2

National Circumstances

Greenhouse gas (GHG) emissions in the United States are influenced by a multitude of factors. These include population and density trends, economic growth, energy production and consumption, technological development, use of land and natural resources, as well as climate and geographic conditions. This chapter focuses on both current circumstances and departures from historical trends since the 2006 *U.S. Climate Action Report* (2006 CAR) was submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2007, and the impact of these changes on GHG emissions and removals (U.S. DOS 2007).

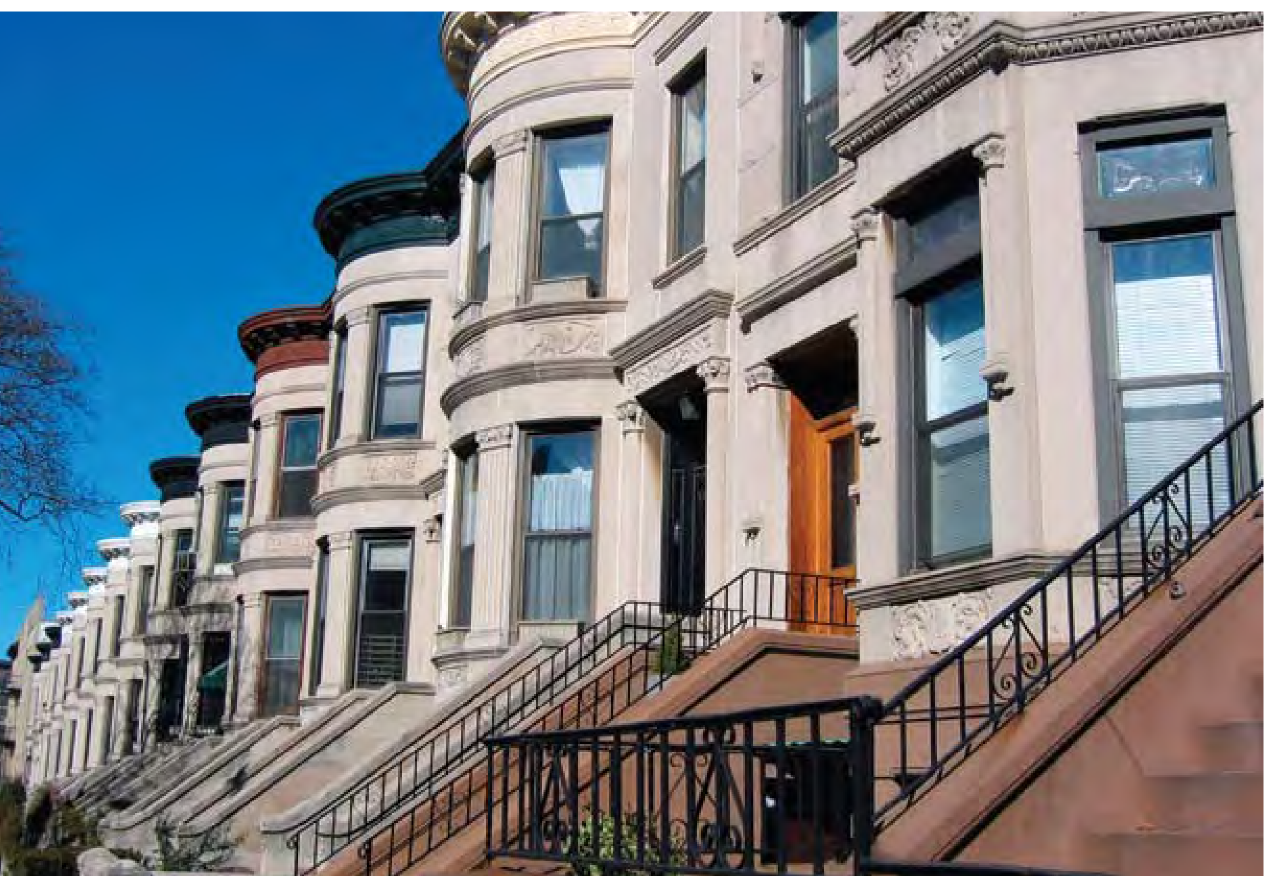
GOVERNMENT STRUCTURE

The United States is a federal republic. As such, local, state, and federal governments share responsibility for the nation's economic development, energy, natural resources, and many other issues. At the federal government level, a number of federal agencies, commissions, and advisory offices to the President are involved in developing, coordinating, and implementing nationwide policies to act on climate change.

The United States government is divided into three distinct branches: executive, legislative, and judicial. Each branch possesses distinct powers, but each also affects the other two, which creates a system of "checks and balances" and separates the powers to create, implement, and adjudicate laws.

Executive Branch

The executive branch is charged with implementing and enforcing the laws of the United States. The President of the United States is the U.S. Head of State and



oversees the executive branch. The President is advised by a Cabinet that includes a Vice President and the heads of 15 executive agencies—the Departments of State, Treasury, Defense, Justice, Interior, Agriculture, Commerce, Labor, Health and Human Services, Housing and Urban Development, Transportation, Energy, Education, Veterans Affairs, and Homeland Security. Other positions with Cabinet rank include the President's Chief of Staff, the Administrator of the Environmental Protection Agency, the Director of the Office of Management and Budget, the U.S. Trade Representative, the Chair of the Council of Economic Advisers, and the U.S. Ambassador to the United Nations. The Executive Office of the President, overseen by the President's Chief of Staff, includes a number of offices that play important roles in U.S. climate policy, such as the the Office of Energy and Climate Change, the Office of Science and Technology Policy, the Council on Environmental Quality, and the National Security Council. The executive branch also includes a number of independent commissions, boards, and agencies, such as the Federal Energy Regulatory Commission and the Export-Import Bank. Collectively, executive branch institutions cover a wide range of responsibilities, such as serving America's interests overseas, developing and maintaining the federal highway and air transit systems, researching the next generation of energy technologies, and managing the nation's abundant public lands.

Legislative Branch

The legislative branch consists of the two bodies in the U.S. Congress—the House of Representatives and the Senate—which are the primary lawmaking bodies of the government. This branch represents the U.S. citizenry through a bicameral system intended to balance power between representation based on population and representation based on statehood. The Senate is composed of 100 members, two from each of the 50 U.S. states. The House is composed of 435 members; each represents a single congressional district of approximately 650,000 people. In Congress, climate change is addressed by committees that are charged with developing legislation on energy and other relevant issues. In the House, the Committees on Agriculture, Labor, Ways and Means, and Energy and Commerce, among others, play vital roles in developing legislation. In the Senate, the Committees on Environment and Public Works; Finance; Foreign Relations; Agriculture; Commerce, Science, and Transportation; and Energy and Natural Resources are critical venues for debate.

Each body of Congress has the authority to develop legislation. A completed bill must receive a majority of votes in both the House and the Senate, and any differences between the House and the Senate versions must be reconciled before that bill can be sent to the President to be signed into law. The legislation becomes effective upon the President's signature.

Because the legislative process requires the support of both chambers of Congress and also involves the executive branch, a strong base of support is necessary to enact new legislation. As climate legislation is developed, this high threshold will remain very relevant.

Judicial Branch

The third branch, the judicial branch, serves as the government's court system responsible for interpreting the U.S. Constitution. It includes the Supreme Court, which is the highest court in the United States. The judicial branch in particular plays a significant role in defining the jurisdiction of the executive departments and interpreting the application of climate and energy policies under existing laws.

