

# 5



## Projected Greenhouse Gas Emissions

This chapter provides projections of U.S. greenhouse gas (GHG) emissions through 2030, including the effects of policies and measures in effect as of September 2012, the cutoff date for the 2013 *Annual Energy Outlook's* baseline projections of energy-related carbon dioxide (CO<sub>2</sub>) emissions (U.S. DOE/EIA 2013b). The “2012 Policy Baseline”<sup>1</sup> scenario presented does not include the impacts of the President’s June 2013 *Climate Action Plan* (EOP 2013a).<sup>2</sup> The projections of U.S. GHG emissions described here reflect national estimates considering population growth, long-term economic growth potential, historic rates of technology improvement, and normal weather patterns. They are based on anticipated trends in technology deployment and adoption, demand-side efficiency gains, fuel switching, and many of the implemented policies and measures discussed in Chapter 4.

Policies that are proposed or planned but had not been implemented as of September 2012, as well as sections of existing legislation that require implementing regulations or funds that have not been appropriated, are not included in this chapter’s projections.<sup>3</sup> The projections include, for example, efficiency and emission standards for cars and trucks, existing appliance efficiency standards and programs, state renewable energy portfolio standards, and federal air standards for the oil and natural gas industry. They do not include additional measures from *The President’s Climate Action Plan*, announced June 2013 (EOP 2013a). Projections that take into account the actions planned as a result of this announcement are contained in the *U.S. Biennial Report*, which accompanies this *Sixth National Communication*.

Projections are provided in total by gas and by sector. Gases included in this report are CO<sub>2</sub>, methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF<sub>6</sub>). Sectors reported include energy (subdivided into electric power, residential, commercial, and industrial); transportation; industrial processes; agriculture; waste; and land use, land-use change, and forestry (LULUCF). Projections for LULUCF through 2030 are presented as a range based on alternative high- and low-sequestration scenarios, while the section also describes longer-term trends in the sector.

The tables in this chapter present emission trends from 2000 through 2030. The discussion in the text focuses on the projected change in emissions between 2005 and 2020.

### U.S. GREENHOUSE GAS EMISSION PROJECTIONS

The U.S. Department of Energy’s (DOE’s) Energy Information Administration (EIA) *Annual Energy Outlook 2013 (AEO2013)* Reference case provided the projection of energy-related CO<sub>2</sub> emissions in the 2012 policy baseline scenario presented in this chapter (U.S. DOE/EIA 2013b). Projected CO<sub>2</sub> emissions in the *AEO2013* Reference case were adjusted to match international inventory convention.<sup>4</sup> The U.S. Environmental Protection Agency (EPA) prepared the projections of non-energy-related CO<sub>2</sub> emissions and non-CO<sub>2</sub> emissions. The methodologies used to project non-CO<sub>2</sub> emissions are explained in the background document *Methodologies for U.S. Greenhouse Gas Emissions Projections: Non-CO<sub>2</sub> and Non-Energy CO<sub>2</sub> Sources* (U.S. EPA 2013b). The U.S. Department of Agriculture (USDA) prepared the estimates of carbon sequestration. Historical emissions data are drawn from the *Inventory of U.S.*

<sup>1</sup> The “baseline” refers to the “with measures” scenario required by the United Nations Framework Convention on Climate Change National Communications reporting guidelines (UNFCCC 2006).

<sup>2</sup> See the *U.S. Biennial Report* for more information on the effects of planned additional measures.

<sup>3</sup> Specifically, the *Annual Energy Outlook 2013*, which provides the baseline projection of energy-related CO<sub>2</sub> emissions, is based generally on federal, state, and local laws in effect as of the end of September 2012 (U.S. DOE/EIA 2013b).

<sup>4</sup> *AEO2013* estimates for CO<sub>2</sub> from fossil fuel combustion were adjusted for the purpose of these projections to remove emissions from bunker fuels and non-energy use of fossil fuels, and to add estimated CO<sub>2</sub> emissions in the U.S. territories (since these emissions are not included in *AEO2013*), consistent with international inventory convention. These changes are consistent with previous U.S. Climate Action Reports.

*Greenhouse Gas Emissions and Sinks: 1990–2011* (U.S. EPA/OAP 2013). In general, the projections reflect long-run trends and do not attempt to mirror short-run departures from those trends.

All GHGs in this chapter are reported in teragrams of CO<sub>2</sub> equivalents (Tg CO<sub>2</sub>e), which are equivalent to megatons. The conversions of non-CO<sub>2</sub> gases to CO<sub>2</sub>e are based on the 100-year global warming potentials listed in the Intergovernmental Panel on Climate Change's (IPCC's) Second Assessment Report (IPCC 1996). Projected emissions for 2015, 2020, 2025, and 2030 are presented with historical GHG emissions from 2000 through 2011 from the 2013 U.S. GHG Inventory (U.S. EPA/OAP 2013). The base year for emission projections is 2011.

## TRENDS IN TOTAL GREENHOUSE GAS EMISSIONS

Given implementation of programs and measures in place as of September 2012 and current economic projections, total gross U.S. GHG emissions are projected to be 5.3 percent lower than 2005 levels in 2020. Between 2005 and 2011, total gross U.S. GHG emissions declined significantly due to a combination of factors, including the economic downturn and fuel switching from coal to natural gas (U.S. EPA/OAP 2013). Emissions are projected to rise gradually between 2011 and 2020. However, emissions are projected to remain below the 2005 level through 2030, despite significant increases in population (26 percent) and gross domestic product (GDP) (69 percent) over that time period (Table 5-1). More rapid improvements in technologies that emit fewer GHGs, new GHG mitigation requirements, or more rapid adoption of voluntary GHG emission reduction programs could result in lower gross GHG emission levels than in the *baseline* projection.

Between 2005 and 2020, CO<sub>2</sub> emissions in the 2012 policy baseline projection are estimated to decline by 7.6 percent. The expected decline over this period differs from the projections presented in the *U.S. Climate Action Report 2010* (2010 CAR) (U.S. DOS 2010). At that time,

Table 5-1 **Historical and Projected U.S. GHG Emissions Baseline, by Gas: 2000–2030** (Tg CO<sub>2</sub>e)

Total gross U.S. GHG emissions are projected to be 5.3 percent lower than 2005 levels in 2020. CO<sub>2</sub> emissions are projected to decline 7.6 percent over this period.

Greenhouse Gases	Historical GHG Emissions <sup>a</sup>				Projected GHG Emissions			
	2000	2005	2010	2011	2015	2020	2025	2030
Carbon Dioxide <sup>b</sup>	5,972	6,109	5,738	5,613	5,545	5,647	5,705	5,732
Methane <sup>c</sup>	609	594	593	587	578	599	619	626
Nitrous Oxide <sup>c</sup>	359	356	344	357	343	347	359	364
Hydrofluorocarbons <sup>c</sup>	105	115	121	129	161	207	269	302
Perfluorocarbons <sup>c</sup>	13	6	6	7	6	5	6	7
Sulfur Hexafluoride <sup>c</sup>	19	15	10	9	10	9	10	10
International Bunker Fuels (not included in totals)	103	114	118	112	115	118	120	122
<b>Total Gross Emissions</b>	<b>7,076</b>	<b>7,195</b>	<b>6,812</b>	<b>6,702</b>	<b>6,643</b>	<b>6,815</b>	<b>6,967</b>	<b>7,041</b>
Sequestration Removals <sup>d</sup>	high sequestration							
	low sequestration	-682	-998	-889	-905	-884	-898	-917
<b>Total Net Emissions</b>	<b>high sequestration</b>							
	<b>low sequestration</b>	<b>6,395</b>	<b>6,197</b>	<b>5,923</b>	<b>5,797</b>	<b>5,759</b>	<b>5,918</b>	<b>6,050</b>
					<b>5,856</b>	<b>6,201</b>	<b>6,394</b>	<b>6,476</b>

<sup>a</sup> Historical emissions and sinks data are from U.S. EPA/OAP 2013. Bunker fuels and biomass combustion are not included in inventory calculations.

