Congressional Research Service
Informing the legislative debate since 1914

U.S. Carbon Dioxide Emissions Trends and Projections: Role of the Clean Power Plan and Other Factors

Jonathan L. Ramseur
Specialist in Environmental Policy

May 31, 2017

Congressional Research Service
7-5700
www.crs.gov
R44451

CRS REPORT
Prepared for Members and
Committees of Congress

Summary

Recent international negotiations and domestic policy developments have generated interest in current and projected U.S. greenhouse gas (GHG) emission levels. GHG emissions are generated throughout the United States from millions of discrete sources. Of the GHG source categories, carbon dioxide (CO_2) emissions from fossil fuel combustion account for the largest percentage (77%) of total U.S. GHG emissions. The electric power sector contributes the second largest percentage (35%) of CO_2 emissions from fossil fuel combustion (one percentage point behind the transportation sector).

In December 2015, delegations from 195 nations, including the United States, adopted an agreement in Paris that creates an international structure for nations to pledge to abate their GHG emissions, adapt to climate change, and cooperate to achieve these ends, including financial and other support. Pursuant to that agreement, the United States pledged (in 2015) to reduce GHG emissions by 26-28% by 2025 compared to 2005 levels. At the date of this report, U.S. involvement in the Paris Agreement remains uncertain. However, some recent reports indicate that President Trump is expected to withdraw from the agreement.

U.S. GHG levels in 2015 were 11% below 2005 levels. Whether the United States achieves its goals would likely depend, to some degree, on CO_2 emissions from power plants. In 2015, under President Obama, the Environmental Protection Agency (EPA) promulgated standards for CO_2 emissions from existing electric power plants. The rule, known as the Clean Power Plan (CPP), is the subject of ongoing litigation involving a number of entities. On February 9, 2016, the Supreme Court stayed the rule for the duration of the litigation.

Multiple factors generally impact CO_2 emission levels from the electric power sector. Some factors are listed below in no particular order:

- Economic growth/recession,
- Relative prices of energy sources for electricity—particularly natural gas and renewable energy sources,
- Electricity generation portfolio (i.e., the ratio of electricity generation from coal, natural gas, and renewable energy sources),
- National and/or state policy developments (e.g., CPP implementation), and
- Demand-side efficiency improvements (e.g., commercial and residential electricity use).

Recent changes in the electric power sector may be informative. Between 1975 and 2010, electricity generation and CO_2 emissions from the electric power sector generally increased. However, in 2010, their courses diverged. While electricity generation remained relatively flat after 2010, CO_2 emissions from the electric power sector decreased. Thus in 2016, electricity generation was essentially equivalent to generation in 2005, while CO_2 emissions were 25% below 2005 levels.

Recent changes in the U.S. electricity generation portfolio played a key role in the CO_2 emission decrease. The electricity portfolio affects CO_2 emission levels because different sources of electricity generation produce different rates of CO_2 emissions per unit of electricity (zero in the case of some renewables). For example, between 2005 and 2016:

- Coal's contribution to total electricity generation decreased from 50% to 30%;
- Natural gas's contribution to total electricity generation increased from 19% to 34%; and

- Renewable energy's contribution to total electricity generation increased from 2% to 8%.

Accurately forecasting future CO_2 emission levels is a complex and challenging endeavor. A comparison of actual CO_2 emissions (from energy use) between 1990 and 2017 with selected emission projections illustrates this difficulty. In general, actual emissions have remained well below projections.

As the future of the CPP is uncertain, some have questioned whether existing policies and trends in electricity generation would continue to lower CO_2 emissions. Modeling results indicate that CO_2 emissions in the electricity sector are expected to continue declining. However, modeling results indicate that the declines would be substantially greater if the CPP were implemented.

Contents

Figures

Tables

Contacts

Introduction

U.S. greenhouse gas (GHG) emission levels, particularly from carbon dioxide (CO_2), remain a topic of interest among policymakers and stakeholders.[1] Recent international negotiations and domestic policy developments have generated attention to current and projected U.S. GHG emission levels. An understanding of GHG emission source data and the underlying factors that affect emission levels might help inform the discussion among policymakers regarding GHG emission mitigation.

In December 2015, delegations from 195 nations, including the United States, adopted an agreement in Paris that creates an international structure for nations to pledge to abate their GHG emissions, adapt to climate change, and cooperate to achieve these ends, including financial and other support.[2] Pursuant to that agreement, the United States pledged (in 2015) to reduce GHG emissions by 26-28% by 2025 compared to 2005 levels.[3] This pledge supplemented a previous Obama Administration commitment to reduce U.S. GHG emissions by 17% below 2005 levels by 2020.[4]

At the date of this report, U.S. involvement in the Paris Agreement remains uncertain.[5] However, some recent reports indicate that President Trump is expected to withdraw from the agreement.[6]

Whether the United States ultimately achieves the 2020 and 2025 targets will likely depend, to some degree, on GHG emission levels, particularly CO_2 emissions, from electric power plants—one of the largest sources of U.S. emissions. During the Obama Administration, the Environmental Protection Agency (EPA) promulgated standards for CO_2 emissions from existing fossil-fuel-fired electric power plants.[7] EPA cited Section 111(d) of the Clean Air Act (CAA) as the authority to issue its final rule.[8] The rule, known as the Clean Power Plan (CPP), appeared in the *Federal Register* on October 23, 2015.[9]

The fate of the CPP is uncertain. First, the rule is the subject of ongoing litigation. A number of states and other entities have challenged the rule, while other states and entities have intervened in support of the rule. On February 9, 2016, the Supreme Court stayed the rule for the duration of the litigation. The rule therefore currently lacks enforceability or legal effect, and if the rule is ultimately upheld, at least some of the deadlines would likely be delayed.[10]

---

[1] The primary GHGs associated with human activity (and estimated by EPA in its annual inventories) include carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, chlorofluorocarbons, hydrofluorocarbons, and perfluorocarbons.

[2] See CRS Insight IN10413, *Climate Change Paris Agreement Opens for Signature*, by Jane A. Leggett.

[3] U.S. Government, "U.S. Cover Note, INDC and Accompanying Information," March 31, 2015, http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx.

[4] Executive Office of the President, "The President's Climate Action Plan," June 2013, http://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf.

[5] For more information on the withdrawal process, see CRS Report R44761, *Withdrawal from International Agreements: Legal Framework, the Paris Agreement, and the Iran Nuclear Agreement*, by Stephen P. Mulligan.

[6] See Michael Shear and Coral Davenport, "Trump Poised to Pull U.S. from Paris Climate Accord," *New York Times*, May 31, 2017.

[7] See CRS Report R44341, *EPA's Clean Power Plan for Existing Power Plants: Frequently Asked Questions*, by James E. McCarthy et al.

[8] 42 U.S.C. §7411(d).

