U.S. Energy Information Administration
Independent Statistics and Analysis

U.S. Carbon Dioxide Emissions in 2009: A Retrospective Review

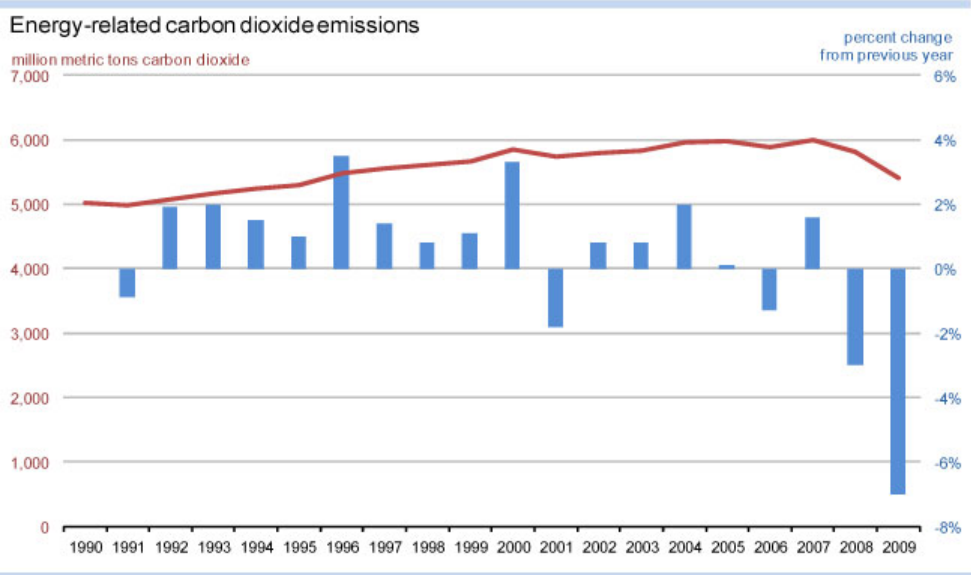
Release Date: May 5, 2010
Next Release Date: May 2011

print version

The U.S. Energy Information Administration (EIA) recently expanded its reporting of energy-related carbon dioxide emissions starting in the fall of 2009. This analysis examines the level and drivers of energy-related carbon dioxide emissions in 2009.

What happened to carbon dioxide emissions from energy use in 2009?

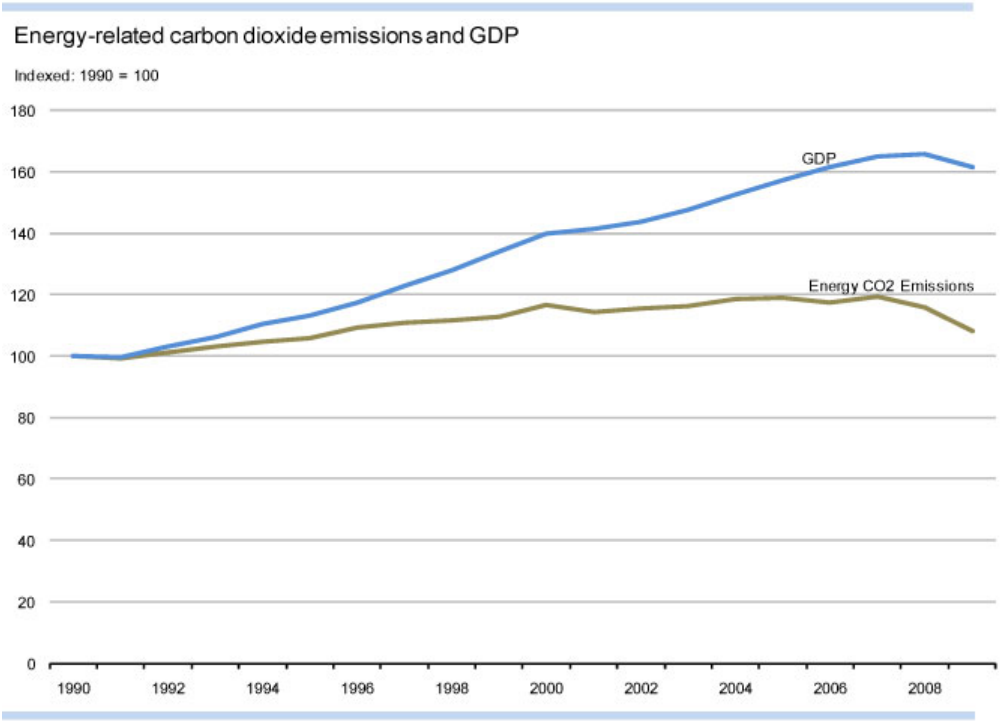
In 2009, energy-related carbon dioxide emissions in the United States saw their largest absolute and percentage decline (405 million metric tons or 7.0 percent) since the start of EIA's comprehensive record of annual energy data that begins in 1949, more than 60 years ago. While emissions have declined in three out of the last four years, 2009 was exceptional. As discussed below, emissions developments in 2009 reflect a combination of factors, including some particular to the economic downturn, other special circumstances during the year, and other factors that may reflect persistent trends in our economy and our energy use.



Source: Monthly Energy Review, (April 2010) Table 12.1 | Chart data

How much of the recent decline has been related to lower economic growth?