Governance of Energy and Climate Change Policy

Jurisdiction for addressing climate change within the federal government cuts across each of the three branches. Within the executive branch alone, some two dozen federal agencies and executive offices work together to advise, develop, and implement policies that help the U.S. government understand the workings of the Earth's climate system, reduce GHG emissions and U.S. dependence on oil, promote a clean energy economy, and assess and respond to the adverse effects of climate change. Chapters 4, 6, 7, 8, and 9 of this report describe the activities of these agencies related to these policies.

As with many other policy areas, jurisdiction for energy policy is shared by federal and state governments. Economic regulation of the energy distribution segment is a state responsibility, with the Federal Energy Regulatory Commission regulating wholesale sales and transportation of natural gas and electricity. In the absence of comprehensive federal climate change legislation, U.S. states have increasingly enacted climate change legislation or other policies designed to promote clean energy. Examples of these policies are described in Chapter 4 of this report. Similarly, land-use oversight is subject to mixed jurisdiction, with localities playing strong roles as well, and many areas related to adaptation policy are taken up by state and local entities. Examples of these activities are provided in Chapter 6.

POPULATION PROFILE

Population changes and growth patterns are fundamental drivers of trends in energy consumption, land use, housing density, and transportation, all of which have a significant effect on U.S. GHG emissions. The United States is the third most populous country in the world, with an estimated population of 308 million. From 1990 to 2009, the U.S. population grew by 55.3 million, at an average annual rate of just over 1 percent, for a total growth of approximately 22 percent since 1990. This growth rate is one of the highest among advanced economies, and is more than three times that of the European Union during this time period. The U.S. Census Bureau projects that the annual growth rate will remain relatively constant at nearly 1 percent through 2020, when the U.S. population is projected to be 341 million. Compared to 2008 levels, the U.S. population is expected to grow to 373 million (22 percent) in 2030 and to 439 million (44 percent) in 2050. Although the projections show increasing population, between 2020 and 2050, the steady increase of immigration is expected to be balanced by decreasing U.S. population growth rates. Overall, U.S. population growth will slow slightly to 0.87 percent in 2030 and will decline to 0.79 percent in 2050 (U.S. DOC/Census 2008b).

Population density trends show that more Americans are moving into cities and metropolitan areas. From 2000 to 2007, the U.S. population living in metropolitan areas grew from 80.2 percent to 83.5 percent. In general, increasing urbanization changes commuter patterns and reduces GHG emissions from the transportation sector. However, compared to cities in many other industrialized countries, major U.S. cities have relatively low population densities, and U.S. urban commuters use more energy for transportation and generate higher GHG emissions per person (U.S. DOE/EIA 2009c).

In addition, within any metropolitan region, the population density, walkability of neighborhoods, and access to public transit vary substantially. As a result, the average GHG emissions from household transportation vary significantly. For example, monitoring surveys at Atlantic Station, a redeveloped steel mill in midtown Atlanta, Georgia, reveal residents drive 14 miles per day compared to the regional average of 33 miles per day (U.S. EPA and Jacoby 2008).

GEOGRAPHIC PROFILE

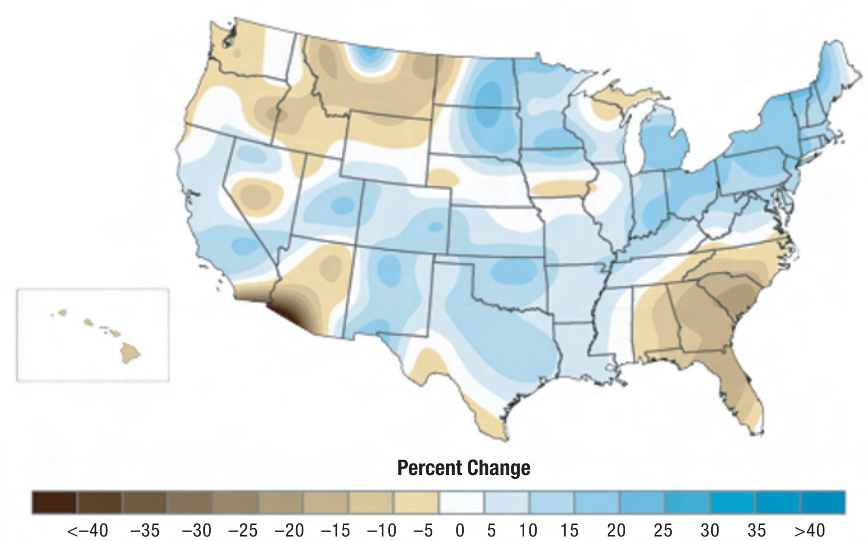
The United States is one of the largest countries in the world, with a total area of 9,192,000 square kilometers (km^2) (3,548,112 square miles [mi^2]) stretching over seven time zones. The topography is diverse, featuring deserts, lakes, mountains, plains, and forests. The federal government owns and manages the natural resources on about 28 percent of U.S. land, most of which is managed as part of the national systems of parks, forests, wilderness areas, wildlife refuges, and other public lands. More than 60 percent of land area is privately owned, 9 percent is owned by state and local governments, and 2 percent is held in trust by the Bureau of Indian Affairs (Lubowski et al. 2006b).

CLIMATE PROFILE

The climate of the United States is highly diverse, ranging from tropical conditions in south Florida and Hawaii to arctic and alpine conditions in Alaska and across the Rocky Mountains. Temperatures for the continental United States show a strong gradient across regions and seasons, from very high temperatures in southern coastal states where the annual average temperatures exceed 21°C (70°F), to much cooler conditions in the northern parts of the country along the Canadian border, and from seasonal differences as great as 50°C (90°F) between summer and winter in the northern Great Plains. Similarly, precipitation also varies across the country and by seasons, measuring more than 127 centimeters (50 inches) per year along the Gulf of Mexico, while annual precipitation can be less than 30 cm (12 in) in the Intermountain West and Southwest (Figure 2-1). The peak rainfall season also varies by region. Many parts of the Great Plains and Midwest experience late-spring peaks, West Coast

Figure 2-1 **Observed Change in Annual Average Precipitation: 1958–2008**

While U.S. annual average precipitation has increased about 5 percent over the past 50 years, there have been important regional differences.



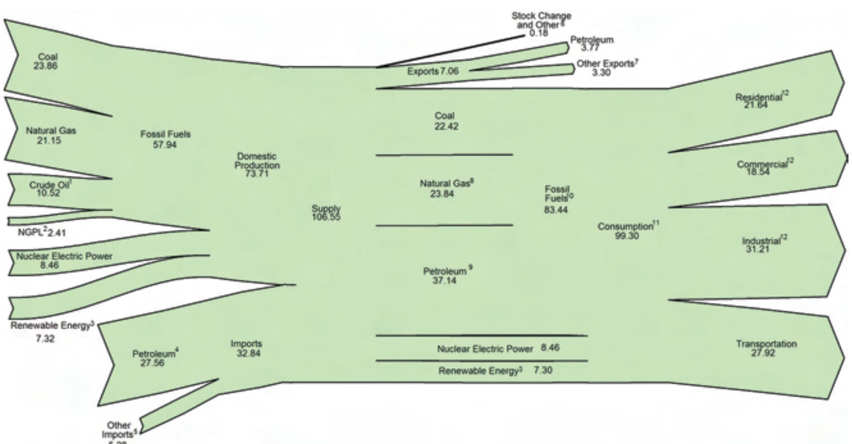
Source: Karl et al. 2009.

states have a distinct rainy season during winter, the Desert Southwest is influenced by summer's North American Monsoon, and many Gulf and Atlantic coastal regions experience summertime peaks.

