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# Renewable Energy Annual 2000

## With Data For 1999

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**Energy Information Administration**
Office of Coal, Nuclear, Electric and Alternate Fuels
U.S. Department of Energy
Washington, DC 20585

This report is available on the Web at:
http://www.eia.doe.gov/fuelrenewable.html.

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# Preface

This is the sixth annual report published by the Energy Information Administration (EIA) that presents information on U.S. renewable energy consumption, capacity, and electricity generation; U.S. solar thermal and photovoltaic collector manufacturing activities; and U.S. geothermal heat pump manufacturing activities. It updates and provides more detail on renewable energy information than what's published in EIA's *Annual Energy Review 1999*.

The renewable energy resources included in the report are: biomass (wood, wood waste, municipal solid waste, landfill gas, ethanol, and other waste); geothermal; wind; solar (solar thermal and photovoltaic); and hydropower. However, hydropower is also regarded as a "conventional" energy source because it has furnished a significant amount of electricity for more than a century. Therefore, the contribution of hydropower to total renewable energy consumption is discussed, but not in great detail. Since EIA collects data only on terrestrial (land-based) solar energy systems, satellite and some military applications are not included in this report.

The first chapter provides an overview of renewable energy use and capability from 1995 through 1999. It discusses renewable energy consumption, electric capability and generation, and energy consumption for nonelectric use. Chapter 2 presents current (through 1999) information on the U.S. solar energy industry. EIA collected this information on the Form EIA-63A, "Annual Survey of Solar Collector Manufacturers," and the Form EIA-63B, "Annual Survey of Photovoltaic Module / Cell Manufacturers." Chapter 3 presents information on the U.S. geothermal heat pump industry. This information was collected on the Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey," and covers the calendar years, 1995 through 1999.

Appendix A describes EIA surveys that include information on renewable energy sources. Appendix B discusses renewable energy data and its limitations. Appendix C presents information on renewable electric generation and capability by State for 1998 and 1999. Appendix D provides a list of Internet addresses for web sites that include renewable energy information. Appendix E lists State agencies that provide energy information, including information on renewable energy. A glossary of renewable energy terms is also included.

The EIA was established formally by the Department of Energy Organization Act of 1977 (Public Law 95-91). The legislation requires EIA to carry out a comprehensive, timely, and accurate program of energy data collection and analysis. It also vests EIA with considerable independence in fulfilling its mission.

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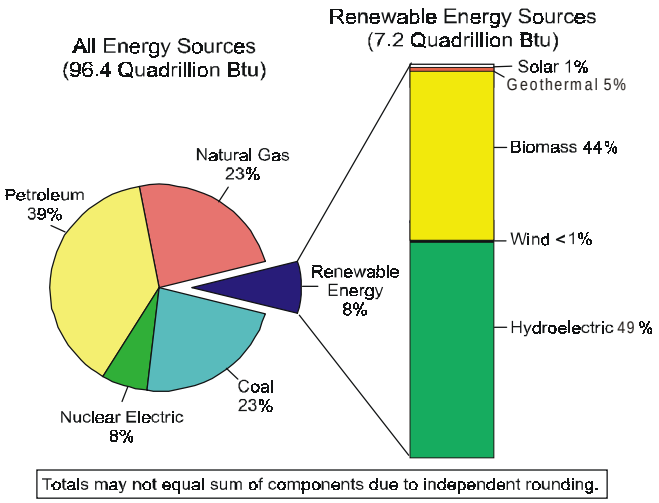
# Highlights

## Renewable Energy Consumption

Renewable energy consumption increased 3 percent between 1998 and 1999 to more than 7 quadrillion Btu, accounting for almost 8 percent of total U.S. energy consumption (Figure H1 and Table H1). Hydroelectric power and biomass continued to dominate the renewable energy market, with 49 percent and 44 percent shares, respectively.

**Figure H1. U.S. Energy Consumption by Source, 1999**




Source: Table 1 of this report.

Most of the increase was due to biomass energy consumption, which continued to be led by wood energy, which accounted for 80 percent of the biomass market. The industrial sector had the largest amount of wood consumption followed by the residential sector. Although comprising far less in market share, geothermal and wind energy consumption grew at a more rapid rate. Consumption of energy for hydroelectric power dropped for a second consecutive year.

U.S. renewable electricity generation rose 1 percent in 1999 from 1998. This reflects a decline in hydroelectric generation balanced against growth in electricity generated from other renewable sources. Biomass had the largest absolute increase in generation, but wind power expanded 50 percent in 1 year, while geothermal increased 14 percent.

The five leading States for renewable generation (in order of importance) in 1999 were Washington, California, Oregon, New York and Idaho. Hydroelectric generation dominated renewable generation in these regions. Combined, these States accounted for 62 percent of the renewable electricity generated in the United States.

Renewable energy consumption for nonelectric use rose nearly 7 percent in 1999, compared with just a 2-percent gain for renewable energy input to electricity generation. Over 97 percent of this was from biomass energy.

## Solar Manufacturing Activities

Total shipments of solar thermal collectors[1] were 9 million square feet in 1999. This represented an increase of 11 percent from the 1998 total of 8 million square feet and thus exceeded the 1997 total.

Low-temperature solar collectors represented 95 percent of total shipments while medium-temperature collectors were responsible for almost 5 percent. High-temperature collectors are used by utilities and nonutilities in experimental grid electricity programs and represent less than 1 percent of total shipments

The value of total shipments was $26 million in 1999, a decrease of 8 percent from 1998. The average price for total shipments decreased 17 percent, from $3.66 per square foot in 1998 to $3.05 per square foot in 1999. This was principally due to a 27-percent decrease in the

[1] Solar thermal collectors are divided into three categories of low, medium, and high-temperature collectors. The type is usually determined by the level of heat generated.

**Table H1. U.S. Renewable Energy Consumption by Energy Source, 1995-1999**
(Quadrillion Btu)

| Energy Source | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| Conventional Hydroelectric Power[a] | R3.481 | R3.892 | R3.961 | R3.569 | 3.512 |
| Geothermal Energy[b] | R0.333 | R0.346 | R0.322 | R0.328 | 0.373 |
| Biomass[c] | R3.044 | R3.104 | R2.982 | R2.991 | 3.208 |
| Solar Energy[d] | 0.073 | 0.075 | 0.074 | 0.074 | 0.072 |
| Wind Energy | 0.033 | 0.035 | R0.033 | 0.031 | 0.046 |
| **Total Renewable Energy** | **R6.964** | **R7.452** | **R7.373** | **R6.993** | **7.212** |

[a]Hydroelectricity generated by pumped storage is not included in renewable energy.
[b]Includes grid-connected electricity, geothermal heat pump and direct use energy.
[c]Includes wood, wood waste, peat, wood sludge, municipal solid waste, agricultural waste, straw, tires, landfill gases, fish oils, and/or other waste.
[d]Includes solar thermal and photovoltaic.
R = Revised data.
Notes: See Appendix B, "Renewable Energy Data Limitations," for a detailed explanation of data issues. Totals may not equal sum of components due to independent rounding.
Source: Table 1 of this report.

average price for low-temperature collectors, from $2.83 per square foot in 1998 to $2.08 per square foot in 1999.

The residential sector continued to be the prime market for solar collectors, totaling nearly 8 million square feet, or 91 percent of total shipments. The commercial sector was the second largest, with 1 million square feet (9 percent). The largest end use for solar collectors shipped in 1999 was for heating swimming pools, consuming 8 million square feet (95 percent) of total shipments.

Photovoltaic (PV) cell and module shipments[2] reached 77 peak megawatts in 1999, a 52-percent increase from the 1998 total of 51 peak megawatts. This was a substantially larger increase than the 9-percent increase experienced from 1997 to 1998. Module shipments accounted for 43 peak megawatts, while cell shipments accounted for 34 peak megawatts. This change in module shipments represented an increase of 33 percent since 1998, compared with an 85-percent gain in cell shipments. Exports totaled 56 peak megawatts in 1999, representing 72 percent of total shipments as compared to 70 percent in 1998. Imports jumped to 5 peak megawatts.