[9] EPA, "Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units," Final Rule, 80 *Federal Register* 64661, October 23, 2015.

[10] See CRS Report R44341, *EPA's Clean Power Plan for Existing Power Plants: Frequently Asked Questions*, by (continued...)

Second, President Trump issued an Executive Order on March 28, 2017, that directs 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."[11] In April, EPA began its review of the CPP and related power plant rules and may consider various options to revise or repeal the rules.[12]

A question for policymakers is whether U.S. GHG emissions will remain at current levels, decrease to meet the 2020 and 2025 goals, or increase toward former (or even higher) levels. Multiple factors—including economics, technology, and climate policies—will likely play a role in future GHG emission levels.

This report examines recent trends in U.S. GHG emissions, particularly CO_2 emissions from electricity generation, and the factors that impact emission levels in that sector. In addition, this report examines the degree to which CPP implementation (or lack thereof) may impact CO_2 emission levels from electric power plants.

The first section provides an overview of various sources of GHG emissions in the United States. This includes an overview of CO_2 emissions from fossil fuel combustion and a closer look at CO_2 emissions from electricity generation, which account for the second largest percentage of CO_2 emission from fossil fuel combustion (1% percentage point behind the transportation sector). The second section examines projections of CO_2 emissions in the electric power sector, with a particular focus on the role of the CPP and other factors. The final section highlights the challenges in making CO_2 emission projections with a comparison of actual CO_2 emissions with prior emission forecasts.

Emissions Data in This Report

This report uses GHG emissions data from two different sources: EPA and the Energy Information Administration (EIA). Estimates of total GHG emissions ("economy-wide") come from EPA's annual GHG emissions inventory. These estimates provide a big-picture view of U.S. GHG emission levels and GHG emission sources, particularly in the context of recent GHG emission reduction goals. EPA released a draft of the most recent version of its inventory in April 2017. This version includes GHG emissions data through 2015. In addition, the CO_2 data in EPA's CPP modeling results come from EPA. EPA released these results in 2015.

Although EPA's Inventory includes CO_2 emissions, this report uses CO_2 emissions data from EIA, because EIA's CO_2 emissions data are released on a monthly basis, including annual numbers for 2016. This allows for more recent comparisons of trends in emissions and related topics.

U.S. GHG Emissions

Figure 1 illustrates U.S. GHG between 1990 and 2015. As the figure indicates, U.S. GHG emissions increased during most of the years between 1990 and 2007. GHG emissions decreased substantially in 2008 and 2009 as a result of a variety of factors—some economic, some the effect of government policies at all levels. Over the last five years, emissions have fluctuated but have not surpassed 2009 levels. Emissions in 2015 were roughly equivalent to 1994 emission levels.

(...continued)

James E. McCarthy et al.

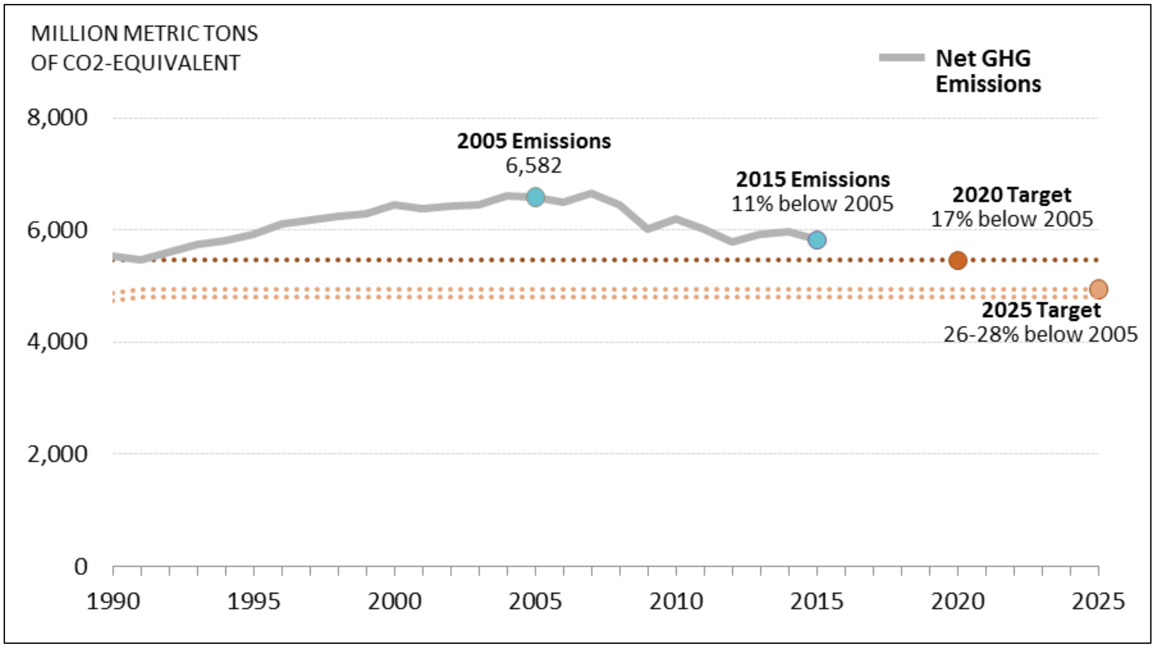
[11] Executive Order 13783, "Promoting Energy Independence and Economic Growth," 82 *Federal Register* 16093, March 31, 2017 (signed March 28, 2017).

[12] EPA, "Review of the Clean Power Plan," 82 *Federal Register* 16329, April 4, 2017; EPA, "Review of the Standards of Performance for Greenhouse Gas Emissions From New, Modified, and Reconstructed Stationary Sources: Electric Generating Units," 82 *Federal Register* 16330, April 4, 2017.

Figure 1 compares recent U.S. GHG emission levels to the 2020 and 2025 emission goals. Based on 2015 GHG emission levels, the United States is more than halfway to reaching the Administration's 2020 goal (17% below 2005 levels). U.S. GHG levels in 2015 were 11% below 2005 levels.

Figure 1. U.S. GHG Emissions (Net)

Compared to 2020 and 2025 Emission Targets



Source: Prepared by CRS; data from EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2015*, April 2017, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2015.

Notes: Net GHG emissions includes net carbon sequestration from Land Use, Land Use Change, and Forestry. This involves carbon removals from the atmosphere by photosynthesis and storage in vegetation.

