Chapter 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 national circumstances and departures from historical trends since the 2010 *U.S. Climate Action Report* (2010 CAR) was submitted to the United Nations Framework Convention on Climate Change. This chapter also discusses the impact of the changes to national circumstances on GHG emissions and removals (U.S. DOS 2010).

Key Developments

Several aspects of the national circumstances of the United States have changed in the past four years. Some of the most important changes to national circumstances are mentioned below.

- **Challenging economic environment**: The U.S. economy is still emerging from the aftermath of the economic downturn that followed the financial crisis of 2007–2008. The U.S. unemployment rate in May 2013 (7.5 percent) was more than 3 percentage points higher than its pre-crisis level (4.4 percent in May 2007), and national output is still below its potential, according to the Congressional Budget Office.[1] U.S. gross domestic produce (GDP) has grown every quarter since the third quarter of 2009, and private nonfarm payroll employment has grown every month since March 2010.
  During the period of this Climate Action Report (2010-2013), the United States has produced fewer GHG emissions annually than it did before the financial crisis. Even as U.S. economic output increased, GHG emissions largely were steady or declining. In 2011, GHG emissions declined by 108 teragrams of carbon dioxide equivalents (Tg CO_2e) (–1.6 percent) from 2010, despite the 1.7 percent growth in the U.S. economy that year.
- **Economic policies:** The United States has adopted several policies to mitigate the economic effects of the downturn, while making the United States economy more energy efficient and less carbon intensive. The 2009 American Recovery and Reinvestment Act (Recovery Act) and subsequent actions by the Federal Reserve of the United States have stimulated U.S. economic activity. The Recovery Act invested in more energy-efficient homes and appliances, as well as provided funds that helped decarbonize U.S. transportation and electricity generation.
- **Energy mix:** The discovery and exploitation of vast reserves of U.S. natural gas have reduced the domestic price per British thermal unit (Btu) of natural gas and sparked demand for natural gas as both a baseload fuel for electricity generation and a heating fuel for U.S. households. In 2012, natural gas generated 30.4 percent of the nation's electric power, up from 17.8 percent of total electricity generation in 2004.[2] As a result, the use of coal for electric power has declined. Coal now represents 37.4 percent of the energy mix, down from a 50 percent share in 2005. Wind power, solar power, biomass, and geothermal energy generated 5.4 percent of total U.S. electricity in 2012 and represent a significant share of new U.S. electrical generation. During the first quarter of 2013, 82 percent of new U.S. electrical capacity was from renewable energy sources. In 2012, conventional hydroelectric power generated 6.82 percent of total electricity generation, and nuclear energy generated 18.97 percent.
- **Transportation patterns:** Since a peak in 2008, Americans drive 2.6 percent fewer passenger miles annually as of 2013 than they did before the financial crisis. Generational preferences, the effects of the recession, the high cost of oil, and new urban development patterns increasingly move Americans to mass transit and other modes of transport. Fewer passenger miles translate to fewer GHG emissions from mobile sources. Cars are also becoming more fuel efficient, due to both a shift in consumer demand and federal and state policies.
- **Legal framework for acting on climate change:** In May 2007, the Supreme Court of the United States ruled that GHGs are air pollutants covered by the Clean Air Act and, if they could reasonably be anticipated to endanger public health or welfare, must

[1] CBO 2013. *See* http://www.cbo.gov/publication/43907.
[2] U.S. Department of Energy (DOE)/Energy Information Administration (EIA) 2013g, Table 7.2a. Net Electricity Generation: Total (All Sectors). *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf.

be regulated by the U.S. Environmental Protection Agency (EPA). In December 2009, EPA issued its Endangerment Finding, which found that current and projected levels of six GHGs threaten the health and human welfare of current and future generations.[3] Since this finding, EPA has set in place rules and regulations to limit GHG emissions from motor vehicles.

- **Extreme weather events**: The United States has experienced several extreme weather events since 2010, which have inflicted major damage and raised awareness of the rising costs of climate change.
- **Evolving public attitudes toward climate change**: Though U.S. public opinion on climate change remains polarized, the public's concern about climate change is on the rise nationwide. Although numbers vary depending on the polling questions, in several 2013 surveys more than 60 percent of Americans said that climate is changing and that it is important to address this issue for the sake of today's and tomorrow's generations. A majority of Americans support the increased deployment of clean and renewable energy and regulation of power plant emissions.[4]

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 national 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 is also not completely independent of the other. This 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 the 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 EPA Administrator, the Director of the Office of Management and Budget, the U.S. Trade Representative, the Chair of the Council of Economic Advisers, the U.S. Ambassador to the United Nations, and the Administrator of the Small Business Administration.

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 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 that play a role in domestic climate policy, such as the Federal Energy Regulatory Commission and the Export-Import Bank. Collectively, executive branch institutions cover a wide range of responsibilities, such as implementing environmental and energy regulations passed by the legislative branch through the rulemaking process, 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 (House) and the Senate—which are the primary lawmaking bodies of the U.S. 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 member represents a single congressional district of approximately 650,000 people.

Each of the two bodies 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 for consideration to be signed into law. The legislation becomes effective upon the President's signature.

In Congress, climate change is addressed by individual members and committees that are charged with developing legislation

[3] U.S. EPA 2009. *See* http://www.epa.gov/climatechange/Downloads/endangerment/Federal_Register-EPA-HQ-OAR-2009-0171-Dec.15-09.pdf.

[4] ESSI 2013. *See* http://www.usclimatenetwork.org/resource-database/polling-the-american-public-on-climate-change.

on energy and other relevant issues relevant to climate change. In the House, the Committees on Appropriations; Agriculture; Science, Space and Technology; Ways and Means; Natural Resources; and Energy and Commerce, among others, play vital roles in developing legislation related to climate change. In the Senate, the Committees on Environment and Public Works; Finance; Foreign Relations; Agriculture; Commerce, Science, and Transportation; and Energy and Natural Resources develop legislation and are critical venues for debate.

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, in the case of climate change, 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. Many activities related to adaptation policy are being initiated 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 316 million. From 1990 to 2012, the U.S. population grew by 64.3 million, at an average annual rate of just over 1 percent, for a total growth of approximately 25 percent since 1990. However, that growth has slowed somewhat since the global recession. Average annual population growth in the United States was less than 1 percent in 2010, 2011, and 2012. Even so, the growth rate of the U.S. population was among the highest in the world among advanced economies over the last 4 years. The U.S. Census Bureau projects that the annual growth rate will shrink slowly from about 0.77 percent in 2015 to 0.5 percent in 2050, when the U.S. population is projected to be almost 400 million.

The U.S. is ranked 149th worldwide in population density and 161st in emissions per capita per square kilometer (k^2).[5] Population density trends show that more Americans are moving into cities and metropolitan areas. In 2012, urban areas—defined as densely developed residential, commercial, and other nonresidential areas—accounted for 80.7 percent of the U.S. population, up from 79.0 percent in 2000. 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

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.

Geographic Profile

The United States is one of the largest countries in the world, with a total area of 9,192,000 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,

[5] Full projections of the U.S. Census Bureau are free and accessible to the global community. *See* http://www.census.gov.

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 United States for the benefit of various Native American tribes.