Crystalline silicon cells[3] and modules continued to dominate the PV industry in 1999, accounting for 96 percent of total shipments. Single-crystal shipments in 1999 totaled 47 peak megawatts, or 61 percent of total PV shipments, compared to 31 peak megawatts in 1998. Cast and ribbon silicon shipments totaled 26 peak megawatts in 1999, or 34 percent of total shipments. Thin-film shipments remained constant at 3.3 peak megawatts in 1999 and represented only 4 percent of total shipments.

The total value of PV cell and module shipments grew 26 percent to $234 million in 1999 from $185 million in 1998. For cells, the average price decreased 26 percent, from $3.15 in 1998 to $2.32 in 1999. The average price for modules (dollars per peak watt) decreased 8 percent, from $3.94 in 1998 to $3.62 in 1999.

The industrial sector replaced the residential sector as the largest market for PV cells and modules, growing 89 percent from 13 peak megawatts in 1998 to 25 peak megawatts in 1999. The residential sector grew 24 percent. Both the residential and industrial sectors have benefitted from new government-sponsored programs and loan subsidies in Japan and Germany. The United States also has implemented a "Million Solar Roofs Initiative" program at the State and national levels as well as various loan programs. In addition, the United States experienced economic growth with higher disposable income levels in 1999. Also, an increasing number of utilities sponsor ongoing programs such as net metering, portfolio standards, and green pricing. In

[2] A photovoltaic cell is an integrated device consisting of layers of semiconductor materials and electric contacts. Such a device is capable of converting incident light directly into electricity. A module is an integrated assembly of interconnected photovoltaic cells.

[3] Photovoltaic (PV) components are divided into three categories by product type: (1) crystalline silicon cells and modules which include single-crystal, cast silicon, and ribbon silicon; (2) thin-film cells and modules made from a number of layers of photosensitive materials such as amorphous silicon; and (3) concentrator cells and modules in which a lens is used to gather and converge sunlight onto the cell or module surface.

general, a growing group of industries and residential sector customers appears willing to pay for PV-based installations.[4]

The commercial sector, although the third largest sector in peak kilowatts shipped, more than doubled its use of PV cells and modules in 1999. PV shipments for consumer goods, which more than tripled from 1997 to 1998, nearly doubled from 1998 to 1999.

Electricity generation, which consists of both grid-interactive and remote applications, continues to be the predominant end use for PV cells and modules. In 1999, this sector accounted for 46 percent of total shipments, with grid interactive usage growing 75 percent.

Export shipments increased 57 percent from 35 peak megawatts in 1998 to 56 peak megawatts in 1999. Germany and Japan were the largest export markets and accounted for 63 percent of U.S. PV shipments exported.

## Geothermal Heat Pump Manufacturing Activities

Manufacturers shipped 49,162 geothermal heat pumps in 1999, an increase of 28 percent from the 1998 total of 38,266. The total rated capacity of heat pumps shipped in 1999 was 188,536 tons, compared to 141,446 tons in 1998.

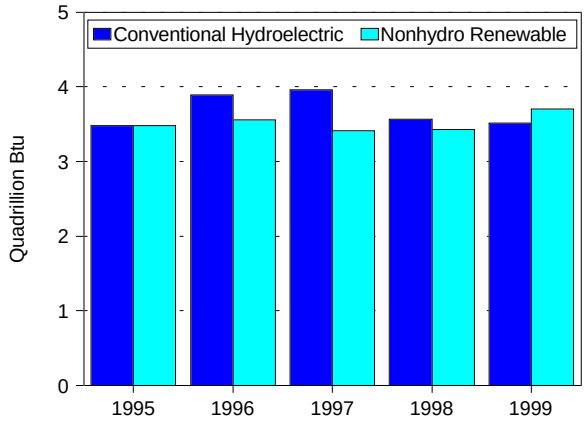
[4] National Renewable Energy Laboratory (NREL), *Willingness to Pay For Electricity from Renewable Resources: A Review of Utility Market Research*, NREL / TP.550.26148 (Golden, CO, July 1999). The report contains the results of a survey indicating that the majority of residential utility customers were willing to pay at least a modest amount more per month on their electric bills for power from renewable sources. PVs were among the most favored renewable sources of electricity.

# 1. U.S. Renewable Energy Consumption

Renewable energy maintained a 7.5 percent share of total U.S. energy consumption in 1999, unchanged from 1998 (Table 1). This represents a 0.2 percent drop in market share from 1995, when renewable energy contributed 7.7 percent of the total.

Conventional hydroelectric power continued to provide about half of renewable energy in 1999, even though it provided 2 percent less energy than a year ago (Figure 1). Energy from biomass increased 7.2 percent during 1999, accounting for 45 percent of total renewable energy consumed. Energy from geothermal and wind sources increased substantially in percentage terms, while solar energy experienced a slight decline. Combined, these 3 sources provided less than 7 percent of total renewable energy consumed in 1999.

**Figure 1. Renewable Energy Consumption by Source, 1995-1999**




Source: Table 1 of this report.

During the past 5 years, the greatest amount of renewable energy consumed was in 1996, when nearly 7.5 quadrillion Btu was consumed. That year, renewable energy accounted for nearly 8 percent of total U.S. energy consumption. Since 1995, total U.S. energy consumption has grown at a 1.5 percent rate,[1] compared with renewable energy's growth rate of nearly 1 percent.

The number of wind energy plants brought online during 1999 has made wind power one of the fastest growing renewable energy sources during the past 5 years.[2] Geothermal power, which had suffered major declines in the early 1990s as a result of production problems at the Geysers, has rebounded with gains in each of the past 2 years and is another fast-growing renewable energy source.

Renewable energy consumption increased in the industrial sector while declining in the electric utility sector (Table 2). This is an artifact of the sale of generating facilities by utilities to non-utilities as a result of electricity restructuring efforts. Transportation sector biomass (i.e., ethanol) increased 6 percent in 1999 and may expand much faster in the future if the other major gasoline oxygenate—methyl tertiary butyl ether (MTBE)—is outlawed as proposed in many States. Residential biomass energy consumption rose by more than 7 percent in 1999 after falling nearly 12 percent in 1998.

Renewable energy input to electricity generation, excluding net electricity imports, increased about 2 percent in 1999 to 4.3 quadrillion Btu (Table 3). Biomass and geothermal led the advance with gains of 9 and 14 percent, respectively, while conventional hydro and solar suffered small declines. Energy input to wind-based electricity scored a major gain, but represented only about 1 percent of total renewable energy input to electricity generation. Energy for net renewable electricity imports declined 7.5 percent to their lowest level in more than 5 years.

Actual electricity generation followed similar patterns. Total renewable-based electricity generation, excluding net electricity imports, rose 1.1 percent in 1999 (Table 4). This rate of growth for renewable generation exceeds the 5-year growth rate of 0.8 percent. The reason that renewable generation grew less than energy input to electricity generation is that, as mentioned previously, the growth in renewable electricity came from two sources (biomass and geothermal), which have relatively

[1] The growth rates shown in this chapter are average annual (compound) growth rates.
[2] Energy produced from photovoltaics technology, not delineated in Table 1, is also growing rapidly.

high heat rates. Renewable generation, excluding net electricity imports, accounted for 11 percent of total U.S. electricity generation in 1998 (Table C15).

Geothermal electricity imports (from Mexico) dropped by nearly one-third in 1999 and have dropped by 97 percent since 1995. This is largely the result of the expiration of two major export agreements with Mexico involving San Diego Gas and Electric and Southern California Edison. Conventional hydropower exports grew 60 percent, outweighing the 4-percent increase in hydropower imports. The result was a 7.5-percent decline in net renewable electricity imports. Thus, total renewable electricity generation (including net imports) grew nearly 1 percent in 1999 to 419 billion kilowatthours.

