieve the 2030 NDC and reach net-zero greenhouse gas emissions no later than 2050, consistent with the pathways outlined in the U.S. Long-Term Strategy.

Introduction

In 2022, the Fifth Biennial Review Report of the United States (BR5) presented a "2021 Policy Baseline" reflecting the effects of policies and measures implemented as of November 2021, and included only separate preliminary analyses of the Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA), which President Biden signed into law following the cutoff date.[1] These two major federal laws have significant implications for the trajectory of U.S. emissions and sequestration. The Executive Summary of the BR5 noted that the U.S. planned to provide an update when more analysis was available, and this Voluntary Supplement report is the result.

This report presents the new "2023 Policy Baseline" which incorporates analysis of the GHG impacts of these two major new federal laws with significant implications for the trajectory of U.S. emissions and sequestration. This report compares the new Baseline to the 2021 Policy Baseline which was presented in the BR5, showing how the IRA and BIL will drive additional emission reductions across sectors, with summaries of key provisions.

This report also presents the updated "2023 Policy Baseline" in the context of the *U.S. Long-Term Strategy* (LTS)[2] analysis, which outlined a range of pathways for different parts of the economy that are consistent with meeting U.S. emissions reductions targets. The LTS analysis highlighted five major strategies to reach net-zero emissions no later than 2050 and achieve the U.S. nationally determined contribution (NDC) economy-wide target of reducing net GHG emissions by 50-52 percent below 2005 levels in 2030. The IRA and BIL legislation contribute to U.S. mitigation by including measures that advance these five strategies:

1. *Decarbonize the electricity sector*
2. *Electrify as many end-uses as possible and switch to other clean fuels*
3. *Cut energy waste and improve energy efficiency*
4. *Reduce methane and other non-CO_2 emissions*
5. *Scale up CO_2 removal through carbon removal technologies and land use practices*

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[1] President Biden signed the BIL into law on November 15, 2021. The official short title of the BIL is the Infrastructure Investment and Jobs Act (Public Law 117-58). President Biden signed the Inflation Reduction Act into law on August 16, 2022 (Public Law 117-169).

[2] U.S. Department of State and the U.S. Executive Office of the President (2021). *The Long Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050*.

These efforts align with the goal to limit global temperature rise to no more than 1.5 degrees Celsius above pre-industrial levels.

This report also includes a qualitative discussion of how the U.S. can go beyond existing measures to further reduce emissions and achieve the NDC economy-wide target, including through a range of additional in-progress measures at the federal level, across other levels of government, and in the private sector.

2023 Policy Baseline

Policies and Measures in the Bipartisan Infrastructure Law (BIL)

The Bipartisan Infrastructure Law (BIL) makes foundational investments in the U.S. clean energy economy, with historic levels of support for upgrading the power grid to transmit more clean energy and withstand extreme weather; building a nationwide network of electric vehicle chargers; improving public transit and passenger rail; deploying zero-emission school and transit buses; weatherizing low-income homes; cleaning up legacy pollution; and supporting demonstration projects and research hubs for next-generation clean technologies.

In many areas, BIL provides key foundations that will enable IRA provisions to drive emissions reductions. For example, power grid upgrades and electric vehicle charging equipment funded by BIL will help unlock the impacts of IRA tax credits for clean energy generation and electric vehicle purchases, by providing the supportive infrastructure necessary for deployment. This Supplement provides more details on IRA provisions, which are incorporated across several multi-sector models that inform the analysis here. BIL provisions that are not directly assessed will help address overall deployment needs by supporting infrastructure buildout, supply chain development, technological advancements, and other hard-to-model enabling factors.

Policies and Measures in the Inflation Reduction Act (IRA)

The 2022 Inflation Reduction Act (IRA) represents a historic investment in climate action through a combination of tax credits, direct federal spending, competitive grants, and loan programs. Together with the BIL, the IRA is poised to inject hundreds of billions of dollars into the U.S. economy to decarbonize electricity, electrify energy services, increase energy efficiency, deploy enabling infrastructure, innovate across economic sectors, expand and secure supply chains, and ensure that benefits are equitable.

Recent investments and incentives included in the IRA are poised to accelerate ongoing trends across the U.S. energy system and deliver significant emission

reductions. The U.S. energy system has been undergoing significant transformations for some time, across the electricity sector, transportation, buildings, and industry. Lower costs of wind, solar, and electricity storage has contributed to rapid deployment. BIL and IRA investments in advanced nuclear technologies will make them a key part of the clean energy portfolio. The declining costs of electric vehicles means that total cost of ownership has reached cost parity with conventional gasoline vehicles.[3] Energy efficiency in buildings and manufacturing have improved productivity while reducing energy costs for homes and businesses. The IRA will help the United States go further and faster on seizing these opportunities.

The IRA includes a wide variety of provisions affecting the energy sector in the United States. Many of these are directed at emission reductions in the major economic sectors of electricity generation, transportation, buildings, and industry. Additionally, the legislation includes initiatives that affect multiple sectors simultaneously. The types of measures generally can be grouped as: tax incentives to encourage private sector investment in clean technology; federal support including grants and loans to support financing that helps accelerate clean technologies in the marketplace; and programs that provide direct support to American communities. This includes technical assistance to U.S. jurisdictions including Tribal Nations to encourage equitable access to clean technology and investment.

The IRA includes historic investments in equity and environmental justice programs to improve public health, reduce pollution, and revitalize communities that are marginalized, underserved, and overburdened by pollution. Across IRA programs there are also specific requirements to engage these communities and ensure benefits from these programs accrue to them. For example, clean energy tax provisions offer bonus credits to projects that are in low-income communities or energy communities.[4] The IRA also places a strong focus on creating good-paying jobs, for example through tax incentives and funding opportunities that encourage projects to pay prevailing wages and use registered apprenticeship programs.

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[3] U.S. National Renewable Energy Laboratory (2023*). 2022 Transportation Annual Technology Baseline: Comparison of LD Vehicles*.

[4] The Inflation Reduction Act provides targeted support for energy communities, which include areas in which a coal mine or coal-fired power plant has closed or that have been economically reliant on the extraction, processing, transport, or storage of coal, oil, or natural gas but now face higher-than-average unemployment (White House Inflation Reduction Act Guidebook).

Key Provisions by Sector

Key IRA and BIL provisions are summarized below by sector. Additional descriptions of these provisions are provided in the Appendix to this report. The Biden-Harris Administration's Bipartisan Infrastructure Law Guidebook[5] and Inflation Reduction Act Guidebook[6] both provide program-by-program information, including details on eligible entities and activities.

Electric Sector

Key BIL provisions for the electric sector include historic investments in strengthening the U.S. power grid.[7] In addition, the BIL includes $6 billion for a Civil Nuclear Credit Program that will provide financial support to existing nuclear reactors that are at risk of closing and being replaced by higher-emitting power resources; more than $700 million for upgrades to the existing U.S. hydropower fleet that will improve efficiency, maintain safety, and reduce environmental impacts; and $21.5 billion for clean energy demonstration projects for innovative technologies like clean hydrogen, carbon capture, direct air capture, grid-scale energy storage, advanced nuclear reactors, and more.

Key IRA provisions for the electric sector include:

- Tax Incentives
  - Extension of Renewable Electricity Production Tax Credit
  - Extension of Renewable Energy Investment Tax Credit
  - Clean Electricity Production Tax Credits
  - Clean Electricity Investment Tax Credits
  - Energy Credit for Solar and Wind in Low-Income Communities
  - Zero-Emission Nuclear Power Production Tax Credit
  - Carbon Capture and Sequestration Tax Credit

- Programs
  - Energy Infrastructure Reinvestment Program (EIR)
  - Grants to Facilitate the Siting of Interstate Electricity Transmission Lines
  - High-Assay Low-Enriched Uranium (HALEU) Availability Program
  - Rural Energy for America Program (REAP)

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[5] U.S. Executive Office of the President (May 2022). *A Guidebook to the Bipartisan Infrastructure law for State, Local, Tribal, and Territorial Governments, and Other Partners*.

[6] U.S. Executive Office of the President (January 2023). *Building a Clean Energy Economy: A Guidebook to the Inflation Reduction Act's Investments in Clean Energy and Climate Action (Version 2)*.

[7] A full list is available in the White House Guidebook to the Bipartisan Infrastructure Law

- Greenhouse Gas Reduction Fund
- Carbon Pollution Reduction Planning and Implementation Grants
- Transmission Facility Financing
- Title 17 Innovative Energy and Supply Chains Financing Programs
- Tribal Energy Financing Program
- USDA Assistance for Rural Electric Cooperatives

Together, these provisions aim to target the entire energy supply chain, from manufacturing through deployment and final demand by consumers.

The IRA modified and extended the availability of the existing Renewable Energy Investment and Renewable Electricity Production Tax Credits. The investment tax credit (ITC) is a 6% tax credit on the up-front capital costs of a project in the year the facility is placed in service, increasing to 30% if prevailing wage and apprenticeship standards are met. The production tax credit (PTC) provides 0.55 cents per kWh of electricity for the first 10 years a zero- or negative-GHG emissions project operates, increasing to 2.75 cents per kWh if prevailing wage and apprenticeship standards are met. Beginning with facilities placed in service on January 1, 2025, a technology-neutral investment tax credit and a technology-neutral production tax credit for zero-emission generation facilities and qualified energy storage technologies replaces the Renewable ITC and PTC and are extended through the later of 2032 or until the power sector achieves a 75% reduction in CO_2 emissions from 2022 levels, after which they begin to phase out.

The Zero-Emission Nuclear Power Production Tax Credit is a new tax credit that provides financial assistance to existing nuclear facilities. The credit amount phases down depending on the amount of energy produced and the gross receipts of the nuclear power facility. Separately, the IRA provides tax credits for both production and investment for new advanced reactors generating electricity.[8]

Under the IRA, various provisions can alter the incentive levels of tax credits and incentives depending upon how much of a particular project uses domestic content, whether the project is located in an energy community, and whether project developers are paying prevailing wages and using apprenticeship programs in the locality where the project is built.

[8] Advanced reactor facilities that qualify for production or investment tax credits may only benefit from one, the production credit or the investment credit, but not both.

Other relevant tax credit provisions impacting the power sector include the new Advanced Manufacturing Production Tax Credit, which creates a tax credit for the production of clean energy technology components that are produced in the United States and the new Clean Hydrogen Production Tax Credit, which creates a 10-year incentive for clean hydrogen production.

The IRA also provides investments into the power sector in the forms of funding and financing provisions. For example, $9.7 billion is available for financial assistance to rural electric cooperatives to purchase renewable energy, renewable energy systems, zero-emissions systems, and carbon capture and storage systems; $5 billion is available for the Department of Energy Loan Programs Office Energy Infrastructure Reinvestment Program for the cost of providing financial support in the form of loans and guarantees to 1) retool, repower, repurpose, or replace energy infrastructure, or 2) enable operating energy infrastructure to avoid, reduce, utilize, or sequester GHG emissions. This allocation has the potential to support over $300 billion of infrastructure project financing.[9] The IRA also provides $700 million for the High-Assay Low-Enriched Uranium (HALEU) Availability Program to support the development of a domestic supply chain for HALEU.

An important financing component of the IRA and BIL is the ability to invest in expanding the capacity of the transmission and distribution system. The IRA provides $2 billion in direct loans for construction or modification of electric transmission facilities. The IRA also provides support for states and local communities in siting and permitting of interstate or offshore electricity transmission lines. These efforts along with BIL capacity contracts provide investment opportunities critical to accessing clean generation.

Additional IRA provisions target distributed generation, energy storage, energy efficiency, and end-use electrification, with most of these funds supporting distribution grid and end-use projects. There are numerous developing low-GHG distributed energy technologies, including nuclear (small modular reactors and microreactors) and innovative energy storage technologies, that the IRA will help encourage. Some of these technologies can be applied as a foundation for microgrids, which provide local resiliency and as parts of virtual power plants and can substitute for higher emitting fossil fuel-fired peaking units.

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[9] U.S. Department of Energy (May 19, 2023). *LPO's Updated Title 17 Clean Energy Financing Program Guidance Connects Eligible Projects to New Financing Opportunities as Part of President Biden's Investing in America Agenda.*

Transportation Sector

The BIL includes major provisions for the transportation sector such as $7.5 billion to deploy electric vehicle chargers; more than $7 billion to ensure domestic manufacturers have the critical minerals and other components necessary to make EV batteries; $10 billion for clean transit and school buses; and significant investments across U.S. public transportation and passenger rail systems.

The IRA includes the following major provisions for the transportation sector:

- Tax Incentives
  - Clean Vehicle Credit
  - Credit for Previously Owned Clean Vehicles
  - Qualified Commercial Clean Vehicle Credit
  - Alternative Fuel Vehicle Refueling Property Credit
  - New Clean Fuel Production Tax Credit
  - Biodiesel and Renewable Fuels Production Tax Credit
  - Second-generation Biofuels Production Tax Credit
  - Sustainable Aviation Fuel Production Tax Credit

- Programs
  - Advanced Technology Vehicle Manufacturing (ATVM) Loan Program
  - Clean Heavy Duty Vehicles Program
  - Clean Ports Program
  - Domestic Manufacturing Conversion Grants
  - Diesel Emissions Reductions Program
  - U.S. Postal Service Clean Fleets
  - Greenhouse Gas Reduction Fund

The IRA includes provisions to support production and sales of low-emissions vehicles. The IRA Clean Vehicle Credit provides a tax credit of up to $7,500 for the purchase of new all-electric, plug-in hybrid, and fuel cell electric vehicles, and is modified to include requirements for the use of critical minerals in production and for battery components. At the same time, the IRA removed manufacturer-specific phaseouts and expanded eligibility. In addition, this credit is only available to consumers below a certain income threshold and has a manufacturer's standard retail price (MSRP) cap on the cost of vehicles that are eligible, to ensure the credits go to those who need it most. Beginning January 1, 2024, buyers may transfer the tax credit for clean vehicles to registered dealers at the point of sale. A new tax credit is created supporting clean commercial vehicles (with more substantial potential credits for larger commercial vehicles and smaller credits for smaller vehicles).

Another new credit is targeted at the purchase of used electric plug-in and fuel cell clean vehicles—this credit is intended to support clean vehicle purchases by lower income consumers.

Additionally, the IRA extends numerous existing tax provisions that encourage production of fuels. These include tax credits for renewable diesel and biodiesel used as fuel, the alternative fuels tax credit, and the second-generation biofuel producer tax credit. The alternative fuel charging or refueling property tax credit is extended, but modified so that it applies to property placed in service in low-income or rural areas.

The IRA also establishes new fuel-related provisions. A new tax credit supports the sale or blending of sustainable aviation fuel. Another provision supports the production of clean hydrogen, which can be used in transportation applications. A new clean fuel credit (which begins in 2025) depends on the emissions factor associated with the fuel.

The IRA creates new funding and loan programs that will affect emissions from the transportation sector. The Environmental Protection Agency's Heavy-Duty Vehicle Program invests $1 billion to replace dirty heavy-duty vehicles with clean, zero-emission vehicles and infrastructure and to train and develop workers. The Environmental Protection Agency's Clean Ports Program provides $3 billion to purchase zero-emission port equipment and technologies. The U.S. Postal Service Clean Fleets program supports the purchase of zero-emitting delivery vehicles. The Advanced Technology Vehicle Manufacturing Loan Program supports the production of low-emissions vehicles and their qualifying components. Through the Domestic Manufacturing Conversion Program, cost-share grants are available for domestic production of clean vehicles.

