Independent Statistics & Analysis
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U.S. Energy-Related Carbon Dioxide Emissions, 2013

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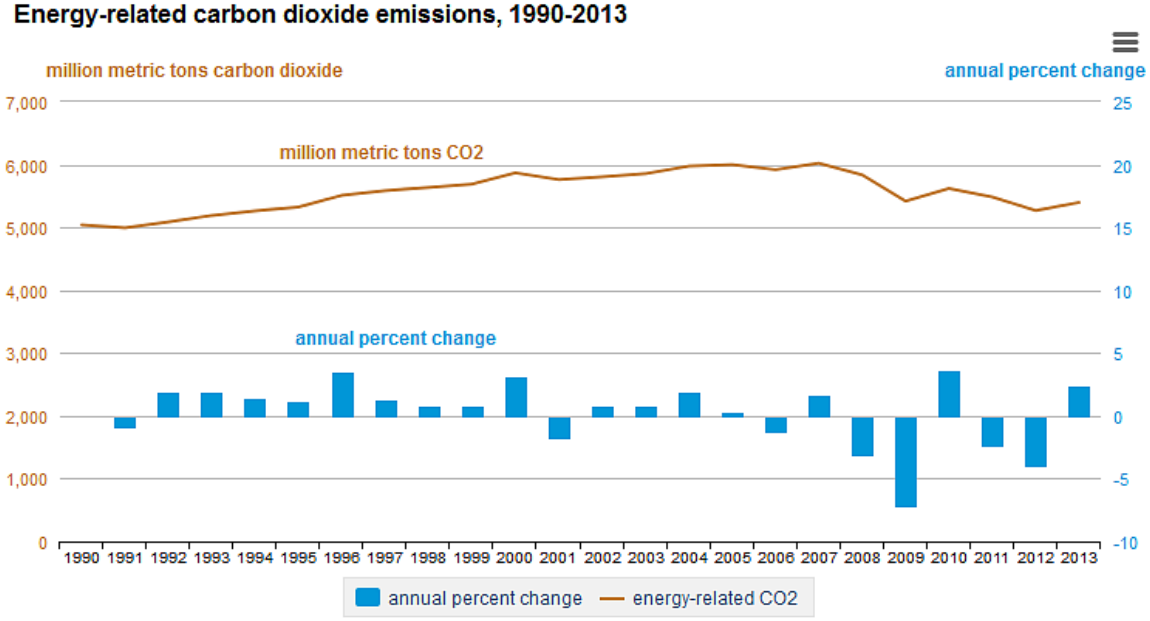
U.S. ENERGY-RELATED CARBON DIOXIDE EMISSIONS INCREASED 2.5% IN 2013

- Energy-related carbon dioxide emissions (CO_2) increased from 5,267 million metric tons (MMmt) in 2012 to 5,396 MMmt in 2013 (2.5%).
- The 2013 increase was largely the result of colder weather leading to an increase in energy intensity (energy measured in Btu per dollar of gross domestic product [GDP]) from 2012.
- Heating degree days were up 18.5% in 2013 versus 2012.
- In only three years since 1990 have emissions increased more: 1996, 2000, and 2010.
- The average delivered price of natural gas to electric generators rose from $3.54 per million Btu (MMBtu) in 2012 to $4.49 per MMBtu in 2013 as average delivered coal prices declined from $2.38 per MMBtu in 2012 to $2.35 per MMBtu in 2013; these price changes shifted some plant dispatch decisions, increasing the share of generation from coal-fired units.
- Despite the increase over 2012, emissions in 2013 were still 10% below their 2005 level.

Energy-related carbon dioxide emissions, 1990-2013



Source: U.S. Energy Information Administration, *Monthly Energy Review* (September 2014), Table 12.1.

Note: All data in this analysis refers to the *Monthly Energy Review* of September 2014 unless otherwise indicated. Because of slightly differing coverage and data vintage, percent changes may differ slightly with other U.S. Energy Information Administration (EIA) publications. Data on heating and cooling degree days are from the Short-Term Energy Outlook, October 2014.