The United States is subject to almost every kind of weather extreme, including severe thunderstorms, almost 1,500 tornadoes per year, and an average of 17 hurricanes that make landfall along the Gulf and Atlantic coasts each decade. At any given time, approximately 20 percent of the country experiences drought conditions. Differing U.S. climate conditions can be expressed by the number of annual heating and cooling degree-days.[1] Heating and cooling degree-days represent the number of degrees that the daily average temperature—the mean of the maximum and the minimum temperatures for a 24-hour period—is below (heating) or above (cooling) 18.3°C (65°F). For example, a weather station reporting a mean daily temperature of 4°C (40°F) would report 25 heating degree-days. From 2001 to 2008, the number of heating degree-days averaged 4,259, which was 3.8 percent below the 20th-century average. Over the same period, the annual number of cooling degree-days averaged 1,335, which was 5.4 percent above the long-term average.

Figure 2-2 **Energy Flow Through the U.S. Economy in 2008** (Quadrillion Btus)

The U.S. energy system is the world's largest, and it uses a diverse array of fuels from many different sources. The United States is largely self-sufficient in most fuels, except for petroleum. In 2008, net imports of crude oil and refined products accounted for about 57 percent of U.S. petroleum consumption on a Btu basis (U.S. DOE/EIA 2009m).



[1] Includes lease condensate.

[2] Natural gas plant liquids.

[3] Conventional hydroelectric power, biomass, geothermal, solar/photovoltaic, and wind.

[4] Crude oil and petroleum products. Includes imports into the Strategic Petroleum Reserve.

[5] Natural gas, coal, coal coke, fuel ethanol, and electricity.

[6] Adjustments, losses, and unaccounted for.

[7] Coal, natural gas, coal coke, and electricity.

[8] Natural gas only; excludes supplemental gaseous fuels.

[9] Petroleum products, including natural gas plant liquids, and crude oil burned as fuel.

[10] Includes 0.04 quadrillion British thermal units (Btus) of coal coke net imports.

[11] Includes 0.11 quadrillion Btus of electricity net imports.

[12] Primary consumption, electricity retail sales, and electrical system energy losses, which are allocated to the end-use sectors in proportion to each sector's share of total electricity retail sales.

See Note, "Electrical Systems Energy Losses," at end of Section 2 of U.S. DOE/EIA 2009b.

Notes:
- Data are preliminary.
- Values are derived from source data prior to rounding for publication.
- Totals may not equal sum of components due to independent rounding.

Sources: U.S. DOE/EIA 2009b, Tables 1.1, 1.2, 1.3, 1.4, and 2.1a.

ECONOMIC PROFILE

The U.S. economy is the largest national economy in the world, with a nominal gross domestic product (GDP) of $14.4 trillion in 2008, slightly smaller than that of the European Union (U.S. DOC/BEA 2009e; Eurostat 2009). The U.S. per capita GDP in 2007 was just over $47,000. Between 1990 and 2008, the U.S. economy grew by over 60 percent (in constant 2005 dollars), one of the highest growth rates among advanced economies in this time frame. Economic growth had a significant impact on GHG emissions during this period, though declining energy intensity in the U.S. economy resulted in significantly lower GHG emission increases in the past decade than in the 1990s.

Between 2005 and 2008, the U.S. GDP grew by $674 billion (in constant 2005 dollars), or 5.3 percent (U.S. DOC/BEA 2009e). Much of this growth was driven by strong consumer demand related to asset appreciation and easy credit. In the second half of 2008, substantial imbalances in the financial sector and in the economy generally gave rise to a deep global recession. The U.S. economy contracted 3.8 percent from the second quarter of 2008 through the second quarter of 2009 (U.S. DOC/BEA 2009e), and unemployment rose precipitously as a result, making job retention and creation the highest domestic policy priority. As one of his first acts, President Obama worked with Congress to enact the American Recovery and Reinvestment Act of 2009 (ARRA), designed to save or create about 3.5 million jobs, while making long-term investments to put the U.S. economy on a sound footing in coming years and decades. ARRA incorporates measures to increase production of alternative energy, modernize and weatherize buildings and homes, expand broadband technology across the country, and create a more efficient health care system.[1]

[1] See http://www.whitehouse.gov/issues/economy.

ENERGY RESERVES AND PRODUCTION

The United States is the world's largest producer and consumer of energy. The United States has large reserves of energy sources currently used for energy production, including fossil fuels, uranium ore, renewable biomass, and hydropower. Other renewable energy sources like solar and wind power, though currently a small portion of the energy resources used in the United States, are growing rapidly, with wind energy in the lead of other non-hydro renewable resources.

Figure 2-2 provides an overview of energy flows through the U.S. economy in 2008. This section focuses on changes in U.S. energy supply and demand since the 2006 CAR, which covered changes through 2005.

Fossil Fuels

The current base of U.S. energy resources used is fossil fuels, accounting for approximately 79 percent of all U.S. energy production from 2005 through 2008 (U.S. DOE/EIA 2009d).

Coal

Coal, the fuel most frequently used for power generation and supplying over 48 percent of the total electricity generated in the United States, also has the highest emissions of carbon dioxide (CO_2) per unit of energy. The United States uses around 1.1 billion tons of coal per year. Current recoverable coal reserves would supply the U.S. demand for energy, assuming constant 2007 rates of consumption, for approximately 232 years (U.S. DOE/EIA 2009f). Coal is particularly plentiful, yet due to property rights, land-use conflicts, and physical and environmental restrictions, only about 50 percent of the world's coal reserves (equal to about 489 billion short tons) may be available or accessible for mining. Of the estimated recoverable coal reserves, the United States holds the world's largest share (27 percent), followed by Russia (17 percent), China (13 percent), and Australia (9 percent) (U.S. DOE/EIA 2009e).

Oil

The trends in oil reserves and production identified in the 2006 CAR have changed very little. Both peaked in 1970, when Alaskan North Slope oil fields were discovered and developed, and generally have declined since then. Proven domestic reserves of crude oil stand at about 21.3 billion barrels. U.S. domestic crude oil production at the end of 2008 was estimated at 4.95 million barrels per day, of which only 0.5 percent was exported. Crude oil imports in 2008 actually averaged 9.95 million barrels per day, with another 3.18 million barrels of petroleum products imported.[2] Since around 1985, net crude oil imports have generally increased, while U.S. production has declined and consumption has grown. The United States relies on net petroleum imports to meet 56.9 percent of its petroleum needs, a decrease of 3.1 percent since the 2006 CAR, but an increase of 3.9 percent since 2000. The countries from which the United States imports the largest shares of crude oil and petroleum products include Canada (18.2 percent), Mexico (11.4 percent), Saudi Arabia (11.0 percent), Venezuela (10.1 percent), and Nigeria (8.4 percent) (U.S. DOE/EIA 2009g).

Natural Gas

Natural gas, the fossil fuel with the lowest emissions of CO_2 per unit of energy, has become an increasingly prominent fuel source in the United States in recent years. The increase in natural gas use for electricity generation, which has grown from 17.8 percent of total electricity generation in 2004 to 21.3 percent in 2008, has boosted demand for natural gas resources. Proven U.S. reserves of dry natural gas are rapidly increasing, growing by 33.6 percent from 177,427 billion cubic feet in 2000 to 237,726 billion cubic feet in 2007. Notably, the 2007 increase in proven dry natural gas reserves represented 237 percent of the total dry gas production for that year.

In 2008, the United States produced 20,561 billion cubic feet of dry natural gas. Imports totaled 3,980 billion cubic feet, of which 91.1 percent was imported by pipeline and 8.9 percent by liquid natural gas terminal. The United States imports natural gas by pipeline from Mexico and Canada, and by liquid natural gas terminal from Canada, Japan, Mexico, and Russia. Since 2004, pipeline imports from Mexico have grown from 0 percent to 1.2 percent, with the remainder of pipeline imports coming from Canada.