Buildings Sector

Key BIL provisions for the buildings sector include a $3.5 billion expansion of the Weatherization Assistance Program to improve home energy efficiency for low-income families; $250 million for the Energy Efficiency Revolving Loan Fund Capitalization Grant Program, through which states can provide loans and grants for energy efficiency audits, upgrades, and retrofits to buildings; $225 million to support Resilient and Efficient Building Energy Codes; and $550 million for the Energy Efficiency and Conservation Block Grant Program, which is designed to assist states, local governments, and Tribes in implementing strategies to reduce energy use, improve energy efficiency, and deploy clean energy.

Key IRA provisions relevant to the buildings sector include:

- Tax Incentives
  - Energy Efficiency Home Improvement Credit
  - Residential Clean Energy Credit
  - New Energy Efficient Homes Credit
  - Energy Efficient Commercial Buildings Deduction

- Programs
  - Building Energy Codes Grants
  - Funding to Address Air Pollution at Schools
  - General Services Administration Assistance for Federal Buildings
  - Greenhouse Gas Reduction Fund
  - High-Efficiency Electric Home Rebates
  - Home Energy Efficiency Contractor Training Grants
  - Home Energy Performance-Based, Whole-House Rebates
  - HUD Green and Resilient Retrofit Program
  - Tribal Electrification Program
  - Title 17 Loan Programs

Note that this list is not exhaustive, but it captures the major provisions for the buildings sector in the IRA. The IRA modifies and extends three tax incentives focusing on clean energy and energy efficiency improvements for residential buildings. For example, the modified residential clean energy credit includes battery storage and is extended to 2032 with a phasedown to 2034. The IRA provides almost $9 billion to states and tribal nations to set up home energy rebate programs, including the Home Energy Performance-Based, Whole-House Rebates program, which requires ENERGY STAR certification, and the High-Efficiency Electric Home Rebates program.

Tax incentives encourage energy efficiency in commercial buildings – such as a business tax deduction for energy efficiency improvements to commercial buildings, including lighting, heating, cooling, ventilation, and hot water. Additionally, both the IRA and BIL provide support for state and local governments to adopt updated building energy codes and support sustained, cost-effective implementation to reduce energy usage.

Several BIL and IRA programs offer additional opportunities to provide financing that accelerate clean technology transitions in low-income and disadvantaged

communities and address specific barriers for these populations. The $27 billion Greenhouse Gas Reduction Fund provides financing and private capital to support clean energy and climate projects, with an emphasis on those that benefit low-income and disadvantaged communities. The $1 billion Green and Resilient Retrofit Program funds projects to upgrade publicly-assisted multi-family properties to be more energy efficient and climate resilient. Title 17 Loan Programs are being used to expand access to distributed energy resources for low- and middle-income households that can be aggregated to form virtual power plants.[10]

Industrial Sector

The BIL includes provisions that allow for demonstrations of advanced decarbonization technologies and processes across sectors, including $500 million in support for Industrial Emissions Demonstration Projects that test and validate technologies to reduce industrial emissions; $400 million toward Industrial Research and Assessment Centers to help optimize energy efficiency and environmental performance at manufacturing and other industrial facilities; $8 billion toward the establishment of Regional Clean Hydrogen Hubs that will improve the production, processing, delivery, storage, and use of clean hydrogen; $2.5 billion toward the Carbon Capture Demonstration Projects Program, which will improve the emissions reductions from coal and natural gas use in manufacturing and industrial facilities; as well as hundreds of millions of dollars in investments across technologies with industrial decarbonization applications.

The IRA sets forth provisions that affect industry and manufacturing across all its sectors. There is potential not only to transform the industrial sector's use of fuel and resulting emissions, but products used by other sectors. The IRA includes the following policies and incentives relevant to the industrial sector:

- Tax Incentives
  - Expansion of Advanced Energy Project Credit
  - Carbon Capture and Sequestration Tax Credit
  - Clean Hydrogen Production Tax Credit

- Programs
  - Advanced Industrial Facilities Deployment Program
  - Low Carbon Transportation Materials Program
  - Title 17 Loan Programs

[10] U.S. Department of Energy (2023). *Pathways to Commercial Liftoff: Virtual Power Plants*.

- Use of Low Carbon Materials

The IRA includes tax incentives for investments in facilities that are established, re-equipped, or expanded for the production of clean technologies or for processing, refining, and recycling of critical minerals, as well as for projects to reduce greenhouse gas emissions from industrial facilities. The Advanced Industrial Facilities Deployment Program provides competitive support for the demonstration and deployment of emissions reductions technologies for energy intensive industries. Potential industrial sector mitigation measures that could be incentivized by the IRA include energy efficiency, electrification, hydrogen, carbon capture, and other advanced manufacturing processes that reduce emissions.

IRA programs also encourage lower-emitting fuel use across all economic sectors, including for developers of clean energy resources and for producers of clean fuels and clean electricity themselves. These include incentives for the production of clean electricity, hydrogen, biofuels, and sustainable aviation fuels. Hydrogen and biofuels are potential ways to fuel high-temperature industrial processes. The Hydrogen Production Tax Credit creates a new incentive for clean hydrogen production. Finally, advanced technology funding encourages industry-specific advances, and development of federal Environmental Product Declarations will provide demand from government and private entities for less carbon-intensive products. Loan programs, such as the Title 17 Loan Program, can be used to reduce financing costs for major industrial decarbonization projects.

Cross-Sectoral Measures

Several significant IRA provisions encourage emission reductions in more than one of the four sectors addressed above, including:

- Tax incentives and rebates
  - Carbon Capture and Sequestration Tax Credit
  - Advanced Manufacturing Production Credit
  - Clean Hydrogen Production Tax Credit

- Programs
  - Climate Pollution Reduction Grants
  - Energy Infrastructure Reinvestment Financing Program
  - Environmental and Climate Justice Block Grants
  - Greenhouse Gas Reduction Fund
  - Methane Emissions Reduction Program

Incentives for carbon capture, use, and storage (CCUS) will ultimately accelerate emissions reductions across a variety of industries and lead to CCUS deployment, particularly in the industrial sector, fuel production, and the electricity sector. In the industrial sector, CCUS is a potential solution to mitigate fossil combustion as well as the bulk of process emissions from cement production. The IRA modifies and extends the existing Carbon Capture & Sequestration Tax Credit, which provides up to $85/metric ton for carbon capture and storage facilities meeting prevailing wage and apprenticeship requirements; the tax credit also includes an incentive of up to $180/metric ton for direct air capture (DAC) facilities. The BIL provides $12 billion for carbon management, research, demonstrations, and deployment. Additionally, the IRA establishes the Advanced Manufacturing Production Tax Credit, which provides a per-unit tax credit for the production of solar, wind, inverter, and battery components, as well as fifty critical minerals.

The Greenhouse Gas Reduction Fund (GGRF), Climate Pollution Reduction Grants (CPRG), and Environmental Justice Block Grants will help U.S. jurisdictions and communities – particularly low-income and disadvantaged communities – reduce GHG emissions and other pollution that harms public health. The Energy Infrastructure Reinvestment Financing investments will result in emission reductions across sectors. The CPRG program will support state, local, and tribal efforts to reduce GHG emissions across multiple sectors (electricity, buildings, transportation, industry, lands). EPA's $27 billion GGRF program is prioritizing emissions reductions from the electricity, buildings, and transportation sectors.

Both the IRA and BIL will also support implementation of the U.S. Methane Emissions Reduction Action Plan.[11] The IRA provides funding for financial and technical assistance to accelerate the reduction of methane and other greenhouse gas emissions from petroleum and natural gas systems by improving and deploying new equipment, supporting technological innovation, permanently shutting in and plugging wells, and other activities. The IRA also imposes a waste emissions charge on facilities with methane emissions that exceed a certain threshold. The BIL provides nearly $4.7 billion to plug and remediate orphaned oil and gas wells on Tribal, federal, state, and private lands, as well as $11.3 billion for abandoned coal mine land reclamation.

The IRA also provides funding for implementation of the American Innovation and Manufacturing Act, the U.S. legislation that directs a national phasedown of

[11] U.S. Executive Office of the President (November 2022). *Delivering on the U.S. Methane Emissions Reduction Action Plan*.

production and consumption of hydrofluorocarbons (HFCs) by 85% by 2036, a schedule that aligns with the Kigali Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer, which the United States has ratified.

Land Use, Land Use Change, and Forestry (LULUCF) and Agriculture

Given available modeling, the analytical focus of this Supplement is impacts of the IRA and BIL on the energy sector. However, this legislation will also help reduce emissions and increase sequestration in the Land Use, Land Use Change, and Forestry (LULUCF) and Agriculture sectors. For example, the BIL provides funding for a variety of ecosystem restoration efforts to support healthy national forests and grasslands. The IRA provides additional investments, including:

- Programs
  - Climate Mitigation and Forest Resilience Practices
  - Conservation Technical Assistance (Greenhouse Gas Emission Quantification Program)
  - Environmental Quality Incentives Program
  - Hazardous Fuel Reduction Projects in Wildland Urban Interface
  - Regional Conservation Partnership Program
  - Urban and Community Forestry Assistance Program

These provisions aim to protect and strengthen the National Forest System as well as forests on non-federal land, including through support for forest landowners to support practices that boost carbon sequestration and for urban tree planting programs. The IRA also makes historic investments to support farmers, ranchers, and forest landowners in deploying climate-smart practices that will reduce greenhouse gas emissions, increase storage of carbon in soils and trees, and make their operations more productive.

Emissions Projections for the 2023 Policy Baseline

Most of the models used in this analysis focus on the impacts of the IRA and conservatively assume that BIL provisions act only as enabling factors toward the full implementation of IRA provisions. Some models also include an explicit representation of key BIL provisions, including the Civil Nuclear Credit Program for the electric sector; the Weatherization Assistance Program, State Energy Program, and the Energy Efficiency and Conservation Block Grant Program for the buildings

sector; as well as overall increases in government spending that affect overall economic activity.[12, 13]

The estimates in this analysis will accordingly tend to understate the combined emission reductions from BIL and IRA. Figure 1 depicts historical U.S. net GHG emissions since 2005 along with the modeling results on the IRA and BIL's impacts (i.e., the 2023 Policy Baseline), and the 2021 Policy Baseline.

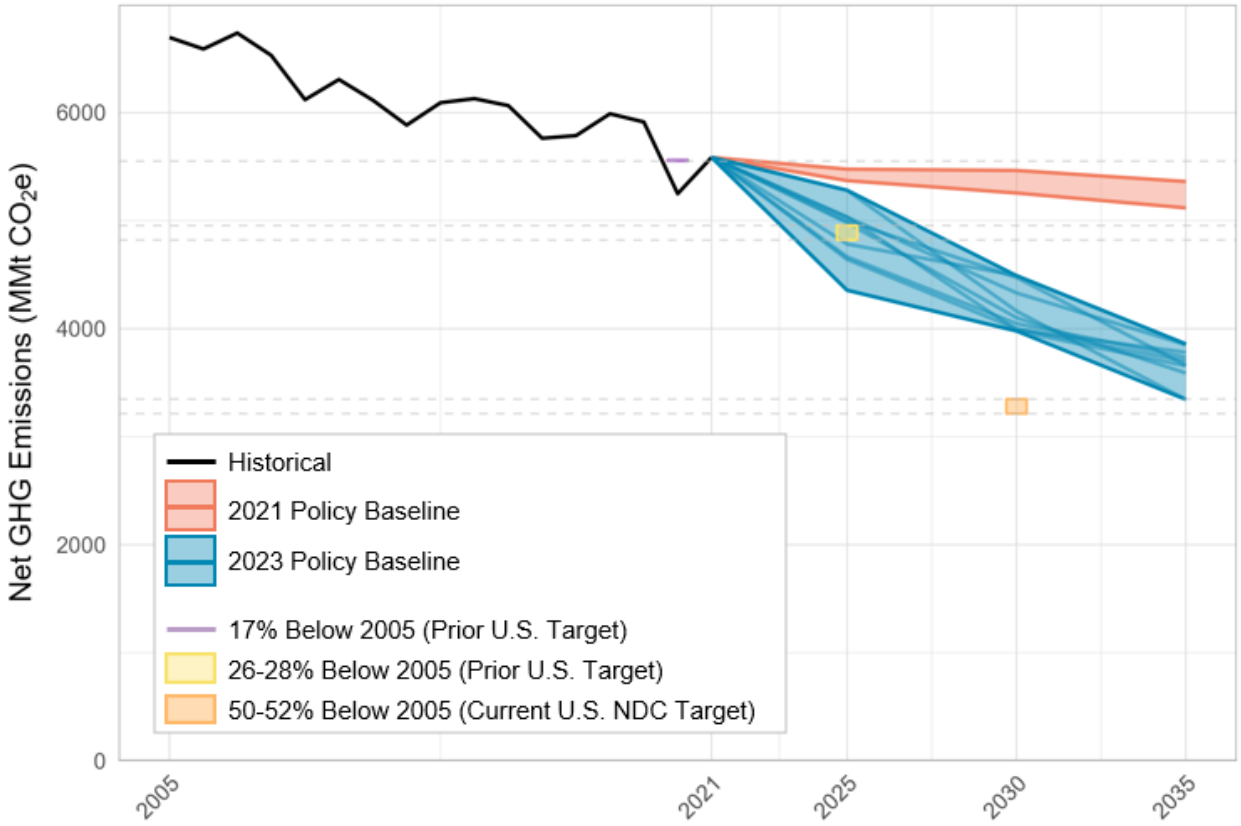

Figure 1. Net greenhouse gas emissions, showing historical (2005-2020) and projected (2020-2035). The blue shaded area represents the range of modeling results for the 2023 Policy Baseline, which incorporates recent analysis of the IRA and some key provisions in the BIL. The solid blue lines represent individual model runs for the analysis. The red shaded area is the 2021 Policy Baseline, previously presented in BR5. The U.S. NDC Target for 2030 is shown as an orange rectangle, and show opportunities for other measures, in addition to the IRA and BIL, to meet U.S. goals. Detailed information on models and scenario assumptions can be found in the Technical Appendix.

[12] U.S. Department of Energy (August 2023). *Technical Appendix: Investing in American Energy.*
[13] U.S. Energy Information Administration (March 2022). *The Bipartisan Infrastructure and Jobs Act in the Annual Energy Outlook 2022.*

In Figure 1, the projections developed for BR5 (shown as the 2021 Policy Baseline in the red shaded region), differs from the 2023 Policy Baseline (shown in the blue shaded region) in three ways: First, at the time of BR5, the IRA and BIL had only recently been signed by President Biden, and analysis of the impacts of the legislation was preliminary. Second, the prior modeling was based on the 1990-2020 U.S. Greenhouse Gas Inventory – whereas the updated analysis is based on the 1990-2021 U.S. Greenhouse Gas Inventory, which includes updated values for the calculation of the global warming potentials of non-CO_2 GHGs. Lastly, the 2021 Policy Baseline through 2035 was conducted using a different modeling system for energy sector emissions.