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 21ºC (70ºF), to much cooler conditions in the northern parts of the country along the Canadian border, and from seasonal differences as great as 50ºC (90ºF) between summer and winter in the northern Great Plains. Similarly, precipitation varies across the country and by seasons, measuring more than 127 centimeters (cm) (50 inches [in]) per year along the Gulf of Mexico, while annual precipitation can be less than 30 cm (12 in) in the Intermountain West and Southwest. The peak rainfall season also varies by region. Many parts of the Great Plains and Midwest experience late-spring peaks, West Coast 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] which 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 (necessitating heating) or above (necessitating cooling) 18.3ºC (65ºF). For example, a weather station reporting a mean daily temperature of 4ºC (40ºF) would report 25 heating degree-days. From 2001 to 2011, the number of heating degree-days averaged 4,324, which was 2.3 percent below the 20th-century average.[6] Over the same period, the annual number of cooling degree-days averaged 1,343, which was 6.0 percent above the long-term average.[7]

Economic Profile

The U.S. economy is currently the largest national economy in the world, with a nominal GDP of $15.7 trillion in 2012. The U.S. per capita GDP in 2012 was just over $49,600. Between 1990 and 2008, the U.S. economy grew by more than 60 percent (in constant 2005 dollars)—one of the highest growth rates among advanced economies in this time frame. However, between 2008 and 2013, the U.S. economy averaged only 0.6 percent in real GDP growth per year. As economic growth has slowed, GHG emissions have declined slightly since 2008. Recent U.S. investments in energy efficiency have also been a factor in the continued decline in U.S. energy intensity, which is projected to decline significantly over the coming decades (Figure 2-1).

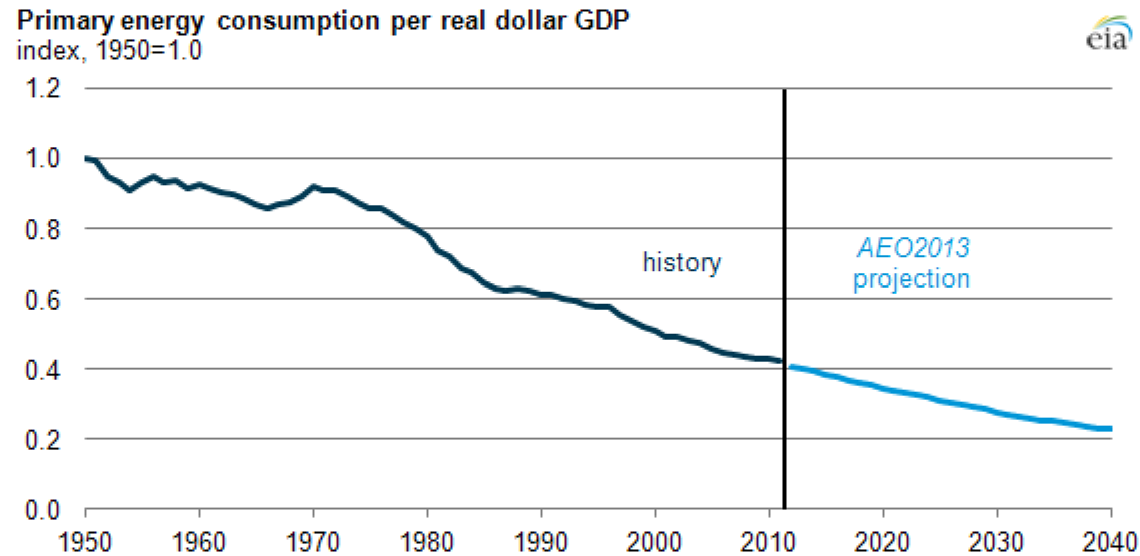
Figure 2-1 shows primary energy consumption per real dollar GDP. The 2013 American Energy Outlook projects that energy intensity will decline significantly over the coming decades.

Figure 2-1: U.S. Primary Energy Consumption per Real Dollar GDP.

This graph demonstrates the significant decline in primary energy consumption per real dollar GDP since the 1950s. The 2013 *American Energy Outlook* projects that this metric will continue to decline in the future.

[6] U.S. DOE/EIA 2012, Table 1.7, Heating Degree-Days by Month, 1949–2011. *See* http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0107.

[7] U.S. DOE/EIA 2012, p. 19.



Sources: U.S. DOE/EIA 2012 and 2013b.

Energy Reserves and Production

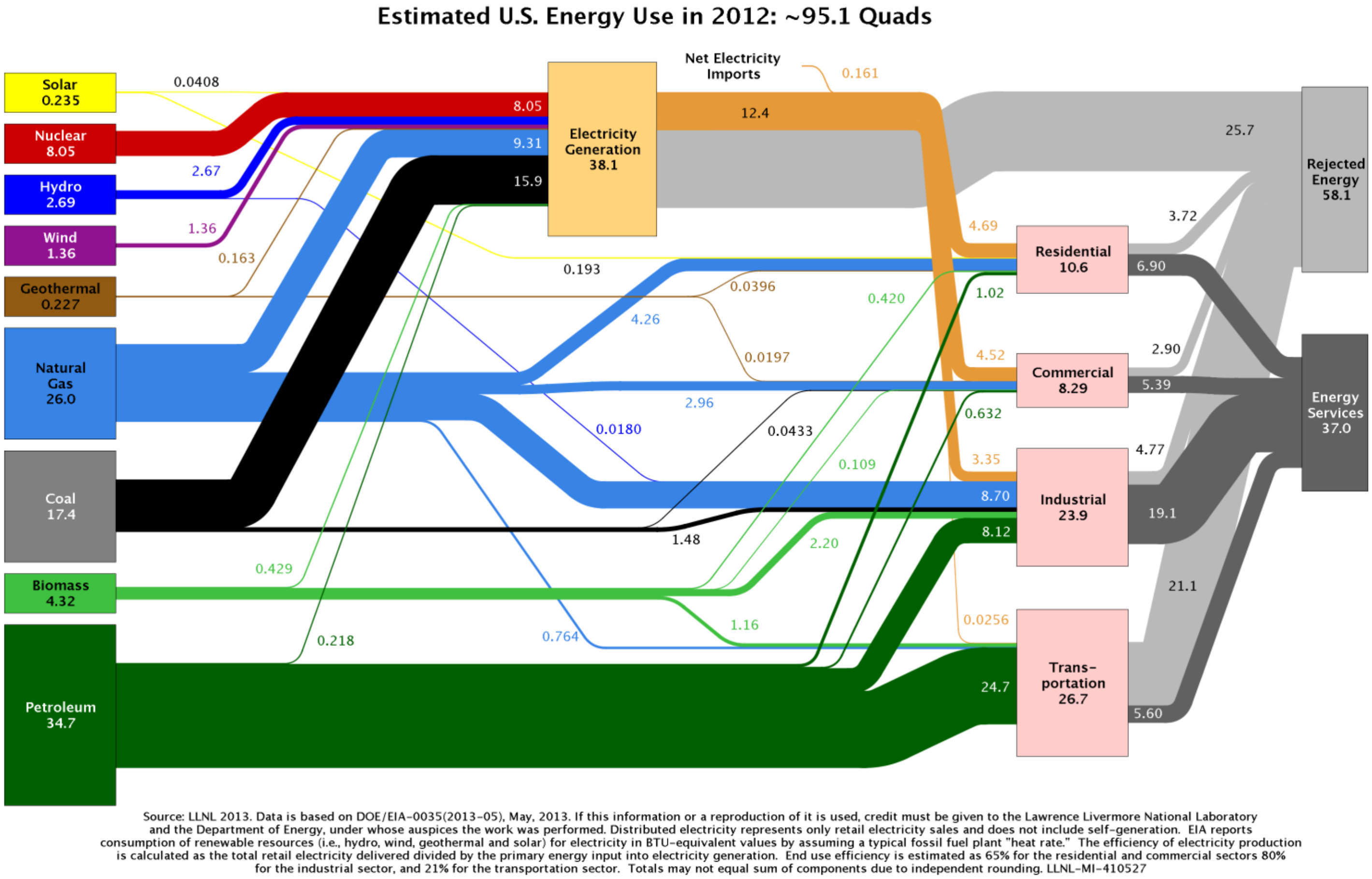
The United States is the world's second-largest producer and consumer of energy. The major energy sources consumed in the United States are petroleum, natural gas, coal, nuclear, and renewable energy. Renewable energy sources, including solar, wind, hydropower, and geothermal, have rapidly expanded. For example, solar power generation grew by more than 400 percent from 2008 through 2012, and wind power generation grew by more 150 percent during that same period.[8] While the three major fossil fuels—petroleum, natural gas, and coal—have dominated the U.S. fuel mix, recent increases in the domestic production of petroleum liquids and natural gas have prompted shifts between the uses of fossil fuels (largely from coal-fired to natural gas-fired power generation).[9]

Figure 2-2 provides an overview of energy flows through the U.S. economy in 2012. This section focuses on changes in U.S. energy supply and demand since the 2010 CAR, which covered changes through 2008.

