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

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**Department of Energy**
Washington, DC 20585
**Environmental Protection Agency**
Washington DC 20460

# Contacts

This report was prepared jointly by the staff of the U.S. Department of Energy and the Environmental Protection Agency. Questions about this publication, as well as other energy inquiries may be directed to the National Energy Information Center on (202) 586-8800.

Questions regarding specific information in the report may be directed as follows:

Electric Power Data and Carbon Dioxide Emission Estimates:


Wiley Barbour (202-260-6972)
Internet e-mail: barbour.wiley@epamail.epa.gov

Channele Carner (202-426-1270)
Internet e-mail: cdonald@eia.doe.gov

Rick Morgan (202-564-9143)
Internet e-mail: morgan.rick@epamail.epa.gov

Roger Sacquety (202-426-1160)
Internet e-mail: rsacquet@eia.doe.gov

Stephen Scott (202-426-1149)
Internet e-mail: sscott@eia.doe.gov

Betty Williams (202-426-1269)
Internet e-mail: bwilliam@eia.doe.gov


Projected Electric Generation and Carbon Dioxide Emissions:


Larry Prete (202-586-2847)
Internet e-mail: lprete@eia.doe.gov


Voluntary Carbon-Reduction and Carbon Sequestration Programs:


Arthur Rypinski (202-586-8425)
Internet e-mail: arypinsk@eia.doe.gov

Virginia Lee (202-564-8977)
Internet e-mail: lee.virginia@epamail.epa.gov


Environmental Effects of Federal Restructuring Legislation:


Tracy Terry (202-586-3383)
Internet e-mail: tracy.terry@hq.doe.gov

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## Introduction

The President issued a directive on April 15, 1999, requiring an annual report summarizing carbon dioxide ($CO_2$) emissions produced by electricity generation in the United States, including both utilities and non-utilities. In response, this report is jointly submitted by the U.S. Department of Energy and the U.S. Environmental Protection Agency. The data on $CO_2$ emissions and generation of electricity were collected and prepared by the Energy Information Administration. This report is structured to address the five areas outlined in the Presidential Directive.

- The emissions of $CO_2$ are presented both 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 on the regional and national levels. The percentage of generation produced by each fuel type or energy resource is indicated.

- The $CO_2$ emissions and generation by fuel type for 1998 are compared to the previous year, 1997. 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 1998 are compared to the actual data summarized in this report to identify deviations between projected and actual $CO_2$ emissions and generation.

- Information on voluntary carbon-reducing and carbon-sequestration projects reported by the electric power sector and the 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 1998, emissions of $CO_2$ in the United States resulting from the generation of electric power were 2,447 million short tons[1] (606 million metric tons carbon), an increase of 3.7 percent from 1997. During this same time period, total generation of electricity increased 3.6 percent. Electricity generated by fossil-fueled plants, the source of $CO_2$ emissions in this report, increased by 4.8 percent, while nonfossil-fueled generation increased by 0.7 percent. The greater proportion of fossil-fueled generation in 1998 than in 1997, and the smaller proportion of nonfossil-fueled generation resulted in an increase in the average output rate[2] of $CO_2$ per kilowatthour. In 1998, the average output rate for $CO_2$ was 1.352 pounds per kilowatthour (lbs / kWh), up from 1.350 in 1997 (Table 1).

Other data show that $CO_2$ emissions from all energy use in the United States grew at a much slower rate than emissions from electricity generation between 1997 and 1998. This outcome reflects the combined effect of emissions growth in electric generation and transportation together with an absolute decline in non-electric energy use by the nation's homes, businesses, and industries. 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.

[1] Short tons of carbon dioxide equal metric tons carbon times 1.1023 times 44 / 12.

[2] The average output rate is the ratio of pounds of carbon dioxide emitted per kilowatthour of electricity produced. The average output rate is based on kilowatthours produced from all energy sources for a region or the Nation.

**Table 1. Summary of Carbon Dioxide Emissions and Net Generation in the United States, 1997 and 1998**

| | 1997 | 1998 | Change | Percent Change |
|---|---|---|---|---|
| **Carbon Dioxide** | | | | |
| Coal | | | | |
| Thousand Short Tons | 1,957,553 | 1,978,928 | 21,375 | 1.09 |
| Thousand Metric Tons Carbon [a] | 484,331 | 489,620 | 5,289 | 1.09 |
| Petroleum | | | | |
| Thousand Short Tons | 90,158 | 121,962 | 31,804 | 35.28 |
| Thousand Metric Tons Carbon | 22,307 | 30,175 | 7,869 | 35.28 |
| Gas | | | | |
| Thousand Short Tons | 283,563 | 317,146 | 33,583 | 11.84 |
| Thousand Metric Tons Carbon | 70,158 | 78,467 | 8,309 | 11.84 |
| Other Fuels [b] | | | | |
| Thousand Short Tons | 28,580 | 29,420 | 840 | 2.94 |
| Thousand Metric Tons Carbon | 7,071 | 7,279 | 208 | 2.94 |
| **Total** | | | | |
| **Thousand Short Tons** | **2,359,853** | **2,447,457** | **87,604** | **3.71** |
| **Thousand Metric Tons Carbon** | **583,867** | **605,541** | **21,675** | **3.71** |
| **Generation** (million kWh) | | | | |
| Coal | 1,844,041 | 1,873,668 | 29,627 | 1.61 |
| Petroleum | 92,796 | 131,337 | 38,541 | 41.53 |
| Gas | 451,951 | 496,570 | 44,619 | 9.87 |
| Other Fuels [b] | 19,386 | 22,803 | 3,417 | 17.63 |
| **Total Fossil-fueled** | **2,408,175** | **2,524,378** | **116,203** | **4.83** |
| **Nonfossil-fueled** [c] | **1,087,127** | **1,094,846** | **7,719** | **0.71** |
| **U.S. Total** | **3,495,302** | **3,619,224** | **123,922** | **3.55** |
| **Output Rate** [d] (pounds $CO_2$ per kWh) | | | | |
| Coal | 2.123 | 2.112 | -0.011 | -0.52 |
| Petroleum | 1.943 | 1.857 | -0.086 | -4.43 |
| Gas | 1.255 | 1.277 | 0.022 | 1.75 |
| Other Fuels [b] | 2.948 | 2.580 | -0.368 | -12.48 |
| **U.S. Average** | **1.350** | **1.352** | **0.002** | **0.15** |