Accurately forecasting future emission levels is a complex and challenging endeavor. Consequently, analysts often provide a range of emissions based on different scenarios or assumptions. The Energy Information Administration (EIA) provides annual forecasts of CO_2 emissions in its *Annual Energy Outlook* (AEO) publications. Regarding its various estimates, EIA states the following:

> Projections in the Annual Energy Outlook 2017 (AEO2017) are not predictions of what will happen, but rather modeled projections of what may happen given certain assumptions and methodologies.... The Reference case projection assumes trend improvement in known technologies, along with a view of economic and demographic trends reflecting the current central views of leading economic forecasters and demographers. It generally assumes that current laws and regulations affecting the energy sector, including sunset dates for laws that have them, are unchanged throughout the projection period.[13]

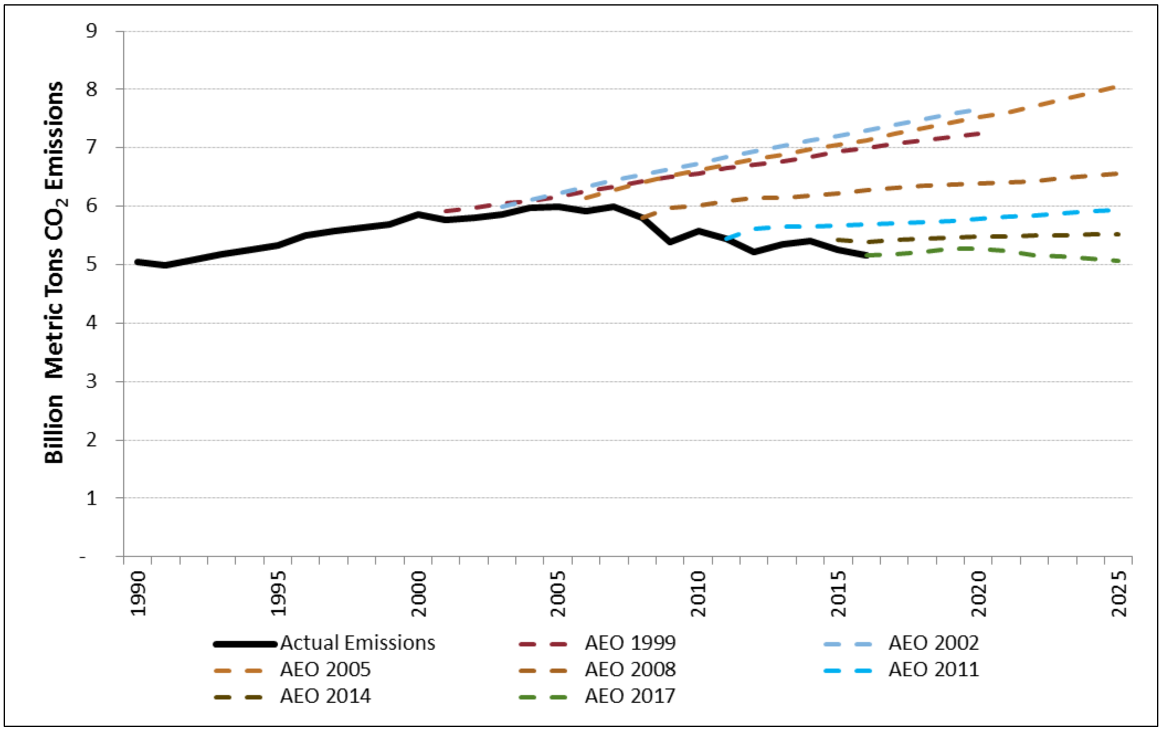
Figure 2 compares actual CO_2 emissions between 1990 and 2016 with selected EIA emission projections made in past years. In general, actual emissions have remained well below projections. For example, the AEO from 2002 projected that CO_2 emissions would be almost 6.9

[13] EIA, *Annual Energy Outlook 2017*, January 2017.

billion metric tons in 2015, about 33% higher than observed emissions. By comparison, the more recent projections (AEO 2014 and AEO 2017) indicated that CO_2 emissions would remain relatively flat or experience modest declines over the next decade.

Figure 2. Actual CO_2 Emissions and Selected Past EIA CO_2 Emission Projections

CO_2 Emissions from Energy Use



Source: Prepared by CRS; data from EIA *Annual Energy Outlook* publications, http://www.eia.gov.

Notes: EIA publishes annual projections. The above figure includes only projections from every third year since 1999. Some of the earlier projections stopped at 2020.

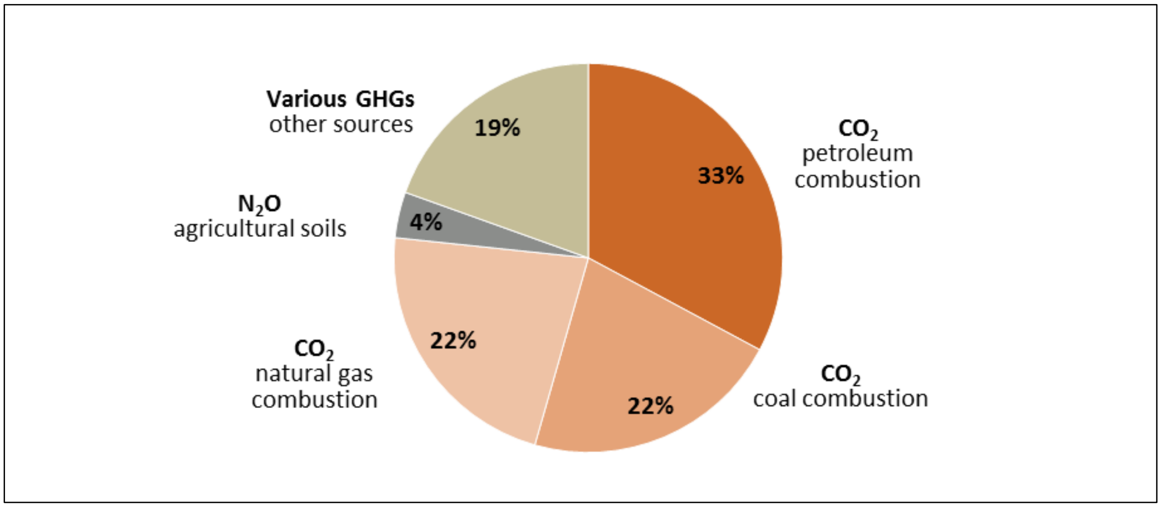
GHG Emission Sources

GHG emissions are generated throughout the United States from millions of discrete sources: power plants, vehicles, households, commercial buildings, agricultural activities (e.g., soils and livestock), and industrial facilities.[14] **Figure 3** 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 77% of total U.S. GHG emissions in 2015. Recent legislative proposals that would address climate change have primarily focused on CO_2 emissions from fossil fuel combustion.

[14] 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.

Figure 3. U.S GHG Emissions by Source

2015 Data Measured in Metric Tons of CO_2-equivalent



Source: Prepared by CRS; data from EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2015*, April 2017, https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2015.

