Independent Statistics & Analysis
U.S. Energy Information Administration

U.S. Energy-Related Carbon Dioxide Emissions, 2017

September 2018

Independent Statistics & Analysis
www.eia.gov

U.S. Department of Energy
Washington, DC 20585

This report was prepared by the U.S. Energy Information Administration (EIA), the statistical and analytical agency within the U.S. Department of Energy. By law, EIA's data, analyses, and forecasts are independent of approval by any other officer or employee of the United States Government. The views in this report therefore should not be construed as representing those of the U.S. Department of Energy or other federal agencies.

Table of Contents

Introduction

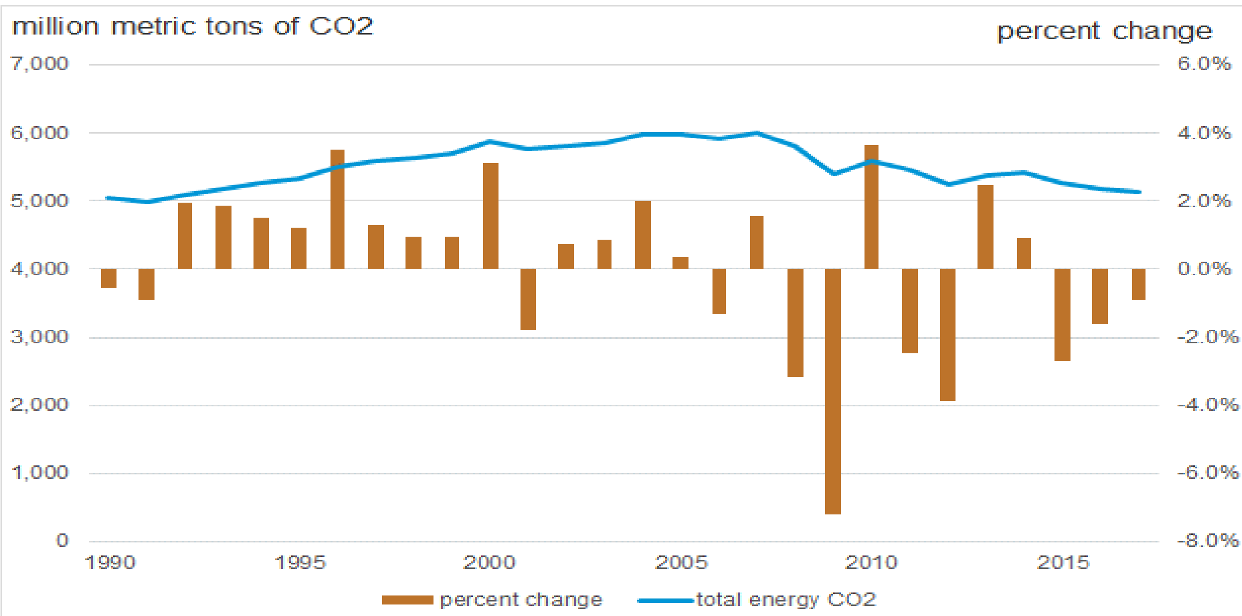
This analysis examines the economic trends and changes in fuel mix that influence energy-related carbon dioxide (CO2) emissions. Year-to-year trends can be influenced by the weather, relative prices of primary fuels, and planned and unplanned outages of electricity generation capacity. Longer-term trends are influenced by policies to encourage renewable energy, reduced costs and improved efficiency of new technologies, and demand-side efficiency gains such as vehicle miles per gallon or appliance efficiencies. Energy-related CO2 emissions result from fossil fuels combusted for their energy content or used as non-energy inputs to the petrochemical and related industries.

Overview

U.S. energy-related carbon dioxide emissions decreased 0.9% in 2017

- Energy-related CO2 emissions decreased by 47 million metric tons (MMmt), from 5,189 MMmt in 2016 to 5,142 MMmt in 2017.
- Although real gross domestic product (GDP) increased 2.3% over that period, the other factors contributing to energy-related CO2 emissions listed below more than offset the growth in GDP:
    - A 1.1% decline in the carbon intensity of the energy supply (CO2/British thermal units [Btu])
    - A 2.0% decline in energy intensity (Btu/GDP)
    - A 3.1% decline in the overall carbon intensity of the economy (CO2/GDP)
- Emissions have declined in 7 out of the past 10 years, and energy-related CO2 emissions in 2017 were 849 MMmt (14%) below 2005 levels.

Figure 1. Energy-related CO2 emissions, 1990–2017



Source: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 12.1 Carbon dioxide emissions from energy consumption by source. **Note**: Unless otherwise indicated, all data in this analysis refer to the U.S. Energy Information Administration's August 2018 *Monthly Energy Review*. Because fossil fuels are used primarily as energy inputs, non-energy uses that both emit and capture carbon are included under the term *energy-related CO2*.

Even though energy-related CO_2 emissions decreased in 2017, emissions growth was 20 million metric tons above trend

- GDP per capita grew by 1.5% 2016 to 2017. This rate compares with the 2006–2016 average annual growth rate of 0.6%, which trended lower largely because of the Great Recession of 2007–2009 (recession). Higher GDP per capita growth in 2017 put upward pressure on CO_2 emissions, adding about 49 MMmt compared with the 2006–2016 average.

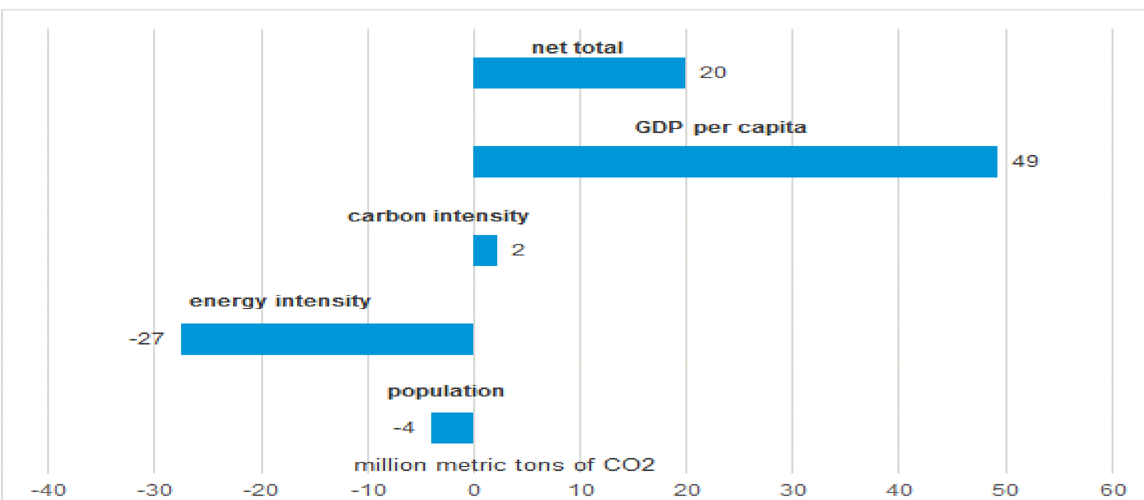
- In 2017, the carbon intensity of U.S. energy consumption declined by 1.1%. From 2006–2016, the average annual decline also rounded to 1.1%. However, the 2017 value rounded up to 1.1%, and the prior trend was slightly above 1.1%. As a result, CO_2 emissions were 2 MMmt greater than where they would have been if the prior trend had continued.