[a] One short ton of carbon dioxide equals one metric ton carbon times 1.1023 times 44/12.

[b] Other fuels include municipal solid waste, tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity.

[c] Non-fossil includes nuclear, hydroelectric, solar, wind, geothermal, biomass, and other fuels or energy sources with zero or net zero $CO_2$ emissions.

[d] Average output rate is based on generation from all energy sources.

Note: 1998 data for $CO_2$ emissions are preliminary.

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 EIA-867, "Annual Nonutility Power Producer Report," 1997. • Federal Energy Regulatory Commission FERC Form 423, "Monthly Report of Cost and Quality of Fuels for Electric Plants."

In the United States, about 40.5 percent[3] of anthropogenic $CO_2$ emissions was attributed to the combustion of fossil fuels for the generation of electricity in 1998.[4] The energy sources used for electricity generation and the output rates for $CO_2$ vary across the United States according to the type of fuels available. All regions use some fossil fuels, but several States have almost no fossil fuel generation which results in extremely low output rates of $CO_2$. For example, in Vermont almost all electricity is produced with nuclear power, while in Washington, Idaho, and Oregon almost all electricity is produced with hydroelectric power. At the other

[3] About 37 percent of $CO_2$ emissions are produced by electric utility generators, as reported in the GHG inventory for 1998. Included in the 40.5 percent are nonutility power producers, which are included in the industrial sector in the GHG inventory.

[4] Energy Information Administration, *Emissions of Greenhouse Gases in the United States* 1997, Chapter 2, "Carbon Dioxide Emissions," DOE/EIA-0573(97) (Washington, DC, October 1998).

extreme, Kentucky, Indiana, New Mexico, West Virginia, and Wyoming—some of the Nation's largest coal-producing States—generate most of their electricity with coal.

## Coal

Emissions of $CO_2$ produced by coal-fired generation of electricity increased by 1.1 percent in 1998 to 1,979 million short tons (Table 2). $CO_2$ emissions from coal-fired electricity generation represent 81 percent of the total $CO_2$ emissions produced by the generation of electricity in the United States. In 1998, coal-fired generators produced 1,874 billion kWh, a 1.6-percent increase from 1997. The share of generation from coal plants declined from 52.8 percent in 1997 to 51.8 percent in 1998 (Table 3). The average output rate for coal-fired generators improved from 2.123 lbs/kWh in 1997 to 2.112 lbs/kWh in 1998, reflecting an increase in thermal efficiency at coal-fired plants (Table 4).

**Table 2. Estimated Carbon Dioxide Emissions From Generating Units at U.S. Electric Plants by Census Division, 1997 and 1998**
(Thousand Short Tons)

| | 1997 | | | | | 1998 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Census Division** | Total | Coal | Petroleum | Gas | Other[a] | Total | Coal | Petroleum | Gas | Other[a] |
| New England | 62,009 | 21,922 | 21,981 | W | W | 58,591 | 17,352 | 24,708 | 9,733 | 6,799 |
| Middle Atlantic | 204,447 | 152,606 | 12,446 | W | W | 217,803 | 153,921 | 19,176 | 36,267 | 8,439 |
| East North Central | 463,764 | 447,315 | 3,619 | 11,139 | 1,691 | 470,285 | 450,393 | 4,796 | 13,439 | 1,657 |
| West North Central | 224,693 | 219,032 | W | 3,178 | W | 239,476 | 231,336 | 1,672 | 5,141 | 1,328 |
| South Atlantic | 470,977 | 408,135 | 30,455 | 24,839 | 7,547 | 496,585 | 411,228 | 48,570 | 28,472 | 8,314 |
| East South Central | 248,461 | 237,889 | W | 7,367 | W | 247,964 | 232,650 | 5,495 | 9,716 | 103 |
| West South Central | 378,534 | 240,669 | 6,409 | 131,376 | 80 | 390,827 | 236,463 | 6,345 | 147,903 | 116 |
| Mountain | 227,381 | 215,800 | W | W | 14 | 241,642 | 227,354 | 979 | 13,309 | -- |
| Pacific Contiguous | 66,343 | 11,938 | 2,633 | 49,714 | 2,058 | 71,961 | 16,049 | 2,966 | 50,810 | 2,136 |
| Pacific Noncontiguous | 13,245 | 2,247 | 7,870 | 2,587 | 541 | 12,322 | 2,182 | 7,254 | 2,357 | 528 |
| **U. S. Total** | **2,359,853** | **1,957,553** | **90,158** | **283,563** | **28,580** | **2,447,457** | **1,978,928** | **121,962** | **317,146** | **29,420** |