[8] U.S. DOE/EIA 2012, Table 8.2a, Electricity Net Generation: Total (All Sectors), 1949–2011. *See* http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0802a.
[9] U.S. DOE/EIA 2013d. *See* http://www.eia.gov/todayinenergy/detail.cfm?id=11951&src=Total-b1.

Figure 2-2: Estimated U.S. Energy Use in 2012.

This graph provides a visual representation of the sources of energy and source endpoints within the U.S. economy. Credit: Lawrence Livermore National Laboratory and the Department of Energy.



Fossil Fuels

The current base of U.S. energy resources used is fossil fuels, accounting for approximately 68.4 percent of all U.S. energy consumption in 2012.[10]

Coal

Coal is the fuel most frequently used fuel for power generation and has the highest emissions of CO_2 per unit of energy for conventional fuel sources. The use of coal in electricity generation has steadily declined to 37.4 percent in 2012, down from 50 percent of the fuel mix in 2005. The United States uses about 890 million short tons of coal per year.[11] Current estimated recoverable coal reserves would supply the U.S. demand for energy, assuming constant 2011 rates of consumption, for approximately 258 years. As of December 31, 2008, of the estimated world recoverable coal reserves of 948 billion short tons, the United States holds the world's largest share (27 percent), followed by Russia (18 percent), China (13 percent), and Australia (9 percent).

[10] U.S. DOE/EIA 2013g, Table 7.2a, Electricity Net Generation: Total (All Sectors). *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf.

[11] U.S. DOE/EIA 2013g, Table 6.2, Coal Consumption by Sector. *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec6_4.pdf.

Natural Gas

Due to the advent of innovative drilling techniques, such as horizontal drilling and hydraulic fracturing, the United States has experienced a boom in shale gas and oil exploration and extraction (Figure 2-3), and natural gas has recently become an increasingly prominent U.S. fuel source. Electricity generation from natural gas increased from 17.8 percent in 2004 to 30.4 percent in 2012. The rapid increase in natural gas production has also heightened awareness of the possible negative environmental impacts of natural gas production through hydraulic fracturing.

Proved U.S. reserves of dry natural gas are rapidly increasing. Between 2007 and 2011, they grew by 28.1 percent—from 237,726 billion cubic feet (cu ft) to 334,067 billion cu ft. In 2012, the United States produced 24,062 billion cu ft of dry natural gas, a 19.4 percent increase since 2008.[12] Imports totaled 3,135 billion cu ft in 2012, while exports increased by 8 percent from 2011 to 1,619 billion cubic feet in 2012.[13] This growth has led to greater domestic natural gas supply and relatively low prices in the United States, thus reducing U.S. reliance on foreign natural gas.[14]

Oil

Horizontal drilling and hydraulic fracturing in shale and other very low-permeability formations continue to drive record increases in proved oil. Field production of crude oil increased from an average of 5 million barrels per day (bpd) in 2008 to 7 million bpd by the end of 2012. Proved domestic reserves of crude oil were 19.1 billion barrels at the end of 2008; by the end of 2011, they had risen to 26.5 billion barrels, a 38.8 percent increase.[15] Crude oil imports in 2008 totaled 9.78 million bpd, with an additional 3.14 million bpd of refined products; by 2012, that number had fallen to 8.49 million bpd, with another 2.56 million barrels of petroleum products imported.[16] In 2012, the United States relied on net petroleum imports to meet approximately 40 percent of its petroleum needs, the lowest level since 1991.[17] The countries from which the United States imports the largest shares of crude oil and petroleum products include Canada (28 percent), Saudi Arabia (13 percent), Mexico (10 percent), Venezuela (9 percent), and Russia (5 percent).[18]

Figure 2-3 shows current and prospective shale gas and oil plays in the contiguous United States. Horizontal drilling and hydraulic fracturing have opened up previously inaccessible deposits of natural gas and oil.

Figure 2-3: Lower 48 Shale Plays

Through enhanced technologies such as hydraulic fracturing and horizontal drilling, producers have been able to exploit previously inaccessible shale deposits through the United States.

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[12] U.S. DOE/EIA. Natural Gas Summary. *See* http://www.eia.gov/dnav/ng/ng_sum_lsum_dcu_nus_a.htm.

[13] U.S. DOE/EIA 2013h, U.S. Natural Gas Imports & Exports 2012. *See* http://www.eia.gov/naturalgas/importsexports/annual/.

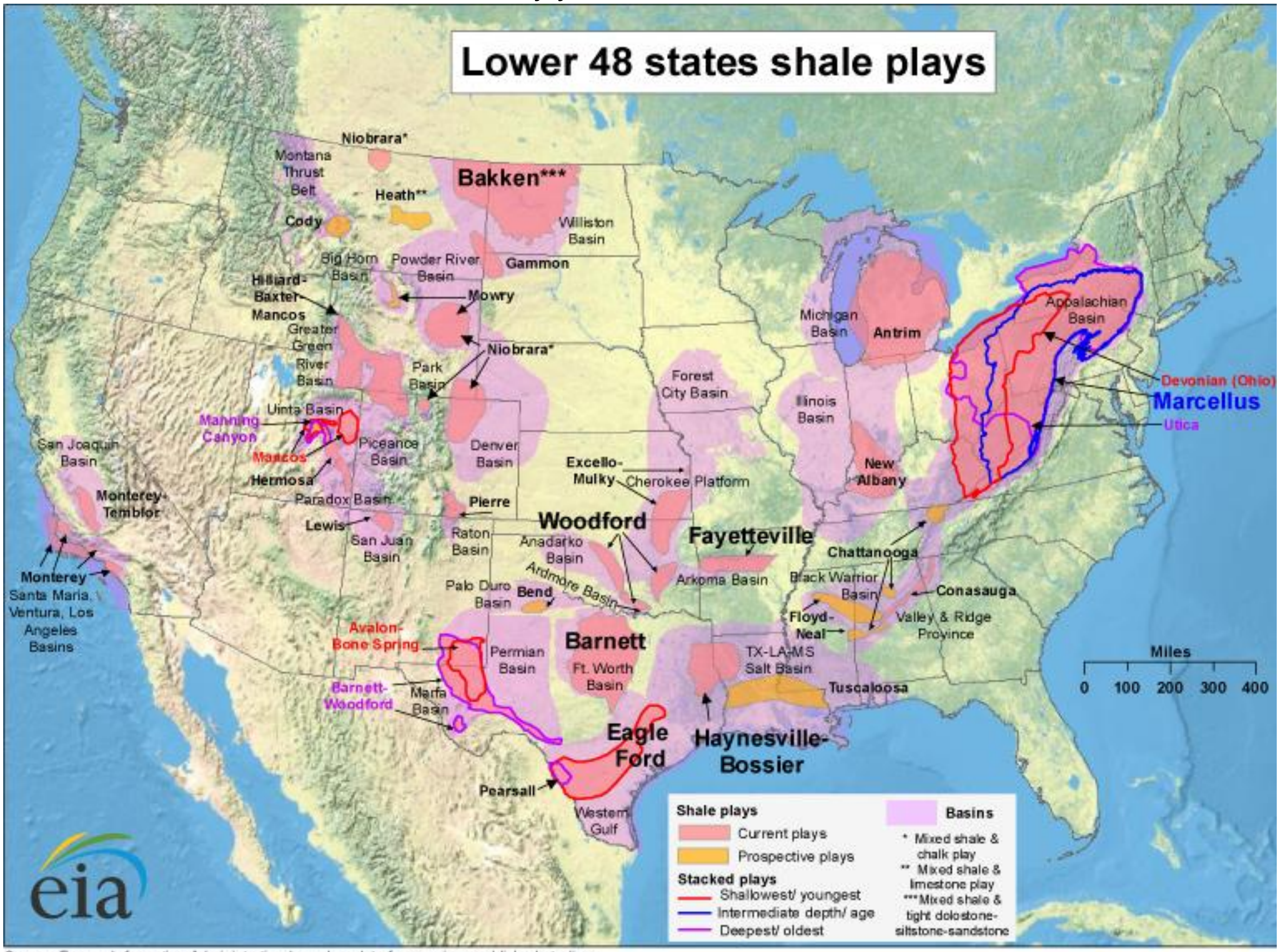
[14] Ibid.