Notes: N_2O is nitrous oxide. The "Various GHGs – other sources" include the following:

Methane (CH_4) from livestock (3%); hydrofluorocarbons from the substitution of ozone-depleting substances (3%); CO_2 from non-energy fuel uses (2%); CH_4 from natural gas systems (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.

GHG emissions are typically measured in tons of CO_2-equivalent. This term of measure is used because GHGs vary by global warming potential (GWP). GWP is an index of how much a GHG may contribute to global warming over a period of time, typically 100 years. GWPs are used to compare gases to CO_2, which has a GWP of 1. For example, in EPA's GHG Inventory, methane's GWP is 25, and thus a ton of methane is 25 times more potent a GHG than a ton of CO_2 (over a 100-year lifetime).

CO_2 Emissions from Fossil Fuel Combustion

Figure 4 illustrates the U.S. CO_2 emission contributions by sector from the combustion of fossil fuels. The electric power sector contributes the second largest percentage (35%) of CO_2 emissions from fossil fuel combustion (one percentage point behind the transportation sector). Within the electricity sector, the residential and commercial sectors account for 14% and 13%, respectively, of fossil fuel combustion CO_2 emissions and the industrial sector accounts for 9% of fossil fuel combustion CO_2 emissions (**Figure 4**).[15]

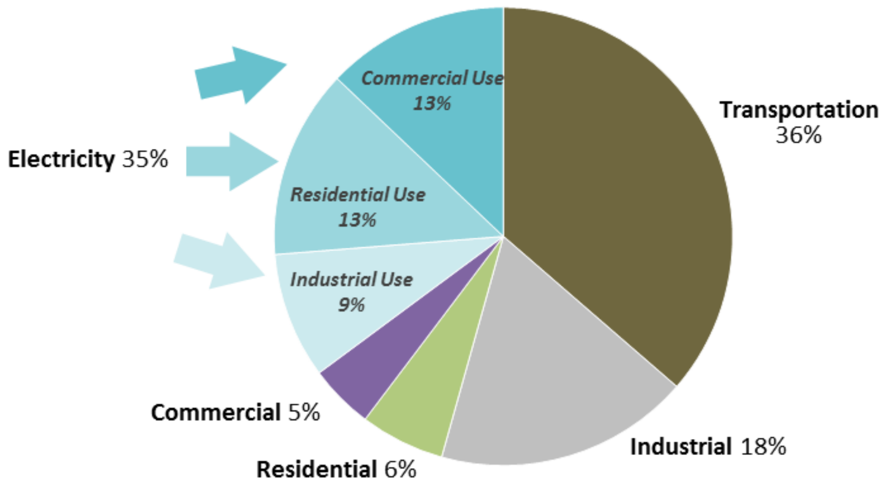
Many GHG emission reduction programs (e.g., the Regional Greenhouse Gas Initiative)[16] and legislative proposals have often focused on CO_2 emissions from the electricity generation sector, due to the sector's GHG emission contribution and the relatively limited number of emission sources. In addition, electric power plants have been measuring and reporting CO_2 emissions to the EPA for multiple decades.

[15] CO_2 emissions related to electricity use in the transportation sector account for less than 1% of CO_2 emissions from total electricity generation.

[16] See CRS Report R41836, *The Regional Greenhouse Gas Initiative: Lessons Learned and Issues for Congress*, by Jonathan L. Ramseur.

Figure 4. U.S. CO_2 Emissions from Energy Consumption by Sector

2016 Data



Source: Prepared by CRS; data from EIA, "Monthly Energy Review," Tables 12.2-12.6, https://www.eia.gov/totalenergy/data/monthly/.

Notes: CO_2 emissions related to electricity use in the transportation sector account for less than 1% of CO_2 emissions from total electricity generation. These emissions are not included in the above figure. In addition, the above chart does not include CO_2 emissions from the U.S. territories, which account for less than 1% of CO_2 emissions from energy consumption.

The data in this figure do not include emissions associated with various processes that may be generated prior to combustion (e.g., fugitive CH_4 emissions from natural gas production). For more details on this issue, see CRS Report R44090, *Life-Cycle Greenhouse Gas Assessment of Coal and Natural Gas in the Power Sector*, by Richard K. Lattanzio.

Regulations of GHG Emissions from Vehicles

Light-duty vehicles (cars, SUVs, vans, and pickup trucks) and medium- and heavy-duty vehicles (including buses, heavy trucks of all kinds, and on-road work vehicles) are collectively the largest emitters of GHGs other than power plants. Together, on-road motor vehicles accounted for about 22% of U.S. GHG emissions in 2012. Reducing GHG emissions from this source category was a key component of President Obama's Climate Action Plan.[17]

EPA began to promulgate GHG emission standards for on-road vehicles in 2010, using its authority under Section 202 of the Clean Air Act. GHG standards for light-duty vehicles first took effect for Model Year (MY) 2012. Allowable GHG emissions will be gradually reduced each year from MY2012 through MY2025. In MY2025, emissions from new vehicles must average about 50% less per mile than in MY2010. The standards for heavier-duty vehicles began to take effect in MY2014. They will require emission reductions of 6% to 23%, depending on the type of engine and vehicle, when fully implemented in MY2018. A second round of standards, to address MY2021 and later medium- and heavy-duty vehicles, was finalized on October 26, 2016.

For more information, see CRS Report R40506, *Cars, Trucks, Aircraft, and EPA Climate Regulations*, by James E. McCarthy and Richard K. Lattanzio.

