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Greenhouse Gas Emissions in the U.S. Electricity Sector: Background, Policies, and Projections

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Greenhouse Gas Emissions in the U.S. Electricity Sector: Background, Policies, and Projections

SUMMARY

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May 18, 2023

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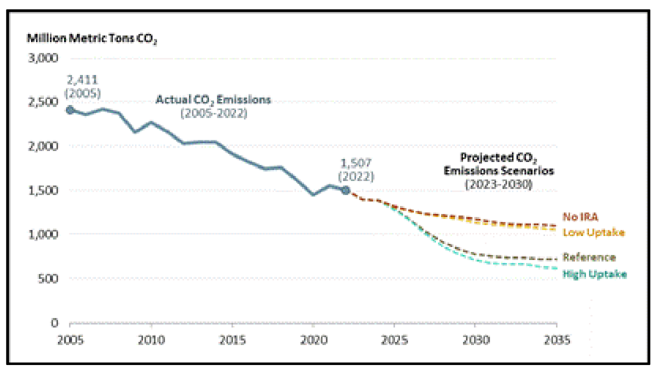
International negotiations and domestic policy developments continue to generate congressional interest in current and projected U.S. greenhouse gas (GHG) emissions. The United States has pledged to reduce its net GHG emissions by 50%-52% below 2005 levels by 2030. Considering recent federal statutes, emissions analyses indicate U.S. net GHG emissions will decrease by 30% to 43% by 2030 compared with 2005 levels, thus not meeting the 2030 reduction target.

Overall U.S. GHG emissions levels will likely be driven by GHG emissions—particularly CO_2 emissions—from electric power plants. Multiple factors generally affect GHG emissions levels from the electric power sector, including electricity market developments, weather, and general U.S. economic conditions. In addition, a primary factor affecting CO_2 emissions levels in the U.S. electricity sector is the electricity generation portfolio, which experienced considerable changes between 2005 and 2022, including the following:

- coal's contribution to total electricity generation decreased from 50% to 19%;
- natural gas's contribution to total electricity generation increased from 19% to 39%; and
- non-hydro renewable energy (mostly wind and solar) generation increased from 2% to 17%.

Climate-related provisions in recent legislation, particularly the tax incentives and funding provisions in P.L. 117-169, commonly known as the Inflation Reduction Act (IRA), are projected to influence the U.S. electricity portfolio, and ultimately CO_2 emissions levels. Among other provisions, IRA creates new and revises existing tax credits that encourage electricity generation from less carbon-intensive sources than fossil fuels, such as renewable sources or nuclear power. Several groups have prepared projections of emissions for the U.S. electricity sector. The figure in this summary illustrates emissions estimates from the U.S. Energy Information Administration (EIA), which included a "No IRA" scenario and three IRA implementation scenarios. EIA's modeling yielded emissions reductions that range between a 54% (for the "No IRA" case) and 74% reduction (for the "High Uptake" IRA case) in CO_2 emissions in the electricity sector in 2035 compared to 2005 levels.

CO_2 Emissions in the Electricity Sector: Actual Levels and EIA Projections Through 2035



Source: Prepared by CRS; data from EIA, *Annual Energy Outlook 2023*.

Notes: See main report text for further details regarding the projected CO_2 emissions scenarios and their assumptions.

On May 11, 2023, the U.S. Environmental Protection Agency (EPA) proposed a rule that, if finalized, would ultimately limit CO_2 emissions from both new and existing fossil-fuel-fired electric generating units. The proposed limits vary by the type of unit, size or capacity of the unit, whether the unit is new or existing, the remaining lifespan of the unit, and the frequency the unit is used for electricity generation. This proposal is likely to receive considerable attention from policymakers and stakeholders, and any future final rule is likely to be subject to litigation.

If Congress wishes to further incentivize U.S. GHG emissions reduction, options may include market-based approaches, such as carbon pricing mechanisms, or regulatory standards for particular facilities or sectors. IRA climate provisions may support the development of additional policies by reducing the costs of lower-carbon energy sources and technologies. If these additional policies are implemented, they may help achieve the U.S. 2030 emissions reduction target. On the other hand, additional policies and regulations are likely to face opposition from some policymakers and stakeholders.

Contents

Figures

Contacts

Introduction

The primary greenhouse gas (GHG)[1] emitted by human activities is carbon dioxide (CO_2), most of which is produced through the combustion of fossil fuels. Although fossil fuels have facilitated economic growth in the United States and around the world, CO_2 emissions from fossil fuel combustion have contributed to an increase in the atmospheric concentration of CO_2 of about 40% over the past 150 years.[2] According to a 2023 report from the Intergovernmental Panel on Climate Change (IPCC):

> Human activities, principally through emissions of greenhouse gases, have unequivocally caused global warming.... Continued greenhouse gas emissions will lead to increasing global warming.... Some future changes are unavoidable and/or irreversible but can be limited by deep, rapid and sustained global greenhouse gas emissions reduction.[3]

U.S. GHG emissions levels, particularly from CO_2, remain a topic of interest among policymakers and stakeholders. A wide array of actions that seek to reduce GHG emissions are under way or being developed by federal governments and subnational entities (e.g., U.S. states or regional partnerships).[4] Federal climate change policies continue to evolve and currently include a range of activities implemented under various legal authorities, such as the Clean Air Act.

The 117th Congress enacted two laws, in particular, that include a number of provisions projected to affect U.S. GHG emissions levels.

1. On November 15, 2021, President Biden signed the Infrastructure Investment and Jobs Act (IIJA; P.L. 117-58). IIJA is a broad infrastructure law that addressees multiple economic sectors that produce GHG emissions, including transportation and energy, among others.[5]
2. On August 16, 2022, President Biden signed a budget reconciliation measure commonly referred to as the Inflation Reduction Act of 2022 (IRA; P.L. 117-169). Each of the eight IRA titles contains some number of provisions that

[1] GHGs in the atmosphere trap solar radiation as heat, warming the Earth's surface and oceans. The primary GHGs emitted by humans (and estimated by the Environmental Protection Agency in its annual inventories) include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride, chlorofluorocarbons, hydrofluorocarbons, and perfluorocarbons.

[2] For more information on climate change science, see CRS Report R43229, *Climate Change Science: Key Points*, by Jane A. Leggett.

[3] Intergovernmental Panel on Climate Change, *Synthesis Report of the IPCC Sixth Assessment Report—Summary for Policymakers*, April 2023, at https://www.ipcc.ch/report/ar6/syr/.

[4] A number of U.S. states have taken action requiring GHG emissions reductions. For example, a coalition of 11 states from the Northeast and Mid-Atlantic regions participate in the Regional Greenhouse Gas Initiative, a cap-and-trade system that took effect in 2009 and applies to CO_2 emissions from electric power plants (see CRS Report R41836, *The Regional Greenhouse Gas Initiative: Background, Impacts, and Selected Issues*, by Jonathan L. Ramseur). California established a cap-and-trade program that took effect in 2013. California's cap covers multiple GHGs, which account for approximately 85% of California's GHG emissions. For more details, see the California Air Resources Board website, at https://www.carb.ca.gov/cc/capandtrade/capandtrade.htm. In addition, Washington State established a cap-and-trade program comparable to California's that started in 2023 (see State of Washington Department of Ecology, "Washington's Cap-and-Invest Program," at https://ecology.wa.gov/Air-Climate/Climate-Commitment-Act/Cap-and-invest).

[5] For more details, see CRS Report R47034, *Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (P.L. 117-58)*, coordinated by Brent D. Yacobucci.

directly or indirectly address issues related to climate change, including reduction of U.S. GHG emissions.[6]

In addition, on May 11, 2023, the U.S. Environmental Protection Agency (EPA) proposed a rule that would seek to limit GHG emissions from both new and existing fossil-fuel-fired electric generating units. This proposal is expected to generate considerable debate among policymakers and stakeholders and, if finalized, would likely be subject to litigation.

International negotiations continue to generate attention to current and projected U.S. GHG emissions levels. The United Nations Framework Convention on Climate Change (UNFCCC) is the principal international treaty to acknowledge and address human-driven climate change. The United States ratified the treaty in 1992.[7] Pursuant to the 2015 Paris Agreement (PA), the second major subsidiary agreement under the UNFCCC,[8] each country must submit a GHG emissions reduction pledge referred to as a *nationally determined contribution* (NDC). Targets and actions pledged in NDCs are nonbinding. Participating countries must update their NDCs every five years. U.S. NDCs include the following:

- **2015 NDC:** reduce net GHG emissions[9] by 26%-28% below 2005 levels by 2025; and
- **2021 NDC:** reduce net GHG emissions by 50%-52% below 2005 levels by 2030.[10]

Whether the United States ultimately achieves its GHG emissions targets will likely depend in part on GHG emissions from electric power plants—one of the largest sources of U.S. GHG emissions. An understanding of GHG emissions from the electricity sector and the underlying factors that affect the sector's emissions levels might help inform the discussion among policymakers regarding GHG emissions mitigation in the electricity sector and in other sectors of the economy.

This report examines recent trends in GHG emissions—particularly CO_2 emissions—from electricity generation and the factors that affect emissions levels in that sector. The first section provides context by including an overview of various sources of GHG emissions in the United States and a comparison of emissions levels to U.S. emissions reduction pledges. The second section discusses CO_2 emissions from the electricity sector, including sources, recent trends, and other factors. The third section discusses federal and state policies that address GHG emissions in the electricity sector, both directly and indirectly. The fourth section provides projections of GHG emissions in the electricity sector, with a particular focus on the role of recently enacted legislation. The final section provides concluding observations.

[6] For more details, see CRS Report R47262, *Inflation Reduction Act of 2022 (IRA): Provisions Related to Climate Change*, coordinated by Jane A. Leggett and Jonathan L. Ramseur; and CRS Report R47385, *U.S. Greenhouse Gas Emissions Trends and Projections from the Inflation Reduction Act*, by Jonathan L. Ramseur.

[7] U.S. Treaty Number 102-38.

[8] See CRS In Focus IF11746, *United States Rejoins the Paris Agreement on Climate Change: Options for Congress*, by Jane A. Leggett.

[9] *Net emissions* includes the sum of gross emissions estimates and removal estimates (see text box "Emissions Data in This Report").

[10] According to the Biden Administration, the 2021 NDC "exceeds a straight-line path to achieve net-zero emissions, economy-wide, by no later than 2050." The White House, "The United States of America Nationally Determined Contribution Reducing Greenhouse Gases in the United States: A 2030 Emissions Target," April 22, 2021, at https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/United%20States%20of%20America%20First/United%20States%20NDC%20April%2021%202021%20Final.pdf.

Emissions Data in This Report

This report uses GHG emissions data from two different sources: EPA and the U.S. Energy Information Administration (EIA). Estimates of total and net GHG emissions ("economy-wide") come from EPA's annual GHG emissions inventory. These estimates provide a big-picture view of U.S. GHG emissions levels and GHG emissions sources, particularly in the context of recent GHG emissions reduction goals. EPA released the most recent version of its inventory in April 2023. This version includes GHG emissions data through 2021.

