5 Projected Greenhouse Gas Emissions

On February 14, 2002, President Bush announced his Global Climate Change policy, committing to reduce the greenhouse gas (GHG) intensity of the U.S. economy by 18 percent by 2012. GHG intensity measures the ratio of GHG emissions to economic output. This approach focuses on reducing the growth of GHG emissions, while sustaining the economic growth needed to finance investment in new, clean energy technologies. It sets the United States on a path to slow the growth of GHG emissions, and—as the science justifies—to stop and then reverse that growth. This chapter provides projections for national emissions under the Global Climate Change policy.

MEETING THE PRESIDENT'S TARGET FOR REDUCING U.S. GHG INTENSITY

The President's commitment to reducing GHG intensity represented a 4 percentage point improvement in absolute terms over the projected U.S. *Business As Usual* GHG intensity improvement.[1] This corresponded to a reduction in GHG emissions of 367 teragrams of carbon dioxide equivalent (Tg CO_2 Eq.) by 2012 relative to *Business As Usual* projections, and more than 1,833 Tg CO_2 Eq. in cumulative GHG reductions between 2002 and 2012.[2] The President's Global Climate Change policy focuses on reducing emissions through technology improvements and dissemination, demand-side efficiency gains, voluntary programs with industry, and shifts to cleaner fuels.

The President's GHG intensity improvement target was developed using the best available data, including GHG projections from the U.S. Environmental Protection Agency (EPA), and GHG and economic projections from the Energy Information Administration (EIA), an independent statistical and analytical agency within the U.S. Department of Energy (DOE). These data have been updated in the present report to reflect actual GHG emissions and gross domestic product (GDP) data for the years 2002 through 2004 and projections of both emissions and economic growth based on the latest available U.S. government analyses from EIA and EPA. The most recent projections published in the *Annual Energy Outlook 2006* (AEO) (U.S. DOE/EIA 2006a) incorporate the effects of many policies enacted through October 2005 and also use much higher oil prices than in previous analyses. These updates result in lower projected energy consumption and lower CO_2 emission projections, as compared to previous editions of the AEO.

[1] At the time of President Bush's announcement in 2002, the estimated GHG intensity of the U.S. economy was 671 metric tons of carbon dioxide equivalent (t CO_2 Eq.) emissions per million dollars of gross domestic product (GDP). The GHG intensity was projected to decrease to 578 t CO_2 Eq. emissions per million dollars of GDP in 2012 under a *Business As Usual* scenario based on existing polices and efforts—a decline of 14 percent. See <www.whitehouse.gov/news/releases/2002/02/addendum.pdf>.

[2] In the metric used at the time of the President's announcement, million metric tons of carbon equivalents (MMTCE), this corresponded to a reduction of more than 100 MMTCE in 2012 and more than 500 MMTCE from 2002 through 2012, over and above the *Business As Usual* projection. (One teragram (Tg) equals one million metric tons (Mt). Carbon dioxide equivalents can be converted to carbon equivalents by multiplying by the ratio of their atomic masses (12/44): 367 Tg CO_2 Eq. = 367 Mt CO_2 Eq. = 100 MMTCE.)

