# Carbon Dioxide Emissions from the Generation of Electric Power in the United States

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## Introduction

The President issued a directive on April 15, 1999, requiring an annual report summarizing the carbon dioxide ($CO_2$) emissions produced by the generation of electricity by utilities and nonutilities in the United States. In response, the U.S. Department of Energy (DOE) and the U.S. Environmental Protection Agency (EPA) jointly submitted the first report on October 15, 1999. This is the second annual report[1] that estimates the $CO_2$ emissions attributable to the generation of electricity in the United States. The data on $CO_2$ emissions and the generation of electricity were collected and prepared by the Energy Information Administration (EIA), and the report was jointly written by DOE and EPA to address the five areas outlined in the Presidential Directive.

- The emissions of $CO_2$ are presented on the basis of total mass (tons) and output rate (pounds per kilowatthour). The information is stratified by the type of fuel used for electricity generation and presented for both regional and national levels. The percentage of electricity generation produced by each fuel type or energy resource is indicated.

- The 1999 data on $CO_2$ emissions and generation by fuel type are compared to the same data for the previous year, 1998. Factors contributing to regional and national level changes in the amount and average output rate of $CO_2$ are identified and discussed.

- The Energy Information Administration's most recent projections of $CO_2$ emissions and generation by fuel type for 1999 are compared to the actual data summarized in this report to identify deviations between projected and actual $CO_2$ emissions and electricity generation.

- Information for 1998 on voluntary carbon-reducing and carbon-sequestration projects reported by the electric power sector and the resulting amount of $CO_2$ reductions are presented. Included are programs undertaken by the utilities themselves as well as programs supported by the Federal government to support voluntary $CO_2$ reductions.

- Appropriate updates to the Department of Energy's estimated environmental effects of the Administration's proposed restructuring legislation are included.

## Electric Power Industry $CO_2$ Emissions and Generation Share by Fuel Type

In 1999,[2] estimated emissions of $CO_2$ in the United States resulting from the generation of electric power were 2,245 million metric tons,[3] an increase of 1.4 percent from the 2,215 million metric tons in 1998. The estimated generation of electricity from all sources increased by 2.0 percent, going from 3,617 billion kilowatthours to 3,691 billion kilowatthours. Electricity generation from coal-fired plants, the primary source of $CO_2$ emissions from electricity generation, was nearly the same in 1999 as in 1998. Much of the increase in electricity generation was produced by gas-fired plants and nuclear plants. The 1999 national average output rate,[4] 1.341 pounds of $CO_2$ per kilowatthour generated, also showed a slight change from 1.350 pounds $CO_2$ per kilowatthour in 1998 (Table 1). While the share of total generation provided by fossil

[1] The Presidential directive required the first report by October 15, 1999, and thereafter the report is required by June 30. See Appendix A for the full text of the directive.

[2] Data for 1999 are preliminary. Data for 1998 are final. Last year, 1998 data were preliminary and have been revised to final numbers.

[3] To convert metric tons to short tons, multiply by 1.1023. Carbon dioxide units at full molecular weight can be converted into carbon units by dividing by 44/12.

[4] The average output rate is the ratio of pounds of carbon dioxide emitted per kilowatthour of electricity produced from all energy sources, both fossil and nonfossil, for a region or the Nation.

fuels rose slightly, a reduction in the emission rate for coal-fired generation combined with growth in the market share of gas-fired generation contributed to the modest improvement in the output rate.[5]

In the United States, about 40.5 percent[6] of anthropogenic $CO_2$ emissions was attributed to the combustion of fossil fuels for the generation of electricity in 1998, the latest year for which all data are available.[7] The available

**Table 1. Summary of Carbon Dioxide Emissions and Net Generation in the United States, 1998 and 1999**

| | 1998 | 1999 [p] | Change | Percent Change |
|---|---|---|---|---|
| **Carbon Dioxide** (thousand metric tons)[a] | | | | |
| Coal | 1,799,762 | 1,787,910 | -11,852 | -0.66 |
| Petroleum | 110,244 | 106,294 | -3,950 | -3.58 |
| Gas | 291,236 | 337,004 | 45,768 | 15.72 |
| Other Fuels [b] | 13,596 | 13,596 | – | – |
| **U.S. Total** | **2,214,837** | **2,244,804** | **29,967** | **1.35** |
| **Generation** (million kWh) | | | | |
| Coal | 1,873,908 | 1,881,571 | 7,663 | 0.41 |
| Petroleum | 126,900 | 119,025 | -7,875 | -6.21 |
| Gas | 488,712 | 562,433 | 73,721 | 15.08 |
| Other Fuels [b] | 21,747 | 21,749 | 2 | – |
| **Total Fossil-fueled** | **2,511,267** | **2,584,779** | **73,512** | **2.93** |
| **Nonfossil-fueled** [c] | **1,105,947** | **1,106,294** | **347** | **0.03** |
| **U.S. Total** | **3,617,214** | **3,691,073** | **73,509** | **2.04** |
| **Output Rate** [d] (pounds $CO_2$ per kWh) | | | | |
| Coal | 2.117 | 2.095 | -0.022 | -1.04 |
| Petroleum | 1.915 | 1.969 | 0.054 | 2.82 |
| Gas | 1.314 | 1.321 | 0.007 | 0.53 |
| Other Fuels [b] | 1.378 | 1.378 | – | – |
| **U.S. Average** | **1.350** | **1.341** | **-0.009** | **-0.67** |

[a] One metric ton equals one short ton divided by 1.1023. To convert carbon dioxide to carbon units, divide by 44/12.

[b] Other fuels include municipal solid waste, tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity. Nonutility data for 1999 for these fuels are unavailable; 1998 data are used.

[c] Nonfossil includes nuclear, hydroelectric, solar, wind, geothermal, biomass, and other fuels or energy sources with zero or net zero $CO_2$ emissions. Although geothermal contributes a small amount of $CO_2$ emissions, in this report it is included in nonfossil.

[d] U.S. average output rate is based on generation from all energy sources.

[P] = Preliminary data.

– = No change.

Note: Data for 1999 are preliminary. Data for 1998 are final.

Sources: • Energy Information Administration, Form EIA-759, “Monthly Power Plant Report”; Form EIA-767, “Steam-Electric Plant Operation and Design Report”; Form EIA-860B, “Annual Electric Generator Report – Nonutility”; and Form 900, “Monthly Nonutility Power Report.” • Federal Energy Regulatory Commission, FERC Form 423, “Monthly Report of Cost and Quality of Fuels for Electric Plants.”

[5] Caution should be taken when interpreting year-to-year changes in the estimated emissions and generation due to an undetermined degree of uncertainty in statistical data for the 1999 estimates. Also, differences in the 1998 and 1999 estimation methodologies have an undetermined effect on the change from 1998 to 1999 estimates. See Appendix B, “Data Sources and Methodology,” for further information. For more information on uncertainty in estimating carbon dioxide emissions, see Appendix C, “Uncertainty in Emissions Estimates,” *Emissions of Greenhouse Gases in the United States*, DOE/EIA-0573(98) (Washington, DC, October 1999). Also, because weather fluctuations and other transitory factors significantly influence short-run patterns of energy use in all activities, emissions growth rates calculated over a single year should not be used to make projections of future emissions growth.

[6] About 37 percent of $CO_2$ emissions are produced by electric utility generators, as reported in the greenhouse gas inventory for 1998. An additional 3.5 percent are attributable to nonutility power producers, which are included in the industrial sector in the GHG inventory.

[7] Energy Information Administration, *Emissions of Greenhouse Gases in the United States 1998*, Chapter 2, “Carbon Dioxide Emissions,” DOE/EIA-0573(98) (Washington, DC, October 1999). Data for 1999 will be available in October 2000.

energy sources used for electricity generation result in varying output rates for $CO_2$ emissions from region to region across the United States. Although all regions use some fossil fuels for electricity generation, several States generate almost all electricity at nuclear or hydroelectric plants, resulting in correspondingly low output rates of $CO_2$ per kilowatthour. For example, Vermont produces mostly nuclear power, while Washington, Idaho, and Oregon generate almost all electricity at hydroelectric plants. At the other extreme, Colorado, Indiana, Iowa, Kentucky, New Mexico, North Dakota, Ohio, West Virginia, and Wyoming—a group that includes some of the Nation's largest coal-producing States—generate most of their electricity with coal. Regions where coal-fired generators dominate the industry show the highest rates of $CO_2$ emissions per kilowatthour.

