

2 National Circumstances

A number of factors influence the Nation's greenhouse gas (GHG) emissions, including government structure, climatic conditions, population growth, geography, economic growth, energy consumption, technology development, resource base, and land use. This chapter focuses on current circumstances and departures from historical trends since the third *U.S. Climate Action Report*¹ (CAR) was submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in 2002, and the impact of these changes on emissions and removals (U.S. DOS 2002).

GOVERNMENT STRUCTURE

The United States is the world's oldest federal republic. Governmental responsibilities affecting economic development, energy, natural resources, and many other issues are shared among local, state, and federal governments. Those interested in learning more about the U.S. government's structure should consult the 2002 CAR, Chapter 2.

POPULATION PROFILE

Population growth can have a significant impact on energy consumption, land-use patterns, housing density, and transportation. Recent data from the U.S. Census Bureau indicate that the U.S. population trends highlighted in the 2002 CAR remain unchanged. As of 2005, the United States was the third most populous country in the world, with an estimated 296.4 million people. From 2000 to 2005, the U.S. population grew by about 15 million, at an annual rate of about 1 percent. This growth was essentially unchanged from the annual rate during the 1990s and is relatively high compared to the growth rates of other industrialized countries (U.S. DOC/Census 2006a). Net immigration continues to have a significant and increasing effect on U.S. population growth. About 42 percent of the growth between 2000 and 2005 was due to immigration, and about 58 percent from natural increase (U.S. DOC/Census 2006b).

The warm "Sunbelt"—i.e., the U.S. South and Southwest—continues to show the greatest population growth. California, Texas, Florida, and Arizona experienced the largest absolute increase in population from 2000 to 2005 (U.S. DOC/Census 2006b). This preference for warmer climates has a mixed impact on energy use. In general, while homes in these areas use less energy for heating, they use more energy for cooling.

In addition to these regional trends, the U.S. population has shifted from rural to metropolitan areas. About 54 percent of the population lives in metropolitan areas of 1 million people or more (U.S. DOC/Census 2006c). Much of the growth in metropolitan areas has not been in city centers; instead, it has occurred in the surrounding suburbs and newly emerging "exurbs." Between 1997 and 2003, the number of houses in suburban metropolitan areas increased by 15.3 percent. The comparable figure for central cities was just 3.4

¹ See <<http://unfccc.int/resource/docs/natc3.pdf>>.

percent, and the number of homes outside of metropolitan areas declined by 2.2 percent (U.S. DOC/Census 1999, 2004). Coupled with the Nation's generally low population density, this decentralizing trend in metropolitan areas has implications for energy use. In the past, commuting patterns were largely between the central city and surrounding suburbs, whereas today there is a much greater amount of suburb-to-suburb commuting, increasing reliance on the automobile for transportation.

GEOGRAPHIC PROFILE

The United States is one of the largest countries in the world, with a total area of 9,192,000 square kilometers (3,548,112 square miles) stretching over seven time zones. The U.S. topography is diverse, featuring deserts, lakes, mountains, plains, and forests. More than 60 percent of the U.S. land area is privately owned. The U.S. government owns and manages the natural resources on about 28 percent of the land, most of which is managed as part of the national systems of parks, forests, wilderness areas, wildlife refuges, and other public lands. States and local governments own about 9 percent, and the remaining 2 percent is held in trust by the Bureau of Indian Affairs (Lubowski et al. 2006). While the private sector plays a major role in developing and managing U.S. natural resources, federal, state, and local governments regulate activities on privately owned lands and provide educational support to ensure the protection and sustainable management of the natural resources on these lands.

CLIMATE PROFILE

The climate of the United States varies greatly, ranging from tropical conditions in south Florida and Hawaii to arctic and alpine conditions in Alaska and the high elevations of the Rocky Mountains and Sierra Nevada. Temperatures for the continental United States show a strong gradient, from very high temperatures in south Florida, south Texas, and parts of

southern California and Arizona, where the annual average temperature exceeds 21°C (70°F), to much cooler conditions in the northern parts of the country along the Canadian border.

Similarly, precipitation shows a strong gradient, measuring more than 127 centimeters (cm) (50 inches (in)) a year along the Gulf of Mexico, and decreasing to desert regions of the intermountain West. A similar but steeper gradient occurs in the Pacific Northwest, ranging from very high annual precipitation in the Cascades and Sierra Nevada, which can exceed 254 cm (100 in), to the rain shadows east of these mountain ranges, where annual precipitation can be less than 30 cm (12 in).

Seasonal variability in temperature also shows a very wide range with distance from the oceans. The difference between summer and winter temperatures is greater than 50°C (90°F) in areas like the northern Great Plains, whereas this difference is less than 8°C (14.4°F) in areas like south Florida. Seasonal variability in precipitation, however, shows a much different pattern. Areas in the eastern third of the country receive rainfall fairly consistently throughout the year. However, parts of the Great Basin (e.g., Arizona) experience two peaks in rainfall—one during the Pacific winter storms, and one in the mid to late summer during the peak of the North American monsoon. Along the West Coast, wet conditions prevail during the winter, and very dry conditions prevail during the summer.

The United States is subject to almost every kind of weather extreme, including countless severe thunderstorms during the warmer months of the year, and almost 1,500 tornadoes a year, most occurring during the spring and early summer. The hurricane season, which runs from June through November, produces an average of seven hurricanes, three of which make landfall. At any given time, approximately 20 percent of the country experiences drought conditions; however, during the largest droughts, almost 80 percent of the

continental United States has been in moderate to severe drought. Blizzards, ice storms, and high wind events occur across the country during the winter, and cold waves often produce freezing temperatures in regions that rarely see these kinds of conditions.