[15] U.S. DOE/EIA. Table 5: Total U.S. Proved Reserves of Crude Oil and Lease Condensate, Crude Oil, and Lease Condensate, 2002–2011. *See* http://www.eia.gov/naturalgas/crudeoilreserves/pdf/table_5.pdf.

[16] U.S. DOE/EIA. Imports by Area of Entry. *See* http://www.eia.gov/dnav/pet/pet_move_imp_dc_nus-z00_mbblpd_a.htm.

[17] U.S. DOE/EIA 2013f. *See* http://www.eia.gov/tools/faqs/faq.cfm?id=32&t=6.

[18] U.S. DOE/EIA 2013e. *See* http://www.eia.gov/energy_in_brief/article/foreign_oil_dependence.cfm.



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Nuclear Energy

In 2012, nuclear energy from 104 operating reactor units accounted for 19 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 about 17.4 percent of the uranium purchased in 2012 being supplied by the United States.[19] Most of these reserves can be found in Wyoming, Texas, New Mexico, Arizona, Colorado, and Utah. The average yearly U.S. uranium concentrate production in 2010–2012 was 4.1 million pounds, up from an average yearly production of 2.3 million pounds during 2003–2005.[20]

Renewable Energy

Renewable energy represents a rapidly growing source of U.S. energy production. In 2012, renewable energy accounted for 5.4 percent of U.S. electric generation excluding conventional hydropower, or 12.2 percent including conventional hydropower.[21] Though there is currently no federally mandated standard for the use of renewable energy sources for electric generation, as of 2013, 29 states have 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.

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[19] U.S. DOE/EIA, Uranium Marketing Annual Report. *See* http://www.eia.gov/uranium/marketing/html/summarytable1a.cfm.
[20] U.S. DOE/EIA. 2012, Domestic Uranium Production Report. *See* http://www.eia.gov/uranium/production/annual/pdf/dupr.pdf.
[21] U.S. DOE/EIA 2012, Table 8.2a. Electricity Net Generation: Total (All Sectors), 1949–2011. *See* http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0802a.

The Energy Policy Act of 2005 (EPAct) established federally mandated investment tax credits for those investing in residential, commercial, and industrial renewable energy, and extended the production tax credit for renewable energy electricity generation through 2012. Similarly, the Energy Improvement and Extension Act of 2008 extended the investment tax credit was until 2016, and the production tax credit was extended in January 2013 for one year.

These policies have played a primary role in the rapid expansion of electricity generated from renewable resources, such as solar energy (Figure 2-4) and wind. Conventional hydropower remains the largest renewable source of electricity generation, producing 277 billion kilowatt-hours (kWh) in 2012.[22] Electricity production from renewable sources, excluding conventional hydro, totaled 219 billion kWh in 2012, which represents a 73.8 percent increase in production from 2008. Major growth is visible in the wind power industry alone, with electricity generation from wind increasing by 153 percent from 2008 levels to reach more than 140 billion kWh in 2012.[23] In 2012, wind energy was the number one source of new U.S. electricity generation capacity for the first time—representing 43 percent of all new electric additions.[24]

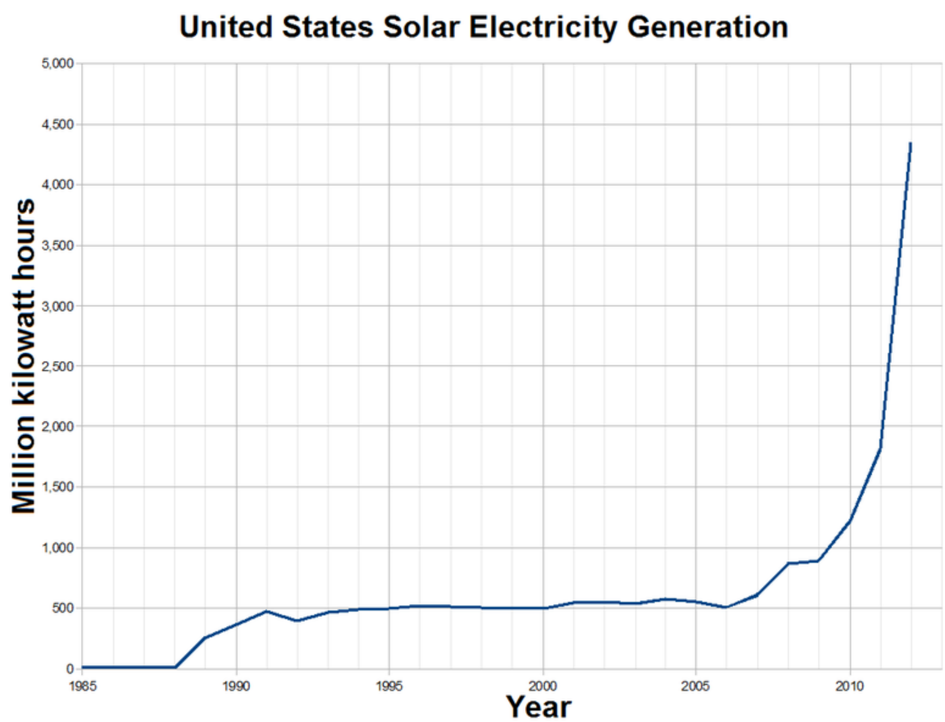


Figure 2-4: U.S. Solar Electricity Generation

U.S. solar energy generation has increased significantly since 2007. Solar energy currently produces approximately one percent of U.S. electricity, but this number is rapidly growing.

Sources: U.S. DOE/EIA 2012, Table 8.2a, and U.S. DOE/EIA 2013c, Table 1.20.B.

Electricity

Total U.S. electricity generation was at 4,054 billion kWh in 2012, down 1.58 percent from 2008, but up by 8.5 percent compared to generation levels in 2001 and up by 0.02 percent compared to 2005 levels. The U.S. Department of Energy's (DOE's) Energy Information Administration (EIA) projects that U.S. electricity demand will continue to rise by 17.6 percent between 2012 and 2030.[25]

[22] U.S. DOE/EIA 2013g, Table 7.2a, Electricity Net Generation: Total (All Sectors). *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec7_5.pdf.

[23] Ibid.

[24] U.S. DOE 2013. *See* http://energy.gov/articles/energy-dept-reports-us-wind-energy-production-and-manufacturing-reaches-record-highs.

[25] U.S. DOE/EIA 2013b, Electricity Supply, Disposition, Prices and Emissions, Total Electricity Use 2012=3837 and 2030 =4513.

In 2012, U.S. electricity generation was largely powered by coal-fired power plants, at 37 percent of total generation. However, compared to previous years, the share of electricity generated from coal is declining, down from 51.7 percent in 2000 and 44 percent in 2009. This declining trend is due to rapid growth in natural gas-fired generation, which has risen from 16 percent of total electric generation in 2000 to more than 30 percent in 2012. Figure 2-2 shows electricity flow through the U.S. economy in 2012.