## Coal

Estimated emissions of $CO_2$ produced by coal-fired generation of electricity were 1,788 million metric tons in 1999 (Table 1), 0.7 percent less than in 1998, while electricity generation from coal was 0.4 percent more than the previous year. The divergent direction of generation and emissions changes may reflect a combination of thermal efficiency improvements, changes in average fuel characteristics, and variances associated with both sampling and nonsampling errors. $CO_2$ emissions from coal-fired electricity generation comprise nearly 80 percent of the total $CO_2$ emissions produced by the generation of electricity in the United States, while the share of electricity generation from coal was 51.0 percent in 1999 (Table 3). Coal has the highest carbon intensity among fossil fuels, resulting in coal-fired plants having the highest output rate of $CO_2$ per kilowatthour. The national average output rate for coal-fired electricity generation was 2.095 pounds $CO_2$ per kilowatthour in 1999 (Table 4).

Coal-fired generation contributes over 90 percent of $CO_2$ emissions in the East North Central, West North Central, East South Central, and Mountain Census Divisions and 84 percent in the South Atlantic Census Division (Table 2). Nearly two-thirds of the Nation's $CO_2$ emissions from electricity generation are accounted for by the combustion of coal for electricity generation in these five regions where most of the Nation's coal-producing States are located. Consequently, these regions have relatively high output rates of $CO_2$ per kilowatthour.

**Table 2. Estimated Carbon Dioxide Emissions From Generating Units at U.S. Electric Plants by Census Division, 1998 and 1999**
(Thousand Metric Tons)

| Census Division | 1998 | | | | | 1999 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Coal | Petroleum | Gas | Other[a] | Total | Coal | Petroleum | Gas | Other[a] |
| New England | 50,450 | 16,470 | 23,068 | 7,966 | 2,945 | 52,822 | 14,637 | 24,224 | 11,015 | 2,945 |
| Middle Atlantic | 189,023 | 139,821 | 17,315 | 28,441 | 3,447 | 190,214 | 134,528 | 15,232 | 37,007 | 3,447 |
| East North Central | 427,580 | 410,141 | 4,351 | 12,039 | 1,049 | 423,063 | 397,266 | 5,415 | 19,333 | 1,049 |
| West North Central | 217,123 | 209,858 | 1,521 | 4,726 | 1,018 | 219,104 | 208,786 | 1,957 | 7,342 | 1,018 |
| South Atlantic | 445,435 | 373,780 | 43,777 | 24,515 | 3,363 | 452,180 | 378,018 | 41,356 | 29,442 | 3,363 |
| East South Central | 226,749 | 212,350 | 5,018 | 9,299 | 82 | 228,240 | 214,486 | 3,212 | 10,460 | 82 |
| West South Central | 364,056 | 214,544 | 5,461 | 143,945 | 106 | 380,792 | 221,309 | 5,744 | 153,634 | 106 |
| Mountain | 219,147 | 206,256 | 888 | 12,002 | * | 217,543 | 202,421 | 1,278 | 13,843 | * |
| Pacific Contiguous | 64,668 | 14,555 | 2,588 | 46,165 | 1,360 | 70,591 | 14,563 | 2,153 | 52,515 | 1,360 |
| Pacific Noncontiguous | 10,606 | 1,985 | 6,257 | 2,138 | 225 | 10,256 | 1,895 | 5,724 | 2,413 | 225 |
| **U.S. Total** | **2,214,837** | **1,799,762** | **110,244** | **291,236** | **13,596** | **2,244,804** | **1,787,910** | **106,294** | **337,004** | **13,596** |

[a] Other fuels include municipal solid waste, tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity. Nonutility data for 1999 for these fuels are unavailable; 1998 data are used.

* = the absolute value is less than 0.5.

Note: Data for 1999 are preliminary. Data for 1998 are final.

Sources: • Energy Information Administration, Form EIA-759, "Monthly Power Plant Report"; Form EIA-767, "Steam-Electric Plant Operation and Design Report"; Form EIA-860B, "Annual Electric Generator Report – Nonutility"; Form EIA-900, "Monthly Nonutility Power Report." • Federal Energy Regulatory Commission, FERC Form 423, "Monthly Report of Cost and Quality of Fuels for Electric Plants."

**Table 3. Percent of Electricity Generated at U.S. Electric Plants by Fuel Type and Census Division, 1998 and 1999**
(Percent)

| Census Division | 1998 | | | | | 1999 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Coal | Petroleum | Gas | Other[a] | Nonfossil | Coal | Petroleum | Gas | Other[a] | Nonfossil |
| New England | 17.9 | 24.4 | 13.8 | 4.6 | 39.3 | 16.3 | 22.9 | 18.0 | 4.6 | 38.3 |
| Middle Atlantic | 38.4 | 5.2 | 13.6 | 1.3 | 41.5 | 35.8 | 4.5 | 17.5 | 1.3 | 40.9 |
| East North Central | 76.3 | 0.8 | 3.8 | 0.4 | 18.8 | 72.0 | 0.7 | 4.4 | 0.4 | 22.5 |
| West North Central | 75.5 | 0.7 | 2.3 | 0.3 | 21.1 | 73.9 | 0.7 | 3.0 | 0.3 | 22.0 |
| South Atlantic | 55.3 | 7.2 | 6.6 | 0.7 | 30.2 | 55.5 | 6.7 | 7.8 | 0.7 | 29.2 |
| East South Central | 66.2 | 2.1 | 3.2 | * | 28.4 | 68.0 | 1.4 | 3.9 | * | 26.7 |
| West South Central | 39.1 | 0.6 | 42.2 | 0.3 | 17.8 | 40.1 | 0.7 | 44.6 | 0.3 | 14.3 |
| Mountain | 67.9 | 0.2 | 6.8 | 0.1 | 25.0 | 67.5 | 0.3 | 8.1 | 0.1 | 24.1 |
| Pacific Contiguous | 4.3 | 0.7 | 23.1 | 0.4 | 71.4 | 4.2 | 0.5 | 26.2 | 0.4 | 68.7 |
| Pacific Noncontiguous | 12.2 | 52.3 | 21.3 | 1.9 | 12.4 | 11.7 | 52.2 | 24.8 | 1.9 | 9.4 |
| **U.S. Total** | **51.8** | **3.5** | **13.5** | **0.6** | **30.6** | **51.0** | **3.2** | **15.2** | **0.6** | **30.0** |

[a] Other fuels include municipal solid waste, tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity. Nonutility data for 1999 for these fuels are unavailable; 1998 data are used.

* = the absolute value is less than 0.05.

Note: Data for 1999 are preliminary. Data for 1998 are final.

Sources: • Energy Information Administration, Form EIA-759, “Monthly Power Plant Report”; Form EIA-767, “Steam-Electric Plant Operation and Design Report”; Form EIA-860B, “Annual Electric Generator Report – Nonutility”; Form EIA-900, “Monthly Nonutility Power Report.” • Federal Energy Regulatory Commission, FERC Form 423, “Monthly Report of Cost and Quality of Fuels for Electric Plants.”

**Table 4. Estimated Carbon Dioxide Emissions Rate From Generating Units at U.S. Electric Plants by Census Division, 1998 and 1999**
(Pounds per Kilowatthour)