<sup>b</sup> Energy-related CO<sub>2</sub> projections are calculated from U.S. DOE/EIA 2013b, with adjustments made to remove emissions from non-energy use of fuels and international bunker fuels, and to add emissions associated with U.S. territories, which are included in totals.

<sup>c</sup> Non-CO<sub>2</sub> and non-energy CO<sub>2</sub> emission projections are based on U.S. EPA/OAP 2013.

<sup>d</sup> Sequestration removals apply only to CO<sub>2</sub> from the land use, land-use change, and forestry sector.

CO<sub>2</sub> emissions were expected to increase by 1.5 percent between 2005 and 2020, a change of about 9 percent. During the same period, CH<sub>4</sub> emissions are expected to grow by 1.0 percent, and N<sub>2</sub>O emissions are expected to decline by 2.5 percent. The most rapid growth is expected in emissions of fluorinated GHGs (HFCs, PFCs, and SF<sub>6</sub>), which are projected to increase by more than 60 percent between 2005 and 2020, driven by increasing use of HFCs as substitutes for ozone-depleting substances (ODSs).

### EMISSION PROJECTIONS BY GAS

Energy-related CO<sub>2</sub> emission estimates are based on the *AEO2013* Reference case, with adjustments to match international inventory convention (U.S. DOE/EIA 2013b). *AEO2013* presents projections and analysis of U.S. energy supply, demand, and prices through 2040, based on results from EIA's National Energy Modeling System.<sup>5</sup> Key issues highlighted in *AEO2013* include the effect of eliminating the sunset provisions of such policies as Corporate Average Fuel Economy standards, appliance standards, and the production tax credit; oil and gas price and production trends; competition between coal and natural gas in electric power generation; high and low nuclear scenarios through 2040; and the impact of growth in natural gas liquids production (US DOE/EIA 2013b).

Non-CO<sub>2</sub> (CH<sub>4</sub>, N<sub>2</sub>O, HFCs, PFCs, and SF<sub>6</sub>) and non-energy CO<sub>2</sub> emission projections are developed by EPA. Specific calculations to project emissions from each source category are detailed within *Methodologies for U.S. Greenhouse Gas Emissions Projections: Non-CO<sub>2</sub> and Non-Energy CO<sub>2</sub> Sources* (U.S. EPA 2013b). These projections use inventory methodologies to estimate emissions in future years based on projected changes in activity data and emission factors. Activity data used vary for each source, but include macroeconomic drivers, such as population, GDP, and energy, and source-specific activity data, such as production and use of fossil fuels and industrial production levels for iron and steel, cement, aluminum, and other products.

### Carbon Dioxide Emissions

CO<sub>2</sub> emissions are expected to decline by 7.6 percent between 2005 and 2020. Between 2005 and 2011, emissions declined by 8.1 percent, but they are projected to increase slightly between 2011 and 2020. Energy-related CO<sub>2</sub> is projected to decline slightly over this time period, while non-energy CO<sub>2</sub> emissions (e.g., process emissions) are expected to grow between 2011 and 2020.

Projected energy-related CO<sub>2</sub> emissions in 2020 are 8.8 percent below their 2005 level, totaling 5,243 Tg CO<sub>2</sub> in 2020, assuming current policies persist. On average, energy-related CO<sub>2</sub> emissions decline by 0.6 percent per year from 2005 to 2020, compared with an average increase of 1.2 percent per year from 1990 to 2005. Reasons for the decline include growing use of renewable technologies and fuels; automobile efficiency improvements; slower growth in electricity demand; increased use of natural gas, which is less carbon-intensive than other fossil fuels; and an expected slow and extended recovery from the recession of 2007–2009 (U.S. DOE/EIA 2013b).

Non-energy-related CO<sub>2</sub> emissions are projected to increase by 12.3 percent between 2005 and 2020. Although these emissions declined between 2005 and 2011, growth in four emission sources results in overall growth: use of fossil fuels for non-energy uses (such as liquefied petroleum gas feedstock, natural gas feedstock, petrochemical feedstock, and asphalt and road oil); iron and steel production; natural gas systems; and cement production.

### Methane Emissions

Between 2005 and 2020, total CH<sub>4</sub> emissions are estimated to increase by 1.0 percent (Table 5-2). Growth of emissions among some sources (e.g., coal mining, enteric fermentation, manure management) is largely offset by reductions among other sources (e.g., natural gas, landfills). The activities driving all of these emission sources (e.g., coal mining, livestock production, natural gas production, and waste generation) increase during this period. Emissions from many of these sources are reduced voluntarily through partnership programs. In addition, CH<sub>4</sub> from some natural gas activities and landfills is reduced as a co-benefit of regulations limiting volatile organic compounds (VOCs) from these sources. Increasing

<sup>5</sup> This chapter presents comprehensive emissions projections through 2030. *AEO2013* covers the period 2010 through 2040.

emissions from livestock are driven by projected increases in livestock population, animal size, and an ongoing shift toward liquid waste management systems.

The quantity of methane capture-and-use projects associated with coal and landfill gas is driven in part by the prices of electricity and natural gas, which are projected to gradually increase over this period.

### Nitrous Oxide Emissions

N<sub>2</sub>O emissions are projected to decrease by 2.5 percent between 2005 and 2020. Emissions from agricultural soil management are driven by increasing crop production and the corresponding rise in nitrogen inputs to agriculture, including nitrogen fertilizer, managed manure, and crop residues. This source is estimated to account for nearly three-quarters of total N<sub>2</sub>O emissions in 2020. N<sub>2</sub>O emissions from stationary and mobile combustion are declining,

Table 5-2 **Select U.S. Non-CO<sub>2</sub> and Non-Energy CO<sub>2</sub> Emission Sources by Gas** (Tg CO<sub>2</sub>e)

GHG emissions other than energy-related CO<sub>2</sub> include methane from natural gas, livestock, landfills, and coal; nitrous oxide from agricultural soils; and hydrofluorocarbons from the use of substitutes for ozone-depleting substances (ODS) and production of hydrochlorofluorocarbon (HCFC)-22.

Gas and Source	Historical GHG Emissions <sup>a</sup>				Projected GHG Emissions			
	2000	2005	2010	2011	2015	2020	2025	2030
<b>Carbon Dioxide (CO<sub>2</sub>)</b>								
Non-Energy Use of Fuels	153	143	133	131	141	158	162	160
Iron and Steel Production	86	67	56	64	72	77	75	65
Natural Gas	30	30	32	32	34	37	40	42
Cement Production	40	45	31	32	42	50	53	58
Other	79	76	76	77	79	83	86	89
<b>Methane (CH<sub>4</sub>)</b>								
Natural Gas	166	159	144	145	132	140	151	157
Enteric Fermentation	138	137	139	137	135	147	151	157
Landfills	112	113	107	103	102	101	99	97
Coal Mines	60	57	72	63	63	65	67	69
Manure Management	42	48	52	52	52	53	54	55
Other	91	81	79	87	95	94	96	91
<b>Nitrous Oxide (N<sub>2</sub>O)</b>								
Agricultural Soil Management	227	238	245	247	250	258	265	273
Stationary and Mobile Combustion	67	57	43	40	33	28	27	27
Nitric and Adipic Acid Production	25	24	21	26	21	21	21	20
Other	39	37	35	43	39	39	46	50
<b>Hydrofluorocarbons (HFCs)</b>								
ODS Substitutes (HFCs)	76	99	115	122	154	200	260	291
HCFC-22 Production (HFC-23)	29	16	6	7	7	7	8	11
Semiconductors	0.3	0.2	0.4	0.3	0.3	0.4	0.4	0.5
<b>Perfluorocarbons (PFCs)</b>								
Aluminum	9	3	2	3	2	2	2	2
Semiconductors	5	3	4	4	4	4	4	5
<b>Sulfur Hexafluoride (SF<sub>6</sub>)</b>								
Electrical Transmission and Distribution	15	11	8	7	7	7	7	8
Magnesium	3	3	1	1	1	1	1	1
Semiconductors	1	1	1	1	1	1	1	1

<sup>a</sup> Historical emissions and sinks data are from U.S. EPA/OAP 2013. Bunker fuels and biomass combustion are not included in inventory calculations.

largely due to improvements in emission control technologies and gradual turnover of the existing vehicle fleet (U.S. EPA/OAP 2013).