Although EPA's inventory includes CO_2 emissions, this report generally uses CO_2 emissions data from EIA, because EIA's CO_2 emissions data are released on a monthly basis, including annual numbers for 2022. This allows for more recent comparisons of trends in electricity-sector emissions and related topics. CO_2 emissions have historically accounted for approximately 80% of total U.S. GHG emissions. A comparison of recent CO_2 emissions data from EPA and EIA reveals that their values vary by approximately 1%. Moreover, changes in U.S. GHG emissions levels are largely due to changes in U.S. CO_2 emissions levels. The fluctuations in CO_2 emissions in EIA's reports generally track with the annual percentage changes in total GHG emissions from EPA's inventories. Non-CO_2 GHG emissions (provided in EPA's inventory) have remained relatively constant during that time frame.

GHG emissions are typically measured in tons of CO_2-equivalent. This unit of measure is used because GHGs vary by global warming potential (GWP). GWP is an index developed by the IPCC that allows comparisons of the heat-trapping ability of different gases over a period of time, typically 100 years. Consistent with international GHG reporting requirements, EPA's most recent GHG inventory uses the GWP values presented in the IPCC's *2013 Fifth Assessment Report*. For example, based on these GWP values, a ton of methane is 28 times more potent than a ton of CO_2 when averaged over a 100-year time frame. The IPCC has since updated the 100-year GWP estimates, with some increasing and some decreasing. For example, the IPCC *2021 Sixth Assessment Report* reported the 100-year GWP for methane as 27.

Gross emissions refer to total emissions from all sources. This value does not account for removals of CO_2 emissions from the atmosphere by emission sinks, such as forests, vegetation, and soils. U.S. sinks removed about 754 million metric tons (MMT) in 2021, about 12% of gross U.S. emissions.[11] *Net emissions* include the sum of gross emissions estimates and removal estimates. The U.S. nationally determined contribution (NDC) is measured in terms of net emissions.

Historical U.S. GHG Emissions and Recent Trends

GHG emissions data and trends can be presented in several ways, with each presentation providing a different perspective. The GHG emissions in EPA's inventory and in this report generally involve annual emissions levels. Other GHG emissions measures include cumulative GHG emissions, GHG emissions intensities (e.g., emissions per a monetary value, such as gross domestic product), and GHG emissions per capita. The following sections discuss recent U.S. emissions levels and trends, the sources of U.S. GHG emissions, and how these sources have changed in recent years.

U.S. GHG Emissions and Reduction Pledges

Figure 1 illustrates net U.S. GHG emissions between 1990 and 2022. As the figure indicates, U.S. GHG emissions increased 20% between 1990 and 2007 and have generally decreased since that time. As discussed below, a range of factors have played a role in this downward trend, including the evolving electricity generation portfolio, technological developments, and relatively short-term economic conditions. For example, the economic downturn in 2008 and 2009 resulted in a decrease of energy consumption (including electricity) across all economic sectors. This decline played a key role in the 10% decrease in emissions levels during that time. Over the next 10 years (2010 through 2019), annual emissions levels fluctuated with a downward trend, ultimately decreasing by 7%. Between 2019 and 2020, emissions decreased by 9%, accounting

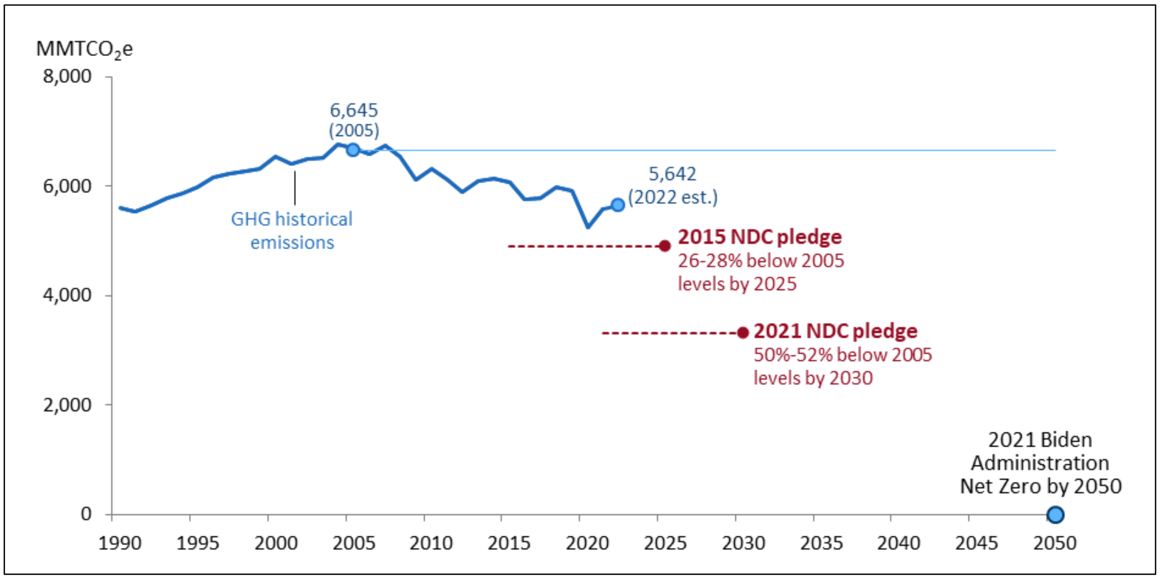
[11] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, 2023, at https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

for the largest annual decline in EPA's inventory history. According to EPA, the decrease was "largely due to the impacts of the coronavirus (COVID-19) pandemic on travel and economic activity."[12] In 2021, GHG emissions rebounded, increasing by 6%. Based on more recent CO_2 emissions data from EIA, CRS estimates that total GHG emissions will increase by 1% between 2021 and 2022, which will still be below prepandemic levels.[13]

In addition, **Figure 1** compares U.S. GHG emissions (including the estimate for 2022) and the NDC pledges for 2025 and 2030 and President Biden's goal to achieve net-zero emissions in 2050. As the figure indicates, the estimated 2022 emissions were 16% below 2005 levels.

Recent analyses from groups in the private sector, academia, and the federal government have used computer simulation models to prepare estimates of U.S. net GHG emissions through 2030. The results of these projections indicate U.S. net GHG emissions would decrease by 30% to 43% by 2030 compared with 2005 levels, thus not meeting the 2030 reduction target.[14]

Figure 1. Historical U.S. GHG Net Emissions Compared with U.S. Emissions Targets



Source: Prepared by CRS; actual U.S. GHG emissions from EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021*, April 2023. See "Emissions Data in This Report" textbox for further details.

Notes: NDC = nationally determined contribution pursuant to the United Nations Framework Convention on Climate Change (UNFCCC) Paris Agreement. $MMTCO_2e$ = million metric tons of CO_2 equivalent. This measure is used because GHGs vary by global warming potential (GWP). GWP is an index that allows comparisons of the heat-trapping ability of different gases over a period of time. The GHG emissions in the figure are net GHG emissions. Net GHG emissions account for removals of CO_2 emissions from the atmosphere by emission sinks, such as forests, vegetation, and soils. The U.S. NDC is measured in terms of net emissions.

CRS calculated the 2022 U.S. GHG emissions estimate based on CO_2 data from EIA. EIA provides energy-related CO_2 emissions on a more up-to-date schedule than EPA's inventory, which includes GHGs from all sources. The CO_2 emissions in EIA's reports account for approximately 80% of total U.S. GHG emissions, and their fluctuations generally track with the annual percentage changes in total GHG emissions from EPA's inventories. EIA data indicate that CO_2 emissions from the energy sector increased by 1% between 2021 and 2022. CRS applied this percentage increase to total net GHG emissions in 2021, resulting in an estimate of 5,642 $MMTCO_2e$

[12] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2020*, 2022.

[13] For more details on this estimate, see the "Notes" in **Figure 1**.

[14] For more details and discussion, see CRS Report R47385, *U.S. Greenhouse Gas Emissions Trends and Projections from the Inflation Reduction Act*, by Jonathan L. Ramseur.

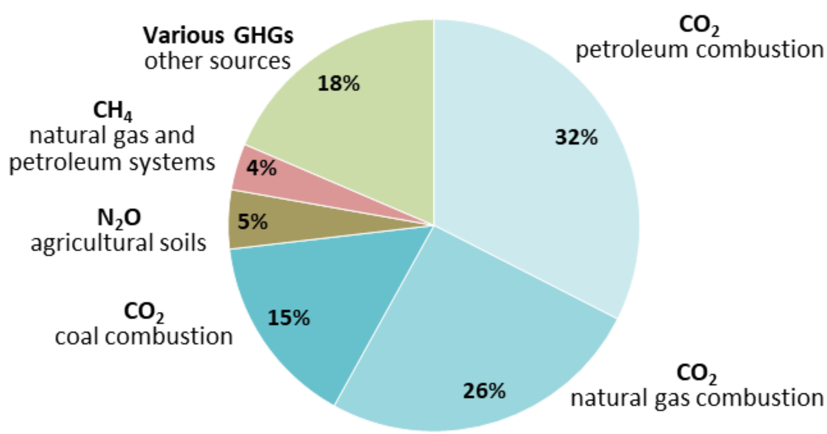
in 2022. EIA, *Monthly Energy Review*, Table 11.1, March 2023, at https://www.eia.gov/totalenergy/data/monthly/#environment.

U.S. GHG Emissions Sources

GHG emissions are produced throughout the United States from millions of discrete sources: power plants, industrial facilities, vehicles, households, commercial buildings, and agricultural activities (e.g., soils and livestock).[15] **Figure 2** illustrates the breakdown of U.S. GHG emissions by gas and type of source. The figure indicates that CO_2 from the combustion of fossil fuels—petroleum, coal, and natural gas—accounted for 73% of total U.S. GHG emissions in 2021. This contribution has decreased in recent years; in 2012, CO_2 from the combustion of fossil fuels accounted for 78% of total GHG emissions.[16]

Figure 2. U.S. GHG Emissions by Source and Gas

2021 Data Reported in Metric Tons of CO_2-Equivalent



Source: Prepared by CRS; data from EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021*, April 2023. See "Emissions Data in This Report" textbox for further details.

Notes: N_2O is nitrous oxide. The "Various GHGs—other sources" category includes the following:

Methane (CH_4) from livestock (3%); hydrofluorocarbons released during the production of ozone-depleting substances (3%); CO_2 from nonenergy fuel uses (2%); CH_4 from landfills (2%); CO_2 from iron and steel production (1%); CH_4 from coal mines (1%); and CH_4 from manure management (1%). Multiple smaller sources account for the remaining 6%. These percentages may not add up precisely due to rounding.