ENERGY INTENSITY WAS THE BIG DIFFERENCE WHEN COMPARED WITH TREND

Emissions trends reflect a combination of economic factors:

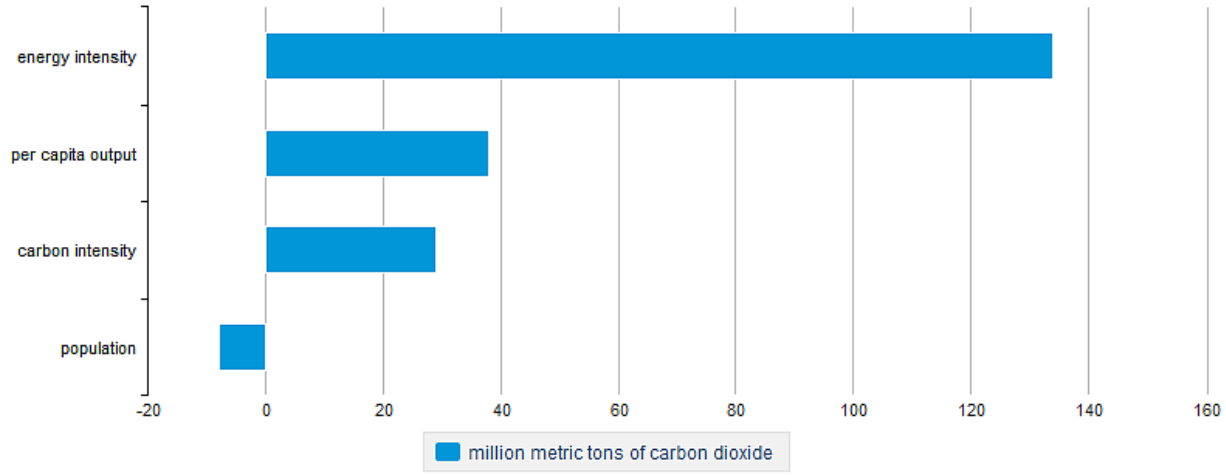
- population
- per capita output (GDP/population)
- energy intensity (energy use per dollar of GDP)
- carbon intensity (CO_2 emissions per unit of energy)

The sum of the changes in these factors approximates the change in total energy-related CO_2. In 2013, several of these factors varied from the trend of the previous decade and this led to the emissions increase.

An increase in energy intensity of 0.5% was a leading cause of the 2013 increase in energy-related CO_2 emissions when compared with the trend from the prior decade (2003-12), which was -2.0%.

- As compared to trend, the increase in energy intensity added about 134 MMmt of CO_2 to the atmosphere.
- Per capita output (GDP/population) contributed 38 MMmt over trend.
- Carbon intensity (CO_2 per Btu of energy consumed), although it did decline, declined less than the 2003 to 2012 time period and led to an increase of about 29 MMmt of CO_2 as compared to trend.
- With population growth of about 0.7%, this put slight downward pressure on emissions growth as compared to the previous trend (-8 MMmt).
- The net effect was that energy-related CO_2 emissions in 2013 were about 193 MMmt higher than they would have been had the trend from 2003 to 2012 held.

Changes in emissions attributed to key drivers from 2012 to 2013 as compared with the trend from 2003 to 2012