The 2023 Policy Baseline uses several different models, including economy-wide models, technology models, and electricity sector models with different strengths and capabilities to incorporate representation of the many different provisions of the IRA and BIL. This approach is detailed in the Technical Appendix. Using a wide variety of modeling systems allows for use of a diverse array of modeling structures and assumptions, with differing respective capacity to represent policy changes. The models have different temporal, spatial, and technological specifications, which means that the range of projected impacts of the legislation is wide. Legislative provisions are represented in different ways in different models, and since the modeling systems were run with several scenarios representing details such as technological costs, future energy prices, and future economic growth, the range of results from the modeling represents a reasonable range of uncertainty in potential future emissions. For most of the models, the analytical focus is on the impacts of the legislation on the energy sector. The legislation includes substantial investments in reductions from agriculture, non-CO_2, and land use sectors – and these measures are represented in a subset of the models. In certain cases, representing certain legislative provisions is difficult, and conservative assumptions are made that limit the potential impact of the IRA and BIL.

The projections show that the IRA and BIL make large contributions to emissions reductions through 2035 compared to the 2021 Policy Baseline. In the 2023 Policy Baseline, the net greenhouse gas emissions are estimated to be 21-35% below 2005 levels in 2025 (consistent with achievement of the prior U.S. target in the range of a 26-28% reduction below 2005 levels in 2025), and between 33-41% below 2005 levels in 2030. This represents a near doubling in emissions reductions compared to the 2021 Policy Baseline, in which emissions were estimated to be 18-20% below 2005 levels in 2025 and 18-21% below 2005 levels in 2030. The IRA and BIL significantly accelerate the transitions needed to meet the U.S. emissions goals. While Figure 1

shows that additional measures are required to meet the U.S. NDC target in 2030, the IRA and BIL play an important role in lowering clean energy costs and providing sustained and uncapped deployment incentives for all the major carbon-reducing technologies and solutions, thereby spurring investment in technologies that are essential to transforming the energy sector. These contributions of the IRA and BIL are expected to catalyze the additional actions at the federal, state, local and company level that are needed for the U.S. to meet our emissions goals.

The GHG emissions analyses from recent modeling also show that the IRA's incentives are a catalyst for emissions reductions that go beyond what can be modeled. They result in reduced costs of clean technology and accelerate its acceptance in the market. In other words, the IRA contributes to reducing both market – and non-market – barriers to adoption of cleaner processes and technologies. States and Federal Agencies are already proposing polices and regulations that will further accelerate decarbonization trends. The impact of the IRA is to lower the costs (and increase the effectiveness) of these additional policies. While this impact is difficult to quantify, it is an important contribution of the IRA.

Table 1. Historical and Projected U.S. GHG Emissions (2023 Policy Baseline), by Gas: 2005-2035 (MMT CO_2e)

Sector	Historical				Projected					
	2005	2010	2015	2021	2025		2030		2035	
					Low	High	Low	High	Low	High
CO2	6,132	5,680	5,377	5,032	4,127	4,772	3,494	3,979	2,763	3,573
CH4	791	808	771	727	668	731	641	731	637	729
N2O	416	411	419	393	342	383	360	376	365	397
HFCs	116	145	158	175	150	150	118	153	83	124
PFCs	6	4	5	4	4	5	5	5	5	5
SF6	16	10	7	8	5	5	4	5	4	5
NF3	0	0	1	1	1	1	1	1	1	1
Total Gross Emissions	7,477	7,058	6,737	6,340	5,350	6,034	4,754	5,241	3,991	4,685
LULUCF	(781)	(751)	(672)	(754)	(994)	(725)	(887)	(709)	(903)	(646)
Total Net Emissions	6,696	6,307	6,066	5,586	4,356	5,282	3,979	4,491	3,344	3,858

Table 2. Historical and Projected U.S. GHG Emissions Baseline (2023 Policy Baseline), by Sector: 2005-2025 (MMT CO_2e)

Sector	Historical				Projected					
	2005	2010	2015	2021	2025		2030		2035	
					Low	High	Low	High	Low	High
Energy	4,385	4,137	3,808	3,392	2,863	3,229	2,336	2,804	2,135	2,468
Transportation	1,966	1,795	1,789	1,804	1,523	1,717	1,353	1,493	1,136	1,346
Industrial Processes	356	352	364	376	318	358	282	311	237	275
Agriculture	578	591	605	598	505	586	448	593	376	592
Waste	192	183	172	169	143	161	127	146	106	140
Total Gross Emissions	7,477	7,058	6,737	6,340	5,350	6,034	4,754	5,241	3,991	4,685
LULUCF	(781)	(751)	(672)	(754)	(994)	(725)	(887)	(709)	(903)	(646)
Total Net Emissions	6,696	6,307	6,066	5,586	4,356	5,282	3,979	4,491	3,344	3,858

Tables 1 and 2 present an overview of historical and projected emissions in the 2023 Policy Baseline across gases and sectors, with low and high projections from across nine multi-sector models, which are described in the Technical Appendix. For projected emissions, each set of columns for the years 2025, 2030, and 2035 present the minimum and maximum projected emissions for each row, thus rows will not necessarily sum up to the total gross or total net emissions. Historical GHG emissions presented are from the 1990-2021 U.S. Greenhouse Gas Inventory published and use AR5 Global Warming Potential (GWP) values for non-CO_2 emissions, as do the projected non-CO_2 emissions. For projected emissions by gas and sector for each model, see the Technical Appendix.

Sector-by-Sector Analysis Highlights

Examining the 2023 Policy Baseline sector-by-sector underscores the accomplishments of the IRA and BIL and shows that there are additional opportunities for emissions reductions to achieve the U.S. NDC target for 50-52% below 2005 GHG emissions levels in 2030, as represented by the orange rectangle shown in Figure 1. The *U.S. Long Term Strategy* (LTS) – published in 2021 – outlined and modeled a range of sector-by-sector pathways for meeting the U.S. NDC target in 2030 toward a goal of reaching net-zero greenhouse gas emissions by 2050. The 2023 Policy Baseline shows how the IRA and BIL are driving emissions reductions toward the LTS Scenarios in each sector. The 2023 Policy Baseline with Additional Measures will be discussed in a later section.

Electricity

Clean electricity is the backbone of decarbonization and reductions in greenhouse gas emissions. A clean grid enables emissions reductions across economic sectors as they electrify. As shown in the analysis presented in the 2023 Policy Baseline, the IRA and BIL greatly accelerate decarbonization in the sector.

Electricity drives major parts of the economy, emitting 1,584MMT CO_2e in 2021, 25% of the U.S. total that year.[14] The 2021 Policy Baseline – even before the analysis of the IRA and BIL – projected that electrification of the American economy is increasing demand for clean electricity. The IRA and BIL will accelerate electrification as well as deployment of clean energy. Clean electricity is not just necessary for decarbonization; it is also quickly becoming the economic choice for American families and businesses, and the IRA and BIL accelerate this trend. These public investments will modernize the grid, improve resilience to extreme weather and price volatilities, improve health in our communities, all while strengthening the American workforce and lowering costs for homes and businesses. The 2023 Policy Baseline across models projects that power sector carbon dioxide emissions fall to 49-80% below 2005 levels in 2030, and to 67-86% below by 2035 (Figure 2). As Figure 2 shows, in some of these model scenarios, power sector emissions would already be within the range of the LTS pathways in both 2030 and 2035, whereas in other scenarios additional measures would be needed.

[14] U.S. Environmental Protection Agency (2022). *Sources of Greenhouse Gas Emissions*.

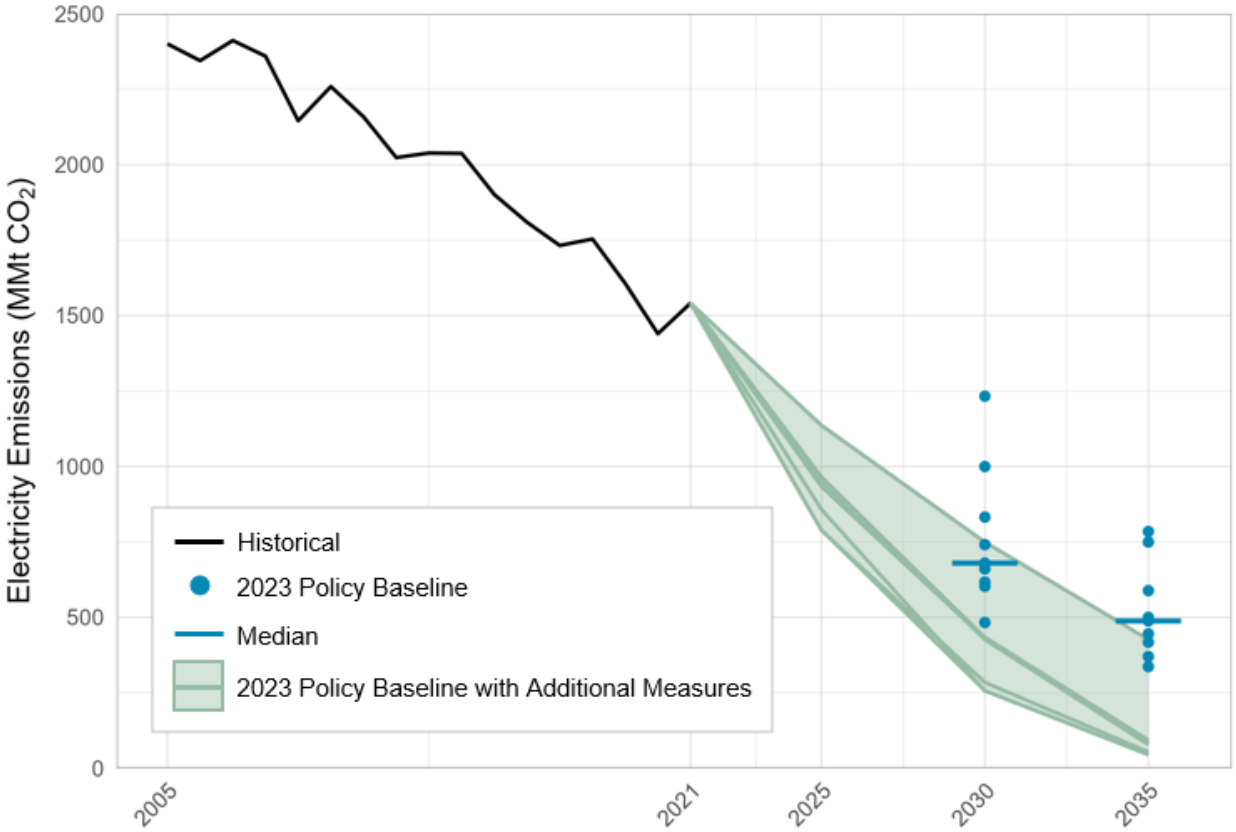

Figure 2. Energy-related carbon dioxide emissions in the electricity sector, historical (2005-2021) and modeled (2025, 2030, 2035).

Solar, wind, and storage are the primary drivers of near-term clean energy growth. Most models indicate that IRA could enable a significant increase in capacity additions of new wind and solar annually between 2021 and 2035. Coal capacity across models declines over this period. This decline is also evident in the 2021 Policy Baseline, which used the U.S. Energy Information Administration (EIA) Annual Energy Outlook 2022 (AEO2022). This reflects planned coal retirements before the passage of the IRA due to the decreasing cost-competitiveness of coal-fired electricity.[5] Most nuclear plants continue operations through 2035 with support from federal incentives provided by the IRA and BIL.

Projections show that the IRA and BIL contribute to substantial growth in clean electricity generation, from 43% of all generation in 2022[15] to up to 80% in 2030. This is in contrast to the 2021 Policy Baseline, in which the share of clean electricity generation increased to 53% in 2035. Collectively, IRA and BIL provisions lead to accelerated growth in clean electricity generation—defined here to include wind, solar, hydropower, geothermal, biomass, nuclear, and fossil-based generation with carbon capture and storage. While these provisions make significant progress toward decarbonizing electricity generation, it is not by itself sufficient to meet the U.S. domestic target of 100% carbon-free electricity by 2035. Additional measures by all levels of government and the private sector, catalyzed by the IRA and BIL, can contribute to meeting that goal.

Notably, the IRA and BIL support nascent technologies that may play an increasing role in later years. IRA and BIL offer historic levels of support for both pre-commercial and commercial clean energy technologies, including through the new Department of Energy Office of Clean Energy Demonstrations and through various Loan Programs Office authorities. These and other investments may open new power sector pathways not fully represented in the scenarios presented in the analysis. Some examples include advanced nuclear reactors, small modular reactors, and advanced carbon capture and storage.[16]

In addition to the significant reductions in projected U.S. GHG emissions, the IRA and BIL will result in substantial additional benefits for the United States. For example, the U.S. Department of Energy estimates that IRA and BIL are poised to save American families between $27 billion and $38 billion on electricity bills from 2022-2030, relative to a scenario without the legislation.[17] Moreover, IRA and BIL investments in clean electricity generation and manufacturing will mobilize billions of dollars in private investment[18] and support good jobs. The U.S. Energy &

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[15] https://www.eia.gov/electricity/data/browser/#/topic/0?agg=2,0,1&fuel=vtvv&geo=g&sec=g&linechart=ELEC.GEN.ALL-US-99.A~ELEC.GEN.COW-US-99.A~ELEC.GEN.NG-US-99.A~ELEC.GEN.NUC-US-99.A~ELEC.GEN.HYC-US-99.A~ELEC.GEN.WND-US-99.A~ELEC.GEN.TSN-US-99.A&columnchart=ELEC.GEN.ALL-US-99.A~ELEC.GEN.COW-US-99.A~ELEC.GEN.NG-US-99.A~ELEC.GEN.NUC-US-99.A~ELEC.GEN.HYC-US-99.A~ELEC.GEN.WND-US-99.A&map=ELEC.GEN.ALL-US-99.A&freq=A&ctype=linechart&ltype=pin&rtype=s&maptype=0&rse=0&pin= U.S. Energy Information Administration (2023). *Electricity Data Browser: Net Generation, U.S., All Sectors, Annual*.

[16] U.S. Department of Energy (2023). *Pathways to Commercial Liftoff Report Series.*

[17] U.S. Department of Energy (August 16, 2023). *DOE Releases New Report on Anniversary of Inflation Reduction Act Detailing How POTUS' Investing in America Agenda will Strengthen U.S. Economy by 2030.*

[18] U.S. Department of the Treasury (August 16, 2023). *The Inflation Reduction Act and U.S. Business Investment.*

Employment Jobs Report (USEER) shows that U.S. clean energy jobs increased in every state from 2021 to 2022 and grew by 3.9% nationally.[19] The IRA and BIL will further accelerate this growth. Clean electricity also reduces local air and water pollution, delivering significant public health benefits, especially for low-income and disadvantaged communities historically overburdened by pollution from combustion of fossil fuels.