**Hydrofluorocarbon, Perfluorocarbon, and Sulfur Hexafluoride Emissions**

HFC emissions are estimated to increase by 80 percent between 2005 and 2020. Over the same period, PFC and SF<sub>6</sub> emissions are estimated to decline somewhat through increased voluntary control.

HFC emissions are increasing because of greater demand for refrigeration and air conditioning and because HFCs are predominantly used as alternatives for ODSs, such as hydrochlorofluorocarbons (HCFCs) that are being phased out under the Montreal Protocol. HFC-23 is also emitted as a by-product during the manufacture of HCFC-22. Both HFCs and HCFCs are GHGs, but HCFCs are not included here to be consistent with the United Nations Framework Convention on Climate Change (UNFCCC) guidelines (UNFCCC 2006). Growth of HFCs is anticipated to continue well beyond 2020 if left unconstrained.

Other sources of HFCs, PFCs, and SF<sub>6</sub> in industrial production include aluminum, magnesium, and semiconductor manufacturing and, in the case of SF<sub>6</sub>, electricity transmission and distribution. These projections assume that voluntary emission reductions will be made in the aluminum and semiconductor industries as part of efforts to meet global voluntary reduction goals (U.S. EPA 2013b).

**EMISSIONS PROJECTIONS BY SECTOR**

This section presents projected GHG emissions for the following sectors: energy, transportation, industrial processes, agriculture, waste, and LULUCF (Table 5-3). These sectors largely correspond to the IPCC sector definitions used for the U.S. GHG inventory in Chapter 3 of this report. For inventory purposes, transportation is included within the energy sector and solvents are treated as a separate sector, whereas here they are included within industrial processes.

**Energy**

The energy sector as described in this chapter includes energy-related CO<sub>2</sub> emissions from electric power production and the residential, commercial, and industrial sectors. It also

Table 5-3 **Historical and Projected U.S. Greenhouse Gas Emissions Baseline, by Sector: 1990–2030** (Tg CO<sub>2</sub>e)

Emissions from the energy, transportation, and waste sectors are projected to decline from 2005 to 2020, while emissions from the industrial processes and agriculture sectors are projected to increase, and sequestration from land use, land-use change, and forestry is projected to decline.

Sectors <sup>b</sup>	Historical GHG Emissions <sup>a</sup>				Projected GHG Emissions			
	2000	2005	2010	2011	2015	2020	2025	2030
Energy	4,258	4,321	4,104	3,981	3,936	4,038	4,141	4,207
Transportation	1,861	1,931	1,786	1,765	1,710	1,702	1,660	1,627
Industrial Processes	357	335	308	331	378	438	504	536
Agriculture	432	446	462	461	461	485	498	512
Forestry and Land Use	31	25	20	37	30	27	40	35
Waste	136	137	131	128	127	126	125	123
<b>Total Gross Emissions</b>	<b>7,076</b>	<b>7,195</b>	<b>6,812</b>	<b>6,702</b>	<b>6,643</b>	<b>6,815</b>	<b>6,967</b>	<b>7,041</b>
Forestry and Land Use (Sinks) <sup>c</sup>	high sequestration				-884	-898	-917	-937
	low sequestration	-682	-998	-889	-905	-787	-614	-573
<b>Total Net Emissions</b>	<b>high sequestration</b>	<b>6,395</b>	<b>6,197</b>	<b>5,923</b>	<b>5,797</b>	<b>5,759</b>	<b>5,918</b>	<b>6,050</b>
	<b>low sequestration</b>	<b>6,395</b>	<b>6,197</b>	<b>5,923</b>	<b>5,797</b>	<b>5,856</b>	<b>6,201</b>	<b>6,394</b>

<sup>a</sup> Historical emissions and sinks data are from U.S. EPA/OAP 2013. Bunker fuels and biomass combustion are not included in inventory calculations.

<sup>b</sup> Sectors correspond to inventory reporting sectors, except that carbon dioxide, methane, and nitrous oxide emissions associated with mobile combustion have been moved from energy to transportation, and solvent and other product use is included within industrial processes.

<sup>c</sup> Sequestration is only included in the net emissions total.

includes fugitive CH<sub>4</sub> and non-energy CO<sub>2</sub> emissions from production of natural gas, oil, and coal; process emissions associated with non-energy uses of fossil fuels; and CH<sub>4</sub> and N<sub>2</sub>O emissions from stationary combustion and incineration of waste for energy. Transportation-related emissions are discussed in the next section.

Under the 2012 policy baseline scenario, total energy sector emissions decline by 6.5 percent from 2005 to 2020. Energy-related CO<sub>2</sub> emissions decline in the electric power and residential sectors between 2005 and 2020, and increase in the industrial and commercial sectors (Table 5-4).

### Electric Power

Total energy-related CO<sub>2</sub> from electricity production declines by 13.4 percent from 2005 to 2020, under the 2012 policy baseline scenario (Table 5-5). The growth of electricity demand (including retail sales and direct use) has slowed in each decade since the 1950s, from a 9.8 percent annual rate of growth from 1949 to 1959 to only 0.7 percent per year in the first decade of the 21st century. In the 2012 policy baseline scenario, growth in electricity demand remains relatively slow, as increasing demand for electricity services is offset by efficiency gains from new appliance standards and investments in energy-efficient equipment. Total electricity generation grows by 7 percent in the projection (0.8 percent per year) from 4,093 billion kilowatt-hours (kWh) in 2011 to 4,389 billion kWh in 2020 (U.S. DOE/EIA 2013b).

Table 5-4 **Historical and Projected U.S. Energy-Related CO<sub>2</sub> Emissions by Sector and Source<sup>a</sup>** (Tg CO<sub>2</sub>e)

Energy-related CO<sub>2</sub> emissions are projected to decline in the electric power and residential sectors between 2005 and 2020, and increase in the industrial and commercial sectors.

Sector and Fuel	Historical GHG Emissions			Projected GHG Emissions	
	2005 <sup>b</sup>	2010	2011	2020	2030
<b>Electric Power Total</b>	<b>2,402</b>	<b>2,259</b>	<b>2,166</b>	<b>2,081</b>	<b>2,224</b>
Petroleum	99	32	27	13	14
Natural Gas	319	399	409	446	482
Coal	1,984	1,828	1,723	1,610	1,717
<b>Transportation<sup>c</sup></b>	<b>1,892</b>	<b>1,764</b>	<b>1,745</b>	<b>1,690</b>	<b>1,617</b>
Petroleum	1,859	1,726	1,706	1,648	1,564
Natural Gas	33	38	39	42	53
<b>Industrial<sup>c</sup></b>	<b>823</b>	<b>780</b>	<b>773</b>	<b>872</b>	<b>888</b>
Petroleum	320	273	267	295	281
Natural Gas	389	411	416	478	499
Coal	115	96	90	99	108
<b>Residential<sup>c</sup></b>	<b>358</b>	<b>335</b>	<b>329</b>	<b>317</b>	<b>299</b>
Petroleum	95	75	74	71	62
Natural Gas	262	259	255	245	236
Coal	1	1	1	1	1
<b>Commercial<sup>c</sup></b>	<b>224</b>	<b>222</b>	<b>222</b>	<b>232</b>	<b>236</b>
Petroleum	51	47	47	47	45
Natural Gas	163	168	170	180	186
Coal	9	6	5	5	5
<b>U.S. Territories</b>	<b>50</b>	<b>50</b>	<b>50</b>	<b>51</b>	<b>53</b>
<b>Total Energy-Related CO<sub>2</sub> Emissions</b>	<b>5,749</b>	<b>5,409</b>	<b>5,277</b>	<b>5,243</b>	<b>5,318</b>

<sup>a</sup> U.S. DOE/EIA 2013b, with adjustments for bunker fuels, non-energy use of fossil fuels, and U.S. territories.