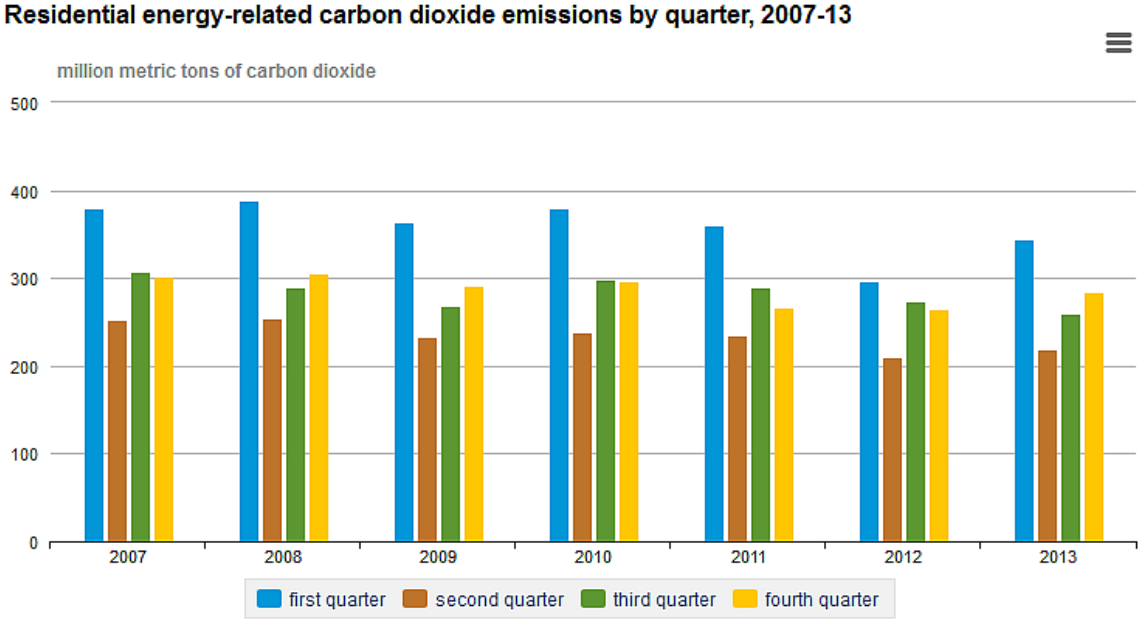
Source: U.S. Energy Information Administration, *Monthly Energy Review* (September 2014), Tables 12.1 and 1.1.
Population growth for 2013, Census Bureau as of September 3, 2014. GDP, Bureau of Economic Analysis, as of July 31, 2014.

A REVERSAL FROM THE MILD HEATING SEASON OF 2012 INCREASED RESIDENTIAL ENERGY DEMAND AND RELATED EMISSIONS IN 2013

Weather played an important role in the year-to-year increase in CO_2 emissions. Residential emissions were up the most of any sector -- 62 MMmt or 48% of the total emissions increase across sectors.

- Residential sector emissions increased from 2012 especially in the first quarter.
- In the second quarter emissions were about the same as in 2012.
- In the third quarter, a cooler summer than in 2012 led to lower emissions in 2013.
- In the fourth quarter they were again higher as the weather continued to be colder than 2012.

Residential energy-related carbon dioxide emissions by quarter, 2007-13



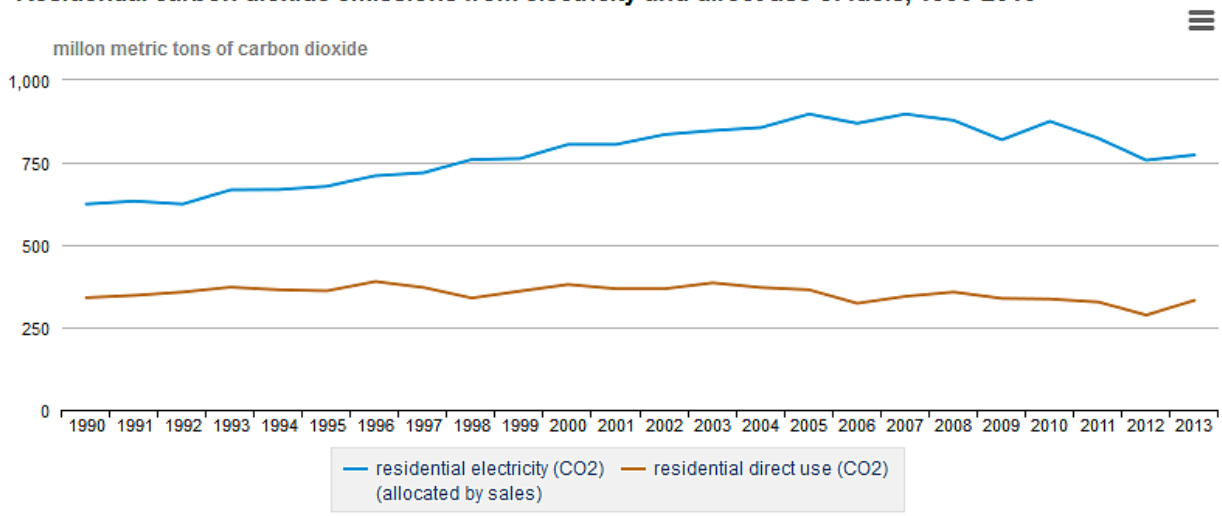
Source: U.S. Energy Information Administration, *Monthly Energy Review* (September 2014), Table 12.2.