Transportation

On-road transportation alone, including light-duty cars and trucks, as well as medium- and heavy-duty trucks, represent 60% of emissions in the U.S. transportation sector, and 21% of total U.S. GHG emissions. The IRA and BIL are expected to drive emissions reductions by increasing uptake of zero emission vehicles (ZEV)—including battery electric (BEV or EV), plug-in hybrid electric, and fuel cell vehicles. These vehicles offer enormous benefits to consumers in reduced tailpipe emissions, improved efficiency, lower operating and maintenance costs, and lower noise pollution. Many of the ZEVs already on the market today cost less to operate than conventional gasoline vehicles, offer improved performance and handling, have a driving range similar to that of conventional vehicles, and can be charged at a growing network of public chargers as well as at home.[20,21,22]

EVs have seen exponential growth in recent years, with the number of EVs sold growing from roughly 1,000,000 vehicles in 2018 cumulatively from 2010 to 2018 to over 1,000,000 in the first ten months of 2023 alone. EVs now account for 9 percent of new domestic light-duty vehicle sales, up from 2 percent in 2018 and this number is projected to rise rapidly, encouraged by the IRA and BIL.[23]

The 2023 Policy Baseline across models suggests that energy-related carbon dioxide emissions in the transportation sector decline to 12-25% below 2005 levels in 2030, and to 20-35% below 2005 levels in 2035 (Figure 3). As Figure 3 shows, in some of these model scenarios, transportation sector emissions would already be within the

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[19] U.S. Department of Energy (June 2023). *United States Energy & Employment Report 2023*.
[20] U.S. Department of Energy, Transportation Analysis Fact of the Week #1190, "Battery-Electric Vehicles Have Lower Scheduled Maintenance Costs than Other Light-Duty Vehicles," June 14, 2021.
[21] Consumer Reports (November 5, 2020). *Electric Cars 101: The Answers to All Your EV Questions*. Accessed June 8, 2021.
[22] U.S. Department of Energy, Transportation Analysis Fact of the Week #1253, "Fourteen Model Year 2022 Light-Duty Electric Vehicle Models Have a Driving Range of 300 Miles or Greater," August 29, 2022.
[23] U.S. Argonne National Laboratory (2023). *Light Duty Electric Drive Vehicles Monthly Sales Updates (Retrieved November 2023)*.

range of the LTS pathways in 2030, but in most scenarios additional measures would be needed to achieve the 2030 target and then drive additional reductions consistent with the long-term pathways.

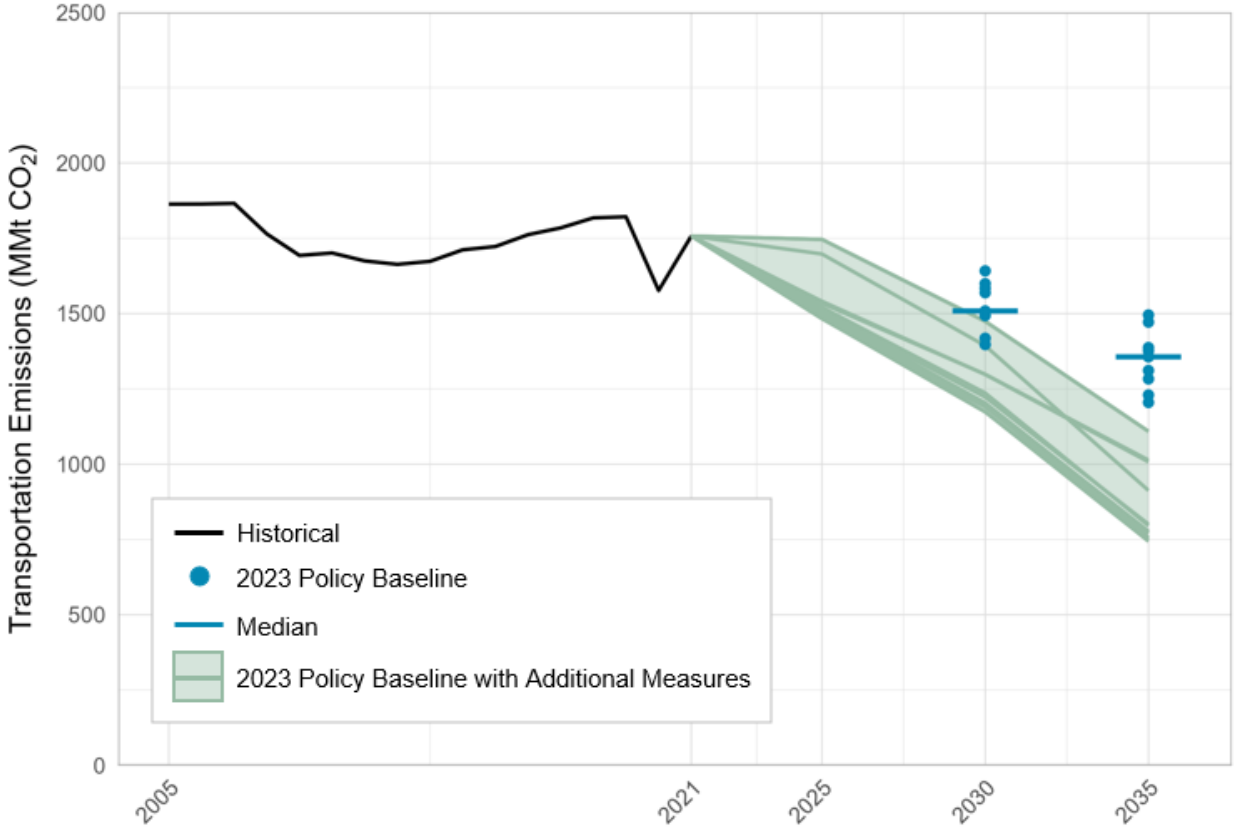

Figure 3. Energy-related carbon dioxide emissions in the transport sector, historical (2005-2021) and modeled (2025, 2030, 2035).

With the IRA and BIL in place, sales of electric vehicles are projected to climb rapidly, rising to 15-65% of new sales in 2030, due primarily to the clean vehicle tax credit and declining upfront costs of EVs**.** The upper bound of the projection range surpasses the Biden Administration's goal that 50% of all new passenger cars and light trucks sold in 2030 be ZEV.[24]

[24] U.S. Executive Office of the President (August 10, 2021). *Executive Order 14037: Strengthening American Leadership in Clean Cars and Trucks*.

In addition to the Clean Vehicle Tax Credit, several IRA programs also spur direct investment in clean vehicles, including $3 billion for the U.S. Postal Service to purchase electric delivery vehicles, and $1 billion to a new EPA clean heavy-duty vehicle program.[16] Additionally, BIL provides $5.5 billion for the Federal Transit Authority's Low or No Emission (Low-No) grant program, which provides funding to states and local authorities to purchase zero- or low-emission transit buses and supporting infrastructure.[17] These direct investment programs not only ensure stable, guaranteed buyers for automakers investing in ZEV manufacturing, but they are also expected to help contribute to future cost reductions, by driving these technologies down the learning curve. These programs also include specific incentives to benefit communities most impacted by local air pollution.

Beyond the IRA and BIL, recent cost declines, technological improvements, and support for the decarbonization of the transportation sector set the stage for continuing additional measures at all levels of government and in the private sectors. Several state governments, including California, are seeking to encourage accelerated transitions to ZEVs. Continued acceleration of the shift to clean transportation will help the U.S. meet its GHG reduction goals, while also improving air quality and public health.

Buildings

The U.S. buildings sector comprises over 130 million residential and commercial buildings where people spend most of their time every day. These buildings are the single largest energy-consuming sector of the economy, accounting for 75% of total U.S. electricity use, 30% of all energy use, and 35% of energy-related carbon dioxide emissions in 2022.[25,26] Building efficiency and electrification can reduce emissions while also improving indoor air quality and lowering energy bills for families and businesses. Building efficiency reduces the amount of energy required to provide the same or better quality of services, for example to heat and cool homes and businesses. The IRA and BIL support various building efficiency programs, as well as electrification opportunities to deploy electric heat pumps for space and water heating.

In the 2023 Policy Baseline, emissions in the U.S. buildings sector are projected to decline to between 49-63% below 2005 levels in 2030, and 57-70% below 2005 levels

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[25] U.S. Energy Information Administration (2022). *U.S. Energy Consumption by Source and Sector, 2022*.
[26] U.S. Energy Information Administration (2022). *U.S. CO_2 Emissions from Energy Consumption by Source and Sector, 2022*.

in 2035 (Figure 4). As Figure 4 shows, in some of these model scenarios, building sector emissions would already be within the range of the LTS pathways in 2030, but in several scenarios additional measures would be needed to achieve the 2030 target and then drive additional reductions consistent with the long-term pathways. Emissions reductions are largely driven by increased electrification and efficiency in building stock. Note that these reductions include indirect emissions, or the emission reductions from a cleaner electricity grid.

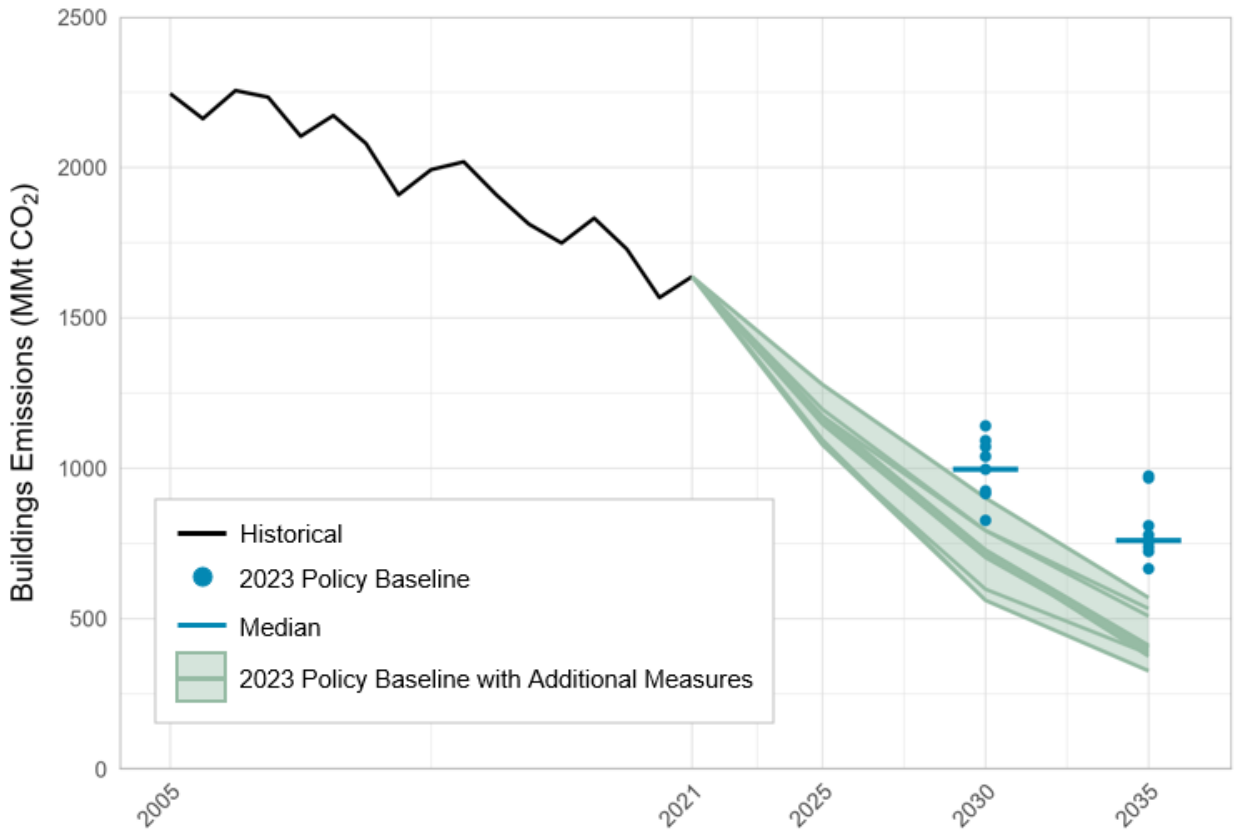

Figure 4. Energy-related carbon dioxide emissions in the buildings sector, historical (2005-2021) and modeled (2025, 2030, 2035).

On average, IRA programs support a significant increase in the sales of electric heat pumps for space heating. According to analysis from the Department of Energy, the combined effect of IRA provisions — particularly the Energy Efficient Home Improvement Tax Credit and the High-Efficiency Electric Home Rebate Program — enables significant switching from inefficient electric radiant heaters and natural gas

furnaces to electric heat pumps.[27] Similarly, building-specific IRA provisions lead to switching from natural gas water heaters and conventional electric water heaters into solar water heaters and heat pump water heaters.

In the last 15 years, buildings in the United States have become much more efficient. According to the Energy Information Administration, residential buildings have reduced their energy intensity (consumption per square foot) by 19% while commercial buildings have reduced their intensity 15% between 2007 and 2017.[28] Further efficiency improvements are supported by the IRA and BIL and will contribute to slowing the growth in energy demand for buildings, even as population and building stock are expected to increase. This change is concentrated in reductions in energy use from space heating, cooling, and water heating, and is driven by IRA tax credits and rebate programs, more stringent building codes, and retrofits funded through federal programs, including the Green and Resilient Retrofit Program. BIL and IRA also include provisions centering on energy efficiency that further reduce residential energy intensity. Energy use in the commercial sector declines in the models due to the Energy Efficient Commercial Buildings Deduction, more efficient building codes, and assumed retrofits funded through the EPA Greenhouse Gas Reduction Fund, with most of the savings occurring in space heat and cooling. IRA and BIL investments and incentive programs contribute directly to building sector emission reductions, and can also help unlock additional policies and measures. Many state and local governments, for example, are considering building code updates for new buildings, and both the IRA and BIL provide resources to help implement code updates that these subnational jurisdictions choose to pursue.

Industry

In 2021 the U.S. industrial sector (which accounts for manufacturing, mining, and construction, and including non-combustion process emissions) emitted over 1,600 Mt of CO_2e, or nearly 32% of U.S. CO_2 emissions. Addressing industrial emissions requires reducing emissions from direct combustion and industrial processes—the predominant emissions of heavy industry—and addressing the emissions associated with electricity use, which play a much greater role in light industry emissions.

A large part of industrial energy consumption in the United States (39%) goes toward producing iron, steel, chemicals, aluminum, cement, and fertilizers. These heavy industries rely on energy-intensive processes in which fossil fuels are more difficult

[27] U.S. Department of Energy (2023). *Investing in American Energy: Significant Impacts of the Inflation Reduction Act and Bipartisan Infrastructure Law on the U.S. Energy Economy and Emissions Reductions*.
[28] U.S. Energy Information Administration (2023). *Annual Energy Outlook 2023.*

to substitute with clean alternatives. IRA and BIL incentives for innovation in clean fuels and clean technologies can contribute to reductions in these industries.

GHG emissions from industry also include “process emissions” that are not due to the combustion of fuel, but rather to chemical changes involved in production of final products. Cement manufacturing, for example, results in the emission of CO_2 from the heating of calcium carbonate. Decarbonizing industry requires addressing both combustion and process emissions, and IRA and BIL investments in new technologies and processes can contribute to reductions.

The 2023 Policy Baseline projects that energy-related industrial carbon dioxide emissions in the U.S. will decline 17-43% below 2005 levels in 2030, and 23-57% below 2005 levels in 2035 (Figure 5). As Figure 5 shows, in some of these model scenarios, industrial sector emissions would already be within the range of the LTS pathways in 2030, and the median projection for the industrial sector falls within – but near the top of – the LTS range in 2030. For several scenarios, additional measures would be needed to achieve the 2030 target and then drive additional reductions consistent with the long-term pathways.