Differing U.S. climate conditions are seen in the number of annual heating and cooling degree-days. From 2000 to 2004, the number of heating degree-days averaged 4,330, which was 4.3 percent below the 30-year normal average. Over the same period, the annual number of cooling degree-days averaged 1,283, which was 5.6 percent above normal (U.S. DOE/EIA 2006b). Figure 2-1 shows the U.S. geographic distribution of heating and cooling degree-days.

ECONOMIC PROFILE

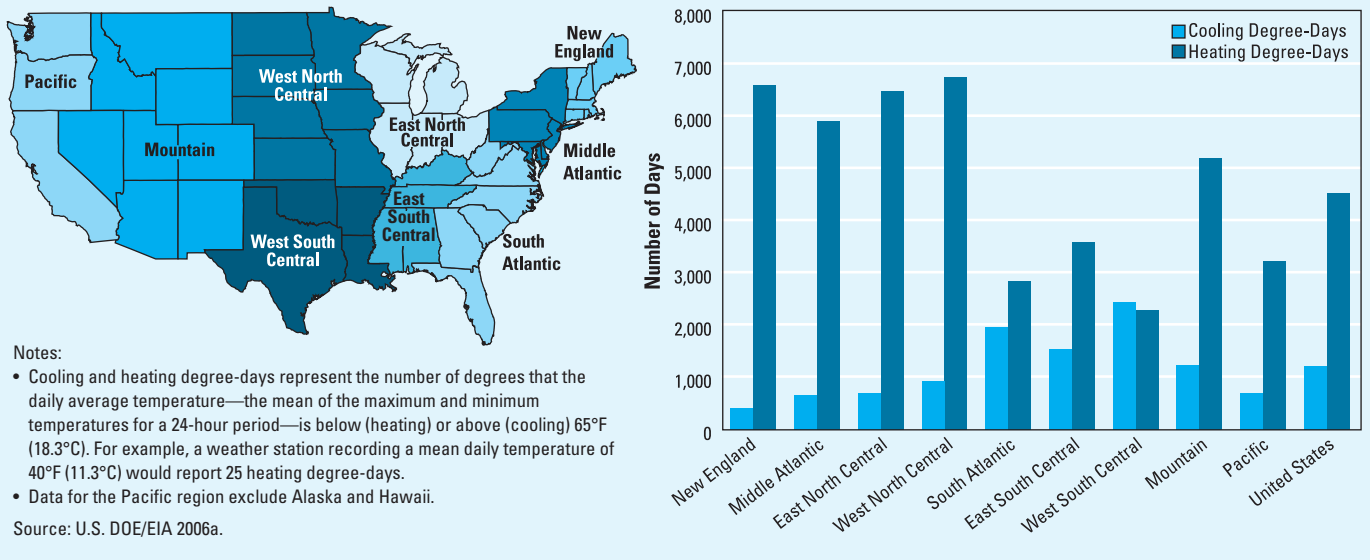
The U.S. economy is the largest in the world. In 2005, the U.S. economy continued a robust expansion, with strong output growth and steady improvement in the labor market. Looking to the future, the U.S. economy is poised for sustained growth for years to come.

From 2000 to 2005, the U.S. economy grew by more than \$1.3 trillion (in constant 2000 dollars), or 13.4 percent. In 2005, real gross domestic product (GDP) was just over \$11.1 trillion (in constant 2000 dollars). Nonfarm payroll employment increased by 2.0 million during 2005, leading to an average unemployment rate of 5.1 percent. Since the business-cycle peak in the first quarter of 2001 (a period that included a recession and a recovery), labor productivity grew at an average 3.6-percent annual rate, notably higher than during any comparable period since 1948.

The performance of the U.S. economy in 2005 was a marked turnaround from the economic situation the Nation faced four years earlier. The bursting of the high-tech bubble of the late 1990s, slow growth among major U.S. trading partners, and the terrorist attacks of September 11, 2001, combined to dampen growth. Business investment slowed sharply in late 2000 and

FIGURE 2-1 Cooling and Heating Degree-Days for the Continental United States (30-Year Normals, 1971-2000)

Geographic cooling and heating patterns have a significant impact on the type and amount of energy consumed. Areas of the country with greater-than-average cooling degree-days typically use more energy for space cooling, while areas with greater-than-average heating degree-days typically use more energy for space heating.



remained soft for more than two years. The economy lost more than 900,000 jobs from December 2000 to September 2001, and nearly 900,000 more in the three months immediately following the September 11 attacks. This slowdown in economic growth contributed to an absolute drop in GHG emissions in 2001.

Substantial tax relief and monetary policy provided stimulus to aggregate demand that softened the recession and helped put the economy on the path to recovery. Pro-growth tax policies not only provided timely stimulus, but improved incentives for work and capital accumulation, fostering an environment favorable to long-term economic growth.

However, high energy prices, which weaken both the supply and the demand sides of the economy, restrained growth somewhat in 2004 and 2005. Strong global demand, especially in Asia, and supply disruptions combined to push the price of crude oil to about \$50 per barrel. Several hurricanes also harmed the productive capacity of the economy, damaging Gulf Coast oil and gas platforms and refining

installations. Despite these factors and a long series of interest rate hikes by the Federal Reserve, the economy grew a healthy 3.5 percent in 2005 (CEA 2006). Although world oil production capacity is expected to increase, so is world demand, and the United States is likely to face tight crude oil markets for a number of years, which could constrain GDP growth and GHG emissions.

Long-term trends in the relative contributions of industrial sectors to GDP have changed little since the 2002 CAR. As a share of GDP, the service sector continues to grow, while the manufacturing sector continues to decline (CEA 2006). This shift has been a factor in improving U.S. GHG emissions intensity.

