Order Code RS22970
October 17, 2008

CRS Report for Congress

Are Carbon Dioxide Emissions Rising More Rapidly Than Expected?

Jane A. Leggett
Specialist in Environmental and Energy Policy
Resources, Science and Industry Division

Jeffrey Logan
Specialist in Energy Policy
Resources, Science and Industry Division

Summary

At least one recent report and numerous news articles suggest that carbon dioxide (CO_2) emissions are rising more rapidly than expected. This contention is often made by comparing recent emissions estimates with the greenhouse gas (GHG) scenarios published by the Intergovernmental Panel on Climate Change (IPCC) in 2000. While CO_2 emissions associated with human activities continue to rise — and may be worthy of alarm because of their influence on climate change — any short-term comparisons between actual emissions and IPCC scenarios miss the mark. First, the IPCC scenarios explicitly are not predictions. Second, the IPCC scenarios are meant to represent different possible GHG trajectories over many decades, and represent smooth emissions paths averaged over at least 10 years. Just as the actual weather over a few years is not necessarily representative of long-term climate, variability of emissions over one or several years is not necessarily representative of long-term trends. Nonetheless, monitoring of CO_2 emissions and concentrations, and analysis of the factors driving changes, is important to designing and evaluating policies to address climate change.

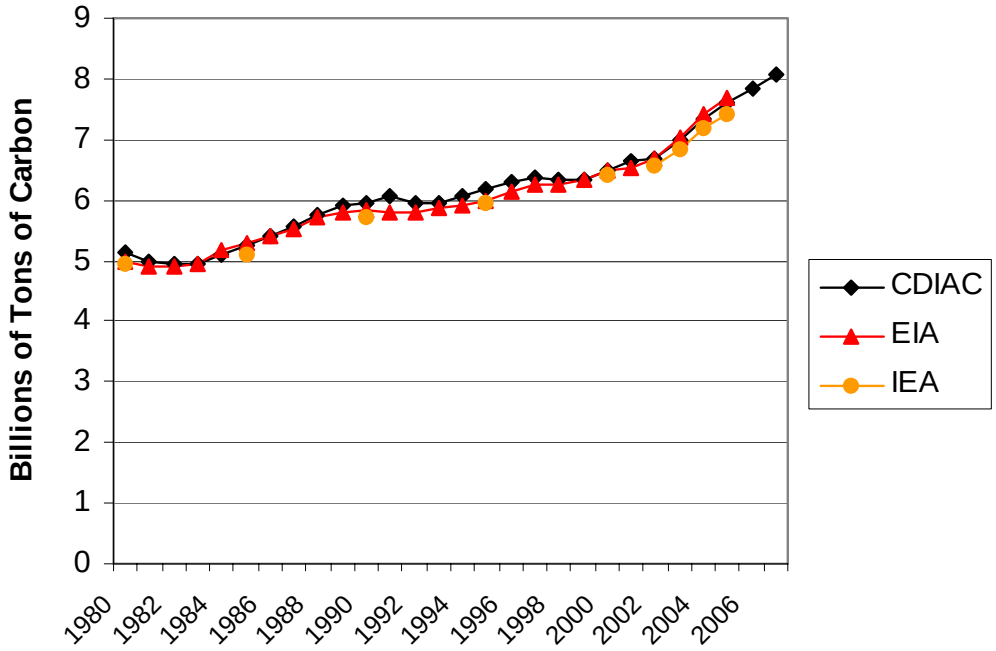
Rising Carbon Dioxide Emissions

At least one recent report and numerous news articles suggest that emissions of carbon dioxide (CO_2) — the leading greenhouse gas (GHG)[1] — are rising more rapidly

[1] For explanation of greenhouse gases and their influence on the Earth's climate, see CRS Report RL33849, *Climate Change: Science and Policy Implications*, by Jane A. Leggett.

than expected.[2] Global CO_2 emissions associated with fossil fuel combustion in 2007 were approximately 8.1 billion metric tons of carbon, compared to estimates of 6.5 billion tons in 2000.[3] Three sources of global emissions estimates are provided in **Figure 1**. The estimates are all similar, but have some degree of uncertainty due to inconsistencies in the quality of energy data provided and estimations made by the compilers.