Nuclear Energy

In 2008, nuclear energy from 104 operating reactor units accounted for 19.6 percent of all electricity generated in the United States. The U.S. supply of uranium, the fuel used for nuclear fission, is mostly imported from other countries, with only 14.5 percent of the uranium used in 2008 being supplied by the United States. Most of these reserves can be found in Wyoming, New Mexico, Arizona, and Texas (U.S. DOE/EIA 2004). The average yearly U.S. uranium concentrate production in 2006–2008 was 4 million pounds, up from an average yearly production of 2 million pounds during 2003–2005.

In July 2007, the first application in over three decades was filed to build and operate a commercial nuclear reactor in the United States. By the end of 2007, 5 combined license (COL) applications were on file with the Nuclear Regulatory Commission (NRC). In 2008, the number of COL applications doubled; and as of November 2009, 17 applications were on file with the NRC.[3]

Renewable Energy

Renewable energy represents a rapidly growing source of U.S. energy production, currently accounting for 3 percent of U.S. electric generation excluding conventional hydro, or 9 percent including conventional hydro (U.S. DOE/EIA 2009i). Though there is currently no federally mandated standard for the use of renewable energy sources, as of 2009, 35 states and the District of Columbia had legislatively mandated a renewable energy portfolio standard (RPS). The RPS requirements vary by state, though many states have mandated that 15–25 percent of electricity sales come from renewable sources by 2020 or 2025. With the passing of the Energy Policy Act of 2005 (EPAct), federally mandated investment tax credits were established for those investing in residential, commercial, and industrial renewable energy, and the production tax credit for renewable energy electricity generation was extended. These provisions were extended until 2016 with the Energy Improvement and Extension Act of 2008.

These policies have played a primary role in the rapid expansion of electricity generated from renewable resources, such as wind, from 2006 to 2009. Conven-

[2] U.S. Department of Energy, Energy Information Adminnistration. See http://tonto.eia.doe.gov/dnav/pet/hist/LeafHandler.x?n=PET&s=MPEIMUS1&f=M

[3] The Energy Policy Act of 2005 (EPAct) provides a production tax credit for new nuclear reactors brought on line through 2020. The credit will pay producers 1.8 cents per kilowatt-hour of nuclear-generated electricity during the first 8 years of operation (U.S. DOE/EIA 2005). In addition, EPAct authorizes the Department of Energy (DOE) to provide up to $18.5 billion in loan guarantees for new reactors. DOE has selected four projects for final due diligence and detailed negotiations to receive the loan guarantees.

tional hydro remains by far the largest renewable source of electricity generation, generating 248 billion kilowatt-hours (kWh) in 2008, slightly more than double that of all other renewable sources combined. However, due to drought conditions on the West Coast that began in 2006 (U.S. DOE/EIA 2008d), this represents an 8 percent decrease from generation levels in 2005. Electricity production from renewable sources, excluding conventional hydro, totaled 123 billion kWh in 2008, which represents a 41 percent increase in production from 2005. Major growth is visible in the wind power industry alone, with electricity generation from wind increasing by 192 percent from 2005 levels to reach 52 billion kWh in 2008 (U.S. DOE/EIA 2009j). Notably, between 2004 and 2008, total installed wind capacity increased by 369 percent to reach 23,847 megawatts (U.S. DOE/EIA 2008d).

Electricity

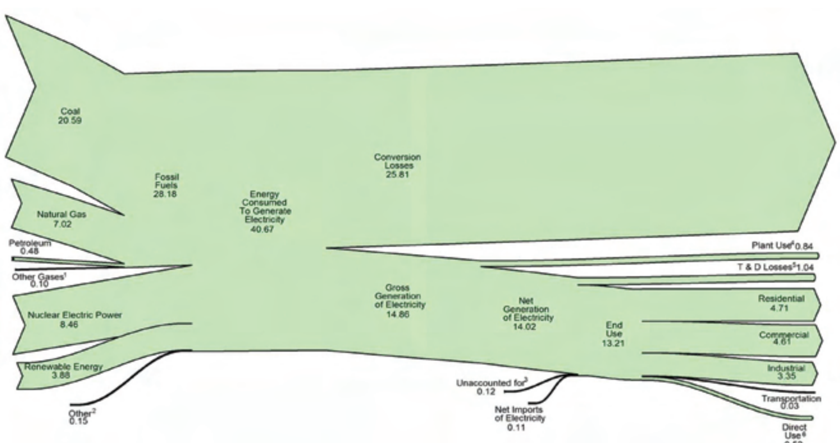
Total U.S. electricity generation reached 4,110 billion kWh in 2008, up by 8.1 percent compared to generation levels in 2000 and 1.3 percent compared to levels in 2005 (U.S. DOE/EIA 2009i). The Energy Information Administration (EIA) projects that U.S. electricity demand will continue to rise by 26 percent between 2007 and 2030 (U.S. DOE/EIA 2009k).[4]

[4] It is important to note that EIA projections used here and elsewhere in this report represent "business as usual" and do not include climate change and energy legislation or other policies currently under consideration.

[5] All EIA projections assume a business-as-usual scenario and do not incorporate any changes from current or future legislative action to curb GHGs supported strongly by the Obama administration.

Figure 2-3 **Electricity Flow Through the U.S. Economy in 2008** (Quadrillion Btus)

In 2008, U.S. electricity generation was mostly powered by coal-fired power plants, at 48.5 percent of total generation.



[1] Blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuels.

[2] Batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, miscellaneous technologies, and non-renewable waste (municipal solid waste from non-biogenic sources, and tire-derived fuels).

[3] Data collection frame differences and nonsampling error. Derived for the diagram by subtracting the "T&D (transmission and distribution) Losses" estimate from "T&D Losses and Unaccounted for" derived from Table 8.1.

[4] Electric energy used in the operation of power plants.

[5] Transmission and distribution losses (electricity losses that occur between the point of generation and delivery to the customer) are estimated as 7 percent of gross generation.

[6] Use of electricity that is (1) self-generated, (2) produced by either the same entity that consumes the power or an affiliate, and (3) used in direct support of a service or industrial process located within the same facility or group of facilities that house the generating equipment. Direct use is exclusive of station use.

Notes:

- Data are preliminary.
- See Note, "Electrical System Energy Losses," at the end of Section 2 of U.S. DOE/EIA 2009b.
- Values are derived from source data prior to rounding for publication.
- Totals may not equal sum of components due to independent rounding.

Sources: U.S. DOE/EIA 2009b, Tables 8.1, 8.4a, 8.9, A6 (column 4), and U.S. DOE/EIA 2008c.

In 2009, U.S. electricity generation was largely powered by coal-fired power plants, at 48 percent of total generation. Compared to previous years, the share of electricity generated from coal is declining, down from 51.7 percent in 2000 and 49.6 percent in 2005. This trend is due to rapid growth in natural gas-fired generation, which has risen from 15 percent of total electric generation in 2000 to 21 percent in 2008 (U.S. DOE/EIA 2009k). Figure 2-3 shows electricity flow through the U.S. economy in 2008.

ENERGY CONSUMPTION

The United States currently consumes energy from petroleum, natural gas, coal, nuclear, conventional hydro, and renewables. Petroleum remains the largest single source of U.S. primary energy consumption; in 2008 it accounted for 37.7 percent of total U.S. energy demand, down from 41 percent in 2005. Natural gas accounts for 24.4 percent, coal for 22.4 percent, nuclear for 8.1 percent, conventional hydro for 2 percent, and other renewables for 3 percent.