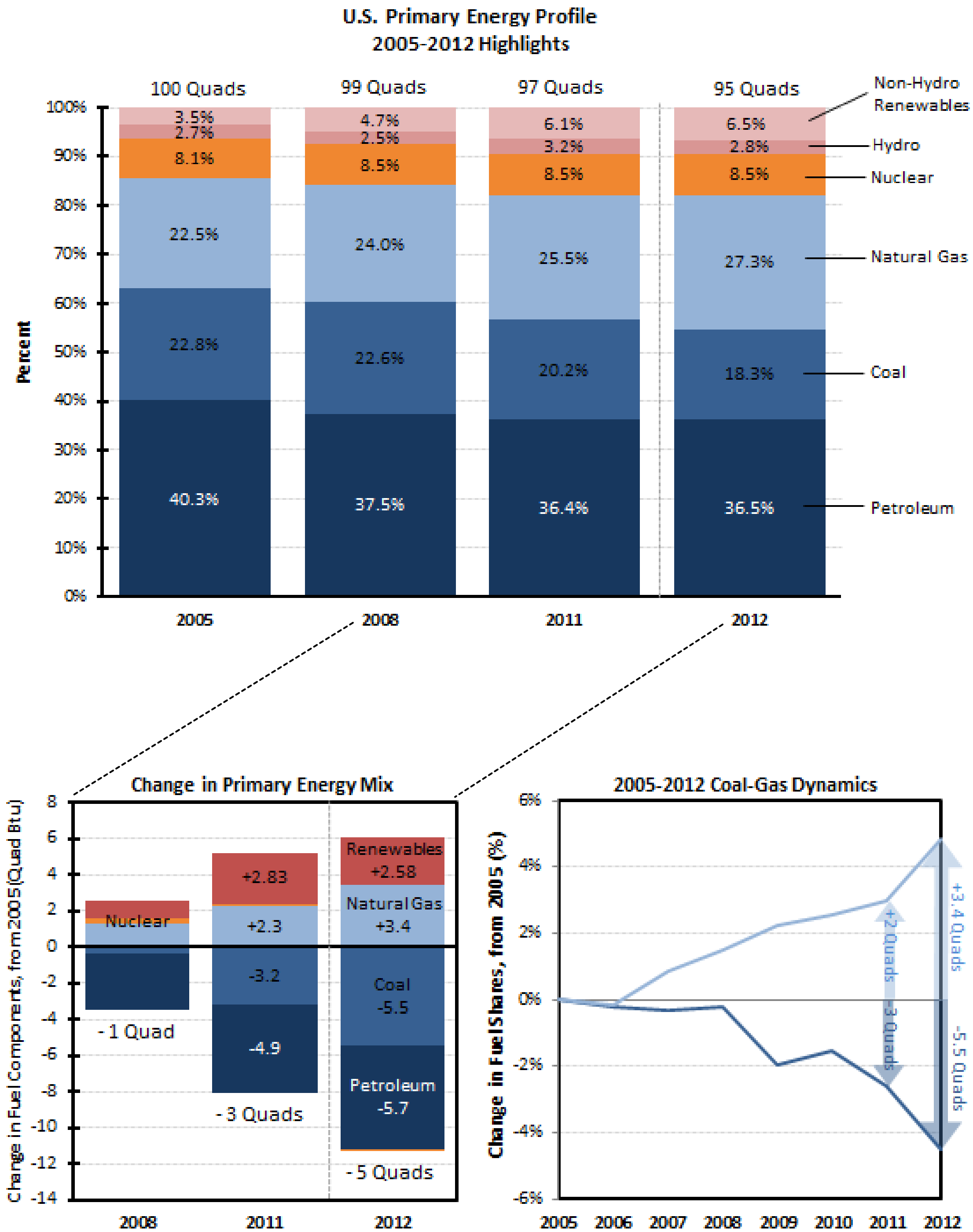
Energy Consumption[26]

The United States currently consumes energy from petroleum, natural gas, coal, nuclear, conventional hydropower, and renewables. While fossil fuels remain predominant, 2005–2012 trends show swift—and ongoing—evolution of the fuel mix toward cleaner sources, with natural gas and renewables increasingly displacing coal and petroleum (Figure 2-5). Petroleum, the single largest source, accounted for 36.5 percent of total primary energy consumption in 2012, down from 37.5 percent in 2008 and 40.34 percent in 2005. Coal declined from 22.8 percent in 2005 to 18.3 percent in 2012, a level surpassed by natural gas at 27.3 percent, representing an approximately equal increase of 5 percentage points. Over the same time frame, conventional hydropower stayed level at about 3 percent, non-hydro renewables expanded from 3.5 to 6.5 percent, and nuclear grew moderately, from 8.1 to 8.5 percent.

[26] U.S. DOE/EIA 2013b and U.S. DOE/EIA 2013g, Table 1.1, Total Energy Flow, 2011 (*see* http://www.eia.gov/totalenergy/data/monthly/pdf/sec1_3.pdf).

Figure 2-5: U.S. Primary Energy Consumption

This graph demonstrates U.S. primary energy consumption. The use of petroleum fuel has decreased as a share of the U.S. energy profile, while natural gas has grown.



Total U.S. energy consumption continues a recent trend of overall decline, falling 2.4 percent between 2011 and 2012.[27] This follows recession-driven drops of 2.0 percent between 2007 and 2008 and 4.7 percent between 2008 and 2009, resulting in a 6.1 percent decline in energy consumption between 2007 and 2012.[28] These shifts reflect both fluctuating economic growth, from recession into early recovery, and generally increasing sectoral and economy-wide energy efficiency. EIA's *Annual Energy Outlook 2013 (AEO2013)* Reference case forecasts growing primary energy consumption from 2013 onward, mainly supplied by natural gas and renewables (U.S. DOE/EIA 2013b).

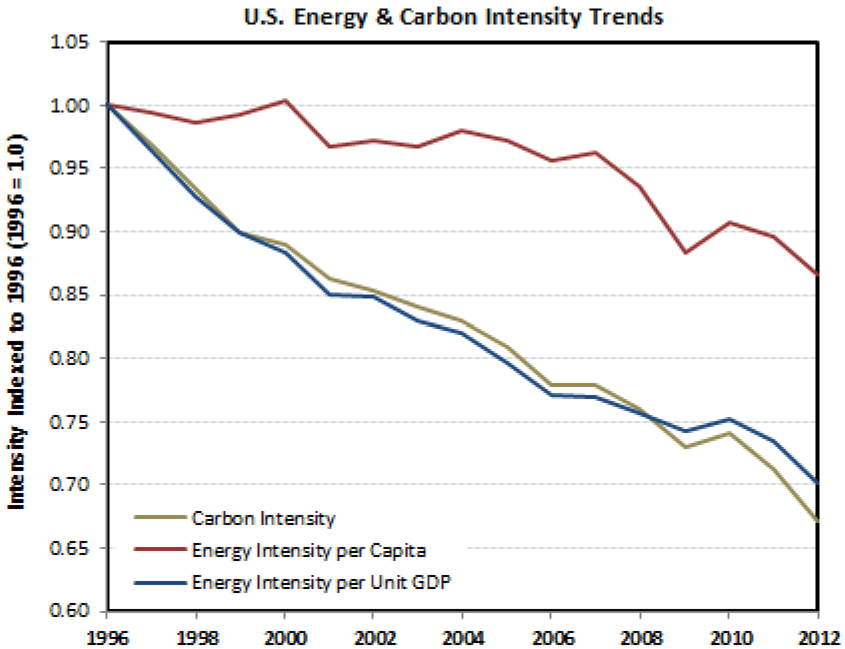
The rates of U.S. energy consumption, per capita and per unit of economic output, are on descending long-term trajectories (Figure 2-6). In 2011, per capita energy use fell by 1.26 percent from 2010, to 312 million Btus per person, comparable to levels last seen in the 1980s.[29] Energy consumption per unit of GDP fell by 2.14 percent from 2010 to 2011, to 7,310 Btus per dollar (2005 dollars).[30] EIA projects per capita consumption to fall below 270 million Btus per person by 2034, largely from mandated efficiency gains in appliances and vehicles.[31]

Decreasing energy intensity and increasing source decarbonization directly drive steadily declining U.S. carbon intensity. The ratio of CO_2 emissions to real GDP (2005 dollars) fell by 7 percent between 2008 and 2011, from 456 to 413 metric tons of CO_2 per million dollars. This ratio fell by 13.05 percent between 2005 and 2011.[32]

Figure 2-6: U.S. Energy and Carbon Intensity Trends

U.S. energy and carbon intensity have declined significantly even as the economy has continued to grow.