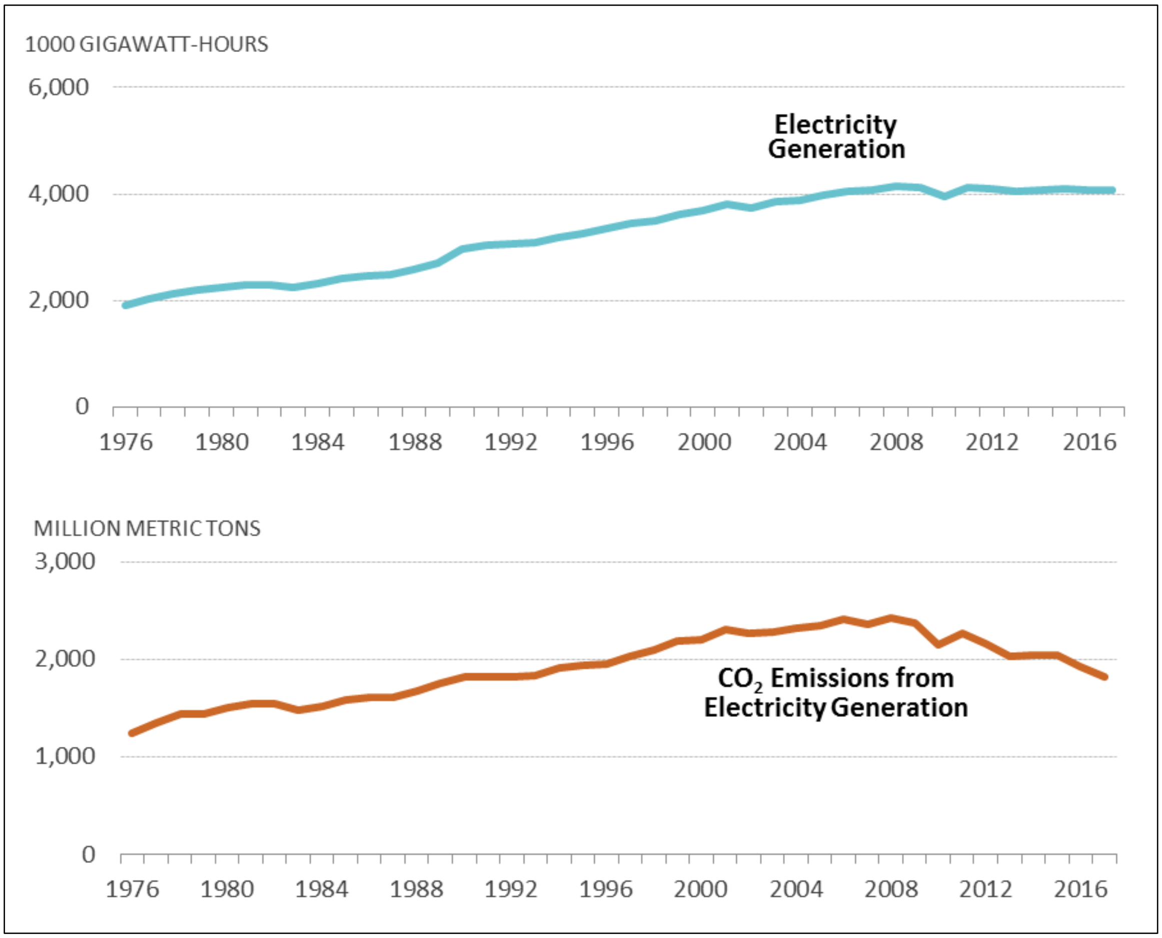
[17] See Executive Office of the President, *The President's Climate Action Plan*, 2013, https://www.whitehouse.gov/sites/default/files/image/president27sclimateactionplan.pdf; and CRS Report R43120, *President Obama's Climate Action Plan*, coordinated by Jane A. Leggett.

CO_2 Emissions from Electricity Generation

Figure 5 compares U.S. electricity generation with CO_2 emissions from the electricity sector between 1976 and 2016. As the figure illustrates, U.S. electricity generation generally increased between 1976 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 remained flat after 2010, CO_2 emissions continued a general trend of reduction. Thus in 2016, electricity generation was essentially equivalent to generation in 2005, while CO_2 emissions were 25% below 2005 levels.

Figure 5. Electricity Generation and CO_2 Emissions from U.S. Electricity Sector

1976-2016



Source: Prepared by CRS; data from EIA, *Monthly Energy Review*, net electricity generation from Table 7.2 and emissions from Table 12.6, http://www.eia.gov/totalenergy/data/monthly/.

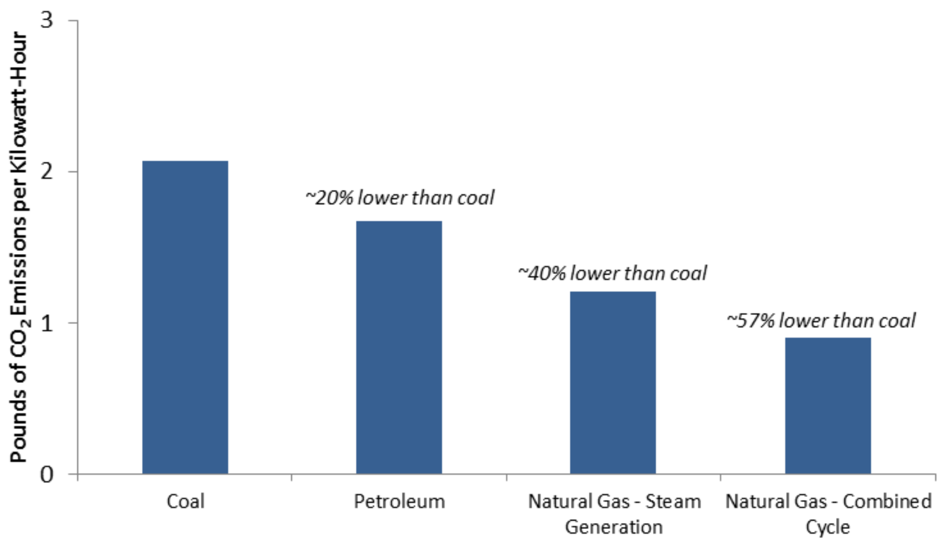
The decrease in CO_2 emissions in the electricity sector in recent years was likely a result of several factors. The economic downturn in 2008 and 2009 likely played a substantial role in both generation and emission levels. The U.S. gross domestic product (GDP) decreased in both of those years. Historically, annual GDP decreases are a relatively uncommon occurrence: The

United States has seen an annual decrease in GDP seven times over the last 50 years. The 2.9% GDP decrease in 2009 was the largest GDP decrease during that time frame.[18]

Another factor contributing to the recent decrease in CO_2 emissions from electricity generation was the change in 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 with their electricity generation. Fossil fuels generate different amounts of CO_2 emissions per unit of electricity generated. **Figure 6** illustrates the relative comparison of CO_2 emissions between electricity produced from coal, petroleum, and natural gas. As the figure indicates, petroleum-fired electricity yields approximately 80% of the CO_2 emission of coal-fired electricity per kilowatt-hour of electricity. Natural-gas-fired electricity from a steam generation unit yields 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 yields approximately 43% of the CO_2 emissions of coal-fired electricity per kilowatt-hour of electricity.[19]

Therefore, altering the U.S. electricity generation portfolio would likely have (all else being equal) a considerable impact on emissions from the electricity sector, which in turn, would have a meaningful impact on total U.S. GHG emissions.

Figure 6. Comparison of Fossil Fuels' Carbon Content in Electricity Generation



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

Notes: Carbon content values are derived by multiplying the fuel's CO_2 emission factor by the heat rate of a particular electric generating unit. In this figure, CRS used the coal emission factor for bituminous coal and the petroleum emission factor measure for distillate oil (number 2). Natural gas has only one 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. For more

[18] Bureau of Economic Analysis, gross domestic product data, http://www.bea.gov/national/index.htm.

[19] For further discussion, see CRS Report R44090, *Life-Cycle Greenhouse Gas Assessment of Coal and Natural Gas in the Power Sector*, by Richard K. Lattanzio.