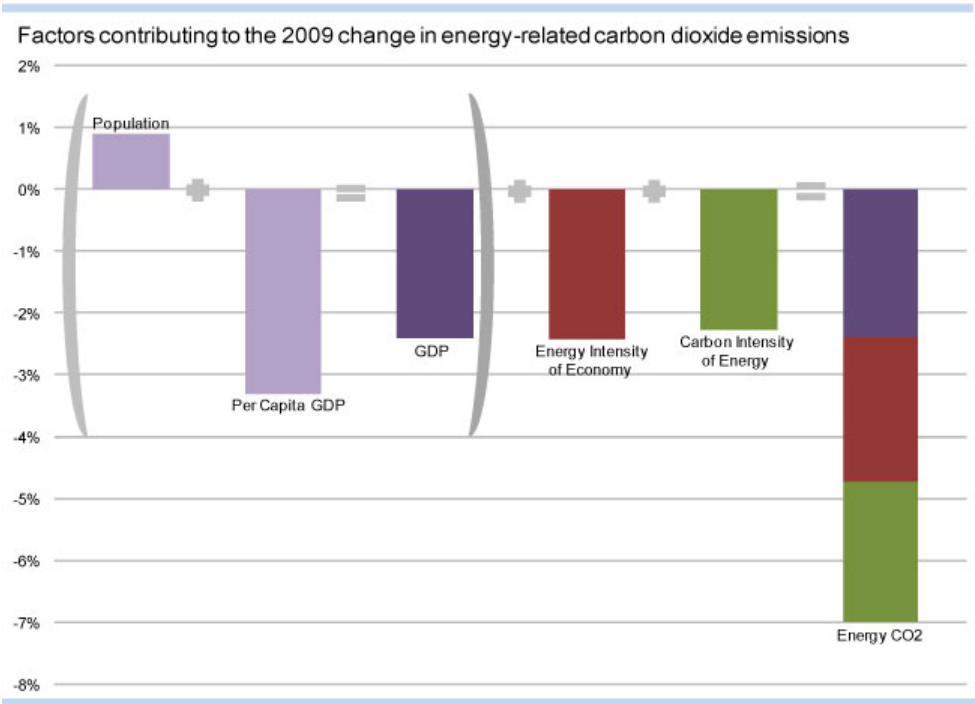
In contrast to the 0.9 percent average annual emissions decline from 2000 to 2009, the prior 1990-to-1999 time period saw U.S. energy-related carbon dioxide emissions grow on average by 1.4 percent per year. Robust GDP (Gross Domestic Product) growth (3.3 percent annually) from 1990 to 1999 on average dropped by half (to 1.6 percent) from 2000 to 2009, particularly due to the recent economic downturn. However, even with the reduction in economic growth since 2000, emissions would nonetheless have grown by 0.6 to 0.7 percent annually had the proportional relationship between economic and emissions growth remained the same as during the 1990s.



Source: CO2 Emissions, Monthly Energy Review, (April 2010) Table 12.1;
Gross Domestic Product (GDP), Bureau of Economic Analysis, WWW.BEA.GOV,
Population growth for 2009 estimated based on 2008. | Chart data

What factors caused the large drop in 2009 emissions?

Changes in carbon dioxide emissions can be decomposed into changes in four major contributing factors: population, per capita GDP, energy intensity of the economy, and carbon intensity of the energy supply*. All of these fell in 2009 except for population. Population grew 0.9 percent.** The downturn of the economy caused per capita GDP to fall (3.3 percent) resulting in a total GDP decline of 2.4 percent. Energy intensity and the carbon intensity of the energy supply also both fell more than 2 percent. These three factors (GDP, energy intensity, and carbon intensity) combined in roughly equal proportions to cause emissions to fall by 7.0 percent.



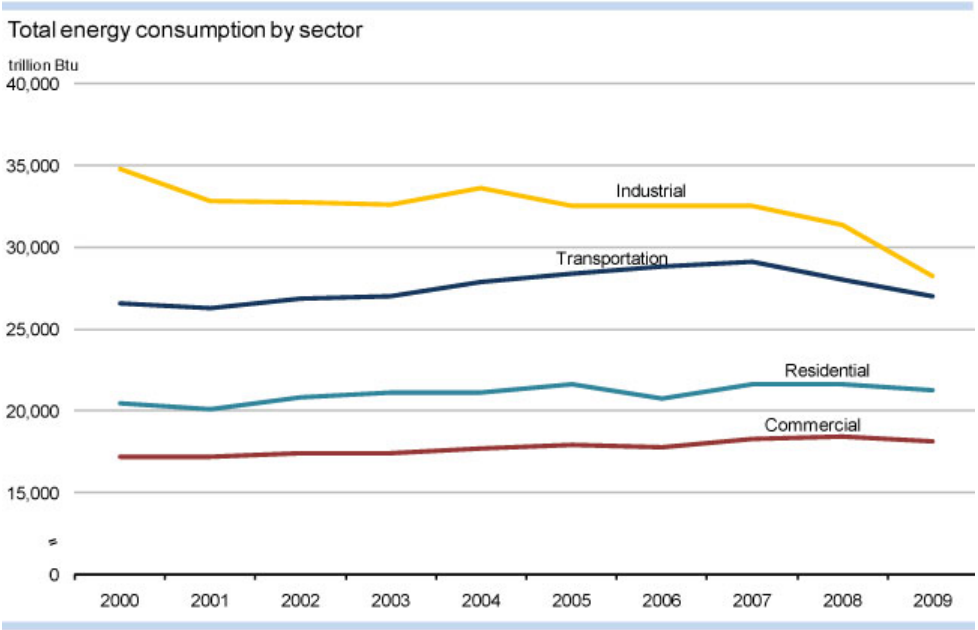
Source: CO2 Emissions, Monthly Energy Review (April 2010) Table 12.1; Gross Domestic Product

(GDP) Bureau of Economic Analysis, www.bea.gov, Population growth for 2009 estimated based on 2008. | Chart data

*Energy intensity is defined as energy consumed per unit of economic activity (Btu/GDP). Carbon intensity of energy is defined as carbon dioxide emissions per unit of energy consumed (CO2/Btu). The term carbon intensity is sometimes used elsewhere to describe the overall carbon intensity of the economy (CO2/GDP).
** Population growth was estimated as 0.9 percent, the same growth rate as 2008.