U.S. GHG Emissions by Economic Sector

Another common method of reporting GHG emissions is by sector. **Figure 3** illustrates the GHG emissions by sector between 1990 and 2021. As the figure indicates, GHG emissions in the electric power sector historically accounted for the largest percentage of total U.S. GHG emissions. However, starting in 2005, GHG emissions in the electricity sector began to decrease. Between 2005 and 2021, electricity sector emissions decreased by 36%. By comparison, emissions in the transportation and industrial sectors decreased by 8% and 6%, respectively,

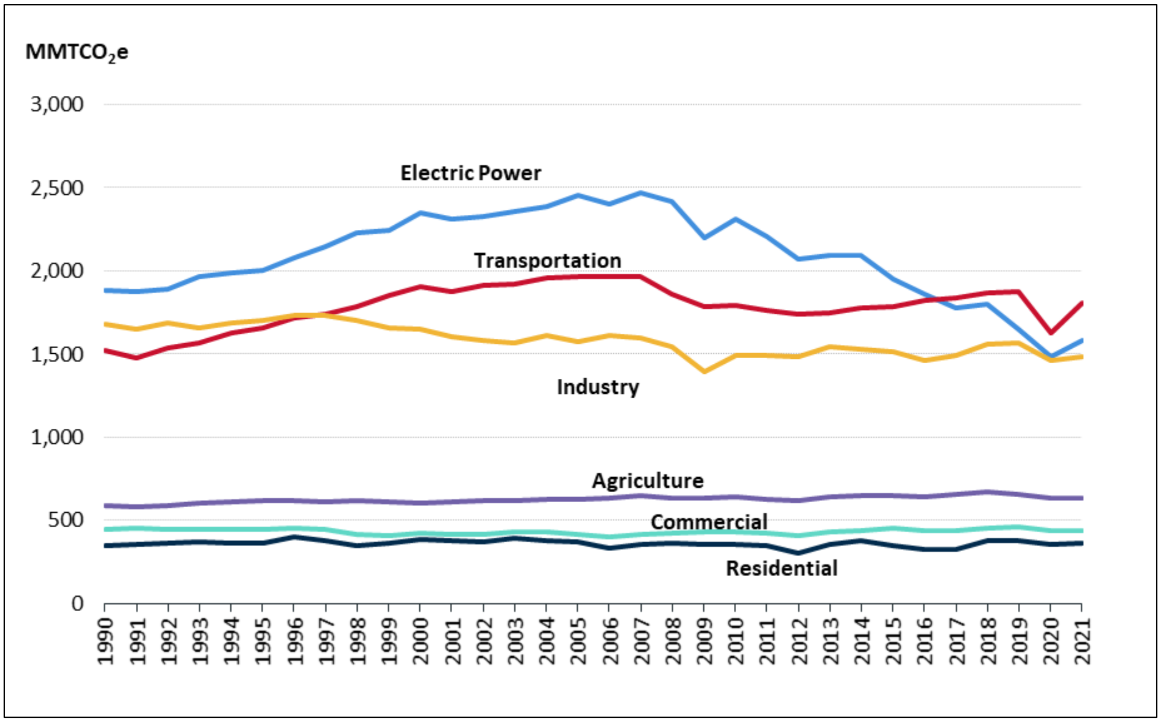
[15] GHG emissions are also released through a variety of natural processes such as methane emissions from wetlands. This report focuses on human-related (anthropogenic) GHG emissions.

[16] Based on comparable data from EPA's GHG Inventory, released in 2014.

during this time frame. Since 2017, emissions in the transportation sector have surpassed emissions in the electricity sector.

Figure 3. U.S. GHG Emissions by Sector

1990-2021



Source: Prepared by CRS; data from EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021*, April 2023. See "Emissions Data in This Report" textbox for further details.

Electricity Sector Emissions: Context and Trends

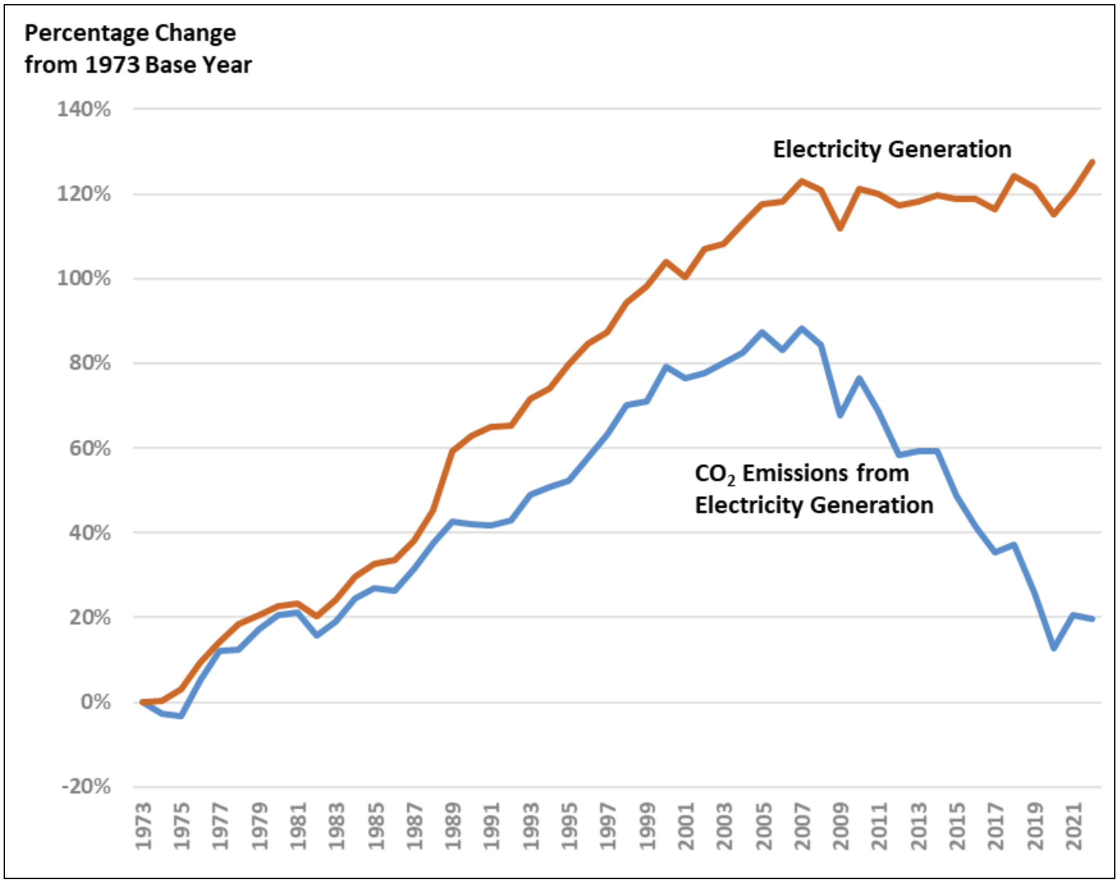
As discussed above, CO_2 emissions from the combustion of fossil fuels account for 73% of all U.S. GHG emissions. The electric power sector contributes the second-largest percentage (31%) of CO_2 emissions from fossil fuel combustion (six percentage points less than the transportation sector). This section provides further background and context regarding GHG emissions in the electricity sector.

Electricity Generation Levels and Emissions

Figure 4 compares U.S. electricity generation with CO_2 emissions from the electricity sector between 1973 and 2021. As the figure illustrates, U.S. electricity generation generally increased between 1973 and 2007 and then decreased in 2008 and 2009. Historically, CO_2 emissions from electricity generation followed a similar course. However, in 2010, these trends decoupled. While electricity generation generally remained flat after 2010, CO_2 emissions continued a general trend of reduction. Thus in 2021, electricity generation was 5% higher than generation in 2005, while CO_2 emissions were 36% below 2005 levels—equivalent to electricity sector CO_2 emission levels in 1983.

Figure 4. Electricity Generation and CO_2 Emissions from U.S. Electricity Sector

1973-2021



Source: Prepared by CRS; data from EIA, *Monthly Energy Review*, Table 7.2 (net electricity generation) and Table 11.6 (emissions), at https://www.eia.gov/totalenergy/data/monthly/.

Notes: Electricity generation in this figure is annual, net electricity generation from all sources, measured in gigawatt hours.

The decrease in CO_2 emissions in the electricity sector over the past 15 years was a result of several factors, including changes in the electricity generation portfolio (discussed below), technology developments, weather variability,[17] and overall U.S. economic conditions, typically measured in terms of the U.S. gross domestic product (GDP). Historically, annual U.S. GDP decreases are a relatively uncommon occurrence; the United States has seen an annual decrease in GDP seven times over the past 50 years. The 2.6% GDP decrease in 2009 and 2.8% decrease in 2020 were the two largest GDP decreases during that time frame.[18] These economic downturns resulted in decreases in energy consumption (including electricity) across all economic sectors.

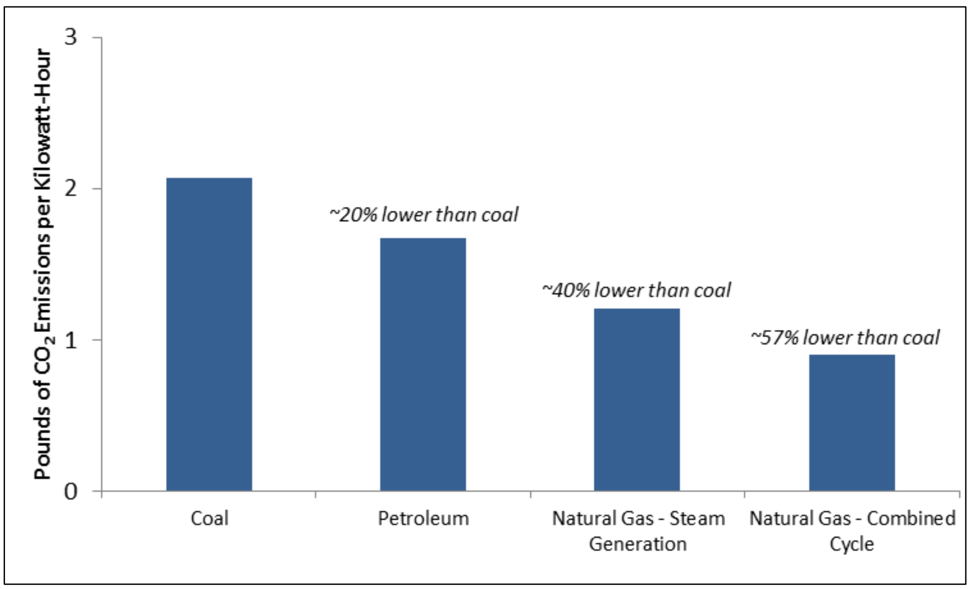
[17] See, for example, EIA, "Record U.S. Electricity Generation in 2018 Driven by Record Residential, Commercial Sales," 2019, at https://www.eia.gov/todayinenergy/detail.php?id=38572.

[18] Bureau of Economic Analysis, "National Data, National Income and Product Accounts," Table 1.1.1. Percent Change From Preceding Period in Real Gross Domestic Product, at https://apps.bea.gov.