[a]Other includes municipal solid waste, tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity.
-- = Not applicable.
W = Confidential data withheld.
Note: Data for $CO_2$ emissions for 1998 are preliminary.
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," 1998; and Form EIA-867, "Annual Nonutility Power Producer Report," 1997. •Federal Energy Regulatory Commission FERC Form423, "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, 1997 and 1998**
(Percent)

| | 1997 | | | | | 1998 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Census Division** | Coal | Petroleum | Gas | Other[a] | Nonfossil[b] | Coal | Petroleum | Gas | Other[a] | Nonfossil[b] |
| New England | 21.0 | 23.7 | W | W | 31.0 | 17.3 | 26.3 | 17.2 | 5.1 | 34.1 |
| Middle Atlantic | 39.4 | 3.2 | W | W | 41.2 | 38.4 | 5.2 | 13.6 | 1.3 | 41.4 |
| East North Central | 76.8 | 0.5 | 3.6 | 0.4 | 18.7 | 76.3 | 0.8 | 3.8 | 0.4 | 18.8 |
| West North Central | 74.5 | W | 1.6 | W | 23.0 | 75.5 | 0.7 | 2.4 | 0.3 | 21.0 |
| South Atlantic | 58.0 | 4.8 | 6.7 | 0.6 | 29.9 | 55.3 | 7.2 | 6.7 | 0.7 | 30.2 |
| East South Central | 68.1 | W | 2.5 | W | 28.3 | 66.2 | 2.1 | 3.3 | * | 28.4 |
| West South Central | 42.0 | 0.8 | 38.4 | 0.1 | 18.7 | 39.1 | 0.8 | 42.6 | 0.3 | 17.2 |
| Mountain | 66.3 | W | W | * | 27.5 | 67.9 | 0.2 | 6.9 | * | 25.0 |
| Pacific Contiguous | 3.1 | 0.7 | 22.2 | 0.5 | 73.5 | 4.4 | 0.7 | 23.2 | 0.7 | 71.0 |
| Pacific Noncontiguous | 12.2 | 49.9 | 22.7 | 2.1 | 13.1 | 12.2 | 52.3 | 21.3 | 2.4 | 11.9 |
| **U.S. Total** | **52.8** | **2.7** | **12.9** | **0.6** | **31.1** | **51.8** | **3.6** | **13.7** | **0.6** | **30.3** |

[a]Other includes municipal solid waste, tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity.
[b]Non-fossil includes nuclear, hydroelectric, solar, wind, geothermal, biomass, and other fuels or energy sources with zero or net zero $CO_2$ emissions.
W = Confidential data withheld.
* = Absolute value less than 0.05.
Sources: •Energy Information Administration, Form EIA-759, "Monthly Power Plant Report"; Form EIA-860B, "Annual Electric Generator Report – Nonutility"; and Form EIA-867, "Annual Nonutility Power Producer Report," 1997.

**Table 4. Estimated Carbon Dioxide Emissions Rate From Generating Units at U.S. Electric Plants by Census Division, 1997 and 1998**
(Pounds per Kilowatthour)

| Census Division | 1997 | | | | | 1998 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Average [a] | Coal | Petroleum | Gas | Other[b] | Average [a] | Coal | Petroleum | Gas | Other[b] |
| New England | 1.215 | 2.046 | 1.814 | 1.128 | 2.845 | 1.091 | 1.873 | 1.748 | 1.054 | 2.480 |
| Middle Atlantic | 1.091 | 2.067 | 2.052 | 1.122 | 3.466 | 1.119 | 2.059 | 1.889 | 1.366 | 3.328 |
| East North Central | 1.683 | 2.114 | 2.536 | 1.115 | 1.696 | 1.676 | 2.105 | 2.233 | 1.249 | 1.609 |
| West North Central | 1.738 | 2.274 | 1.540 | 1.515 | 3.369 | 1.768 | 2.262 | 1.751 | 1.596 | 2.864 |
| South Atlantic | 1.370 | 2.046 | 1.827 | 1.085 | 3.804 | 1.349 | 2.022 | 1.827 | 1.162 | 3.311 |
| East South Central | 1.453 | 2.042 | 1.898 | 1.726 | NM | 1.445 | 2.048 | 1.507 | 1.733 | 3.791 |
| West South Central | 1.456 | 2.204 | 2.976 | 1.317 | NM | 1.431 | 2.213 | 2.810 | 1.270 | NM |
| Mountain | 1.540 | 2.204 | 1.864 | 1.254 | NM | 1.572 | 2.179 | 2.803 | 1.255 | -- |
| Pacific Contiguous | 0.382 | 2.211 | 2.198 | 1.288 | 2.431 | 0.421 | 2.158 | 2.385 | 1.283 | 1.819 |
| Pacific Noncontiguous | 1.598 | 2.221 | 1.904 | 1.373 | 3.108 | 1.532 | 2.223 | 1.726 | 1.375 | 2.791 |
| **U. S. Average** | **1.350** | **2.123** | **1.943** | **1.255** | **2.948** | **1.352** | **2.112** | **1.857** | **1.277** | **2.580** |

[a]Average output is the ratio of pounds of carbon dioxide to total kilowatthours produced from all energy sources (fossil fuels and nonfossil energy sources) in a region or the Nation.

[b]Other includes municipal solid waste, tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity.

-- = Not applicable.

NM = Data are not meaningful because generation and fuel consumption for this fuel type respresented less than 0.5 percent in the region.

Note: Data for $CO_2$ emissions for 1998 are preliminary.