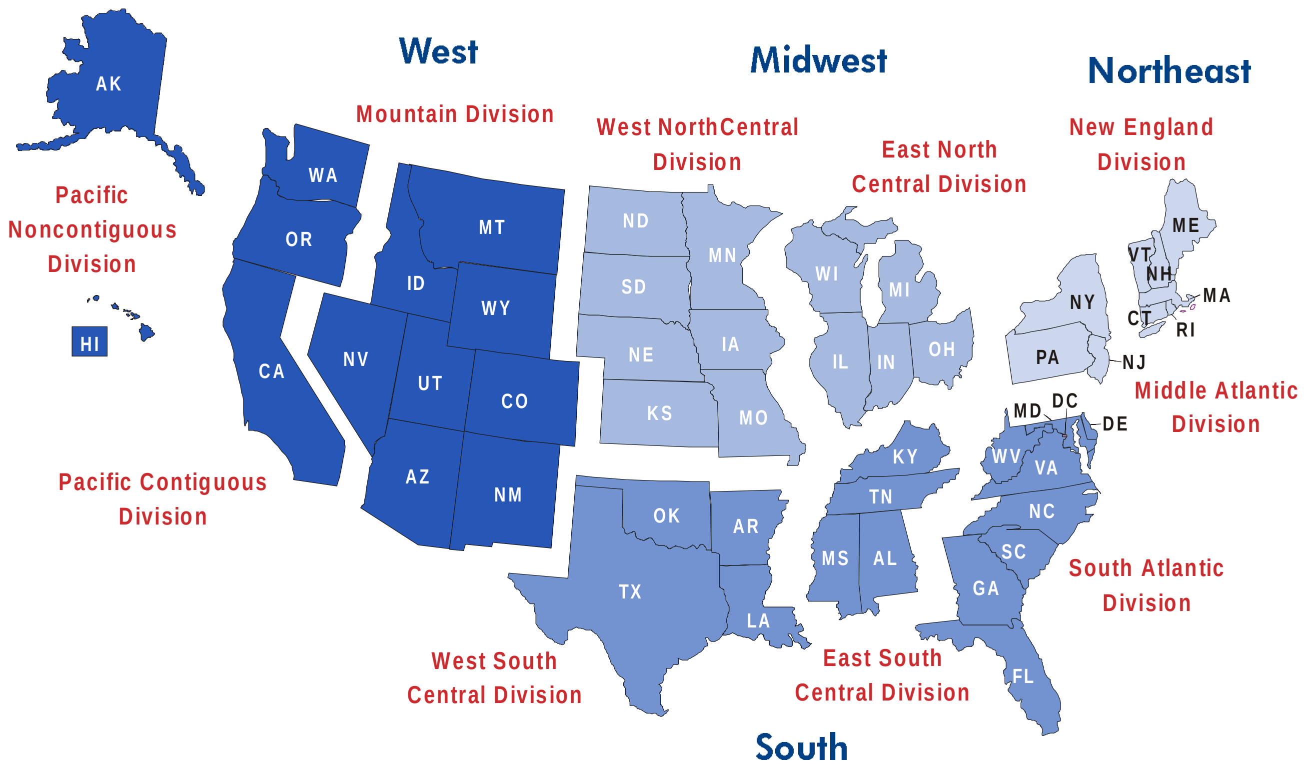
| Census Division | 1998 | | | | | 1999 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total | Coal | Petroleum | Gas | Other[a] | Total | Coal | Petroleum | Gas | Other[a] |
| New England | 1.059 | 1.934 | 1.984 | 1.213 | 1.339 | 1.077 | 1.827 | 2.156 | 1.250 | 1.328 |
| Middle Atlantic | 1.071 | 2.062 | 1.884 | 1.188 | 1.502 | 1.058 | 2.089 | 1.872 | 1.178 | 1.502 |
| East North Central | 1.680 | 2.113 | 2.244 | 1.239 | 1.124 | 1.579 | 2.061 | 2.759 | 1.630 | 1.131 |
| West North Central | 1.767 | 2.262 | 1.759 | 1.659 | 2.422 | 1.746 | 2.250 | 2.207 | 1.958 | 2.596 |
| South Atlantic | 1.334 | 2.026 | 1.821 | 1.113 | 1.377 | 1.342 | 2.019 | 1.822 | 1.115 | 1.372 |
| East South Central | 1.457 | 2.060 | 1.515 | 1.857 | 3.244 | 1.470 | 2.031 | 1.530 | 1.734 | 3.244 |
| West South Central | 1.469 | 2.214 | 3.955 | 1.376 | 0.151 | 1.529 | 2.215 | 3.170 | 1.382 | 0.151 |
| Mountain | 1.572 | 2.179 | 2.802 | 1.257 | 0.005 | 1.542 | 2.128 | 3.036 | 1.214 | 0.005 |
| Pacific Contiguous | 0.417 | 2.158 | 2.396 | 1.287 | 2.140 | 0.435 | 2.152 | 2.419 | 1.238 | 2.108 |
| Pacific Noncontiguous | 1.453 | 2.229 | 1.641 | 1.375 | 1.661 | 1.393 | 2.209 | 1.488 | 1.319 | 1.661 |
| **U.S. Average** | **1.350** | **2.117** | **1.915** | **1.314** | **1.378** | **1.341** | **2.095** | **1.969** | **1.321** | **1.378** |

[a] Other fuels include municipal solid waste, tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity. Nonutility data for 1999 for these fuels are unavailable; 1998 data are used.

Note: Data for 1999 are preliminary. Data for 1998 are final.

Sources: • Energy Information Administration, Form EIA-759, “Monthly Power Plant Report”; Form EIA-767, “Steam-Electric Plant Operation and Design Report”; Form EIA-860B, “Annual Electric Generator Report – Nonutility”; Form EIA-900, “Monthly Nonutility Power Report.” • Federal Energy Regulatory Commission, FERC Form 423, “Monthly Report of Cost and Quality of Fuels for Electric Plants.”

**Figure 1. Census Regions and Divisions**




Note: Map not to scale.

Source: Adapted from U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1998* (Washington, DC, October 1998), Figure 1.

### Petroleum

$CO_2$ emissions from petroleum-fired electricity generation were 106 million metric tons in 1999, 3.6 percent less than in 1998. Generation of electricity from petroleum-fired plants decreased from 127 billion kilowatthours in 1998 to 119 billion kilowatthours in 1999. $CO_2$ emissions from petroleum-fired electricity generation accounted for 4.7 percent of the national total, while generation from petroleum plants was 3.2 percent of the Nation's total electricity generation. The national average output rate for all petroleum-fired generation was 1.969 pounds $CO_2$ per kilowatthour in 1999.

The New England Census Division generates about one-fourth of its electricity at petroleum-fired plants which produce approximately 45 percent of that region's $CO_2$ emissions. The Pacific Noncontiguous Census Division generates about one-half of its electricity at petroleum-fired plants, producing about one-half of the region's $CO_2$ emissions. The South Atlantic and Middle Atlantic Census Divisions also use some petroleum for electricity generation, particularly in Florida. The South Atlantic Census Division contributes the largest share of $CO_2$ emissions from petroleum-fired plants, 1.8 percent of the Nation's total $CO_2$ emissions from all sources.

### Natural Gas

Emissions of $CO_2$ from the generation of electricity at natural gas-fired plants were 337 million metric tons in 1999. Natural gas-fired plants were the only fossil-fueled plants to substantially increase generation from 1998 to 1999. Generation increased an estimated 15.0 percent, with $CO_2$ emissions increasing a corresponding 15.7 percent. Emissions of $CO_2$ from natural gas-fired plants represented 15.0 percent of total $CO_2$ emissions from electricity generation in 1999, while natural gas-fired electricity generation accounted for 15.2 percent of total generation. The output rate for $CO_2$ from natural gas-fired plants in 1999 was 1.321 pounds $CO_2$ per kilowatthour. Natural gas is the least carbon-intensive fossil fuel.

The West South Central Census Division, which includes Texas, Oklahoma, and Louisiana, is where much of the Nation's natural gas-fired capacity is located. The Northeast and Pacific Contiguous Census Divisions also use natural gas to generate a substantial portion of their electricity. About 40.4 percent of the West South Central Division's $CO_2$ emissions from the generation of electricity comes from gas-fired plants, representing approximately 45.6 percent of all $CO_2$ emissions from natural gas combustion for electricity generation in the Nation. About three-fourths of the Pacific Contiguous Census Division's $CO_2$ emissions are from natural gas-fired plants; however, most of that division's electricity generation is produced at nonfossil-fueled plants, such as hydroelectric and nuclear plants.

### Nonfossil Fuels

Nonfossil-fueled generation from nuclear, hydroelectric, and other renewable sources (wind, solar, biomass, and geothermal) represented about 30.0 percent of total electricity generation in 1999 and 30.6 percent in 1998. The use of nonfossil fuels and renewable energy sources to generate electricity avoids the emission of $CO_2$ that results from the combustion of fossil fuels. Due to lower marginal costs, nuclear and hydroelectric power generation typically displace fossil-fueled electricity generation.

Nuclear plants increased their output by 8.1 percent in 1999 as several plants in the East North Census Division returned to service, contributing to a record capacity factor of 86 percent for nuclear plants in 1999.[8] Nuclear energy provided 19.7 percent of the Nation's electricity in 1999.[9] Two-thirds of the Nation's nuclear power is generated in the New England, East North Central, South Atlantic, and Middle Atlantic Census Divisions, which generate 27.6 percent, 21.0 percent, 26.0 percent, and 35.6 percent, respectively, of their electricity with nuclear power.