<sup>b</sup> Historical emissions data are from U.S. EPA/OAP 2013a.

<sup>c</sup> Sector total emissions do not include indirect emissions from electricity use.

Coal-fired power plants continue to be the largest source of electricity generation in the 2012 policy baseline scenario, but their market share declines significantly. From 42 percent in 2011, coal's share of total U.S. generation declines to 38 percent in 2020 and 37 percent in 2030 (U.S. DOE/EIA 2013b).

Most new capacity additions use natural gas or renewable energy. Natural gas-fired plants account for 44 percent of capacity additions from 2012 through 2020 in the 2012 policy baseline scenario, compared with 43 percent for renewables, 7 percent for coal, and 6 percent for nuclear. Escalating construction costs have the largest impact on capital-intensive technologies, which include nuclear, coal, and renewables. However, federal tax incentives, state energy programs, and rising prices for fossil fuels increase the competitiveness of renewable and nuclear capacity. Current federal and state environmental regulations also affect the use of fossil fuels, particularly coal. Uncertainty about future limits on GHG emissions and other possible environmental programs also reduces the competitiveness of coal-fired plants (U.S. DOE/EIA 2013b).

### Residential

Total energy-related CO<sub>2</sub> emissions from residential energy use (excluding indirect emissions from electricity use) decline by 11.5 percent from 2005 to 2020 under the 2012 policy baseline scenario. The energy intensity of residential demand, defined as annual energy use per household, declines from 97.2 million British thermal units (Btus) in 2011 to 86.0 million Btus in 2020. The projected 12 percent decrease in intensity occurs along with a 10 percent increase in the number of homes. Residential energy intensity is affected by various factors—for example, population shifts to warmer and drier climates, improvements in the efficiency of building construction and equipment stock, and the attitudes and behavior of residents toward energy savings (U.S. DOE/EIA 2013b).

### Commercial

Total energy-related CO<sub>2</sub> emissions from commercial energy use (excluding indirect emissions from electricity) increase by 3.7 percent from 2005 to 2020 under the 2012 policy baseline scenario. Commercial floor space grows by an average of 1.0 percent per year from 2011 to 2020, while energy consumption grows by about 0.2 percent over the same period.

Table 5-5 Details on the Electric Power Sector

Most new capacity additions use natural gas or renewables. Natural gas-fired plants account for 44 percent of capacity additions from 2012 through 2020 in the 2012 policy baseline scenario, compared with 43 percent for renewables, 7 percent for coal, and 6 percent for nuclear.

Electric Power by Fuel	Historical GHG Emissions						Projected GHG Emissions			
	2005		2010		2011		2020		2030	
	Emissions (Tg CO <sub>2</sub> e)	Generation (billion kWh)	Emissions (Tg CO <sub>2</sub> e)	Generation (billion kWh)	Emissions (Tg CO <sub>2</sub> e)	Generation (billion kWh)	Emissions (Tg CO <sub>2</sub> e)	Generation (billion kWh)	Emissions (Tg CO <sub>2</sub> e)	Generation (billion kWh)
<b>Fossil Fuels</b>	<b>2,402</b>	<b>2,491</b>	<b>2,259</b>	<b>2,874</b>	<b>2,158</b>	<b>2,779</b>	<b>2,081</b>	<b>2,878</b>	<b>2,224</b>	<b>3,184</b>
Petroleum	99	122	32	37	27	28	13	17	14	18
Natural Gas	319	761	399	970	409	1,000	446	1,184	482	1,379
Coal	1,984	1,594	1,828	1,847	1,723	1,730	1,610	1,656	1,717	1,766
Other	8	13	12	19	11	20	11	20	11	20
<b>Non-Fossil Fuels</b>	<b>0</b>	<b>1,140</b>	<b>0</b>	<b>1,236</b>	<b>0</b>	<b>1,314</b>	<b>0</b>	<b>1,511</b>	<b>0</b>	<b>1,593</b>
Nuclear	0	782	0	807	0	790	0	885	0	908
Renewable	0	358	0	429	0	524	0	627	0	685
<b>Non-Fossil % Share Generation</b>	<b>31%</b>		<b>30%</b>		<b>32%</b>		<b>34%</b>		<b>33%</b>	
<b>Total Generation</b>	<b>3,630</b>		<b>4,110</b>		<b>4,093</b>		<b>4,389</b>		<b>4,777</b>	



Federal efficiency standards, which help to foster technological improvements in end uses (e.g., space heating and cooling, water heating, refrigeration, and lighting) act to limit the growth in energy consumption to less than the growth in commercial floor space (U.S. DOE/EIA 2013b).

### Industrial

Total energy-related CO<sub>2</sub> emissions from the industrial sector (excluding indirect emissions from electricity use) increase by 5.9 percent from 2005 to 2020 under the 2012 policy baseline scenario. Despite a 31 percent increase in industrial shipments, industrial delivered energy consumption increases by only 12 percent from 2011 to 2020. The continued decline in energy intensity within the industrial sector is explained in part by a shift in the share of shipments from energy-intensive manufacturing industries (bulk chemicals, petroleum refineries, paper products, iron and steel, food products, aluminum, cement and lime, and glass) to other, less energy-intensive industries, such as plastics, computers, and transportation equipment.

Much of the growth in industrial energy consumption in the 2012 policy baseline scenario is accounted for by natural gas use, which increases by 15 percent from 2011 to 2020. With domestic natural gas production increasing sharply in the projection, natural gas prices remain relatively low. However, the mix of industrial fuels changes relatively slowly, reflecting limited capability for fuel switching in most industries (U.S. DOE/EIA 2013b).

### Transportation

The transportation sector, as described in this chapter, consists of energy-related CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O from mobile source combustion. Total transportation GHG emissions decline by 11.9 percent between 2005 and 2020 under the 2012 policy baseline scenario.

CO<sub>2</sub> emissions from fossil fuel combustion in the transportation sector decline by 10.7 percent between 2005 and 2020. The decline occurred between 2005 and 2012, while emissions are expected to remain flat from 2012 through 2020. The growth in transportation energy consumption is flat across the projection. The transportation sector consumes 27.2 quadrillion Btus of energy in 2020, nearly the same as the level of energy demand in 2011. The projection of no growth in transportation energy demand differs markedly from the historical trend, which saw 1.1 percent average annual growth from 1975 to 2011. No growth in transportation energy demand is the result of declining energy use for light-duty vehicles (LDVs), which offsets increased energy use for heavy-duty vehicles, aircraft, marine and rail transportation, and pipelines. Higher fuel economy for LDVs more than offsets modest growth in vehicle miles traveled per driver (U.S. DOE/EIA 2013b).

N<sub>2</sub>O emissions from mobile combustion decrease faster than energy-related CO<sub>2</sub> emissions, by nearly three-quarters from 2005 to 2020. Emissions from this source are declining due to improvements in emission control technologies and gradual turnover of the existing vehicle fleet (U.S. EPA/OAP 2013).

### Industrial Processes

The industrial processes sector corresponds to the IPCC inventory guidelines category of the same name, plus emissions categorized as Solvent and Other Product Use (IPCC 2006). The sector includes emissions of GHGs associated with chemical transformations as part of industrial production of iron and steel, cement, nitric and adipic acid, and HCFC-22. It also includes emissions of fluorinated GHGs associated with the use of HFCs as substitutes for ODSs and other industrial uses.

Total emissions from industrial processes are projected to grow by 31 percent from 2005 to 2020 under the 2012 policy baseline scenario. From 2005 to 2011, emissions declined by 1.3 percent, but emissions are expected to grow rapidly between 2011 and 2020.

The total value of shipments from energy-intensive industries is expected to grow by an average of 1.7 percent from 2011 to 2020 in the 2012 policy baseline scenario. The iron and steel, cement, and glass industries show the greatest variability in shipments as a result of changes in economic growth assumptions. Energy efficiency improvements reduce the rate of growth of energy consumption relative to shipments. The strong growth can be explained largely by



low natural gas prices that result from increased domestic production of natural gas from tight formations, as well as the continued economic recovery (U.S. DOE/EIA 2013b).