[27] Ibid.
[28] Ibid.
[29] U.S. DOE/EIA 2012. Table 1.5, Energy Consumption, Expenditures, and Emissions Indicators Estimates, Selected Years, 1949–2011. *See* http://www.eia.gov/totalenergy/data/annual/pdf/sec1_13.pdf.
[30] Ibid.
[31] U.S. DOE/EIA 2013b, p. 59.
[32] U.S. DOE/EIA, International Energy Statistics. *See* http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=91&pid=46&aid=31&cid=US,&syid=2005&eyid=2011&unit=MTCDPUSD.



Residential Sector

The residential sector's energy base fluctuates according to season, region, year, and prevailing economic conditions. Although petroleum and natural gas use typically varies more elastically than electricity consumption, demand for all three decreased from 2008 through 2012. Consumption of petroleum, as fuel oil or liquefied petroleum gas, has been in decline since a peak of 861,000 bpd in 2003, dropping to 758,000 bpd in 2008 and 602,000 bpd in 2012. Consumption of natural gas has fluctuated as well in recent years, declining after a 2003 peak of 5,079 billion cu ft to 4,368 billion cu ft in 2006—a level not seen since 1987— then increasing again to 4,892 billion cu ft in 2008, before trending down to 4,180 billion cu ft in 2012.

The residential sector, made up of living quarters for private households, uses energy for various applications: space heating, water heating, air conditioning, lighting, refrigeration, cooking, appliances, and electronics. In 2012, residential energy consumption, including electricity losses, totaled 20.2 quadrillion Btus (21.2 percent of total consumption), down from 21.7 quadrillion Btus (21.9 percent) in 2008, representing a 6.9 percent decline.[33] Residential fossil CO_2 emissions, representing 20.0 percent of total energy CO_2 (equaling the sector's 2000 share) also fell by 14.5 percent, from 1.2 megatons in 2008 to 1.1 megatons in 2012, a 16 percent reduction from 2005.

Commercial Sector

The commercial sector is made up of service facilities and equipment used by businesses, federal and local 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 operation of office and other equipment. Less common uses of energy include transportation.

As of 2012, electricity accounted for 78.5 percent of the commercial sector's energy use, followed by natural gas at just under 17 percent.[34] Demand responds largely to a combination of prices, among other market factors, and weather, although the impact of weather is less significant in commercial than in residential buildings. Since the period covered by the 2010 CAR, demand for electricity has declined gradually, falling by 0.7 percent between 2009 and 2012.[35] After notable increases of 6.3 percent in 2007 and 4.7 percent in 2008, demand for natural gas fell for three out of four years (all but 2011), declining most steeply by 7.8 percent in 2012.[36] In 2012, total commercial energy consumption was 4.9 percent lower than in 2008, more than

[33] U.S. DOE/EIA 2013g, Table 2.1, Energy Consumption by Sector. *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec2_3.pdf.

[34] U.S. DOE/EIA 2013g, Table 2.3, Commercial Energy Sector Consumption. *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec2_7.pdf.

[35] Ibid.

[36] Ibid.

offsetting a 3 percent increase between 2005 and 2008.[37] At 17.5 quadrillion Btus, the commercial sector's energy use represented 18.4 percent of total U.S. energy demand in 2012.[38]

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. In 2012, electricity use, including system losses, represented around one-third of all energy consumed in the industrial sector.[39]

Since 2008, natural gas has narrowly displaced petroleum as the primary energy source.[40] In 2012, natural gas and petroleum accounted for 28.3 percent and 26.4 percent of energy consumption, respectively. Renewable energy use—primarily biomass—surpassed coal in 2007.[41] Between 2008 and 2012, industrial renewable energy consumption expanded from 6.5 to 7.2 percent, while coal dropped from 5.9 to 4.8 percent.[42]

Industrial sector energy use fell from 43 percent of total energy consumption in 1973 to 32.0 percent in 2007, and grew to 32.3 percent in 2012.[43] Industry consumed 2.1 percent less energy between 2008 and 2012, largely from coal and petroleum, because of a decline in electrical system energy losses.[44] Within the industrial sector, energy consumption decreased by 2.0 percent in 2008 and 10.2 percent in 2009, then increased by 5.5 percent in 2010 and 1.4 percent in 2011, and again decreased by 2.0 percent in 2012.[45] At 30.7 quadrillion Btus, the industrial sector's energy use represented 32.3 percent of total U.S. energy demand in 2012.[46]

Approximately three-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 industrial energy use, but comprise only 26 percent of shipments. Projected slow growth in these energy-intensive industries is likely to result from increased foreign competition, reduced domestic demand for raw materials and the basic goods they produce, and movement of investment capital to more profitable areas.[47] EIA's *AEO2013* Reference case projects that, despite a 76 percent increase in industrial shipments, industrial energy consumption will grow by only 19 percent between 2011 and 2040, primarily because of a shift in the share of shipments from energy-intensive manufacturing to plastics, computers, transportation equipment, and other less energy-intensive industries.[48]

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 2013 was about 87 percent of the total, down 2 percentage points from the 2010 CAR. Air travel accounted for slightly more than 11 percent of passenger miles traveled (up 1.5 percentage points from the 2010

[37] Ibid.
[38] U.S. DOE/EIA 2013g, Table 2.1. Energy Consumption by Sector. *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec2_3.pdf.
[39] U.S. DOE/EIA 2013g, Industrial Sector Energy Consumption Estimates. *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec2_9.pdf.
[40] Ibid.
[41] Ibid.
[42] Ibid.
[43] U.S. DOE/EIA 2013g, Table 2.1. Energy Consumption by Sector. *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec2_3.pdf.
[44] U.S. DOE/EIA 2013g, Table 2.4. Industrial Sector Energy Consumption Estimates. *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec2_9.pdf.
[45] U.S. DOE/EIA 2013g, Table 2.1. Energy Consumption by Sector. *See* http://www.eia.gov/totalenergy/data/monthly/pdf/sec2_3.pdf.
[46] Ibid.
[47] U.S. DOE/EIA 2013b. *See* http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf.
[48] U.S. DOE/EIA 2013b, Industrial. *See* http://www.eia.gov/forecasts/aeo/sector_industrial_all.cfm.

CAR), and mass transit and rail travel combined accounted for only about 1 percent. For-hire transport services, as a portion of GDP, have barely changed since the 2010 CAR, accounting for 2.96 percent of GDP in 2011.[49]

Highway Vehicles

The trends in highway vehicles have not changed appreciably in the past decade. Between 2008 and 2011, the number of passenger vehicles declined by 1.1 percent, reaching 253.1 million in 2011.[50] This 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 between home and workplace in 2009, with more than three-quarters of the nation's workforce individually driving to and from work.[51] Just more than 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.).[52]

Private vehicles, which include automobiles, light trucks, vans, and motorcycles, are used for 84 percent of all trips nationwide. Most of these trips—55 percent—are made by car or van, 18 percent are by sport utility vehicle (SUV), and 10 percent are by pickup truck.[53] The largest sources of transportation GHGs in 2011 were passenger cars (41.2 percent); light-duty trucks, which include sport utility vehicles; pickup trucks, and minivans (17.4 percent); freight trucks (21.0 percent); rail (6.5 percent); and commercial aircraft (6.1 percent). These figures include direct emissions from fossil fuel combustion, as well as hydrofluorocarbon emissions from mobile air conditioners and refrigerated transport allocated to these vehicle types (U.S. EPA 2013a).[54]

The number of miles driven is another major factor affecting energy use in the highway sector. The number of vehicle miles traveled by passenger cars and light-duty trucks increased by 34 percent from 1990 through 2011.[55] From 2006 through 2008, the total number of vehicle miles driven each year reached around 3 trillion miles, but in 2012 dropped to 2.95 trillion miles, a decline of almost 2 percent.[56]

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 increased from an average 22.3 miles per gallon (MPG) for 2004–2006 to an average of 23.1 MPG in 2008–2010.[57] In 2011, the average fuel efficiency of new passenger cars and light trucks was 35.6 MPG and 25.0 MPG,[58] respectively.[59] Fuel economy standards,

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49 U.S. DOT/BTS, Table 3-2: U.S. Gross Domestic Product (GDP) Attributed to For-Hire Transportation Services (*see* http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_03_02.html); and U.S. DOT/Research and Innovative Technology Administration (RITA)/BTS, *National Transportation Statistics 2013* (*see* http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/NTS_Entire_Q1.pdf).