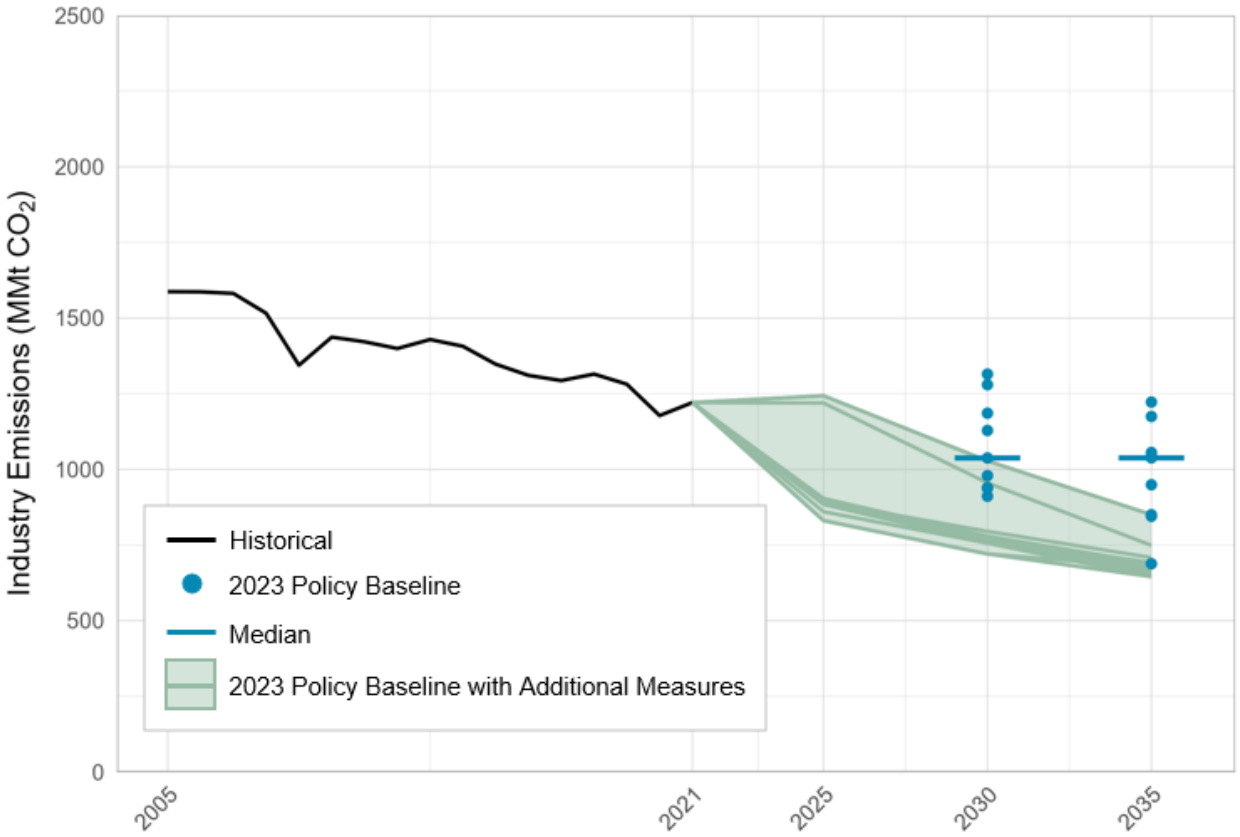

Figure 5. Energy-related carbon dioxide emissions in the industry sector, historical (2005-2021) and modeled (2025, 2030, 2035).

Projected declines in industrial emissions are driven in large part by IRA provisions for carbon capture and sequestration (the 45Q Credit for Carbon Oxide Sequestration), hydrogen deployment (the 45V Clean Hydrogen Production Tax Credit), and the 48C Advanced Energy Project Credit. The BIL also provides a range of support for clean hydrogen and carbon capture and sequestration technologies. The remainder of the observed reduction is driven by industrial facilities electrifying their activities and thus purchasing more, and cleaner, electricity from the grid or expanding their own on-site renewables-based generation.

Current models do not fully account for how the IRA's Advanced Industrial Facilities Deployment Program and the BIL's Industrial Emissions Demonstration Projects could help validate and expand use of industrial decarbonization technologies, or how IRA support for federal Environmental Product Declarations can validate emissions reductions associated with government procurement of less carbon-intensive materials. In addition, key manufacturing provisions such as the Advanced

Manufacturing Production Credit, and in some instances the Advanced Energy Project Credit, are not modeled.[29]

2023 Policy Baseline with Additional Measures

The 2023 Policy Baseline shows the U.S. projections of GHG emissions that include the effects of policies and measures that have already been fully adopted as of July 2023, including the IRA and BIL. As noted above, the cost reductions and incentives from IRA and BIL are expected to catalyze the additional actions at the federal, state, local and company level that are needed for the U.S. to meet our emissions goals. This section details some of these measures across economic sectors, shown in the context of modeling completed for the *Long-Term Strategy of the United States* (LTS).

The modeling for the LTS shows that there are multiple pathways for achieving the U.S. NDC targets for 2030 and net-zero GHG emissions by 2050. While the LTS did not model specific additional measures, the pathways it explored show how the U.S. can go beyond the policies and measures included in the 2021 policy baseline to reach our emissions goals. This section qualitatively discusses some of the additional measures already in progress, in most cases directly supported by IRA and BIL implementation, that will help put the U.S. on the path to achieving our 2030 NDC.

The LTS highlighted five major strategies to reduce emissions in line with achieving the U.S. nationally determined contribution:

1. Decarbonize the electricity sector
2. Electrify as many end uses as possible and switch to other clean fuels;
3. Cut energy waste and improve energy efficiency
4. Reduce methane and other non-CO_2 emissions
5. Scale up CO_2 removal through carbon removal technologies and land use practices

The IRA and BIL make historic investments in each of the five major strategies that contribute to reducing emissions as shown in the 2023 Policy Baseline, and they also enable additional measures by lowering clean energy costs, spurring investment in technologies that are essential to transforming the energy sector, and increasing market acceptance of these new technologies. These impacts on the costs and availability of clean technologies are expected to catalyze additional actions by federal, state, local, and Tribal governments, along with private sector actors, with

[29] Policy implementation across models can be found in the Technical Appendix

many entities already proposing regulations, policies, and initiatives that will further accelerate decarbonization trends. The IRA and BIL will help lower the costs (and increase the effectiveness) of these additional policies and provide powerful sustained deployment incentives that are encouraging unprecedented private sector investment as well as ambitious new federal and subnational policies and measures. While this impact is difficult to quantify, it is an important contribution of these laws.

Accordingly, the 2023 Policy Baseline with Additional Measures represented in Figure 6 shows "with additional measures" pathways representing four broad categories of action:[30, 31]

- Additional federal action, including through currently proposed but not-yet-finalized policies and measures.
- Action by states – in some cases individual states pursuing policies and measures, and in other cases groups of states working together.
- U.S. municipalities and other local governments pursuing policies and measures to mitigate emissions.
- Private sector initiatives – at the level of individual firms and across sectors – also contribute to GHG mitigation.
- Actions by civil society actors, including individuals and non-governmental organizations.

Figure 6 shows the role of additional measures, in line with the LTS pathways, to contribute emissions reductions beyond those projected in the 2023 Policy Baseline from the IRA, BIL, and the suite of existing policies and measures under implementation.

[30] These categories are somewhat broader than the "With Additional Measures" definition in the UNFCCC Biennial Report / National Communications guidance.

[31] This report focuses on climate action by the U.S. Federal government and subnational governments. Due to Tribal sovereignty, climate action by Tribal nations is beyond the scope of this report.

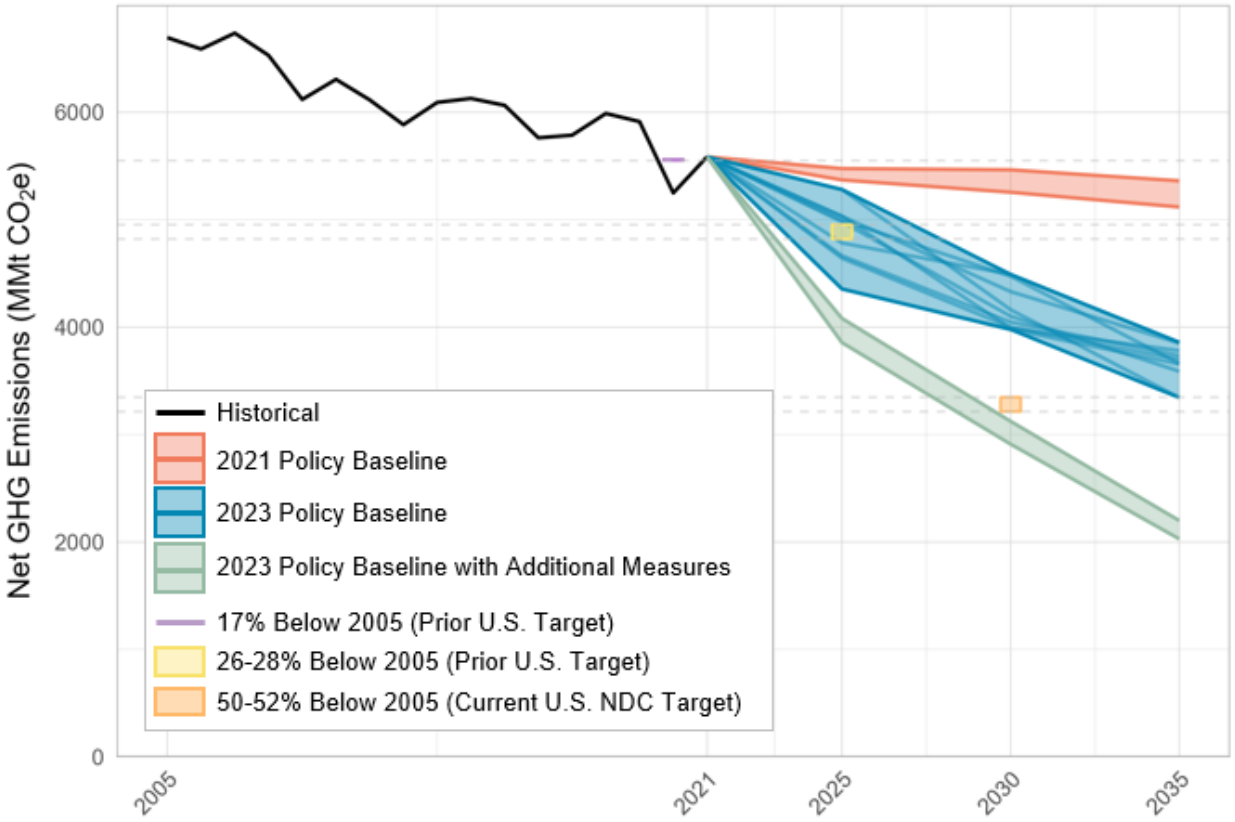

Figure 6. Net greenhouse gas emissions, historical (2005-2020) and modeled (2025, 2030, 2035). The light green shaded range represents the '2023 Policy Baseline with Additional Measures' scenario as modeled and presented in the *U.S. Long Term Strategy (LTS)*. The LTS did not model specific policies but showed a range of possible pathways for meeting the U.S. NDC Target based on 2005 emissions from the 2020 GHGI. The blue shaded area represents the range of model projections with BIL and IRA impacts (i.e., 2023 Policy Baseline). The red shaded area represents the range the 2021 Policy Baseline. (The solid blue lines represent projections from individual models).

There are many pathways to address the gap between the modeled 2023 Policy Baseline and the U.S. NDC target. While additional measures are needed to put the United States on a path to meet its NDC goals as modeled in the LTS, many of these actions are already underway, and the Administration's whole-of-government approach to tackling the climate crisis is putting us on a path to achieving the necessary reductions. This section highlights just some additional measures from the federal government, state and local governments, and the private sector that have recently advanced or are expected to advance with IRA and BIL support.

Federal Action

As detailed in the 2022 U.S. Eighth National Communication and Fifth Biennial Report, the United States takes a whole-of-government approach to tackling the climate crisis using a variety of policy instruments including economic policy (tax

credits, direct funding, loans), voluntary programs (e.g., public-private partnerships, campaigns), and regulations. The United States will continue to provide updated information on policies and measures through the reporting cycles required by the UN Framework Convention on Climate Change.

For the purposes of this Voluntary Supplement, the following section presents a small subset of much broader federal efforts in the past year to advance additional measures:

- **EPA Rulemakings:** The Environmental Protection Agency (EPA) proposed the Multi-Pollutant Emissions Standards for Model Years 2027 and Later Light-Duty and Medium-Duty Vehicles and the Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles (Phase 3), which would set emission standards on vehicles that can be met through increased fuel efficiency and electrification alongside the Department of Transportation National Highway Traffic Safety Administration's proposed Corporate Average Fuel Economy (CAFE) Standards for Passenger Cars and Light Trucks for Model Years 2027-2032 and Fuel Efficiency Standards for Heavy-Duty Pickup Trucks and Vans for Model Years 2030-2035; the New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Electric Utility Generating Units, which would limit GHG emissions from new and existing fossil fuel power plants, thereby accelerating the decarbonization of American electricity generation; and the Supplemental Proposal to Reduce Methane and Other Harmful Pollution from Oil and Natural Gas Operations that would strengthen and expand its November 2021 proposal to reduce emissions of methane and other harmful air pollution from new and existing oil and gas operations. EPA also finalized a rule to support the overall phasedown of HFCs production and use by 85% by 2036, authorized through the American Innovation and Manufacturing (AIM) Act.

- **Department of Energy Rulemakings:** The Department of Energy implement minimum energy conservation standards in the Appliance and Equipment Standards Program, which sets energy efficiency standards for over 60 categories of appliances and equipment per statutory direction. Just from January to September 2023, the Department of Energy issued proposed or final efficiency standards for 24 product categories, including a final rule on Energy Conservation Standards for Consumer Furnaces, which is expected to reduce 332 million metric tons of carbon emissions and 4.3 million tons of methane emissions over 30 years.

- **U.S. National Blueprint for Transportation Decarbonization:** In January 2023, the U.S. Departments of Energy, Transportation, Housing and Urban Development, and the Environmental Protection Agency issued the *U.S. National Blueprint for Transportation Decarbonization*, a landmark interagency framework of strategies and actions to remove all emissions from the U.S. transportation sector by 2050. The Blueprint identifies key actions before 2030 to help achieve the U.S. NDC, and after 2030 to help achieve net-zero emissions, with a focus on how IRA and BIL investments can catalyze efforts by the public and private sector.

- **Methane Task Force:** In July 2023, the Biden-Harris Administration launched a new Cabinet-level Methane Task Force, which will advance a whole-of-government approach to proactive methane leak detection and data transparency, and support state and local efforts to mitigate and enforce methane emissions regulations. The Task Force will accelerate execution of the U.S. Methane Emissions Reduction Action Plan, building on over 80 Administration actions taken to date under the Plan.