### **Agriculture**

The agriculture sector includes CH<sub>4</sub> and N<sub>2</sub>O emissions associated with livestock (e.g., enteric fermentation, manure management); crop production (e.g., agricultural soil management, rice production); and field burning of agricultural residues. CO<sub>2</sub> emissions and sinks associated with agricultural soils are included in the LULUCF sector. Emissions from the agriculture sector are projected to increase by 8.7 percent from 2005 to 2020 under the 2012 policy baseline scenario.

Livestock and crop production data are drawn from *USDA Agricultural Projections to 2022* (Westcott and Trostle 2013). The projections assume no domestic or external shocks that would affect global agricultural markets, normal weather, and extension of existing policies, such as the Food, Conservation, and Energy Act of 2008 (Farm Bill). Agricultural activities are extrapolated through 2030 based on their trends from 2012 through 2022 for the purpose of estimating emissions from agricultural sources.

Emissions from agricultural soil management are expected to increase by 8.8 percent between 2005 and 2020 as a result of increased crop production. Over the long run, steady global economic growth provides a foundation for continuing strong crop demand. U.S. corn-based ethanol production is projected to rebound from the 2012 decline, although the pace of further expansion slows considerably. Nonetheless, the combination of world economic growth, a depreciating dollar, and continued expansion of global biofuels production supports longer-run gains in world consumption and trade of crops (Westcott and Trostle 2013).

As a result of increased livestock production, enteric fermentation emissions are expected to rise by 7.0 percent from 2005 to 2020. Emissions from manure management rise from a combination of increased livestock populations and shift toward liquid waste management systems. High feed prices, the economic recession, and drought in the U.S. Southern Plains have combined to reduce producer returns and lower production incentives in the livestock sector over the past several years. Over the rest of the projection period, higher net returns and improved forage supplies lead to expansion of meat and poultry production (Westcott and Trostle 2013).

### **Waste**

The waste sector includes CH<sub>4</sub> and N<sub>2</sub>O emissions from landfills, wastewater treatment, and composting. Emissions from incineration of waste are included within the energy sector. Emissions from the waste sector are projected to decline by 8.1 percent between 2005 and 2020 under the 2012 policy baseline scenario.

Approximately 80 percent of emissions in the waste sector is CH<sub>4</sub> from landfills. Between 2005 and 2020, emissions from landfills are projected to decline, despite increasing waste disposal amounts, as a result of an increase in the amount of landfill gas collected and combusted. The quantity of recovered CH<sub>4</sub> that is either flared or used for energy purposes is expected to continually increase as a result of 1996 federal regulations that require large municipal solid waste landfills to collect and combust landfill gas, as well as voluntary programs that encourage CH<sub>4</sub> recovery and use (U.S. EPA/OAP 2013).

### **Land Use, Land-Use Change, and Forestry**

The LULUCF sector includes net CO<sub>2</sub> flux from carbon (C) sequestration (such as carbon stored in trees and agricultural soils) (Table 5-6), and emissions from land-use activities (such as liming and urea fertilization of cropland and CH<sub>4</sub> and N<sub>2</sub>O emissions resulting from forest fires) (Table 5-7).

LULUCF activities in 2011 resulted in a net carbon sequestration of 905.0 Tg CO<sub>2</sub>e (246.8 Tg C). This represents an offset of 16.1 percent of total U.S. CO<sub>2</sub> emissions, or 13.5 percent of total U.S. GHG emissions in 2011 (U.S. EPA/OAP 2013). Forests currently account for the vast majority of net carbon sequestration among all land uses in the United States. Trends in net sequestration over the last two decades are principally the result of a positive growth-to-harvest ratio for U.S. forests nationally and small annual expansions in the area of forested land.

Table 5-6 Projections of Net Carbon Sequestration

In the long term, U.S. forest carbon stocks are likely to accumulate at a slower rate, and eventually may decline as a result of forestland conversion and changes in growth related to climate change and other disturbances. The timing of these changes is uncertain, represented by the range between the high- and low-sequestration scenarios.

Sources of Sequestration	Historical CO <sub>2</sub> Sink <sup>a</sup>				Projected CO <sub>2</sub> Sink				
	2000	2005	2010	2011	2015	2020	2025	2030	
Forests <sup>b</sup>	high sequestration	-431	-800	-758	-762	-720	-728	-742	-755
	low sequestration					-623	-445	-397	-383
Wood Products <sup>c</sup>	-113	-105	-59	-72	-83	-83	-83	-83	
Urban Forests	-58	-63	-68	-69	-73	-77	-82	-86	
Agricultural Soils <sup>d</sup>	-66	-18	10	10	5	5	5	5	
Landfilled Yard Trimmings and Food Scraps	-13	-12	-13	-13	-14	-15	-16	-17	
<b>Total Sequestration</b>	<b>high sequestration</b>	<b>-682</b>	<b>-998</b>	<b>-889</b>	<b>-905</b>	<b>-884</b>	<b>-898</b>	<b>-917</b>	<b>-937</b>
	<b>low sequestration</b>					<b>-787</b>	<b>-614</b>	<b>-573</b>	<b>-565</b>

<sup>a</sup> Historical values are from U.S. EPA/OAP 2013.

<sup>b</sup> Estimates include carbon in above-ground and below-ground biomass, dead wood, litter, and forest soils. The high-sequestration scenario represents an extrapolation of historical inventory trends (slight annual increases in both forest land and carbon density). The low-sequestration scenario assumes that forest accumulation slows until there is no net loss or gain of forestland and carbon densities decline slightly from current rates to the historical average from 1991 through 2011. CO<sub>2</sub> emissions from forest fires are implicitly included in these estimates.

<sup>c</sup> Historical estimates are composed of changes in carbon held in wood products in use and in landfills, including carbon from domestically harvested wood and exported wood products (Production Accounting Approach).

<sup>d</sup> Includes cropland and grassland soils, while forest soils are included within forests above.

Table 5-7 Emissions from Land Use, Land-Use Change, and Forestry (Tg CO<sub>2</sub>e)

Emissions from land use, land-use change, and forestry (LULUCF) include CO<sub>2</sub> from croplands and CH<sub>4</sub> and N<sub>2</sub>O from forest fires.

Gas	Historical Emissions <sup>a</sup>				Projected Emissions			
	2000	2005	2010	2011	2015	2020	2025	2030
Carbon Dioxide (CO <sub>2</sub> ) <sup>a</sup>	9	9	9	9	9	9	9	9
Methane (CH <sub>4</sub> ) <sup>b</sup>	11	8	5	14	11	9	16	13
Nitrous Oxide (N <sub>2</sub> O) <sup>c</sup>	11	8	6	13	10	9	15	13
<b>Total</b>	<b>31</b>	<b>25</b>	<b>20</b>	<b>37</b>	<b>30</b>	<b>27</b>	<b>40</b>	<b>35</b>

<sup>a</sup> CO<sub>2</sub> emissions from LULUCF include liming and urea fertilization of croplands, and peatland emissions.

<sup>b</sup> CH<sub>4</sub> emissions from LULUCF include emissions from forest fires.

<sup>c</sup> N<sub>2</sub>O emissions from LULUCF include emissions from forest fires, fertilizer use in forests and settlements, and peatlands.

The amount of carbon stored in forests depends primarily on the density of carbon stored and the area of forested land. Forest carbon density can change as a forest ages and as stand dynamics change. Forest carbon density can also change as a result of forest fires, insect infestations, and other natural disturbances, as well as forest harvesting or other forest management techniques. The USDA Forest Service (USDA/FS) estimates that from 1991 to 2011, net forested area increased by an average of 0.2 percent (about 556,560 hectares [ha], or 1.4 million acres [ac.] per year (U.S. EPA/OAP 2013).

Forested areas may change when they are cleared for other land-use activities. Over time, U.S. forestland has been converted to urban/developed use, and conversions between agricultural uses and forests have also occurred. Net losses of forestland in the 1970s and 1980s, largely driven by conversion to crop uses, gave way to gains in forestland in the 1990s and 2000s, as economic returns to crops fell relative to economic returns to forests. According to USDA/FS estimates, the average carbon density of forests in the inventory increased by about 0.23 percent per year between 1991 and 2011, or about 9 percent. During the same

period, annual forest sequestration of carbon amounted to 0.5 percent of the forest carbon inventory (U.S. EPA/OAP 2013).