- Energy intensity fell at a higher rate than the 2006–2016 annual average (2.0% versus 1.5%), which led to CO_2 emissions that were 27 MMmt lower than if the prior trend had continued.

- Population growth of 0.7% —slightly lower than the 2006–2016 annual average of 0.8%— resulted in a 4 MMmt decline in CO_2 emissions in 2017 compared with the 2006–2016 trend.

- The net effect for 2017 was CO_2 emissions that were about 20 MMmt higher than they would have been had components of the Kaya energy/carbon decomposition (shown in Figure 2) matched their 2006–2016 trend rates. However, most of that difference can be attributed to more robust economic growth.

Figure 2. Changes in CO_2 emissions attributed to Kaya Identity factors from 2016 to 2017 compared with the trend from the prior decade



Sources: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 12.1 Carbon dioxide emissions from energy consumption by source. Bureau of Economic Analysis, *Current-Dollar and "real" Gross Domestic Product*. Bureau of Census, *U.S. Population 2017*. See details on the Kaya Identity.

Fuels

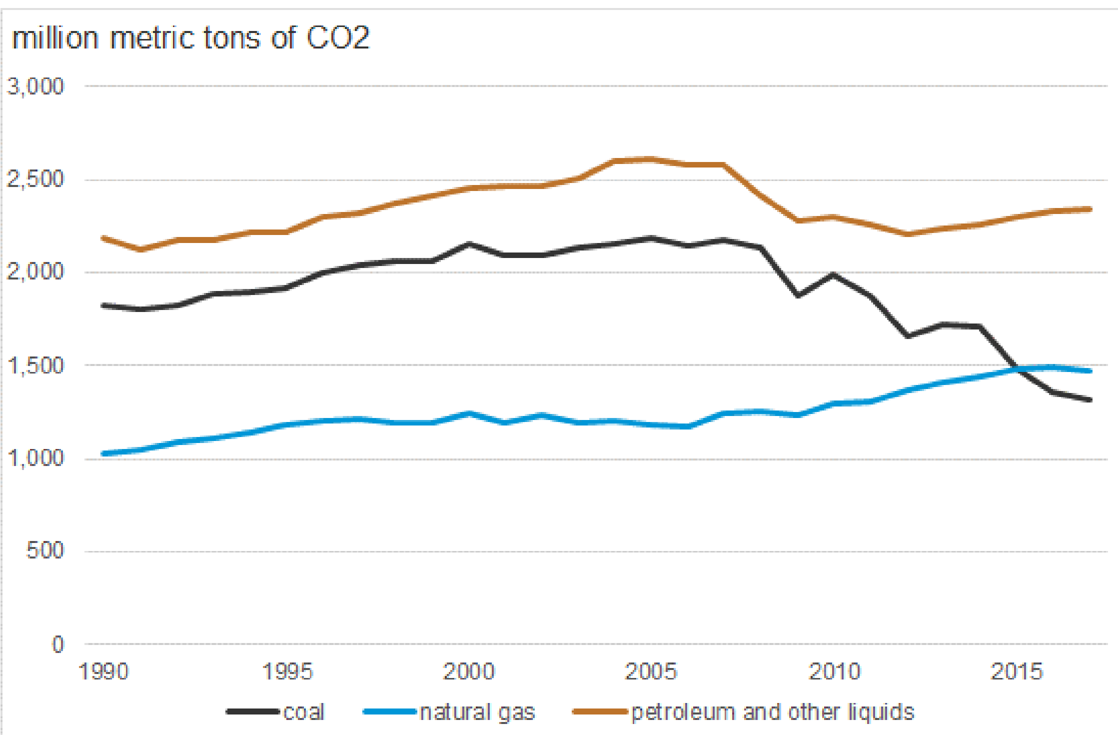
Natural gas CO_2 emissions continued to exceed those from coal in 2017

- Since the beginning of the recession, CO2 emissions from coal have generally declined. Although total coal CO2 emissions in 2017 were lower than those from petroleum and other liquids, coal is comparatively more carbon intensive, with more CO2 released per Btu of energy. The decline in coal CO2 emissions has contributed to a lower overall carbon intensity of U.S. energy consumption and kept emissions below pre-recession levels.

- Natural gas CO2 emissions increased every year from 2009 to 2016. However, in 2017 they declined by 1.5% (22 MMmt). The natural gas share of electricity generation has generally been growing, while the coal share has been declining. Natural gas CO2 emissions surpassed those from coal in 2015. However, because natural gas produces more energy for the same amount of emissions as coal, growth in natural gas consumption contributed to the overall 2017 decline in carbon intensity and emissions.

- CO2 emissions from petroleum and other liquids, which have been the largest source of energy-related CO2 in recent decades, have been increasing since 2012 after remaining relatively constant from 2004 to 2007 and then generally decreasing through 2012.