U.S. energy consumption has shifted over the last decade with economic growth rates and trends in energy efficiency in the residential, commercial, industrial, and transportation sectors. Between 2005 and 2007, total U.S. primary energy consumption grew by slightly over 1 percent. However, along with the current decrease in economic growth, total primary energy consumption fell by 2.2 percent in 2008 alone. The 99.3 quadrillion British thermal units (Btus) of energy consumed in 2008 represent a 1.1 percent decrease in consumption from 2005 levels and a 0.3 percent increase from 2000 levels.

The effects of the economic crisis on energy consumption are visible on a per capita basis as well. With an annual population growth rate of around 1 percent, per capita energy consumption between 2000 and 2007 declined to nearly 0.3 percent per year (Figure 2-4). In 2008, however, per capita energy use dropped sharply, down by 2.9 percent to 327 million Btus per person (U.S. DOE/EIA 2009b). EIA projects that high oil prices, increasing energy efficiency due to fuel efficiency standards, and increasing regulations on carbon intensity between 2008 and 2020 will contribute to declining per capita energy use, which is expected to reach 310 million Btus per person in 2020 and decline thereafter (U.S. DOE/EIA 2009h).[5]

In addition to the trend of decreasing energy consumption in recent years, overall energy intensity in the United States has decreased, indicating an overall trend toward increasing energy efficiency in the economy. Between 2000 and 2005, the energy intensity (energy consumed per dollar of GDP) of the U.S. economy declined on average by 1.9 percent per year. Between 2006 and 2008, energy intensity fell by 2.3 percent per year, from 9,140 Btus per dollar in 2005 to 8,520 Btus per dollar in 2008 (U.S. DOE/EIA 2009b). These data reflect a trend of advances in energy technologies and efficiency, and the growing importance of service industries and declining contribution of energy-intensive industries to the GDP.

The decline of the U.S. economy's energy intensity has a direct effect on U.S. CO_2 emissions, 94 percent of which derived directly from the burning of fossil fuels in 2007 (U.S. EPA/OAP 2009). As a result, the carbon intensity—measured as the ratio of metric tons of CO_2 emitted from energy consumption per million dollars of real GDP—also declined steadily in the past few years, falling by 4.5 percent from 544 in 2005 to 520 in 2007 (U.S. DOE/EIA 2009b).

Residential Sector

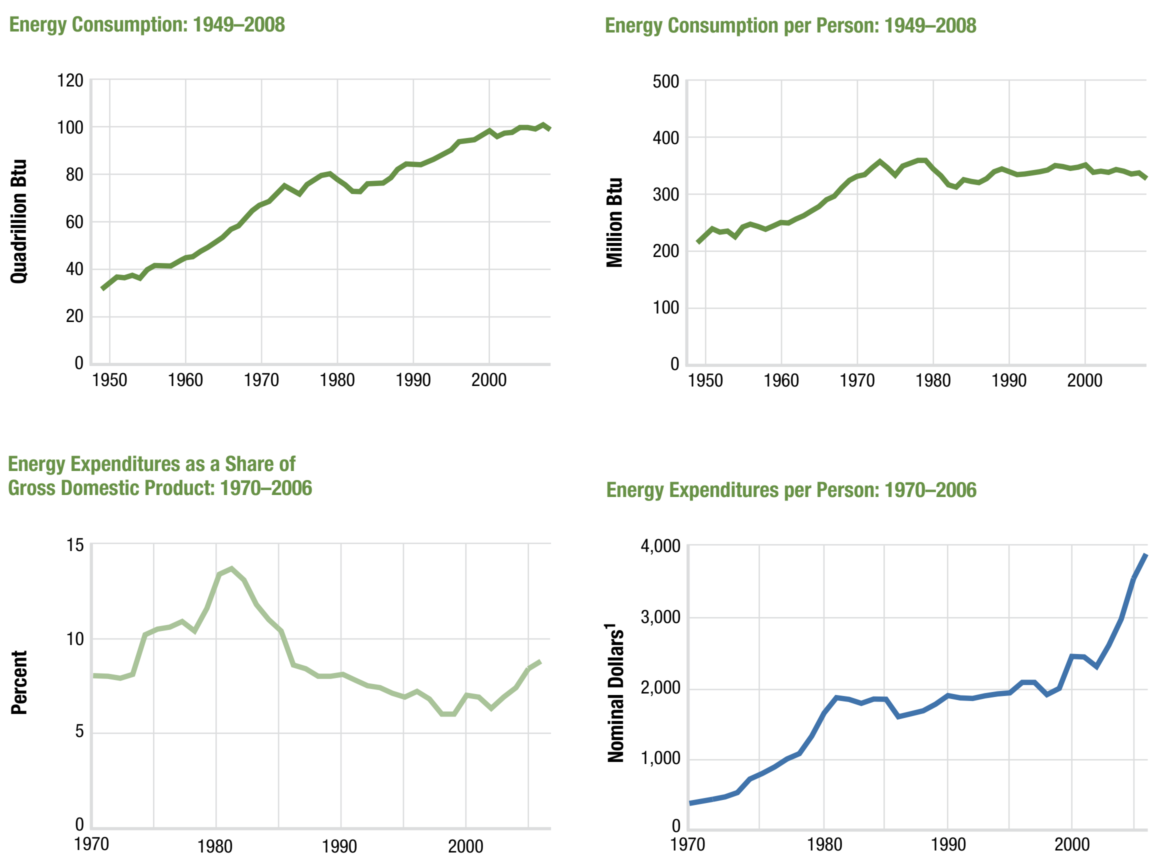
The residential sector's energy base fluctuates according to season, region, and year, and petroleum and natural gas demand varies much more than electricity demand. Consumption of petroleum, as fuel oil or liquefied petroleum gas, has been on a relative decline after a peak of 885,000 barrels per day in 2003, dropping to 684,000 barrels per day in 2008. Consumption of natural gas has fluctuated as well in recent years, declining after a 2003 peak of 5,079 billion cubic feet to 4,368 billion cubic feet in 2006—a level not seen since 1987—and then increasing again to 4,866 billion cubic feet in 2008 (U.S. DOE/EIA 2009b).

The residential sector, made up of living quarters for private households, uses energy through a variety of sources: space heating, water heating, air conditioning, lighting, refrigeration, cooking, appliances, and electronics. In 2008, residential energy consumption, including electricity losses, totaled 21.6 quadrillion Btus, representing 21.7 percent of U.S. consumption. Residential buildings accounted for nearly 21 percent of GHG emissions from the use of fossil fuels.

The residential sector's energy use has also declined. Residential electricity consumption grew an average of 2.9 percent annually between 2000 and 2005, but slowed to an average 0.5 percent growth between 2006 and 2008.

Figure 2-4 **Energy Consumption and Expenditures Indicators**

Over the last decade, the U.S. demand for energy has plateaued, while the total relative cost of energy for individual Americans has risen dramatically.



[1] See "Nominal Dollars" in Glossary of U.S. DOE/EIA 2009b.

Source: U.S. DOE/EIA 2009b, Table 1.5.

Commercial Sector

The commercial sector is made up of service facilities and equipment used by businesses, governments, private and public organizations, institutional living quarters, and sewage treatment plants. The most common uses of energy in this sector include space ventilation and air conditioning, water heating, lighting, refrigeration, cooking, and the operation of office and other equipment. Less common uses of energy include transportation. In 2008, the total energy consumed in the commercial sector was 3.7 percent higher than in 2005. At 18.5 quadrillion Btus, the commercial sector's energy use represented 18.6 percent of total U.S. energy demand in 2008. When GHG emissions from electricity generation are assigned to end-use sectors, the commercial sector was responsible for approximately 17 percent of total U.S. GHG emissions in 2007 (U.S. DOE/EIA 2009b; U.S. EPA/OAP 2008).