There are indications that in the long term, U.S. forest carbon stocks are likely to accumulate at a slower rate, and eventually may decline as a result of forestland conversion and changes in forest growth related to climate change and other disturbances (Box 5-1; Haynes et al. 2007, Alig et al. 2010, Haim et al. 2011). The exact timing of these changes is uncertain, but U.S. forests are unlikely to continue historical trends of sequestering additional carbon stocks in the future under current policy conditions. While these changes may already be starting, major changes in U.S. forest inventory monitoring results are not expected in the next 5 to 10 years, partly due to lags in the time needed to collect and synthesize data for the entire nation.

For the above reasons, Table 5-6 provides two estimates for U.S. LULUCF carbon sequestration pathways to the year 2030. The high sequestration scenario (which reflects lower CO<sub>2</sub> emissions to the atmosphere) is an extrapolation based on recent forestland and forest carbon density accumulation rate trends (2000–2010 annual average increases of 556,560 ha [1.4 million ac] and 0.26 percent carbon density, respectively). The low sequestration scenario reflects expectations of slower accumulation of forestland and carbon density. With this scenario, forest area change declines from recent levels (accumulation of 556,560 ha [1.4 million ac] annually) and reaches a steady state of no net change in forest area in next decade. Forest carbon density declines from recent accrual rates (0.28 percent) to the 1991–2010 average (0.23 percent) by 2030.

Table 5-6 also shows CO<sub>2</sub> emissions or sequestration resulting from carbon stock changes in wood products, urban forests, agricultural soils, and landfilled yard trimmings and food scraps. Net CO<sub>2</sub> sequestration from these categories is projected to decline by 14 percent

#### Box 5-1 2010 Resources Planning Act Assessment

The USDA Forest Service recently published the 2010 Resources Planning Act (RPA) Assessment, which synthesizes key results of a comprehensive scientific assessment concerning the long-term outlook for the nation's forest and rangelands (USDA/FS 2012).

The RPA Assessment uses four scenarios with different assumptions about the potential rates of population growth, economic growth, land-use change, biomass energy use, and climate change over the next 50 years. This approach enables testing the sensitivity of future forest and other natural resource conditions against alternative assumptions regarding key economic, demographic, and climate variables. Viewed collectively, the RPA Assessment results highlight several long-term anthropogenic and natural forces that, absent changes in policy, demographic, or economic conditions, may act to diminish and, over time, possibly eliminate the U.S. forest carbon sink. The drivers of this anticipated decline include:

- *Aging forests:* U.S. forests are aging, and large areas of forest, particularly in the U.S. West, have reached or may reach in the next 10–20 years an age where their annual rate of growth, and thus their annual carbon sequestration rate, is expected to start declining.
- *Land-use change out of forest:* As the U.S. population increases, so too will the pressure to develop forestland for residential, commercial, and other purposes. This pressure is likely to be most acute around urban centers and in the South. All four 2010 RPA scenarios indicate a change to net losses in forestland at some point in the next 20 years.
- *Forest disturbance effects:* Climate change, wildfire, insects, disease, and other natural disturbances will continue to influence forest growth rates and mortality, leading to forest type changes under some circumstances. The combined impact of these effects can be seen in historical data on growth, age distribution, and mortality. A recent synthesis of climate change effects on forests found that area of forests affected by wildfire, invasive species, and other disturbances will increase, and that drought will lead to higher mortality and slow regeneration of some species, and altered species assemblages (Vose et al. 2012).

The forest carbon change projections from the 2010 RPA Assessment are determined by how forest area and forest growth are modified in response to changing harvest for timber products and wood energy. The carbon change projections for harvested wood products are determined primarily by how the production of solid wood products changes in response to changing U.S. and foreign demand for timber products and wood energy. Details about the 2010 RPA Assessment scenarios, the forest inventory projections, and forest sector carbon projections can be found in USDA/FS 2012, Wear 2011, and Wear et al. 2013.

from 2005 to 2020. Sequestration values for historical years are taken from U.S. EPA/OAP (2013), while projections are based on historical averages or extrapolation of historical trends over 2005–2011, depending on expected industry trends.

CO<sub>2</sub> sequestration in urban forests and landfilled yard trimmings and food scraps are projected to increase gradually, based on expected increases in urban land use and population. Sequestration in wood products has declined in recent years as a result of reduced home-building and wood product production during the economic downturn, but is expected to recover to the average of recent years over 2011 to 2020.

Since 2005, agricultural soils have switched from a carbon sink to a net source of CO<sub>2</sub> emissions. This has been driven by relatively high commodity prices since 2007, which have resulted in farmers shifting millions of hectares into crop production and an accompanying increase in CO<sub>2</sub> emissions from agricultural lands. According to the USDA National Agricultural Statistics Service, land area planted to crops in the United States increased by almost 2 million ha (5 million ac) between 2005 and 2012 (USDA/NASS 2013). During this same period, land enrolled in USDA's Conservation Reserve Program (CRP), which pays farmers to put environmentally sensitive cropland into conservation plantings, decreased by almost the same amount (USDA/FSA 2013). The projections for agricultural soil carbon are based on projections for cropland enrolled in the CRP, which decreases from 12.5 million ha (31.1 million ac) in 2011 to 11.3 million ha (28.5 million ac) in 2015, and then rebounds to 13 million ha (32 million ac) in 2020 (Westcott and Trostle 2013).

## TOTAL EFFECT OF POLICIES AND MEASURES

### Changes in Gross Emission Projections between the 2010 and 2014 Climate Action Reports

Projections of gross GHG emissions under the 2012 policy baseline scenario presented in this report are significantly lower than emission projections presented in the 2010 CAR. These differences can be traced to a combination of changes in policies, energy prices, and economic growth. The current 2012 policy baseline projection and the analogous projections from the 2010 and 2006 CARs are shown in Figure Table 5-8 and Figure 5-1 for comparison (U.S. DOS 2007 and 2010). In the 2010 CAR, emissions were projected to increase by 4.3 percent from 2005 through 2020, versus a 5.2 percent *decline* from 2005 levels projected in this report. In the 2006 CAR, the expected growth was even higher, totaling 17 percent over the same time period. Actual emissions for 2011 are significantly below those projected in past reports.

Current emissions include the effects of a number of policies that have been implemented since the analysis was completed for the 2010 CAR. These policies include the GHG emission and fuel efficiency standards for light-, medium-, and heavy-duty vehicles; various state renewable portfolio standards; the American Recovery and Reinvestment Act of 2009 (ARRA); and California Assembly Bill (AB) 32, which established the GHG emissions cap in California. CH<sub>4</sub> emission projections also account for GHG co-benefits from new federal air standards for the oil and natural gas industry that require controls to reduce VOC emissions. (See Chapter 4 of this report for a fuller discussion of the major regulatory changes relevant to GHG emissions.) Figure 5-2 displays the energy-related CO<sub>2</sub> projections contained in Reference case projections from AEO2006 through AEO2013.

### Top-Down Estimate of the Effects of New Policies and Measures

An analysis was conducted to disaggregate changes in emission projections due to macroeconomic factors from changes resulting from policies and measures. The analysis decomposes emissions into factors representing population, per capita GDP, energy intensity, and carbon intensity of energy, referred to as a Kaya analysis (Figure 5-3). Between the 2010 and 2014 CARs, projections of population, GDP, energy use, and emissions were all adjusted (Table 5-9). By changing individual factors, the Kaya analysis can be used to associate proportions of the total change in emissions with each factor in the decomposition equation. By removing the portion of emissions change due to population and GDP changes, the remaining emissions change associated with energy and emission intensity is assumed to relate to new policies and measures and changing energy market conditions over the time period when the two sets of projections were prepared.