RESIDENTIAL EMISSIONS INCREASED FROM BOTH DIRECT USE AND ELECTRICITY-RELATED ENERGY

Residential sector electricity consumption was higher in 2013 than in 2012, however direct use of heating fuels increased by a greater percentage.

- Although cooling degree days (CDD) were much lower (12.8%) for the year compared with 2012, there was a 2.2% increase in electricity-related emissions as electricity retail sales to the residential sector sales were up by 1.2% and the carbon intensity of generation increased by 1%. As compared to 2012, the colder weather in 2013 contributed to increased electricity consumption in regions that heat with electricity.
- The larger emissions increase on a percentage basis was from direct use energy (total minus electricity-related) that rose about 16% in 2013.
- Despite the 2013 increase, residential sector electricity-related carbon dioxide emissions remained below their level from 2000 through 2011 and, with the exception of 2006, direct use emissions remained below their level from 1990 through 2010.

Residential carbon dioxide emissions from electricity and direct use of fuels, 1990-2013



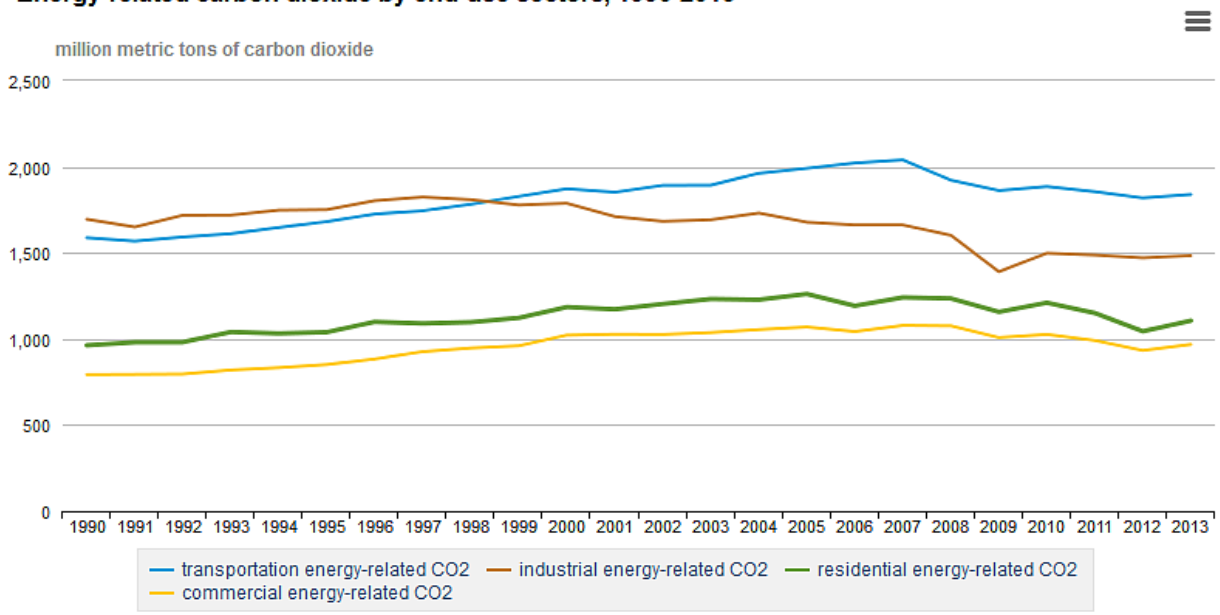
Sources: U.S. Energy Information Administration, *Monthly Energy Review* (September 2014), Table 12.2.

