INSTITUTE FOR 21ST CENTURY ENERGY

AN AFFILIATE OF THE U.S. CHAMBER OF COMMERCE

METRIC OF THE MONTH: FEBRUARY 2012

A DEEPER LOOK INTO INTERESTING TRENDS IN ENERGY SECURITY DATA

ENERGY-RELATED CARBON DIOXIDE EMISSIONS

Total U.S. Energy-Related Carbon dioxide Emissions, February's Metric of the Month, serves as an indicator of the exposure of the U.S. economy to domestic and international emissions reduction mandates and is one of four environmental metrics used in the Index of U.S. Energy Security Risk® (Index).

The amount of carbon dioxide (CO_2) emitted from energy use is dependent on many different factors, including energy mix, economic growth, efficiency, and population. Data on U.S. CO_2 emissions, both historical and forecast, were gathered from the Energy Information Administration (EIA). The figures for 1970 to 2035 are presented in Figure 1.

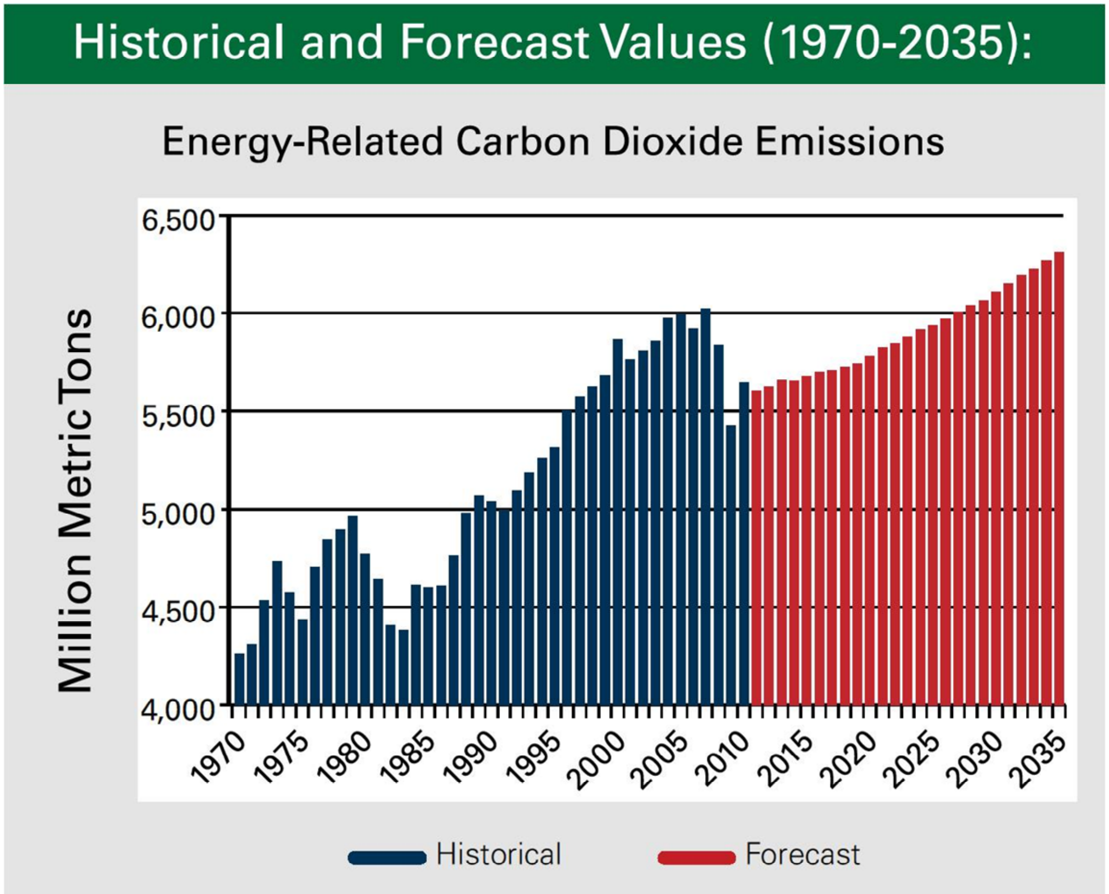
Except for a few short periods—notably the mid-1970s and early 1980s, when CO_2 emissions dipped largely in response to oil price shocks and economic slowdowns—the historical data generally show a rising level of CO_2 emissions, consistent with economic growth, population growth, and rising energy consumption. Since about 2005, however, CO_2 emissions have been essentially flat or declining, with high fuel prices, economic slowdowns, and energy and environmental policies all playing a role. After peaking at about 6 gigtons CO_2 in 2007, the severe economic recession caused emissions to drop by about 3% in 2008 and an unprecedented 7% in 2009 (to 5.6 gigatons CO_2). In 2010, emissions bounced back somewhat but still remain well below their historical peak.