**Table 5-8 Comparison of 2012 Policy Baseline Projections with Previous U.S. Climate Action Reports**

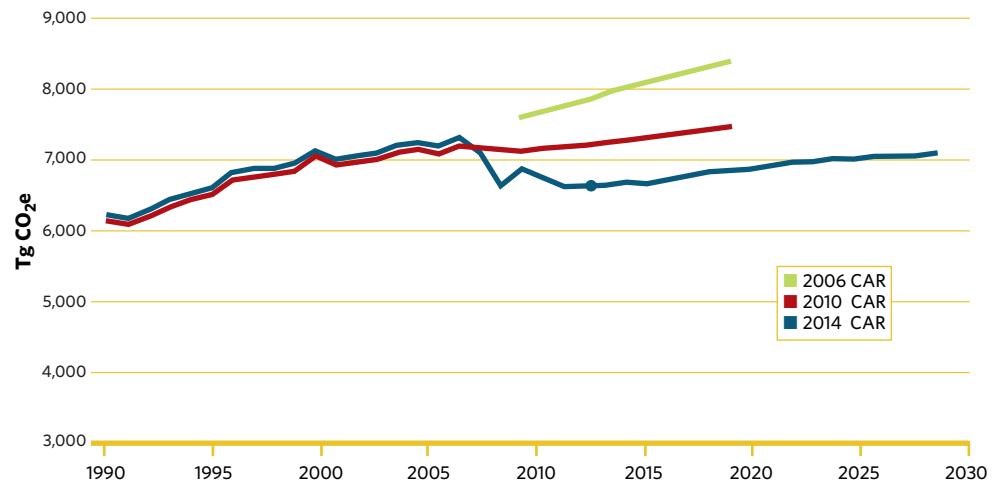
In the 2010 *Climate Action Report* (CAR), emissions were projected to increase by 4.3 percent from 2005 through 2020, versus a 5.2 percent decline from 2005 levels projected in this report.

Projection	Historical GHG Emissions <sup>a</sup>				Projected GHG Emissions			
	2000	2005	2010	2011	2015	2020	2025	2030
2014 CAR	7,076	7,195	6,812	6,702	6,643	6,815	6,967	7,041
2010 CAR		7,109	7,074		7,233	7,416		
2006 CAR			7,550		7,942	8,330		

<sup>a</sup> Historical and projected years vary between CARs. For the 2014 CAR, the base year inventory is 2011; for the 2010 CAR, it was 2007; and for the 2006 CAR, it was 2004.

**Figure 5-1 Comparison of Climate Action Report Baseline “With Measures” Projections of Gross Greenhouse Gas Emissions**

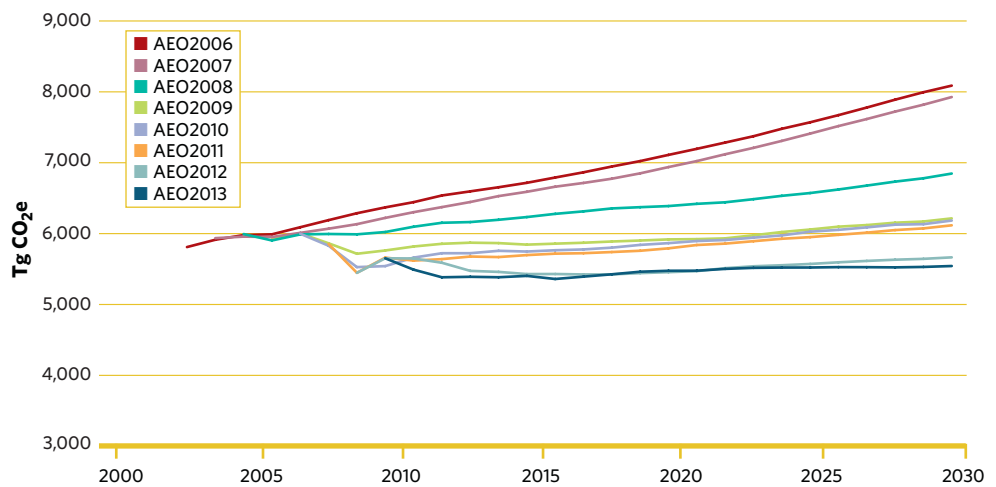
Projections of gross GHG emissions under the 2012 policy baseline case presented in this report are significantly lower than emission projections presented in the 2010 *Climate Action Report* (CAR).



Note: Emission projections displayed are gross emissions and do not include CO<sub>2</sub> removals from land use, land-use change, and forestry (LULUCF). Projections from each report reflect a baseline “with measures” scenario, including the effect of policies and measures implemented at the time the projections were prepared (before 2012 in the case of the 2014 CAR), but not planned or proposed additional measures.

**Figure 5-2 Comparison of Energy-Related CO<sub>2</sub> Projections from Annual Energy Outlook 2013 Reference Case Projections**

Recent projections of energy-related CO<sub>2</sub> emissions have declined relative to AEO2013 projections.



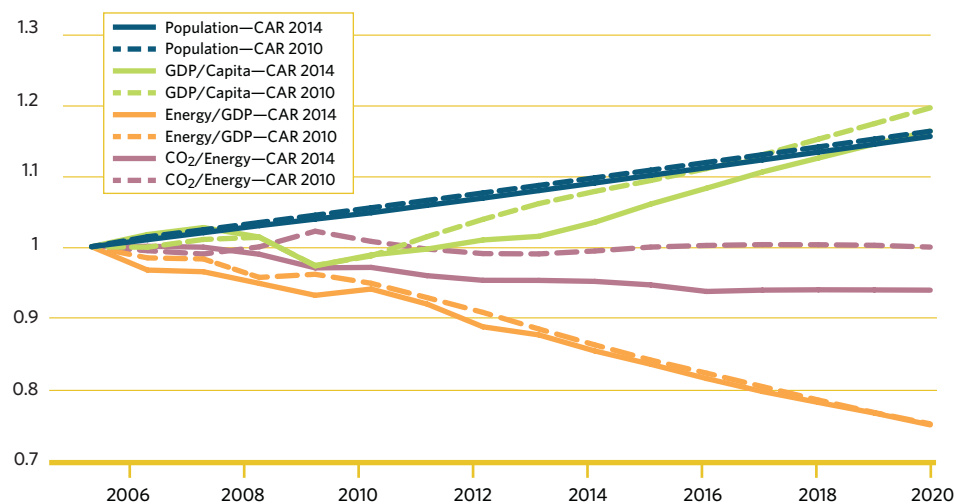
Source: U.S. DOE/EIA 2013b.

When this analysis was performed on the change in emission projections from the 2010 CAR to the 2014 CAR, about three-fifths of the total change in 2020 emission projections was found to be associated with changes in energy and emission intensity, resulting in an estimated reduction of about 350 Tg CO<sub>2e</sub> in both 2015 and 2020 from new policies and measures implemented between 2009 and 2013 (Figure 5-4). This methodology is sensitive to various assumptions, including revisions in macroeconomic, energy, and emissions data, and cannot be used to disaggregate the effects of policy from changes due to shifts in global energy markets.

AEO2013 provided the baseline projection of energy-related CO<sub>2</sub> emissions (U.S. DOE/EIA 2013b). Projected CO<sub>2</sub> emissions in AEO2013 were adjusted to match international inventory convention. EPA prepared the projections of non-energy-related CO<sub>2</sub> emissions and non-CO<sub>2</sub>

**Figure 5-3 Normalized Kaya Identity Factors Used for Assessing the Effects of New Policies and Measures**

The analysis decomposes emissions into factors representing population, per capita gross domestic product (GDP), energy intensity, and carbon intensity of energy, and compares the figures in the 2010 *Climate Action Report* (CAR) with those in this report.



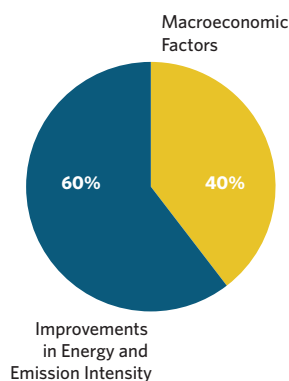
**Table 5-9 Comparison of Key Factors to Previous Climate Action Reports**

The 2014 *Climate Action Report* (CAR) reflects lower gross domestic product (GDP) and energy intensity in 2020 than was projected in the 2010 and 2006 CARs.