ENERGY RESERVES, PRODUCTION, AND CONSUMPTION

The considerable size of the United States and its variable and often severe climatic conditions, large and growing population, dynamic economy and industries, and rich endowment of energy resources are all factors that contribute to making the Nation the world's largest producer

and consumer of energy. Figure 2-2 provides an overview of energy flows through the U.S. economy in 2005. This section focuses on changes in U.S. energy supply and demand since the 2002 CAR, which covered energy through 2000.

Reserves and Production

The United States has vast reserves of energy, especially fossil fuels, which have been instrumental in the country's economic development. Uranium ore, renewable biomass, and hydropower are three other major sources of energy. Other renewable energy sources contribute a relatively small but growing portion of the U.S. energy portfolio.

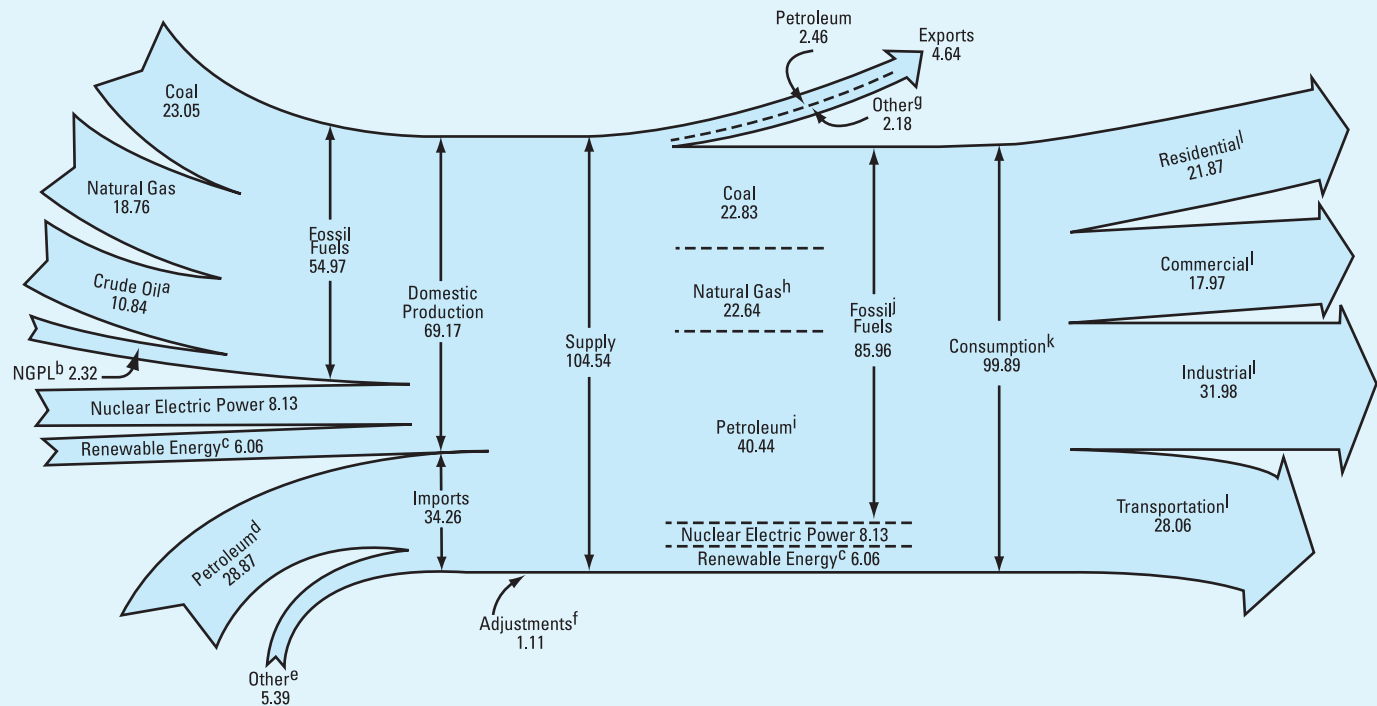
Fossil Fuels

Fossil fuels accounted for about four-fifths of U.S. domestic energy production in 2005, slightly less than in 2000.

Coal, which has the highest emissions of carbon dioxide (CO₂) per unit of energy, is particularly plentiful, and is the largest source of energy produced domestically. Coal remains the preferred fuel for power generation, supplying about half of the energy used to generate electricity in

FIGURE 2-2 Energy Flow Through the U.S. Economy: 2005 (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 2005, net imports of crude oil and refined products accounted for about 65 percent of U.S. petroleum consumption on a Btu basis.



^a Includes lease condensate.

^b Natural gas plant liquids.

^c Conventional hydroelectric power, wood, waste, ethanol blended into motor gasoline, geothermal, solar, and wind.

^d Crude oil and petroleum products. Includes imports into the Strategic Petroleum Reserve.

^e Natural gas, coal, coal coke, and electricity.

^f Stock changes, losses, gains, miscellaneous blending components, and unaccounted-for supply.

^g Coal, natural gas, coal coke, and electricity.

^h Includes supplemental gaseous fuels.

ⁱ Petroleum products, including natural gas plant liquids.

^j Includes 0.04 quadrillion Btus of coal coke net imports.

^k Includes, in quadrillion Btus: (1) 0.34 ethanol blended into motor gasoline, which is accounted for in both fossil fuels and renewable energy, but is counted only once in total consumption; and (2) 0.08 electricity net imports.

^l 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. Electrical system energy loss is the amount of energy lost during the generation, transmission, and distribution of electricity.

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.
- Source: U.S. DOE/EIA 2006b.

the United States. Moreover, from 2000 to 2005, coal's competitive position vis-à-vis oil and natural gas improved because of the rising cost of the latter fuels. Coal reserves are estimated at about 449 billion metric tons (495 billion tons), enough to last for about 440 years at current recovery rates. Annual coal production from 2000 to 2005 averaged about 1.0 billion metric tons (1.1 billion tons) (U.S. DOE/EIA 2006f).