Electricity accounts for 78 percent of the commercial sector's energy use, followed by natural gas, which is close to 17 percent. Demand responds largely to a combination of prices and weather, although the impact of weather is less significant in the commercial sector than in the residential sector. Since the period covered by the 2006 CAR, demand for electricity increased annually at 1.96 percent; demand for natural gas fluctuated between 2005 and 2008, but increased by 6.6 percent in 2007 and by 3.3 percent in 2008.

EIA projects that between 2008 and 2030, greater energy efficiency will offset growth in commercial energy demand and thereby lead to an overall decline in the energy intensity of the commercial sector over the next two decades.

Industrial Sector

The U.S. industrial sector consists of all facilities and equipment used for producing, processing, or assembling goods, including manufacturing, mining, agriculture, and construction. The sector depends largely on coal, natural gas, and petroleum for its energy use. Electricity use, including system losses, represents around one-third of all energy consumed in the industrial sector, while petroleum and natural gas account for 27 percent and 26 percent, respectively. Use of coal in industrial energy consumption, falling from about 6.4 percent in 2000 to 5.7 percent in 2008, is slowly being replaced by increasing use of renewable energy sources, notably biomass.

Industrial sector energy consumption has declined steadily since 1973, falling from 43 percent of total energy consumption to 35 percent in 2000. This trend has steadily continued in recent years, dropping from 32.3 percent in 2005 to 31.4 percent in 2008. Within the industrial sector, total energy consumption has been decreasing—slightly from 2006 to 2008, and more quickly in 2008, when it fell by 4.1 percent. In 2008 energy consumption in the industrial sector had dropped by 10.2 percent compared to 2000 levels, largely due to the U.S. economic downturn, which drastically reduced demand for manufactured goods. When emissions from electricity generation are distributed to end-use sectors, fossil fuel-related CO_2 emissions from the industrial sector have risen by 0.2 percent since 2006 and 2.4 percent since 1990 (U.S. DOE/EIA 2009n). As of 2007, using the same assumptions, the industrial sector accounted for 29.1 percent of total U.S. GHG emissions (U.S. EPA/OAP 2009).

Approximately four-fifths of the total energy used in the industrial sector is for manufacturing, with chemicals and allied products, petroleum and coal products, paper and nonmetallic minerals, and primary metals accounting for most of this share. The top five energy-consuming industries—bulk chemicals, refining, paper, steel, and food—account for around 60 percent of total industrial energy use but comprise only 20 percent of the total shipments. Projected slow growth in these energy-intensive industries is likely to result from increased foreign competition, reduced domestic demand for raw materials and basic goods they produce, and movement of investment capital to more profitable areas (U.S. DOE/EIA 2009h). Therefore, EIA estimates that industrial energy consumption will grow by only 4 percent between 2007 and 2030, primarily as a result of declines in output from most of the energy-intensive manufacturing industries.

Transportation Sector

Energy consumption in the transportation sector includes all energy used to move people and goods: automobiles, trucks, buses, and motorcycles; trains, subways, and other rail vehicles; aircraft; and ships, barges, and other waterborne vehicles.[6] Transportation is responsible for about 70 percent of all the petroleum used. In 2008, petroleum supplied 94 percent of the energy used in the transportation sector, down slightly from 96 percent in 2005, and the passage of the Energy Independence and Security Act of 2007 (EISA) (U.S. DOE/EIA 2009b). Energy consumption of biomass has grown significantly in recent years. High world oil prices, EPAct's passage in 2005, and EISA's passage in 2007 have encouraged the use of agriculture-based ethanol and biodiesel in the transportation sector. Therefore, between 2007 and 2008, for example, biomass consumption grew by over 35 percent, while petroleum consumption fell by 5.1 percent. In comparison, biomass consumption grew by an annual average of 20 percent from 2000 to 2004 and by 25 percent from 2005 to 2008 (U.S. DOE/EIA 2009b).

Demand in the transportation sector accounted for 28 percent of total U.S. energy demand in 2008 and approximately 28 percent of total U.S. GHG emissions. Slowing economic growth and high oil prices in 2008 were primary factors affecting the change in energy use

[6] Transportation does not include such vehicles as construction cranes, bulldozers, farming vehicles, warehouse tractors, and forklifts, whose primary purpose is not transportation.

from the transportation sector during the period since the 2006 CAR. Between 2000 and 2004, transport-related energy use grew by around 5 percent, at an average annual rate of 1.4 percent, continuing at nearly the same rate of annual growth between 2005 and 2007. However, in 2008 transport-related energy consumption declined by over 4 percent (U.S. DOE/EIA 2009b). Crude oil prices had increased rapidly in mid-2007, due to several factors, including the inability of non-Organization of the Petroleum Exporting Countries (OPEC) production rates to meet increasing global demand, OPEC members' production decisions, lack of spare production capacity, and geopolitical instability in key oil-producing regions. Therefore, crude oil prices increased from around $60 per barrel in 2007 to a peak of $145.16 per barrel in July 2008 (U.S. DOE/EIA 2009l), in stark contrast to 2005–2006 average prices of approximately $53 per barrel. With the decline in energy use, 2008 transportation-related energy consumption returned to 2005 levels, at approximately 27.94 quadrillion Btus.

Federal Government

The U.S. government remains the nation's largest single user of energy. Facilitated and coordinated by DOE's Federal Energy Management Program, federal agencies have invested in energy efficiency over the past two decades. As of 2007, the last year for which final data are available, the U.S. government's total primary energy consumption—excluding energy consumed to produce electricity and enrich uranium—was 1.085 quadrillion Btus, about 1.0 percent of total U.S. energy consumption. This is down by 6.6 percent compared to 2005 levels and 24.5 percent from 1990 levels. Compared to 2000 levels, however, the U.S. government's total primary energy consumption is up by 9.2 percent.

EISA set new goals for federal government energy use, including: a requirement to reduce energy intensity by 30 percent in 2030 compared to 2003 levels; a requirement to reduce the fossil-fuel-based energy consumption of new federal buildings, beginning with a 55 percent reduction in 2010 compared to 2003 levels and reaching a 100 percent reduction in 2030; a prohibition against purchasing light- or medium-duty vehicles that are not low-GHG-emitting vehicles; a requirement to reduce annual petroleum consumption by 20 percent in 2015 compared to 2005; and many other requirements regarding procurement of energy-efficient products, improved metering, and reporting (U.S. DOE/FEMP 2007).

Federal agencies are also subject to requirements for the use of electricity from renewable sources. Section 203 of EPAct requires the federal government to consume:

- not less than 3 percent in FY 2007–2009,
- not less than 5 percent in FY 2010–2012, and
- not less than 7.5 percent in FY 2013 and each fiscal year thereafter.

Preliminary data for FY 2008 indicate that federal agencies purchased or produced 1.9 terawatt-hours of renewable electric energy in 2008, which is equivalent to 3.4 percent of the federal government's electricity use of 56.1 terawatt-hours.

Executive Order 13123 of June 3, 1999 (later superseded by Executive Order 13423) established a GHG reduction goal for federal government facilities at 30 percent below 1990 levels by 2010.[7] Data for FY 2005 (the last year for findings under this reporting framework) show emissions from these facilities decreased by 22.1 percent since FY 1990, from 54.8 teragrams of CO_2 equivalent (Tg CO_2 Eq.) in FY 1990 to 42.7 Tg CO_2 Eq. in FY 2005.[8]

On October 5, 2009, President Obama signed Executive Order 13514, *Federal Leadership in Environmental, Energy, and Economic Performance*. The order expands the energy reduction and environmental requirements of Executive Order 13423 by making GHG management a priority for the federal government.[9] Under the new order, federal agencies are required to measure, manage, and reduce GHG emissions toward agency-defined targets. Provisions of the order require agencies to:

- Set scope 1, 2, and 3 GHG emission reduction targets for 2020 relative to a 2008 baseline.
- Reduce vehicle fleet petroleum use by 30 percent by 2020 compared to 2005.
- Improve water efficiency by 26 percent by 2020 compared to 2007.
- Implement the 2030 net-zero-energy building requirement.
- Meet sustainability requirements across 95 percent of all applicable contracts.
- Develop and carry out an integrated strategic sustainability performance plan.