Figure 1. Global Carbon Emissions from Fossil Fuel Combustion



Source: CDIAC, Carbon Dioxide Informamation Analysis Center [http://cdiac.ornl.gov/]; EIA, Energy Information Administration [http://www.eia.doe.gov/emeu/international/carbondioxide.html]; IEA, International Energy Agency, *CO2 Emissions from Fossil Fuel Combustion 2007* .

There has been a notable increase in the rate of growth of CO_2 emissions this decade. Data from the Energy Information Administration (EIA) indicate that global CO_2 emissions rose at an annual rate of 1.5% during the 1980s, 0.9% during the 1990s,[4] and 3.2% during the first five years of this decade. Emissions increases in 2003 and 2004

---

[2] J. Eilperin, "Carbon Is Building Up in Atmosphere Faster Than Predicted." *The Washington Post*, September 26, 2008. [http://www.washingtonpost.com/wp-dyn/content/article/2008/09/25/AR2008092503989.html] This article was based on a report entitled "Carbon Budget 2007," issued by the Global Carbon Project on September 26, 2008. [http://www.globalcarbonproject.org/carbontrends/index.htm]

[3] Carbon dioxide emissions presented in figures are measured in metric tons of carbon. Carbon measurements can be converted to carbon dioxide units after multiplying by 3.67, the ratio of the molecular weights of carbon dioxide to carbon.

[4] The GHG emissions of the 1990s were strongly influenced by the collapse of the former Soviet Union and Eastern European economies, as well as by restructuring of the energy systems in the United Kingdom.

were particularly pronounced. As noted later, increased coal consumption, especially in developing countries, is one of the main drivers behind the recent surge in emissions.[5]

When CO_2 emissions accumulate in the atmosphere faster than the rate at which they are removed from the atmosphere by "sinks," atmospheric concentrations rise. Scientists have concluded that the increased concentration of greenhouse gases (GHG) over the past century, due to human activities, is likely responsible for most of the global warming observed since the 1970s, and could lead to climate changes over the next century that would be unprecedented in the course of human civilization. The potential impacts of such climate change, including the possibility of non-linear or abrupt effects, cause alarm among many scientists and citizens. Reports that CO_2 emissions may be rising more rapidly than expected often conclude, therefore, that the climate system may be changing sooner than expected.

Comparing CO_2 Emissions with Established Scenarios

Carbon dioxide emissions have been rising, almost continuously, since the beginning of the Industrial Revolution at least 120 years ago. One press report contended that "[t]he rise in global carbon dioxide emissions last year outpaced international researchers' most dire projections"[6] — a statement drawn by comparing annual emissions for the year 2007 (or even a multi-year average from 2000 to 2007) with the GHG scenarios published by the Intergovernmental Panel on Climate Change (IPCC) in 2000.[7] While CO_2 emissions associated with human activities continue to rise — and may be worthy of alarm because of their influence on climate change — a comparison of one or a few years' emissions with the IPCC emissions scenarios misses the mark.

First, the IPCC scenarios are not predictions. The IPCC's *Special Report on Emission Scenarios*[8] (SRES), which produced the CO_2 emissions estimates cited above, stated "[s]cenarios are alternative images of how the future might unfold and are an appropriate tool with which to analyze how driving forces may influence future emission outcomes and to assess the associated uncertainties.... The possibility that any single emissions path will occur as described in the scenarios is highly uncertain." While observed increases in CO_2 emissions merit attention and concern, comparing annual or short-term multi-year emissions with the IPCC GHG scenarios reflects misunderstanding or mischaracterization of the IPCC scenarios (and the models that produce them).