More than one-half of the Nation's hydroelectric capacity is located in the Pacific Contiguous Census Division, which includes California, Oregon, and Washington. In the Mountain Census Division, Idaho generates virtually all of its electricity at hydroelectric plants. The availability of hydroelectric power is affected by both the amount and patterns of precipitation. High snowpack levels in the Northwest increased hydroelectric generation in Washington and Oregon during 1999, despite the fact that on an annual basis both States received less precipitation in 1999 than they did in 1998. However, the remainder of the Nation experienced dry conditions in 1999, decreasing the amount of hydroelectric power available to displace fossil-fueled generation.[10]

## Factors Contributing to Changes In $CO_2$ Emissions and Generation

The primary factors that alter $CO_2$ emissions from electricity generation from year to year are the growth in demand for electricity, the type of fuels or energy sources used for generation, and the thermal efficiencies of the power plants. A number of contributing factors influencing the primary factors can also be identified: economic growth, the price of electricity, the amount of imported electricity, weather, fuel prices, and the amount of available generation from hydroelectric, renewable, and nuclear plants. Other contributing factors include demand-side management programs that encourage energy efficiency, strategies to control other air emissions to comply with the requirements for the Clean Air Act Amendments of 1990, and the installation of new capacity utilizing advanced technologies to increase plant efficiency, such as combined-cycle plants and combined heat and power projects. Annual changes in $CO_2$ emissions are a net result of these complex and variable factors.

As estimated in this report, the amount of anthropogenic $CO_2$ emissions attributable to the generation of electricity in the United States increased 1.4 percent since the previous year. In 1999, fossil-fueled generation increased by about 2.9 percent; however, almost all of the increase was associated with natural gas, the least carbon-intensive fossil fuel. The increase in $CO_2$ emissions from the combustion of natural gas for electricity generation

[8] Capacity factor is the ratio of the amount of electricity produced by a generating plant for a given period of time to the electricity that the plant could have produced at continuous full-power operation during the same period. Based on national level consumption and generation data presented in the *Electric Power Monthly*, and assuming a net summer nuclear capability of 99,000 MW, a 1-percent increase in the annual nuclear plant capacity factor (equivalent to 8,672,400 megawatthours of additional nuclear generation) translates into a reduction in annual consumption of either 4.4 million short tons of coal, 14 million barrels of petroleum, or 92 billion cubic feet of gas, or most likely a combination of each.

[9] Energy Information Administration, *Electric Power Annual 1999, Volume I*, DOE/EIA-0348(99)/1 (Washington, DC, forthcoming).

[10] Energy Information Administration, *Cost and Quality of Fuels for Electric Utility Plants, 1999*, http://www.eia.doe.gov/cneaf/electricity/cq/cq_sum.html.

amounted to 46 million metric tons, while the $CO_2$ emissions from the combustion of petroleum and coal decreased 16 million metric tons.

The national average output rate declined from 1.350 pounds of $CO_2$ per kilowatthour in 1998 to 1.341 pounds $CO_2$ per kilowatthour in 1999. The primary driver of this change was the decreased output rate for coal-fired electricity generation, which went from 2.117 pounds of $CO_2$ per kilowatthour to 2.095 pounds of $CO_2$ per kilowatthour. A change in the output rate for coal-fired electricity generation in the absence of significant change in non-emitting generation will have the greatest effect on the national average output rate of $CO_2$ per kilowatthour both because coal-fired generation dominates the industry and is the most carbon-intensive fuel.

## Economic Growth

Economic factors influence the demand for electric power. In 1999, a strong economy was measured by the 4.2-percent increase in the Gross Domestic Product (GDP).[11] Electricity consumption grew by 1.7 percent,[12] while the average national price of electricity decreased 2.1 percent, from 6.74 cents in 1998 to 6.60 cents in 1999.[13] Although the growing demand for electricity is primarily met by a corresponding growth in generation, a small amount is met by imported power, primarily from Canada.

## Weather

Weather is another factor affecting the year-to-year changes in the demand for electricity. Both 1999 and 1998 were record-breaking years in terms of warm weather in the United States. The availability of hydroelectric power to displace fossil-fueled power was limited by dry conditions in much of the Nation, with the exception of the Pacific Northwest States.

During the summer months, the demand for power for air conditioning is a major factor in setting record high peak demands for some utilities. In 1999, electricity generating plants consumed almost as much coal as the record amount consumed in 1998 and increased their natural gas consumption to meet the continuing high demand for electricity in the summer of 1999.

## Demand-Side Management (DSM)

Energy efficiency programs and DSM activities, such as improving insulation and replacing lighting and appliances with more energy efficient equipment, can reduce the demand for electricity. The reductions in demand achieved by DSM programs contribute to avoided $CO_2$ emissions. In 1998, 49.2 billion kilowatthours of energy savings were achieved by DSM activities at electric utilities, a decrease from 56.4 billion kilowatthours in 1997. Declining levels of energy savings reflect, in part, lower utility spending on DSM programs. In 1998, utilities' total expenditures on DSM were $1.4 billion, a decrease of 13.1 percent from the previous year, and nearly 50 percent below the 1994 spending level.[14] Data for 1999 are not yet available.

## Fossil and Nonfossil Fuels for Electricity Generation

The fuel or energy source used to generate electricity is the most significant factor affecting the year-to-year changes in $CO_2$ emissions. Because hydroelectric and nuclear generation displace fossil-fueled generation when available, $CO_2$ emissions increase when hydroelectric or nuclear power is unavailable and fossil-fueled generation is used as a replacement. Conversely, $CO_2$ emissions can be reduced through a greater use of nuclear, hydroelectric, and renewable energy for electricity generation. Collectively, nonfossil-fueled electricity generation by nuclear, hydroelectric, and renewable energy sources that do not contribute to anthropogenic $CO_2$ emissions remained almost unchanged in 1999 as compared to 1998, with much of the increase in nuclear generation being offset by an absolute decrease in hydroelectric power generation and other generation from fuels such as municipal solid waste, tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity.

As stated previously, the amount of available hydroelectric power is affected by precipitation patterns. In 1999, hydroelectric power generation was lower in all regions, except in the Northwestern States. Oregon, Idaho, and Washington typically generate more than 90 percent of their power at hydroelectric plants and export power to California. Hydroelectric power generation

[11] http://www.bea.doc.gov/bea/dn1.htm, Department of Commerce web site, accessed May 10, 2000.

[12] Retail sales by utilities grew 1.73 percent from 1998 to 1999. Retail sales by marketers in deregulated, competitive retail markets are not included. The addition of an estimated 48 billion kilowatthours in retail marketer sales would result in an increase in electricity consumption of 2.45 percent from 1998 to 1999.

[13] Energy Information Administration, *Electric Power Annual 1999, Volume I,* DOE/EIA-0348(99)/1 (Washington, DC, forthcoming).

[14] DSM data for 1999 will be available in the latter part of 2000.

increased in 1999 in these States, reducing the need for fossil-fueled generation and contributed to keeping $CO_2$ emissions low in the Pacific Contiguous Census Division. Nationally, hydroelectric power generation decreased by 3.6 percent in 1999.

Nuclear power generation increased by 8.1 percent to a record level in 1999, which contributed to keeping $CO_2$ emissions lower by displacing fossil-fueled generation, particularly in the East North Central Census Division. Several nuclear plants came back online in 1999, helping to increase the average nuclear capacity factor to 86 percent. An absolute increase in the amount of nuclear power more than offset the loss of some hydroelectric power in 1999.

## Fuel Quality and Price

The amount of $CO_2$ emissions from the combustion of fossil fuels to generate electricity varies according to the quality of the fuels, defined by their carbon content and the associated heating value (Btu).[15] The Btu content of fuels is a determinant of the number of kilowatthours that can be produced[16] and carbon content is a determinant of the amount of $CO_2$ released when the fuel is burned. Fossil fuels are categorized as either coal, natural gas and other gaseous fuels, or petroleum and petroleum products. Coal-fired electricity generation has the highest output rate of $CO_2$ per kilowatthour produced, averaging 2.095 pounds per kilowatthour in 1999. Petroleum-fired electricity generation averaged 1.969 pounds per kilowatthour, and natural gas-fired electricity generation had the lowest rate of 1.321 pounds per kilowatthour. With coal-fired plants generating the majority of electricity in the Nation and having the highest output rate, they produced the greatest share of $CO_2$ emissions from electricity generation, approximately 80 percent of the total.

Some plants are capable of switching fuels to take advantage of the least expensive or the most available resources. In 1998, the price of crude oil reached its lowest level since 1976, causing the price of petroleum delivered to electric utilities to fall below that of natural gas for the first time since 1993. This factor is important when considering the capability of some electric plants to burn the least expensive of these two fuels. As a result of falling prices in 1998, petroleum-fired generation was higher in 1998 than in 1997. However during 1999, the price of petroleum began to increase, and generation from petroleum plants declined. Petroleum has a higher output rate of $CO_2$ than natural gas; therefore, switching from petroleum to natural gas can have a beneficial effect on both the overall amount and output rate of $CO_2$ emissions.