The trends in oil reserves and production identified in the 2002 CAR have changed very little. Both peaked in 1970, when Alaskan North Slope fields came on line, and generally have declined since then. Proved domestic reserves of oil stand at about 3.4 trillion liters (21.9 billion barrels). At the 2005 production rate of about 912 billion liters (5.7 million barrels) per day, these reserves would be recovered in

slightly less than 12 years (absent additions) (U.S. DOE/EIA 2006g).

U.S. refining capacity, while well off its 1981 peak, has increased since 1994, even as the number of refineries declines. Although the number of operable refineries fell from 158 to 148 from 2000 to 2005, refining capacity over the period actually rose from 26.3 billion to 27.2 billion liters (16.5 to 17.1 million barrels) per day (U.S.

DOE/EIA 2005e). However, this capacity is still well below the demand for petroleum products, which in 2005 averaged 32.8 billion liters (20.7 million barrels) per day.

In 2005, net imports of crude oil and refined products accounted for 60 percent of U.S. petroleum (volumetric) consumption, about 7 percentage points above the level for 2000.² In addition to strong global demand, the active hurricane season in 2005 temporarily affected Gulf Coast crude oil production and refining, which contributed to the rising cost of crude oil and petroleum products in 2005.

Natural gas is the fossil fuel with the lowest emissions of CO₂ per unit of energy. The 2002 CAR pointed to the introduction of market pricing and regulatory changes in the 1980s as factors that led to a recovery in natural gas production and demand. The addition of natural gas-fired electricity-generating capacity also has boosted demand. Estimated dry natural gas reserves of about 5.5 trillion cubic meters (192.5 trillion cubic feet) at the beginning of 2005 were 8.5 percent higher than reserves at the beginning of 2000. Natural gas production also increased since the 2002 CAR, but only modestly, rising 1 percent between 2000 and 2005 to 1.5 million cubic meters (53.2 million cubic feet) per day. As a result, the reserves-to-production ratio increased from 9.2 to 10.6 years (U.S. DOE/EIA 2006g).

Nuclear Energy

The United States has about 120 million kilograms (kg) (265 million pounds (lb)) of uranium oxide reserves recoverable at \$66 per kg (\$30 per lb) (U.S. DOE/EIA 2004b). Although U.S. uranium production has been trending downward for many years, production saw a turnaround in 2004, as U.S. uranium drilling, mining, production, and employment activities increased for the first time since 1998. Total U.S. uranium concentrate production in 2005 was about 1.2 million kg (2.7 million lb). Although well below its 1980 peak, it was 35 percent above the 2003 level (U.S. DOE/EIA 2005a).

Production from nuclear energy facilities in 2005 contributed 20 percent of total electricity generation³ and 12 percent of total domestic energy production.

Renewable Energy

Renewable energy production in 2005 was 6.1 quadrillion Btus, accounting for 8.8 percent of total U.S. energy production. Of this amount, biomass accounted for 46 percent; hydropower, 45 percent; geothermal, 5.8 percent; wind, 2.5 percent; and solar, 1.1 percent. Owing largely to higher than normal hydropower output, renewable energy production reached its highest point in 1996 at 7.1 quadrillion Btus, or just below 10 percent of total U.S. energy production.

After peaking in 1997, hydropower production declined for four consecutive years, and has been at normal or below-normal levels since 2000. Geothermal output in 2005 reached its highest level since 1993. Wind expanded rapidly in recent years, but its share of the total was not enough to significantly affect the overall renewable industry trend (U.S. DOE/EIA 2006e).

Electricity

The United States relies on electricity to meet a significant portion of its energy demands, especially for lighting, electric motors, heating, and air-conditioning. The electricity generation sector, the largest U.S. economic sector, is composed of traditional electric utilities as well as other entities, such as power markets and non-utility power producers.

Coal-fired capacity in 2005 maintained the largest share of U.S. electric generating capacity, at 32 percent. Natural gas capacity accounted for 23 percent of the total generating capacity; dual-fired (natural gas and petroleum), 18 percent; nuclear, 10 percent; hydroelectric, 8 percent; and other renewables (wood products, solar, wind, etc.), 2 percent.

While coal-fired capacity remains the largest, its share of total capacity fell relative to other fuels, particularly natural gas. In 2004, 72 percent of the new unit capacity was natural gas-fired, and at 15.3 gigawatts was well ahead of natural gas plant retirements. Also notable was the growth in renewable capacity, which added about 9 megawatts for every megawatt retired. Additionally, re-powering of large coal-fired plants into more efficient natural gas combined-cycle plants, as well as the retirement of older coal-fired units, has slightly reduced coal-fired capacity. However, new orders for natural gas-fired units could slow because of high fuel costs.

In 2005, net generation of electricity was 4.06 trillion kilowatt-hours, 6.7 percent above the 2000 level. Regulated electric utilities' share of total generation continues to decline as independent power producers' share continues to increase (U.S. DOE/EIA 2005c). Although coal-fired capacity represents roughly one-third of total generating capacity, it accounts for about half of the electricity generated. This is because coal-fired plants are for the most part run constantly to meet base-load capacity, rather than sporadically to meet peak-load demand.

Consumption

Since 2000, the overall trend in U.S. energy demand has been driven largely by economic activity. From 2000 to 2001, total U.S. energy consumption fell 2.5 percent, primarily in response to weakness in the U.S. economy and the effects of increased oil prices. As the economy began to recover in 2002, energy consumption also picked up. By 2004, U.S. energy consumption topped 100 quadrillion Btus, before dipping slightly in 2005, owing in part to hurricane-related damage along the Gulf Coast and Florida. Figure 2-3 presents U.S. energy use by sector.