Second, the IPCC exercises are intended to produce scenarios (not predictions) over multiple decades and to provide only long-term averages. The "time steps" of model outputs from the six models that produced the "illustrative scenarios" typically is 5 to 10

---

[5] International Energy Agency, "CO2 Emissions from Fuel Combustion," 2007. p. xix.

[6] J. Eilperin, op. cit.

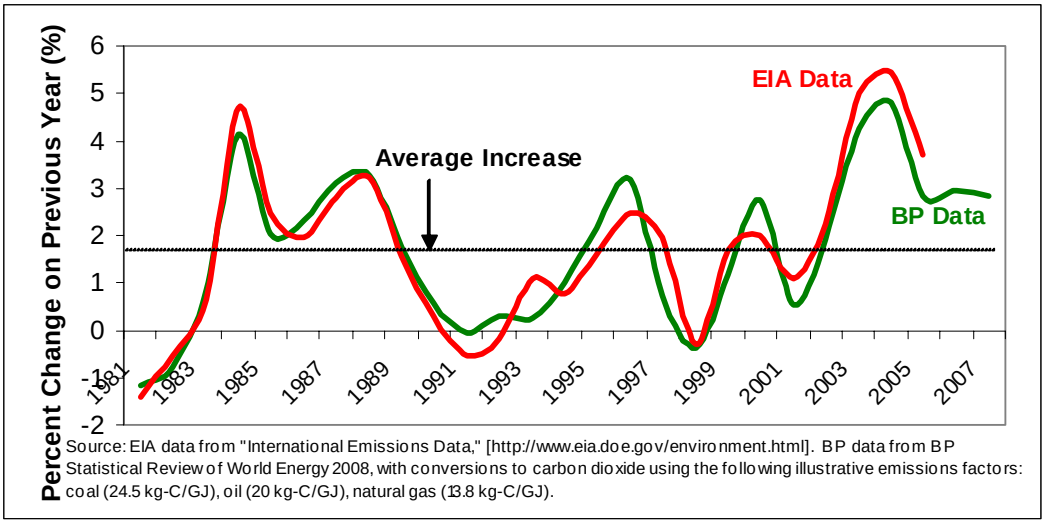
[7] The International Panel on Climate Change is a panel established by national governments that assesses scientific research and publishes consensus findings for use by national policy-makers and the public. The IPCC published *Special Report on Emissions Scenarios* in 2000. For more information, see [http://www.ipcc.ch/].

[8] Nakicenovic, Nebojsa, et al. 2000. *Special Report on Emissions Scenarios*. Published for the Intergovernmental Panel on Climate Change by Cambridge University Press.

years, represented by the reporting of outcomes for 2000, 2010, 2020, etc. Even with these long periods between model outputs, the scenarios are meant to provide conceptual results over multi-decadal periods, not predictions for a year or a particular decade. As the SRES report states, "[t]he modeling tools that have been used to develop these scenarios that focus on the century time scale are less suitable for analysis of near term (a decade or less) developments."[9] In addition, the assumptions and parameters used in modeling will change over time, creating value in updating the scenarios periodically.

Normal inter-annual and inter-decadal variability of actual energy use and resulting CO_2 emissions would be expected to produce yearly emission values that fall both above and below multi-year averages. For example, although recent economic growth in China and India may have been higher than projected in the first part of this decade, those rates may drop below the projected level (perhaps substantially) due to the current and expected economic adjustments. **Figure 2** provides estimates of recent annual changes in energy-related global CO_2 emissions. The average annual rate of increase between 1981 and 2005 was about 1.8%, but clear cyclical patterns are evident. In 1981, global emissions declined by 1.4%. In 2004, they rose by 5.5%.