Role of Electricity Generation Portfolio

A primary factor affecting CO_2 emissions levels in the electricity sector is the electricity generation portfolio. Electricity is generated from a variety of sources in the United States. Some sources—nuclear, hydropower, and some renewables—directly produce no CO_2 emissions when used for electricity generation. Fossil fuels emit different amounts of CO_2 emissions per unit of electricity generated (often described as *carbon intensity*). **Figure 5** illustrates the relative comparison of CO_2 emissions per unit of electricity produced from coal, petroleum, and natural gas. As the figure indicates, petroleum-fired electricity produces approximately 80% of the CO_2 emissions of coal-fired electricity per kilowatt-hour of electricity. Natural-gas-fired electricity from a steam generation unit produces approximately 60% of the CO_2 emissions of coal-fired electricity per kilowatt-hour of electricity. Natural-gas-fired electricity from a combined cycle unit produces approximately 43% of the CO_2 emissions of coal-fired electricity per kilowatt-hour of electricity. Therefore, a shift in the carbon intensity of the U.S. electricity generation portfolio (all else being equal) would likely have an impact on emissions from the electricity sector, which in turn, would affect total U.S. GHG emissions.

Figure 5. Comparison of Fossil Fuels' Carbon Intensity in Electricity Generation



Source: Prepared by CRS; data from EIA, "How Much Carbon Dioxide Is Produced per Kilowatthour When Generating Electricity with Fossil Fuels?" at https://www.eia.gov/tools/faqs/faq.php?id=74&t=11.

Notes: Carbon content values are derived by multiplying the fuel's CO_2 emissions factor by the heat rate of a particular electric generating unit. In this figure, CRS used the coal emissions factor for bituminous coal and the petroleum emissions factor measure for distillate oil (Number 2 fuel oil). Natural gas has only one emissions factor. The heat rates of different electricity unit types can vary substantially. CRS used EIA's average steam generation value for coal, petroleum, and natural gas, as well as the average combined cycle value for natural gas. The above comparison does not account for the so-called life-cycle emissions associated with the energy supply chain (e.g., fugitive methane emissions from natural gas production). For more information, see CRS Report R44090, *Life-Cycle Greenhouse Gas Assessment of Coal and Natural Gas in the Power Sector*, by Richard K. Lattanzio.

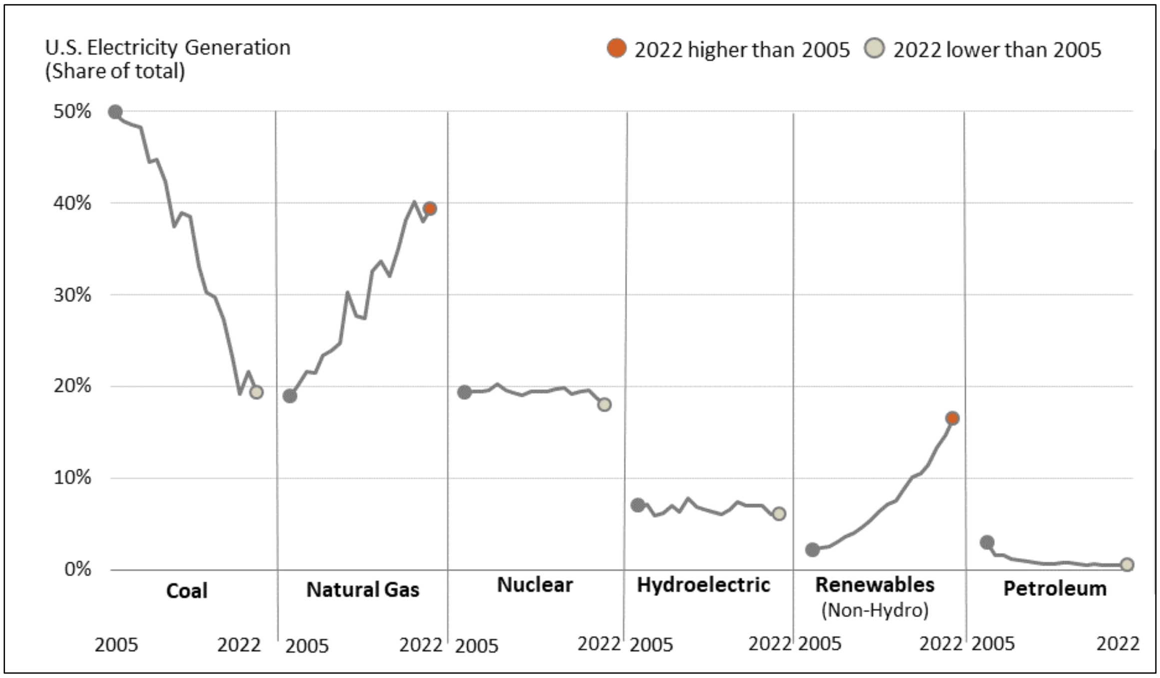
Figure 6 illustrates the percentage of electricity generated by source between 2005 and 2022. As the figure indicates, the U.S. electricity generation portfolio has changed considerably. During this time frame (2005-2022), highlights include the following:

- Coal-fired generation decreased by 59%. Its contribution to total electricity generation decreased from 50% to 19%.

- Natural-gas-fired generation increased by 122%. Its contribution to total electricity generation increased from 19% to 39%. *In 2016, natural gas surpassed coal in terms of percentage of total generation.*
- Non-hydro renewable energy generation—mainly wind and solar—increased by 645% (a seven-fold increase). Its contribution to total electricity generation increased from 2% to 17%.

Figure 6. Percentage of Total Electricity Generation by Energy Source

2005-2022



Source: Prepared by CRS; data from EIA, *Electric Power Monthly*, Table 1.1, at http://www.eia.gov/beta/epm/.

Notes: Renewable sources include wind, utility scale and distributed solar, wood fuels, landfill gas, biogenic municipal solid waste, other biomass, and geothermal. Petroleum includes petroleum liquids and petroleum coke. EIA began to collect estimates for distributed solar in 2014. Electricity generation in this figure is annual, net electricity generation from all sources, measured in gigawatt hours.

Several factors played a role in these recent changes. Due in large part to technological advances, particularly directional drilling and hydraulic fracturing,[19] U.S. natural gas production increased by 98% between 2005 and 2022.[20] Relatedly, the weighted average annual price of natural gas dropped by about 13% between 2005 and 2021. By comparison, the weighted average annual coal price increased by about 46% during that time frame.[21] This change in relative fuel prices has played a key role in altering the economics of power generation, leading to considerable natural gas displacement of coal in particular regions of the country.[22] These market forces have played a

[19] *Hydraulic fracturing* is an industry technique that uses water, sand, and chemicals under pressure to enhance the recovery of natural gas and oil from certain geologic formations. It has taken on new prominence as it has been applied to tight oil and shale gas formations as an essential method for resource extraction. See CRS Report R45988, *U.S. Natural Gas: Becoming Dominant*, by Michael Ratner.

[20] EIA, "U.S. Dry Natural Gas Production," at http://www.eia.gov/dnav/ng/hist/n9070us2a.htm.

[21] EIA, *Electric Power Annual*, Table 7.4, at https://www.eia.gov/electricity/annual/html/epa_07_04.html.

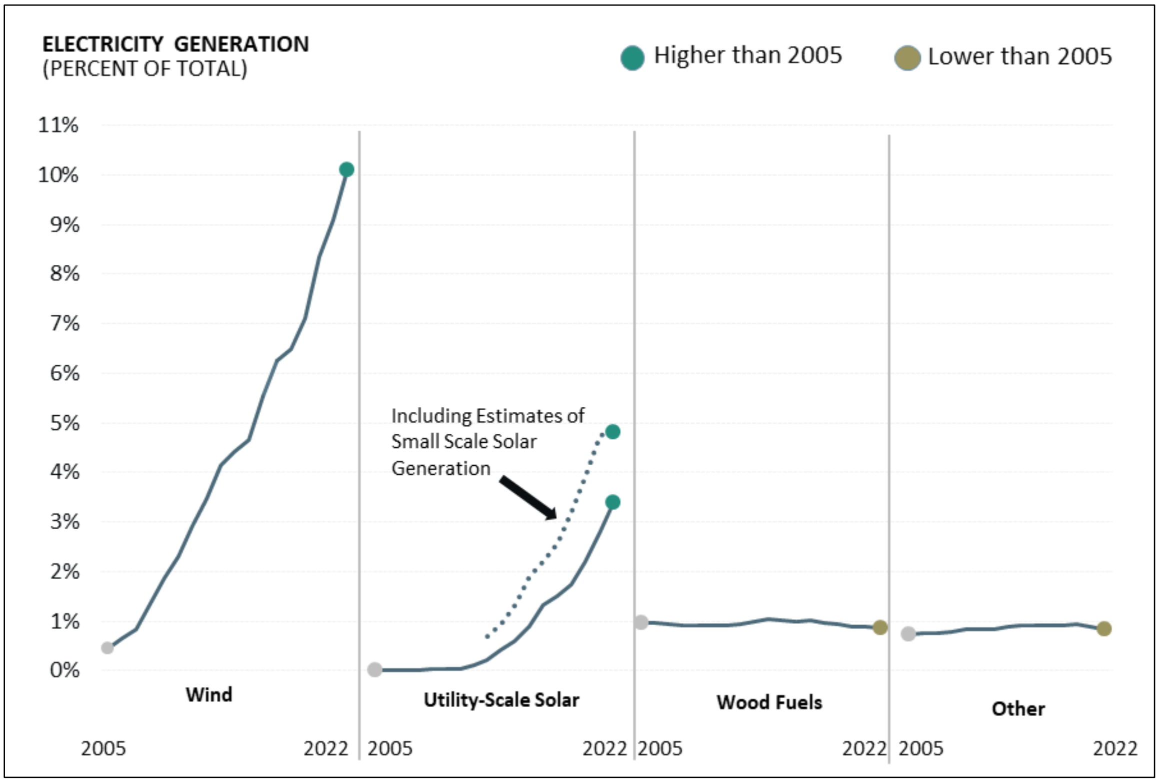
[22] For more discussion, see CRS Report R47521, *Electricity: Overview and Issues for Congress*, by Ashley J. Lawson.

role in the retirement of coal-fired electric power plants: Between 2006 and 2021, the number of U.S. coal-fired power plants decreased from 616 to 269.[23]

Figure 7 provides a more detailed breakdown of the changes in generation from renewable energy sources, not including hydroelectricity. The majority of the increased generation from renewable energy over the past 14 years has been from wind power, which increased 24-fold between 2005 and 2022.

Figure 7. Percentage of Total Electricity Generation from Renewable Energy Sources (Not Including Hydroelectricity)

2005-2022



Source: Prepared by CRS; data from EIA, *Electric Power Monthly*, Table 1.1A, at https://www.eia.gov/electricity/monthly/.

Notes: Utility-scale and small-scale solar generation (e.g., rooftop solar on commercial building and residences) are counted separately, because EIA began to provide estimates for small-scale solar in 2014. Including both utility data and small-scale estimates would increase the percentage of solar generation in 2022 from 3.4% to 4.8%. The "other" category includes landfill gas, biogenic municipal solid waste, other biomass, and geothermal sources. Electricity generation in this figure is annual, net electricity generation from all sources, measured in gigawatt hours.