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," 1998; and Form EIA-867, "Annual Nonutility Power Producer Report," 1997. •Federal Energy Regulatory Commission FERC Form423, "Monthly Report of Cost and Quality of Fuels for Electric Plants."

Coal-fired generation dominates the East North Central, West North Central, East South Central, Mountain, and South Atlantic Census Divisions (Figure 1) where the Nation's coal-producing States are located. These regions have high output rates for $CO_2$ because coal is the dominant fuel and has a higher carbon intensity than other fossil fuels. In 1998, West Virginia, Ohio, Kentucky, Indiana, Iowa, North Dakota, Wyoming, Colorado, New Mexico, and Utah generated over 85 percent of their power at coal-fired plants. The region with the greatest share of $CO_2$ emissions from coal-fired plants is the East North Central Census Division, which produced 23 percent of the $CO_2$ emissions associated with coal-fired generation. At the State level, Texas had the greatest amount of $CO_2$ emissions in tons from coal-fired generation, followed by Ohio, Pennsylvania, Indiana, West Virginia, and Kentucky.

## Petroleum

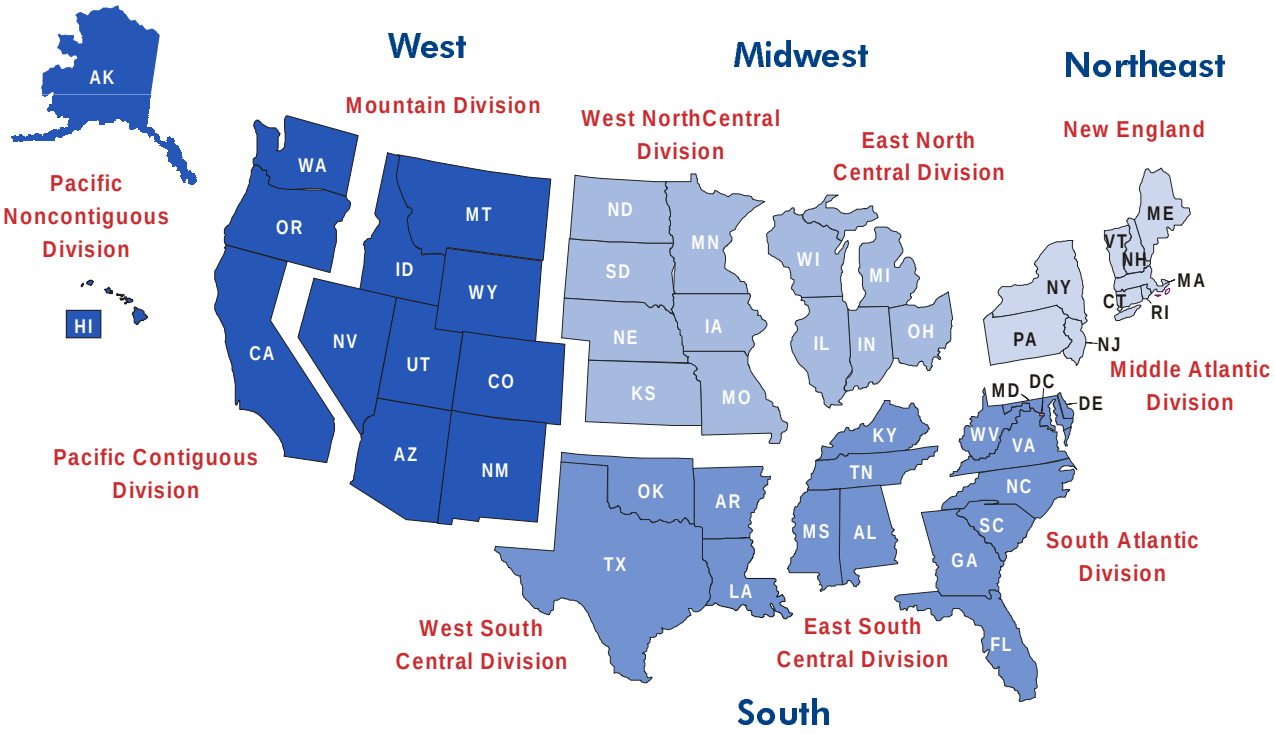
$CO_2$ emissions from petroleum-fired generation were 122 million short tons, 35.3 percent higher than in 1997. Petroleum-fired generation was 41.5 percent higher and accounted for 3.6 percent of total generation, up from 2.7 percent in 1997. The increase in petroleum-fired generation was the result of a drop of 26 percent in the average price of petroleum delivered to electric utilities. The $CO_2$ emissions from petroleum-fired plants contributed 5 percent of the total from electricity generation in 1998. The average output rate for all petroleum-fired generation was 1.857 lbs / kWh in 1998, a decrease from the rate of 1.943 in 1997.

Petroleum-fired generation is concentrated mainly in the New England, South Atlantic, and Pacific Noncontiguous Census Divisions. In these regions, Connecticut, Maine, Massachusetts, Delaware, Florida, Alaska, and Hawaii use petroleum-fired generation to provide a substantial portion of their electricity. In 1998, Florida, New York, and Massachusetts contributed the largest amounts in tons of $CO_2$ emissions from petroleum-fired plants.

## Natural Gas

Emissions of $CO_2$ from natural gas-fired generation were 317 million short tons, 11.8 percent higher in 1998 than in 1997. Emissions of $CO_2$ from natural gas-fired plants represented 13 percent of total $CO_2$ emissions from electricity generation in 1998. Natural gas-fired electricity generation increased by 9.9 percent and accounted for 13.7 percent of total generation in 1998, up from 12.9 percent in 1997. Gas-fired plants were slightly less efficient in 1998 than in 1997. The output rate in 1997 was 1.255 lbs / kWh, rising to 1.277 lbs / kWh in 1998.