THE COMMERCIAL SECTOR SAW THE NEXT LARGEST INCREASE IN ENERGY CONSUMPTION AND RELATED CO_2 EMISSIONS

After the residential sector, the next biggest increase in CO_2 emissions was from the commercial sector – 36 MMmt or 28% of the total increase.

- Indirect CO_2 emissions from the use of electricity in the commercial sector increased by 1.8% (13 MMmt), which was 37% of the total sector increase.
- However direct CO_2 emissions increased 11% (22 MMmt) for 63% of the total sector increase.
- The commercial sector like the residential sector, was affected by increased use of energy for heating and cooling between 2012 and 2013. Economic growth also contributed to increased energy consumption.
- Overall commercial sector energy demand increased 3.7% and CO_2 emissions increased by 3.8%.

Energy-related carbon dioxide by end-use sectors, 1990-2013



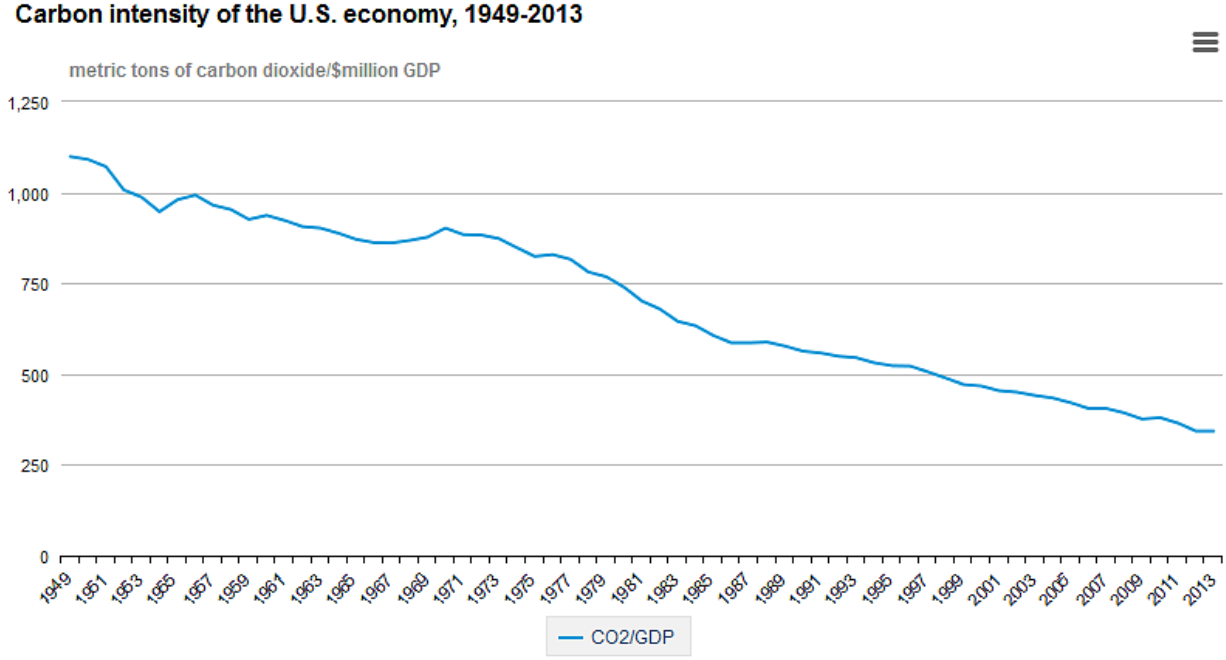
Source: U.S. Energy Information Administration, *Monthly Energy Review* (September 2014), Table 12.2 to 12.5.

THE OVERALL INCREASE IN THE CARBON INTENSITY OF THE U.S. ECONOMY WAS SLIGHT IN 2013

The combined increase in energy use per dollar of GDP (0.5%) minus the reduced carbon intensity of the energy supply (-0.3%) meant that the overall carbon intensity of the economy (CO_2 per dollar of GDP) increased about 0.2% in 2013.