In 1999, virtually all of the increase in fossil-fueled generation was from natural gas-fired plants. Coal-fired electricity generation was close to unchanged, while petroleum-fired electricity generation fell. Most of the increase in $CO_2$ emissions from gas-fired plants was offset by the decline in $CO_2$ emissions from petroleum- and coal-fired plants.

## Thermal Efficiencies of Power Plants

$CO_2$ emissions from electric power generation are influenced by the efficiency with which fossil fuels are converted into electricity. In a typical power plant, about one-third of the energy contained in the fuel is converted into electricity, while the remainder is emitted as waste heat. Substantial improvements in generation efficiency can be achieved in the future through the replacement of traditional power generators with more efficient technologies, such as combined-cycle generators and combined heat and power (CHP) systems. In these types of systems, waste heat is captured to produce additional kilowatthours of electricity or displace energy used for heating or cooling. Both strategies result in lower $CO_2$ emissions. The national average thermal efficiency of power generation from fossil fuels in 1999 was estimated to be 32.54 percent, slightly higher than the previous year's average of 32.42 percent.[17]

The average thermal efficiency of coal-fired plants went from 33.15 percent to 33.54 percent in 1999. The improvement in efficiency is also reflected in the national average output rate of pounds of $CO_2$ per kilowatthour. The output rate for coal-fired plants decreased from 2.117 pounds of $CO_2$ per kilowatthour in 1998 to

[15] Heating value is measured in British thermal units (Btu), a standard unit for measuring the quantity of heat energy equal to the quantity of heat required to raise the temperature of 1 pound of water 1 degree Fahrenheit.

[16] Boiler type and efficiency, capacity factor, and other factors also affect the number of kilowatthours that can be produced at a particular plant.

[17] The thermal efficiency is a ratio of kilowatthours of electricity produced multiplied by 3,412 Btu to the fuel consumed, measured in Btu. This ratio is dependent on the estimated generation and fuel consumption for 1999. Uncertainty and an undetermined degree of variation in both generation and fuel consumption data for the nonutility sector may contribute to an apparent change in the ratio, which should be regarded as a preliminary value at this time.

2.095 in 1999. Petroleum-fired plants and natural gas-fired plants showed slightly lower thermal efficiencies in 1999, with a corresponding change in the output rate. The rate for petroleum-fired plants increased from 1.915 to 1.969 pounds of $CO_2$ per kilowatthour, and natural gas-fired plants' output rate increased from 1.314 to 1.321 pounds of $CO_2$ per kilowatthour.

## Conclusion

The emission of $CO_2$ by electric power plants is not controlled because no standards or required reductions currently exist. Some technology is available to limit $CO_2$ emissions, but it is extremely expensive. The options to limit the emission of $CO_2$ from electricity generation are to encourage reduction of the overall consumption of electricity through energy efficiency and conservation initiatives, to improve combustion efficiency at existing plants or install new units that employ more efficient technologies, such as combined-cycle units and combined heat and power (CHP) systems, and to replace fossil-fueled generation with nonfossil-fueled alternatives, such as nuclear, hydroelectric, and other renewable energy sources.

## Comparison of Projected with Actual $CO_2$ Emissions and Generation by Fuel Type

Each year, the Energy Information Administration prepares the *Annual Energy Outlook* (AEO), which contains projections of selected energy information. Projections for electricity supply and demand data, including $CO_2$ emissions and generation by fuel type, are made for the next 20 years. To evaluate the accuracy and usefulness of the forecast, a comparison was made between the latest forecast for 1999 (from the AEO2000) and the estimated actual data for 1999 (Table 5). The near-term projections in the AEO are based on a combination of the partial-year data available when the forecast was prepared, the latest short-term forecast appearing in the *Short-Term Energy Outlook*, and the regional detail contained in the National Energy Modeling System (NEMS). Consequently, comparisons with the actual data for 1999 are not a definitive indicator of the accuracy of the longer-term projections appearing in the AEO. Nevertheless, they do provide a useful preliminary gauge for tracking and measuring the projections against actual data over time.

Total electricity-related $CO_2$ emissions for fossil fuels in 1999 were 1.4 percent below the projected emissions level, while the actual total generation from fossil fuels was 0.9 percent above the projected generation level. The largest percentage difference between projected and actual generation by fuel (other than for "Other") was for natural gas-fired generation, which was 3.7 percent higher than projected, but with a corresponding difference in $CO_2$ emissions of 7.7 percent. However, the largest absolute difference between projected and actual $CO_2$ emissions by fuel was for coal-fired generation, whose emissions were 75 million metric tons, or 4.0 percent, below the projected level, even while generation was 0.2 percent higher. Three primary factors contribute to the divergence in projected and actual $CO_2$ emissions:

- **Efficiency of generating units**. Average generating efficiencies for coal-fired capacity were higher in 1999 than those assumed by NEMS, on the order of about 4 percent. On the other hand, the efficiency of natural gas-fueled capacity was about 4 percent lower than the NEMS assumptions. Because coal-fired units produce more than three times the generation of natural gas-fired generators, the impact of the higher efficiencies of coal-burning capacity outweighs the lower actual efficiencies for natural gas capacity. Efficiencies for petroleum-based generation, a much smaller share of overall supply, were 5.6 percent lower than the NEMS assumptions.

- **Total generation requirements**. Overall electricity generation was 1.6 percent higher in 1999 than projected. This was due to the combined effects of higher sales, lower imports, and higher losses for electricity than expected. The incremental generation requirements were met in part by higher natural gas-fired generation, as well as greater reliance on nonfossil sources of electricity such as nuclear and renewables. To the extent that natural gas-fired generation was above the forecast, higher $CO_2$ emissions resulted.

- **Increased nuclear and hydroelectric generation**. Nuclear generation was 30 billion kilowatthours, or 5.7 percent, above the projected levels in 1999. The difference was due primarily to improving performance of nuclear generating units, beyond that assumed in the projections. Also, hydroelectric generation was 13 billion kilowatthours, or 4.3 percent, above projections. Given the same overall level of generation, higher nuclear and hydroelectric projections would have resulted in less projected

**Table 5. U.S. Electric Power Industry Projected and Actual Carbon Dioxide Emissions and Generation, 1999**

| | Projected | Actual | Percentage Difference |
|---|---|---|---|
| $CO_2$ Emissions (million metric tons) | | | |
| Coal | 1,863 | 1,788 | -4.0 |
| Petroleum | 100 | 106 | 6.0 |
| Natural Gas, Refinery and Still Gas | 313 | 337 | 7.7 |
| Other[a] | -- | 14 | N/A |
| **Total $CO_2$ Emissions** | **2,277** | **2,245** | **-1.4** |
| Generation (billion kWh) | | | |
| Coal | 1,878 | 1,882 | 0.2 |
| Petroleum | 121 | 119 | -1.7 |
| Natural Gas, Refinery and Still Gas | 542 | 562 | 3.7 |
| Other[a] | 20 | 22 | 10.0 |
| Non-Fossil Fuels [b] | 1,072 | 1,106 | 3.2 |
| **Total Generation** | **3,632** | **3,691** | **1.6** |
| Net Imports | 47 | 29 | -38.0 |
| **Total Electricity Supply** | **3,679** | **3,720** | **1.1** |
| Retail Electricity Sales by Utilities (billion kWh) | 3,288 | 3,296 | 0.2 |
| Nonutility Generation for Own Use/Sales (billion kWh)[c] | 173 | 165 | -4.6 |
| Losses and Unaccounted For (billion kWh) | 218 | 259 | 18.8 |

[a]Other fuels include municipal solid waste (MSW), tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity. MSW generation represents the largest share of this category. MSW projections in the *Annual Energy Outlook 2000* are assumed to have zero net $CO_2$ emissions. Due to a change in the accounting for MSW by the Environmental Protection Agency, future AEOs will estimate the $CO_2$ emissions attributed to the non-biomass portion of this fuel. If this had been done for the AEO2000, $CO_2$ emissions for MSW would have been 14 million metric tons for 1999.

[b]Includes nuclear and most renewables, which either do not emit $CO_2$ or whose net $CO_2$ emissions are assumed to be zero.

[c]Data for 1999 are estimated.

Note: Actual data for $CO_2$ emissions and electricity generation for 1999 are preliminary. Components may not add to total due to independent rounding.