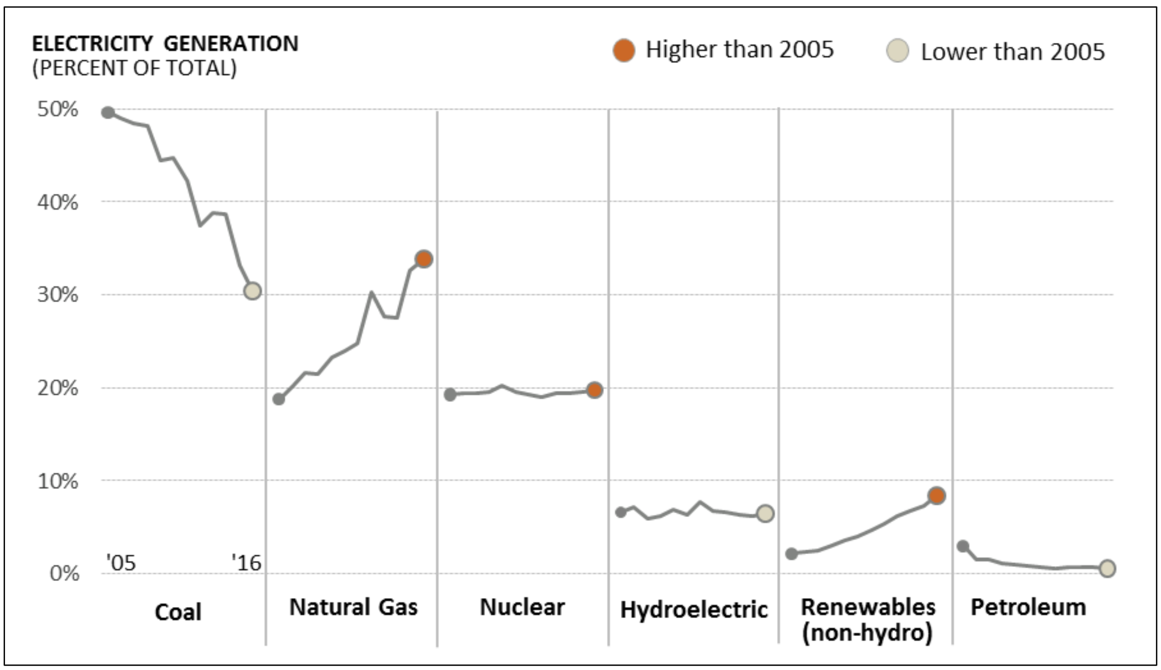
information, see CRS Report R44090, *Life-Cycle Greenhouse Gas Assessment of Coal and Natural Gas in the Power Sector*, by Richard K. Lattanzio.

Figure 7 illustrates the percentage of electricity generated by source between 2005 and 2016. As the figure indicates, the U.S. electricity generation portfolio has changed considerably in recent years. Highlights include:

- Coal: Between 2005 and 2016, coal-fired generation decreased by 38%. Its contribution to total electricity generation decreased from 50% to 30%.
- Natural gas: Between 2005 and 2016, natural-gas-fired generation increased by 81%. Its contribution to total electricity generation increased from 19% to 34%. *In 2016, natural gas surpassed coal in terms of percentage of total generation.*
- Renewable energy: Between 2005 and 2016, non-hydro renewable energy generation increased by 254%. Its contribution to total electricity generation increased from 2% to 8%.
- Petroleum: Between 2005 and 2016, petroleum-fired generation decreased by 87%. Its contribution to total electricity generation decreased from 2% to less than 1%.

Figure 7. Percentage of Total Electricity Generation by Energy Source

2005-2016



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

Notes: Renewable sources include wind, utility scale solar, wood fuels, landfill gas, biogenic municipal solid waste, other biomass, and geothermal. Petroleum includes petroleum liquids and petroleum coke.

Several factors likely played a role in these recent changes. Due in large part to technological advances—particularly directional drilling and hydraulic fracturing[20]—U.S. natural gas

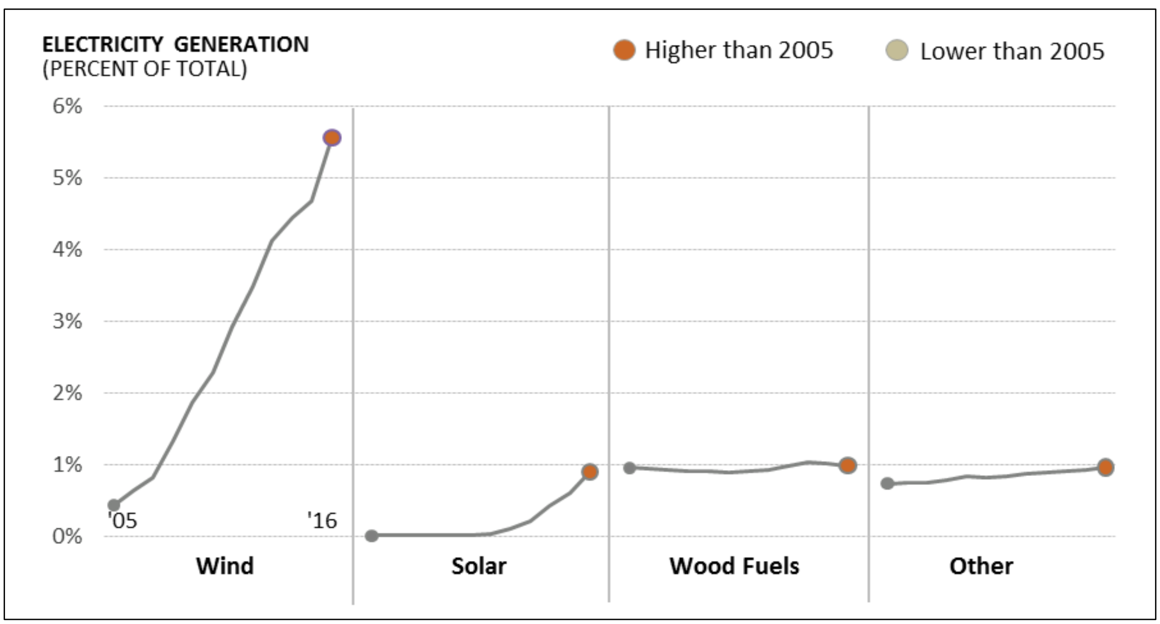
[20]Hydraulic fracturing is an industry technique that uses water, sand, and chemicals under pressure to enhance the recovering of natural gas and oil. It has taken on new prominence as it has been applied to tight oil and shale gas (continued...)

production increased dramatically (by 46%) between 2005 and 2016.[21] Natural gas production levels reached record levels in 2011 and have increased further each year until declining in 2016.[22] Relatedly, the weighted average annual price of natural gas dropped by about 60% between 2005 and 2015. By comparison, the weighted average annual coal price increased by about 40% during that time frame.[23] This change in relative fuel prices has played a key role in altering the economics of power generation (i.e., order of dispatch), leading to some natural gas displacement of coal in particular regions of the country.[24]

Figure 8 provides a more detailed breakdown of the changes in generation from non-hydro renewable energy sources. The vast majority of the increased generation from renewable energy over the past 11 years is due to wind power, which increased 13-fold between 2005 and 2016. Although solar increased 67-fold over that time frame, the magnitude of wind generation dwarfs solar generation (227 Terawatt-hours of wind in 2016 versus 37 Terawatt-hours of solar). Energy from wood fuels has remained relatively constant during this time frame. The increase in "other" renewable sources is due to increased use of landfill gas, which more than doubled between 2005 and 2016.