Figure 3. Energy-related CO2 emissions by fuel, 1990–2017



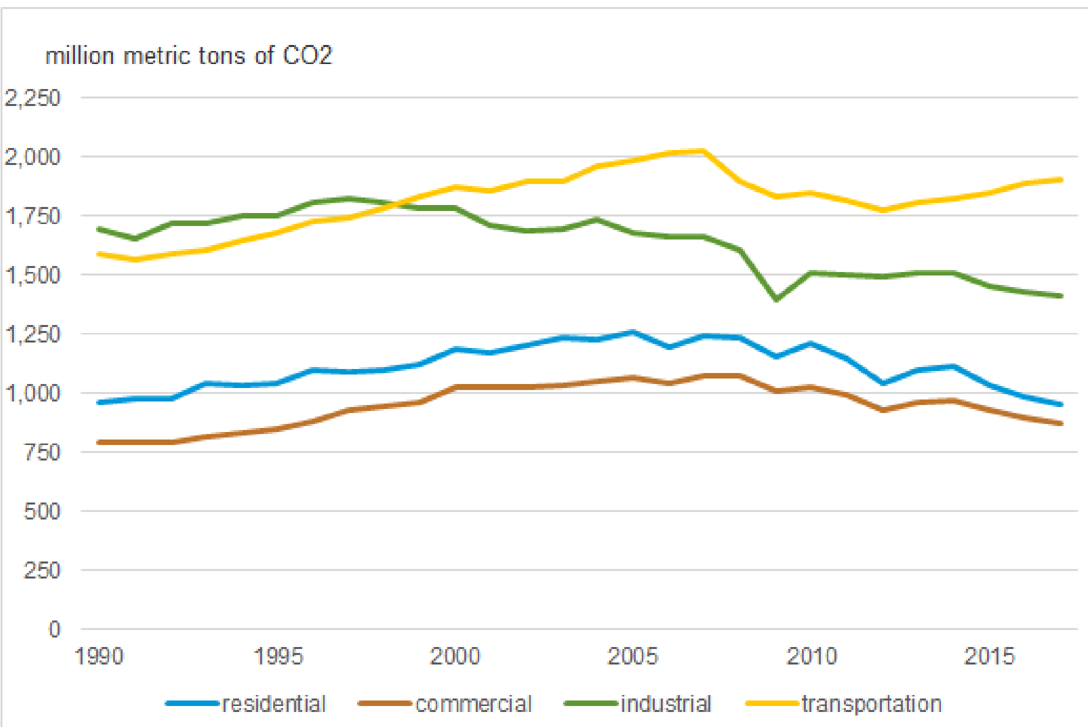
Source: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 12.1 Carbon dioxide emissions from energy consumption by source.

End-use sectors

Of the four end-use sectors, only transportation CO2 emissions increased in 2017

- Since the late 1990s, the transportation sector has produced the most CO2 emissions. These emissions were highest in 2007, prior to the recession, and have not returned to those levels, despite increasing every year since 2012.
- The industrial sector, which was the largest source of CO2 emissions throughout most of the 1990s, has experienced declining emissions, with further declines occurring in 2017.
- Emissions from the residential and commercial sectors, defined collectively as the building sector, are mainly indirect emissions from consumption of electricity purchased from the electric power sector. These indirect emissions declined by about 3.9% in 2017. Direct building sector CO2 emissions—primarily from heating—increased by 1.6% in 2017—leading to a net building sector CO2 emissions decline of 2.4%.

Figure 4. Energy-related CO2 by end-use sectors, 1990–2017

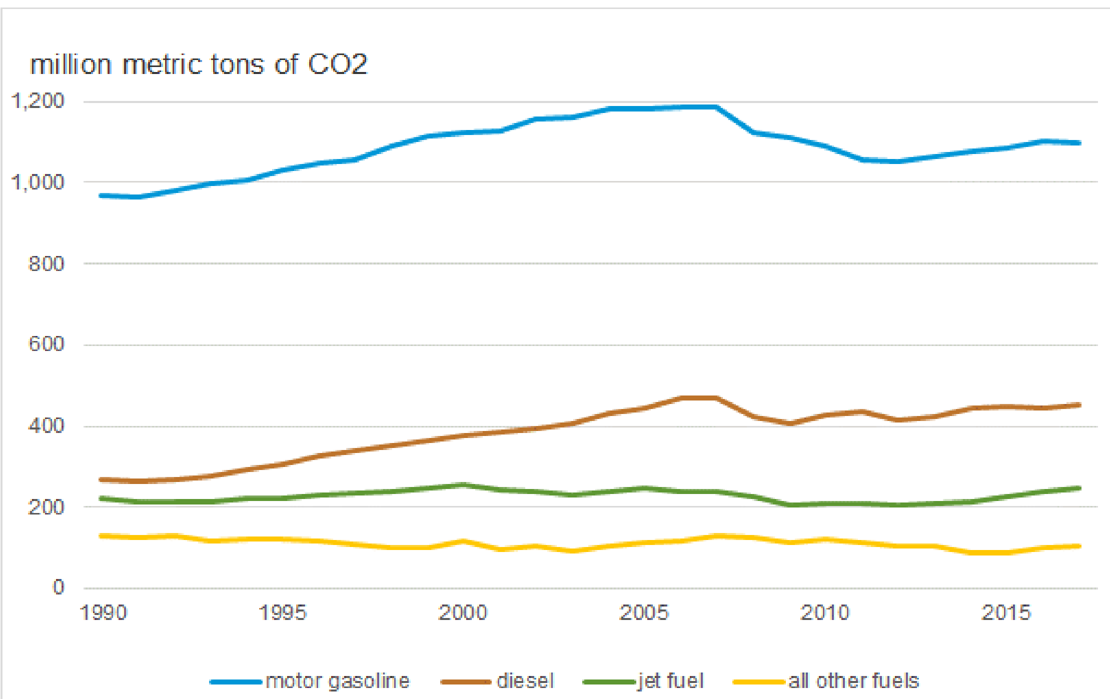


Sources: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 12.2 Carbon dioxide emissions from energy consumption: residential sector; Table 12.3 Carbon dioxide emissions from energy consumption: commercial sector; Table 12.4 Carbon dioxide emissions from energy consumption: industrial sector; Table 12.5 Carbon dioxide emissions from energy consumption: transportation sector.

The 2017 increase in energy-related CO_2 emissions from the transportation sector was led by jet and diesel fuel—motor gasoline CO_2 emissions declined

- Transportation-related CO_2 emissions increased by 16 MMmt (0.8%) in 2017. From 2012 to 2016, declines and the subsequent stability in the price of motor gasoline, along with the continued economic recovery, led to higher fuel consumption and increases in energy-related CO_2 emissions in the transportation sector.
- However, in 2017 motor gasoline prices increased 14%. and emissions declined by 0.3%. Although this is a small percentage change, because of motor gasoline's share of the market, these changes resulted in a 4 million metric tons (MMmt) decline.
- Jet fuel accounted for 58.0% of the 16 MMmt net increase in transportation sector CO_2 emissions in 2017— totaling 9 MMmt—an increase of 3.9% from the 2016 level.
- Emissions from diesel fuel increased by about 1.4% (6 MMmt) between 2016 and 2017—38% of the total CO_2 emissions increase in the transportation sector.
- Residual fuel emissions increased by 11.4% between 2016 and 2017—35% of the total increase in CO_2 emissions from the transportation sector.