- **Energy Earthshots:** The 2022 U.S. Eighth National Communication and Fifth Biennial Report noted how the Biden-Harris Administration created the Energy Earthshots Initiative to drive breakthroughs and reduce the costs of clean energy technologies. In 2023, the Department of Energy launched additional Earthshots—the Clean Fuels & Products Shot, focusing on decarbonizing the fuel and chemical industry through alternative sources of carbon to advance cost-effective technologies with a minimum of 85% lower GHG emissions by 2035, and the Affordable Home Energy Shot, aiming to reduce the upfront cost of upgrading a home by at least 50% while reducing energy bills by 20% within a decade.

- **Pathways to Commercial Liftoff:** In 2022, the Department of Energy launched a cross-departmental effort to deepen engagement between the public and private sectors by creating a 'common fact base' defining roadmaps to widespread market adoption for key clean energy and decarbonization technologies. These reports are intended to inform and shape industry and investor capital allocation decisions, as well as agency strategy and policy execution.

State and Local Action

With additional support available from the IRA and BIL, state and local governments have continued to make progress toward setting and achieving climate targets. As of

October 2023, 33 states have climate action plans, 29 states and the District of Columbia have renewable portfolio standards or clean energy standards (an additional 7 states have renewable or clean energy goals), and 7 states have low carbon or alternative fuel standards.[32,33]

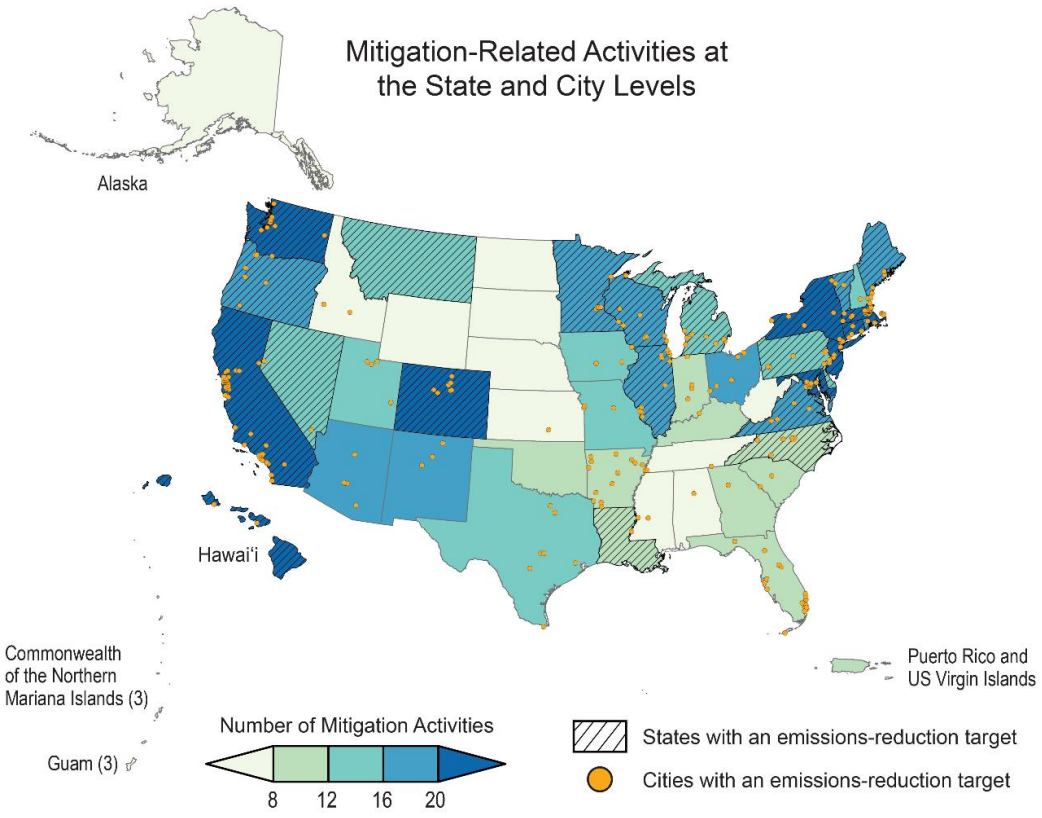

Figure 7. Map of state-level and municipal climate action. Shading indicates the number of mitigation activities taken by each state, and orange circles indicate cities with emissions-reduction targets (as of April 2023). Source: The Fifth National Climate Assessment (Chapter 32)

Examples of state and local action over the last year include:

- **State Legislation:** Recent state legislation includes a Colorado law requiring statewide GHG reductions, relative to 2005 levels, of 65% by 2035, 75% by 2040, and 90% by 2045; a Minnesota law establishing a state carbon-free electricity standard for 100% clean by 2040; a New York law to support the

[32] Center for Climate and Energy Solutions (2023). *State Climate Policy Maps*.
[33] Lawrence Berkeley National Laboratory (2023). *U.S. State Renewables Portfolio & Clean Electricity Standards: 2023 Status Update.*

national goal of conserving at least 30% of U.S. land and water by 2030; a Delaware law setting a target of reducing statewide net greenhouse gas emissions by at least 50% below 2005 levels by 2030; a California law to require companies to disclose annual greenhouse gas emissions to do business in the state; a Hawaii law setting zero-emission goals for all modes of transportation with the state; and a Vermont law establishing a performance standard for the heating fuel sector to reduce emissions and increase deployment of cleaner options like heat pumps.

- **Partnerships:** The U.S. Climate Alliance, a bipartisan coalition of governors representing more than half the U.S. population, announced a new shared target to collectively quadruple heat pump installations by the end of the decade. The U.S. Climate Alliance also launched a new database to share information about more than 2,000 climate policies underway across state governments. Twelve states—California, Colorado, Hawaii, Illinois, Maine, Massachusetts, Maryland, Michigan, New Jersey, New York, Oregon, and Washington—joined a new Federal-State Buy Clean Partnership launched by the Biden-Harris Administration to advance state procurement and use of low-carbon construction materials. Climate Mayors, a bipartisan coalition of nearly 500 mayors, and C40 Cities, a network of mayors of nearly 100 world-leading cities, released, "Climate Action and the Inflation Reduction Act: A Guide for Local Government Leaders," outlining how cities can deploy IRA funding in a way that accelerates climate action. America Is All In, a coalition of U.S. cities, states, tribal nations, businesses, schools, and institutions of faith, health, and culture, hosted the Cash In on Clean Energy Tour to provide guidance on how non-federal actors can leverage IRA funding.

- **Local Climate Plans:** Local governments, including counties and cities, are at the forefront of implementing climate policy. Examples include the city of Chattanooga, Tennessee, which adopted a Climate Action Plan that includes a goal to achieve net-zero carbon emissions in city operations by 2040; the city of Portland, Oregon, which adopted its Climate Investment Plan that will invest $750 million over five years in reducing emissions and preparing for climate change impacts; and the city of Tucson, Arizona which adopted a Climate Action and Adaptation Plan to achieve carbon neutrality for city operations by 2030 and community-wide carbon neutrality by 2045, while increasing climate resilience. The Climate Pollution Reduction Grants, funded by the IRA, is facilitating state and local climate planning and implementation.

Private Sector Action

In August 2023, the U.S. Department of the Treasury highlighted how the IRA is mobilizing private capital to advance climate goals and strengthen long-term growth, by providing demand- and supply-side incentives to invest in developing and deploying clean energy technologies. In the IRA's first year, companies announced nearly 200 new projects totaling over $110 billion of investment in building the U.S. clean energy economy, and outside estimates indicate that the IRA could unlock $3 trillion of investment in the United States for renewable energy technology. [34,35]

In the power sector, many utilities are taking advantage of lower costs for clean electricity and have announced plans to increase their share of electricity coming from clean sources. For example, 50 power producers have announced CO_2 reduction goals, two-thirds of which include net-zero carbon emissions by 2050.[36] The geographic footprint of zero or net-zero carbon commitments made by utilities or states covers portions of 47 states and includes 75 percent of U.S. customer accounts.[37]

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[34] U.S. Department of the Treasury (2023). *Memorandum from Deputy Secretary Wally Adeyemo - Inflation Reduction Act – Year 1*.

35 Goldman Sachs (April 17, 2023). *The US is poised for an energy revolution*.

[36] See Comments of Edison Electric Institute to EPA's Pre-Proposal Docket on Greenhouse Gas Regulations for Fossil Fuel-fired Power Plants, Docket ID No. EPA-HQ-OAR-2022-0723, November 18, 2022

[37] Smart Electric Power Alliance Utility Carbon Tracker. https://sepapower.org/utility-transformation-challenge/utility-carbon-reduction-tracker/. Accessed January 12, 2023

Appendix: IRA and BIL Measures

The tables below provide detailed descriptions of the IRA provisions, programs, and incentives that inform the net greenhouse gas emissions projections presented in this report, as well as the BIL provisions that enable them. The Technical Appendix provides more information about the representation of these provisions in the modeling. For detailed descriptions of all Bipartisan Infrastructure Law provisions, see the Bipartisan Infrastructure Law Guidebook.[38]

Electricity Sector

Section	Program Name	Description
IRA 13101	Production Tax Credit for Electricity from Renewables	Provides a production tax credit with a base of $0.55/kW (inflation adjusted) for renewables-based electricity generation. The credit value can increase 5 times if a project meets prevailing wage and registered apprenticeship requirements, by 10% if the project meets domestic content requirements, and by 10% if the project is located in an "energy community".
IRA 13102	Investment Tax Credit for Energy Property	Provides an investment tax credit of 6% of qualified investment in renewable energy projects. The credit value can increase 5 times if a project meets prevailing wage and registered apprenticeship requirements, by 10 percentage points if the project meets domestic content requirements, and by 10 percentage points if the project is located in an "energy community".
IRA 13103	Increase in Energy Credit for Solar and Wind Facilities Placed in Service in Connection with Low-Income Communities	Provides an additional investment tax credit of 6% for small-scale solar and wind projects on an allocated basis. The credit value increases by 10 percentage points for facilities in low-income communities or tribal lands. The credit value increases by 20 percentage points for projects in federally subsidized housing programs or that offer at least 50% of the financial benefits of electricity production to low-income households.
IRA 13105	Zero-Emission Nuclear Power Production Credit	Provides a production tax credit of 0.3 cents per kWh (inflation adjusted after 2024) for nuclear electricity generation, phasing down depending on gross receipts from the nuclear facility. The credit value can increase 5 times if a project meets prevailing wage and registered apprenticeship requirements.

[38] U.S. Executive Office of the President (May 2022). *A Guidebook to the Bipartisan Infrastructure law for State, Local, Tribal, and Territorial Governments, and Other Partners*.

IRA 13701	Clean Electricity Production Tax Credit	Provides a technology-neutral production tax credit for clean electricity, replacing the Section 13101 production tax credit after 2024.
IRA 13702	Clean Electricity Investment Tax Credit	Provides a technology-neutral investment tax credit for clean electricity, replacing the Section 13102 investment tax credit after 2024.
IRA 13703	Cost Recovery for Qualified Facilities, Qualified Property, and Energy Storage Technology	Offers an additional tax deduction for qualifying facilities and properties, allowing taxpayers to deduct an accelerated depreciation on the value of their business assets. This effectively allows clean energy investments to take bigger deductions in the earlier, more expensive years of the project.
IRA 22001	Electric Loans for Renewable Energy	Finance construction of electricity distribution, transmission, and generation facilities in rural areas.
IRA 22002	Rural Energy for America Program	Provide loan and grant funding to agricultural and rural businesses to leverage renewable energy technologies.
IRA 22004	USDA Assistance for Rural Electric Cooperatives	Funds construction of electricity distribution, transmission, and generation facilities for rural electric cooperatives.
IRA 50141	Funding for Department of Energy Loan Programs Office	Provides $40 billion of loan authority, supported by $3.6 billion in credit subsidies, to eligible clean energy technologies.
IRA 50145	Tribal Energy Loan Guarantee Program	Increase the loan authority to $20 billion to support Tribal investment in energy-related projects, providing $75 million to carry out the program.
IRA 50151	Transmission Facility Financing	Establish a direct loan program for the construction/modification of electric transmission facilities.
IRA 50152	Grants to Facilitate the Siting of Interstate Electricity Transmission Lines	Provides grants to siting authorities to expedite the siting and permitting process.
IRA 50153	Interregional and Offshore Wind Electricity Transmission Planning, Modeling, and Analysis	Conduct transmission analysis regarding interregional electricity transmission and transmission of electricity generated by offshore wind projects.
IRA 60107	Low Emissions Electricity Program	Funds activities to encourage low emissions electricity generation coordinated by the Environmental Protection Agency.

IRA 80003	Tribal Electrification Program	Provides financial and technical assistance to increase number of Tribal homes with clean electricity.
BIL 40103	Energy Improvement in Rural or Remote Areas	Provides $1 billion to improve, in rural or remote areas of the United States, the resilience, safety, reliability, and availability of energy, as well as environmental protection form adverse impacts of energy generation.
BIL 40106	Transmission Facilitation Program	Provides $2.5 billion to facilitate the construction of electric power transmission lines related to facilities to enable greater clean energy growth.
BIL 40304	Carbon Dioxide Transportation Infrastructure Finance and Innovation Program	Provides $2.1 billion to establish and carry out a carbon dioxide transportation infrastructure finance and innovation program.
BIL 40305	Carbon Storage Validation and Testing	Provides $2.5 billion to establish a program of research, development, and demonstration for carbon storage.
BIL 40323	Civil Nuclear Credit Program	Provides $6 billion to establish a Civil Nuclear Credit (CNC) Program to prevent premature retirements of existing commercial nuclear reactors due to economic factors.
BIL 40331	Hydroelectric Production Incentives	Provides $125 million toward incentive payments for electric energy generated and sold by a qualified hydroelectric facility during the incentive period, to the owner or authorized operator of such a facility.
BIL 40332	Section 243 Hydroelectric Efficiency Improvement Incentives	Provides $75 million to incentivize upgrades to hydroelectric facilities to increase their efficiency.
BIL 40333	Maintaining and Enhancing Hydroelectricity Incentives	Provides $553.6 million toward incentive payments to the owners or operators of qualified hydroelectric facilities for capital improvements.
BIL 40334	Pumped Storage Hydropower Wind and Solar Integration and System Reliability Initiative	Provides $10 million in financial assistance to eligible entities to carry out project design, transmission studies, power market assessments, and permitting for a pumped storage hydropower project to facilitate the long-duration storage of intermittent renewable electricity.
BIL 41001	Long-Duration Energy Storage Demonstration	Provides $505 million in funding toward the Long Duration Energy Storage Demonstration Initiative and Joint Program, as well as demonstration and pilot grant programs

	Initiative and Joint Program	
BIL 41002	Advanced Reactor Demonstration Program	Provides $2.477 billion toward two large demonstrations of advanced nuclear reactors for electricity generation.
BIL 41007	Enhanced Geothermal Systems and Pilot Demonstrations	Provides $84 million to support four pilot demonstration projects for enhanced geothermal systems development.