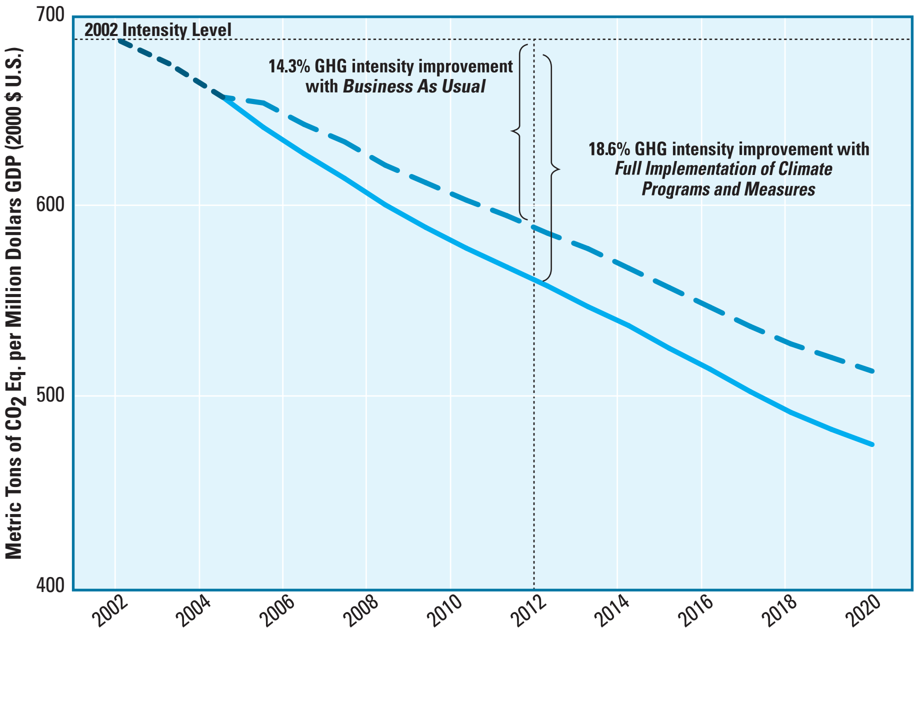
Given *Full Implementation of Climate Programs and Measures*, and based on recent U.S. government forecasts that reflect current economic conditions, the United States is projected to exceed the President's 18 percent goal by 2012. The gross 686 t CO_2 Eq. emissions per million dollars of GDP emitted in 2002 are projected to be lowered to 559 t CO_2 Eq. per million dollars GDP in 2012—an 18.6 percent reduction in GHG intensity. Over the same period from 2002 to 2012, while GHG intensity is declining, total gross GHG emissions are expected to rise by 11 percent to 7,709 Tg CO_2 Eq.

Since 2002, the President has expanded existing measures and has implemented new short- and long-term measures to reduce GHG intensity. The short-term measures, such as voluntary reductions of methane and fluorinated gases from industry and tax incentives on renewables and cogeneration, are expected to further reduce GHG intensity by 2012. Using the latest available data, these additional measures—as outlined in Chapter 4 of this report—are accounted for in the *Full Implementation of Climate Programs and Measures* baseline. The calculation of overall reductions in GHG emissions due to the federal climate programs is based on the methodology originally presented in the 2002 *Climate Action Report* (CAR) (U.S. DOS 2002).

Based on actual data from 2002 through 2004 (U.S. EPA/OAP 2006c), Figure 5-1 contains two projections: the GHG intensity associated with the *Business As Usual* projection and the additional GHG intensity improvement resulting from the *Full Implementation of Climate Programs and Measures.*[3] The influence of U.S. policies and measures in encouraging the development and use of cleaner, more efficient technologies can be seen in the reduction of GHG intensity over the period examined. Other important factors improving U.S. GHG intensity include the substitution of fuels that emit lower volumes of GHGs and changes in the composition of GDP to goods and services with fewer fuel inputs.

FIGURE 5-1 **Historical and Projected U.S. Greenhouse Gas Intensity**

U.S. greenhouse gas intensity under *Full Implementation of Climate Programs and Measures* is projected to meet the President's target for 2012. The GHG emission reduction in 2012 is projected to be 407 Tg CO_2 Eq. (111 MMTCE), and the cumulative GHG emission reduction from 2002 through 2012 is projected to be 2,225 Tg CO_2 Eq. (607 MMTCE), relative to projected emissions under *Business As Usual* conditions. From 2002 through 2012, GHG emissions are expected to rise by 11 percent to 7,709 Tg CO_2 Eq.



Note: One teragram (Tg) equals one million metric tons.

ASSUMPTIONS USED TO ESTIMATE FUTURE GREENHOUSE GAS EMISSIONS

EIA's AEO 2006 provided the baseline projection of energy-related CO_2 emissions (U.S. DOE/EIA 2006a). This baseline partially reflects the impact of the energy-related policies and measures discussed in Chapter 4. Federal agencies with direct responsibility for implementing polices and measures adjusted the AEO 2006 reference case to reflect their own estimates of the expected impacts of their programs. EPA prepared the emission projections for source categories other than CO_2 emissions resulting from fossil fuel consumption (U.S. EPA/OAP 2006b), and the U.S. Department of Agriculture (USDA) prepared the estimates of carbon sequestration rates based on the carbon sequestration models developed for the U.S. inventory (U.S. EPA/OAP 2002). The projections reflect long-run trends and do not attempt to mirror short-run departures from those trends.