Figure 5. Transportation-related CO_2 emissions by fuel, 1990–2017

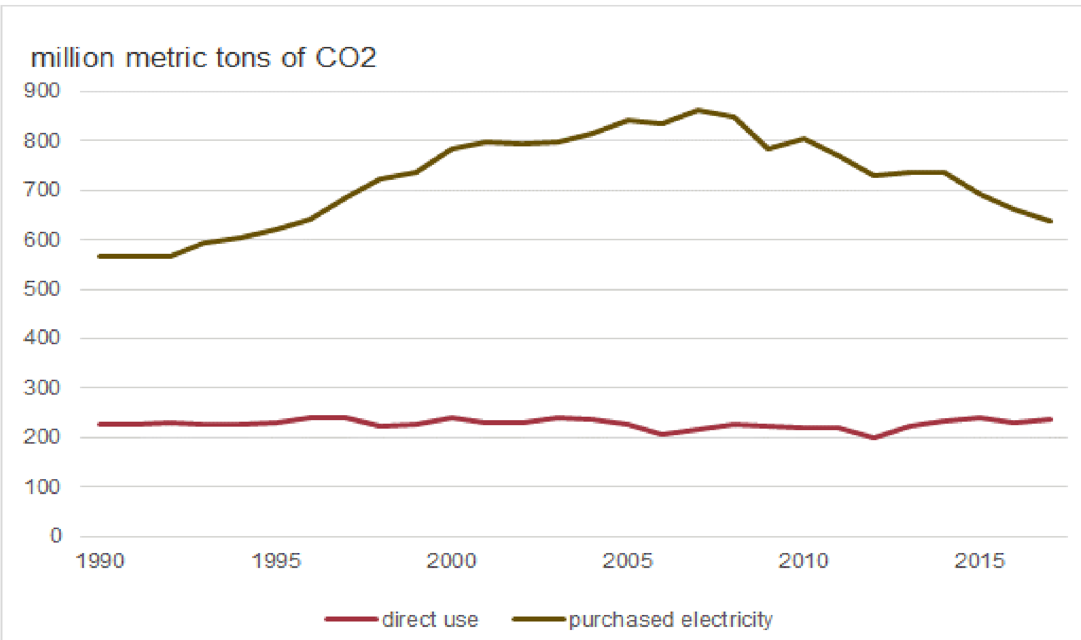


Source: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 12.5 Carbon dioxide emissions from energy consumption: transportation sector.

Commercial sector energy-related CO2 emissions declined in 2017

- Commercial sector CO2 emissions declined by 19 MMmt (2.1%) in 2017.
- Indirect commercial-sector CO2 emissions from the use of electricity purchased from the electric power sector decreased by 3.5% (23 MMmt) in 2017. This decrease was partially offset by an increase in direct CO2 emissions.
- Direct CO2 emissions in the commercial sector increased 1.7% by (4 MMmt).
- The decline in indirect CO2 emissions of 23 MMmt and the increase in direct CO2 emissions of 4 MMmt yielded the 19 MMmt decline.

Figure 6. Commercial sector energy-related CO2 emissions, 1990–2017



Source: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 12.3 Carbon dioxide emissions from energy consumption: commercial sector.

Residential sector energy-related CO2 the lowest since the late 1980s

- Residential sector emissions, which are strongly influenced by the weather, fell by 26 MMmt (2.6%) in 2017. In total, residential CO2 emissions in 2017 (956 MMmt) were the lowest since 1987.

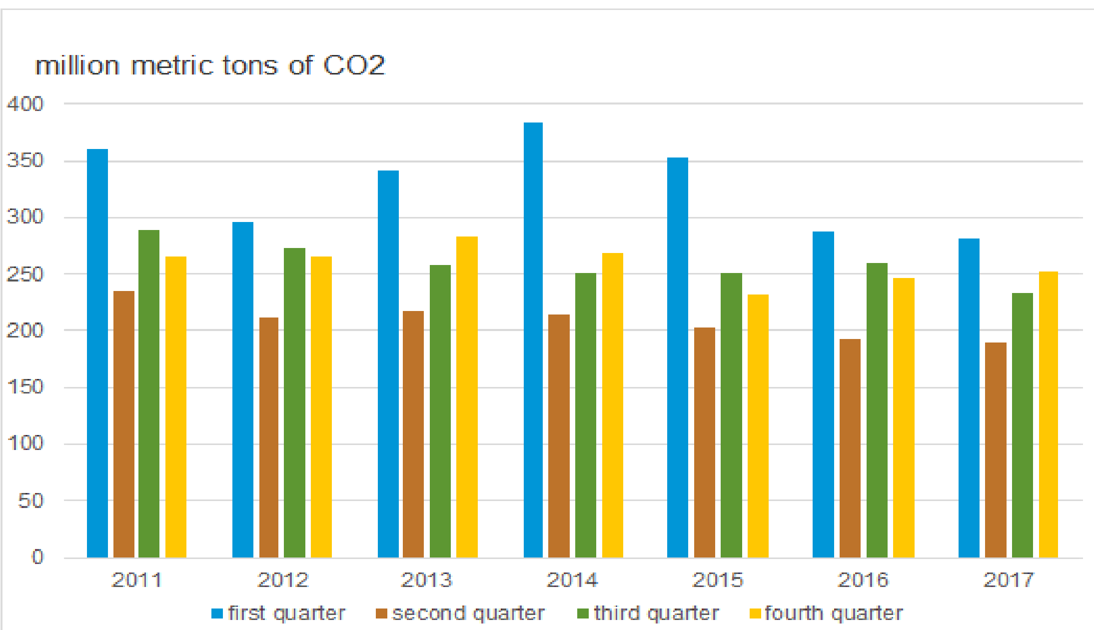
- First-quarter emissions in 2017 were below the six previous years because population-weighted heating degree days for that period were 15% below the 10-year average. Because of heating demands, the first quarter is typically the largest producer of CO2 emissions related to the residential sector.

- Emissions are typically lowest in the second quarter because residential heating/cooling demands are low; residential CO2 emissions in the second-quarter 2017 were lower than the six previous years. Lighting energy efficiency has been improving in recent years.

- The third quarter is the warmest time of year. Third-quarter CO2 emissions have generally declined since 2010—supported by the decline in the carbon intensity of fuels used to generate electricity. Third-quarter cooling degree days in 2017 were 2% lower than the 10-year average, leading to lower emissions than in the six previous years.

- In the fourth quarter of 2017, emissions were higher than the 2015 and 2016 levels, but they were still lower than in other recent years.