**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.

Gas-fired generation is concentrated in the West South Central Census Division in Texas, Oklahoma, and Louisiana. Also, Rhode Island, California, and Alaska use natural gas for a substantial portion of their generation. The largest amount in tons of $CO_2$ emissions from natural gas-fired generation was in Texas, followed by California, Louisiana, New York, and Florida.

## Nonfossil Fuels

Nonfossil-fueled generation from nuclear, hydroelectric and renewable sources (wind, solar, biomass, and geothermal) represented 30.3 percent of total electricity generation in 1998, compared with 31.1 percent in 1997. The use of nonfossil fuels and energy sources to generate electricity avoids the emission of $CO_2$ from combustion of fossil fuels. Due to lower marginal costs, nuclear and hydroelectric generation typically displace fossil-fueled generation.

Hydroelectric generation declined 9.5 percent in 1998. This caused the generation share from hydroelectric plants to be 8.4 percent of the total electricity generated, down from 9.6 percent in 1997.[5] The availability of hydroelectric power is affected by the weather. The Northwest began 1998 with a lower than normal snowpack level (despite 1998 being one of the wettest years on record[6]). However, the seasonal variation and distribution of precipitation were not as favorable in 1998 as in 1997 for hydroelectric generation, particularly in the Northwest.

More than one-half of all U.S. hydroelectric generation is located in the Pacific Contiguous Census Division, which includes California, Oregon, and Washington. In 1998, Oregon and Washington experienced lower hydroelectric generation by 15 and 23 percent, respectively. Montana, Idaho, South Dakota, Maine, New York, and Arizona also generate a substantial share of their power

[5] Energy Information Administration, *The Electric Power Monthly*, DOE/EIA-0226(99/03) (Washington, DC, March 1999).
[6] Energy Information Administration, *The Cost and Quality of Fuels for Electric Utility Plants*, 1998, http://www.eia.doe.gov/cneaf/electricity/cq/cq_sum.html.

from hydroelectric plants. Due to poor weather conditions in 1998, hydroelectric generation decreased in all regions of the United States, except the South Atlantic Census Region.

Nuclear-powered generation increased by 7.2 percent in 1998, nearly returning to the record level of 1996. Nuclear power plants generated 18.6 percent of the total electricity in 1998, an increase from 17.9 percent in 1997.[7] The increase can be attributed to the reopening of plants that were offline in 1997 and to the trend of increasing nuclear plant capacity factors.[8] In 1998, the national nuclear capacity factor reached an all-time high of 78 percent compared to 71 percent in 1997. Almost half of nuclear power is generated in the New England, South Atlantic, and Middle Atlantic Census Divisions. About one-third of generation in these Divisions is produced at nuclear plants. At the State level, Pennsylvania, Illinois, and South Carolina generate the most nuclear-powered electricity.

The increase in nuclear generation offset much of the decrease in hydroelectric generation, resulting in a net increase of 0.7 percent for nonfossil-fueled generation in 1998 from 1997. Still, nonfossil-fueled electricity generation contributed a smaller share of total generation than in the previous year. The effect on $CO_2$ emissions is an increase in the average output rate, since a larger share of electricity was generated using fossil fuels.

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

The primary factors that change $CO_2$ 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. Many factors could contribute to these primary causes of change including economic growth, the price of electricity, the amount of imported electricity, weather, fuel prices, available generation from hydroelectric, renewable, and nuclear plants, demand-side management programs that encourage energy efficiency, programs that directly or indirectly limit other air emissions, such as requirements for the Clean Air Act Amendments of 1990, and the installation of new capacity with advanced technology that increases plant efficiency, such as combined-cycle plants and combined heat and power projects. The annual changes in $CO_2$ emissions are a net result of these complex and variable factors.

The increase of 3.7 percent in $CO_2$ emissions in 1998 is accounted for by the increase in fossil-fueled generation to meet the demand for electricity. Consumption of electricity in the United States grew by approximately 3.5 percent[9] in 1998. Most of the 3.6 percent increase (124 billion kWh) in generation of electricity in 1998 was produced by fossil-fueled plants, which increased generation by 4.8 percent (116 billion kWh). Emissions of $CO_2$ increased at a higher rate than total generation because of a greater increase in fossil-fueled generation in relation to nonfossil-fueled generation.

### Economic Growth

The demand for electric power is influenced by economic factors. In 1998, a strong economy was measured by the 3.9-percent increase in the Gross Domestic Product (GDP). Electricity consumption for the industrial and commercial sectors grew by 1.2 and 5.5 percent, respectively. Another economic factor that could increase demand for electricity is lower retail price. The national average revenue per kilowatthour (real price) fell 2.6 percent from 6.14 cents in 1997 to 5.98 cents[10] (in chained 1992 dollars) in 1998. Although the growing demand for electricity is mostly met by a corresponding growth in generation, a small amount is met by imported power, primarily from Canada. Net imports of electricity were 28.8 billion kWh in 1998, down from 31.9 billion kWh in 1997.[11]

### Weather

Another factor that affects the year-to-year changes in demand for electricity is the weather. The year 1998

[7] Energy Information Administration, *The Electric Power Monthly*, DOE/EIA-0226(99/03) (Washington, DC, March 1999).