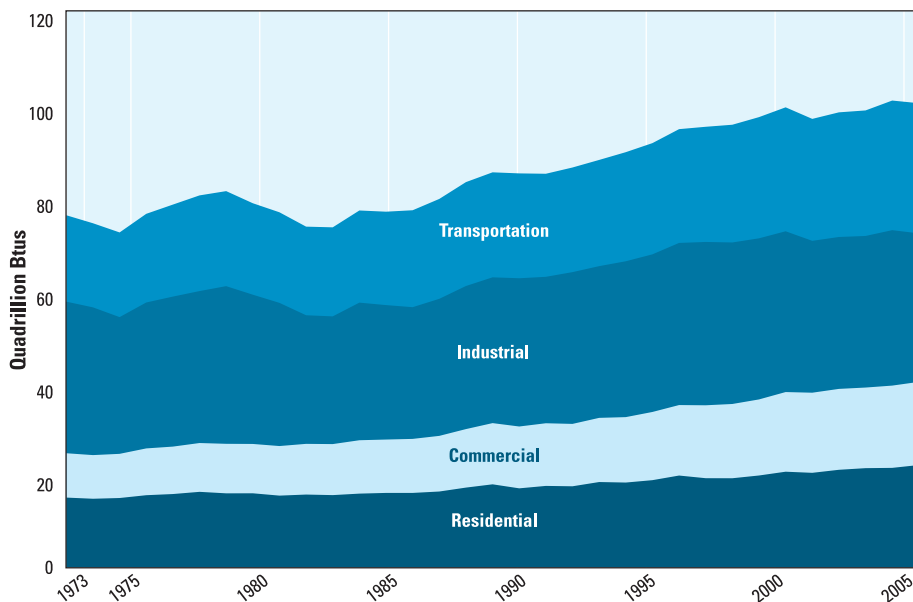
While absolute U.S. energy use has risen since 2000, the amount of energy

² On a Btu basis, net petroleum imports accounted for 65 percent of U.S. petroleum consumption in 2005, about 7 percentage points higher than in 2000.

³ For the electric power sector; excludes electricity production in the commercial and industrial sectors.

FIGURE 2-3 U.S. Energy Consumption by Sector: 1973-2005

Between 2000 and 2005, energy consumption in the residential, commercial, and transportation sectors rose by 6.6, 4.4, and 5.0 percent, respectively, while energy demand in the industrial sector fell by 7.6 percent. Since 1973, the industrial sector has accounted for a gradually shrinking portion of total energy consumed in the United States, falling from 43 percent to less than one-third in 2005.



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

used per dollar of economic output—the energy intensity of the U.S. economy—has declined on average by 1.9 percent a year. From 10,100 Btus per dollar in 2000, U.S. energy intensity dropped by 11 percent to 9,000 Btus (per 2000 dollar) in 2005. These data reflect a continuing trend driven by advances in energy technology and efficiency, and by the growing importance of service industries and the declining contribution of energy-intensive industries to the GDP. Between 1992 and 2004, the energy-intensive industries' share of total industrial production fell by 1.3 percent a year on average (U.S. DOE/EIA 2006a).

Petroleum remains the largest single source of U.S. energy consumption; in 2005 it accounted for 41 percent of total U.S. energy demand. Other major energy sources consumed include natural gas, at

24 percent; coal, at 23 percent; nuclear, at 8 percent; and renewables, at 6 percent (U.S. DOE/EIA 2006e).

Emissions of CO₂ from energy reflect the changing economic conditions and adoption of more energy-efficient technologies over the period since the 2002 CAR. While CO₂ emissions from fossil fuel combustion tracked economic growth, the intensity of CO₂ emissions from fossil fuel combustion—measured as the ratio of metric tons of CO₂ emitted per \$1,000 of real gross domestic product—declined steadily over the period, from 0.59 in 2000 to 0.54 in 2004, the latest year for which data are available (U.S. DOE/EIA 2006d).

Residential Sector

The residential sector is made up of living quarters for private households. Common uses of energy associated with this sector include space heating—the largest

single source of residential energy consumption—water heating, air conditioning, lighting, refrigeration, cooking, and running a variety of other appliances.⁴ In 2005, energy consumption in this sector, including electricity losses, totaled 21.9 quadrillion Btus, or 22 percent of U.S. consumption. About one-fifth of GHG emissions from burning fossil fuels is attributable to residential buildings.

Between 2000 and 2005, total energy consumption in the residential sector rose 6.6 percent. As more people move to warmer climates, and as plug load from consumer electronics continues to grow, electricity is expected to comprise a growing share of energy consumption in this sector, a trend that is reflected in the consumption data. From 2000 to 2005, electricity consumption, including system losses, increased every year, regardless of weather or economic conditions; in 2005 it accounted for 68 percent of total residential energy consumption⁵ (U.S. DOE/EIA 2006e).

Compared to electricity, demand for petroleum (primarily fuel oil) and natural gas is much more variable and fluctuates seasonally, regionally, and annually based on winter temperatures. Consumption of natural gas during 2000–2005 peaked in 2003, largely because of high demand for natural gas brought on by a relatively cold winter heating season throughout much of the country. Demand also was affected by changes in relative prices between natural gas and its substitutes.

Commercial Sector

Service-providing facilities and equipment of businesses, governments, and private and public organizations, institutional living quarters, and sewage treatment plants are the main components that make up the commercial sector. The most common uses of energy in this sector include space ventilation and air conditioning, water heating, lighting, refrigeration, cooking, and running a wide variety of office and other equipment. A relatively small portion is used for transportation. In

⁴ For data on the energy-consuming characteristics of U.S. households, see Figure 2-8 of the 2002 CAR.

⁵ Total electricity, including retail sales and energy losses.