50 U.S. Department of Transportation (DOT)/Bureau of Transportation Statistics (BTS), Table 4-9: Motor Vehicle Fuel Consumption and Travel. *See* http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_ statistics/html/table_04_09.html.

51 McKenzie and Rapino 2011, *Commuting in the United States: 2009*. *See* http://www.census.gov/prod/2011pubs/acs-15.pdf.

52 McKenzie 2010, *Public Transportation Usage Among U.S. Workers: 2008 and 2009*. http://www.census.gov/prod/2010pubs/acsbr09-5.pdf.

53 U.S. DOT/Federal Highway Administration (FHWA). Our Nation's Highways, 2011: 2. Highway Travel. *See* http://www.fhwa.dot.gov/policyinformation/pubs/hf/pl11028/chapter2.cfm#fig22.

54 U.S. EPA 2013a. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2011*. *See* http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Main-Text.pdf.

55 U.S. EPA, Sources of Greenhouse Gas Emissions: Transportation Sector Emissions. *See* http://www.epa.gov/climatechange/ghgemissions/sources/transportation.html.

56 U.S. DOE/Energy Efficiency and Renewable Energy (EERE), Alternative Fuels Data Center, Annual Vehicle Miles Traveled in the U.S. See http://www.afdc.energy.gov/data/#tab/all.

57"U.S. DOT/RITA/BTS, Table 4-23: Average Fuel Efficiency of U.S. Light Duty Vehicles. See http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_04_23.html.

58 Ibid. *See also* Light Truck Fuel Economy Standard Rulemaking, MY 2008-2011, Final Rule, p. 12, at http://www.nhtsa.gov/fuel-economy

known as Corporate Average Fuel Economy (CAFE) standards, and GHG emission standards for new vehicles, 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 11 years, and are projected to require the overall fleet to reach an average CO_2 emissions level of 163 grams per mile in 2025, while nearly doubling new vehicle fuel economy.

Air Carriers

U.S. airlines carried 0.6 percent more domestic passengers in 2012 and 2 percent more international passengers than in 2011, for a system-wide increase of 0.8 percent.[60] Collectively, in 2011, the 728 million passengers traveling on U.S.-based airlines traveled 809 billion miles. On average, a passenger traveling domestically traveled 883 miles.[61] Since the low of 704 million passengers in 2009, airline ridership has risen, but has yet to reach the high levels experienced prior to the economic recession of 2008.

The impact of the economic recession, coupled with the high price of fuel and lower demand for travel, led airlines to cut back on available capacity by reducing the number of flights—especially those involving smaller aircraft. For example, airlines reduced the number of domestic scheduled passenger flights by 13.9 percent between June 2007 and June 2012.[62]

Freight

Between 2007 and 2009 (the latest year for which freight data are available), U.S. freight transportation declined by 8.3 percent to 4.30 trillion ton-miles, representing an average decline of 2.8 percent per year, compared to a 1.3 percent average annual growth between 2003 and 2007.[63] Rail accounts for the largest share of total freight ton-miles (36.8 percent), followed by trucks (30.8 percent), pipelines (21.1 percent), waterways (11.1 percent), and air (less than 1 percent).[64]

In recent years, increases in fuel costs, a slight decrease in the number of trucks on the road, and improved energy efficiency have affected the number of gallons of fuel burned by commercial trucks. From 2007 through 2010, truck fuel consumption declined by nearly 5 percent. Fuel use in Class I freight railroads declined by 14 percent, from 4.1 billion gallons in 2007 to 3.5 billion gallons in 2010.[65] In terms of energy consumption per ton-mile in 2010, trucking accounted for the largest share, followed by water, which was a distant second.[66]

In 2011, 17.6 billion tons of freight moved throughout the U.S. transportation system.[67] Trucks led in both tonnage and dollar value, carrying more than 70 percent of all freight in both in 2009.[68]

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[59] *See* Average Fuel Economy Standards, Passenger Cars and Light Trucks, MY 2011, See Updated CAFE Final Rule, p. 3, at http://www.nhtsa.gov/fuel-economy

[60] U.S. DOT/BTS 2013b, "Total Passengers on U.S Airlines and Foreign Airlines U.S. Flights Increased 1.3% in 2012 from 2011." See http://www.rita.dot.gov/bts/press_releases/bts016_13

[61] U.S. DOT/BTS, "U.S. Airline Revenue Passenger-Miles and Load Factor," Feb. 2013. http://www.rita.dot.gov/bts/publications/multimodal_transportation_indicators/2013_02/passenger_usage/us_airline_revenue

[62] U.S. DOT/Office of Inspector General (OIG) 2012, *Aviation Industry Performance: A Review of the Aviation Industry, 2008–2011*. *See* http://www.oig.dot.gov/sites/dot/files/Aviation%20Industry%20Performance%5E9-24-12.pdf.

[63] U.S. DOT/BTS, Table 1-50: U.S. Ton-Miles of Freight. *See* http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_50.html.

[64] Ibid.

[65] U.S. DOT/FHWA, Freight Facts and Figures 2012, Tables 5-7 and 5-7M: Fuel Consumption by Transportation Mode: 2007–2010. *See* http://www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/12factsfigures/table5_7.htm.

[66] U.S. DOT/FHWA, Freight Facts and Figures 2012, Table 5-8: Energy Consumption by Selected Freight Transportation Mode: 2007–2010."*See* http://www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/12factsfigures/table5_8.htm.

[67] U.S. House of Representatives, Committee on Transportation and Infrastructure, "Overview of the United States' Freight Transportation System," April 24, 2013." *See* http://transportation.house.gov/hearing/overview-united-states%E2%80%99-freight-transportation-system.

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 more than 18 percent of total GDP in 2012, and utilities accounted for another 1.9 percent of GDP.

The industrial sector as a whole represents 20 percent of total U.S. GHG emissions (2011 data). Compared to the period covered under the 2010 CAR, the portion of GHG emissions produced by industry has shrunk dramatically (from 28 percent of 2007 emissions to 20 percent of 2011 emissions).