TRANSPORTATION

The U.S. transportation system has evolved to meet the needs of a highly mobile, dispersed population and a large, dynamic economy. While the transportation system supports the movement of people and goods and the economic vitality of the country, efforts are underway to ensure that it is also as sustainable as possible.

Over the years, the United States has developed an extensive multimodal system that includes road, air, rail, and water transport capable of moving large volumes of people and goods long distances. Automobiles and light trucks still dominate the passenger transportation system, and the highway share of passenger miles traveled in 2006, the most recent year of avail-

[7] See http://www1.eere.energy.gov/femp/pdfs/eo13123.pdf.

[8] See http://www1.eere.energy.gov/femp/pdfs/annrep05.pdf.

[9] See http://www.eere.energy.gov/femp/pdfs/eo13514.pdf.

able data, was about 89 percent of the total, down by around 1 percent from the 2006 CAR. Air travel accounted for slightly over 10 percent (up 1 percent from the 2006 CAR), and mass transit and rail travel combined accounted for only about 1 percent of passenger miles traveled. For-hire transport services, as a portion of GDP, have barely changed since the 2006 CAR, accounting for 2.9 percent of GDP in 2007 (U.S. DOT/BTS 2010).

Highway Vehicles

The trends in highway vehicles described in the 2006 CAR have not changed appreciably. Between 2004 and 2007, the number of passenger vehicles rose steadily by an annual average of 1.8 percent to reach 254.3 million. This high degree of vehicle ownership is a result of population distribution, land-use patterns, location of work and shopping, and public preferences for personal mobility. Single-occupant passenger automobiles dominated daily traveling between home and work place in 2007, with 76 percent of the workforce (105 million of 139 million) driving themselves, down slightly from almost 80 percent in 2004. Just over 10 percent of workers commuted in carpools of two or more people, around 5 percent used public transportation, and the rest of the workforce used other means (biking, walking, taxis, etc.) (U.S. DOT/BTS 2010).

Passenger cars account for over 50 percent of highway vehicles and over one-third of all the energy consumed in the transportation sector. Light trucks, sport utility vehicles (SUVs), and vans comprise almost 40 percent of all highway vehicles and consume around 39 percent of energy in the sector. Between 2004 and 2006, the number of registered light trucks, SUVs, and vans increased by an annual average of 4.3 percent, continuing the upward trend seen in the previous years. This growth declined to 2.8 percent in 2007, as crude oil and gasoline prices began to rise steadily in mid-2007 and consumer preferences changed due to the increased costs of operating less fuel-efficient vehicles.

The number of miles driven is another major factor affecting energy use in the highway sector. From 2004 to 2006, the total number of vehicle miles driven each year by all on-road vehicles grew by an average of 0.8 percent to reach around 3 trillion miles, compared to around 1.8 percent average annual growth between 2000 and 2003. During these periods, total energy consumed by on-road vehicles grew by 1.02 percent and 1.1 percent, respectively (U.S. DOT/BTS 2010).

The fuel efficiency of passenger cars, light trucks, SUVs, and vans plays a large role in determining energy consumption and GHG emissions from the highway transport sector. The average fuel efficiency of passenger cars in the United States was relatively unchanged in the period since the 2006 CAR, increasing from an average of 22.1 miles per gallon (MPG) for 2000–2003 to an average of 22.3 MPG for 2004–2006. In 2008, the average fuel efficiency for new passenger cars and light trucks was 24.3 MPG and 18.2 MPG, respectively (U.S. DOT/BTS 2010). Standards for new vehicles, known as Corporate Average Fuel Economy (CAFE) standards, play an integral role in determining the fuel efficiency of passenger cars and light trucks in the United States. New laws and policies outlined in Chapter 4 of this report will result in substantial increases in fuel efficiency over the next six years, with all new fleets of passenger vehicles and light trucks required to reach an average fuel efficiency of 35.5 MPG and a fleet average CO_2 emissions level of 250 grams per mile by 2016.

Air Carriers

Despite significant economic turbulence in 2008 and 2009, total U.S. air passenger miles remain near historic highs. Fueled in part by economic growth, airlines booked more revenue-paying U.S. passengers in 2007—more than 835 million—than in any other year. In 2008, total passengers (810 million) and total passenger miles (824 billion) declined by 3 and 2 percent, respectively, but those figures were still 10 and 18 percent above 2000 levels, respectively (U.S. DOT/BTS 2009b, 2009c).

Overall air passenger miles traveled are still declining in sync with the recent economic recession. Energy consumed from jet fuel of certified air carriers is decreasing more rapidly, spurred by the rising cost of fuel, increasing passenger load factors, and, to a greater degree, improvements in energy efficiency. In 2008, fuel use in aviation declined by 2.5 percent from 2007 levels, as the average price of a gallon of jet fuel jumped by 46 percent over 2007 prices (U.S. DOT/BTS 2009a).

Freight

Between 2004 and 2007 (the latest year for which freight data are available), U.S. freight transportation grew by 1.5 percent to 4.61 trillion ton miles, representing an average annual growth rate of 0.5 percent compared to 0.7 percent average annual growth between 2000 and 2003. Rail accounts for the largest share of total freight ton miles (39 percent), followed by trucks (29 percent), pipelines (20 percent), waterways (12 percent), and air (less than 1 percent) (U.S. DOT/BTS 2010).

INDUSTRY

The U.S. industrial sector boasts a wide array of light and heavy industries in manufacturing and nonmanufacturing subsectors, the latter of which include mining, agriculture, and construction. Private goods-producing industries accounted for slightly less than 19 percent of total GDP in 2008, and utilities accounted for another 2.1 percent of GDP. The industrial sector as a whole represents just over 29 percent of total U.S. GHG emissions (2007 data). Compared to the period covered under the 2006 CAR, declines in the portion of the economy made up by manufacturing have slowed, with the average change in manufacturing as a percentage of total GDP slowing from a decline of 3.7 percent between 2000 and 2004 to a decline of 1.5 percent between 2005 and 2008 (U.S. DOC/BEA 2009c).

The decline in housing prices, which began in 2007, took a large toll on the construction industry, which saw decreases in total value-added output of 5.4 percent and 4.8 percent in 2007 and 2008, respectively. Mining continued to rise as a share of GDP, growing from 1.8 percent in 2005 to 2.2 percent in 2008.

WASTE

In 2007, the United States generated approximately 230 million metric tons (254 million tons) of municipal solid waste (MSW), about 45 million metric tons (nearly 50 million tons) more than in 1990. Paper and paperboard products made up the largest component of MSW generated by weight (33 percent), and yard trimmings comprised the second-largest material component (more than 13 percent). Glass, metals, plastics, wood, and food each constituted between 5 and 13 percent of the total MSW generated, while rubber, leather, and textiles combined made up about 8 percent of the MSW.

Recycling has been the most significant change in waste management from a GHG perspective. From 1990 to 2007, the recycling rate increased from just over 16 percent to about 33 percent. Of the remaining MSW generated, about 13 percent was combusted and 54 percent was disposed of in landfills. The number of operating MSW landfills in the United States has decreased substantially over the past 20 years, from about 8,000 in 1988 to about 1,750 in 2007, while the average landfill size has increased (U.S. EPA/OSW 2008).