2005, total energy in the commercial sector was 4.4 percent higher than in 2000. At nearly 18 quadrillion Btus, it represented 18 percent of total U.S. energy demand and approximately 18 percent of GHG emissions from fossil fuel consumption.

Electricity, including system losses,⁶ supplies a little over three-quarters of energy used by the sector, and natural gas, about 18 percent. Demand for these fuels responded largely to a combination of prices and weather, although normally the impact of weather is less marked than in the residential sector. Demand for electricity increased every year except 2003. In 2005, electricity retail sales were about 9.1 percent higher than in 2000, while natural gas demand, which is more variable, fluctuated over the period (U.S. DOE/EIA 2006e).

Industrial Sector

The industrial sector consists of all facilities and equipment used for producing, processing, or assembling goods, including manufacturing, mining, agriculture, and construction. Since 1973, the industrial sector has accounted for a gradually shrinking portion of total energy consumed in the United States, falling from 43 percent to about one-third in 2005. Fossil fuel-related CO₂ emissions from the industrial sector also have fallen by about 33 percent since 1990, and account for about 28 percent of total U.S. CO₂ emissions.

Overall energy use in the industrial sector is largely for process heating and cooling and powering machinery, with lesser amounts used for facility heating, air conditioning, and lighting. Fossil fuels are also used as raw material inputs to manufactured products. 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.

Electricity use, including system losses, represents a little more than one-third of all energy consumed in the industrial sector, while petroleum and natural gas account for 30 percent and 25 percent, respectively.

Since the 2002 CAR, economic conditions and high energy costs affected industrial and manufacturing outputs, which were declining or flat until 2004, when both increased significantly. Nevertheless, compared to 2000, energy demand in this sector was 7.6 percent lower in 2005. At 7.9 quadrillion Btus in 2005, natural gas demand was at its lowest level in this sector since 1988. Coal and electricity consumption also has not returned to 2000 levels, but by 2005 petroleum consumption was 5.7 percent higher than in 2000 (U.S. DOE/EIA 2006e).

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.⁷ Total energy demand in this sector accounts for nearly 28 percent of total U.S. energy demand and approximately one-third of GHG emissions from fossil fuels.

In 2005, petroleum supplied 98 percent of the energy used in the transportation sector. Transportation is responsible for about two-thirds of all the petroleum used, and personal transportation accounts for 60 percent of this consumption.

Slower economic growth and the terrorist attacks of September 11, 2001, were the major factors affecting energy demand in this sector since the 2002 CAR. Overall, transportation-related energy demand dropped 1.6 percent between 2000 and 2001, which was confined largely to aviation jet fuel (especially in the two years after the September 11 attacks) and resid-

ual fuel oil (e.g., bunker fuels). However, demand rose in each subsequent year, reaching a historic high of 28 quadrillion Btus in 2005, which was 5 percent above the 2000 level (U.S. DOE/EIA 2006e). The basic factors affecting energy demand in this sector that were identified in the 2002 CAR—increasingly decentralized land-use patterns, population growth, and economic expansion—continue to drive much of the increase in the sector's energy consumption.

Concerns about methyl tertiary butyl ether (MTBE) contamination of groundwater from leaking storage tanks have led several states to institute bans on MTBE. As a result, ethanol use has grown significantly as a transportation fuel over the past few years, jumping from 139 trillion Btus in 2000 to 340 trillion Btus in 2005 (U.S. DOE/EIA 2006c). As CO₂ emissions from ethanol consumption are not net additions to the atmosphere (as long as no new land is put into production), this trend has tended to mitigate the growth of transportation-related emissions.

Federal Government

The U.S. government remains the Nation's largest single user of energy. Under the Federal Energy Management Program, federal agencies have invested in energy efficiency over the past two decades. The U.S. government's total primary energy consumption—including energy consumed to produce, process, and transport energy—was 1.65 quadrillion Btus during fiscal year 2004, about 1.7 percent of total U.S. energy consumption.⁸ Combined, federal agencies reported a 22 percent decrease in total primary energy consumption, compared to consumption during fiscal year 1990 (U.S. DOE 2006a).

Executive Order 13123 establishes a number of goals that go beyond what is required under the National Energy Conservation Act. These include goals related to improved energy efficiency and GHG reduction in federal buildings, renewable

⁶ Electrical system energy loss is the amount of energy lost during generation, transmission, and distribution of electricity.

⁷ Transportation does not include such vehicles as construction cranes, bulldozers, farming vehicles, warehouse tractors, and forklifts, whose primary purpose is not transportation.

⁸ Just over 1.1 quadrillion Btus for site-delivered energy consumption.

energy, reduction of petroleum use, reduction of primary energy use, and water conservation.

The GHG reduction goal for federal government facilities—which includes standard buildings and industrial, laboratory, and other energy-intensive facilities—was set at 30 percent below 1990 levels by 2010. Recent data show emissions from these facilities have decreased by 19.4 percent since fiscal year 1990, from 54.7 teragrams of CO₂ equivalent (Tg CO₂ Eq.) in fiscal year 1990 to 44.1 Tg CO₂ Eq. in fiscal year 2004 (U.S. DOE 2006b).

TRANSPORTATION

The U.S. transportation system has evolved to meet the needs of a highly mobile, dispersed population and a large, dynamic economy. Over the years, the United States has developed an extensive multimodal system that includes waterborne, highway, mass transit, air, rail, and pipeline transport capable of moving large volumes of people and goods long distances. For-hire transport services account for 2.8 percent of GDP (U.S. DOC/BEA 2006b).