Sources: **Projections**: Energy Information Administration, *Annual Energy Outlook 2000*, DOE/EIA-0383 (2000) (Washington, DC, December 1999) and supporting runs of the National Energy Modeling System. **Actual**: Carbon dioxide emissions and generation: Table 1; other data: Energy Information Administration, *Monthly Energy Review, April 2000*, DOE/EIA-0035(2000/04) (Washington, DC, April 2000); Energy Information Administration, *Short-Term Energy Outlook*, May 2000 (EIA Web site, www.eia.doe.gov/emeu/steo/pub/contents.html).

generation from fossil fuels, thus bringing electricity-related $CO_2$ emissions more in line with actual data.

## Voluntary Carbon-Reduction and Carbon-Sequestration Programs

Both the DOE and the EPA operate voluntary programs for reducing greenhouse gas emissions and reporting such emission reductions. Voluntary programs that contribute to emission reductions in the electricity sector include DOE/EIA's Voluntary Reporting of Greenhouse Gases Program and EPA's ENERGY STAR program.

EIA's Voluntary Reporting of Greenhouse Gases Program collects information from organizations that have undertaken carbon-reducing or carbon-sequestration projects. Most of the electric utilities that report to the Voluntary Reporting Program also participate in voluntary emission reduction activities through DOE's Climate Challenge Program. In 1998, as part of the Voluntary Reporting Program, 120 organizations in the electric power sector reported on 1,166 projects undertaken in 1998.[18] By undertaking these projects, participants indicated that they reduced $CO_2$ emissions by 165.8 million metric tons[19] (Table 6). The organizations almost universally measured their project-level reductions by comparing emissions with what they would have been in the absence of the project. Reported $CO_2$ reductions from these projects accounted for 7.5 percent of 1998 $CO_2$ emissions attributed to the generation of electric power in the United States. Foreign reductions, largely from carbon-sequestration projects, account for 6.0 percent of total electric utility sector reductions reported for 1998.

DOE's Climate Challenge Program, a voluntary initiative with the electric utility sector established under the President's 1993 Climate Change Action Plan, has become the principal mechanism by which electric utilities participate in voluntary emission reduction activities. Participants that reported the $CO_2$ emission reductions summarized in this report include electric utilities and holding companies, independent power producers, and landfill methane operators. Climate Challenge participants negotiate voluntary commitments with the DOE to achieve a certain level of emission reductions and/or to participate in specific projects. Companies making Climate Challenge commitments as of 1998 accounted for about 71 percent of 1990 U.S. electric utility generation.[20] Climate Challenge participants are required to report their achieved emissions reductions to the Voluntary Reporting of Greenhouse Gases Program.

Results from the Climate Challenge program cannot be compared directly to other figures in this report because

**Table 6. Electric Power Sector Carbon Dioxide Emission Reductions, 1997 and 1998**
(Million Metric Tons Carbon Dioxide)

| Type of Reduction | Carbon Dioxide[a] | |
|---|---|---|
| | 1997 | 1998 |
| **Domestic Reductions** | | |
| Emission Reductions Projects | 135.9 | 155.3 |
| Sequestration Projects | 0.3 | 0.5 |
| **Total Domestic Reductions** | **136.2** | **155.8** |
| **Foreign Reductions** | | |
| Emission Reductions Projects | 0.1 | 0.1 |
| Sequestration Projects | 9.4 | 9.9 |
| **Total Foreign Reductions** | **9.5** | **10.0** |
| **Total $CO_2$ Reductions Reported** | **145.8** | **165.8** |

[a]The Voluntary Reporting of Greenhouse Gases Program is currently in the 1999 data reporting cycle; the most recent year for which complete data are available is 1998. The 1997 and 1998 data in last year's report were preliminary and have been revised in this report due to subsequent completion of internal EIA review of those data. Emission reductions also include those reported by landfill methane operators. The use of landfill methane to generate electricity displaces fossil fuel power generation and produces a reduction in $CO_2$ emissions equivalent to the amount of $CO_2$ that would have resulted from fossil fuel power generation. In calculating $CO_2$ reductions, it is assumed that landfill carbon is biogenic and, thus, the $CO_2$ emissions from landfill gas combustion are zero.

Note: Totals may not equal the sums of the parts due to independent rounding. This data cannot be compared directly to other figures in this report because reporters to EIA's Voluntary Reporting of Greenhouse Gases Program may report emission reductions using baselines and valuation methods different from those applied elsewhere.

Source: Energy Information Administration, Form EIA-1605, "Voluntary Reporting of Greenhouse Gases," (long form) and EIA-1605EZ, "Voluntary Reporting of Greenhouse Gases," (short form), 1997 and 1998 data.

[18] The Voluntary Reporting of Greenhouse Gases Program is currently in the 1999 data reporting cycle; the most recent year for which complete data are available is 1998. The 1997 and 1998 data in last year's report were preliminary and have been revised in this report due to subsequent completion of internal EIA review of those data. Emission reductions also include those reported by landfill methane operators.

[19] The EIA also receives numerous reports on projects and emissions reductions from reporters outside the electric power sector. In addition, many reports submitted to the Voluntary Reporting Program (including electric power sector reports) include reductions of greenhouse gases other than carbon dioxide, such as methane and nitrous oxide and the high Global Warming Potential gases such as HFCs, PFCs and sulfur hexafluoride.

[20] U.S. Department of Energy, Climate Challenge Fact Sheet (1998), and conversation with Larry Mansueti, August 10, 1999. See also http://www.eren.doe.gov/climatechallenge/execsumm/execsumm.htm.

the Climate Challenge program allows participants to report emissions reductions using baselines and calculation methods different from those applied elsewhere. For this reason, EIA keeps an accounting of reports submitted by Climate Challenge participants, but the United States counts only a fraction of these reported reductions in comprehensive assessments of overall reductions in greenhouse gases.[21]

The largest reductions claimed for 1998 are from these major U.S. electric utilities: the Tennessee Valley Authority (26.0 million metric tons of $CO_2$), TXU (19.9 million metric tons of $CO_2$), Duke Energy (12.1 million metric tons of $CO_2$), and FirstEnergy (10.6 million metric tons of $CO_2$).[22] These four companies accounted for about 41.4 percent of the $CO_2$ emissions reductions reported in 1998 by the electric power sector. Each of these companies owns one or more nuclear power plants, and the bulk of their reported reductions is calculated by comparing either actual or additional nuclear output from their plants with the emissions that would have occurred if the same quantity of electricity had been generated using fossil fuels.

Electric power industry companies also reported on projects reducing other greenhouse gases.[23] Combining all projects and all greenhouse gases, the electric power sector reporters claimed 176.9 million metric tons of carbon dioxide equivalent reductions in 1998.

Utilities also undertook a number of carbon-sequestration projects. Although these projects do not directly affect $CO_2$ emissions, they do offset utility $CO_2$ emissions. Foreign carbon-sequestration projects from the electric sector were reported to be 9.9 million metric tons of $CO_2$ in 1998, while domestic projects were reported to be 0.5 million metric tons. These activities were dominated by three independent power producer subsidiaries of the AES Corporation, which reported 7.6 million metric tons of $CO_2$ sequestration annually from three projects with activities in Belize, Bolivia, Ecuador, Peru, and Guatemala. These projects undertake tropical rain forest management, preservation, or reforestation.

In addition, more than 30 companies reported on their pro-rated share of participation in the Edison Electric Institute's UtiliTree program.[24] The UtiliTree program is a carbon-sequestration mutual fund in which electric utilities purchase shares. UtiliTree uses the funds to participate in forest management and reforestation projects in the United States and abroad.

The United States' voluntary programs are reducing domestic emissions of greenhouse gases in a number of sectors across the economy through a range of partnerships and outreach efforts. For example, the ENERGY STAR Program, run by the EPA in partnership with DOE, reduces energy consumption in homes and office buildings across the Nation. EPA and DOE set energy-efficiency specifications for a range of products including office equipment, heating and cooling equipment, residential appliances, televisions and VCRs, and new homes. The ENERGY STAR label for buildings is based on a performance rating system that allows building owners to evaluate the efficiency of their buildings relative to others. On average, buildings across the country can improve efficiency by 30 percent through a variety of improvements. Manufacturer and retailer partners in the program may place the nationally recognized ENERGY STAR label on qualifying products.

In the past several years, the ENERGY STAR label has expanded to include more than 30 products and nearly 7,000 product models. In 1999, energy consumption was reduced by approximately 28 billion kilowatthours as a result of the program, reducing greenhouse gas emissions by nearly 21 million metric tons $CO_2$ (Table 7). Through EPA's ENERGY STAR Buildings and Green Lights Partnership, more than 15 percent of the square footage in U.S. buildings has undergone efficiency upgrades resulting in electricity savings in excess of 21 billion kilowatthours and emissions reductions of more than 16 million metric tons $CO_2$.