The AEO 2006 presents medium-term scenarios of energy supply, demand, and prices through 2030 (U.S. DOE/EIA 2006a), based on results from EIA's National Energy Modeling System (NEMS), a publicly shared and well-documented model. The AEO 2006 cases reflect an integrated analysis of CO_2 emissions, accounting for interaction and feedback effects in energy markets and the economy.

[3] Some of the impact of existing national policies and programs is already being captured in the *Business As Usual* projection, as described in the following section of this chapter.

In some cases, however, the AEO uses assumptions about technology diffusion and adoption rates that differ from the assumptions used for the independent policies and measures estimates in Chapter 4 of this report.

The reported effects of the individual policies and measures in Chapter 4 are based on assumptions regarding the adoption and impacts of each measure. Because this approach differs from the approach implicit in NEMS, a precise mapping to the emission reductions from individual policies and measures against the aggregate estimates developed in the AEO cases is not possible. There are two distinct challenges. First, the energy-related measures described in Chapter 4 are already partially reflected in the AEO results (for example, the 2003 corporate average fuel economy (CAFE) increase for light trucks). Second, the impacts reported in Chapter 4, which are typically estimated on a stand-alone basis, recognize fewer interactions and competitive effects within and among the economic sectors in which the individual measures are applied. In contrast to the NEMS model, which addresses interaction effects between a comprehensive set of economic variables and policies, the models used in projecting the direct impacts of Chapter 4 policies and measures are partial equilibrium models that do not represent the economy as a whole. The Chapter 4 programs and measures effects do not reflect interactions between competitive alternatives, which could include overlapping, double counting, or synergistic effects. To address these challenges, the mitigation impacts of all policies and measures as reported in Chapter 4 were adjusted downward by 25 percent or greater[4] and then subtracted from the appropriate baseline to generate the projections in this chapter. This adjustment was necessary to address the possible interactions between the policies and measures as well as uncertainty in market responses, and the potential for some portion of the mitigation impact of the policies and measures to already be captured in the *Business As Usual* baseline.

TABLE 5-1 Comparison of the 2002 CAR and the 2006 CAR Assumptions and Model Results for the Year 2020

Several measures of the U.S. economy generate energy consumption and related carbon emission estimates. This table compares the values used in the 2002 CAR to those relied upon for this report.

Factors	Assumptions for 2020	
	2002 CAR	2006 CAR
Real GDP (billions of 2000 dollars)	18,136	17,541
Population (millions)	325	337
Energy Intensity (Btus per 2000 dollar GDP)	8,712	6,877
Light-Duty Vehicle Miles Traveled (billions)	3,631	3,474
Energy Commodity Price/Imported Crude Oil Price (2000 dollars/barrel)	24.68	41.24
Wellhead Natural Gas (2000 dollars/1,000 cubic feet)	3.26	4.49
Minemouth Coal (2000 dollars/ton)	12.79	18.52
Average Price Electricity (2000 cents/kWh)	6.50	6.64
Average Price Gasoline (2000 dollars/gallon)	1.40	1.90

Source: U.S. DOE/EIA 2006a.

The AEO 2006 projects a declining ratio of emissions to GDP by incorporating the enacted regulatory and fiscal policies as well as the impacts—including costs—of technology dissemination.[5] The degree of technology improvement reflected in the projections is internally generated in the modeling process based on EIA's judgment about the availability, cost, and performance of technologies, their rates of adoption, and their potential for efficiency improvement. The assumptions under which the AEO 2006 estimates were prepared include real GDP growth of 3.0 percent annually from 2004 through 2030, without specific regard to interim business cycles. Based on the AEO 2006 reference case estimates, the average U.S. cost of imported crude oil in real 2000 dollars is projected to be just over $41 per barrel by 2020.[6] To support projections of increased demand, natural gas supplies are supplemented with growing imports—in particular, liquefied natural gas—and domestic unconventional production. The natural gas wellhead price is projected to be $4.49 per thousand cubic feet in 2020 in real 2000 dollars. EIA's projection assumes that current laws and regulations will continue in force, but it does not anticipate measures not yet enacted or implemented. Table 5-1 presents several measures of the U.S. economy that generate estimates of energy consumption and related carbon emissions for 2020, and compares the values used in the 2002 CAR to those relied upon for this report (2006 CAR). In this report, 2020 real GDP is somewhat lower, energy intensity per dollar of GDP is notably lower, and the prices of natural gas and crude oil are higher than the levels assumed in the 2002 CAR.