Factors	Assumptions for 2020		
	2006 CAR	2010 CAR	2014 CAR
Population (millions)	337	343	340
Real GDP (billion chain-weighted 2005 dollars)	19,770	17,356	16,859
Energy Intensity (Btu per 2005 chain-weighted dollar of GDP)	6,102	6,031	5,993
Light-Duty Vehicle Miles Traveled (billion miles)	3,474	3,137	2,870
Refiners Acquisition Cost of Imported Crude Oil (2005 dollars per barrel)	46.49	107.79	90.15
Wellhead Natural Gas Price (2005 dollars per thousand cubic feet)	5.06	6.39	3.48
Henry Hub (2005 dollars per thousand cubic feet)	5.45	7.23	3.75
Minemouth Coal Price (2005 dollars per ton)	20.87	25.78	43.46
Average Electricity Price (2005 cents per kilowatt-hour)	7.44	8.75	8.28
All-Sector Motor Gasoline Price (2005 dollars per gallon)	2.14	3.41	2.93
Energy Consumption	120.63	104.67	101.04

### Figure 5-4 Assessing Proportion of Change in Emission Projections

According to an analysis of the change in emission projections from the 2010 *Climate Action Report (CAR)* to the 2014 CAR, about three-fifths of the total change in 2020 emission projections was found to be associated with changes in energy and emission intensity, resulting in an estimated reduction of about 350 Tg CO<sub>2</sub>e in both 2015 and 2020 from new policies and measures implemented between 2009 and 2013.



emissions. The methodologies used to project non-CO<sub>2</sub> emissions are explained in the background document *Methodologies for U.S. Greenhouse Gas Emissions Projections: Non-CO<sub>2</sub> and Non-Energy CO<sub>2</sub> Sources* (U.S. EPA 2013b). USDA and EPA prepared the estimates of carbon sequestration. Historical emissions data are drawn from the *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2011* (U.S. EPA/OAP 2013). In general, the projections reflect long-run trends and do not attempt to mirror short-run departures from those trends. Information on the key factors underlying the projections is in Table 5-10.

### ADJUSTMENTS

Adjustments were made to the energy-related CO<sub>2</sub> emissions reported in this chapter to more closely adhere to UNFCCC guidelines (UNFCCC 2006). Fuel-related emissions in U.S. territories were added based on extrapolation of historical trends because *AEO2013* does not include these emissions. Emissions of CO<sub>2</sub> from non-energy use of fossil fuels were subtracted from *AEO2013* projections of energy-related CO<sub>2</sub> and were estimated as described in the methodologies background document (U.S. EPA 2013b). Military and civilian international use of bunker fuels was subtracted from the totals and is reported separately. Emissions from fuel use in U.S. territories remain at approximately 50 Tg CO<sub>2</sub>e from 2005 through 2020.

### Bunker Fuels

Bunker fuels consist of jet fuel, residual fuel oil, and distillate fuel oil used for international aviation and marine transport. Between 2005 and 2020, GHG emissions from bunker fuels are projected to increase by 3 percent from 114 Tg CO<sub>2</sub> to 118 Tg CO<sub>2</sub>. Emissions from international flights departing the United States are projected to increase by 8 percent between 2011 and 2020, while emissions from international shipping voyages are projected to increase by 2 percent over the same time period. Projections of bunker fuel emissions are subtracted from energy-related CO<sub>2</sub> totals from the *AEO2013* Reference case and are scaled to ensure consistent coverage as the historical GHG inventory.

### Legislation and Regulations Included in the Current Projections

As discussed in Chapter 4 of this report, since the 2010 CAR the U.S. government has continued to make important progress toward reducing GHG emissions through policies and measures

Table 5-10 Summary of Key Variables and Assumptions Used in the Projections Analysis

Emissions are projected to remain below the 2005 level through 2030, despite significant increases in population (26 percent) and gross domestic product (GDP—69 percent) over that period.

Key Variable	Historical Values				Projected Values			
	2000	2005	2010	2011	2015	2020	2025	2030
Population (millions)	282	296	309	312	325	340	356	372
Real GDP (billion 2005 dollars)	\$11,216	\$12,623	\$13,063	\$13,299	\$14,679	\$16,859	\$18,985	\$21,355
Total Primary Energy Consumption (quadrillion Btus)	98.8	100.3	97.7	97.3	97.7	101.0	102.3	102.8
Energy Intensity (Btu per chain-weighted dollar of GDP)	8,810	7,944	7,481	7,316	6,657	5,993	5,391	4,814
Natural Gas Consumption (dry gas) (quadrillion Btus)	23.8	22.6	24.3	24.8	25.9	26.8	27.3	28.0
Petroleum Consumption (quadrillion Btus)	38.3	40.4	36.0	35.3	37.0	37.5	36.9	36.1
Coal Consumption (quadrillion Btus)	22.6	22.8	20.8	19.6	18.2	18.6	19.3	19.7
Vehicle Miles Travelled, All Vehicles (billion miles)	2,747	2,989	2,967	2,946	2,960	3,194	3,439	3,694



that promote increased investment in technologies and practices that reduce CO<sub>2</sub>, methane, and other GHG emissions across all sectors. The projections presented in this chapter reflect this progress and include the effects of legislative and regulatory actions finalized before September 2012. In particular, the 2012 policy baseline includes regulatory and statutory changes enacted since the 2010 CAR, which relied on the AEO2009 Reference case (U.S. DOE/EIA 2009 and U.S. DOS 2010). These regulatory and statutory changes apply to emissions in multiple sectors, including transportation, residential, commercial, and electric power.

However, the current projections of U.S. GHG emissions do not include the effects of any legislative or regulatory action that was not finalized before September 2012. For example, the 2012 policy baseline does not reflect the provisions of the American Taxpayer Relief Act of 2012, enacted on January 1, 2013, or the measures in *The President's Climate Action Plan* (U.S. Congress 2013 and EOP 2013a).

### Description of NEMS and Methodology

The National Energy Modeling System (NEMS) was developed and is maintained by EIA's Office of Energy Analysis. The projections in NEMS are developed with the use of a market-based approach to energy analysis. For each fuel and consuming sector, NEMS balances energy supply and demand, accounting for economic competition among the various energy fuels and sources. The time horizon of NEMS is through 2040, approximately 25 years into the future.

NEMS is organized and implemented as a modular system. The modules represent each of the fuel supply markets, conversion sectors, and end-use consumption sectors of the energy system. NEMS also includes macroeconomic and international modules. The primary flows of information among the modules are the delivered prices of energy to end users and the quantities consumed by product, region, and sector. The delivered fuel prices encompass all the activities necessary to produce, import, and transport fuels to end users. The information flows also include other data on such areas as economic activity, domestic production, and international petroleum supply.

Each NEMS component represents the impacts and costs of existing legislation and environmental regulations that affect that sector. NEMS accounts for all combustion-related CO<sub>2</sub> emissions, as well as emissions of sulfur dioxide, nitrogen oxides, and mercury from the electricity generation sector. The potential impacts of pending or proposed federal and state legislation, regulations, or standards—or of sections of legislation that have been enacted but that require funds or implementing regulations that have not been provided or specified—are not reflected in NEMS.

### Technology Development

The projections of U.S. GHG emissions 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.

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

**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. These two drivers work in opposing directions. However, the effect on energy service demand is the stronger of the two, so that levels of primary energy use are positively correlated with the size of the economy. The economy is projected to grow more slowly through 2020 than projected in the 2010 CAR, which is expected to slow emissions growth.

**Weather and Climate**

Energy use for heating and cooling is directly responsive to climate variability and change. *AEO2013* projection of CO<sub>2</sub> emissions account for trends in demand for heating and cooling based on the 30-year historical trend in heating- and cooling-degree days, and on state-level population projections. Therefore, the projections reflect both population migration and linear changes in heating- and cooling-degree days at a state level.