Why did the energy intensity of the economy decline in 2009?

Total energy consumption fell across all end-use* sectors by 4.8 percent, attributable to a decline in energy intensity of around 2.4 percent, plus a decline in GDP of 2.4 percent. While this drop in energy intensity was large, it is not unprecedented. The average decline in energy intensity from 2000 to 2008 was 2.0 percent. The economic decline did not affect the other sectors as much as the industrial sector, which saw the greatest drop in energy consumption – 9.9 percent.

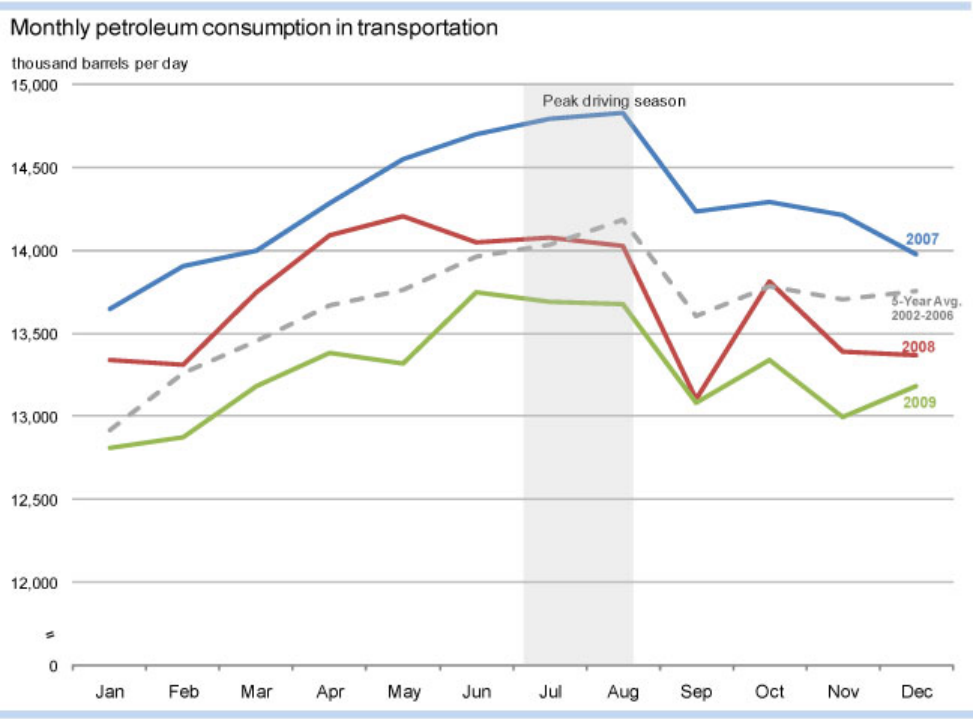


Source: Monthly Energy Review, (April 2010) Table 2.1 | Chart data

*End-use sector energy consumption includes purchased electricity.

What's behind falling energy demand in the transportation sector?

About 95 percent of the energy consumed in the transportation sector is petroleum – motor gasoline alone accounts for about 60 percent of total transportation energy use. Total consumption of petroleum-based fuels in 2007 averaged 14,287 thousand barrels per day. By 2008 that had fallen to 13,712 thousand barrels per day and by 2009 to 13,277 barrels per day – 7.1 percent lower than 2007 and 3.2 percent lower than 2008. In 2008 the drop in demand was caused primarily by a spike in fuel prices during the first half of the year followed by an accelerating economic slide. In 2009 the continuing economic downturn further lowered demand despite average fuel prices that remained well below their 2008 level. According to preliminary Department of Transportation data the fuel economy of the total U.S. fleet improved from 27 miles per gallon in 2008 to 28.5 miles per gallon in 2009.*