The figure also provides estimates of small-scale solar generation (e.g., rooftop solar on commercial building and residences).[24] In 2014, EIA began to provide estimates for small-scale solar generation, which has increased five-fold since that time. Including both utility data and

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[23] EIA, *Electric Power Annual*, Table 4.1, 2022, at https://www.eia.gov/electricity/annual/. This includes electric utilities, independent power producers, and plants in the commercial and industrial sectors.

[24] For more information on solar energy, see CRS Report R46196, *Solar Energy: Frequently Asked Questions*, coordinated by Ashley J. Lawson.

small-scale estimates would increase the percentage of solar generation in 2022 from 3.4% to 4.8%.

Energy from wood fuels has remained relatively constant during this time frame. Although the total percentage of electricity from "other" renewable sources has remained relatively constant, the use of landfill gas increased by 75% between 2005 and 2022.

Policies Addressing Electricity Sector Emissions

Policymaking entities in the United States—Congress, federal agencies, state and local governments—have proposed and established a variety of climate change policy approaches. Many GHG emissions reduction programs at the state levels (e.g., the Regional Greenhouse Gas Initiative) and federal legislative proposals have focused on CO_2 emissions from the electricity generation sector due to the sector's large GHG emissions contribution and the relatively limited number of emissions sources.[25] As discussed below, enacted legislation in the 117th Congress included provisions that seek to reduce CO_2 emissions in the electricity sector, among other sectors.

Federal Policies[26]

Federal climate policies have involved a range of activities implemented under various legal authorities that have influenced emissions in a range of sectors. These activities have included regulatory standards, tax incentives, data gathering and reporting, and financial support for GHG mitigation technologies.

A 2007 Supreme Court decision established one of the key underpinnings of the federal GHG policy landscape. In *Massachusetts v. EPA*, the Court ruled that EPA has authority under the Clean Air Act to regulate GHG emissions from motor vehicles as air pollutants. At that time, the decision led to a shift in federal policies toward more direct regulation of GHG emissions, including emissions in the electricity sector.

Clean Power Plan and Affordable Clean Energy Rulemakings

Executive branch policies and actions addressing U.S. GHG emissions typically reflect the policy objectives of the Administration at the time. Both the Obama and Trump Administrations issued EPA rulemakings that would regulate GHG emissions from power plants. These include the 2015 Clean Power Plan (CPP)[27] and the 2019 Affordable Clean Energy (ACE)[28] rulemakings. These

[25] See CRS Report R45472, *Market-Based Greenhouse Gas Emission Reduction Legislation: 108th Through 117th Congresses*, by Jonathan L. Ramseur; and CRS In Focus IF11316, *A Brief History of U.S. Electricity Portfolio Standard Proposals*, by Ashley J. Lawson.

[26] For more details regarding the history of federal climate change policies, see CRS Report R46947, *U.S. Climate Change Policy*, coordinated by Richard K. Lattanzio.

[27] During the Obama Administration, the U.S. Environmental Protection Agency (EPA) promulgated a final rule for CO_2 emissions from existing fossil-fuel-fired electric power plants (EPA, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," Final Rule, 80 *Federal Register* 64661, October 23, 2015). In 2017, President Trump issued an executive order that directed EPA to review the CPP (and other rulemakings) and "as soon as practicable, suspend, revise, or rescind the guidance, or publish for notice and comment proposed rules suspending, revising, or rescinding those rules."

[28] In a July 2019 final rulemaking, EPA repealed the CPP and replaced it with new emissions guidelines for coal-fired power plants, known as the Affordable Clean Energy (ACE) rule (EPA, "Repeal of the Clean Power Plan; Emission Guidelines for Greenhouse Gas Emissions From Existing Electric Utility Generating Units; Revisions to Emission Guidelines Implementing Regulations," 84 *Federal Register* 32520, July 8, 2019).

rulemakings, and related efforts that followed, generated considerable interest and controversy. Both the CPP and ACE rules were the subject of extensive litigation, ultimately involving the Supreme Court.[29] On June 30, 2022, the Supreme Court decided *West Virginia v. EPA*, and held that the EPA exceeded its authority under the CAA in its 2015 CPP rule.[30] Under that decision, EPA retains the ability to regulate GHG emissions from power plants and other sources, but it now faces more constraints in how it regulates those emissions.[31] As a result of this decision, the ACE rule, which had been previously vacated, was reinstated in October 2022.[32] Although the ACE rule is in effect, EPA has extended its implementation deadlines, "making it clear that states are not expected to take immediate action."[33] EPA proposed to repeal the ACE rule in its 2023 rulemaking, discussed below.

In addition, a related 2015 final rule establishing GHG emissions standards for new fossil-fuel-fired utility boilers and natural-gas-fired stationary combustion turbines remains in place. The New Source Performance Standard for new and modified power plants relies in part on carbon capture and sequestration (CCS) technology to reduce emissions by about 20% compared with the emissions of what was considered (at the time of the rule) a state-of-the-art coal-fired plant without CCS.[34]

2023 Proposed Rule for Coal- and Gas-Fired Electric Power Plants

On May 11, 2023, the EPA proposed a rule that would seek to limit GHG emissions from both new and existing fossil-fuel-fired electric generating units.[35] The proposed limits vary by the type

[29] A comprehensive discussion of the history and factors that have played a role in the development of these rules is beyond the scope of this report. For more background on these legal developments, see CRS Legal Sidebar LSB10791, *Supreme Court Addresses Major Questions Doctrine and EPA's Regulation of Greenhouse Gas Emissions*, by Kate R. Bowers.

[30] See CRS Legal Sidebar LSB10791, *Supreme Court Addresses Major Questions Doctrine and EPA's Regulation of Greenhouse Gas Emissions*, by Kate R. Bowers.

[31] Ibid.

[32] For a more detailed discussion of these developments, see the section "D.C. Circuit Order to Reinstate the ACE Rule" in EPA's 2023 Proposed Rule, discussed below.

[33] EPA, "Greenhouse Gas Standards and Guidelines for Fossil Fuel-Fired Power Plants Proposed Rule," Factsheet, 2023, at https://www.epa.gov/stationary-sources-air-pollution/greenhouse-gas-standards-and-guidelines-fossil-fuel-fired-power.

[34] See EPA, "Standards of Performance for Greenhouse Gas Emissions from New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units," 80 *Federal Register* 64509, October 23, 2015.

For more background on CCS, see CRS Report R44902, *Carbon Capture and Sequestration (CCS) in the United States*, by Angela C. Jones and Ashley J. Lawson.

[35] EPA, "New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule" (hereinafter "2023 Proposal"). The EPA Administrator signed the proposed rule on May 8, 2023. The version released on May 11, 2023, is an unofficial version that has not been published in the *Federal Register*. The text of the proposal and supporting documents are available at https://www.epa.gov/stationary-sources-air-pollution/greenhouse-gas-standards-and-guidelines-fossil-fuel-fired-power.

Leading up to the proposal, EPA solicited "pre-proposal" outreach (in September 2022) with questions for stakeholders regarding its strategy to address CO_2 emissions from existing fossil-fuel-fired power plants. See EPA, "Pre-Proposal Public Docket: Greenhouse Gas Regulations for Fossil Fuel-fired Power Plants," at https://www.epa.gov/stationary-sources-air-pollution/pre-proposal-public-docket-greenhouse-gas-regulations-fossil-fuel; and EPA, "Questions for Consideration," at https://downloads.regulations.gov/EPA-HQ-OAR-2022-0723-0002/content.pdf.

of unit (e.g., coal or natural gas), size or capacity of the unit, whether the unit is new or existing, the remaining lifespan of the unit, and the frequency the unit is used for electricity generation.[36]

For example, the limits for existing coal-fired units would apply on January 1, 2030. The limits for units that plan to operate after 2039 are based on a 90% rate of carbon capture and sequestration (CCS).[37] Existing coal-fired units that make a federally enforceable commitment to cease operations before 2040 have less-stringent emissions limitations. For these units, the limits are based on substituting natural gas for coal (referred to as "co-firing") at a rate of 40%, which EPA states would equate to a 16% reduction in the unit's emission rate (measured in tons of CO_2 emissions per megawatt hour of electricity generation).[38]

For existing natural-gas-fired combustion units with relatively large capacities that operate on a frequent basis,[39] EPA proposes an emissions limit based on either (1) the use of CCS by 2035 or (2) co-firing with low-GHG hydrogen[40] at a rate of 30% by 2032 and a rate of 96% by 2038. EPA proposes a revised framework for new gas-fired units that varies based on the unit's capacity and frequency of operation. The new source standards for the larger, baseload units are similar to the proposed limits for existing natural gas-fired units of comparable size and operating frequency.[41]

EPA proposes these emissions limits pursuant to authorities in the Clean Air Act. Under this statutory framework, the states establish, implement, and enforce the standards proposed by EPA. EPA proposes several compliance options that states can choose to adopt, including emissions trading or state-wide averaging of emissions. EPA notes that states must ensure that use of these compliance flexibilities will result in a level of emission performance that is equivalent to each source individually achieving its standard of performance.[42]

This proposal is likely to receive considerable attention from policymakers and stakeholders. This rulemaking would follow from the legal developments with the CPP and ACE rules. As with those rulemakings, any future final rule based on the May 2023 proposal is likely to be subject to litigation. Therefore, its ultimate fate and potential effects are uncertain. If the rule were finalized and allowed to go into effect, the rule's potential implementation and effect on emissions would not operate in a policy vacuum; it would be influenced by a range of other state and federal policies, including climate-related provisions enacted in recent legislation, particularly the Inflation Reduction Act (discussed below).

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[36] Some electric generating units produce "base load power," which means the unit typically operates throughout all hours of the year. In contrast, "peaking units" operate only during certain times of the day, week, or year to meet the fluctuating demand from users.

[37] EPA states this would reduce CO_2 emissions from these units by 88.4%. 2023 Proposal, p. 22.

[38] Coal-fired units that commit to permanently cease operations by December 31, 2034, and operate at 20% capacity, are subject to the same emissions limit.

[39] This includes units with a capacity greater than 300 megawatts with a "capacity factor" of 50% or more. A capacity factor is a measure of how much a unit operates relative to how much it could potentially operate. See 2023 Proposal, p. 306.

[40] EPA proposes a definition for low-GHG hydrogen that aligns with the highest of the four tiers of tax credit available for hydrogen production in the Internal Revenue Code (IRC) Section 45V(b)(2)(D). This tax credit was created by IRA (discussed below). In addition, EPA proposes to adopt the Department of the Treasury's eligibility, monitoring, verification, and reporting protocols for IRC Section 45V (see 2023 Proposal, p. 333).

[41] These units are currently subject EPA's 2015 final rule establishing GHG emissions standards for new fossil-fuel-fired utility boilers and natural-gas-fired stationary combustion turbines. See EPA, "Standards of Performance for Greenhouse Gas Emissions from New, Modified, and Reconstructed Stationary Sources: Electric Utility Generating Units," 80 *Federal Register* 64509, October 23, 2015.