- Although the increase was only slight, it was in contrast to most recent years that have experienced declines.
- There was increased consumption of heating fuels because of a cold first quarter in 2013 – leading to increased energy intensity as compared with 2012 when a warm first quarter reduced energy demand compared with past periods with normal weather.
- Growth in energy-related CO_2 (2.5%) just slightly exceeded the growth in the economy (2.2%).

Carbon intensity of the U.S. economy, 1949-2013



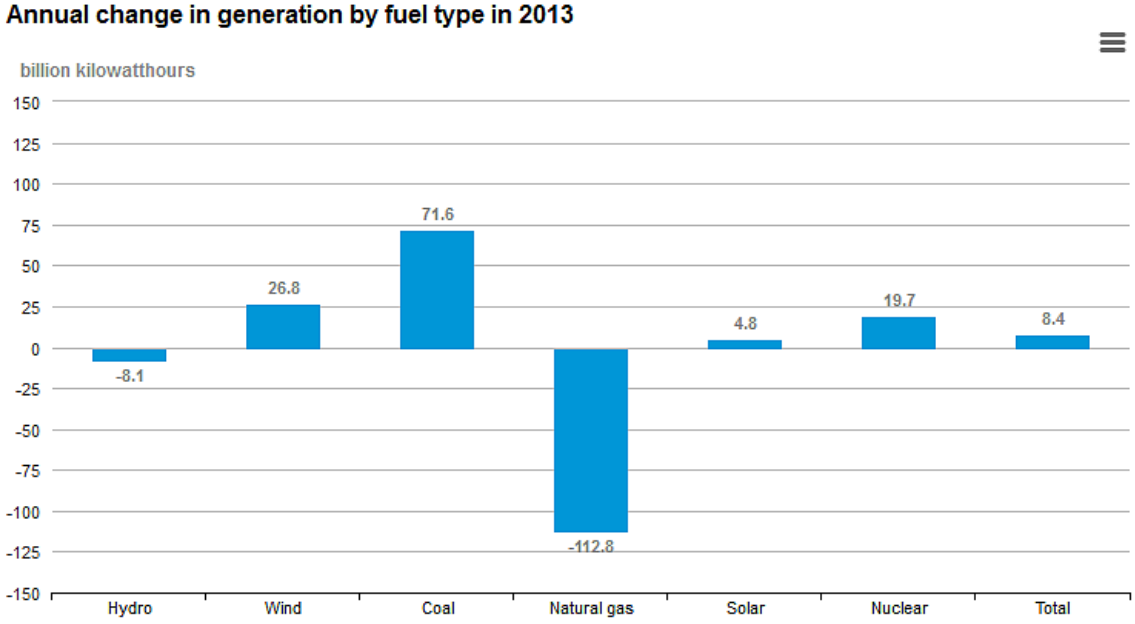
Sources: 1949 - 2011, (2011) *Annual Energy Review* (September 2012), Table D1, 2012-2013 *Monthly Energy Review* (September 2014), Table 12.1; GDP, Bureau of Economic Analysis, chained 2009 dollars as of July 31, 2014.

A 2013 RISE IN NATURAL GAS PRICES SHIFTED SOME PLANT DISPATCH DECISIONS, RESULTING IN MORE COAL-FIRED GENERATION

Because the generation of electricity, which is widely used in all sectors except transportation, is an important source of emissions, changes in the carbon intensity of electricity generation affects emissions throughout the economy.

- Coal-fired generation increased 4.8% in 2013, as natural gas generation fell by 10%.
- There was an increase in wind, solar and nuclear generation and only a slight decline in hydropower generation.
- So despite the increase in coal generation, the carbon intensity of the electric power supply rose less than one percent.