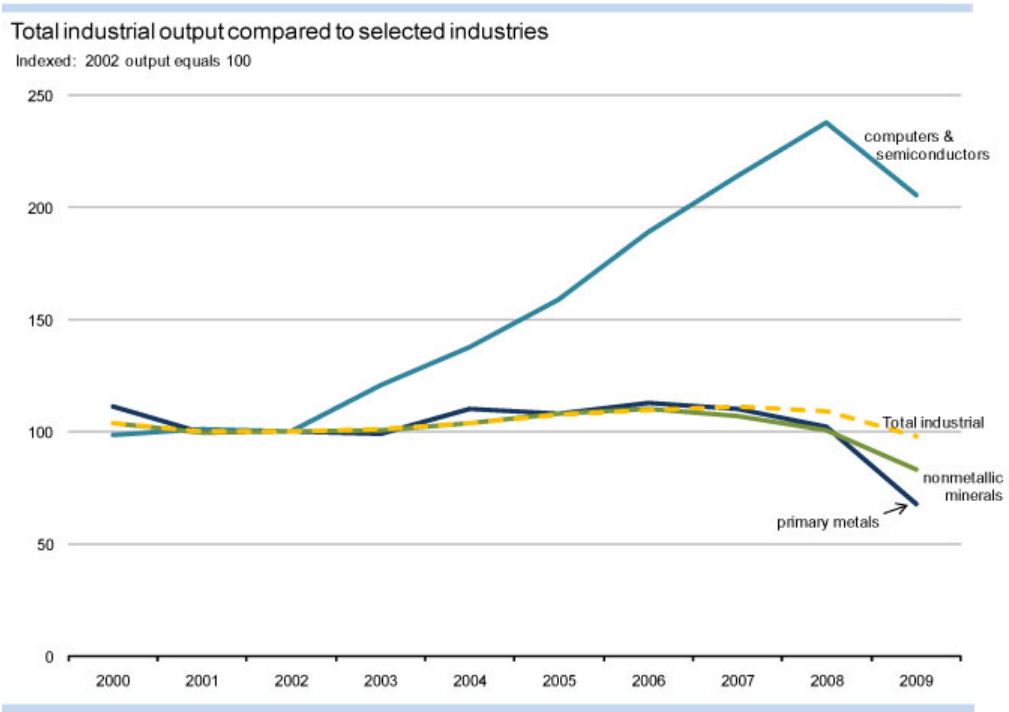


Source: Monthly Energy Review, (April 2010) Table 3.7c | Chart data

*U.S. Department of Transportation, NHTSA, *Summary of Fuel Economy Performance*, December 9, 2009

Why did energy consumption in the industrial sector fall so much in 2009?

Recent industrial growth has been led by industries such as computers and electronic equipment. Output from energy-intensive industries such as primary metals (-33.9 percent) and nonmetallic minerals (-17.4 percent) fell much faster than total industrial production (-9.8 percent). This recent decline in industrial energy use reflects the combined effect of the downturn in the economy (which has disproportionately impacted energy-intensive industries) and the continuation of a long-term trend of growth in the service sector relative to the industrial sector of the U.S. economy.

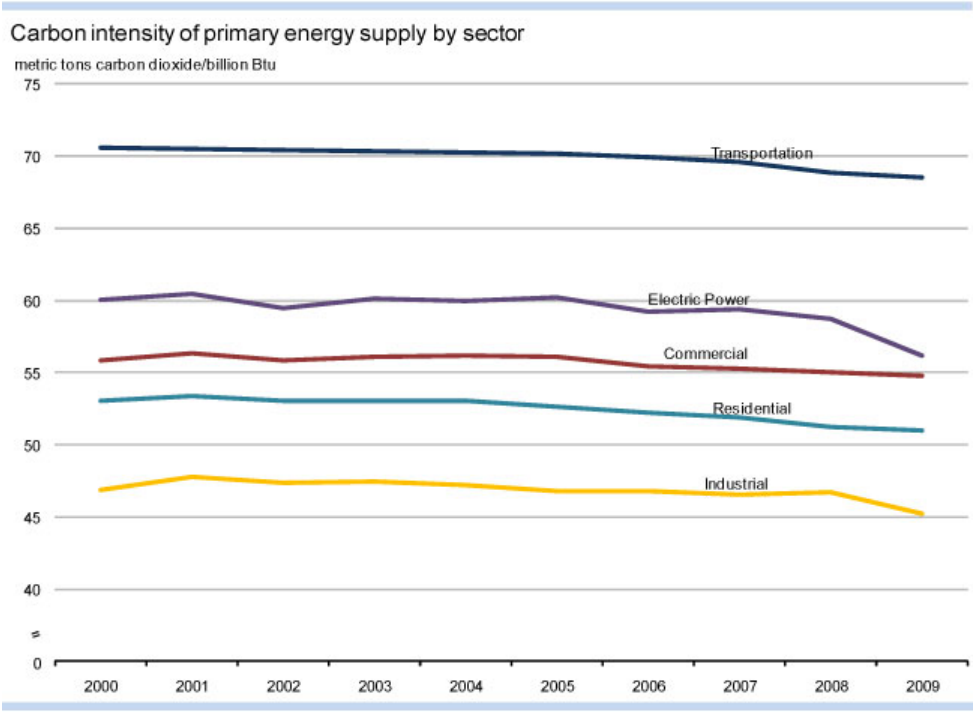


Source: Federal Reserve Board, http://www.federalreserve.gov/releases/G17/download.htm | Chart data

What caused the drop in the carbon intensity of energy supply in 2009?

Across all sectors of the economy, decreasing consumption of carbon-emitting fossil fuels resulted in both a lower carbon intensity and lower absolute emissions. Emissions from coal dropped 12.0 percent, petroleum emissions were down 5.3 percent and natural gas emissions were down 1.6 percent. Non-fossil fuel consumption, on the other hand increased about 2 percent.