When considering both direct emissions from primary energy consumption and indirect emissions from electricity consumption, in 2010 the transportation sector emitted about 33% of the U.S. total, the industrial sector 27%, the residential sector 22%, and the commercial sector 18%.

When considering direct CO_2 emissions only, in 2010 the electric power sector emitted 40% of the U.S. total, the transportation sector 33%, the industrial sector 16%, the residential sector 6%, and the commercial sector 4%.

As a share of global emissions, U.S. emissions fell from a little over 30% in 1970 to below 18% in 2010, as U.S. emissions began to flatten and developing country emissions began to increase sharply as their economies, energy use, and populations underwent rapid growth.

Figure 1.



Looking forward, EIA's *Annual Energy Outlook* (*AEO*) 2011 indicated a slow but steady rate of increase in energy-related CO_2 emissions. In the *AEO2011* Reference Case, energy-related CO_2 emissions grow by 0.2% per year from 2007 to 2035, as compared with 1% per year from 1970 to 2007.

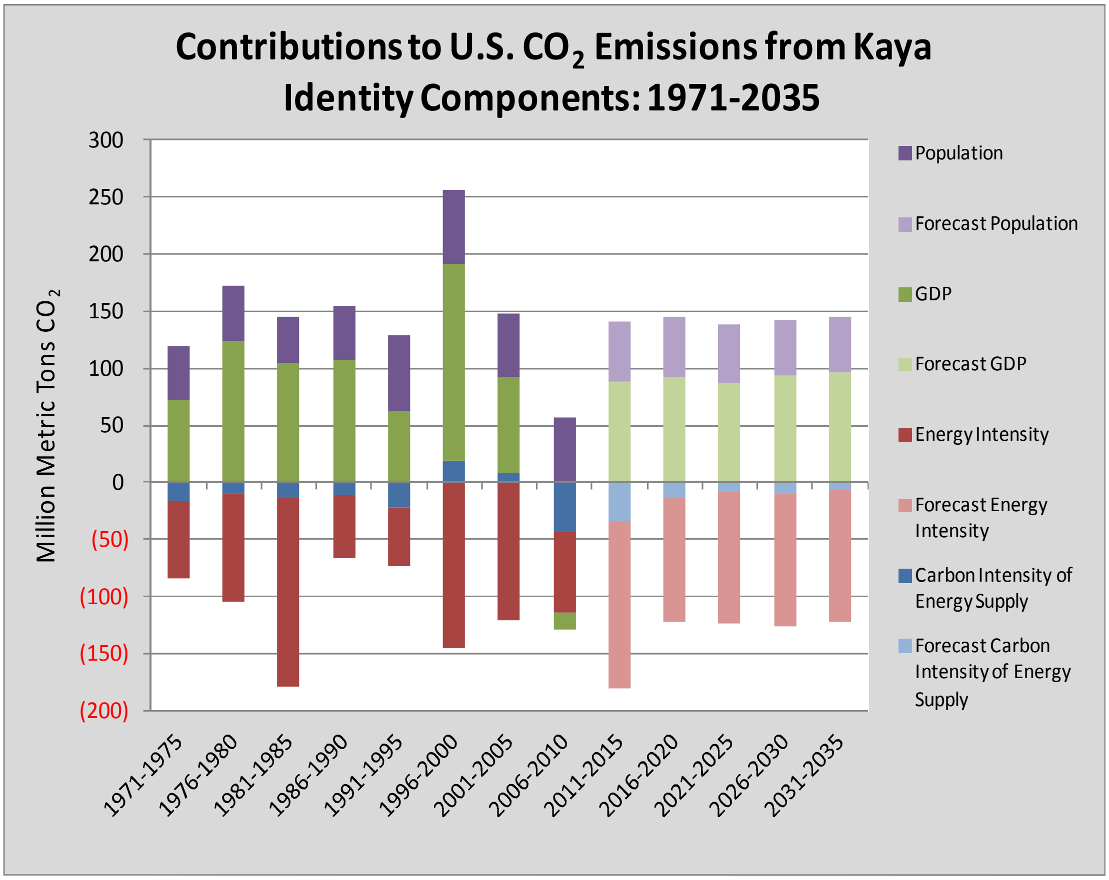
By 2035, EIA projects energy-related CO_2 emissions to be about 5% higher than in 2005. As we will see below, EIA's latest 2012 projection suggests even slower emissions growth is in store.