Annual change in generation by fuel type in 2013



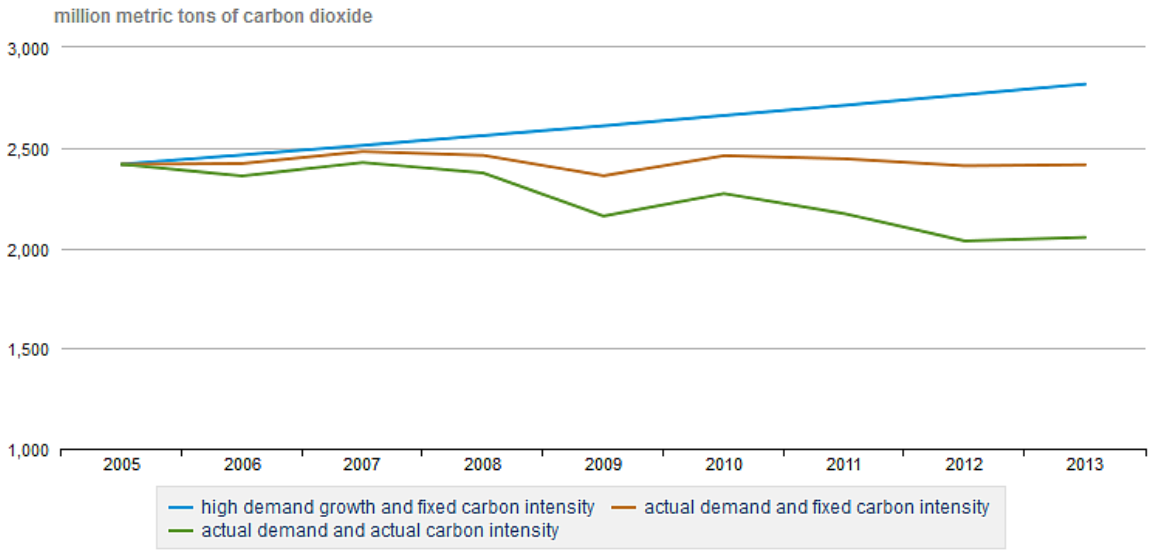
Source: U.S. Energy Information Administration, *Monthly Energy Review* (September 2014), Table 7.2b.

THE POWER SECTOR HAS HELPED TO STABILIZE OVERALL ENERGY-RELATED CARBON DIOXIDE EMISSIONS SINCE 2005

Despite the uptick in emissions in 2013, there has been an overall decrease in energy-related CO_2 since 2005. The electric power sector has contributed to this.

- Both lower demand growth compared to the 1996-2005 trend and lower carbon intensities since 2005 have played a role in mitigating emissions growth. Without these two factors decreasing, power sector emissions would have been about 2,817 MMmt CO_2 in 2013 (top line below).
- Reduced electricity demand growth from the 1996-2005 trend meant CO_2 emissions in 2013 would have been about 2,415 MMmt had the carbon intensity not also fallen (middle line below).
- When added to the lower demand growth, the lower carbon intensity produced actual CO_2 emissions of 2,053 MMmt in 2013 (bottom line below).

Carbon dioxide emissions from the electric power sector actual versus two hypothetical cases, 2005-13