Figure 8. Percentage of Total Electricity Generation from Renewable Energy Sources (Not Including Hydroelectricity)

2005-2016



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

(...continued)

formation as an essential method for producing resources from those types of formations. See CRS Report R43148, *An Overview of Unconventional Oil and Natural Gas: Resources and Federal Actions*, by Michael Ratner and Mary Tiemann.

[21] EIA, "U.S. Dry Natural Gas Production, 1930-2016," http://www.eia.gov/dnav/ng/hist/n9070us2a.htm.

[22] In 2016, natural gas production decreased by 2%, but remained above 2015 levels.

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

[24] See for example, EIA, *Fuel Competition in Power Generation and Elasticities of Substitution*, 2012, http://www.eia.gov/analysis/studies/fuelelasticities/.

Notes: Solar generation does not include estimates of distributed solar generation, which EIA began to provide in 2014. Including these estimates would increase the percentage of solar generation in 2014 from 0.4% to 0.7%, in 2015 from 0.6% to 1.0%, and in 2016 from 0.9% to 1.4%. The "other" category includes landfill gas, biogenic municipal solid waste, other biomass, and geothermal sources.

Electricity CO_2 Emission Projections and the CPP

As previously discussed, CO_2 emissions from fossil fuel combustion account for the vast majority (77%) of total U.S. GHG emissions, and the electric power sector contributes a large percentage (35%) of CO_2 emissions from fossil fuel combustion. Therefore, policymakers and stakeholders are paying attention to both recent trends and future projections of CO_2 emissions in the electricity generation sector.

Multiple factors will likely impact CO_2 emission levels from the electricity sector. Some of these factors, identified below in no particular order, are interrelated:

- Economic impacts (e.g., level of GDP growth);
- Prices of fossil fuels—particularly natural gas—and renewable energy sources;
- Electricity generation portfolio (e.g., whether recent trends in coal, natural gas, and renewable energy use continue);
- Federal and/or state policy developments (e.g., CPP implementation, state renewable energy requirements); and
- Improvements in demand-side energy efficiency (e.g., commercial and residential electricity use).

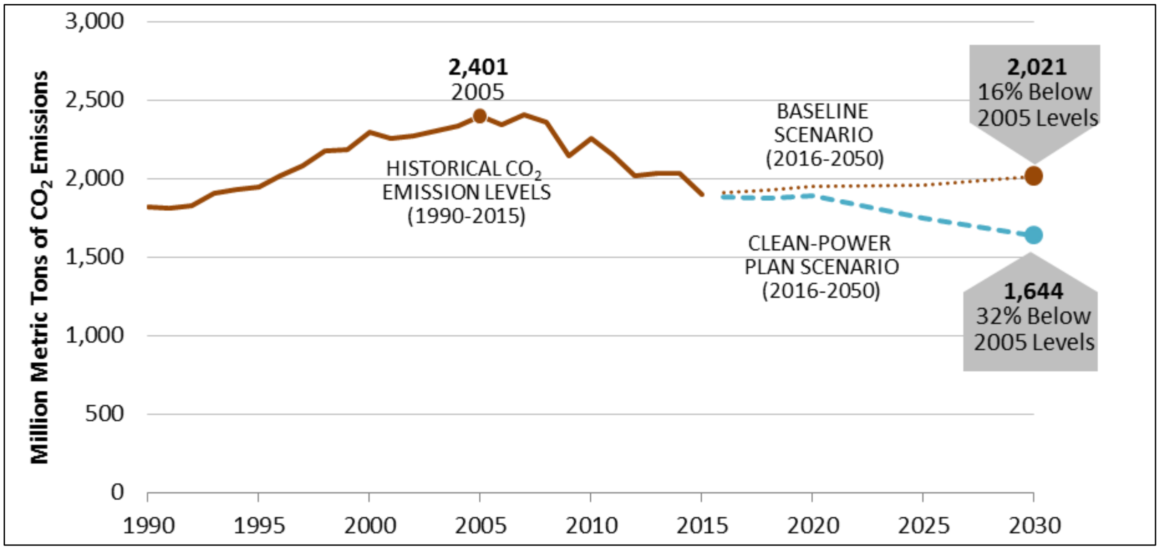
Most, if not all, of these factors are difficult to forecast with precision. In particular, the fate of the CPP is unknown, which raises a question: What impact would the CPP have on CO_2 emissions in the electricity sector?

Although it has been widely reported that the rule would require a 32% reduction in CO_2 emissions from the electricity sector by 2030 compared to 2005 levels, this percentage reduction comes from EPA's modeling of the effects of the rule in conjunction with other factors. The rule would establish uniform national CO_2 emission performance rates—measured in pounds of CO_2 per megawatt-hour of electricity generation—and state-specific CO_2 emission rate and emission targets. Each state would determine which measure to use to be in compliance.

Figure 9 compares EPA's projections of CO_2 emissions in the electricity sector resulting from the final rule with historical CO_2 emissions (1990-2015) from the electricity sector and projected emissions under EPA's baseline scenario. This scenario does not include the 2015 renewable energy tax extensions, discussed below. The figure indicates that the final rule would reduce CO_2 emissions in the electricity sector by 32% in 2030 compared to 2005 levels. Under the baseline scenario (i.e., without the CPP), EPA projects a 16% reduction by 2030 compared to 2005 levels. In terms of metric tons, EPA's CPP scenario would reduce an additional 377 million metric tons (or 15 percentage points) of CO_2, compared to EPA's baseline scenario.

Figure 9. CO_2 Emissions from U.S. Electricity Generation

Historical Emissions, EPA Baseline Projection, and EPA Clean Power Plan Projection



Source: Prepared by CRS; historical emissions from EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2015*, April 2017; baseline and CPP projections from EPA, Power Sector Modeling, 2015, http://www.epa.gov/airmarkets/programs/ipm/cleanpowerplan.html.