Figure 7. Residential energy-related CO2 emissions by quarter, 2011–2017

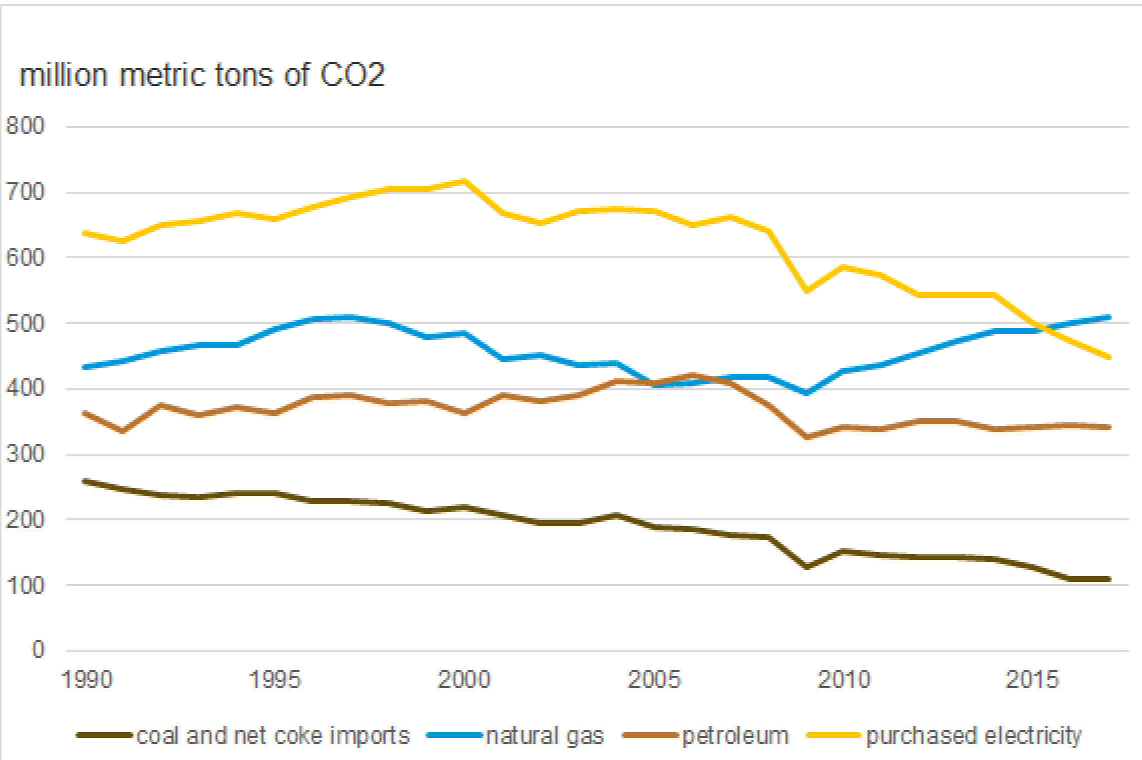


Source: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 12.2 Carbon dioxide emissions from energy consumption: residential sector. Residential sector monthly CO2 emissions—that are summed for the quarterly estimates above—when totaled for the year differ slightly from the annual values because of the timing of certain data series such as retail electricity. However, the total monthly values for all sectors equal the annual values.

Natural gas is becoming the dominant industrial emissions source

- The industrial sector's CO2 emissions, which fell by 1.3% (18 MMmt) in 2017, have remained essentially flat in recent years despite increasing industrial output. Continuing growth in less energy-intensive industrial output was a factor in stabilizing emissions in this sector.
- Industrial natural gas CO2 emissions have risen every year since 2009—except in 2015 when they declined slightly. In 2016, industrial CO2 emissions from natural gas exceeded those of purchased electricity and this difference in emissions increased in 2017. Because it is the least carbon-intensive fossil fuel, natural gas use has contributed to reduced overall CO2 emissions growth.
- Industrial CO2 emissions from purchased electricity and coal declined in most years from 2011 to 2017.
- Petroleum CO2 emissions in the industrial sector were relatively flat in recent years.

Figure 8. CO2 emissions from industrial fuels, 1990–2017



Source: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 12.4 Carbon dioxide emissions from energy consumption: industrial sector.

Electricity generation

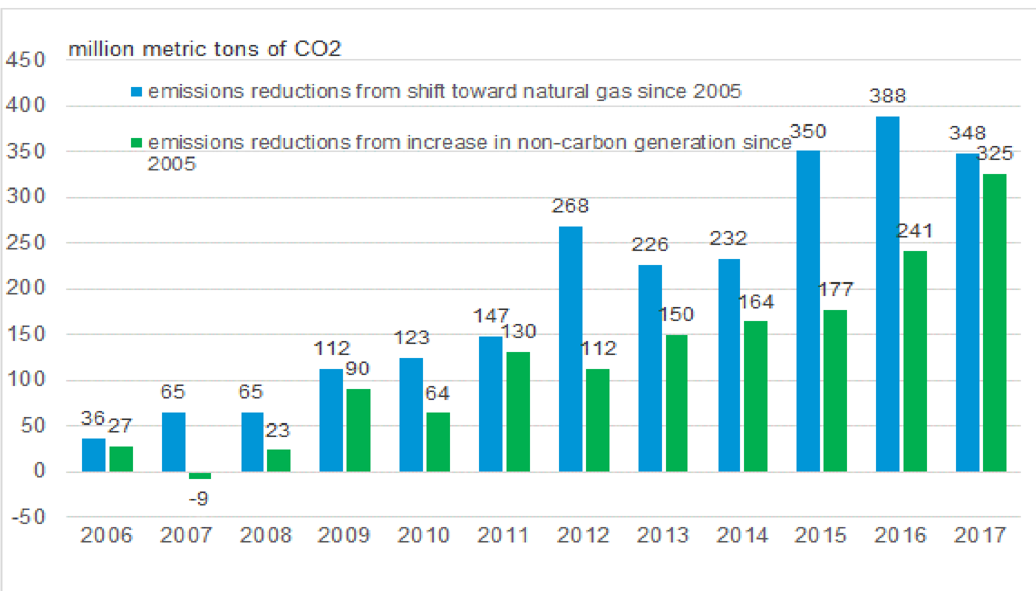
Natural gas replacing coal-fired generation and increasing generation from non-carbon sources have led to the decline in the carbon intensity of electricity generation in recent years

- Two basic factors contributed to lower carbon intensiy of electricity generation (CO2/kilowatthour) since 2005—the substitution of coal-fired generation with the less-carbon-intensive and more efficient combined-cycle natural gas-fired generation and the growth in non-carbon electricity generation, especially from wind and solar.

- Between 2005 and 2017, CO2 emissions declined by a cumulative 3,855 MMmt as a result of these two factors (see methodology on page 21). Of this total, 2,360 MMmt can be attributed to the shift in fossil fuels to natural gas, and 1,494 MMmt can be attributed to the increase in non-carbon generation sources.