[4] The effects of the non-CO_2 policies and measures in reducing emissions as presented in Chapter 4 were adjusted downward by 25 percent to generate the projections for 2012 and 2020 presented in this chapter. The effects of the CO_2 policies and measures were adjusted downward by 25 percent in 2012 and by 50 percent in 2020 to reflect an increasing amount of energy efficiency reductions included in the AEO 2006 reference case.

[5] A description of the policies and measures and technology assumptions embodied in the AEO projections can be found at <www.eia.doe.gov>.

[6] While current oil prices are higher, the AEO 2006 reference case does not project the recent growth trend to continue. Alternatively, the AEO 2006 high-price case projects the imported crude oil price to be $73 per barrel in 2020. If this 2007 CAR analysis were to use the AEO 2006 high-price case, energy consumption would likely be lower, resulting in lower U.S. GHG emissions than the projections presented in this chapter.

Emission projections in this report are converted to Tg CO_2 Eq., in keeping with the reporting guidelines of the United Nations Framework Convention on Climate Change (UNFCCC). To analyze the non-CO_2 gases in the same framework as CO_2, this report uses the 100-year global warming potential (GWP) listed in the Intergovernmental Panel on Climate Change's Second Assessment Report (IPCC 1996b), to determine the relative heat-trapping ability of each gas.

The 2002 CAR—the analysis used by the Bush Administration in setting its intensity goal—and the analysis presented in this 2006 CAR use consistent analytical techniques. Baseline projections of energy-related CO_2 emissions are developed based on the latest edition of the AEO produced by EIA's NEMS model. Using the reference case scenario provided by EIA as a starting point, agencies with policy responsibility then adjust it to reflect their assessments of the additional impact of the policies and measures, as described above. For non-CO_2 GHGs and estimates of carbon sequestration, the inventory models described in Chapter 3 are used to project emissions based on economic activity from the AEO 2006 report.

U.S. GREENHOUSE GAS EMISSION ESTIMATES: 2000–2020

Projections for both the *Business As Usual* baseline and the *Full Implementation of Climate Programs and Measures* scenario are presented in Table 5-2 for the years 2012 and 2020, along with historical inventory data for the years 2000, 2002, and 2004. The projections of U.S. GHG emissions described here reflect estimates of GHG emissions considering national trends in population growth, long-term economic growth potential, historical rates of technology improvement, normal weather patterns, and reductions due to implemented policies and measures.

The total projected levels of U.S. greenhouse gas emissions are tallied by combining the CO_2 contributions of energy and nonenergy activities with the non-CO_2 greenhouse gases (which include methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons

TABLE 5-2 Historical and Projected U.S. Greenhouse Gas Emissions From All Sources (Tg CO_2 Eq.)

U.S. GHG emissions from energy consumption and other anthropogenic sources are projected to grow from historic levels, although emissions projected with the *Full Implementation of Climate Programs and Measures* are lower than under the *Business As Usual* baseline.

GREENHOUSE GASES	HISTORICAL GHG EMISSIONS: Business As Usual 2000[1]	2002[1]	2004[1]	PROJECTED GHG EMISSIONS: Business As Usual 2012[2]	2020	Full Implementation of Climate Programs and Measures[7] 2012[2]	2020
Energy-Related CO_2[3]	5,534	5,502	5,657	6,318	6,931	6,060	6,447
Nonenergy CO_2[4]	331	314	331	361	396	361	396
Methane	567	560	557	621	667	599	621
Nitrous Oxide	416	407	387	383	399	380	397
High GWP Gases	135	133	143	434	622	312	417
Adjustments[5]	0	0	0	-3	52	-3	52
Total Gross Emissions	**6,982**	**6,916**	**7,074**	**8,115**	**9,067**	**7,709**	**8,330**
Sinks[6]	-760	-769	-780	-776	-675	-806	-709
Total Net Emissions	**6,223**	**6,147**	**6,294**	**7,340**	**8,392**	**6,903**	**7,621**
GROSS GHG INTENSITY							
GDP (billions of 2000 dollars)		$10,075		$13,793		$13,793	
Gross GHG Intensity		686		588		559	
2002–12 Gross GHG Intensity Reduction				-14.3%		-18.6%	