Notes: CRS converted EPA's projected emissions from short tons to metric tons. The historical emission levels are included for illustrative purposes only. In its analysis, EPA compared its CO_2 emission projections to a 2005 emission level (2,433 million metric tons) produced from the Emissions & Generation Resource Integrated Database. This 2005 value includes emissions only from the contiguous United States; the historical levels in the figure include all 50 states. However, the CO_2 emissions from Alaska's and Hawaii's electricity sectors generally account for less than 1% of total CO_2 emissions from that sector.

Based on EPA's *Regulatory Impact Analysis*, several factors may explain the emission results in 2030 between the baseline and CPP scenarios:

- Demand-side energy efficiency (DSEE) improvements: States may employ DSEE improvement activities as part of their plans to meet their targets. In its analysis, EPA assumed that DSEE efforts would decrease total electricity generation by 8% in 2030 compared to its baseline projection.[25]
- Coal generation decreases: EPA projected coal generation to decrease by 22%-23% in 2030 compared to its 2030 baseline projection.[26]
- Natural gas generation increases: EPA projected natural gas generation to increase by 5%-18% in 2030 compared to its 2030 baseline projection.[27]
- Renewable energy generation increases: EPA projected non-hydro renewable energy generation is expected to increase by 8%-9% in 2030 compared to its 2030 baseline projection.[28]

[25] EPA, *Regulatory Impact Analysis for the Clean Power Plan Final Rule*, August 2015 (hereinafter RIA), http://www2.epa.gov/cleanpowerplan/clean-power-plan-final-rule-regulatory-impact-analysis.

[26] EPA, RIA, Table 3-11. The range reflects the different compliance options in EPA's model: rate-based and mass-based approaches.

[27] Ibid.

[28] Ibid.

Other organizations used models to compare baseline scenarios with various CPP scenarios. **Table 1** lists the CO_2 emission projections from these groups and EPA. Some of these groups produced multiple projections, employing different assumptions of future activities: CPP implementation options (e.g., whether states engaged in emissions trading) and levels of energy efficiency improvements, among others.

All of the modeling scenarios below (except for EPA) included the December 2015 renewable energy tax extensions. On December 18, 2015, President Obama signed into law the Consolidated Appropriations Act, 2016 (P.L. 114-113). The act, among other provisions, extended and modified the production tax credit (PTC) and the investment tax credit (ITC) for specific renewable energy technologies.[29] Prior to the December 2015 development, the PTC had expired and the ITC was scheduled to expire at the end of 2016. The PTC will not be available to projects starting construction after December 31, 2019. However, PTC tax expenditures will continue after that date, because the PTC is available for the first 10 years of renewable electricity production. The ITC for solar is scheduled to decline from 30% to 26% in 2020, and 22% in 2021, before returning to the permanent rate of 10% after 2021.[30]

Table 1. Comparison of Selected Modeling Projections: CPP and Non-CPP Scenarios

Million Metric Tons of CO_2 Emissions

Modeling Group	Non-CPP Scenario: 2030 CO_2 Emissions	% Below 2005 Levels	CPP Scenario(s): 2030 CO_2 Emissions	% Below 2005 Levels
EPA (2015)	2,021	16%	1,644	32%
Energy Information Administration (2017)	1,886	22%	1,537	36%
Rhodium Group (2017)	1,774	26%	1,524	37%
M. J. Bradley and Associates (2016)	1,780-1,876	22%-26%	1,577-1,729	28%-34%
National Renewable Energy Laboratory (2016)	Not included	Not included	1,448–1,556	32%-36%

Source: EPA data from the agency's Power Sector Modeling, 2015, http://www.epa.gov/airmarkets/programs/ipm/cleanpowerplan.html; Energy Information Administration data from *Annual Energy Outlook 2017,* 2017, https://www.eia.gov/outlooks/aeo/. Rhodium Group data from "Taking Stock 2017: Adjusting Expectations for US GHG Emissions," 2017, http://rhg.com/reports/taking-stock-2017-adjusting-expectations-for-us-ghg-emissions; and personal correspondence with authors to provide 2030 estimate for CCP scenario. M. J. Bradley and Associates data from "EPA's Clean Power Plan Summary of IPM Modeling Results with ITC/PTC Extension," 2016, http://www.mjbradley.com/reports/updated-modeling-analysis-epas-clean-power-plan. National Renewable Energy Laboratory data from *Impacts of Federal Tax Credit Extensions on Renewable Deployment and Power Sector Emissions*, 2016, http://www.nrel.gov/docs/fy16osti/65571.pdf (and personal correspondence with report authors).

Notes: The groups in the table used different values for 2005 emission levels, but the differences were minimal. The percentage reductions in the table are based on the specific group's emission level in 2005.

In general, the modeling results in **Table 1** indicate that the CPP would have a substantial impact on future CO_2 emission levels from electricity generation compared to scenarios that do not include the CPP.

[29] See National Renewable Energy Laboratory, *Impacts of Federal Tax Credit Extensions on Renewable Deployment and Power Sector Emissions*, February 2016, http://www.nrel.gov/docs/fy16osti/65571.pdf.

[30] For further information, see CRS Report R44852, *The Value of Energy Tax Incentives for Different Types of Energy Resources: In Brief*, by Molly F. Sherlock.

Concluding Observations

Recent international negotiations and domestic policy developments have increased interest in current and projected U.S. GHG emission levels. In the context of international climate change negotiations, President Obama announced, on separate occasions, U.S. GHG emission reduction goals for both 2020 and 2025. Whether the United States ultimately achieves its goals would likely depend, to some degree, on CO_2 emissions from power plants.

Historically, CO_2 emissions from electricity generation have followed an upward course similar to electricity generation levels. However, in 2010, their courses diverged. While electricity generation remained flat after 2010, CO_2 emissions continued a trend of reduction. Thus in 2016, electricity generation was essentially equivalent to generation in 2005, while CO_2 emissions were 25% below 2005 levels.

Multiple factors generally impact CO_2 emission levels from the electric power sector. Recent changes in the U.S. electricity generation portfolio between 2005 and 2016 played a key role:

- Coal's contribution to total electricity generation decreased from 50% to 30%;
- Natural gas's contribution to total electricity generation increased from 19% to 34%, surpassing coal in percentage of total generation in 2016; and
- Renewable energy's contribution to total electricity generation increased from 2% to 8%.

If these recent trends in the electric power sector continue, CO_2 emissions in that sector may continue to decrease. Assuming this were to occur, some might question the importance of the CPP in terms of meeting U.S. GHG emission goals (e.g., 26%-28% below 2005 levels by 2025). However, modeling results cited above indicate that the CPP would have a substantial impact on future CO_2 emission levels from the electric power sector.

Author Contact Information

Jonathan L. Ramseur
Specialist in Environmental Policy
jramseur@crs.loc.gov, 7-7919

Acknowledgments

Amber Hope Wilhelm, a Visual Information Specialist, contributed to this report.