U.S. renewable generating capability grew 1.3 percent to 96 gigawatts in 1999 (Table 5). This was less than the 2.5 percent growth in non-renewable U.S. generating capability. Since 1995, the growth rates of renewable and non-renewable generating capability have been roughly comparable. Wind's market share of renewable capability increased 0.5 percent in 1999.

Over 80 percent of wood energy consumption in 1999 occurred in the industrial sector (Table 6). Most of the balance was from wood burned at residences. Residential wood energy use has generally declined over the past 5 years, in line with a decrease in average heating degree days. However, residential use of wood energy increased nearly 7 percent in 1999. Wood provides nearly 80 percent of total biomass energy. Consumption of waste energy, a component of biomass, was virtually unchanged in 1999. Alcohol fuels consumption increased 6 percent in 1999.

Renewable energy input to produce "direct" energy (i.e., heat, mostly in the form of steam) rose nearly 7 percent in 1999, compared with just a 2 percent gain for renewable energy input to produce electricity (Table 7). Of the 2.7 quadrillion Btu of renewable energy consumed to produce "non-electric" energy, over 97 percent was from biomass.

The vast majority of biomass energy used to produce non-electric energy was from wood and wood waste products used for process heat for the paper and pulp industries (in the industrial sector). Since 1995, industrial biomass energy for non-electric purposes has grown at nearly a 5 percent rate, and accounts for over three-fourths of all renewable energy consumed to produce non-electric energy. By comparison, industrial biomass energy accounted for only two-thirds of all renewable energy consumed to produce non-electric energy in 1995.

## Table 1. U.S. Energy Consumption by Energy Source, 1995-1999

(Quadrillion Btu)

| Energy Source | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| **Fossil Fuels** | | | | | |
| Coal | 20.024 | 20.940 | 21.444 | R21.593 | 21.698 |
| Coal Coke (Net Imports) | R0.061 | R0.023 | R0.046 | R0.067 | 0.058 |
| Natural Gas [a] | 22.163 | R22.559 | R22.530 | R21.921 | 22.096 |
| Petroleum [b] | R34.553 | R35.757 | R36.266 | R36.934 | 37.706 |
| **Total Fossil Fuels** | **R76.802** | **R79.279** | **R80.286** | **R80.515** | **81.557** |
| **Nuclear Electric Power** | **7.177** | **7.168** | **6.678** | **7.157** | **7.733** |
| **Hydroelectric Pumped Storage [c]** | **-0.028** | **-0.032** | **-0.042** | **-0.046** | **-0.063** |
| **Renewable Energy** | | | | | |
| Conventional Hydroelectric Power [d] | R3.481 | R3.892 | R3.961 | R3.569 | 3.512 |
| Geothermal Energy [e] | R0.333 | R0.346 | R0.322 | R0.328 | 0.373 |
| Biomass [f] | R3.044 | R3.104 | R2.982 | R2.991 | 3.208 |
| Solar Energy [g] | 0.073 | 0.075 | 0.074 | 0.074 | 0.072 |
| Wind Energy | 0.033 | 0.035 | R0.033 | 0.031 | 0.046 |
| **Total Renewable Energy** | **R6.964** | **R7.452** | **R7.373** | **R6.993** | **7.212** |
| **Total Energy Consumption** | **R90.940** | **R93.881** | **R94.331** | **R94.579** | **96.435** |

[a]Includes supplemental gaseous fuels.
[b]Petroleum products supplied, including natural gas plant liquids and crude oil burned as fuel.
[c]Represents total pumped-storage facility production minus energy used for pumping.
[d]Hydroelectricity generated by pumped storage is not included in renewable energy.
[e]Includes grid-connected electricity, geothermal heat pump and direct use energy.
[f]Includes wood, wood waste, peat, wood sludge, municipal solid waste, agricultural waste, straw, tires, landfill gases, fish oils, digester gas, methane and/or other waste.
[g]Includes solar thermal and photovoltaic.
R = Revised data.

Notes: See Appendix B for a detailed explanation of limitations on renewable energy data. Totals may not equal sum of components due to independent rounding.

Sources: **Non-renewable energy:** Energy Information Administration (EIA), *Annual Energy Review 1999*, DOE/EIA-0384(99) (Washington, DC, July 2000), Table 1.3. **Renewable Energy:** Table 2 of this report.

## Table 2. Renewable Energy Consumption by Sector and Energy Source, 1995-1999

(Quadrillion Btu)

| Sector and Source | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| **Residential/Commercial** | | | | | |
| Biomass | 0.641 | 0.644 | R0.480 | R0.424 | 0.455 |
| Solar | 0.065 | 0.066 | 0.065 | 0.065 | 0.063 |
| Geothermal [a] | 0.011 | 0.012 | 0.013 | 0.015 | 0.015 |
| **Total** | **0.717** | **0.722** | **R0.558** | **R0.503** | **0.534** |
| **Industrial** [b] | | | | | |
| Biomass | R2.281 | R2.366 | R2.385 | R2.441 | 2.620 |
| Geothermal [a] | R0.204 | R0.210 | R0.194 | R0.204 | 0.322 |
| Conventional Hydroelectric Power [c] | R0.151 | R0.169 | R0.183 | R0.150 | 0.202 |
| Solar | 0.008 | 0.009 | 0.009 | 0.009 | 0.009 |
| Wind | 0.033 | 0.035 | 0.033 | 0.031 | 0.046 |
| **Total** | **R2.677** | **R2.789** | **R2.804** | **R2.835** | **3.199** |
| **Transportation** | | | | | |
| Biomass [d] | **0.104** | **0.074** | **0.097** | **0.105** | **0.112** |
| **Electric Utility** | | | | | |
| Biomass | 0.017 | 0.020 | R0.021 | 0.021 | 0.021 |
| Geothermal [a] | 0.099 | 0.110 | 0.115 | R0.109 | 0.036 |
| Conventional Hydroelectric Power [c] | 3.056 | R3.423 | R3.535 | R3.195 | 3.103 |
| Solar and Wind | * | * | * | * | * |
| Net Renewable Energy Imports [e] | 0.293 | R0.313 | R0.244 | R0.225 | 0.208 |
| **Total** | **R3.466** | **R3.867** | **R3.914** | **R3.550** | **3.367** |
| **Total Renewable Energy Consumption** | **R6.964** | **R7.452** | **R7.373** | **R6.993** | **7.212** |

[a]Includes geothermal heat pump and direct use energy. The Industrial and Electric Utility sectors also include grid connected electricity.
[b]Includes generation of electricity by cogenerators, independent power producers, and small power producers.
[c]Hydroelectricity generated by pumped storage is not included in renewable energy.
[d]Ethanol blended into gasoline.
[e]Includes only net imports of electricity known to be from renewable resources (geothermal and hydroelectric).
R = Revised data.
* = Value less than 0.5 trillion Btu.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **Electricity Consumption—**Energy Information Administration, Form EIA-759, "Monthly Power Plant Report;" Form EIA-867, "Annual Nonutility Power Producer Report;" and Form EIA-860B, "Annual Electric Generator Report – Nonutility." **Non-electricity Consumption—**Based on analysis by the EIA, Office of Coal, Nuclear, Electric and Alternate Fuels. **Net Renewable Energy Imports, 1995-1999:** Based on data from the National Energy Board of Canada, the California Energy Commission and analysis by the EIA, Office of Coal, Nuclear, Electric and Alternate Fuels.