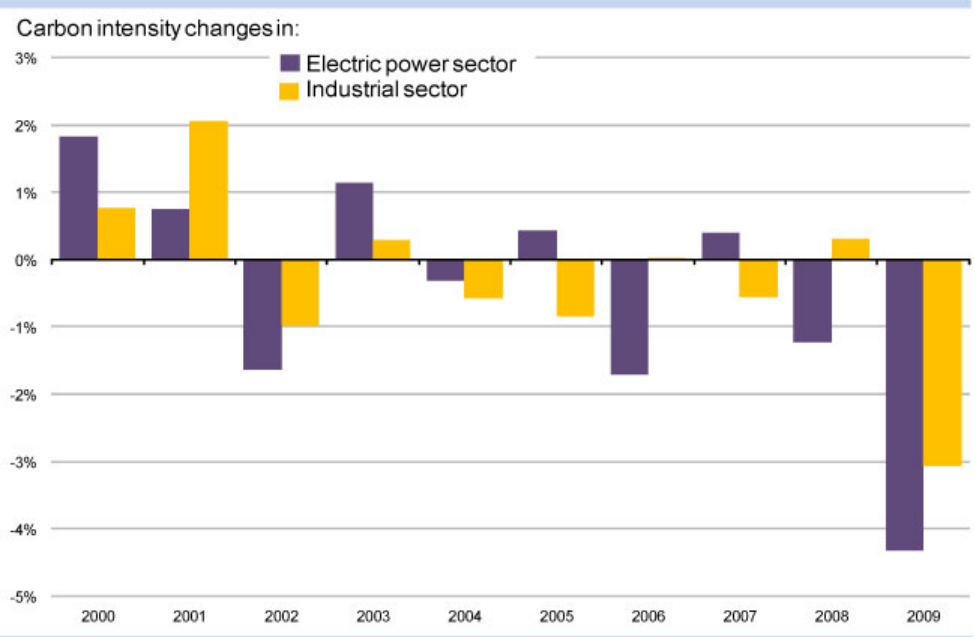
The fuel mix and associated carbon intensity of most sectors have tended to be very stable over time. However, in 2009, the carbon intensity of the electric power sector decreased by nearly 4.3 percent, primarily due to fuel switching as the price of coal rose 6.8 percent from 2008 to 2009 while the comparable price of natural gas fell 48 percent on a per Btu basis. The carbon content of natural gas is about 45 percent lower than the carbon content of coal and modern natural gas generation plants that can compete to supply base load electricity often use significantly less energy input to produce a kilowatt-hour of electricity than a typical coal-fired generation plant. For both of these reasons, increased use of natural gas in place of coal caused the sector's carbon intensity to decrease. The industrial sector, also a large coal consumer, showed a similar decline in carbon intensity in 2009 – over 3 percent – due to lower coal and petroleum consumption.



Source: Monthly Energy Review, (April 2010) Tables 2.1, 12.2 - 12.6 | Chart data

How typical were the carbon intensity changes for the electric and industrial sectors?

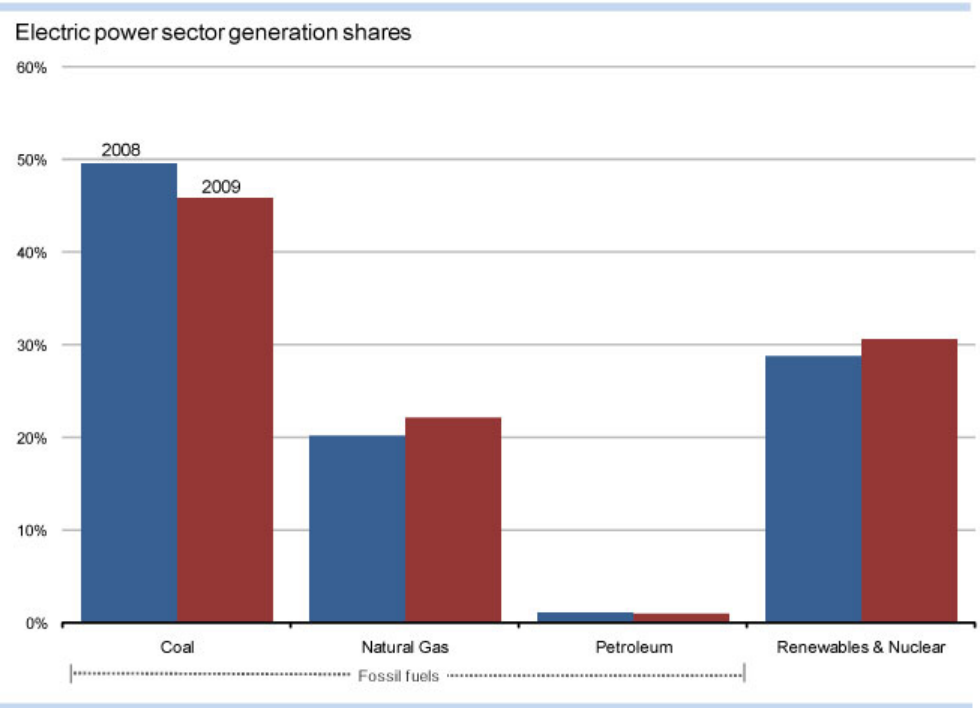
Since 2000, the carbon intensity of energy used in the two sectors has not decreased (or improved) by as much as 2 percent. A decline in carbon intensity of over 4 percent in the electric power sector and over 3 percent in the industrial sector in the same year is unprecedented. This drop in carbon intensity added to the general trend towards a less energy-intensive economy, resulting in the very substantial decline in carbon dioxide emissions in 2009.



Source: Monthly Energy Review, (April 2010) Tables 2.1, 12.4, & 12.6 | Chart data

How did the change in fuel supply mix in the electric power sector impact the carbon intensity of energy supply in 2009?