[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 megawatts, 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 Sales and Revenue 1998*, DOE-0540(98) (Washington, DC, October 1999).

[10] In nominal dollars, average revenue per kilowatthour was 6.85 cents/kWh in 1997 and 6.74 cents/kWh in 1998.

[11] Energy Information Administration, *Monthly Energy Review, August 1999*, at http://www.eia.doe.gov/emeu/mer/contents.html.

was one of the warmest years on record for the United States, and the warmest summer on record in Florida and Texas. All regions, except the Pacific and Mountain Census Divisions, had more cooling degree days[12] in 1998 than in 1997.

Many electric utilities reached record peak loads in the summer of 1998, driven mostly by the demand for power for air conditioning. Electric utilities consumed a record amount of coal to meet the higher than normal demand. Warmer summer weather in 1998 caused electricity generation in June, July, and August to be 6.5 percent higher[13] than in the same months of 1997. Although the winter was also warmer than normal, generation of electricity for January, February, and December of 1998 was down by about 1 percentage point from 1997, not enough to completely offset the summer increase. Increased demand in the summer of 1998 contributed to increases in $CO_2$ emissions of 6.5, 5.4, 6.6, and 3.3 percent in the Middle Atlantic, South Atlantic, West North Central, and West South Central Census Divisions, respectively.

## Demand-Side Management

The demand for electricity can be reduced by energy efficiency programs and demand-side management (DSM) programs. Some examples of DSM are improving insulation and replacing lighting and appliances with more energy efficient equipment. The reductions in demand achieved by DSM programs contribute to avoided $CO_2$ emissions. In 1998, 49.2 billion kWh of energy savings were achieved by DSM activities at electric utilities, a decrease from 56.4 billion kWh in 1997. Declining levels of energy savings reflect, in part, lower utility spending on DSM programs. 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.

## Fossil and Nonfossil Fuels for Electricity Generation

The type of fuel or energy source used to generate electricity affects the amount of $CO_2$ emissions produced. Since hydroelectric and nuclear generation displace fossil-fueled generation when available, $CO_2$ emissions increased where hydroelectric power was unavailable and fossil-fueled generation was used to replace it.

As stated earlier, the amount of hydroelectric power that is available is affected by precipitation patterns. Consequently, hydroelectric generation was lower in 1998 in all regions, except the South Atlantic Census Division and California. Oregon and Washington typically generate over 90 percent of their power at hydroelectric plants and export hydroelectric power to California. Because fossil-fueled generation was used to replace the hydroelectric power in these States, $CO_2$ emissions increased 8.5 percent in the Pacific Contiguous Census Division and 6.3 percent in the Mountain Census Division. In these Census Divisions, coal- and gas-fired generation likely increased to replace the loss of hydroelectric power. Even though hydroelectric generation increased in California, it was not enough to make up for the loss of imported power from the Northwest.

On the other hand, in the New England Census Division, gas-fired generation and its resultant $CO_2$ emissions decreased due to a 26-percent increase in nuclear generation. Higher nuclear generation in Florida, New Jersey, and Wisconsin also helped avoid emissions of $CO_2$ that would have occurred if fossil-fueled generation were used to meet the increased demand for electricity during the warmer than normal summer.

## Fuel Quality and Price

$CO_2$ emissions from the combustion of fossil fuels to generate electricity vary according to the quality of the fuels, defined by the carbon content and the heating value (Btu)[14] content. The Btu content of fuels is a determinant of the number of kilowatthours that can be produced[15] and carbon content is a determinate of the amount of carbon dioxide 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 generation had the highest output rate of carbon dioxide per kilowatthour produced, averaging 2.112 lbs / kWh in 1998. Petroleum-fired generation averaged 1.857 lbs / kWh, and natural gas-fired plants had the lowest rate of 1.277 lbs / kWh.

[12] Degree-days are relative measurements of outdoor air temperature. Cooling degree-days are deviations of the mean daily temperature above 65 degrees Fahrenheit. For example, a weather station recording a mean daily temperature of 78 degrees would report 13 cooling degree-days.

[13] Energy Information Administration, *Electric Power Monthly*, DOE / EIA-0226(99 / 03) (Washington, DC, March 1999).

[14] 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.

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

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, almost 81 percent of the total.

Some plants are capable of switching fuels to take advantage of the least expensive or the most available fuels. 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 is important when considering the capability of some electric plants to burn the least expensive of these two fuels. Some natural gas-fired generation was displaced by petroleum-fired generation, especially in New York and Florida. Since petroleum has a higher output rate of carbon dioxide than natural gas, switching to petroleum contributed to a higher average output rate for $CO_2$ emissions.

### 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 replacement of traditional power generators with more efficient technologies, such as combined-cycle generators and combined heat and power (CHP), thereby reducing wasted energy and resulting $CO_2$ emissions.

The national average efficiency of power generation from fossil fuels in 1998 was 32.7 percent, which was unchanged from the previous year. The average thermal efficiency of coal-fired plants increased slightly in 1998, reflected by the decrease in the average $CO_2$ emissions output rate of coal plants from 2.123 lbs / kWh in 1997 to 2.112 lbs / kWh in 1998. Petroleum-fired plants also showed an increase in thermal efficiency, with the average output rate going from 1.943 lbs / kWh in 1997 to 1.857 lbs / kWh in 1998. On the other hand, the thermal efficiency of gas-fired plants was lower in 1998 than in 1997, with the average output rate rising from 1.255 lbs / kWh to 1.277 lbs / kWh.