Notes:
1 Historical emissions and sinks data are from U.S. EPA/OAP 2006c. Bunker fuels and biomass combustion are not included in inventory calculations.
2 2012 data are interpolated when specific data are unavailable.
3 Energy-related CO_2 projections are calculated from U.S. DOE/EIA 2006a CO_2, with any CO_2 from nonenergy sources removed.
4 Nonenergy CO_2 includes emissions from nonenergy fuel use and other industrial emission sources.
5 Adjustments include international bunker fuels and emissions in U.S. territories.
6 Sinks projections are extrapolated from U.S. EPA/OAP 2006c, with programs and measures projections from the U.S. Department of Agriculture.
7 Programs and measures reductions for 2002 are presented in Chapter 4, but are not shown in this table because historical data are used to calculate the GHG intensity in 2002. Programs and measures reductions shown in this table are net of 2002 reductions for the purpose of calculating the reduction in emissions intensity from the initial implementation of the President's policy in 2002.

(PFCs), and sulfur hexafluoride (SF_6)), and then aggregating these using equivalence factors. Because some types of GHG emissions cannot be attributed to a particular economic sector, the totals are reported in aggregate.

U.S. GHG emissions from energy consumption, industrial and agricultural activities, and other anthropogenic sources continue to grow from 2002 levels as shown in Table 5-2. Gross emissions are projected to rise under the impetus of population and economic growth. Under the *Business As Usual* path, total gross U.S. GHG emissions would be expected to rise 30 percent between 2000 and 2020. However, in the *Full Implementation of Climate Programs and Measures* case, emissions are projected to rise from 6,982 Tg CO_2 Eq. in 2000 to 8,330 Tg CO_2 Eq. in 2020, a growth of 19 percent. Increased efforts to use cleaner fuels, more efficient technologies, and better management methods for agriculture, forestry, mines, and landfills are projected to keep the growth of GHG emissions below the concurrent growth of the U.S. economy. Moreover, emissions of some non-CO_2 greenhouse gases—e.g., methane and industrial gases associated with the production of aluminum and HCFC-22—have declined from 1990 levels and are projected to remain below 1990 levels out through 2020.

The projected emission levels with full programs and measures for the year 2020 are lower than the levels projected for the same year in the 2002 CAR. Conversely, the actual level of net emissions reported for 2000 is higher than the projected value in the 2002 CAR, mainly due to a revision of the available sinks. The sections that follow present more detailed projections of specific categories of total U.S. GHG emissions.

CO_2 Emissions

Energy CO_2 Emissions

From 2000 to 2020, total CO_2 emissions—as calculated with *Full Implementation of Climate Programs and Measures*—are projected to increase by 17 percent to an absolute level of 6,843 Tg CO_2. The estimated level of U.S. CO_2 emissions from fossil fuel combustion for the year 2020 is 6,447 Tg CO_2. These rising absolute levels of CO_2 emissions occur against a background of growing population and GDP.

Nonenergy CO_2 Emissions

Nonenergy sources of CO_2 emissions include natural gas production and processing, cement production, and waste handling and combustion. These CO_2 emissions are subject to increasing voluntary control, as U.S. firms use recapture technologies to reduce their emission levels. Because the underlying sources are so varied, there is no clear projection method available other than historical extrapolation. These nonenergy CO_2 emissions are projected to grow by 1 percent annually, from 331 Tg CO_2 in 2000 to 396 Tg CO_2 in 2020. The total nonenergy CO_2 emission estimates in this 2006 CAR are approximately two and a half times higher than in the 2002 CAR. This is due to the inclusion of significantly more nonenergy sources of CO_2 emissions.[7]

Non-CO_2 Greenhouse Gas Emissions

Emissions other than CO_2 include (1) CH_4 emissions from natural gas production and transmission, coal mine operation, landfills, and livestock operations; (2) N_2O emissions from agriculture and, to a lesser degree, transportation; and (3) HFC, PFC, and SF_6 gases from industrial activities and, in some cases, the life cycles of the resulting products.