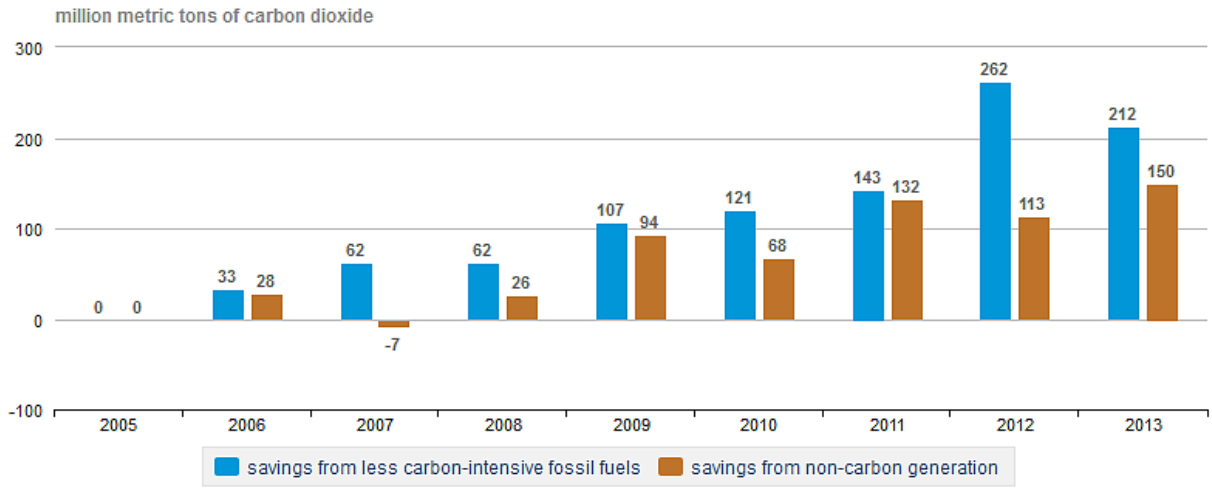


Sources: U.S. Energy Information Administration, *Monthly Energy Review* (September 2014), Table 12.1.
U.S. Energy Information Administration, *Annual Energy Review* (September 2012), Table D1. Census Bureau for 2011 and 2012. GDP, Bureau of Economic Analysis, as of July 31, 2014.

INCREASED USE OF NATURAL GAS AND THE GROWTH IN RENEWABLES HAVE CONTRIBUTED TO THE DECLINE IN POWER SECTOR CARBON INTENSITY

- There are two basic factors that have contributed to lower carbon intensity (CO_2/kilowatthour [kWh]) in the electric power sector: 1) substitution of the less-carbon-intensive natural gas for coal and petroleum, and 2) growth in non-carbon generation, especially renewables such as wind and solar.
- These two factors, when applied to the lower electricity demand growth, produced actual CO_2 emissions of 2,053 MMmt in 2013 in the power sector. In total, over a billion metric tons of CO_2 emissions have been averted in the 8 years since 2005 by the two factors that contributed to the decline in the carbon intensity of the electric power sector.

Electric power sector carbon dioxide savings since 2005 from less carbon-intensive fossil fuels and from non-carbon generation, 2005-13



Source: U.S. Energy Information Administration, Monthly Energy Review (September 2014), Tables 12.1 and 1.1.
Population growth, Census Bureau as of September 3, 2014. GDP, Bureau of Economic Analysis, as of July 31, 2014.

IMPLICATIONS OF THE CARBON DIOXIDE EMISSIONS INCREASE IN 2013 FOR FUTURE EMISSIONS

It is difficult to draw conclusions from one year of data. Specific circumstances such as the 18.5% increase in heating degree days between 2012 and 2013 and the increase in coal in the generation mix relative to 2012 affected the year-to-year change. In the longer term, other factors, such as improvements in vehicle fuel efficiency and increased use of renewable generation, could play a continuing role in subsequent years and help to mitigate future emissions growth.

For EIA projections on emissions and their key drivers see either the Short-Term Energy Outlook, updated monthly with projections through 2015 (2016 beginning in January 2015) or the Annual Energy Outlook with annual projections through 2040. EIA's International Energy Outlook contains current projections of international energy consumption and emissions through 2040.

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

Terms used in this analysis:

British thermal unit (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. It is most commonly applied to the economy as a whole, where output is measured as the gross domestic product (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 measured using the full weight of the carbon dioxide emitted (CO_2/GDP).

Carbon intensity (energy supply): The amount of carbon by weight emitted per unit of energy consumed. A common measure of carbon intensity is weight of carbon per Btu of energy. When there is only one fossil fuel under consideration, the carbon intensity and the emissions coefficient are identical. When there are several fuels, carbon intensity is based on their combined emissions coefficients weighted by their energy consumption levels. Note: this value is currently measured using the full weight of the carbon dioxide emitted (CO_2/energy or CO_2/Btu).

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. It is most commonly applied to the economy as a whole, where output is measured as the gross domestic product (GDP) and energy is measured in Btu to allow for the summing of all energy forms (energy/GDP or Btu/GDP). On an economy-wide level, it is reflective of both energy efficiency as well as the structure of the economy. Economies in the process of industrializing tend to have higher energy intensities than economies that are 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 and, 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.

For other definitions see the EIA glossary.

Note: This analysis uses MMmt as the abbreviation for million metric tons. This abbreviation is used for consistency with other EIA abbreviations – e.g., million short tons (MMst).