Kaya Identity

To get a better handle on what factors have the biggest impact on emissions over time, these data can be broken down using the Kaya Identity. Named for its originator, the Japanese energy economist Yoichi Kaya, the Kaya Identity posits that total emissions is the product of four variables: (1) gross domestic product (GDP) per capita; (2) population; (3) energy intensity; and (4) the carbon intensity of energy supply.[1]

[1] The calculation would be expressed as: Population × GDP per Capita × Energy Intensity × Carbon Intensity = CO_2 Emissions.

Figure 2.



Sources: EIA *Annual Energy Review*, *Monthly Energy Review*, and *AEO2012* (CO_2 emissions, energy consumption, and projected GDP and population); Department of Commerce, Bureau of Economic Analysis (historical GDP); Department of Commerce, Census Bureau (historical population).

Figure 2 shows the results of applying the Kaya Identity to track annual changes in U.S. emissions of CO_2 from energy going back to 1951 and, using EIA's most recent *AEO2012 Early Release*, going forward to 2035. Each bar represents the average change in annual emissions over a five-year period and includes the average contribution—either plus or minus—of each of the four Kaya Identity components. Those component parts of each bar appearing above the "0" line running horizontally across the chart represent increased emissions while the parts below the "0" line represent decreased emissions.

In any given year, changes in each of the Kaya components can send emissions higher or lower, but as the chart shows, in the United States changes in population and GDP are usually on the plus side of the ledger and energy intensity and carbon intensity of energy supply are usually on the minus side of the ledger.[2]

[2] Other countries have much different profiles. Many rapidly growing developing countries, for example,

Over the entire historical period from 1971 to 2010, emission increases from economic growth (green section of the bars) have been largely offset by emissions decreases from improved energy intensity (red section) and, to a lesser degree, a lower carbon intensity of energy supply (blue section).

Table 1 looks at the data used to create Figure 2 in terms of a ratio, with emissions attributed to GDP set at "1" and emissions attributed to the other three Kaya components set in relation to that.

Table 1. Ratio of Average Annual Changes in Energy CO_2 Emissions from Changes in Kaya Identity Components: GDP = 1

	GDP	Energy Intensity	Carbon Intensity of Energy Supply	Population
1970-2010	1.00	(1.07)	(0.13)	0.62
2011-2035	1.00	(1.32)	(0.16)	0.55

The table shows that on average over the 1970 to 2010 period, for every 1 metric ton of CO_2 emissions growth attributed to GDP expansion each year there was an *offsetting* emission reduction of about 1.1 ton attributed to energy intensity improvements.[3] In other words, since 1970, average improvements in energy intensity alone have been enough to negate entirely higher emissions from economic growth.[4]

That being the case, why have emissions grown over most of this period? The answer is population growth, which since 1970 has increased by an average of 1% a year, adding on average 0.6 metric tons of CO_2 for every ton of CO_2 generated by GDP growth.[5]

EIA forecasts from 2011 to 2035 see energy intensity improving more rapidly than it did in the preceding 40 years while the population grows more slowly.

Changing EIA Emissions Projections Over Time

We commented above how EIA has changed its outlook for CO_2 emissions considerably between the *AEO2011* and the *AEO2012* early release—changes that will be reflected in the next edition of the Index. EIA now expects that CO_2 emissions will grow much slower than previously thought and will remain below their 2005 level throughout the entire forecast period to 2035. Just last year, EIA's *AEO2011* projected that emissions in 2035 would be about 5% higher than in 2005 (see Figure 1). There are a number of reasons for EIA's lower estimate, such as greater use of natural gas, regulations targeting coal-fired

are "recarbonizing" rather than "decarbonizing" their energy supplies.

[3] That is to say, on average in any given year from 1970 to 2010, the improvement in energy intensity resulted in emissions being lower than they would have been if the energy intensity of the economy remained unchanged from the previous year.