**Table 3. Renewable Energy Consumption for Electricity Generation by Energy Source, 1995-1999**
(Quadrillion Btu)

| Source | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| **Industrial Sector** [a] | | | | | |
| Biomass | R0.567 | R0.574 | R0.547 | R0.528 | 0.576 |
| Geothermal | R0.201 | R0.207 | R0.191 | R0.201 | 0.318 |
| Hydroelectric | R0.151 | R0.169 | R0.183 | R0.150 | 0.202 |
| Solar | 0.008 | 0.009 | 0.009 | 0.009 | 0.009 |
| Wind | 0.033 | 0.035 | 0.033 | 0.031 | 0.046 |
| **Total** | **R0.960** | **R0.994** | **R0.963** | **R0.918** | **1.151** |
| **Electric Utility Sector** [b] | | | | | |
| Biomass | 0.017 | 0.020 | R0.021 | 0.021 | 0.021 |
| Geothermal | 0.099 | 0.110 | 0.115 | R0.109 | 0.036 |
| Conventional Hydroelectric | 3.056 | R3.423 | R3.535 | R3.195 | 3.103 |
| Solar and Wind | * | * | * | * | * |
| **Total** | **3.173** | **R3.553** | **R3.670** | **R3.325** | **3.159** |
| **Electric Power Industry** | | | | | |
| Biomass | 0.584 | 0.594 | 0.567 | 0.548 | 0.596 |
| Geothermal | 0.300 | 0.317 | 0.305 | 0.309 | 0.353 |
| Hydroelectric | 3.207 | 3.593 | 3.718 | 3.345 | 3.305 |
| Solar | 0.008 | 0.009 | 0.009 | 0.009 | 0.009 |
| Wind | 0.033 | 0.035 | 0.033 | 0.031 | 0.046 |
| **Total** | **4.133** | **4.548** | **4.633** | **4.243** | **4.310** |
| **Imports and Exports** | | | | | |
| Geothermal | 0.019 | 0.014 | * | 0.001 | 0.001 |
| Conventional Hydroelectric | R0.291 | R0.306 | R0.281 | R0.269 | 0.280 |
| Conventional Hydroelectric (Exports) | R0.017 | R0.007 | R0.037 | R0.046 | 0.073 |
| **Total Net Renewable Energy Imports** | **R0.293** | **R0.313** | **R0.244** | **R0.225** | **0.208** |
| **Total** | **R4.425** | **R4.861** | **R4.877** | **R4.468** | **4.518** |

[a]Includes generation of electricity by cogenerators, independent power producers, and small power producers.
[b]Excludes imports.
R = Revised data.
* = Value less than 0.5 trillion Btu.
Note: Totals may not equal sum of components due to independent rounding.
Sources: Energy Information Administration, Form EIA-759, "Monthly Power Plant Report;" Form EIA-867, "Annual Nonutility Power Producer Report;" and Form EIA-860B "Annual Electric Generator Report – Nonutility." Trade data from the National Energy Board of Canada, the California Energy Commission, and analysis by the EIA, Office of Coal, Nuclear, Electric and Alternate Fuels.

## Table 4. Electricity Net Generation From Renewable Energy by Energy Source, 1995-1999

(Thousand Kilowatthours)

| Source | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| **Nonutility Sector** [a] | | | | | |
| Biomass | 55,008,210 | 55,481,480 | 52,795,538 | 50,987,505 | 55,637,552 |
| Geothermal | 9,614,310 | 9,891,589 | 9,100,196 | 9,549,539 | 15,114,210 |
| Hydroelectric | 14,626,063 | 16,389,835 | 17,672,917 | 14,486,196 | 19,569,876 |
| Solar | 799,467 | 875,745 | 866,105 | 853,742 | 844,920 |
| Wind | 3,153,156 | 3,365,645 | 3,215,659 | 2,985,342 | 4,464,997 |
| **Total** | **83,201,206** | **86,004,294** | **83,650,415** | **78,862,324** | **95,631,555** |
| **Electric Utility Sector** [b] | | | | | |
| Biomass | 1,649,178 | 1,967,057 | 1,983,065 | 2,024,242 | 1,991,535 |
| Geothermal | 4,744,804 | 5,233,927 | 5,469,110 | 5,176,280 | 1,698,400 |
| Conventional Hydroelectric | 296,377,840 | 331,058,055 | 341,273,443 | 308,843,770 | 299,913,955 |
| Solar | 3,909 | 3,169 | 3,481 | 2,518 | 3,035 |
| Wind | 11,097 | 10,123 | 5,977 | 2,957 | 23,001 |
| **Total** | **302,786,828** | **338,272,331** | **348,735,076** | **316,049,767** | **303,629,926** |
| **Electric Power Industry** [b] | | | | | |
| Biofuels | 56,657,388 | 57,448,537 | 54,778,603 | 53,011,747 | 57,629,087 |
| Geothermal | 14,359,114 | 15,125,516 | 14,569,306 | 14,725,819 | 16,812,610 |
| Hydroelectric | 311,003,903 | 347,447,890 | 358,946,360 | 323,329,966 | 319,483,831 |
| Solar | 803,376 | 878,914 | 869,586 | 856,260 | 847,955 |
| Wind | 3,164,253 | 3,375,768 | 3,221,636 | 2,988,299 | 4,487,998 |
| **Total** | **385,988,034** | **424,276,625** | **432,385,491** | **394,912,091** | **399,261,481** |
| **Imports and Exports** | | | | | |
| Geothermal (Imports) | 884,950 | 649,514 | 16,493 | 45,145 | 30,529 |
| Conventional Hydroelectric (Imports) | R28,258,173 | R29,641,876 | R27,095,696 | R26,025,972 | 27,042,653 |
| Conventional Hydroelectric (Exports) | R1,648,456 | R663,705 | R3,567,105 | R4,401,860 | 7,025,492 |
| **Total Net Imports** | **R27,494,667** | **R29,627,685** | **R23,545,084** | **R21,669,257** | **20,047,690** |
| **Total Renewable Electricity Generation** | **R413,482,701** | **R453,904,310** | **R455,930,575** | **R416,581,348** | **419,309,171** |

[a]Includes generation of electricity by cogenerators, independent power producers, and small power producers.
[b]Excludes imports.
R = Revised data.
Note: Totals may not equal sum of components due to independent rounding.
Sources: Energy Information Administration, Form EIA-759, "Monthly Power Plant Report"; Form EIA-867, "Annual Nonutility Power Producer Report"; and Form EIA-860B, "Annual Electric Generator Report – Nonutility." Trade data from the National Energy Board of Canada, the California Energy Commission, and analysis by the EIA, Office of Coal, Nuclear, Electric and Alternate Fuels.

## Table 5. U.S. Electric Generating Capability, 1995-1999

(Megawatts)

| Source | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| Hydroelectric [a] | 78,563 | 76,437 | 79,788 | 79,573 | 79,511 |
| Geothermal | 2,968 | 2,893 | 2,853 | 2,917 | 2,898 |
| Biomass [b] | 10,283 | 10,560 | 10,538 | R10,263 | 11,010 |
| Solar/Photovoltaic | 333 | 333 | 334 | 365 | 374 |
| Wind | [c]1,731 | 1,678 | 1,579 | 1,698 | 2,251 |
| **Total Renewables** | **93,877** | **91,900** | **95,093** | **R94,816** | **96,044** |
| Nonrenewables [d] | 675,640 | 683,972 | 683,409 | R681,069 | 697,913 |
| **Total** | **769,517** | **775,872** | **778,502** | **R775,885** | **793,957** |

[a]Excludes pumped storage, which is included in "Nonrenewables."

[b]There is a discontinuity in capability between 1999 and earlier years due to a change in reporting practices. In 1999 for the first time, nonutility respondents self identified the facility's primary energy source resulting in a reclassification compared to earlier years in some cases.

[c]Excludes 6.6 megawatts of utility capability and 35 megawatts of nonutility capability that were not captured by EIA sources.

[d]In addition to fossil-fired and nuclear capability, includes hydrogen, sulfur, batteries, chemicals, spent sulfite liquor, and hydroelectric pumped storage.