Figure 2. Estimated Annual Change in Energy-Related Global CO_2 Emissions



Economies routinely experience cycles of faster and slower growth; the GHG emissions associated with these cycles normally fluctuates as well (if policies controlling emissions remain constant). China, whose emissions have contributed substantially to recent global CO_2 increases, is also likely to experience periodic increases and slowdowns in emissions. After a recent period of very strong growth, Chinese officials now expect a period of slower emissions growth over the next few years.[10]

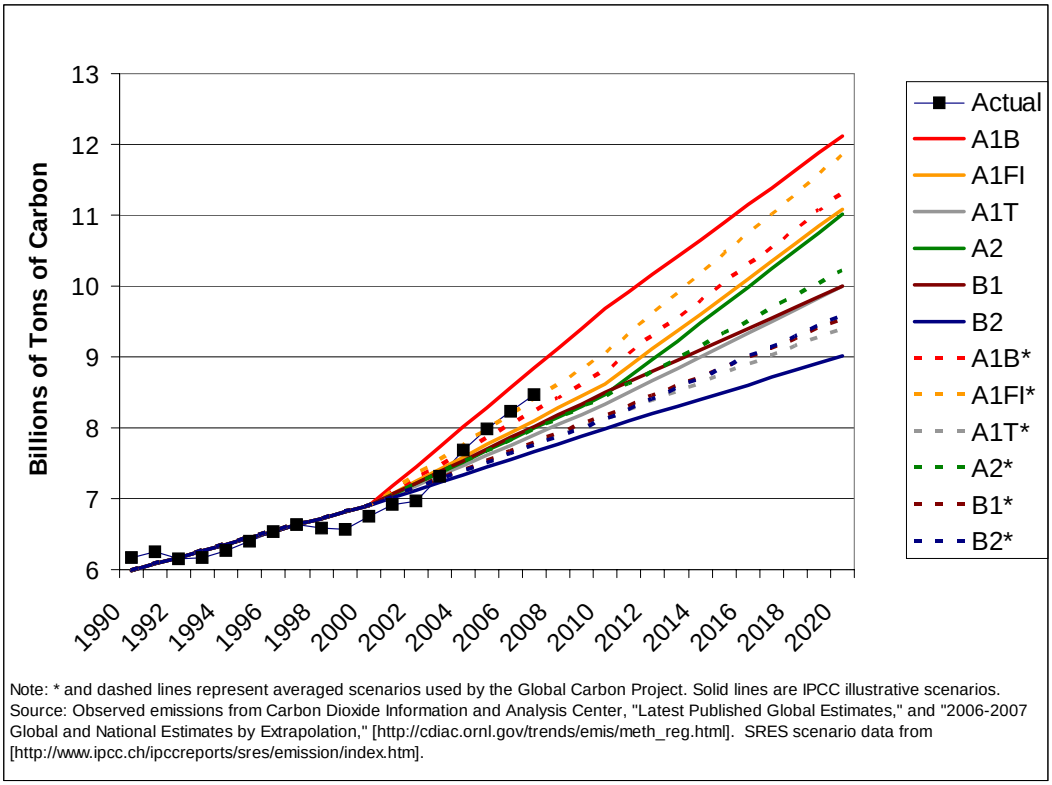
---

[9] Ibid., p. 11.

[10] Y. Wang, 2008. *Transcript*. Executive Vice President, China's Academy of Macroeconomic Research. Presented at Brookings Institution, September 18. [http://www.brookings.edu/events/2008/0918_china_environment.aspx].

Comparisons with the IPCC Scenarios. Returning to the question of whether recent carbon dioxide emission trends are higher than IPCC forecasts, **Figure 3** shows recent CO_2 emissions (including from cement production) compared to IPCC scenarios. The figure displays the six official IPCC "illustrative scenarios," represented by solid lines. It also displays six "averaged" IPCC scenarios represented by dashed lines that were introduced by the Global Carbon Project (GCP), whose "Carbon Budget 2007" report was cited in the media.[11] The dashed lines are the numerical averages of all model results for each of the IPCC scenario storylines.[12] The IPCC did not calculate or publish such averaged results; rather, the IPCC illustrative scenarios were chosen as best representing each of the scenario storylines.[13] The SRES illustrative scenarios intentionally did not use all the models' results because of certain models' limitations and other reasons.