The 4-percent drop in the carbon intensity of the electric power sector, the largest in recent times, reflects a large increase in the use of lower-carbon natural gas because of an almost 50-percent decline in its price. This reduced coal's share of overall generation. Renewable generation also increased.* Nuclear generation, although down slightly, increased its share of the total. The drop in carbon intensity of the supply combined with lower demand from the economy resulted in carbon dioxide emissions from the electric power sector dropping by 205 million metric tons.

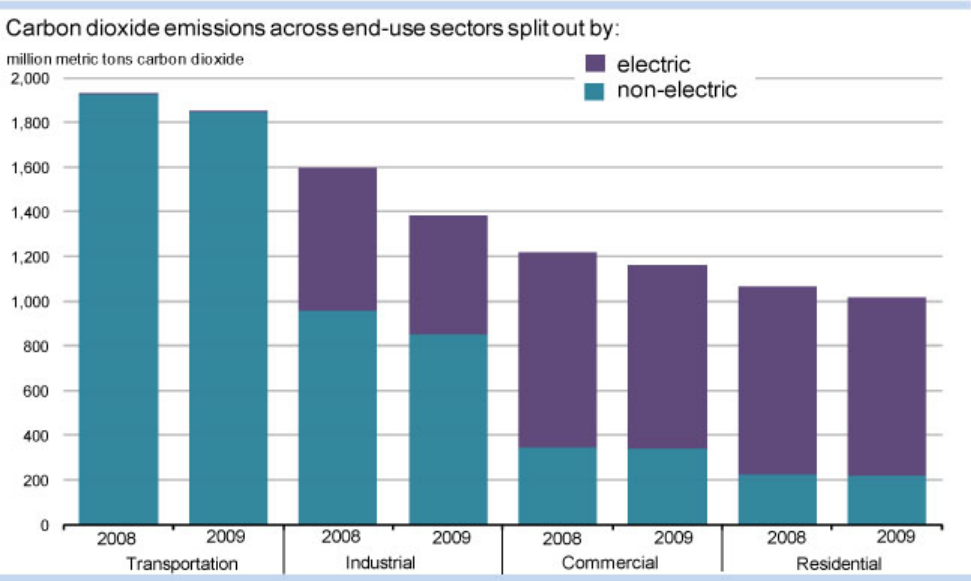


Source: Monthly Energy Review, (April 2010) Table 7.2b | Chart data

*Although biomass-based renewable electricity generation emits carbon dioxide during combustion, this analysis assumes those emissions are offset through biological sequestration, resulting in net-zero emissions.

How does the generation of electric power contribute to emissions across end-use sectors?

The drop in the carbon intensity of the energy mix used to supply electricity impacts end-use sectors where the electricity is consumed. The residential and commercial sectors rely predominantly on electricity and the lowered carbon intensity of the energy supply mitigated emissions in those sectors. Transportation consumes almost no electricity and the industrial sector, while a large electricity consumer, directly consumes about twice the primary energy as it consumes in electrical energy.

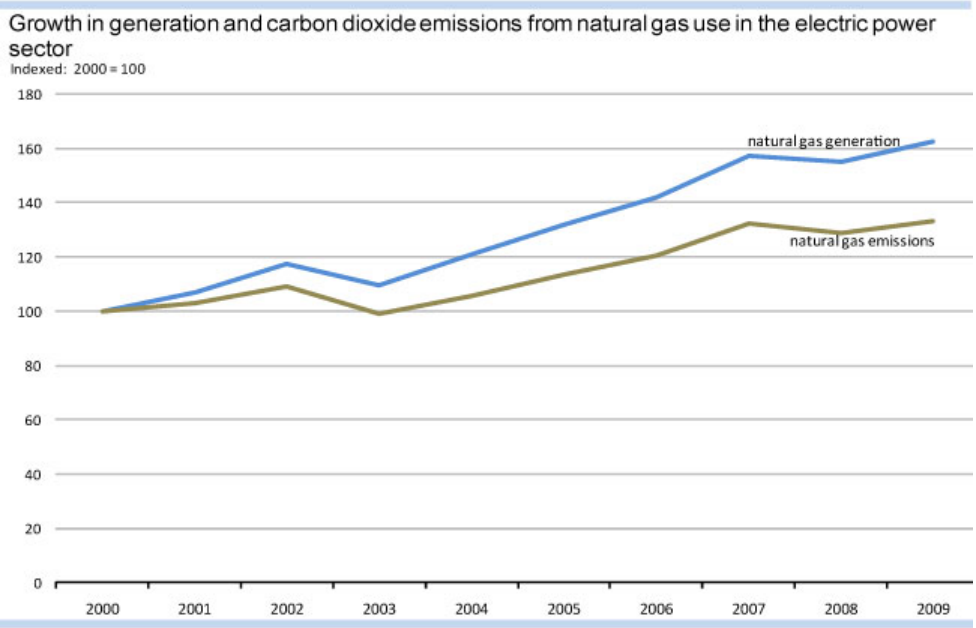


Source: Monthly Energy Review, (April 2010) Tables 12.2 - 12.6 | Chart data

What role have efficiency improvements in natural gas generation played in lower carbon intensity of electric power generation since 2000?

As indicated in the graph below, new and efficient natural gas generators that have come online in recent years have played a large role in lowering the carbon intensity of the electric power sector. From 2000 to 2008, about 120 gigawatts of natural gas combined cycle generation capacity were added.