R = Revised data.

Notes: Capacity ratings for nonrenewables have been revised to reflect estimated net summer capability rather than nameplate capacity. The methodology for estimating net summer capability from reported nameplate capacity is presented in Energy Information Administration, *Inventory of Electric Utility Power Plants in the United States 1999,* DOE/EIA-0095(99/1) (Washington, DC, September 2000), p. 209. Totals may not equal sum of components due to independent rounding.

Sources: Energy Information Administration, Form EIA-860, "Annual Electric Generator Report;" Form EIA-867, "Annual Nonutility Power Producer Report;" Form EIA-860A, "Annual Electric Generator Report – Utility;" and Form EIA-860B, "Annual Electric Generator Report – Nonutility."

## Table 6. Biomass Energy Consumption by Sector and Census Region, 1995-1999

(Trillion Btu)

| Energy Source | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| **Wood Energy** [a] | **R2,418** | **R2,465** | **R2,348** | **R2,346** | **2,555** |
| Sector | | | | | |
| Residential | 596 | 595 | 433 | R377 | 404 |
| Commercial | 45 | 49 | R47 | R47 | 51 |
| Industrial | 1,771 | 1,813 | 1,860 | 1,914 | 2,093 |
| Electric Utility | R7 | R8 | R8 | R7 | 7 |
| Census Region | | | | | |
| Northeast | R368 | R267 | R253 | R237 | 257 |
| Midwest | R289 | R254 | R213 | R206 | 224 |
| South | R1,100 | 1,523 | R1,488 | R1,513 | 1,651 |
| West | R660 | R422 | R394 | R389 | 422 |
| **Waste Energy** [b] | **521** | **565** | **538** | **R540** | **541** |
| Source | | | | | |
| Municipal Solid Waste | 408 | 447 | 415 | R412 | 412 |
| Combustion | 333 | 359 | 317 | R303 | 303 |
| Landfill Gas | 75 | 88 | 98 | R109 | 109 |
| Manufacturing | 113 | 118 | 123 | 129 | 129 |
| Census Region | | | | | |
| Northwest | 172 | 187 | 191 | R185 | 185 |
| Midwest | 58 | 63 | 61 | 63 | 63 |
| South | 219 | 235 | 213 | R217 | 217 |
| West | 73 | 80 | 72 | R75 | 76 |
| **Alcohol Fuels (Ethanol)** | **104** | **74** | **97** | **105** | **112** |
| Census Region | | | | | |
| Northwest | R* | 7 | 9 | R9 | 10 |
| Midwest | R73 | 43 | 56 | 61 | 65 |
| South | R17 | 8 | 11 | 12 | 12 |
| West | R13 | 16 | 21 | 23 | 25 |
| **Biomass Energy Consumption** | **R3,044** | **R3,104** | **R2,982** | **R2,991** | **3,208** |

[a]Assuming an average energy yield of 17 million Btu per ton.
[b]Municipal solid waste, manufacturing waste, refuse-derived fuel, and methane recovered from landfills.
* = Less than 0.5 trillion Btu.
R = Revised data.
Note: Totals may not equal sum of components due to independent rounding.
Source: **1995-1998**: Energy Information Administration (EIA), *Annual Energy Review 1999,* DOE/EIA-0384(99) (Washington, DC, July 2000), Table 10.3. **1999**: Analysis by the EIA, Office of Coal, Nuclear, Electric and Alternate Fuels.

**Table 7. Renewable Energy Consumption for Nonelectric Use by Sector and Energy Source, 1995-1999**
(Quadrillion Btu)

| Sector and Source | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| **Residential/Commercial** | | | | | |
| Biomass | 0.641 | 0.644 | R0.480 | R0.424 | 0.455 |
| Solar | R0.065 | 0.066 | 0.065 | 0.065 | 0.063 |
| Geothermal | 0.011 | 0.012 | 0.013 | 0.015 | 0.015 |
| **Total** | **0.717** | **0.722** | **R0.558** | **R0.503** | **0.534** |
| **Industrial** [a] | | | | | |
| Biomass | R1.714 | R1.792 | R1.838 | R1.914 | 2.044 |
| Geothermal | 0.003 | 0.003 | 0.003 | 0.003 | 0.004 |
| **Total** | **R1.717** | **R1.795** | **R1.841** | **R1.917** | **2.048** |
| **Transportation** | | | | | |
| Biomass | 0.104 | 0.074 | 0.097 | 0.105 | 0.112 |
| **Total** | **R2.538** | **R2.591** | **R2.496** | **R2.526** | **2.694** |

[a]Does not include small amounts of energy from solar and wind in the industrial sector, because data are not available.
R = Revised data.
Note: Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels analysis.

# 2. Solar Thermal and Photovoltaic Collector Manufacturing Activities

## Introduction

Material in this chapter is based upon manufacturing shipment information reported on Form EIA-63A ("Annual Solar Thermal Collector Manufacturers Survey") and Form EIA-63B ("Annual Photovoltaic Module/Cell Manufacturers Survey"). Domestic shipments of photovoltaic cells and modules have more than tripled since 1993 (Table 8), while solar thermal collector shipments have grown 23 percent (Table 9).

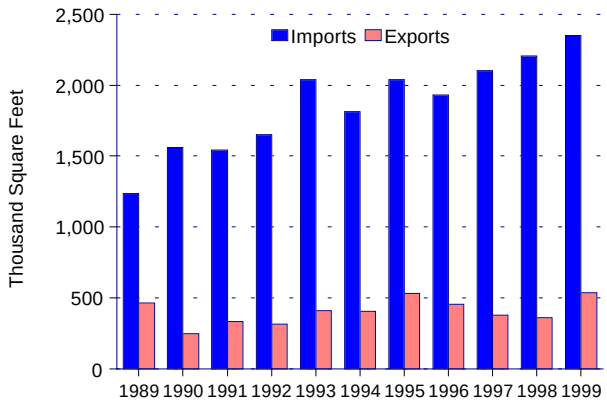
## Solar Thermal Collector Manufacturing Activities

Total shipments of solar thermal collectors[3] were 8.6 million square feet in 1999. This represented an increase of 10.7 percent from the 1998 total of 7.8 million square feet and exceeded the 1997 total of 8.1 million square feet. There were 29 companies shipping solar collectors in 1999. Import shipments totaled 2.4 million square feet, while export shipments were 0.5 million square feet (Figure 2).

Low-temperature solar collectors represented 95 percent of total shipments, while medium-temperature collectors were responsible for almost 5 percent (Table 10). High-temperature collectors are used by utilities and nonutilities in experimental grid electricity programs and represent less than 1 percent of total shipments (Table 10, Figure 3). U.S. manufacturers from 6 States (California, New Jersey, Florida, Hawaii, Texas, and New York) and Puerto Rico manufactured nearly all of U.S. solar thermal collectors in 1999 (Table 11). Shipments included both components and integrated solar collector systems.

Domestic shipments were sent to 41 States, the District of Columbia, Guam, Puerto Rico, and the Virgin Islands

**Figure 2. Import and Export Shipments of Solar Thermal Collectors, 1989-1999**




Notes: Total shipments as reported by respondents include all domestic and export shipments and may include imports that subsequently were shipped to domestic or foreign customers.

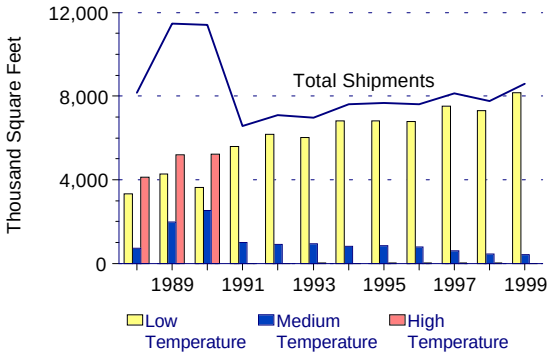
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

(Table 12). Exports went mainly to Canada (46.6 percent), Sweden (8.4 percent), Mexico (7.9 percent), and Germany (5.2 percent) (Table 13). Fifty-seven percent of total shipments was sent directly to wholesale distributors, 36 percent to retail distributors, 2 percent to installers, 2 percent to exporters, and 2 percent to other end users (Table 14). Compared with 1998, wholesale distributors gained at the expense of retail distributors.