Economic circumstances, increased oil prices, and the terrorist attacks of September 11, 2001, interrupted some of the long-term trends noted in the 2002 CAR. Automobiles and light trucks still dominate the passenger transportation system, and the highway share of passenger kilometers traveled in 2003 was about 90 percent of the total, relatively unchanged from the 2002 CAR. Air travel accounted for a little less than 10 percent, and mass transit and rail travel combined accounted for only about 1 percent of passenger kilometers traveled. The following sections focus on changes in transportation since the 2002 CAR.

Highway Vehicles

The trends in highway vehicles described in the 2002 CAR have not changed appreciably. Vehicle ownership continues to increase. Between 1997 and 2004, the number of passenger vehicles rose nearly 15 percent to 243.0 million, about 1.2

vehicles for every licensed driver. This high degree of vehicle ownership, which reflects a strong desire for personal mobility, affects and is affected by population distribution, land-use patterns, location of work and shopping, energy use, and GHG emissions. It also contributes to decreased use of carpooling and public transport.

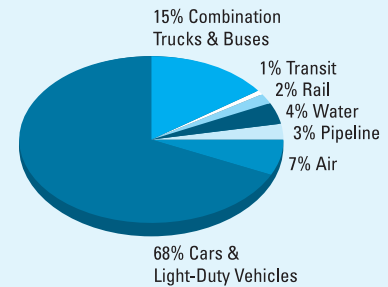
Passenger cars account for more than half of highway vehicles and over one-third of all the energy consumed in the transportation sector (Figure 2-4). However, between 1997 and 2004, the number of registered light trucks, sport utility vehicles, and vans increased by a combined 31 percent. In 2004, they made up nearly 38 percent of the highway vehicle fleet and used almost 28 percent of all the energy in the transportation sector. Though these types of vehicles are generally less energy efficient, consumers often choose them on the basis of other concerns, such as safety, affordability, capacity, and aesthetics. More recent data suggest that sales of light trucks as a percent of total vehicle sales have declined.

The number of miles driven is another major factor affecting energy use in the highway sector. From 1997 to 2003, the average number of kilometers driven per vehicle each year increased by 1 percent, and the total number of vehicle kilometers traveled increased by 16 percent.

Despite the large increase in the total number of vehicle kilometers traveled, associated increases in energy consumption have been more moderate, due to enhanced fuel efficiencies driven in part by the corporate average fuel economy (CAFE) standards for cars (11.7 kilometers per liter (kpl), or 27.5 miles per gallon (mpg)) and light trucks (8.8 kpl, or 20.7 mpg). In 2004, new passenger cars entering the U.S. fleet averaged 12.4 kpl (29.3 mpg), and new trucks averaged 9.1 kpl (21.5 mpg), compared to 12.2 and 8.8 kpl (28.7 and 20.7 mpg), respectively, in 1997. However, the growing portion of less fuel-efficient light trucks in the vehicle fleet has offset these efficiency gains somewhat. In 2006, fuel economy standards were raised

FIGURE 2-4 Share of Transportation Energy Consumption by Mode: 2003

In 2003, cars and light-duty vehicles accounted for just over two-thirds of the energy consumed in the transportation sector.



Source: U.S. DOT 2006.

for model years 2008–11, using an innovative vehicle, size-based approach, reaching 10.2 kpl (24.0 mpg) for model year 2011. This reform is expected to save 40.5 billion liters (10.7 billion gallons) of fuel.

Air Carriers

The terrorist attacks of September 11, 2001, the slowdown in economic activity in 2001, and industry restructuring had a significant impact on the airline industry since the 2002 CAR. In 2001, U.S. domestic passenger kilometers dropped sharply by 5.7 percent from the previous year, and dipped another 0.9 percent in 2002. However, a recovering economy helped push domestic airline passenger distance traveled to 896 billion kilometers (558 billion miles) in 2003, 8.1 percent above the 2000 level.

Increased competitive pressures and the higher cost of aviation fuel were among the factors contributing to a 19 percent improvement in the energy efficiency of domestic industry operations between 1997 and 2004, based on energy used per passenger kilometer.

Freight

From 1997 to 2003 (the latest year for which data for all modes are available), U.S. freight transportation grew by 5.3 percent to 6.36 trillion metric ton kilometers (4.36

trillion ton miles). The predominant mode of freight transportation was rail (37 percent), followed by trucks (29 percent), pipelines (20 percent), waterways (14 percent), and air (less than 1 percent).

Revenue per metric ton kilometer for railroads grew by nearly 15 percent between 1997 and 2003. While the number of railroad cars in use also rose, it did so at a much slower pace (less than 1 percent). With comparatively fewer cars being called on to carry more freight greater distances, the energy intensity of Class 1 railroad freight services, measured as Btus per metric ton kilometer of freight, improved by 7 percent.

Freight trucks are the second largest consumers of energy in the transport sector, behind a category of vehicles comprising passenger cars and light-duty vehicles. Between 1997 and 2003, their share of energy use rose from 11 to 14 percent. The total amount of energy consumed by freight trucks increased by about one-third over the period. The number of registered combination trucks increased by about 12 percent, and the number of metric ton kilometers of freight increased by 13 percent.

Metric ton kilometers shipped by air grew steadily from 1997 to 2000, before dropping sharply (16 percent) in 2001. While air freight recovered over the next two years, its 2003 level was still below its 2000 peak. The metric ton kilometers shipped by domestic water transport declined from 1997 to 2003, a continuation of a long-term trend. Water transport metric ton kilometers fell by 14 percent over the period, led largely by declines in coastwise and lakewise shipping (U.S. DOT 2006a).

INDUSTRY

The U.S. industrial sector boasts a wide array of light and heavy industries in manufacturing and nonmanufacturing subsec-

tors, the latter of which include mining, agriculture, and construction. Together, the value added of manufacturing and nonmanufacturing activities accounts for about 20 percent of total GDP, with utilities adding another 2 percent.