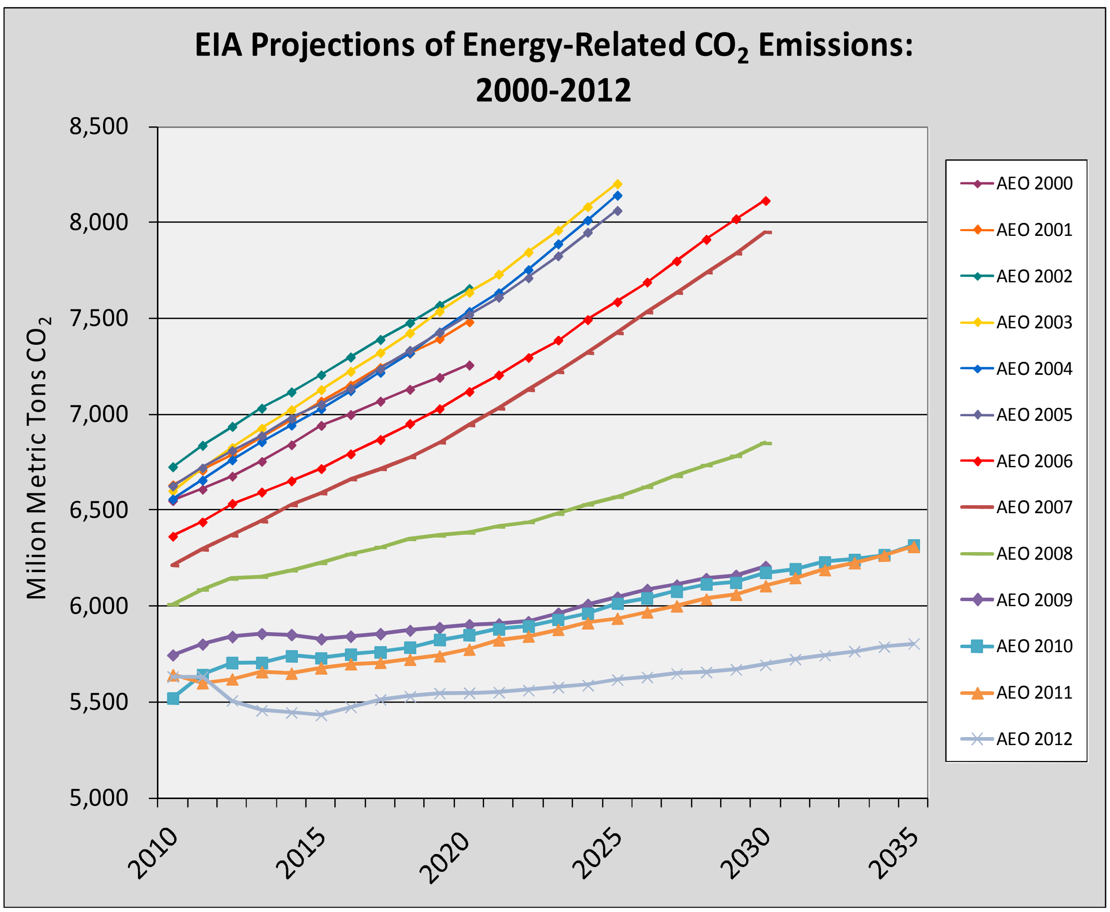
[4] Since 1970, the average annual change in emissions attributed to GDP was 88.7 million metric tons CO_2 ($MMTCO_2$) while the average attributed to energy intensity was -96.8 $MMTCO_2$ (which yields the ratio of 1.00 to -1.07).

[5] In most other developed countries—Australia and Canada being notable exceptions—the relative contribution from population growth is much smaller than in the United States.

power plants, and automobile efficiency standards.

Indeed, EIA has been lowering its projections of future CO_2 consistently over the past seven years or so. Figure 3 compares projections of energy-related CO_2 emissions made by EIA from 2000 to 2012. Up to 2005, EIA was predicting rapidly rising emissions. Since then, EIA's projected emission trajectories have flattened substantially with each new version of the *AEO*. In the *AEO2005*, for example, CO_2 emissions were projected to total over 8 gigatons in 2025. Now, the *AEO2012* forecasts only 5.6 gigaton tons in 2025 (more than 2 billion tons less than projected in 2005) and only 5.8 gigatons in 2035 (about 0.5 gigatons less than projected just two years ago).

Figure 3.



Sources: EIA, *AEO*s 2000 to 2012.