Transportation Sector

Section	Program Name	Description
IRA 13401	Clean Vehicle Credit	Provides up to $7,500 for qualifying clean vehicles, with values varying based on meeting critical minerals or battery component sourcing requirements.
IRA 13402	Credit for Previously Owned Clean Vehicles	Provides a tax credit of up to $4,000 or 30% for qualifying pre-owned clean vehicles.
IRA 13403	Commercial Clean Vehicles Credit	Provides a tax credit to business of up to 30% for qualifying commercial clean vehicles.
IRA 13404	Alternative Fuel Vehicle Refueling Property Credit	Provides an investment tax credit of 6% for alternative fuel vehicle refueling and charging property in low-income and rural areas. The credit increases to 30% for projects meeting prevailing wage and apprenticeship requirements.
IRA 50142	Advanced Technology Vehicle Manufacturing Loan Program	Provides $3 billion in credit subsidies to support loans for manufacturing qualifying advanced technology vehicles under the Advanced Technology Vehicles Manufacturing Program.
IRA 50143	Domestic Manufacturing Conversion Grants	Provides $2 billion for cost-shared grants for the domestic production of alternative and clean vehicle technologies.
IRA 60102	Grants to Reduce Air Pollution at Ports	Provides $3 billion to purchase and install zero-emission port equipment and technology.
IRA 60101	Clean Heavy Duty Vehicles	Provides $1 billion to replace heavy duty commercial vehicles with zero-emission vehicles.
IRA 60104	Diesel Emissions Reductions	Provides $60 million to identify and reduce diesel emissions in low-income and disadvantaged communities.

IRA 70002	U.S. Postal Services Clean Fleets	Provides $3 billion for the U.S. Postal Service to purchase zero-emission delivery vehicles and required infrastructure.
BIL 71101	Clean School Bus Program	Provides $5 billion, 50% are authorized for zero-emission school buses, and 50% are authorized for alternative fuels and zero-emission school buses. Funds may be prioritized for rural or low-income communities and entities that have matching funds available.
BIL 11101; 11401	Charging and Fueling Infrastructure Grants (Corridor and Community Charging)	Provides $1.25 billion to deploy electric vehicle charging and hydrogen/propane/natural gas fueling infrastructure along designated alternative fuel corridors and in communities. Provides $1.25 billion to install electric vehicle charging and alternative fuel in locations on public roads, schools, parks, and in publicly accessible parking facilities. These grants will be prioritized for rural areas, low-and moderate-income neighborhoods, and communities with low ratios of private parking, or high ratios of multiunit dwellings.
BIL 30007	Low or No Emission Vehicle Component Assessment Program	Provides $26.170 million to conduct testing, evaluation, and analysis of low or no emission components intended for use in low- and zero emission buses used to provide public transportation.
BIL 30018	Low or No Emission (Bus) Grants	Provides roughly $5.625 billion in capital funding to replace, rehabilitate, purchase, or lease buses and bus related equipment/facilities, and provides capital funding for low or no emissions bus projects.
BIL 40208	Electric Drive Vehicle Battery Recycling and Second Life Applications	Provides $200 million to expand an existing program at the Department of Energy for research on electric vehicle battery recycling and second-life applications for vehicle batteries.
BIL 11101; 11402	Reduction of Truck Emissions at Port Facilities	Provides $400 million to reduce truck idling and emissions at ports, including through the advancement of port electrification.
Division J, Title VIII	National Electric Vehicle Infrastructure Formula Program	Provides $5 billion to strategically deploy electric vehicle charging infrastructure and establish an interconnected network.

Refineries and Fuels

Section	Program Name	Description
IRA 13201	Extension of Tax Credits for Biodiesel and Renewable Diesel	Extends $1/gallon for biodiesel, biodiesel mixtures, and renewable diesel production. The credit increases by $0.10/gallon for small productions.
IRA 13202	Extension of Second Generation Biofuel Incentives	Extends a $1.01/gallon tax credit for producers of second-generation biofuels.
IRA 13203	Sustainable Aviation Fuel Credit	Provides $1.25/gallon tax credit for the production of sustainable aviation fuels. The credit value increases by up to $0.50/gallon based on lifecycle greenhouse gas emissions.
IRA 13204	Clean Hydrogen Production Tax Credit	Provides up to $3/kg for the production of clean hydrogen at a qualifying production facility. This upper bound includes bonus credit amount.
IRA 13704	Clean Fuel Production Credit	Provides a $0.20/gallon for clean non-aviation fuels and $0.35/gallon for clean aviation fuels, inflation adjusted after 2024. The credit value increases 5 times for projects meeting prevailing wage and apprenticeship requirements.
IRA 22003	Biofuel Infrastructure and Agriculture Product Market Expansion (Higher Blend Infrastructure Incentive Program)	Provides $500 million in grants through the Higher Blend Infrastructure Incentive Program, which aims to increase the use of higher blends of ethanol and biodiesel.
IRA 40007	Fueling Aviation's Sustainable Transition through Sustainable Aviation Fuels	Provides grant funding to develop, demonstrate, and deploy low-emission aviation technologies.
BIL 40314	Clean Hydrogen Programs	Provides: $1 billion to establish the Clean Electrolysis Program $500 million to establish the Clean Hydrogen Manufacturing Recycling Research, Development, and Demonstration Program $8 billion to establish the Regional Clean Hydrogen Hubs

Buildings Sector

Section	Program Name	Description
IRA 13301	Energy Efficient Home Improvement Credit	Modifies and extends a 30% tax credit on energy efficiency improvements in residential homes. Up to $600 for qualifying energy property (e.g., heating/cooling equipment), $600 for windows, $500 for doors, $2,000 for heat pumps, $1,200 for building envelope improvements. Annual credit total (except for heat pumps) is capped at $1,200.
IRA 13302	Residential Clean Energy Credit	Modifies and extends a 30% tax credit on the purchase of a residential clean energy equipment, adds battery storage beginning in 2023.
IRA 13303	Energy Efficient Commercial Buildings Deduction	Provides a business tax deduction for energy efficiency improvements to commercial buildings, including lighting, heating, cooling, ventilation, and hot water.
IRA 13304	New Energy Efficient Homes Credit	Provides a tax credit on the construction of new energy efficient homes. Homes meeting Energy Star standards receive a $2,500 credit; zero-energy ready homes receive $5,000. Multifamily residences receive $500/unit for Energy Star standards and $1,000/unit for zero-energy ready.
IRA 30002	Green and Resilient Retrofit Program	Provides $940 million toward retrofitting HUD-assisted properties, including (i) $837.5 million toward grants and direct loans to improve efficiency, enhance air quality/sustainability, use zero-emission electricity generation, use low-emission building materials/processes, install energy storage, electrify buildings, or increase resiliency; (ii) $60 million toward covering contracting or cooperative agreements to implement the Green and Resilient Retrofit Program; and (iii) $42.5 million to conduct energy and water benchmarking of HUD-assisted properties.
IRA 50121	Home Efficiency Rebates	Provides $4.3 billion in grants to state energy offices to develop energy saving retrofit programs that provide rebates to homeowners and aggregators.
IRA 50122	Home Electrification and Appliance Rebates	Provides $4.5 billion to state energy offices and Tribal entities to develop and implement a high-efficiency electric home rebate program.
IRA 50131	Assistance for Latest and Zero	Provides $1 billion in grants to states and local government to adopt updated building energy codes.

	Building Energy Code Adoption	
IRA 60106	Funding to Address Air Pollution at Schools	Provides $50 million in competitive grants or other activities to monitor and reduce air pollution and greenhouse gas emissions at schools in low-income and disadvantaged communities.
IRA 60502	Assistance for Federal Buildings	Provides $250 million to convert government facilities to green buildings.
IRA 80003	Tribal Electrification Program	Provides $150 million toward financial and technical assistant to increase zero-emission electricity use in Tribal homes
BIL 40551	Weatherization Assistance Program	Provides $3.5 billion to increase the energy efficiency of dwellings owned or occupied by low-income persons , reduce their total residential energy expenditures, and improve their health and safety, especially low-income persons who are particularly vulnerable such as the elderly, the handicapped, and children.
BIL 40552	Energy Efficiency and Conservation Block Grant Program	Provides $550 million assist States, local governments, and Tribes in implementing strategies to reduce energy use, reduce fossil fuel emissions, and improve energy efficiency.
BIL 40502	Energy Efficiency Revolving Loan Fund Capitalization Grant Program	Provides $250 million in grants to States to provide loans and grants for energy efficiency audits, upgrades, and retrofits to increase energy efficiency and improve the comfort of buildings.
BIL 40541	Grants for Energy Efficiency and Renewable Energy Improvements at Public School Facilities	Provides $500 million in competitive grants to make energy efficiency, renewable energy, and alternative fueled vehicle upgrades and improvements at public schools.
BIL 40542	Energy Efficiency Materials Pilot Program	Provides $50 million in grants to supply nonprofit buildings with energy-efficiency materials.
BIL 40551	Cost-effective Codes Implementation for Efficiency and Resilience	Provides $225 million to establish a competitive grant program to enable updated building energy codes to save customers money on their energy bills.

Industrial Sector

Section	Program Name	Description
IRA 13501	Advanced Energy Project Credit	Provides a 6% investment tax credit toward qualifying advanced energy projects that leads to (i) the production or recycling of clean energy technologies, (ii) reductions in greenhouse gas emissions in industrial facilities, (iii) processing, refining, or recycling of critical minerals. The credit value increases to 30% if a project meets prevailing wage and apprenticeship requirements.
IRA 13502	Advanced Manufacturing Production Credit	Provides a per-unit tax credit for domestic manufacturing of components for solar, wind, inverters, battery components, and critical minerals.
IRA 50161	Advanced Industrial Facilities Deployment Program	Provides $5.812 billion in competitive support to demonstrate and deploy emissions-reducing projects at energy intensive industrial facilities.
IRA 60503	Use of Low Carbon Materials	Provides $2.150 billion toward acquiring and installing construction materials and products with low embodied greenhouse gas emissions.
IRA 60506	Low Carbon Transportation Materials Program	Provides $2 billion toward the use of low-embodied carbon construction materials and products in federally-funded highway projects.
BIL 40308	Four Regional Clean Direct Air Capture Hubs	Provides $3.5 billion to establish a program under which the Secretary shall provide funding for eligible projects that contribute to the development of 4 regional direct air capture hubs.
BIL 41003	Programs to Secure Supply Chains for Rare Earths and Other Critical Minerals and Materials	Provides: $127 million toward Rare Earth Security Activities $75 million toward a Critical Material Supply Chain Research Facility $600 million toward Critical Material Innovation, Efficiency, and Alternatives Programs
BIL 40207	Battery Manufacturing and Recycling Grants	Provides: $10 million in funding toward battery recycling $3 billion in funding toward battery manufacturing and recycling grants $3 billion in funding toward battery materials processing grants $125 million in funding toward battery and critical mineral recycling grants

BIL 40302	Carbon Utilization Program	Provides $310.141 million to establish a grant program for State and local governments to procure and use products derived from captured carbon oxides.
BIL 40209	Advanced Energy Manufacturing and Recycling Grants	Provides $750 million in grants to small- and medium-sized manufacturers to enable them to build new or retrofit existing manufacturing and industrial facilities to produce or recycle advanced energy products in communities where coal mines or coal power plants have closed.
BIL 41008	Industrial Emission Demonstration Projects	Provides $500 million toward demonstration projects that test and validate technologies that reduce industrial emissions.
BIL 40521	Industrial Research and Assessment Center Funding	Provides $150 million toward upgrading industrial and manufacturing facilities to upgrade to energy efficient and environmental practices
BIL 41005	Direct Air Capture Technology Competitions	Provides $115 million toward the reauthorization of programs that support pilots and demonstrations of pre-commercial and commercial direct air capture technologies.

Cross-Cutting

Section	Program Name	Description
IRA 13104	Credit for Carbon Oxide Sequestration	Provides a credit of $17 per ton of carbon dioxide captured and sequestered ($36 per ton carbon dioxide for direct air capture); $12 per ton of carbon dioxide injected for enhanced oil recovery ($26 per ton carbon dioxide for direct air capture). The credit value increases 5 times for projects meeting prevailing wage and apprenticeship requirements.
IRA 50144	1706 Program (Energy Infrastructure Reinvestment Financing)	Provides $5 billion in credit subsidy to support up to $250 billion in loan guarantees for qualifying clean energy infrastructure.
IRA 60103	Greenhouse Gas Reduction Fund	Provides (1) $7 billion for states, tribes, and territories to implement low-income solar programs; (2) $14 billion for the National Clean Investment Fund, which will provide grants to national nonprofit clean financing institutions; and (3) $6 billion for the Clean Communities Investment Accelerator, which will provide grants to hub nonprofits

		that will, in turn, deliver funding and technical assistance to local community lenders.
IRA 60113	Methane Emissions Reduction Program	Provides $1.55 billion in financial and technical assistance to reduce methane and other greenhouse gas emissions from the petroleum and natural gas systems. Establishes a waste emissions charge for facilities reporting more than 25,000 metric tons of carbon dioxide equivalent annually.
IRA 60114	Climate Pollution Reduction Grants	Provides $5 billion in grants to Tribes, states, air pollution control agencies, and local governments to develop and implement plans for reducing greenhouse gas emissions.
IRA 60201	Environmental and Climate Justice Block Grants	Provides $3 billion in grants and technical assistance to community-based organizations and their partners to reduce pollution, including greenhouse gas emissions, and improve community climate resilience.
BIL 40109	State Energy Program	Provides $500 million in funding to States to support electric transmission and distribution planning, as well as activities that reduce carbon emissions in all sectors of the economy
BIL 41004	Carbon Capture Pilot and Demonstration Programs	Provides: $2.537 billion toward the Carbon Capture Demonstration Projects Program $937 million toward the Carbon Capture Large-Scale Pilot Program

Technical Appendix

This report builds on the U.S. Department of Energy's August 2023 report on "Investing in American Energy: Significant Impacts of the Inflation Reduction Act and Bipartisan Infrastructure Law on the U.S. Energy Economy and Emissions Reductions and the U.S. Environmental Protection Agency's September 2023 report on "Electricity Sector Emissions Impacts of the Inflation Reduction Act." It incorporates results from nine models, robustly showing how IRA and BIL help position the United States to achieve ambitious climate goals.

Most of the modeling for this analysis focuses on the IRA and assumes that BIL provisions act as enabling factors toward the full implementation of IRA provisions. Key BIL provisions are described in the BIL Measures section of the Appendix.

Modeling Methodology for the IRA Analysis in the "Electricity Sector Emissions Impacts of the Inflation Reduction Act" Report

The economy is inter-related and complex, and the investments made in the recent legislation are far reaching – analyzing the impacts of these changes requires the use of sophisticated energy-economy models that can capture the breadth of the IRA's incentives.

The analysis performed is responsive to §60107(5) of the Low Emissions Electricity Program within the IRA, which requires EPA to assess "… the reductions in greenhouse gas emissions that result from changes in domestic electricity generation and use that are anticipated to occur on an annual basis through fiscal year 2031."

To estimate the emission reductions, the analysis relies upon modeling results from recent peer reviewed literature, government reports, and EPA-supported modeling and analysis. By leveraging the results from multiple energy-economy models, this analysis characterizes both the general trends in emission reductions, an estimate of the range of reductions, and insights into what drivers of emission reductions are robust across models.