In 2000, electric power sector generation from natural gas was 518 billion kWh, leading to emissions of 281 million metric tons carbon dioxide. By 2009, generation had risen to 841 billion kWh and emissions were 374 million metric tons. Therefore the emissions intensity fell from 0.542 to 0.445 metric tons per thousand kWh, or by 18 percent. If the emissions intensity had not changed and emissions had risen at the same rate as generation, they would have reached 456 million metric tons in 2009. Therefore, the increased efficiency of new generation capacity resulted in avoided emissions of 82 million metric tons of carbon dioxide.



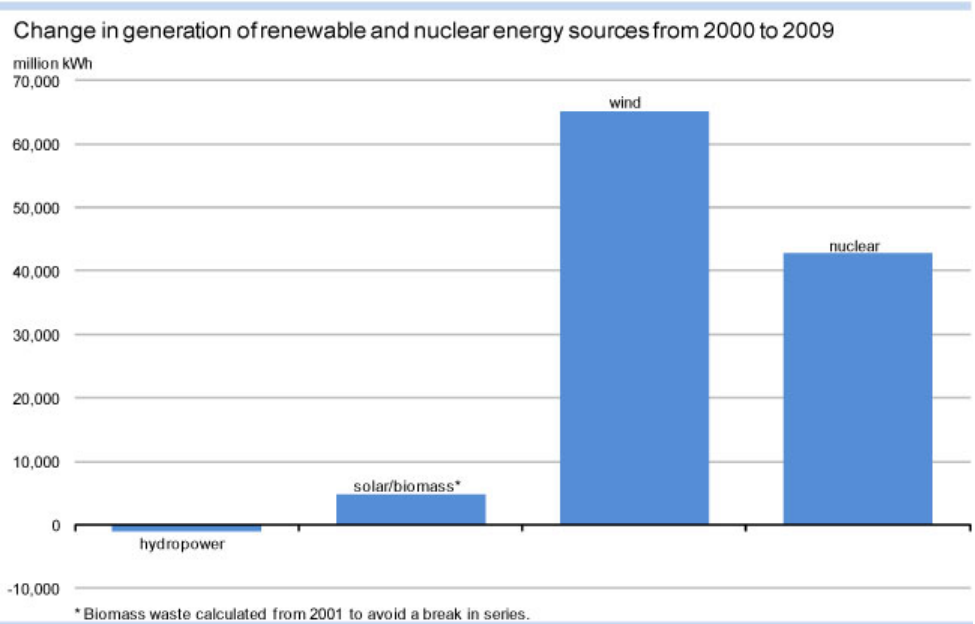
Source: Monthly Energy Review, (April 2010) Tables 7.2b & 12.6 | Chart data

Has generation from renewable and nuclear sources helped to lower emissions intensity?

Wind generation rose by 65,000 million kilowatthours (kWh), from only 6,000 million kWh in 2000 to 71,000 million kWh in 2009. This nearly 11-fold jump places wind second only to hydropower in renewable generation. While no new nuclear capacity has been built in recent years, higher utilization of existing capacity has meant increases in nuclear generation as compared to 2000. While the nuclear generation increases appear to have leveled-off in 2007, nuclear generation had nonetheless grown by 45,000 million kWh between 2000 and 2009.

The recent national average emission rate for all electric generation is around 601 metric tons per million kWh. Thus, increased wind-based generation since 2000 was responsible for about 39 million metric tons of avoided emissions in 2009 relative to electricity supplied at the average emissions rate. Wind generation increased by 15,000 million kilowatthours in 2009 alone.

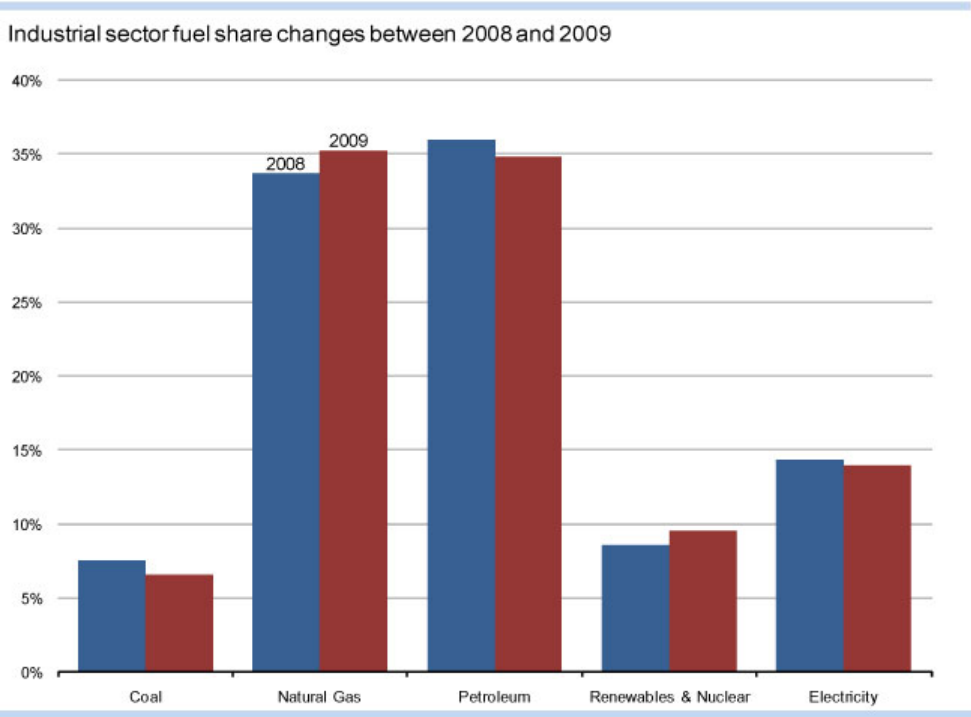
Using the same methodology, the increase in nuclear generation since 2000 would signify an additional 26 million metric tons of emissions avoided in 2009. The avoided emissions from new wind capacity, natural gas efficiency improvements, and nuclear improvements made since 2000 meant about 147 million fewer metric tons of carbon dioxide were emitted in 2009 than would have been the case had these changes not occurred.