The value of total shipments was $26.2 million in 1999, a decrease of 8 percent from 1998 (Table 15). The average price for total shipments decreased 17 percent, from $3.66 per square foot in 1998 to $3.05 per square foot in 1999. Low-temperature collectors registered a decrease in total value of 18 percent, from $20.6 million in 1998 to $17.0 million. This was principally due to a 27-percent

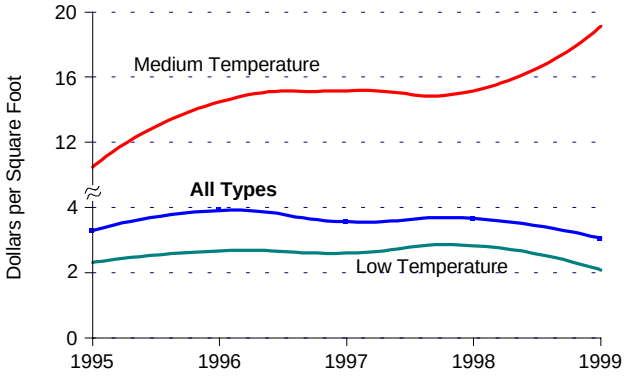
[3] Solar thermal collectors are divided into three categories: low-, medium-, and high-temperature collectors. The type is usually determined by the level of heat generated.

**Figure 3. Solar Thermal Collector Shipments by Collector Type, 1988-1999**




Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

**Figure 4. Average Price of Solar Thermal Collector Shipments by Collector Type, 1995-1999**




Note: The average price of high-temperature collectors, not shown in this figure, increased dramatically in 1999 from 1998. However, shipments of high-temperature collectors represented less than 0.25 percent of total shipments and thus had little impact on the overall trend.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

decrease in the average price for low-temperature collectors, from $2.83 per square foot in 1998 to $2.08 per square foot in 1999 (Figure 4, Table 15). This decrease was due primarily to decreasing material costs.

The residential sector continues to be the prime market for solar collectors, totaling nearly 7.8 million square feet, or 91 percent of total shipments (Table 16). The commercial sector was the second largest, with 0.8 million square feet (9.1 percent). The largest end use for solar collectors shipped in 1999 was for heating swimming pools, consuming 8.1 million square feet (95 percent) of total shipments. The second-largest use was for domestic hot water heating (4 percent). This marked a decrease from 1998, when domestic hot water heating represented approximately 6 percent of total shipments. The value of shipments of complete systems increased from $15.2 million in 1998 to $17.9 million in 1999 (Table 17).

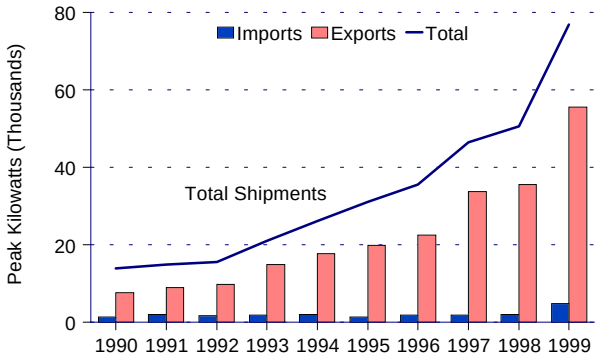
Of the 29 active companies shipping solar collectors, one is planning to introduce new low-temperature collectors, three are planning new medium-temperature collectors (two less than in 1998), and two expect to introduce high-temperature collectors (Table 18). In 1999, the industry remained highly concentrated—the 10 largest companies accounted for 98 percent of total shipments (Table 19). Employment increased 40 percent in 1999 from 1998 (Table 20). A total of 23 firms were involved in the design of collectors or systems, 12 were involved in prototype collector development, and 11 were active in prototype system development (Table 21). Twenty companies had over 90 percent of their total company-wide sales in solar collectors, while four companies had 50 to 89 percent, and 5 companies had less than 10 percent (Table 22).

## Photovoltaic Module and Cell Manufacturing Activities[4]

Photovoltaic (PV) cell and module shipments[5] reached 76.8 peak megawatts in 1999, a 52-percent increase from the 1998 total of 50.6 peak megawatts. This was a substantially larger increase than the 9.1-percent increase experienced from 1997 to 1998. Module shipments accounted for 43.1 peak megawatts, while cell shipments accounted for 33.7 peak megawatts. This change in module shipments represented an increase of 33 percent since 1998, compared with an 85-percent gain in cell shipments (Table 23). Exports totaled 55.6 peak megawatts in 1999, representing 72 percent of total shipments as compared to 70 percent in 1998. Imports jumped to 4.8 peak megawatts (Table 24 and Figure 5). Nineteen companies reported PV cell and module shipments, two fewer than in 1998 (Table 24).

[4] Data for cells and modules are for terrestrial use only (i.e., excludes space applications).
[5] A photovoltaic cell is an integrated device consisting of layers of semiconductor materials and electric contacts. Such a device is capable of converting incident light directly into electricity. A module is an integrated assembly of interconnected photovoltaic cells.

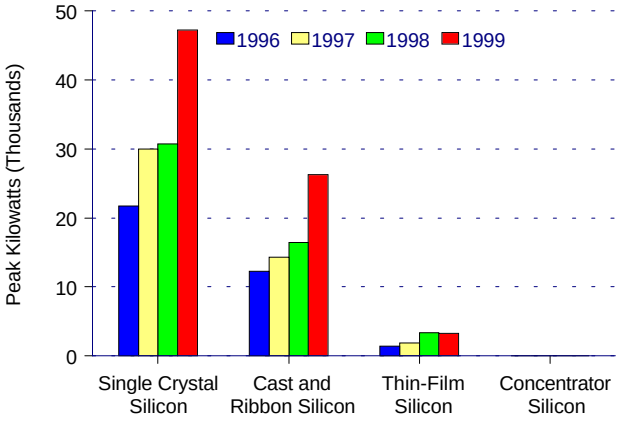
**Figure 5. Import and Export Shipments of Photovoltaic Cells and Modules, 1990-1999**




Note: Total shipments as reported by respondents include all domestic and export shipments and may include imports that subsequently were shipped to domestic or foreign customers.

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

**Figure 6. Photovoltaic Cell and Module Shipments by Type, 1996-1999**




Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Nearly 40 peak megawatts (52 percent) of total shipments were sent directly to wholesale distributors (Table 25). Module manufacturers and exporters combined received 27.5 peak megawatts, or 36 percent. Installers and retail distributors combined purchased 7.7 peak megawatts, or 10 percent.

Crystalline silicon cells[6] and modules continued to dominate the PV industry in 1999, accounting for 96 percent of total shipments (Table 26). Single-crystal shipments in 1999 totaled 47.2 peak megawatts, or 61 percent of total shipments, compared to 30.8 peak megawatts in 1998. Cast and ribbon silicon shipments totaled 26.2 peak megawatts in 1999, or 34 percent of total shipments. By comparison, cast and ribbon totaled 16.4 peak megawatts or 32 percent of total shipments in 1998. Thin-film shipments remained constant at 3.3 peak megawatts in 1999, and represented only 4 percent of total shipments (Figure 6).

The total value of photovoltaic cell and module shipments grew 26.6 percent to $234 million in 1999 from $185 million in 1998 (Table 27). The average price for modules (dollars per peak watt) decreased 8 percent, from $3.94 in 1998 to $3.62 in 1999. For cells, the average price decreased 26 percent, from $3.15 in 1998 to $2.32 in 1999.