Methane

With full programs and measures, total CH_4 emissions are estimated to increase from 567 Tg CO_2 Eq. in 2000 to 621 Tg CO_2 Eq. in 2020 (U.S. EPA/OAP 2006a), primarily due to increases in natural gas usage. The projection of total CH_4 emissions presented in this report is lower than that reported in the 2002 CAR in absolute terms. This is primarily due to an improved inventory accounting model for the landfill sector, which substantially lowered projected emissions from the sector.

Nitrous Oxide

N_2O emissions are expected to decline from 416 Tg CO_2 Eq. in 2000 to 397 Tg CO_2 Eq. in 2020. The largest single source of these emissions is agricultural soils. Emissions of N_2O from transportation are also expected to decrease over this period (U.S. EPA/OAP 2006b).

HFCs, PFCs, and SF_6

Emissions of HFCs, PFCs, and SF_6 are projected to rise from 135 Tg CO_2 Eq. in 2000 to 417 Tg CO_2 Eq. in 2020 (U.S. EPA/OAP 2006b). This increase stems largely from the use of HFCs as replacements for ozone-depleting substances. Growth in the use of HFCs will allow rapid phase-out of chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), and halons in a number of important applications where other alternatives are not available.

HFCs are expected to be selected for applications where they provide superior technical reliability or safety (low toxicity and flammability) performance. In many cases, HFCs provide equal or better energy efficiency compared to other available alternatives. Moreover, their acceptance in the market will reduce long-term net environmental impacts, because HFCs are expected to replace a significant portion of past and current demand for CFCs and HCFCs in insulating foams, refrigeration and air-conditioning, propellants used in metered dose inhalers, and other applications. Emissions of HFCs, PFCs, and SF_6 from all other industrial sources are expected to be reduced significantly below 1990 levels, despite high growth rates of manufacturing in some sectors.

[7] Since the 2002 CAR, the following CO_2 sources have been added to the U.S. inventory: nonenergy use of fuels, iron and steel production, ammonia production and urea application, petrochemical production, titanium dioxide production, phosphoric acid production, and ferroalloys.

Carbon Sequestration

U.S. forests and agricultural soils account for a significant removal of CO_2 from the atmosphere, representing 11 percent of total gross U.S. CO_2 emissions in 2000. This net removal—or sequestration—is related to a continuation of trends in land use and land management observed throughout the 1990s in the forestry and agriculture sectors, including the reforestation and regeneration of previously cleared forests and expanded use of no-till and reduced-tillage systems in agriculture.

While significant in quantity, the carbon sequestration that occurred in U.S. forests and agricultural soils prior to 2000 occurred in the absence of government incentives to sequester carbon. Since 2000, the U.S. government has implemented a number of innovations in its farm sector conservation programs to encourage private landowners to voluntarily adopt land uses and management practices that sequester additional carbon in forest systems and agricultural soils. Examples include a program to plant 203,250 hectares (500,000 acres) of bottomland hardwood forest (primarily in the Mississippi River Valley) and revised ranking criteria for prioritizing lands offered for enrollment in USDA's Environmental Quality Incentives Program and Conservation Reserve Program. These revised criteria allow federal program managers to give additional weight to bids that include the implementation of activities and/or practices that sequester carbon.

Table 5-2 shows both recent historical data and projections for 2012 and 2020 for annual carbon sequestration (i.e., sinks) in U.S. forests and agricultural soils.[8] Sequestration associated with forests includes carbon stored in the forest ecosystem, wood products in use, and wood products in landfills. Annual carbon sequestration due to innovative farm conservation programs (e.g., encouraging landowners to adopt carbon-sequestering land uses and/or management practices) is projected to increase by 2020, according to USDA estimates.

KEY UNCERTAINTIES AFFECTING PROJECTED GREENHOUSE GAS EMISSIONS

Any projection of future emissions is subject to considerable uncertainty. In the short term (less than 5 years), the key factors that can increase or decrease estimated net emissions include unexpected changes in retail energy prices, shifts in the competitive relationship between natural gas and coal in electricity generation markets, changes in economic growth, abnormal winter or summer temperatures, and imperfect forecasting methods. Additional factors may influence emission rates over the longer term, notably technology developments, shifts in the composition of economic activity, and changes in government policies.