Relative to the economy as a whole, the industrial sector overall has shown slower output growth in recent decades, and imports have met a growing share of demand for industrial goods. From 1990 to 2005, the value added by manufacturing fell from 16.3 percent to 12.1 percent of total GDP, with declines in both durable and nondurable goods.⁹ The shares attributed to agriculture and utilities also fell.

In contrast, mining rose from 1.5 percent to 1.9 percent of GDP, owing to a recovery in oil and gas extraction that began around 2000. After falling in the early 1990s, construction's share also rose, boosted by rapid growth in the housing sector (U.S. DOC/BEA 2006b).

The energy intensity of the industrial sector has improved appreciably. Delivered energy consumption is roughly the same today as it was in 1980, despite a more than doubling of GDP and a 50 percent increase in the value of shipments. Within the industrial sector, manufacturing activities are more energy-intensive than nonmanufacturing activities, using about 50 percent more energy per dollar of output. Since the mid-1980s, energy intensity declined more rapidly for nonmanufacturing than for manufacturing industries, primarily because most of the historical reduction in energy intensity in manufacturing had already occurred in response to the high energy prices of the late 1970s and early 1980s. Much of the decline in energy intensity in nonmanufacturing activities resulted from a compositional shift, with the relatively low-intensity construction industry growing more rapidly than the relatively high-intensity mining sector,

particularly in the late 1990s and early 2000s (U.S. DOE/EIA 2006a).

WASTE

The 2002 CAR reported waste data through 1999. This section updates these data to 2004, the most recent reporting year available. In 2004, the United States generated approximately 247 million metric tons (272 million tons) of municipal solid waste (MSW), about 17 million metric tons (nearly 19 million tons) more than in 1999. Paper and paperboard products made up the largest component of MSW generated by weight (35 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 12 percent of the total MSW generated. Rubber, leather, and textiles combined made up about 7 percent of the MSW, while other miscellaneous wastes comprised approximately 3 percent of the MSW generated in 2004. These shares have not changed appreciably since the 2002 CAR.

Recycling has resulted in a change in waste management from a GHG perspective (U.S. EPA 2006b). From 1990 to 2004, the recycling rate increased from just over 16 percent to about 32 percent. Of the remaining MSW generated, about 14 percent is combusted and 55 percent is 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 1,654 in 2004, while the average landfill size has increased.

Landfills are the largest U.S. source of anthropogenic methane emissions, accounting for 25 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 2006c).

⁹ Durable goods include wood products; nonmetallic mineral products; primary metals; fabricated metal products; machinery; computer and electronic products; electrical equipment, appliances, and components; motor vehicles, bodies and trailers, and parts; other transportation equipment; furniture and related products; and miscellaneous manufacturing. Nondurable goods include food and beverage and tobacco products; textile mills and textile product mills; apparel and leather and allied products; paper products; printing and related support activities; petroleum and coal products; chemical products; and plastics and rubber products.

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. About 37 percent of total U.S. energy consumption and about 70 percent of total electricity consumption are in buildings.

Residential Buildings

The economic slowdown had little effect on the housing market, which has remained relatively strong since the 2002 CAR. 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.

Most of the recent growth in housing has occurred in the U.S. South and West. Combined, between 1997 and 2003 these two regions added nearly three times as many homes to the U.S. building stock as the Northeast and Midwest. The sustained growth in new housing in the Sunbelt, where almost all new homes have air conditioning, and the increasing market penetration of consumer electronics will continue to fuel the demand for residential electricity.

The desire for larger lots and more affordable housing has helped drive the decentralizing trend observed in metropolitan areas, and has created greater demand for more and larger homes. Between 1997 and 2003, the share of housing units of four or fewer rooms fell, while the shares of units with five to seven rooms and with eight to ten or more rooms rose (U.S. DOC/Census 1999, 2004).

While new homes are larger and more plentiful, their energy efficiency has increased greatly. 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 2006a). New homes are on av-

erage 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 2005b).

Commercial Buildings

Between 2000 and 2003, commercial floor space rose an estimated 1.8 percent a 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 floor space. 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 floor space (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 2006a).

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. In 2002, U.S. cropland was 137.6 million hectares (ha) (399.9 million acres (ac)), about 2.6 percent lower than in 1997 (Lubowski et al. 2006).

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 16 million ha (39.5 million ac) of land is 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 residue burning and methane from rice cultivation and residue burning. Nitrous oxide related to fertilizer use is by far the largest source, representing more than 97 percent of emissions from croplands (U.S. EPA/OAP 2006c).

Grasslands account for slightly more than one-third of the major U.S. land uses. Pasture and range ecosystems can include a variety of different flora and fauna communities, and are generally managed by varying grazing pressure, by using fire to shift species abundance, and by occasionally disturbing the soil surface to improve water infiltration. In 2002, grasslands totaled about 316 million ha (780.5 million ac), about the same as in 1997. Since 1949, grassland acreage has declined by about 8 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. 2006).

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 2002, forests covered about one-third of the total area. Historically,

most of the forest land loss was due to agricultural conversions, but today most losses are due to such intensive uses as urban development.

Of the 303 million ha (748.4 million ac) of U.S. forest land, nearly 204 million ha (503.9 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 2002 accounted for about one-third of forest land, about 99 million ha (244.5 million ac) (Lubowski et al. 2006).

Since the 1950s, timber growth for both softwoods and hardwoods in the United States has consistently exceeded harvests. In 2001, net growth exceeded removals by 33

percent (i.e., U.S. forest inventory accrued more volume than it lost by mortality and harvest by nearly one-third). Recent declines in harvesting on public lands in the West have significantly deviated from historic growth and removal patterns, and have placed more pressure on eastern forests that are predominantly in private ownership (Smith et al. 2004).

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 CO₂ every year since 1990 (U.S. EPA/OAP 2006c).