EPA-supported analysis of emissions reductions includes the use of two multi-sector models, the Global Change Assessment Model (GCAM-PNNL) and the U.S. Regional Energy Policy Model (MIT's USREP model) linked to the Regional Energy Deployment System (NREL's ReEDS), and an electric sector model IPM-EPA. Results from these models are presented along with results from three studies:

- A multi-model, peer-reviewed study of the *Emissions and Energy Impacts of the Inflation Reduction Act* published in *Science.* This study includes six multi-sector models and three electric sector models.[39]
- An economy-wide study using version of the National Energy Modeling System (NEMS) model supported by the Office of Policy at the Department of Energy.[40]
- An electric sector study using NREL's ReEDS model.[41]

Emissions reductions are presented in two ways: 1) relative to historical 2005 emission levels and 2) contrasting a scenario with IRA provisions included in the model ("IRA") versus a counterfactual scenario ("No IRA"), which does not include the tax incentives, grants, and loan provisions of the IRA. For chapters 1 through 5, results are presented through 2035 for two reasons. Some important IRA provisions extend past 2031 and most of the models we use report projections in five-year increments. To estimate reductions in 2031, the emissions need to be interpolated between 2030 and 2035. While the analysis focuses on the effect of the IRA through 2035, many modeling tools project results to 2050, and these are presented here as well.

Scenarios and Sensitivities

The study is structured around two scenarios to evaluate the potential impacts of the IRA on emissions:

- ***IRA***: A scenario that reflects all federal and state policies enacted including the IRA.
- ***No IRA***: A counterfactual scenario that reflects federal and state policies enacted except for the IRA.

Several sensitivities are also explored in the study including:

- IRA implementation (*Core, Optimistic, Pessimistic*). The literature and internal modeling both explore sensitivities surrounding the effectiveness of the IRA to reduce emissions.
- Energy prices and economic growth. These sensitivities were explored using the GCAM-PNNL model by taking the high and low energy prices and economic growth assumptions from the EIA's 2023 Annual Energy Outlook.

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[39] Bistline, J., et al. (2023). Emissions and energy impacts of the Inflation Reduction Act. *Science, 380* (6652), 1324–1327. https://doi.org/10.1126/science.adg3781

[40] U.S. Department of Energy (August 2023). *Technical Appendix: Investing in American Energy.*

[41] Steinberg, Daniel C., et al. (2023). Evaluating Impacts of the Inflation Reduction Act and Bipartisan Infrastructure Law on the U.S. Power System. *National Renewable Energy Laboratory Technical Report (NREL/TP-6A20-85242).*

Multi-sector models used or cited

The following list describes the nine multi-sector models cited and shown herein:

- **Energy Policy Simulator from Energy Innovation LLC (EPS-EI):** EPS simulates major sectors of the U.S. economy on an annual basis. The model tracks changes from business-as-usual projections to examine how user-selected policies impact energy demand, costs, and emissions.
- **Global Change Analysis Model (GCAM-CGS) from Center for Global Sustainability (CGS):** GCAM-CGS is based on GCAM 5.3 and models the United States at the state level. It includes detailed sector-specific, state-level climate policies across multiple sectors of the U.S. economy. GCAM solves for prices of energy resources and the associated demand from other sectors, recursively converging to an equilibrium.
- **Global Change Analysis Model (GCAM-PNNL) from Joint Global Change Research Institute (JGRCI):** GCAM-PNNL is based on GCAM 6.0 and models the United States as a single region. It adds detailed sector-specific, climate policies across multiple sectors of the U.S. economy. GCAM solves for prices of energy resources and the associated demand from other sectors, recursively converging to an equilibrium.
- **Market Allocation (MARKAL) from National Energy Technology Laboratory (NETL):** MARKAL solves a linear program defined by the nine U.S. census regions, accounting for trade flows of energy in the form of electricity, gas, coal, and other fuels.
- **National Energy Modeling System (NEMS-OP) from the Office of Policy at the Department of Energy:** This version of NEMS incorporates more provisions of the IRA than are represented in EIA's Annual Energy Outlook for 2023 and includes more extensive representation of industrial carbon capture and storage, hydrogen production, and direct air capture technologies.
- **National Energy Modeling System (NEMS-RHG) from Rhodium Group:** This version of NEMS incorporates more provisions of the IRA than are represented in EIA's Annual Energy Outlook for 2023 and includes more extensive representation of industrial carbon capture and storage, hydrogen production, and direct air capture technologies.
- **Regional Economy, Greenhouse Gas, and Energy (REGEN) from Electric Power Research Institute (EPRI):** The U.S. REGEN model links a detailed power sector planning and dispatch linear program model with a logit-choice energy end-use model.
- **Regional Investment and Operations Model (RIO) from REPEAT:** The combination of the RIO supply-side model and EnergyPATHWAYS demand-

side model developed by Evolved Energy Research and used by the REPEAT project models detailed energy accounting across sectors of the economy with special detail on infrastructure investment and efficiency.

- **USREP-ReEDS:** This modeling framework consists of the MIT U.S. Regional Energy Policy (USREP) model, a computable general equilibrium model of the United States with 12 regions, linked to NREL's Regional Energy Deployment System (ReEDS) model, a capacity planning model of the U.S. electricity system. The linked modeling system combines ReEDS's spatial and technological detail with USREP's representation of other sectors and the macroeconomy. Note that the version of ReEDS linked with USREP is the same as the standalone version (see below) with one important exception. The linked version does not have plant-level carbon capture and storage (CCS) retrofit decisions, which leads to less CCS adoption and higher electric sector emissions in the linked model.

Representation of IRA Provisions

Table A: Summary of IRA provisions represented in multi-sector energy models

			Multi-sector									
			EPS-EI	GCAM-CGS	GCAM-PNNL	MARKAL-NETL	NEMS-EIA	NEMS-OP	NEMS-RHG	REGEN-EPRI	RIO-REPEAT	USREP-ReEDS
		Total # of provisions covered for each model out of 44.	27	22	23	19	16	32	22	19	29	26
Section	Tax code	Program										
Electricity												
13101	45	Production tax credit (PTC) for electricity from renewables										
13102	48	Investment tax credit (ITC) for energy property										
13103	45(e), 45E(h)	Solar and wind facilities placed in low-income communities										
13105	45U	Zero-emission nuclear power PTC										
13701	45Y	New clean electricity PTC										
13702	48E	New clean electricity ITC										
13703	168(e)(3)(B)	Cost recovery for qualified property (13703)										
22004	-	USDA assistance for rural electric cooperatives										
50151	-	Transmission facility financing										
Multi-Sector												
13104	45Q	Credit for carbon oxide sequestration (CCS & DAC)										
13204	45V	Clean hydrogen PTC										
22001	-	Electric loans for renewable energy										
50141	-	Funding for DOE Loan Programs Office										
50144	-	Energy infrastructure reinvestment financing										
50145	-	Tribal energy loan guarantee program										
Transportation												
13201	40A, others	Biodiesel and renewable fuels PTC										
13202	40	Second-generation biofuels PTC										
13203	40B	Sustainable aviation fuel PTC										
13401	30D	Clean vehicle credit										
13402	25E	Credit for previously-owned clean vehicles										
13403	45W	Qualified commercial clean vehicle credit										
13404	30C	Alternative fuel vehicle refueling property credit										
13704	45Z	New clean fuel PTC										
60101	-	Clean heavy-duty vehicles										
70002	-	U.S. Postal Service clean fleets										

Buildings			
13301	25C	Energy efficient home improvement PTC	
13302	25D	Residential clean energy PTC	
13303	179D	Energy efficient commercial buildings deduction	
13304	45L	New energy efficient homes credit	
30002	-	Green and resilient (HUD) retrofit program	
50121	-	Home energy performance-based, whole-house rebates	
50122	-	High-efficiency electric home rebate program	
60502	-	Assistance for federal buildings	
Industry			
13501	48C	Advanced energy project credit	
13502	45X	Advanced manufacturing production credit	
50161	-	Advanced industrial facilities deployment program	
60113	-	Methane emissions reduction program	
Multiple	-	Vehicle manufacturing loans/grants	
Multiple	-	Low-carbon materials	
Multiple	-	Agriculture and forestry provisions	
Multiple	-	Oil and gas lease sales	
Cross-Cutting Funds and Grants			
60103	-	Greenhouse gas reduction fund	
60114	-	Climate pollution reduction grants	
60201	-	Environmental and climate justice block grants	

Included Not Included Not Applicable

Caveats and Limitations

The models used in this analysis are simplified representations of the decision making by all the actors in the economy, and it is important to note that even the most sophisticated modeling is subject to limitations. It is important to note that the implementation of the IRA and BIL will depend upon government decisions that have yet to be made. Some specific incentives provided by the legislation – such as rules about tax credits to be developed by the Department of the Treasury, depend on guidance from that either has yet to be issued or was issued after the provisions were modeled. These details will affect investment decisions and, consequently, they will affect future emissions. To model the impacts of the IRA, modelers have made assumptions about how these details will be resolved, and the scenarios reflect these and other uncertainties.

Additionally, some of the provisions of the IRA will affect parts of the economy that are difficult to analyze in currently available economy-wide and electricity-sector models, and thus are reflected in a limited or high-level manner in multi-sector and electricity sector modeling. Examples include specific technical characteristics of the

transportation, building, and industrial sectors, as well as characteristics of decision-making by individual consumers and companies to invest in efficient and electrified vehicles or appliances, energy efficiency measures in buildings or industrial plants, or purchasing renewable electricity.[42] There are also dynamics that cannot be reflected in models, like some non-market barriers (see Text Box on Non-Market Barriers). Despite these caveats, the models provide an overall sense of the magnitude of impacts of the legislation and the range of possible outcomes.

In short, there is uncertainty both in the models themselves and in the way that the economy and energy sector develop, so to provide our best analyses, we include a range of assumptions, and present a range of outcomes. Where possible, we show how sensitivities to input assumptions such as IRA implementation and economic growth impact results.

Finally, the results of the models are presented at the national level. Some of the models (the electricity sector models in particular), represent generation activities at a relatively fine scale to account for differences in regional markets. The models reflect, for example, how some areas are more conducive to solar or wind power development. These sub-national details are beyond the scope of this report.

[42] O'Shaughnessy E and Sumner J (2023). The need for better insights into voluntary renewable energy markets. *Frontiers in Sustainable Energy Policy*.

Projected Emissions by Gas, Sector, and Model

1990-2021 U.S. Greenhouse Gas Inventory historical emissions and BR5 net GHG projections converted to AR5 global warming potentials

		GHGI 2023				BR5 w/ AR5 GWPs		
	Breakout	2005	2010	2015	2021	2025	2030	2035
by Gas	CO2	6132	5680	5377	5032	4886	4807	4737
	CH4	791	808	771	727	731	731	729
	N2O	416	411	419	393	371	367	365
	HFCs	116	145	158	175	150	153	124
	PFCs	6	4	5	4	5	5	5
	SF6	16	10	7	8	5	4	4
	NF3	0	0	1	1	1	1	1
	Total Gross Emissions	7477	7058	6737	6340	6149	6069	5965
Net	LULUCF	-781	-751	-672	-754	-725	-709	-724
	Total Net Emissions	6696	6307	6066	5586	5424	5361	5241
by Sector	Energy	4385	4137	3808	3392	3290	3247	3191
	Transportation	1966	1795	1789	1804	1750	1727	1697
	Industrial Processes	356	352	364	376	365	360	354
	Agriculture	578	591	605	598	580	573	563
	Waste	192	183	172	169	164	162	159
	Total Gross Emissions	7477	7058	6737	6340	6149	6069	5965
Net	LULUCF	-781	-751	-672	-754	-725	-709	-724
	Total Net Emissions	6696	6307	6066	5586	5424	5361	5241
	Total Net Emissions % Below 2005	0%	6%	9%	17%	19%	20%	22%

Projected Net GHG Emissions and Data Sources by Model

		EPS-EI			GCAM-CGS			GCAM-PNNL			MARKAL-NETL			NEMS-OP			NEMS-RHG			REGEN-EPRI			RIO-REPEAT			USREP-ReEDS		
	Breakout	2025	2030	2035	2025	2030	2035	2025	2030	2035	2025	2030	2035	2025	2030	2035	2025	2030	2035	2025	2030	2035	2025	2030	2035	2025	2030	2035
by Gas	CO2	4532	3625	3038	4143	3535	3265	4151	3632	3310	4265	3979	3386	4495	3778	3347	4618	3731	3573	4460	3921	3158	4772	3693	2763	4127	3494	3232
	CH4	684	696	729	722	688	688	668	674	690	731	731	729	731	731	729	684	641	637	731	731	729	731	731	729	731	731	729
	N2O	342	360	397	371	367	365	371	367	365	371	367	365	371	367	365	383	376	381	371	367	365	371	367	365	371	367	365
	HFCs	150	153	124	150	153	124	150	153	124	150	153	124	150	153	124	150	118	83	150	153	124	150	153	124	150	153	124
	PFCs	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5
	SF6	5	4	4	5	4	4	5	4	4	5	4	4	5	4	4	5	5	5	5	4	4	5	4	4	5	4	4
	NF3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Total Gross Emissions	5719	4844	4298	5397	4754	4451	5350	4836	4499	5528	5241	4613	5758	5040	4575	5845	4877	4685	5722	5183	4386	6034	4955	3991	5390	4756	4459
Net	LULUCF	-738	-742	-708	-755	-754	-752	-994	-857	-842	-744	-750	-755	-725	-709	-724	-811	-887	-903	-725	-709	-724	-753	-792	-646	-725	-709	-724
	Total Net Emissions	4981	4102	3589	4642	4000	3700	4356	3979	3657	4784	4491	3858	5033	4331	3851	5035	3991	3782	4997	4474	3662	5282	4163	3344	4665	4047	3735
by Sector	Energy	3060	2592	2299	2887	2543	2382	2863	2588	2407	2958	2804	2468	3081	2697	2448	3113	2336	2333	3062	2773	2347	3229	2651	2135	2884	2545	2386
	Transportation	1627	1379	1223	1536	1353	1267	1523	1376	1280	1573	1491	1313	1639	1434	1302	1637	1493	1346	1629	1475	1248	1717	1410	1136	1534	1353	1269
	Industrial Processes	340	288	255	320	282	264	318	287	267	328	311	274	342	299	272	356	311	275	340	308	260	358	294	237	320	282	265
	Agriculture	539	457	405	509	448	420	505	456	424	521	494	435	543	475	432	586	593	592	540	489	414	569	467	376	508	449	421
	Waste	153	129	115	144	127	119	143	129	120	148	140	123	154	134	122	154	146	140	153	138	117	161	132	106	144	127	119
	Total Gross Emissions	5719	4844	4298	5397	4754	4451	5350	4836	4499	5528	5241	4613	5758	5040	4575	5845	4877	4685	5722	5183	4386	6034	4955	3991	5390	4756	4459
Net	LULUCF	-738	-742	-708	-755	-754	-752	-994	-857	-842	-744	-750	-755	-725	-709	-724	-811	-887	-903	-725	-709	-724	-753	-792	-646	-725	-709	-724
	Total Net Emissions	4981	4102	3589	4642	4000	3700	4356	3979	3657	4784	4491	3858	5033	4331	3851	5035	3991	3782	4997	4474	3662	5282	4163	3344	4665	4047	3735
	Total Net Emissions % Below 2005	26%	39%	46%	31%	40%	45%	35%	41%	45%	29%	33%	42%	25%	35%	42%	25%	40%	44%	25%	33%	45%	21%	38%	50%	30%	40%	44%

KEY	
BR5 Projection	
Model-reported	
Calculated	

	% Below 2005		
	Min	Med	Max
2025	21%	26%	35%
2030	33%	39%	41%
2035	42%	45%	50%