Source: Monthly Energy Review, (April 2010) Table 7.2b | Chart data

Did the fuel supply mix impact the industrial sector as well?

Like the electric power sector, the industrial sector experienced a large drop in the carbon intensity of its energy supply in 2009. Consumption of higher-carbon fossil fuels, coal and petroleum, was down, while lower-carbon natural gas and renewable fuel consumption went up. In addition, while the share of energy from the electric power sector fell slightly, the electricity that was delivered was less carbon intensive.

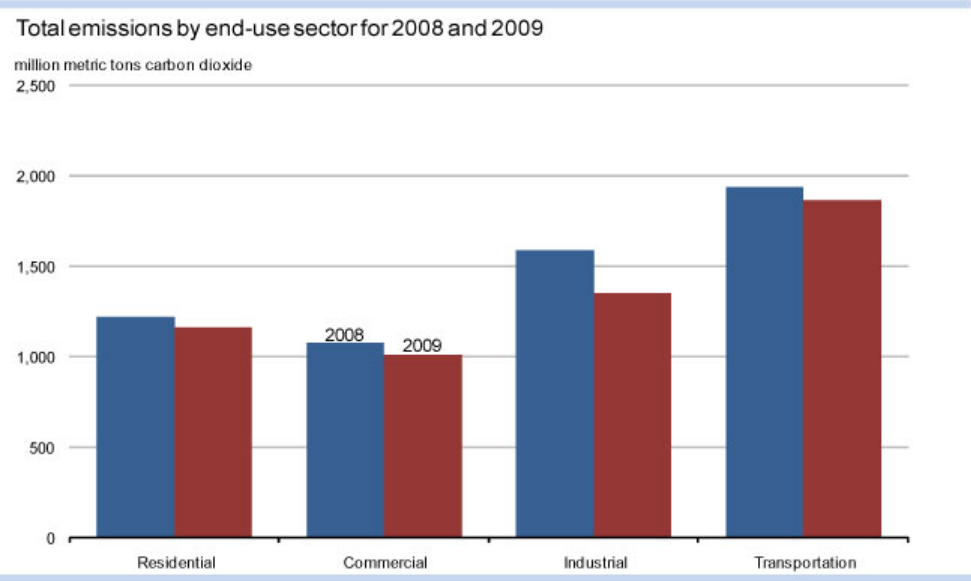


Source: Monthly Energy Review, (April 2010) Table 2.4 | Chart data

What are the implications of the carbon dioxide emissions drop in 2009?

Total emissions of energy-related carbon dioxide fell across all end-use sectors* in 2009, with the drop especially pronounced in the industrial sector. As the economy recovers, the structure of that recovery will be important to the future emissions profile of the United States. If energy-intensive industries lead the economic recovery, emissions would increase faster than if service industries or light manufacturing play the leading role. If coal, which was more heavily impacted by the recent economic downturn than other energy sources, rebounds disproportionately, the carbon intensity of the energy supply could rise above the 2009 level. However, longer-term trends continue to suggest decline in both the amount of energy used per unit of economic output and the carbon intensity of our energy supply, which both work to restrain emissions.

For EIA's projections on emissions and the factors that contribute to their underlying trends, see either our short-term forecast through 2011 that is updated monthly at www.eia.gov/steo, or longer-term projections through 2035 that are updated annually at www.eia.doe.gov/aeo. EIA's projection of international energy consumption and emissions to 2035 can be found at www.eia.gov/ieo.



Source: Monthly Energy Review, (April 2010) Tables 12.2 - 12.5 | Chart data

*End-use sector carbon dioxide emissions from energy consumption include purchased electricity.

All the latest emissions data can now be found in the Monthly Energy Review at www.eia.gov/mer.
Starting in the fall of 2009, the Energy Information Administration (EIA) expanded its reporting of energy-related carbon dioxide emissions in both the *Monthly Energy Review* (MER) and the *Short-term Energy Outlook* (*STEO*). The MER now reports monthly energy-related carbon dioxide emissions derived from our monthly energy data (link) , while the STEO now provides forecasts these emissions to accompany its traditional forecasts of energy use.

Other recent EIA products that report on data, forecasts, and projections for energy-related carbon dioxide emissions include: an October 2009 STEO Supplement, which developed a forecast for 2009 emissions based on reported energy data for the first 7 months of the year; a December 2009 report summarizing emissions of all greenhouse gases in the United States in 2008; and an August 2009 analysis of H.R. 2454, The American Clean Energy and Security Act, which was passed in 2009 by the House of Representatives.

Unlike the October 2009 STEO supplement, which provided a forecast based on part-year data, the MER reflects monthly data for all of 2009. This article addresses issues that had been discussed in previous editions of the annual "flash" estimate of energy-related carbon dioxide emissions, a publication that has been superseded by the enhanced coverage of emissions data in the MER.