[42] 2023 Proposal, p. 575.

State and Local Policies

Authority over the electricity generation profile currently resides primarily in the states.[43] Some state and local governments have taken a variety of actions—both legal mandates and voluntary efforts—for approximately 20 years. Selected examples of currently implemented policies in the electricity sector include the following:[44]

- California and Washington implement a GHG emissions cap-and-trade program that covers electric power, selected industries, and fossil fuel distributors.[45]
- Eleven U.S. states participate in the Regional Greenhouse Gas Initiative (RGGI),[46] a cap-and-trade program that covers CO_2 emissions from electric power.
- Thirty states, three U.S. territories, and the District of Columbia require a minimum amount of electricity generation by low- or non-emitting energy sources such as renewables.[47]
- Governors from 23 states and Puerto Rico announced a commitment to reduce net GHG emissions from their states by at least 50%-52% below 2005 levels by 2030 and to achieve net-zero GHG emissions no later than 2050.[48]

Climate Change Legislation

Historically, Members of Congress have expressed various perspectives regarding climate change issues. Members seeking to limit GHG emissions from the electricity sector (and other sectors) have considered a range of policy options, including

- carbon pricing frameworks (e.g., carbon taxes or cap-and-trade programs);[49]

[43] For an overview of the current regulatory framework for the electricity sector, see CRS Report R47521, *Electricity: Overview and Issues for Congress*, by Ashley J. Lawson.

[44] Seventeen states have adopted California's more stringent vehicle emissions standards, and 45 states and the District of Columbia provide incentives for electric vehicles, hybrids, or both. California Air Resources Board, "Low Emissions Vehicle Program," at https://ww2.arb.ca.gov/our-work/programs/low-emission-vehicle-program. In addition, the California Air Resources Board adopted regulations in August 2022 to phase out the sale of conventional gas-powered vehicles by 2035. New York, Washington, and Massachusetts have similar requirements in various stages of development. The regulations were sent to the state's Office of Administrative Law, which will make a determination by November 22, 2022 (see California Air Resources Board, "Advanced Clean Cars II," at https://ww2.arb.ca.gov/rulemaking/2022/advanced-clean-cars-ii).

[45] For more information, see the California Air Resources Board website at https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program. Washington State established a comparable cap-and-trade program that started in 2023 (see State of Washington Department of Ecology, "Washington's Cap-and-Invest program," at https://ecology.wa.gov/Air-Climate/Climate-Commitment-Act/Cap-and-invest).

[46] The Regional Greenhouse Gas Initiative (RGGI) states are Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Virginia, and Vermont.

[47] Database of State Incentives for Renewables & Efficiency, "Renewable & Clean Energy Standards," at https://s3.amazonaws.com/ncsolarcen-prod/wp-content/uploads/2019/07/RPS-CES-June2019.pdf.

[48] The degree to which state and local governments can achieve these targets without federal action is uncertain, as the legal authorities and jurisdictions over GHG emissions sources may be limited. U.S. Climate Alliance, "U.S. Climate Alliance Commits to Achieve Net-Zero Emissions No Later than 2050," press release, April 23, 2021, at https://www.usclimatealliance.org/publications/newtargets.

[49] For more information, see CRS Report R45472, *Market-Based Greenhouse Gas Emission Reduction Legislation: 108th Through 117th Congresses*, by Jonathan L. Ramseur.

- clean energy standard;[50]
- research funding or tax policies that support low-emissions technologies; and
- creation of publicly funded entities to facilitate private investment into domestic low-carbon, climate-resilient infrastructure (i.e., green banks).

Other legislative approaches have sought to prohibit certain approaches. For example, a number of congressional resolutions introduced in recent years have stated that multisector carbon pricing approaches are not in the economic interests of the United States.[51] In addition, some Members have introduced bills that would limit the authority to regulate GHG emissions under the Clean Air Act.

Votes on comprehensive climate change policy have been relatively rare in either chamber of Congress.[52] Prior to the 117th Congress, examples of enacted legislation involving climate change mitigation in the electricity sector included tax incentives to promote renewable energy sources and carbon capture and sequestration efforts.[53] During the 117th Congress, both President Biden and majority leadership in the House and the Senate called for comprehensive approaches to address climate change. The following sections focus on two enacted legislative measures in the 117th Congress: IIJA and the budget reconciliation measure commonly referred to as the Inflation Reduction Act, or IRA. These acts include provisions that are likely to have direct or indirect effects on GHG emissions levels, particularly the provisions in IRA.

Infrastructure Investment and Jobs Act (IIJA)

On November 15, 2021, President Biden signed the IIJA (P.L. 117-58). IIJA is a broad infrastructure law that addresses a range of sectors, including the electricity sector.[54] IIJA provisions involve a number of issues that may affect GHG emissions from the electricity sector, including the following:

- energy efficiency and renewable energy;
- electric grid reliability, resilience, and cybersecurity;
- carbon capture, utilization, and storage;
- hydrogen research and development;
- nuclear energy;

[50] For more information on clean energy standards and related policies, see CRS Report R45913, *Electricity Portfolio Standards: Background, Design Elements, and Policy Considerations*, by Ashley J. Lawson.

[51] For example, from the 112th Congress through the 115th Congress, Members introduced resolutions in both the House and Senate expressing the view that a carbon tax is not in the economic interests of the United States. In 2016 and 2018, the House passed resolutions "expressing the sense of Congress that a carbon tax would be detrimental to the United States economy" (H.Con.Res. 89 and H.Con.Res. 119, respectively). In the 117th Congress, during debate on S.Con.Res. 5, the Senate voted (50-50, not agreed to) on S.Amdt. 887, which would have established "a deficit-neutral reserve fund relating to prohibiting a Federal carbon tax."

[52] One example is H.R. 2454, the American Clean Energy and Security Act of 2009 ("Waxman-Markey"), in the 111th Congress, which would have established an economy-wide cap-and-trade system to reduce GHG emissions. The House passed H.R. 2454 in 2009. Companion legislation in the Senate, S. 1733, was reported from the Committee on Environment and Public Works; the bill was not brought up for consideration on the Senate floor.

[53] For more information on the energy tax incentives available before the 117th Congress, see CRS Report R46865, *Energy Tax Provisions: Overview and Budgetary Cost,* by Molly F. Sherlock.

[54] IIJA provisions include climate mitigation policies and programs in surface transportation with increased funding for public transportation and intercity passenger rail. For more details, see CRS In Focus IF11921, *Surface Transportation and Climate Change: Provisions in the Infrastructure Investment and Jobs Act (P.L. 117-58),* by William J. Mallett.

- battery manufacturing, recycling, and critical minerals; and
- fossil energy programs.[55]

A number of studies have estimated the impact of IIJA on GHG emissions. For example, a 2022 study from Princeton University estimated that U.S. emissions would decrease to 26% below 2005 levels without IIJA and 27% below 2005 levels with IIJA.[56] This analysis did not include potential effects (e.g., changes in passenger and freight miles traveled) from IIJA funding for transportation, rail, and public transit. However, a 2021 analysis from the Georgetown Climate Center concluded that the emissions effects from the IIJA transportation provisions are uncertain and could result in an increase or decrease in emissions. This analysis concluded emissions effects would depend on implementation and funding decisions made by state, federal, and local governments.[57]

Inflation Reduction Act (IRA)

On August 16, 2022, President Biden signed H.R. 5376 (P.L. 117-169), the budget reconciliation measure commonly referred to as the Inflation Reduction Act of 2022 (IRA). The eight titles in IRA address a range of issues, including climate change matters, among other policy objectives. Each of the titles contains some number of provisions that directly or indirectly address issues related to climate change, including reduction of U.S. GHG emissions.[58] Several IRA sections would influence GHG emissions in the electricity sector, including provisions that

- modify, extend, or provide new tax credits for electricity from "clean" and renewable resources, alternative fuels, energy efficiency, and clean vehicles;[59]
- provide funding for energy efficiency projects;
- provide funding for low-emissions fuels and technologies;
- provide funding for energy rebates and efficiency, electricity transmission, industrial and energy infrastructure;
- provide funding to support zero-emissions technologies in low-income areas;
- provide funding for a tribal electrification program.

Several recent analyses from groups in the private sector, academia, and the federal government used computer simulation models to prepare estimates of U.S. net GHG emissions through 2030. **Figure 8** illustrates these results. These models compare baseline scenarios with emissions scenarios that include IRA. Based on the results from these models, IRA's climate change provisions are likely to result in net GHG emissions reductions as compared to emissions

[55] For more details on the energy provisions, see CRS Report R47034, *Energy and Minerals Provisions in the Infrastructure Investment and Jobs Act (P.L. 117-58)*, coordinated by Brent D. Yacobucci.

[56] Princeton University REPEAT, *Preliminary Report: The Climate and Energy Impacts of the Inflation Reduction Act of 2022*, August 2022, at https://repeatproject.org/docs/REPEAT_IRA_Prelminary_Report_2022-09-21.pdf.

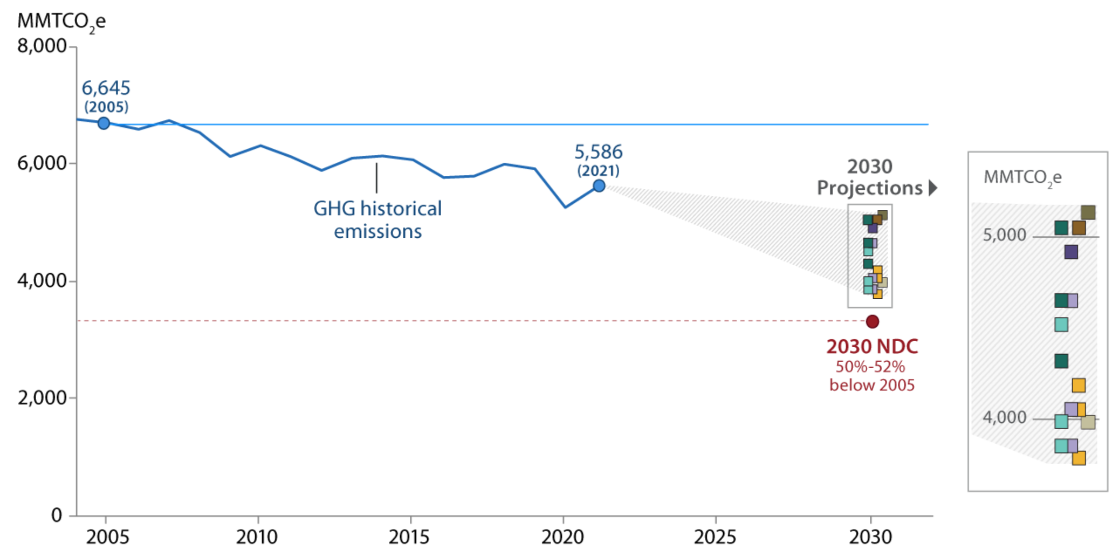
[57] Georgetown Climate Center, "Issue Brief: Estimating the Greenhouse Gas Impact of Federal Infrastructure Investments in the IIJA," December 2021, at https://www.georgetownclimate.org/articles/federal-infrastructure-investment-analysis.html.