Technology Development

Forecasts of net U.S. emissions of GHGs take into consideration likely improvements in technology over time. For example, technology-based energy-efficiency gains, which have contributed to reductions in U.S. energy intensity for more than 30 years, are expected to continue. However, while long-term trends in technology are often predictable, the specific areas in which significant technology improvements will occur and the specific new technologies that will become dominant in commercial markets are highly uncertain, especially over the long term.

Unexpected scientific and technical breakthroughs can cause changes in economic activities, with dramatic effects on patterns of energy production and use. Such breakthroughs could enable the United States to considerably reduce future GHG emissions. While U.S. government and private support of research and development efforts can accelerate the rate of technology change, the effect of such support on specific technology developments is unpredictable.

The AEO 2006 *Business As Usual* baseline referenced in this report assumes continuing improvement of energy-consuming and -producing technologies, consistent with historical trends. In the AEO 2006 high technology growth case, energy use in 2020 is projected to be 5 percent lower than in the reference case, while CO_2 emissions are projected to be 5 percent (or 385 Tg) lower than in the reference case.

Regulatory or Statutory Changes

The current forecast of U.S. GHG emissions does not include the effects of any legislative or regulatory action that was not finalized before October 31, 2005. Consequently, the forecast does not include any increase in the stringency of equipment efficiency standards, even though existing law requires DOE to periodically strengthen its existing standards and issue new standards for other products. Similarly, the forecast does not assume any future increase in new building or auto fuel economy standards, even though such increases are either required by law or under consideration in various states. For example, while the AEO 2006 includes the CAFE standards for light trucks covering 2005–07 and finalized in 2003, the more recent standards covering 2008–11 were not finalized in time to be incorporated.

Energy Prices

The relationship between energy prices and emissions is complex. Lower energy prices generally reduce the incentive for energy conservation and tend to encourage increased energy use and related emissions. However, a reduction in the price of natural gas relative to other fuels could encourage fuel switching that could, in turn, reduce carbon emissions. Alternatively,

8 The projections for carbon sequestration are lower than the corresponding projections in the 2002 CAR due to revised inventory methods. An explanation of the revision has been provided to the UNFCCC in the 2002 edition of the *Inventory of U.S. Greenhouse Gas Emissions and Sinks* (U.S. EPA/OAP 2002), available at <http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2002.html>.

coal could become more competitive vis-à-vis natural gas, which could increase emissions from the power sector.

The AEO 2006 projections reflect a shift in oil market assumptions, with projected oil prices substantially higher than in previous editions (U.S. DOE/EIA 2006a). However energy and oil price projections are subject to significant uncertainty. Decreases in delivered energy prices could result from increased competition in the electric utility sector or improved technology. On the other hand, energy price increases could result from the faster than expected depletion of oil and gas resources, or from political or other disruptions in oil-producing countries.

Economic Growth

Economic growth increases the future demand for energy services, such as vehicle miles traveled, amount of lighted and ventilated space, and process heat used in industrial production. However, growth also stimulates capital investment and reduces the average age of the capital stock, increasing its average energy efficiency. The energy-service demand and energy-efficiency effects of economic growth work in opposing directions. However, the effect on service demand is the stronger of the two, so that levels of primary energy use are positively correlated with the size of the economy.

In addition to the reference case cited previously, the AEO 2006 provides high and low economic growth cases. The high-growth case raises the GDP growth rate by 0.5 percentage points to 3.5 percent, while the low-growth case reduces the GDP growth rate by 0.6 percentage points to 2.4 percent.

- In the high-growth case, 2020 energy use is 5 percent higher than in the reference case. By 2020, carbon emissions from energy use are 423 Tg CO_2 (6.1 percent) greater than in the reference case.
- In the low-growth case, 2020 energy use is 6 percent lower than in the reference case. By 2020, carbon emissions from energy use are 399 Tg CO_2 (5.8 percent) lower than in the reference case.

Weather

Energy use for heating and cooling is directly responsive to weather variation. The AEO forecast of CO_2 emissions assumes 30-year average values for population-weighted heating and cooling degree-days. Unlike other sources of uncertainty, for which deviations between assumed and actual trends may follow a persistent course over time, the effect of weather on energy use and emissions in any particular year is largely independent from year to year.