Landfills are the second-largest U.S. source of anthropogenic methane emissions, accounting for 23 percent of the total. Present data suggest a marked increase in the amount of methane recovered for either gas-to-energy or flaring purposes in recent years (U.S. EPA/OAP 2009).

BUILDING STOCK AND URBAN STRUCTURE

Buildings are large users of energy. Their number, size, and distribution and the appliances and heating and cooling systems that go into them influence energy consumption and GHG emissions. Buildings account for about 37 percent of total U.S. energy consumption and about 70 percent of total electricity consumption.

Residential Buildings

Growth in the U.S. housing market has slowed significantly since the advent of the U.S. economic slowdown in 2007. Prior to the economic slump, the housing market had been relatively strong since 2000. Between 1997 and 2003, the number of residences in the United States grew by 8.3 percent to approximately 121 million households, 62 percent of which were single, detached dwellings. However, since 2007, the number of new residential units under construction fell from an all-time high of two million new housing units per year in 2005 to less than one million by 2008. During the downturn, the amount of new multi-family rental units (i.e., apartment buildings) has held steady, and they now account for 24 percent of new residential construction (U.S. DOC/Census 2009a).

As the growth of the U.S. housing market has slowed, the growth of energy use in residential buildings has also slowed. The housing boom of 2000–2005 had been especially strong in the Sunbelt, where almost all new homes have air conditioning. Overall, the growth in residential buildings' energy use has been mitigated by recent economic events.

While new homes are larger and more plentiful, their energy efficiency has increased significantly. In 2004, 8 percent of all new single-family homes were certified as ENERGY STAR compliant, implying at least a 30 percent energy savings for heating and cooling relative to comparable homes built to current code (U.S. DOE/EIA 2006). New homes are on average about 13 percent larger than the stock of existing homes, and thus have greater requirements for heating, cooling, and lighting. Nevertheless, under current building codes and appliance standards for heat pumps, air conditioners, furnaces, refrigerators, and water heaters, the energy requirement per square foot of a new home is typically lower than of an existing home (U.S. DOE/EIA 2005).

Commercial Buildings

Between 2000 and 2003 (the latest data available), commercial floorspace rose an estimated 1.8 percent per year. By 2003 there were nearly 4.9 million commercial buildings and more than 6.7 billion square meters (71.7 billion square feet) of floorspace. Much of this growth has been related to the rapidly expanding information, financial, and health services sectors.

More than half of commercial buildings are 465 square meters (5,000 square feet) or smaller, and nearly three-fourths are 929 square meters (10,000 square feet) or smaller. Just 2 percent of buildings are larger than 9,290 square meters (100,000 square feet), but these large buildings account for more than one-third of commercial floorspace (U.S.DOE/EIA 2003).

Electricity and natural gas are the two largest sources of energy used in commercial buildings. Over 85 percent of commercial buildings are heated, and more than 75 percent are cooled. The use of computers and other office electronic equipment continues to grow and will have an impact on the demand for electricity (U.S. DOE/EIA 2006).

AGRICULTURE AND GRAZING

Agriculture in the United States is highly productive. U.S. croplands produce a wide variety of food and fiber crops, feed grains, oil seeds, fruits and vegetables, and other agricultural commodities for both domestic and international markets. Although the United States harvests roughly the same area as it did in 1910, U.S. agriculture feeds a population three times larger, with crops still available for export. Technological changes account for most of the increased productivity. In 2002, U.S. cropland was 179 million hectares (ha) (442 million acres[ac]), about 3 percent lower than in 1997 (Lubowski et al. 2006a, 2006b; USDA 2008).

Soils vary across the landscape in response to the effects of climate, topography, vegetation, and other organisms (including humans) on the rate and direction of soil development processes acting on parent materials over time. In the United States, the wide range and endless combinations of these factors have resulted in a great range of soils with widely varying properties. All soils provide an effective natural filter that protects ground and surface water by removing potential contaminants applied on or in the soil. Soils across the United States have the potential to sequester substantial amounts of organic and inorganic carbon to help reduce atmospheric CO_2 levels. Although soils vary in their resistance and resilience, all are subject to degradation through erosion, salinization, and other mechanisms without proper management.

Conservation is an important objective of U.S. farm policy. The U.S. Department of Agriculture administers a set of conservation programs that have been highly successful at removing environmentally sensitive lands from commodity production and encouraging farmers to adopt conservation practices on working agricultural lands. The largest of these programs, the Conservation Reserve Program (CRP), seeks to reduce soil erosion, improve water quality, and enhance wildlife habitat by retiring environmentally sensitive lands from crop production. About 12.6 million ha (31.2 million ac) of land are enrolled in CRP.

Improved tillage practices also have helped reduce soil erosion and conserve and build soil carbon levels. From 1998 to 2004, the amount of cropland managed with no-till systems increased by 31 percent to 25.4 ha (62.7 ac), in part because of the widespread adoption of herbicide-tolerant crops developed using biotechnology. Land managed using all conservation tillage systems has fluctuated between about 40 and 46 million ha (98.8 and 113.6 million ac) (CTIC 2004).

Sources of GHG emissions from U.S. croplands include nitrous oxide from nitrogen fertilizer use and methane from farm animals' enteric fermentation and manure management. Nitrous oxide from agricultural soil management is the largest source of GHG emissions from the agricultural sector, representing just over 35 percent of that sector's emissions in 2007 (USDA 2008).

Grasslands account for slightly more than one-third of U.S. land uses. Pasture and range ecosystems can include a variety of different flora and fauna communities. They are generally managed by varying grazing pressure, using fire to shift species abundance, and occasionally disturbing the soil surface to improve water infiltration. In 2002, grasslands totaled about 238 million ha (587 million ac), about the same as in 1997. Since 1949, grassland acreage has declined by about 9 percent, reflecting improved productivity of grazing lands, land-use changes, and a decline in the number of domestic animals raised on grazing lands (Lubowski et al. 2006b).

FORESTS

U.S. forests are predominately natural stands of native species, and vary from the complex hardwood forests in the East to the highly productive conifer forests of the Pacific Coast. Planted forest land is most common in the East, and planted stands of native pines are common in the South. In 1630, forest land comprised an estimated 46 percent of the total U.S land area, whereas in 2007, forests covered about one-third of the total area. Historically, most of the forest land loss was due to agricultural conversions in the late 19th century, but today most losses are due to such intensive uses as urban development.

Of the 305 million ha (751 million ac) of U.S. forest land, nearly 208 million ha (514 million ac) are timberland, most of which is privately owned in the conterminous United States. However, a significant area of forest land is reserved forests, which in 2007 accounted for 10 percent of all forest land, or about 30 million ha (75 million ac) (Smith et al. 2009).

Most timber removals come from private lands, with the South providing nearly two-thirds of all domestic timber. Management inputs over the past several decades have been gradually increasing the production of marketable wood in U.S. forests, especially on the private lands and in the South. The United States currently grows more wood than it harvests, with a growth-to-harvest ratio of nearly 2 to 1. As the average age of U.S. forests continues to rise and growth continues to exceed removals, standing volume has increased by 37 percent since 1953 to a level of nearly 33 billion cubic meters.

Existing U.S. forests are an important net sink for atmospheric carbon. Improved forest management practices, the regeneration of previously cleared forest areas, as well as timber harvesting and use have resulted in net sequestration of CO_2 every year since 1990 (U.S. EPA/OAP 2009). In 2007, the land use, land-use change, and forestry sector absorbed a net of 1,062.6 Tg of CO_2. This sequestration represents an offset of 14.9 percent of U.S. GHG emissions on a global warming potential-weighted basis.