[58] For more details on the climate-change-related provisions of the budget reconciliation measure commonly referred to as the Inflation Reduction Act of 2022 (IRA), see CRS Report R47262, *Inflation Reduction Act of 2022 (IRA): Provisions Related to Climate Change*, coordinated by Jane A. Leggett and Jonathan L. Ramseur.

[59] For more information on these tax provisions, see CRS Report R47202, *Tax Provisions in the Inflation Reduction Act of 2022 (H.R. 5376)*, coordinated by Molly F. Sherlock.

scenarios without IRA.[60] The projected results in the figure indicate that even though U.S. net GHG emissions will decrease by 30% to 43% by 2030 including provisions in the IRA compared with 2005 levels, they still would not meet the U.S. 2030 reduction target.

Figure 8. Net U.S. GHG Emissions, Selected Emission Estimates, and U.S. NDC



Rhodium Group	Emissions $MMTCO_2e$	Change fr. 2005
Baseline 1 *	5,050	-24%
Baseline 2 *	4,652	-30%
Case 1	4,519	-32%
Baseline 3 *	4,319	-35%
Case 2	3,987	-40%
Case 3	3,854	-42%

Princeton	Emissions $MMTCO_2e$	Change fr. 2005
Baseline *	4,917	-26%
Case 1	4,652	-30%
Case 2	4,053	-39%
Case 3	3,854	-42%

Energy Innovation	Emissions $MMTCO_2e$	Change fr. 2005
Baseline *	5,050	-24%
Case 1	4,186	-37%
Case 2	4,053	-39%
Case 3	3,921	-43%

Dept. of Energy	Emissions $MMTCO_2e$	Change fr. 2005
Baseline *	5,137	-23%
Case 1	3,987	-40%

* no IRA

Sources: Prepared by CRS; actual U.S. GHG emissions from EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2021*, April 2023; Rhodium Group, *A Turning Point for US Climate Progress: Assessing the Climate and Clean Energy Provisions in the Inflation Reduction Act*, August 12, 2022, at https://rhg.com/research/climate-clean-energy-inflation-reduction-act/; Princeton University REPEAT, *Electricity Transmission is Key to Unlock the Full Potential of the Inflation Reduction Act*, September 2022, at https://repeatproject.org/docs/REPEAT_IRA_Transmission_2022-09-22.pdf; Energy Innovation, *Modeling the Inflation Reduction Act Using the Energy Policy Simulator*, August 23, 2022, at https://energyinnovation.org/publication/modeling-the-inflation-reduction-act-using-the-energy-policy-simulator/; and Department of Energy, "The Inflation Reduction Act Drives Significant Emissions Reductions and Positions America to Reach Our Climate Goals," August 2022, at https://www.energy.gov/sites/default/files/2022-08/8.18%20InflationReductionAct_Factsheet_Final.pdf.

Notes: NDC = nationally determined contribution pursuant to the UNFCCC Paris Agreement. $MMTCO_2e$ = million metric tons of CO_2 equivalent. This measure is used because GHGs vary by global warming potential (GWP). GWP is an index that allows comparisons of the heat-trapping ability of different gases over a period of time. The GHG emissions in the figure are *net* GHG emissions. Net GHG emissions account for removals of CO_2 emissions from the atmosphere by emissions sinks, such as forests, vegetation, and soils. The U.S. NDC is measured in terms of net emissions.

60 For more information, see CRS Report R47385, *U.S. Greenhouse Gas Emissions Trends and Projections from the Inflation Reduction Act*, by Jonathan L. Ramseur.

Emissions Projections in the Electricity Sector

Multiple factors will likely affect CO_2 emissions levels from the electricity sector. Some of these factors, which are identified below, are interrelated:

- electricity generation portfolio (i.e., whether recent trends in coal, natural gas, and renewable energy use continue);
- prices of fossil fuels—particularly natural gas—and renewable energy technologies;
- federal and/or state policy developments;
- economic impacts (e.g., level of GDP growth); and
- improvements in demand-side energy efficiency (e.g., commercial and residential electricity use).

Some groups have prepared U.S. GHG emissions projections for IRA scenarios that include projections of emissions for the U.S. electricity sector. **Figure 9** illustrates the results of four scenarios from the U.S. Energy Information Administration's (EIA's) *Annual Energy Outlook 2023* and two scenarios from documentation associated with EPA's 2023 proposed rule on emissions from fossil-fuel-fired electric power plants (discussed above).[61]

EIA's analysis included three IRA scenarios and one scenario without IRA. The IRA scenarios included different assumptions about the outcome of specific IRA provisions. IRA creates new and revises existing tax credits that encourage electricity generation from less carbon-intensive sources than fossil fuels, such as renewable sources or nuclear power. The tax credits include a base credit with tiers of additional credit if certain conditions are met. These conditions include prevailing wage or apprenticeship requirements, domestic content requirements, and whether a facility is located in an "energy community."[62] EIA's "IRA Low Uptake" case generally assumes facilities will receive the base credit amounts. The "IRA High Uptake" scenario generally assumes facilities will receive all of the available tiers of credit. The "IRA Reference" scenario reflects EIA's view of the "most likely tax credit uptake," which includes a mixture of base tax credit and some bonus credits.[63]

As the figure illustrates, EIA projects that each scenario results in decreased emissions compared to 2022 levels. The IRA "Reference" and "High Uptake" scenarios yield similar projections, with CO_2 emissions in the electricity sector decreasing by 68% and 70%, respectively, compared to 2005 CO_2 levels by 2030. By comparison, the "No IRA" and "Low Uptake" scenarios indicated CO_2 emissions in the electricity sector would decrease by 51% and 53%, respectively, compared to 2005 CO_2 levels by 2030. Note that the 2030 emissions reductions in the electricity sector are lower than the projected reductions in total U.S. GHG emissions, as illustrated in **Figure 8**.

Figure 9 indicates that emissions in the electricity sector will continue to decrease after 2030. EIA's IRA "Reference" and "High Uptake" scenarios result in emissions decreases of 70% and

[61] For more information on the U.S. Energy Information Administration's *Annual Energy Outlook*, see CRS In Focus IF11691, *The Annual Energy Outlook (AEO): A Brief Overview*, by Ashley J. Lawson and Kelsi Bracmort.

[62] The IRA defines *energy communities*, for purposes of bonus tax credits, as those meeting certain criteria related to employment in fossil fuel industries, proximity to closed coal mines or retired coal-fired power plants, or brownfield sites. Energy communities will change over time as these criteria change. An estimate of areas currently meeting some of these criteria is at U.S. Department of Energy, "Energy Community Tax Credit Bonus," at https://arcgis.netl.doe.gov/portal/apps/experiencebuilder/experience/?id=a2ce47d4721a477a8701bd0e08495e1d.

[63] For more details about EIA's assumptions for their different scenarios, see the Appendix to the *Annual Energy Outlook 2023*, at https://www.eia.gov/outlooks/aeo/IIF_IRA/#appendix.

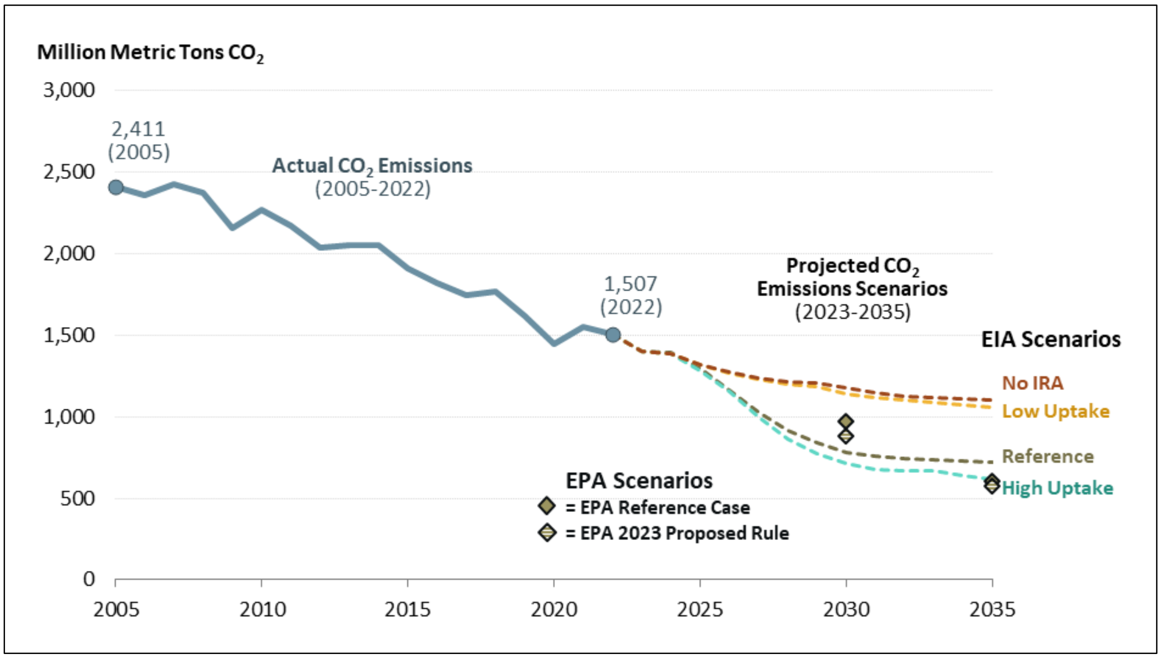
74%, respectively, compared to 2005 CO_2 levels by 2035. By comparison, the "No IRA" and "Low Uptake" scenarios indicate emissions decreases of 54% and 56%, respectively, compared to 2005 CO_2 levels by 2035.

In addition, **Figure 9** includes emissions projections that EPA prepared as part of its 2023 proposed rule for coal- and natural-gas-fired power plants (discussed above).[64] In EPA's reference case (i.e., IRA provisions without the 2023 proposed rule), EPA projected that CO_2 emissions in the electricity sector would decrease by 60% in 2030 compared to 2005 levels, and by 75% in 2035 compared to 2005 levels. EPA's projection for 2035 is nearly identical to EIA's 2035 "High Uptake" projection.

The figure also illustrates EPA's projected emissions results from its 2023 proposed rule. As the figure indicates, EPA projects that the proposed rule would result in further emissions decreases below EPA's IRA reference case. EPA estimates that CO_2 emissions in the electricity sector would decrease by 63% in 2030 compared to 2005 levels, and by 76% in 2035 compared to 2005 levels.

Figure 9. EIA and EPA Projections of CO_2 Emissions in the Electricity Sector

Actual Levels and Projected Scenarios Through 2035



Source: Prepared by CRS with data from EIA, *Annual Energy Outlook 2023*, at https://www.eia.gov/outlooks/aeo/; and EPA, *Regulatory Impact Analysis for the Proposed New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units*, 2023, at https://www.epa.gov/stationary-sources-air-pollution/greenhouse-gas-standards-and-guidelines-fossil-fuel-fired-power.