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

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

The Energy Information Administration prepares the *Annual Energy Outlook*, which contains annual projections of selected energy information, including carbon dioxide emissions and generation by fuel type. To evaluate the accuracy and usefulness of the forecast, a comparison was made between the latest forecast for 1998[16] and the actual data for 1998 (Table 5). The actual total $CO_2$ emissions were about 3.3 percent below the projected emissions, while the actual total generation was about 0.2 percent above the projected generation. The actual emissions were less than the projected level because not only was there less generation from coal than projected, but coal-fired plants operated more efficiently in 1998 than in 1997, therefore emitting less $CO_2$ per kWh than projected. Compared to the projection, the actual data show that coal was replaced by petroleum and nuclear energy for electricity generation, thus lowering the expected $CO_2$ emissions.

Electricity restructuring and the opening of retail competition in a number of States have added to the uncertainty of forecasting electricity demand and the generation mix that will be dispatched to meet this demand. The comparison of the data reflects these differences as well as possible differences in generating plant efficiencies and heat content of fossil fuels.

## Voluntary Carbon-Reduction and Carbon-Sequestration Programs

The Department of Energy (DOE) and the Environmental Protection Agency (EPA) operate voluntary

[16] The last projection for 1998 was made in October 1998 and published in the *Annual Energy Outlook* 1999. Actual data for 1998 becomes available in April 1999 for generation and September 1999 for carbon dioxide emissions.

**Table 5. U.S. Electric Power Industry Projected and Actual Carbon Dioxide Emissions and Generation, 1998**

| | Projected | Actual |
|---|---|---|
| $CO_2$ Emissions (million short tons)[a] | | |
| Coal | 2,057 | 1,979 |
| Petroleum | 109 | 122 |
| Natural Gas | 364 | 317 |
| Other Fuels (gas) | 4 | * |
| Other Fuels[b] | ** | 29 |
| **Total** | **2,530** | **2,447** |
| Generation (billion kWh)[c] | | |
| Coal | 1,900 | 1,874 |
| Petroleum | 120 | 131 |
| Natural Gas | 517 | 497 |
| Other Fuels (gas) | 5 | * |
| Other Fuels[b] | ** | 23 |
| Non-Fossil Fuels[d] | 1,072 | 1,095 |
| **Total** | **3,613** | **3,619** |

[a]Table 17, *Annual Energy Outlook 1999*, NEMS run–base case (calculated for cogenerators, see worksheet).

[b]Other includes municipal solid waste, tires, and other fuels that emit anthropogenic $CO_2$ when burned to generate electricity.

[c]Table 8, *Annual Energy Outlook 1999*, NEMS run–base case.

[d]Have zero or net zero carbon emissions.

* Included in Natural Gas in Actual Data.

** Not counted as anthropogenic emissions in the projected estimates.

Notes: Data for $CO_2$ emissions for 1998 are preliminary. Components may not add to total due to rounding. Emissions for cogenerators is based on the estimated fuel consumed only for electricity generation (excludes the fuel consumed for useful thermal output).

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

The Energy Information Administration's (EIA) Voluntary Reporting of Greenhouse Gases Program collects information from organizations that have undertaken carbon-reducing or carbon-sequestration projects. Most electric utilities participate in voluntary emission reduction activities through the Climate Challenge program. In 1998, 123 organizations in the electric power sector reported on 1,224 projects. By undertaking these projects, participants indicate that they reduced $CO_2$ emissions by 172 million short tons of $CO_2$ (42.6 million metric tons of carbon)[17] (Table 6). The organizations almost universally measured their project-level reductions by comparison with what emissions would have been in the absence of the project. Reported reductions are 7.0 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 7.0 percent of total reported reductions.

The Climate Challenge program 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 U.S. Department of Energy to achieve a certain level of emissions reductions to participate in specific projects. Companies making Climate Challenge commitments accounted for about 71 percent of 1990 U.S. electric utility generation.[18] Climate Challenge participants are required to report their achieved emissions reductions to the Voluntary Reporting Program.

Results from the Climate Challenge program cannot be compared directly to other figures in this report because 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.[19]

The largest reductions claimed for 1998 are from major U.S. electric utilities: the Tennessee Valley Authority (29 million tons), TXU (22 million tons), Duke Energy (13

[17] The EIA also receives numerous reports on projects and emission reductions from reporters outside the electric power sector. Many reports (including electric power sector reports) include reductions of greenhouse gases other than carbon dioxide.

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

[19] See the *1997 Climate 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.

**Table 6. Electric Power Sector Carbon Dioxide Emission Reductions, 1997 and 1998**
(Million Short Tons of $CO_2$)

| Type of Reduction | 1997 | 1998 |
|---|---|---|
| **Domestic Reductions** | | |
| Emission Reduction Projects | 124.6 | 144.2 |
| Sequestration Projects | 0.3 | 0.6 |
| **Total Domestic Reductions** | **124.9** | **144.8** |
| **Foreign Reductions** | | |
| Emission Reduction Projects | 0.4 | * |
| Sequestration Projects | 10.7 | 10.9 |
| **Total Foreign Reductions** | **11.1** | **10.9** |
| **Total Long Form Emission Reductions** | **136.0** | **155.7** |
| Reductions Reported on Short Form | 7.2 | 16.5 |
| **Total $CO_2$ Reductions Reported** | **143.3** | **172.1** |

* = Less than 0.05 million short tons.

Note: Preliminary data from the 1998 reporting cycle. This data cannot be compared directly to other figures in this report because Climate Challenge participants can report emissions reductions using baselines and calculation methods different from those applied elsewhere.