## Environmental Effects of Federal Restructuring Legislation

In April 1999, the Administration submitted to Congress the Comprehensive Electricity Competition Act (CECA), a bill to restructure the U.S. electricity industry and foster retail competition. CECA was designed to ensure

[21] See the *1997 Climate Change Action Report* (the Submission of the United States of America under the United Nations Framework Convention on Climate Change), p. 100, for one such assessment.

[22] TXU was formerly known as Texas Utilities, while FirstEnergy is the result of a merger between Ohio Edison and Centerior Energy (Cleveland Electric).

[23] Other greenhouse gases include methane reductions from landfills and oil and natural gas systems, and sulfur hexafluoride ($SF_6$), which has 23,900 times the global warming impact of carbon dioxide when released into the atmosphere.

[24] The more than 40 companies referenced in last year's report are participants in EEI's UtiliTree program. Of these companies, 31 reported their share of participation to the Voluntary Reporting of Greenhouse Gases Program for 1998.

**Table 7. $CO_2$ Emission Reductions and Energy Savings from EPA's Voluntary Programs, 1998 and 1999**

| | 1998 | | 1999 | |
|---|---|---|---|---|
| | Million Metric Tons of $CO_2$ Reduced | Billion kWh Saved | Million Metric Tons of $CO_2$ Reduced | Billion kWh Saved |
| ENERGY STAR Labeled Products | 14.7 | 20 | 20.9 | 28 |
| ENERGY STAR Buildings and Green Lights | 8.8 | 13 | 16.5 | 21 |
| Climate Wise | 9.9 | 3 | 13.9 | 5 |

Source: U.S. Environmental Protection Agency, Climate Protection Division, *1998 Annual Report: Driving Investment in Energy Efficiency, ENERGY STAR and Other Voluntary Programs* (EPA 430-R-99-005), forthcoming.

that the full economic and environmental benefits of electricity restructuring are realized. The expected environmental benefits are the result of both the effects of competition and specific provisions included in the Administration's proposal, such as a renewables portfolio standard, a public benefits fund, and tax incentives for investment in combined heat and power facilities. Competition itself will also provide incentives to generators to improve their own efficiencies, and create new markets for green power and end-use efficiency services, all of which reduce greenhouse gas emissions.

Following an exhaustive interagency review, the DOE issued a *Supporting Analysis*[25] that quantified both the economic and environmental benefits of the Administration's plan in May 1999. The analysis focused on the impacts of full national retail competition relative to continued cost-of-service regulation. The results showed that the Administration's proposal will reduce $CO_2$ emissions by 216 million metric tons in 2010. An EIA study[26] using the same assumptions from the supporting analysis produced similar results. Carbon dioxide emissions in the EIA report were estimated to be 194 million metric tons lower in the competitive case than in the cost-of-service reference case in 2010. A number of key uncertainties, however, can affect these projections, and some of the reductions could be realized due to actions already taken by individual States. Recognizing uncertainties and the need to avoid double-counting, the Administration projected that its proposal would reduce $CO_2$ emissions from energy use by 147 to 220 million metric tons annually by 2010.

The DOE and EPA see no recent developments that would change our projection of the expected impact of the Administration proposal. However, we note that restructuring bills that have recently moved forward in the Congress differ significantly from the Administration's comprehensive proposal. These bills do not include key provisions that support the effective functioning of competitive electricity markets and energy diversity while at the same time providing reductions in $CO_2$ emissions. In addition to maintaining our capability to reassess the impacts of our own proposal, we are also prepared to provide quantitative analyses of alternative restructuring bills. Additional measures could offer potential for cost-effective emissions reductions in the electric power sector, although they are no substitute for comprehensive restructuring legislation that promotes competitive markets and consumer benefits while providing important reductions in $CO_2$ emissions from electric power generation.

[25] U.S. Department of Energy, *Supporting Analysis for the Comprehensive Electricity Act*, May 1999.

[26] Energy Information Administration, *The Comprehensive Electricity Competition Act: A Comparison of Model Results*. Internet site at http://www.eia.doe.gov/oiaf/servicerpt/ceca.html.

## Appendix A

# Presidential Directive

April 15, 1999
MEMORANDUM FOR THE
SECRETARY OF ENERGY
ADMINISTRATOR OF THE ENVIRONMENTAL PROTECTION AGENCY

SUBJECT: Report on Carbon Dioxide ($CO_2$) Emissions

My Administration's proposal to promote retail competition in the electric power industry, if enacted, will help to deliver economic savings, cleaner air, and a significant down payment on greenhouse gas emissions reductions. The proposal exemplifies my Administration's commitment to pursue both economic growth and environmental progress simultaneously.

As action to advance retail competition proceeds at both the State and Federal levels, the Administration and the Congress share an interest in tracking environmental indicators in this vital sector. We must have accurate and frequently updated data.

Under current law, electric power generators report various types of data relating to generation and air emissions to the Department of Energy (DOE) and the Environmental Protection Agency (EPA). To ensure that this data collection is coordinated and provides for timely consideration by both the Administration and the Congress, you are directed to take the following actions:

- On an annual basis, you shall provide me with a report summarizing $CO_2$ emissions data collected during the previous year from all utility and nonutility electricity generators providing power to the grid, beginning with 1998 data. This information shall be provided to me no more than 6 months after the end of the previous year, and for 1998, within 6 months of the date of this directive.

- The report, which may be submitted jointly, shall present $CO_2$ emissions information on both a national and regional basis, stratified by the type of fuel used for electricity generation, and shall indicate the percentage of electricity generated by each type of fuel or energy resource. The $CO_2$ emissions shall be reported both on the basis of total mass (tons) and output rate (e.g., pounds per megawatt-hour).

- The report shall present the amount of $CO_2$ reduction and other available information from voluntary carbon-reducing and carbon-sequestration projects undertaken, both domestically and internationally, by the electric utility sector.

- The report shall identify the main factors contributing to any change in $CO_2$ emissions or $CO_2$ emission rates relative to the previous year on a national, and, if relevant, regional basis. In addition, the report shall identify deviations from the actual $CO_2$ emissions, generation, and fuel mix of their most recent projections developed by the Department of Energy and the Energy Information Administration, pursuant to their existing authorities and missions.

- In the event that Federal restructuring legislation has not been enacted prior to your submission of the report, the report shall also include any necessary updates to estimates of the environmental effects of my Administration's restructuring legislation.

- Neither the DOE nor the EPA may collect new information from electricity generators or other parties in order to prepare the report.

WILLIAM J. CLINTON

## Appendix B

# Data Sources and Methodology

This section describes the data sources and methodology employed to calculate estimates of carbon dioxide ($CO_2$) emissions from utility and nonutility electric generating plants. Due to the report being submitted in June of 2000, the annual census data, on which 1998 emission estimates are based, are not yet available from the Form EIA-860B and Form EIA-767. The methodology employed for estimating 1999 $CO_2$ emissions in this report are based on two monthly data collections, Form EIA-759 and Form EIA-900. The Form EIA-759 collects monthly generation and fuel consumption from all utility-owned generating plants, and the Form EIA-900 collects generation and fuel consumption from nonutility plants with a nameplate capacity of 50 megawatts (MW) or more. The 1999 estimates of $CO_2$ emissions and net generation are preliminary estimates; final emissions estimates based on annual census data will be published in the *Electric Power Annual Volume II 1999*, later this year.

### Electric Utility Data Sources

The electric utility data are derived from several forms. The Form EIA-767, "Steam-Electric Plant Operation and Design Report," collects information annually for all U.S. power plants with a total existing or planned organic- or nuclear-fueled steam-electric generator nameplate rating of 10 MW or larger. Power plants with a total generator nameplate rating of 100 MW or more must complete the entire form, providing among other data, information about fuel consumption and quality. Power plants with a total generator nameplate rating from 10 MW to less than 100 MW complete only part of the form, including information on fuel consumption.

Form EIA-759, "Monthly Power Plant Report," is a cutoff model sample of approximately 360 electric utilities drawn from the frame of all operators of electric utility plants (approximately 700 electric utilities) that generate electric power for public use. The monthly data collection is from all utilities with at least one plant with a nameplate capacity of 50 MW or more. For all utility plants not included in the monthly sample, those with nameplate capacities less than 50 MW, monthly data are collected annually. Form EIA-759 is used to collect data on net generation; consumption of coal, petroleum, and natural gas; and end-of-the-month stocks of coal and petroleum for each plant by fuel-type combination.