- Total electricity generation use fell slightly from 2005 to 2017, and related CO2 emissions fell by 28% over that period. From 2005 to 2017, fossil-fuel electricity generation declined by about 14%, and non-carbon electricity generation rose by 33%.

Figure 9. Electricity generation CO2 savings from changes in the fuel mix since 2005

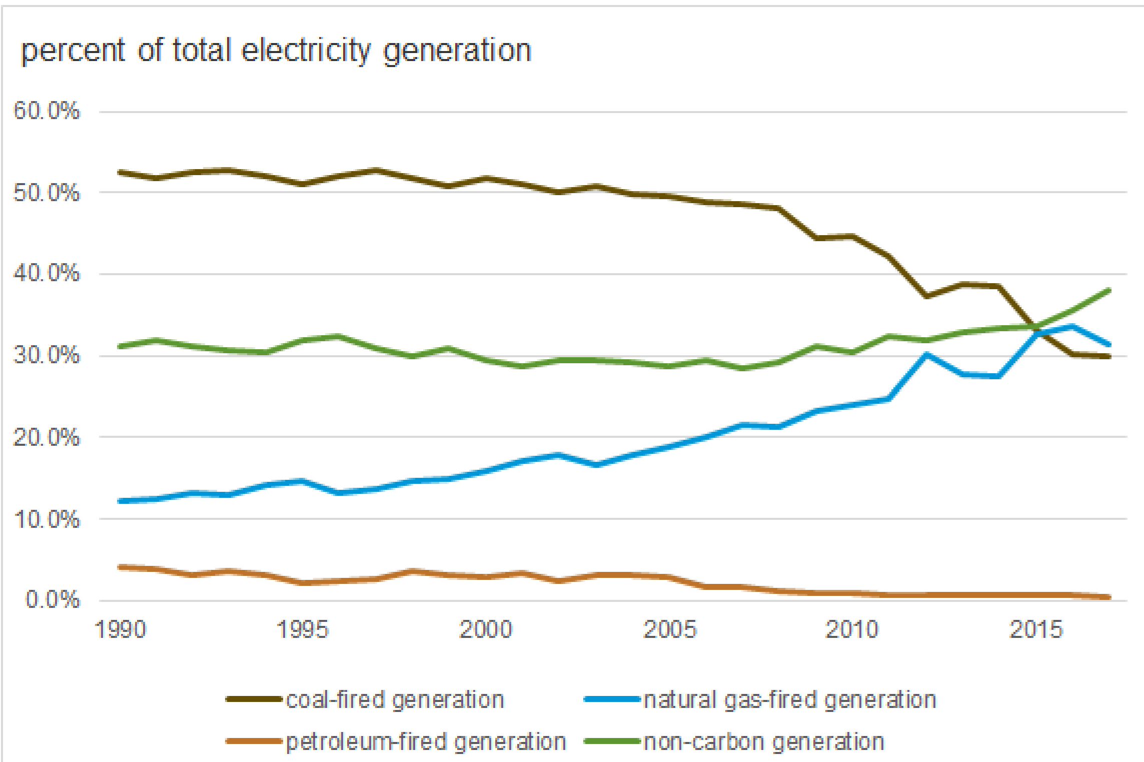


Sources: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 12.6 Carbon Dioxide Emissions From Energy Consumption: Electric Power Sector and calculations made for this analysis based on Table 7.3c Consumption of Selected Combustible Fuels for Electricity Generation: Commercial and Industrial Sectors (Subset of Table 7.3a). Distributed solar generation from Table 10.6 Solar Electricity Net Generation is added to generation values from Table 7.2a Electricity Net Generation: Total (All Sectors). See Table 2 on page 17 for carbon dioxide values for the commercial and industrial sectors. This analysis includes estimated CO2 emissions from electricity generated in all sectors. Non-carbon electricity generation includes distributed solar.

The increasing share of non-carbon electricity generation has lowered the carbon intensity of electricity supply in recent years

- The trend of declining coal-fired electricity generation and increasing non-carbon and natural gas-fired generation continued in 2017.
- Coal's share of total electricity generation fell from 52% in 1990 to 30% in 2017.
- The natural gas share of total electricity generation grew from approximately 12% in 1990 to 30% in 2012 and to 32% in 2017—a decline from the 34% share in 2016.
- The non-carbon electricity generation share, including both nuclear and renewables, exceeded that of both coal and natural gas in 2016 and 2017.

Figure 10. Electricity generation share of three fossil fuels and of non-carbon generation, 1990–2017

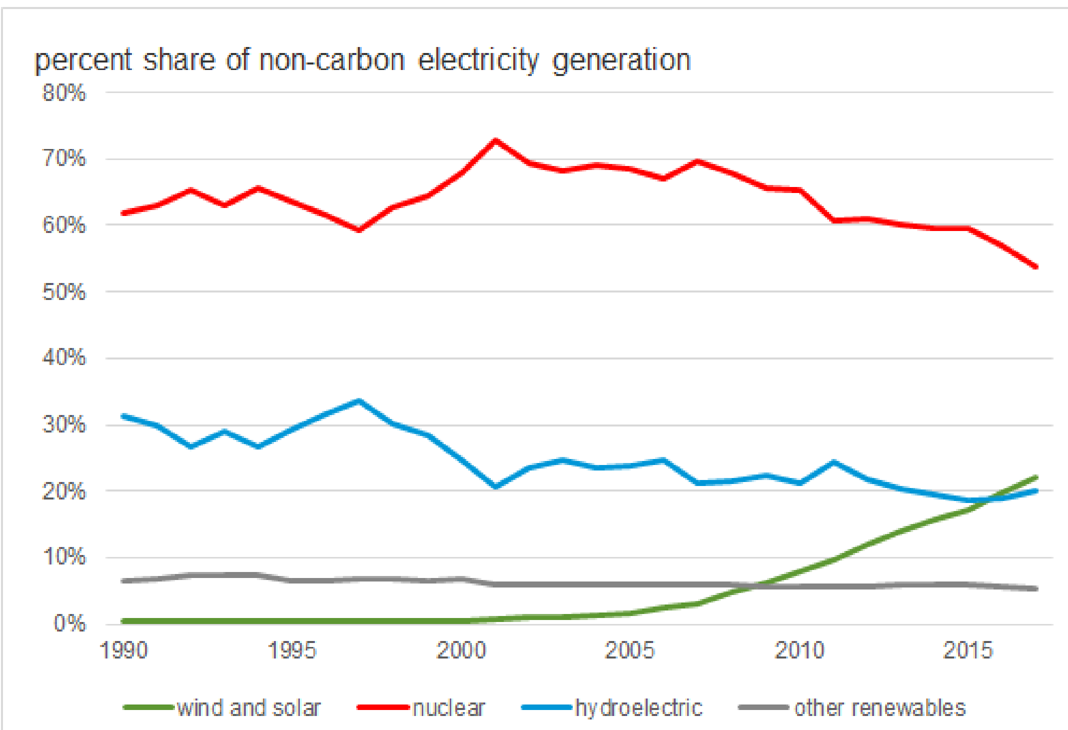


Source: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 7.2a Electricity net generation: Total (All Sectors); Table 10.6 Solar Electricity Net Generation.