The industrial sector replaced the residential sector as the largest market for PV cells and modules, growing 89 percent from 13 peak megawatts in 1998 to 25 peak megawatts in 1999 (Table 28). The residential sector grew 24 percent. Both the residential and industrial sectors have benefitted from new government sponsored programs and loan subsidies in Japan and Germany. Japan and Germany have increased the residential and industrial demand for PVs with subsidies for PV systems, as well as favorable tax credits and loan repayment timeframes. In developing countries like Indonesia and Brazil, the World Bank has made low interest energy loans with long term pay-back schedules for the installation of residential applications for PVs. The United States also has implemented a "Million Solar Roofs Initiative" program at the State and national levels as well as various loan programs. In addition, the United States experienced economic growth with higher disposable income levels in 1999. Also, an increasing number of utilities sponsor programs such as net metering, portfolio standards, and green pricing. In general, a growing group of industries and residential sector customers appears willing to pay for PV-based installations.[7]

[6] Photovoltaic (PV) components are divided into three categories by product type: (1) crystalline silicon cells and modules which include single-crystal, cast silicon, and ribbon silicon; (2) thin-film cells and modules made from a number of layers of photosensitive materials such as amorphous silicon; and (3) concentrator cells and modules in which a lens is used to gather and converge sunlight onto the cell or module surface.

[7] National Renewable Energy Laboratory (NREL), *Willingness to Pay For Electricity from Renewable Resources: A Review of Utility Market Research*, NREL / TP.550.26148 (Golden, CO, July 1999). The report contains the results of a survey, indicating that the majority of residential utility customers said that they were willing to pay at least a modest amount more per month on their electric bills for power from renewable sources. PVs were among the most favored renewable sources of electricity.

The commercial sector, the third largest sector in peak kilowatts shipped, more than doubled its use of PV cells and modules in 1999. PV shipments for consumer goods, which more than tripled from 1997 to 1998, nearly doubled from 1998 to 1999. This was the result of targeting the recreational vehicle and marine sectors, two fast-growing markets.

Electricity generation, which consists of both grid-interactive and remote applications, continues to be the predominant end use for PV cells and modules. In 1999, electric generation accounted for 46 percent of total shipments with grid interactive usage growing 75 percent. In 1999, communications and transportation end-uses were the second- and third-largest end uses, respectively. Cells and modules sold to Original Equipment Manufacturers, who fabricate products for sale to end users, surged from 5,044 peak kilowatts in 1998 to 12,400 in 1999.

Export shipments increased 57 percent from 35 peak megawatts in 1998 to 56 peak megawatts in 1999 (Table 29). Germany and Japan were the largest export markets. Germany accounted for 36 percent of exports and Japan received 27 percent of shipments exported (Table 30).

While complete PV systems[8] shipped increased by 72 percent in 1999, the total value of complete systems tripled to $23.3 million, as larger systems were shipped in 1999 than in 1998 (Table 31). Employment in the PV manufacturing industry increased by 1 percent in 1999, despite a decline in the number of manufacturers (Table 32). Nine companies plan to introduce crystalline silicon products, and 6 companies plan to introduce thin-film products (Table 33) in 2000. Many companies who are engaged in the manufacture and/or importation of PV modules and cells, reported that they also are involved in other PV-related activities—11 are involved in cell manufacturing and 15 in module or system design; 14 are involved in prototype module development and 11 in prototype systems development; 12 companies are active in wholesale distribution, 6 in retail distribution, and 6 in installation (Table 34).

[8] A complete PV system is defined as a power supply unit that satisfies all the power requirements of an application. Such a system is generally made up of one or more modules, a power conditioning unit to process the electricity into the form needed by the application, wires, and other electrical connectors. Batteries for back-up power supply are an option that can be included.

## Table 8. Annual Photovoltaic and Solar Thermal Domestic Shipments, 1993-1999

| Year | Photovoltaic Cells and Modules [a] (Peak Kilowatts) | Solar Thermal Collectors [a] (Thousand Square Feet) |
|---|---|---|
| 1993 | 6,137 | 6,557 |
| 1994 | 8,363 | 7,222 |
| 1995 | 11,188 | 7,136 |
| 1996 | 13,016 | 7,162 |
| 1997 | 12,561 | 7,759 |
| 1998 | 15,069 | 7,396 |
| 1999 | R21,225 | 8,046 |
| **Total** | **R87,559** | **51,278** |

[a] Total shipments minus export shipments.

R = Revised data.

Sources: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 9. Annual Shipments of Solar Thermal Collectors, 1993-1999

| Year | Number of Companies | Collector Shipments [a] (Thousand Square Feet) | | |
|---|---|---|---|---|
| | | Total [b] | Imports | Exports |
| 1993 | 41 | 6,968 | 2,039 | 411 |
| 1994 | 41 | 7,627 | 1,815 | 405 |
| 1995 | 36 | 7,666 | 2,037 | 530 |
| 1996 | 28 | 7,616 | 1,930 | 454 |
| 1997 | 29 | 8,138 | 2,102 | 379 |
| 1998 | 28 | 7,756 | 2,206 | 360 |
| 1999 | 29 | 8,583 | 2,352 | 537 |

[a] Includes imputation of shipment data to account for nonrespondents.

[b] Includes shipments of solar thermal collectors to the government, including some military, but excluding space applications.

Note: Total shipments as reported by respondents include all domestic and export shipments and may include imported collectors that subsequently were shipped to domestic or foreign customers.

Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 10. Annual Shipments of Solar Thermal Collectors by Type, 1993-1999

(Thousand Square Feet)

| Year | Low-Temperature | | Medium-Temperature | | High-Temperature |
|---|---|---|---|---|---|
| | Total Shipments [a, b] | Average per Manufacturer | Total Shipments [a] | Average per Manufacturer | Total Shipments [a, c] |
| 1993 | 6,025 | 464 | 931 | 28 | 12 |
| 1994 | 6,823 | 426 | 803 | 26 | 2 |
| 1995 | 6,813 | 487 | 840 | 32 | 13 |
| 1996 | 6,821 | 487 | 785 | 41 | 10 |
| 1997 | 7,524 | 579 | 606 | 29 | 7 |
| 1998 | 7,292 | 607 | 443 | 23 | 21 |
| 1999 | 8,152 | 627 | 427 | 21 | 4 |

[a] Includes imputation of shipment data to account for nonrespondents.
[b] Includes shipments of solar thermal collectors to the government, including some military, but excluding space applications.
[c] For high-temperature collectors, average annual shipments per manufacturer are not disclosed.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 11. Shipments of Domestic Solar Collectors Ranked by Top Five Origins and Destinations, 1998 and 1999

| Origin/Destination | 1998 Shipments | | 1999 Shipments | |
|---|---|---|---|---|
| | Thousand Square Feet | Percent of U.S. Total | Thousand Square Feet | Percent of U.S. Total |
| **Origin** | | | | |
| New Jersey, Florida and Hawaii | 2,596 | 47 | 3,207 | 51 |
| California | 2,651 | 48 | 2,838 | 46 |
| Texas | 160 | 3 | 72 | 1 |
| Puerto Rico | 63 | 1 | 71 | 1 |
| New York | 34 | 1 | 23 | * |
| **Top Five Total** | **5,504** | **100** | **6,211** | **100** |
| **Destination** [a] | | | | |
| Florida | 3,306 | 45 | 3,740 | 46 |
| California | 1,629 | 22 | 2,148 | 27 |
| Arizona | 412 | 6 | 430 | 5 |
| Nevada | 267 | 4 | 298 | 4 |
| Hawaii | 267 | 4 | 273 | 3 |
| **Top Five Total** | **5,880** | **81** | **6,889** | **86** |