Figure 3. Comparison of Actual Carbon Emissions with SRES Illustrative and Average* Scenarios



Note: * and dashed lines represent averaged scenarios used by the Global Carbon Project. Solid lines are IPCC illustrative scenarios. Source: Observed emissions from Carbon Dioxide Information and Analysis Center, "Latest Published Global Estimates," and "2006-2007 Global and National Estimates by Extrapolation," [http://cdiac.ornl.gov/trends/emis/meth_reg.html]. SRES scenario data from [http://www.ipcc.ch/ipccreports/sres/emission/index.htm].

---

[11] J. Eilperin, op. cit.

[12] More information on the A1, A2, B1, and B2 scenarios is available in the IPCC's *Special Report on Emissions Scenarios* at [http://www.ipcc.ch/ipccreports/sres/emission/index.htm]. The IPCC report notes 40 individual simulations in the A1, A2, B1, and B2 family of scenarios: 17 model runs used in the A1 scenario, six in the A2 scenario, nine in B1, and eight in B2.

[13] However, some of the six models used to analyze the storylines were better able than others to represent certain storylines; some models could not produce results consistent with certain storyline assumptions. This is one reason that all the model results for a scenario were not averaged, but the "most representative" was selected for publication.

The GCP averaged all models' results for each scenario rather than using the IPCC's "most representative" model results when saying that "[t]his makes current trends in emissions higher than the worst case IPCC-SRES scenario."[14] The GCP statement is true only when comparing emissions with its averaged model results, not those published by the IPCC. Recent emissions are below the A1B illustrative scenario and the top of the range IPCC found in published research literature.

Moreover, comparing recent emissions with the IPCC scenarios is not, in itself, adequate to understand future global GHG trajectories. Although the SRES A1B scenario has the highest GHG emissions in the near term of all the IPCC illustrative scenarios, its assumptions result in emissions beyond 2050 that are far below some other scenarios (like A1F, which has lower near-term emissions). Understanding the factors driving emissions in the short- and long-run is more revealing than comparing current emissions with scenarios.

Monitoring Emissions Trends. Watchfulness over annual CO_2 and other GHG emissions is a vital element of addressing climate change and evaluating the effectiveness of actions to mitigate it, and it is important to use appropriate data in monitoring progress. Evaluating recent trends may help to discern which future GHG emission paths are most likely and why.[15] For example, recent population growth has been lower than many of the SRES scenarios, while the use of some low-emission technologies (e.g. low emissions vehicles, wind power, etc.) has been faster than in many of the scenarios. The combined effects of such differences, however, require complex analysis.

Both the Environmental Protection Agency (EPA) and the Energy Information Administration (EIA), in cooperation with additional federal agencies, track CO_2 and other GHG emissions and evaluate the factors that influence inter-annual variability and longer-term trends. Several international entities provide similar services, including the International Energy Agency, the World Bank, and BP (formerly British Petroleum). The EPA and EIA also analyze how changes in the factors driving GHG emissions may affect understanding of future climate trajectories. Some analysts believe, however, that the EPA and EIA do not have adequate funding to analyze sufficiently how policies may influence emissions and climate trajectories.

In sum, the past few years of exceptionally high growth may not provide a good basis for setting expectations for emissions rates in the coming few years or in the long run. Other changes, including the rate of growth in the global economy, emission control policies and regulations, and the specific technologies drawing investment, may provide greater insights into future GHG trajectories. Monitoring these factors, and how they may be determining future emissions and climate paths, remains important as input to policy-making to address climate change.

---

[14] [http://www.globalcarbonproject.org/carbontrends/index.htm]

[15] For more discussion of factors that drive long-term GHG trends, see CRS Report RL33970, *Greenhouse Gas Emission Drivers: Population, Economic Development and Growth, and Energy Use*, by John Blodgett and Larry Parker.