Growth in wind and solar electricity generation has resulted in the decreasing carbon intensity of the electricity supply

- Although nuclear power remains the dominant source of non-carbon electricity generation, growth in wind and solar generation since 2008 has contributed to a decline in the carbon intensity of electricity generation.
- The nuclear share of non-carbon electricity generation has generally declined since the 73% share in 2001.
- Hydropower, which historically has been the largest source of renewable electricity generation, has also lost share, falling from 34% of non-carbon electricity generation in 1997 to 20% in 2017.
- Wind and solar (combined) accounted for about 22% of non-carbon electricity generation in 2017 and exceeded hydropower in 2016 after rising from less than 1% in 2000 to 2% in 2006.
- Other renewables, such as biomass, have remained flat at about a 5%–6% share since 2001.

Figure 11. Share of non-carbon electricity generation by source, 1990–2017



Source: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, Table 7.2a Electricity net generation: Total (All Sectors); Table 10.6 Solar Electricity Net Generation.

Table 1. Weighted factors for electricity and primary energy by sector for the energy-related CO2 emissions, percent change from 2016 to 2017

	Electricity change 2016–2017	Change in carbon intensity of electricity 2016–2017	Electricity share of sector CO2 2017	Change in electricity-weighted CO2 2016–2017
Residential	-1.4%	-3.0%	68.3%	-3.0%
Commercial	-0.4%	-3.0%	73.1%	-2.5%
Industrial	-2.2%	-3.0%	31.8%	-1.7%
Transportation	1.3%	-3.0%	0.2%	0.0%

	Primary energy change 2016–2017	Change in carbon intensity of primary energy 2016–2017	Primary energy share of sector CO2 2017	Change in primary energy-weighted CO2 2016–2017
Residential	1.7%	-0.2%	31.7%	0.5%
Commercial	2.0%	-0.3%	26.9%	0.5%
Industrial	1.2%	-0.5%	68.2%	0.5%
Transportation	0.7%	0.2%	99.8%	0.8%

	Sector CO2 change MER tables 2016–2017	Electricity and primary energy CO2 change times sector share 2016–2017	Sector share of total CO2 2017	Sum of change in electricity and primary energy-weighted CO2 2016–2017
Residential	-2.6%	-0.5%	18.6%	-2.6%
Commercial	-2.1%	-0.4%	17.0%	-2.1%
Industrial	-1.3%	-0.3%	27.4%	-1.2%
Transportation	0.8%	0.3%	37.0%	0.8%
Total all sectors	-0.9%	-0.8%		

Sources: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*,
Table 12.1 Carbon Dioxide Emissions From Energy Consumption by Source
Table 12.2 Carbon Dioxide Emissions From Energy Consumption: Residential Sector
Table 12.3 Carbon Dioxide Emissions From Energy Consumption: Commercial Sector
Table 12.4 Carbon Dioxide Emissions From Energy Consumption: Industrial Sector
Table 12.5 Carbon Dioxide Emissions From Energy Consumption: Transportation Sector
Differences in percent changes with actual values are because of rounding error.
Electricity is purchased electricity. Emissions from fuels consumed to generate electricity within the commercial and industrial sectors are counted as CO2 from primary energy.

Table 1 decomposes the rates of change by sector for electricity (indirect) and primary (direct) energy consumption and separates those rates of change in electricity and primary energy consumption from the changes in the respective carbon intensities. The sums of those changes multiplied by the share of CO2 emissions from each energy type approximate the CO2 changes in each sector.

For example, the residential sector—with the 1.4% decrease in electricity consumed between 2016 and 2017 was enhanced by a decline in carbon intensity of the electricity supply (-3.0%)—has a total change of -4.4% (not shown in the table). When -4.4% is multiplied by the 2017 electricity CO2 emissions share of 68.3%, the resulting electricity-weighted change is -3.0%. Adding -3.0% to the residential sector's weighted change of primary energy (0.5%) results in a total sector change of -2.6%. Finally, when weighted by the residential share of total CO2 emissions (18.6%), the weighted-sector share is -0.5%. The sectors are summed to determine total energy-related CO2 emission changes. Rounding errors account for slight differences in totals.

Table 2. Carbon dioxide emissions from the generation of electricity in the commercial and industrial sectors

million metric tons of carbon dioxide

	Commercial				Industrial				Commercial and Industrial Total
	Coal	Natural gas	Petroleum	Total	Coal	Natural gas	Petroleum	Total	Total
2005	0.80	1.84	0.25	2.89	15.87	28.25	2.42	46.54	49.43
2006	0.73	1.89	0.14	2.76	15.57	29.23	1.90	46.70	49.46
2007	0.76	1.86	0.11	2.72	10.85	30.18	1.87	42.90	45.63
2008	0.81	1.82	0.07	2.70	10.79	28.35	1.35	40.49	43.19
2009	0.69	1.86	0.08	2.63	9.73	28.28	1.21	39.21	41.85
2010	0.68	2.14	0.07	2.89	16.92	30.15	0.88	47.95	50.84
2011	0.73	2.56	0.06	3.35	11.79	31.00	0.77	43.56	46.91
2012	0.62	3.43	0.11	4.17	9.54	34.46	1.70	45.69	49.86
2013	1.04	3.63	0.13	4.80	9.62	35.03	1.37	46.03	50.83
2014	0.41	3.94	0.18	4.54	9.50	34.18	0.92	44.59	49.13
2015	0.32	3.86	0.10	4.29	8.10	34.40	0.67	43.18	47.46
2016	0.21	2.55	0.05	2.81	6.06	29.42	0.60	36.08	38.83
2017	0.18	2.47	0.08	2.73	5.51	28.94	0.52	34.97	37.69

Sources: U.S. Energy Information Administration, August 2018 *Monthly Energy Review*, calculations made for this analysis based on Table 7.3c Consumption of Selected Combustible Fuels for Electricity Generation: Commercial and Industrial Sectors (Subset of Table 7.3a). Carbon factors used: Coal, 95.35 million metric tons per quadrillion Btu for both sectors; natural gas, 53.07 million metric tons per quadrillion Btu for both sectors; and petroleum, 78.8 million metric tons per quadrillion Btu for the commercial sector, and 72.62 million metric tons per quadrillion Btu for the industrial sector.