Notes: EIA modeled three IRA scenarios and one scenario without IRA provisions. The IRA scenarios included different assumptions about the implementation of specific IRA provisions. IRA creates new and revises existing tax credits that encourage electricity generation from less carbon-intensive sources than fossil fuels, such as

[64] See EPA, *Regulatory Impact Analysis for the Proposed New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units*; *Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units*; *and Repeal of the Affordable Clean Energy Rule*, 2023, at https://www.epa.gov/stationary-sources-air-pollution/greenhouse-gas-standards-and-guidelines-fossil-fuel-fired-power; and EPA, *Analysis of the Proposed Greenhouse Gas Standards and Guidelines*, 2023, at https://www.epa.gov/power-sector-modeling/analysis-proposed-greenhouse-gas-standards-and-guidelines.

renewable sources or nuclear power. The tax credits include a base credit with tiers of additional credit if certain conditions are met. These conditions include prevailing wage or apprenticeship requirements, domestic content requirements, and whether a facility is located in an "energy community." The IRA "Reference" scenario reflects EIA's view of the "most likely tax credit uptake," which includes a mixture of base tax credit and some bonus credits. EIA's "IRA Low Uptake" case generally assumes facilities will receive the base credit amounts. The "IRA High Uptake" scenario assumes facilities will receive all of the available tiers of credit.

EPA's "Reference Case" includes IRA provisions, but does not include effects from the 2023 proposed rule. EPA's "2023 Proposed Rule" scenario includes IRA provision and effects from the proposed rule addressing fossil-fuel-fired electric power plants. For more information about EPA's modeling assumptions, see https://www.epa.gov/power-sector-modeling/analysis-proposed-greenhouse-gas-standards-and-guidelines.

Other groups have prepared projections of emissions levels in the electricity sectors as part of their analyses of the emissions impacts from IRA. These groups measured total GHG emissions, rather than just CO_2 emissions.[65] For example, a 2022 analysis from the Rhodium Group included three IRA scenarios and estimated that GHG emissions in the electricity sector would decrease between approximately 70% and 80% below 2005 GHG emissions levels.[66]

As illustrated above, GHG emissions projections generally involve a range of estimates, as they contain considerable uncertainty. For example, one factor of uncertainty specific to the electricity sector is the rate at which electricity transmission is expected to expand over the next decade. New transmission lines are likely needed to access some, though not all, new low- or zero-emissions energy sources.[67] A 2022 analysis from Princeton examined the specific role of this factor by isolating this variable in its IRA modeling scenarios.[68] The Princeton model found that the annual rate of transmission expansion is likely to play a pivotal role in the degree to which IRA provisions reduce emissions in the electricity sector. In part prompted by concerns about the pace of transmission development, some Members have focused on options for accelerating transmission planning, siting, and permitting.[69]

Another factor of uncertainty is the degree to which carbon capture and storage (CCS) is implemented in the future. Some models estimate CCS to increase substantially after 2030.[70]

[65] In the electricity sector, CO_2 emissions accounted for 98% of total GHG emissions in 2021.

[66] Rhodium Group, *A Turning Point for US Climate Progress: Assessing the Climate and Clean Energy Provisions in the Inflation Reduction Act*, August 12, 2022, at https://rhg.com/research/climate-clean-energy-inflation-reduction-act/. Rhodium Group estimates are measured in total GHG emissions, rather than CO_2 emissions. CRS calculated the 70%-80% reduction range based on a 2005 GHG emissions level of 2,457 MMTCO2e from EPA's inventory (accounting for GHG emissions in the electricity sector).

[67] A number of nonemitting energy sources incentivized by IRA do not require new transmission lines. Examples include distributed solar generation, retrofits of existing power plants with carbon capture and storage or with hydrogen blending, and rebuilds of existing power plants with nuclear energy or other nonemitting energy source such as solar energy combined with energy storage.

[68] Princeton University Rapid Energy Policy Evaluation and Analysis Toolkit (REPEAT), *Electricity Transmission Is Key to Unlock the Full Potential of the Inflation Reduction Act*, September 2022, at https://repeatproject.org/docs/REPEAT_IRA_Transmission_2022-09-22.pdf; Princeton University REPEAT, *Preliminary Report: The Climate and Energy Impacts of the Inflation Reduction Act of 2022*, August 2022, at https://repeatproject.org/docs/REPEAT_IRA_Prelminary_Report_2022-09-21.pdf. Other energy models—such as those used by EIA and Rhodium Group—do not explicitly project transmission capacity.

[69] For more information on transmission development, see CRS In Focus IF12253, *Introduction to Electricity Transmission*, by Ashley J. Lawson.

[70] For example, the Rhodium Group study estimated that installed carbon capture would more than double between 2030 and 2035. The 2022 Princeton study indicated similar results. See Rhodium Group, *A Turning Point for US Climate Progress*; and Princeton University REPEAT, *Preliminary Report: The Climate and Energy Impacts of the Inflation Reduction Act of 2022*, August 2022. For further information on carbon capture and sequestration, see CRS Report R44902, *Carbon Capture and Sequestration (CCS) in the United States*, by Angela C. Jones and Ashley J. Lawson.

Concluding Observations

International negotiations and domestic policy developments continue to generate congressional interest in current and projected U.S. GHG emissions levels. The United States has pledged to reduce its net GHG emissions by 50%-52% below 2005 levels by 2030. Recent analyses indicate U.S. net GHG emissions would decrease by 30% to 43% by 2030 compared with 2005 levels, thus not meeting the 2030 reduction target.[71]

U.S. GHG emissions levels will likely depend, to some degree, on CO_2 emissions from power plants. Multiple factors generally affect GHG emissions levels from the electric power sector. In particular, the following recent changes in the U.S. electricity generation portfolio between 2005 and 2022 have played a key role in reducing emissions to date:

- coal's contribution to total electricity generation has decreased from 50% to 19%;
- natural gas's contribution to total electricity generation has increased from 19% to 39%; and
- renewable energy (other than hydroelectricity) generation has increased from 2% to 17%; these increases primarily involve wind and solar sources.

Although models generally project that these trends will continue, the degree to which they will continue is uncertain. Moreover, the projected trends in the electricity sector do not appear sufficient to meet the U.S. GHG emissions reduction pledges, according to the various models. The emissions levels in other sectors, particularly transportation and industry, also play important roles in overall U.S. emissions. The emissions models do not project comparable emissions reduction in the other key sectors: transportation and industry. As an illustrative example, **Figure 10** displays the results from one of the studies, depicting the GHG emissions reductions estimated by sector: electric power, industry, transportation, and carbon removal. Compared with a baseline scenario (without IRA), electric power sector emissions decrease by 51%. In contrast, industry and transportation sector emissions are projected to decrease by 4% and 1%, respectively.[72] On the other hand, many of the IRA provisions may take longer than 2030 to have full effect, such as tax incentives for electric or zero-emission vehicles that would penetrate vehicle markets slowly and would have more influence on GHG emissions after 2030. Therefore, these estimates likely do not represent a full accounting of potential effects of the law.

[71] These models compare scenarios with and without IRA. Based on the results from these models, IRA's climate change provisions are likely to result in net GHG emissions reductions as compared to emissions scenarios without IRA. Each of the analyses included multiple IRA scenarios to account for uncertain factors, such as future oil and natural gas prices, the rate of increase in electricity transmission, and implementation of IRA provisions, among other factors. For more details and discussion, see CRS Report R47385, *U.S. Greenhouse Gas Emissions Trends and Projections from the Inflation Reduction Act*, by Jonathan L. Ramseur.

[72] The Energy Innovation model produced comparable results for the electric power and transportation sectors (Figure 2 in Energy Innovation estimates from Energy Innovation, Modeling the Inflation Reduction Act). The Princeton model produced larger reductions in the transportation sector compared with the other models (Princeton REPEAT, Electricity Transmission, p. 9). See Energy Innovation, *Modeling the Inflation Reduction Act Using the Energy Policy Simulator*, August 23, 2022, at https://energyinnovation.org/publication/modeling-the-inflation-reduction-act-using-the-energy-policy-simulator/; and Princeton University REPEAT, *Electricity Transmission Is Key to Unlock the Full Potential of the Inflation Reduction Act*, September 2022, at https://repeatproject.org/docs/REPEAT_IRA_Transmission_2022-09-22.pdf.

Figure 10. Estimated GHG Emissions Reductions by Sector in 2030

Based on Rhodium Group Modeling

Source: Prepared by CRS; emissions estimates from Rhodium Group, *A Turning Point for US Climate Progress: Assessing the Climate and Clean Energy Provisions in the Inflation Reduction Act*, August 12, 2022, at https://rhg.com/research/climate-clean-energy-inflation-reduction-act/.

Notes: $MMTCO_2e$ = million metric tons of CO_2 equivalent. This measure is used because GHGs vary by global warming potential (GWP). GWP is an index that allows comparisons of the heat-trapping ability of different gases over a period of time. Carbon removal includes "forest and soil practices, direct air capture and other actions."

The GHG emissions levels in the various economic sectors are interrelated in complicated ways. For example, climate mitigation policies that increase the use of electric vehicles and electrification of industrial processes (i.e., using electricity instead of fossil fuels for onsite operations) will, all else being equal, increase overall electricity generation and emissions in the electricity sector. The net effects on U.S. emissions from these relationships will depend, in part, on the degree and pace of the electrification in the transportation and industrial sectors and the degree and pace of carbon intensity changes in the electricity generation portfolio.

Climate-related provisions in recent legislation, particularly the tax incentives and funding provisions in IRA, are projected to play a role in GHG emissions levels from the electricity sector and other sectors. EPA's 2023 proposed rule for fossil-fuel-fired electric power plants could provide additional emissions reductions, but the fate of this proposal is uncertain.

If Congress wishes to incentivize U.S. GHG emissions reduction beyond the projections from the models discussed in this report, a range of policy options remain available. IRA contains a number of climate-related provisions across multiple economic sectors. The general approach of IRA's climate provisions is to promote GHG reduction through tax incentives and direct funding. Policymakers could increase and/or extend the funding amounts or tax incentives in these provisions. Alternatively, policymakers could employ different approaches in subsequent legislation. Options include market-based approaches, such as carbon pricing mechanisms (e.g., fee on emissions or a cap-and-trade program) or regulatory standards for particular facilities or sectors.[73] To some degree, such efforts are under way at the state and local level.

[73] For more discussion of general approaches to GHG emissions mitigation, see CRS In Focus IF11791, *Mitigating Greenhouse Gas Emissions: Selected Policy Options*, by Jonathan L. Ramseur et al.

IRA climate provisions may support the development of additional requirements from the federal government, such as the 2023 proposed rule, or state and local governments by reducing the costs of lower-carbon energy sources and technologies. In particular, the IRA provisions may complement EPA's regulations requiring emissions performance standards at electric power plants by reducing the costs of potential compliance options. If these additional policies are implemented, they may help achieve the U.S. 2030 emissions reduction target. However, the role of these regulations is uncertain, as their implementation is likely to face opposition from some policymakers and stakeholders.

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