Waste

In 2011, the United States generated approximately 250 million tons of municipal solid waste (MSW), about 3 million metric tons less than 2005.[69] Paper and paperboard products made up the largest component of MSW generated by weight (28 percent), and food waste comprised the second-largest material component (14.5 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.[70]

Recycling and composting have been the most significant change in waste management from a GHG perspective. In 2011, Americans composted or recycled 86.9 million tons of MSW, which saved more than 1.1 quadrillion Btus of energy and provides an annual benefit of more than 183 million metric tons of CO_2e emissions reduced, comparable to removing the emissions from more than 34 million passenger vehicles.[71] On average, Americans recycled and composted 1.53 pounds of waste, or 4.40 pounds per person per day.[72] From 1990 to 2011, the recycling rate increased from slightly more than16 percent to 34.7 percent. Of the remaining MSW generated, about 12 percent was combusted, and less than 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 1,908 in 2009, while the average landfill size has increased.[73]

The United States is working to reduce methane emissions from landfills by encouraging the recovery and beneficial use of landfill gas (LFG) as an energy source. EPA operates a Landfill Methane Outreach Program, a voluntary assistance program that forms partnerships with communities, landfill owners, utilities, power marketers, states, project developers, tribes, and nonprofit organizations to overcome barriers to project development by helping them assess project feasibility, find financing, and market the benefits of project development to the community. As of June 2012, there were 594 operational LFG energy projects in the United States and approximately 540 landfills that are good candidates for projects.[74]

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. As of 2012, buildings accounted for about 39.7 percent (37.7 quadrillion Btus) of total U.S. energy consumption, 41.2 percent (7 quadrillion Btus) more than the transportation sector and 22.8 percent (11 quadrillion Btus) more than the industrial sector.[75]

Residential Buildings

The U.S. housing market is gradually strengthening since the U.S. economic slowdown in 2007–2008, with home prices continuing to rise and existing home sales increasing. Between 2010 and 2012, the number of privately owned housing units under construction

68 U.S. DOT/FHWA, Our Nation's Highways, 2011: 2. Highway Travel. *See* http://www.fhwa.dot.gov/policyinformation/pubs/hf/pl11028/chapter2.cfm.
69 U.S. EPA, Municipal Solid Waste. *See* http://www.epa.gov/epawaste/nonhaz/municipal/index.htm.
70 U.S. EPA 2013b. *See* http://www.epa.gov/epawaste/nonhaz/municipal/pubs/MSWcharacterization_508_053113_fs.pdf.
71 U.S. EPA 2013c. *See* http://www.epa.gov/epawaste/nonhaz/municipal/pubs/MSWcharacterization_fnl_060713_2_rpt.pdf.
72 U.S. EPA 2013b.
73 U.S. EPA 2013c.
74 U.S. EPA, Landfill Methane Outreach Program. *See* http://www.epa.gov/lmop/basic-info/index.html.
75 U.S. DOE, "How Much Energy is Consumed in Residential and Commercial Buildings in the United States?" *See* http://www.eia.gov/tools/faqs/faq.cfm?id=86&t=1.

increased by nearly 30 percent.[76] In 2011, there were an estimated 132 million housing units in the United States, 61.6 percent of which were single, detached dwellings and 25.9 percent of which were housing units in multi-unit structures.[77]

While new homes are larger and more plentiful, their energy efficiency has increased significantly. In 2012, more than 100,000 new homes earned the ENERGY STAR® certification, implying at least a 30 percent energy savings for heating and cooling relative to comparable homes built to current code and bringing the total number of certified homes to more than 1.4 million.[78] On average, homes built between 2000 and 2005 used 14 percent less energy per square foot than homes built in the 1980s and 40 percent less energy per square foot than homes built before 1950. There has, however, been a trend toward larger home sizes. Specifically, single-family homes built between 2000 and 2005 are 29% larger on average than those built in the 1980s, and therefore have greater requirements for heating, cooling, and lighting.[79]

Commercial Buildings

Between 2000 and 2010, commercial floor space rose approximately 1.8 percent per year.[80] The Energy Information Administration estimates that commercial floor space will grow 28% between 2009 and 2035. In 2003 (the most recent data available), there were nearly 4.9 million commercial buildings and more than 6.7 billion square meters (71.7 billion square feet) of floor space. Much of this growth has been related to the rapidly expanding information, financial, and health services sectors.

The top three end uses in the commercial sector are space heating, lighting, and space cooling, which represent close to half ofcommercial energy consumption.[81] Commercial primary energy consumption grew by 65.5 percent between 1980 and 2009.[82] Electricity (78.5 percent) and natural gas (16.9 percent) are the two largest sources of energy used in commercial buildings. In aggregate, commercial buildings represented 46.4 percent of building energy consumption and 18.4 percent of U.S. energy consumption in 2012.[83] The top three end uses in the commercial sector are space heating, lighting, and space cooling, which represent close to half of commercial site energy consumption.[84]

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 2007, there were 1,685,339 farms with cropland in the United States.[85] U.S. cropland was 164 million hectares (ha) (406 million acres[ac]), about 9 percent lower than in 1997.[86]

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. 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, and through this sequestration have the

[76] U.S. Census Bureau, New Privately Owned Housing Units Under Construction, Annual Data: 1969–2012. *See* http://www.census.gov/construction/nrc/pdf/underann.pdf.

[77] U.S. Census Bureau, American FactFinder (*see* http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk); and U.S. Census Bureau, Statistical Abstract of the United States: 2012, Table 989, Housing Units by Units in Structure and State: 2009 (*see* http://www.census.gov/compendia/statab/2012/tables/12s0989.pdf).

[78] U.S. EPA 2013d, *Energy Star® Overview of 2012 Achievements*. *See* http://www.energystar.gov/ia/partners/publications/pubdocs/ES%20bi-fold%20031313%20FINAL%20for%20print%20rev.pdf?8254-b82b.

[79] U.S. DOE, Chapter 2, Residential Sector. *See* http://buildingsdatabook.eren.doe.gov/ChapterIntro2.aspx.

[80] U.S. DOE, Table 3.2.1, Total Commercial Floorspace and Number of Buildings, by Year. *See* http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=3.2.1.

[81] U.S. DOE, Chapter 3: Commercial Sector. *See* http://buildingsdatabook.eren.doe.gov/ChapterIntro3.aspx.

[82] U.S. DOE, 2009 Annual Energy Review. *See* http://www.eia.gov/totalenergy/data/annual/index.cfm.

[83] Ibid.

[84] Ibid.

[85] U.S. Department of Agriculture (USDA)/National Agricultural Statistics Service (NASS), *2007 Census of Agriculture. See* http://www.agcensus.usda.gov/Publications/2007/Full_Report/usv1.pdf.

[86] Ibid.

potential 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.

Sources of GHG emissions from U.S. croplands include nitrous oxide (N_2O) from nitrogen fertilizer use and methane from farm animals' enteric fermentation and manure management. Agricultural soil management activities, such as fertilizer application and other cropping practices, were the largest source of U.S. N_2O emissions in 2011, accounting for 69.3 percent.

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. In terms of GHG mitigation, 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. As of June 2013, about 11 million ha (27 million ac) are under contract in CRP on 389,722 farms.[87]

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. Forests established through planting of tree species comprise more than 26 million ha (63 million ac), or 8 percent of all forests, and nearly all planted stands are established with native species. In 1907, forests comprised an estimated 34 percent of the total U.S land area (307 million ha, or 758 million ac), which has remained roughly the same, as of 2010 (303 million hectares, or 748 million ac).[88] Historically, most of the forestland loss was due to agricultural conversions in the late 19th century, but today most losses are due to intensive uses, such as urban development. Since 1990, net forestland area has increased by approximately 0.56 million ha (1.4 million ac) per year, as marginal agriculture and pasture lands previously converted from forest in the 19th century revert to forestland faster than new losses to urban or other uses.

Of the 305 million ha (751 million ac) of U.S. forestland, 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 forestland is reserved forests, which in 2007 accounted for 10 percent of all forestland, or about 30 million ha (75 million ac).[89]

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 private forestland 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, and timber harvesting and use have resulted in net sequestration of CO_2 every year since 1990. In 2011, the land use, land-use change, and forestry sector absorbed a net of 905.0 Tg of CO_2. This sequestration represents an offset of 17.1 percent of U.S. fossil fuel emissions (5,277 Tg CO_2e, U.S. EPA 2013a).

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[87] USDA/CRP, Status—End of June 2013. *See* http://www.fsa.usda.gov/Internet/FSA_File/june2013onepager.pdf,

[88] Trading Economics, Forest Area (% of Land Area) in the United States. *See* http://www.tradingeconomics.com/united-states/forest-area-percent-of-land-area-wb-data.html.

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