Future implications of the 2017 decline in CO2 emissions

The 2017 conditions that put downward pressure on emissions do not necessarily reflect future trends.

For EIA's forecasts and projections on emissions and their key drivers, see the Short-Term Energy Outlook (STEO), with monthly forecasts through 2019, and the Annual Energy Outlook (AEO), with annual projections through 2050. EIA's International Energy Outlook (IEO) contains projections of international energy consumption and emissions through 2050.

The analysis of energy-related CO2 emissions presented here is based on data in the *Monthly Energy Review* (MER). Chapter 12 of the MER reports monthly U.S. energy-related CO2 emissions derived from EIA's monthly energy data. For the full range of EIA's emissions products, see EIA's Environment analysis.

Terms used in this analysis

British thermal unit(s) (Btu): The quantity of heat required to raise the temperature of 1 pound of liquid water by 1 degree Fahrenheit at the temperature at which water has its greatest density (approximately 39 degrees Fahrenheit).

Carbon intensity (economy): The amount of carbon by weight emitted per unit of economic activity—most commonly gross domestic product (GDP) (CO2/GDP). The carbon intensity of the economy is the product of the energy intensity of the economy and the carbon intensity of the energy supply. Note: this value is currently expressed as the full weight of the carbon dioxide emitted.

Carbon intensity (energy supply): The amount of carbon by weight emitted per unit of energy consumed (CO2/energy or CO2/Btu). A common measure of carbon intensity is weight of carbon per Btu of energy. When only one fossil fuel is under consideration, the carbon intensity and the emissions coefficient are identical. When several fuels are under consideration, carbon intensity is based on their combined emissions coefficients weighted by their energy consumption levels. Note: this value is currently measured as the full weight of the carbon dioxide emitted.

Cooling degree days (CDD): A measure of how warm a location is over a period of time relative to a base temperature, most commonly specified as 65 degrees Fahrenheit. The measure is computed for each day by subtracting the base temperature (65 degrees) from the average of the day's high and low temperatures, with negative values set equal to zero. Each day's cooling degree days are summed to create a cooling-degree-day measure for a specified reference period. Cooling degree days are used in energy analysis as an indicator of air conditioning energy requirements or use.

Energy intensity: A measure relating the output of an activity to the energy input to that activity. Energy intensity is most commonly applied to the economy as a whole, where output is measured as GDP, and energy is measured in Btu to allow for the summing of all energy forms (Btu/GDP). On an economy-wide level, energy intensity is reflective of both energy efficiency and the structure of the economy. Economies in the process of industrializing tend to have higher energy intensities than economies in their post-industrial phase. The term *energy intensity* can also be used on a smaller scale to relate, for example, the amount of energy consumed in buildings to the amount of residential or commercial floor space.

Gross domestic product (GDP): The total value of goods and services produced by labor and property located in the United States. As long as the labor and property are located in the United States, the supplier (that is, the workers or, for property, the owners) may be either U.S. residents or residents of foreign countries.

Heating degree days (HDD): A measure of how cold a location is over a period of time relative to a base temperature, most commonly specified as 65 degrees Fahrenheit. The measure is computed for each day by subtracting the average of the day's high and low temperatures from the base temperature (65 degrees), with negative values set equal to zero. Each day's heating degree days are summed to create a heating-degree-day measure for a specified reference period. Heating degree days are used in energy analysis as an indicator of space heating energy requirements or use.

See the EIA glossary for other definitions.

Methodology used in this analysis

With the exception of Figures 2 and 9, the data in this report are directly from the published values in the EIA's *Monthly Energy Review* (MER) or based on relatively simple calculations, such as CO2/Btu. The methodology of Figures 2 and 9 is as follows:

Figure 2. *Changes in CO2 emissions attributed to Kaya Identity factors from 2016 to 2017 compared with the trend from the prior decade*: This figure gives context to the most recent year-to-year change by comparing it with the average change for key parameters over the previous decade. The key parameters are population, per capita GDP (GDP/population), energy intensity, and carbon intensity of the energy supply—which are the factors in the Kaya Identity. The changes in these key parameters determine changes in energy-related CO2. By comparing the rate of change for each parameter from 2016 to 2017 with the average rate of change for that parameter for the previous decade, the contribution of each parameter to the overall deviation from trend can be calculated. The table below summarizes the rates of change used in the calculations. The larger the positive value, the greater the increase in emissions. The larger the negative value, the lesser the increase in emissions.

Parameter	Previous decade annual % change	2016–2017 % change
Population	+0.8	+0.7
Carbon intensity (CO2/Btu)	-1.1	-1.1
Per capita GDP (GDP/pop.)	+0.6	+1.5
Energy intensity (Btu/GDP)	-1.5	-2.0
Change in energy CO2	-1.3	-0.9

Sources: Population, U.S. Bureau of the Census; Carbon intensity, EIA; Per capita GDP, Bureau of Economic Analysis and U.S. Bureau of the Census; Energy intensity, EIA.

Figure 9. *Electricity generation CO2 savings from changes in the fuel mix since 2005*: This figure shows the emissions savings from two factors that have resulted in decreases in emissions from 2005 to 2017, while total generation has risen slightly. The first factor is the shift within fossil fuel generation from coal to natural gas. The second factor is the increase in non-carbon electricity generation.

To capture this CO2 savings from the shift to natural gas, the fossil fuel carbon factor (fossil fuel CO2/fossil fuel generation) remains constant at the 2005 level. This factor is then multiplied by the actual fossil fuel generation for subsequent years. The difference between that value and the actual value for fossil fuel-generated CO2 emissions is the savings in that year. For example, the carbon factor in 2005 for fossil fuel generation was 0.851 metric tons per megawatthour (mt/MWh). By 2017, the carbon intensity had declined to 0.712 mt/MWh. Multiplying the 2005 value by the 2017 level of generation yields 2,130 million metric tons (MMmt) of CO2, versus the actual value of 1,781 MMmt.

Therefore, the savings from the shift to natural gas is estimated to have been 348 MMmt of CO2 in 2017.

Because non-carbon generation (the second factor) has a zero-carbon factor for direct emissions, the overall reduction in total carbon intensity was applied to total generation, i.e., multiplying total generation by the 2005 value of 0.608 mt/MWh. The savings in fossil fuel generation was subtracted from the total, and the difference was credited to non-carbon electricity generation. For example, the total savings in 2017 was 674 MMmt, so the amount allocated to non-carbon generation (674 MMmt minus 348 MMmt) equals 325 MMmt of CO2.