Source: Energy Information Administration, Form EIA-1605, "Voluntary Reporting of Greenhouse Gases," and EIA-1605EZ, "Voluntary Reporting of Greenhouse Gases (Short Form)."

million tons), and FirstEnergy (12 million tons).[20] These four companies account for more than half of the $CO_2$ emission reductions reported in 1998 by electric utilities in the United States. 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 reported on many other types of activities, including construction of low emitting or zero-emitting generation capacity, demand-side management activities, distribution and transmission system upgrades, cogeneration projects, and coal ash recycling.

Utilities also undertook a number of carbon-sequestration projects. Although these projects do not directly affect $CO_2$ emissions from the electric sector, they do offset utility emissions. Foreign carbon-sequestration projects saved 10.9 million tons of $CO_2$ emissions, and domestic projects saved 0.6 million tons. These activities are dominated by three independent power producer subsidiaries of the AES Corporation, which reported 8.4 million tons of carbon 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 40 companies reported on their pro-rated share of their participation in the Edison Electric Institute's Utilitree program. 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, is reducing energy consumption in homes and office buildings across the Nation. EPA and DOE set energy-efficiency specifications for products ranging from office equipment, heating and cooling equipment, residential appliances, televisions and VCRs to new homes. The ENERGY STAR label for buildings serves as a benchmarking tool that allows building owners to evaluate the efficiency of their building relative to others. On average, buildings across the country can improve efficiency by 30 percent through a variety of

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

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 over 27 products and 3,400 product models. In 1998, energy consumption was reduced by more than 20 billion kWh due to the program, reducing greenhouse gas emissions by nearly 16 million short tons of $CO_2$ (Table 7). Through EPA's ENERGY STAR Buildings and Green Lights Partnership, more than 4 percent of U.S. buildings have undergone efficiency upgrades resulting in electricity savings in excess of 13 billion kWh and emissions reductions of 10 million short tons of $CO_2$.[21]

**Table 7. $CO_2$ Emission Reductions and Energy Savings from EPA's Voluntary Programs, 1997 and 1998**

| | 1997 | | 1998 | |
|---|---|---|---|---|
| | Million Short Tons of $CO_2$ Reduced | Billion kWh Saved | Million Short Tons of $CO_2$ Reduced | Billion kWh Saved |
| ENERGY STAR Labeled Products . . . . . | 8 | 10 | 16 | 20 |
| ENERGY STAR Buildings and Green Lights . . . . | 6 | 7 | 10 | 13 |
| Climate Wise . . . . . | 6 | 2 | 11 | 3 |

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), July 1999.

## 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 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 renewable portfolio standard, a public benefits fund, and tax credits for combined heat and power. 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 will reduce greenhouse gas emissions.

Following an exhaustive interagency review, the Department of Energy issued a *Supporting Analysis*[22] 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 carbon emissions by 238 million short tons (59 million metric tons carbon) in 2010. An EIA study[23] using the same assumptions from the supporting analysis produced similar results. Carbon emissions were 214 million short tons (53 million metric tons carbon) 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 carbon dioxide emissions from energy use by 162 to 243 million short tons (40 to 60 million metric tons carbon) annually by 2010. The Department of Energy and the Environmental Protection Agency see no recent developments that would change this projection. While competitive electricity markets can play an important role in reducing $CO_2$ emissions from electric power generation, additional measures could offer potential for cost-effective emission reductions in the electric power sector.

[21] 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), July 1999.

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

[23] 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.

## Electric Utility Data Sources

The electric utility data comes 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 megawatts (MW) or larger. Power plants with a total generator nameplate rating of 100 MW or more must complete the entire form, providing, among other things, 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.

The 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 megawatts or more (note: includes all nuclear units). Data are collected on an annual basis from the remaining operators of electric utility plants. The 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 or more megawatts. The Form FERC-423 is used to collect data on fuel contracts, fuel type, coal origin, fuel quality and delivered cost of fuel.

## Nonutility Data Source

The 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 megawatt (MW) or more, including cogenerators, small power producers, and other nonutility electricity generators. Facilities with a total generator nameplate rating of 1 MW or more must complete the entire form, providing, among other things, information about fuel consumption and quality. Facilities with a combined nameplate capacity of less than 25 megawatts are not required to complete Schedule V, "Facility Environmental Information," of the Form EIA-860B.

## $CO_2$ Coefficients

The coefficients for determining emissions of $CO_2$ from electric utility power plants come from the publication, "Emissions of Greenhouse Gases in the United States," (DOE/EIA-0573). The nonutility coefficients were developed to be consistent with the utility coefficients.

## Methodology

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

### *Steam Utility 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.

Step 5. Divide Annual $CO_2$ Emissions (Step 4) by 2000 to obtain result in short tons.

### *Nonsteam Utility Plants*

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

Step 1(b). If monthly EIA-759 is available, but not monthly FERC-423: Sum of Monthly Consumption (EIA-759) times Average Monthly Btu Content (calculated from FERC-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-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) 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.

Step 5. Divide Annual $CO_2$ Emissions (Step 4) by 2000 to obtain result in short tons.

### *Nonutility Plants*

Step 1. Annual Consumption (EIA-867) times Average Annual Btu Content (calculated from FERC-423) divided by Total Annual Consumption = Weighted Annual Btu Content Factor.

Step 2. Annual Consumption (EIA-867) 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.

Step 5. Divide Annual $CO_2$ Emissions (Step 4) by 2000 to obtain result in short tons.