The Federal Energy Regulatory Commission (FERC) Form 423, "Monthly Report of Cost and Quality of Fuels for Electric Plants," is a monthly record of delivered-fuel purchases, submitted by approximately 230 electric utilities for each electric generating plant with a total steam-electric and combined-cycle nameplate capacity of 50 MW or more. FERC Form 423 collects data on fuel contracts, fuel type, coal origin, fuel quality and delivered cost of fuel.

### Nonutility Data Sources

Form EIA-860B, "Annual Electric Generator Report – Nonutility," (prior Form EIA-867, "Annual Nonutility Power Producer Report") collects information annually from all nonutility power producers with a total generator nameplate rating of 1 MW or more, including cogenerators, small power producers, and other non-utility electricity generators. All facilities must complete the entire form, providing, among other data, information about fuel consumption and quality; however facilities with a combined nameplate capacity of less than 25 MW are not required to complete Schedule V, "Facility Environmental Information," of the Form EIA-860B.

Form EIA-900, "Monthly Nonutility Power Plant Report," is a cutoff model sample of approximately 500 nonutilities drawn from the frame of all nonutility facilities (approximately 2000 nonutilities) that have existing or planned nameplate capacity of 1 MW or more. The monthly data collection comes from all nonutilities with a nameplate rating of 50 MW or more. A cutoff model sampling and estimation are employed using the annual Form EIA-860B.

### $CO_2$ Coefficients

The coefficients for determining carbon released from the combustion of fossil fuels were developed by the

Energy Information Administration. A detailed discussion of the development and sources used is contained in the publication, *Emissions of Greenhouse Gases in the United States*, (DOE/EIA-0573), Appendix B. The nonutility coefficients were developed to be consistent with the utility coefficients.

## Methodology for 1998

The methodology for developing the $CO_2$ emission estimates for steam utility plants and nonsteam utility plants (calculations performed on a plant basis by fuel), as well as for nonutility plants (calculations performed on a facility basis by fuel), is as follows:

### *Steam Utility Plants*

Form EIA-767, "Steam-Electric Plant Operation and Design Report"
Form EIA-759, "Monthly Power Plant Report"
FERC Form 423, "Monthly Report of Cost and Quality of Fuels for Electric Plants"

Step 1. Sum of Monthly Consumption (EIA-767) times Monthly Average Btu Content (EIA-767) divided by Total Annual Consumption (EIA-767) = Weighted Annual Btu Content Factor.

Step 2. Annual Consumption (EIA-767) times Weighted Annual Btu Content Factor (Step 1) = Annual Btu Consumption.

Step 3. Annual Btu Consumption (Step 2) times $CO_2$ factors = Annual $CO_2$ Emissions.

Step 4. Reduce Annual $CO_2$ Emissions (Step 3) by 1 percent to assume 99 percent burn factor.

### *Nonsteam Utility Plants*

Form EIA-759, "Monthly Power Plant Report"
FERC Form 423, "Monthly Report of Cost and Quality of Fuels for Electric Plants"

Step 1(a). If monthly EIA-759 and monthly FERC Form 423 are available: Sum of Monthly Consumption (EIA-759) times Monthly Average Btu Content (FERC Form 423) divided by Total Annual Consumption = Weighted Annual Btu Content Factor.

Step 1(b). If monthly EIA-759 is available, but not monthly FERC Form 423: Sum of Monthly Consumption (EIA-759) times Average Monthly Btu Content (calculated from FERC Form 423) divided by Total Annual Consumption = Weighted Annual Btu Content Factor.

Step 1(c). If only annual EIA-759 is available: Annual Consumption (EIA-759) times Average Annual Btu Content (calculated from FERC Form 423) divided by Total Annual Consumption = Weighted Annual Btu Content Factor.

Step 2. Annual Consumption (EIA-759) times Weighted Annual Btu Content Factor (Step 1) = Annual Btu Consumption.

Step 3. Annual Btu Consumption (Step 2) times $CO_2$ Factors = Annual $CO_2$ Emissions.

Step 4. Reduce Annual $CO_2$ Emissions (Step 3) by 1 percent to assume 99 percent burn factor.

### *Nonutility Plants*

Form EIA-860B, "Annual Electric Generator Report – Nonutility"
FERC Form 423, "Monthly Report of Cost and Quality of Fuels for Electric Plants"

Step 1. Annual Consumption (EIA-860B) times Average Annual Btu Content (EIA-860B) divided by Total Annual Consumption = Weighted Annual Btu Content Factor.

Step 2. Annual Consumption (EIA-860B) times Weighted Annual Btu Content Factor (Step 1) = Annual Btu Consumption.

Step 3. Annual Btu Consumption (Step 2) x $CO_2$ Factors = Annual $CO_2$ Emissions.

Step 4. Reduce Annual $CO_2$ Emissions (Step 3) by 1 percent to assume 99 percent burn factor.

## Methodology for 1999

### *Utility Plants*

Form EIA-767, "Steam-Electric Plant Operation and Design Report"
Form EIA-759, "Monthly Power Plant Report"
FERC Form 423, "Monthly Report of Cost and Quality of Fuels for Electric Plants"

Step 1(a). If monthly EIA-759 and prior year annual EIA-767 are available: Sum of Monthly Consumption (EIA-759) times Monthly Average Btu Content (EIA-767) divided by Total Annual Consumption (EIA-759) = Weighted Annual Btu Content Factor.

Step 1(b). If prior year annual EIA-767 is not available, but monthly EIA-759 and monthly FERC Form 423 are available: Sum the Monthly Consumption (EIA-759) times the Monthly Average Btu Content (FERC Form 423) divided by the Total Annual Consumption (EIA-759) = Weighted Annual Btu Content Factor.

Step 1(c). If prior year annual EIA-767 and monthly FERC Form 423 are not available, but monthly EIA-759 is available: Sum the Monthly Consumption (EIA-759) times the Average Monthly Btu Content (calculated at State level from FERC Form 423) divided by the Total Annual Consumption (EIA-759) = Weighted Annual Btu Content Factor.

Step 1(d). If prior year annual EIA-767, monthly EIA-759 and monthly FERC Form 423 are not available, but only annual EIA-759 is available: Annual Consumption (EIA-759) times the Average Annual Btu Content (calculated at State level from FERC Form 423) divided by the Total Annual Consumption (EIA-759) = Weighted Annual Btu Content Factor.

Step 2. Annual Consumption (EIA-759) times the Weighted Annual Btu Content Factor (Step 1) = Annual Btu Consumption.

Step 3. Annual Btu Consumption (Step 2) times $CO_2$ Coefficients (*Emissions of Greenhouse Gases in the United States*) = Annual Gross $CO_2$ Emissions.

Step 4. Reduce Annual Gross $CO_2$ Emissions (Step 3) by 1 percent to assume 99 percent burn factor.

### *Nonutility Plants*

Form EIA-900, "Monthly Nonutility Power Report"
Form EIA-860B, "Annual Electric Generator Report – Nonutility"
FERC Form 423, "Monthly Report of Cost and Quality of Fuels for Electric Plants"

Step 1(a). If monthly EIA-900 and prior year annual EIA-860B are available: Sum the Monthly Generation by Census Division and Fuel Type (EIA-900), and apply annual growth factor model to estimate 1999 Annual Generation. Divide 1999 Annual Generation by 1998 Annual Generation (EIA-860B), subtract 1, and multiply by 1998 Total Annual Consumption[27] (EIA-860B) = 1999 Total Annual Consumption. 1999 Total Annual Consumption times Average Btu Content (EIA-860B for prior year) = 1999 Annual Btu Consumption.

Step 1(b). If monthly EIA-900 and FERC Form 423 for 1998 are available: (sold utility plant to nonutility in 1999): Annual Consumption (EIA-900) times the Average Btu Content (FERC Form 423) = 1999 Annual Btu Consumption.

Step 1(c). If only monthly EIA-900 is available (new nonutility plants): Annual Consumption (EIA-900) times the Average Btu Content (calculated at State level from FERC Form 423) = 1999 Annual Btu Consumption.

Step 2. 1999 Annual Btu Consumption (Step 1) times $CO_2$ Coefficients (*Emissions of Greenhouse Gases in the United States*) = Annual Gross $CO_2$ Emissions.

Step 3. Reduce Annual Gross $CO_2$ Emissions (Step 2) by 1 percent to assume 99 percent burn factor.

[27] 1998 Annual Consumption for cogenerators is adjusted to exclude fuel not used for generation of electricity.