[a] Represents all domestic shipments, including imported solar collectors.
* = Less than 0.5 percent.
Notes: Totals may not equal sum of components due to independent rounding. U.S. total includes territories.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 12. Shipments of Solar Thermal Collectors by Destination, 1999 (Square Feet)

| Destination | Shipments |
|---|---|
| Alabama | 13,032 |
| Alaska | 0 |
| Arizona | 429,748 |
| Arkansas | 1,282 |
| California | 2,147,947 |
| Colorado | 24,352 |
| Connecticut | R119,465 |
| Delaware | 0 |
| District of Columbia | 54 |
| Florida | 3,740,074 |
| Georgia | 69,525 |
| Guam | R11 |
| Hawaii | 272,914 |
| Idaho | 0 |
| Illinois | 100,434 |
| Indiana | 4,497 |
| Iowa | 1,375 |
| Kansas | 1,419 |
| Kentucky | 833 |
| Louisiana | 2,232 |
| Maine | 15,902 |
| Maryland | 2,625 |
| Massachusetts | 7,880 |
| Michigan | 21,879 |
| Minnesota | 14,684 |
| Mississippi | 0 |
| Missouri | 3,719 |
| Montana | 351 |
| Nebraska | 0 |
| Nevada | 298,074 |
| New Hampshire | 1,444 |
| New Jersey | 98,171 |
| New Mexico | 35,653 |
| New York | 61,658 |
| North Carolina | 8,790 |
| North Dakota | 0 |
| Ohio | 47,619 |
| Oklahoma | 1,730 |
| Oregon | 139,448 |
| Pennsylvania | 34,893 |
| Puerto Rico | 80,490 |
| Rhode Island | 0 |
| South Carolina | 1,704 |
| South Dakota | 0 |
| Tennessee | 5,611 |
| Texas | 128,581 |
| U.S. Virgin Islands | 15,491 |
| Utah | 364 |
| Vermont | 13,100 |
| Virginia | 27,546 |
| Washington | 42,352 |
| West Virginia | 0 |
| Wisconsin | 6,948 |
| Wyoming | 35 |
| **Shipments to United States/Territories** | **R8,045,935** |
| **Exports** | **R536,662** |
| **Total Shipments** | **8,582,597** |

R = Revised data.

Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 13. Distribution of U.S. Solar Thermal Collector Exports by Country, 1999

| Country | Percent of U.S. Exports |
|---|---|
| **Asia and the Middle East** | |
| Japan | 0.1 |
| Philippines | 0.3 |
| Taiwan | 1.6 |
| Vietnam | 0.5 |
| **Total** | R**2.5** |
| **Europe** | |
| Austria | 2.8 |
| Czech Republic | 4.4 |
| Denmark | 2.2 |
| France | 2.9 |
| Germany | 5.2 |
| Spain | 3.5 |
| Sweden | 8.4 |
| Switzerland | 1.1 |
| **Total** | **30.5** |
| **North America** | |
| Aruba | 0.2 |
| Bahamas | 0.2 |
| Bermuda | 0.0 |
| Bonaire | 0.1 |
| British Virgin Islands | 1.0 |
| Canada | 46.6 |
| Costa Rica | 0.8 |
| Guatemala | 0.0 |
| Honduras | 0.2 |
| Jamaica | 1.1 |
| Mexico | 7.9 |
| Netherlands Antilles | 0.1 |
| St Kitts | 0.1 |
| St Vincent | 0.2 |
| Trinidad & Tobago | 0.1 |
| Turks & Caicos Islands | 0.1 |
| **Total** | **58.7** |
| **South America** | |
| Argentina | 2.2 |
| Bolivia | 1.6 |
| Chile | 4.1 |
| **Total** | **7.9** |
| **Other** | **0.4** |
| **Total** | **100.0** |

R = Revised data.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 14. Distribution of Solar Thermal Collector Shipments, 1998 and 1999

| Recipient | Shipments (Thousand Square Feet) 1998 | 1999 |
|---|---|---|
| Wholesale Distribution | 3,872 | 4,922 |
| Retail Distributors | 3,199 | 3,075 |
| Exporters | 237 | 201 |
| Installers | 326 | 203 |
| End Users and Other [a] | 122 | 182 |
| **Total** | **7,756** | **8,583** |

[a] Other includes minimal shipments not explained on form EIA-63A.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration. Form EIA-63A. "Annual Solar Thermal Collector Manufacturers Survey."

## Table 15. Solar Thermal Collector Shipments by Type, Quantity, Value, and Average Price, 1998 and 1999

| Type | 1998 | | | 1999 | | |
|---|---|---|---|---|---|---|
| | **Quantity** (Thousand Square Feet) | **Value** (Thousand Dollars) | **Average Price** (Dollars per Square Foot) | **Quantity** (Thousand Square Feet) | **Value** (Thousand Dollars) | **Average Price** (Dollars per Square Foot) |
| Low-Temperature | | | | | | |
| Liquid and Air | 7,292 | 20,608 | 2.83 | 8,152 | 16,975 | 2.08 |
| Medium-Temperature | | | | | | |
| Air | 190 | 1,858 | 9.75 | 11 | 116 | 10.41 |
| Liquid | | | | | | |
| ICS/Thermosiphon | 76 | 1,879 | 24.76 | 84 | 2,131 | 25.34 |
| Flat Plate | 174 | 2,790 | 16.04 | 328 | 5,663 | 17.27 |
| Evacuated Tube | 2 | 168 | 84.00 | 2 | 194 | 94.07 |
| Concentrator | 0 | 0 | -- | 2 | 60 | 30.00 |
| All Medium-Temperature | 443 | 6,695 | 15.17 | 427 | 8,164 | 19.12 |
| High-Temperature | | | | | | |
| Parabolic Dish and Trough | 21 | 1,120 | 53.21 | 4 | 1,050 | 286.49 |
| **Total** | **7,756** | **28,423** | **3.66** | **8,583** | [a] **26,189** | **3.05** |

[a] Total includes institutional research project.
ICS = Integral collector storage.
Notes: Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 16. Shipments of Solar Collectors by Market Sector, End Use, and Type, 1998 and 1999

(Thousand Square Feet)

| Type | Low-Temperature | Medium-Temperature | | | | | High-Temperature | | |
|---|---|---|---|---|---|---|---|---|---|
| | Liquid/Air | | Liquid | | | | | | |
| | Metallic and Nonmetallic | Air | ICS/Thermosiphon | Flat-Plate (Pumped) | Evacuated Tube | Concentrator | Parabolic Dish/Trough | 1999 Total | 1998 Total |
| **Market Sector** | | | | | | | | | |
| Residential | 7,408 | 11 | 74 | 280 | 0 | 0 | 0 | **7,774** | **7,165** |
| Commercial | 726 | 0 | 9 | 48 | 2 | 0 | 0 | **785** | **517** |
| Industrial | 18 | 0 | 0 | 0 | 0 | 0 | 0 | **18** | **62** |
| Utility | 0 | 0 | 0 | * | 0 | * | 4 | **4** | **10** |
| Other [a] | 0 | 0 | 0 | 0 | 0 | 2 | 0 | **2** | **3** |
| **Total** | **8,152** | **11** | **84** | **328** | **2** | **2** | **4** | **8,583** | **7,756** |
| **End use** | | | | | | | | | |
| Pool Heating | 8,129 | 0 | 0 | 12 | 0 | 0 | 0 | **8,141** | **7,201** |
| Hot Water | 0 | 1 | 84 | 287 | 1 | 0 | 0 | **373** | **463** |
| Space Heating | 18 | 10 | 0 | 13 | 1 | 0 | 0 | **42** | **67** |
| Space Cooling | – | – | – | – | – | – | – | – | – |
| Combined Space and Water | 0 | 0 | 0 | 16 | 0 | 0 | * | **16** | **15** |
| Process Heating | 5 | 0 | 0 | 0 | 0 | 0 | 0 | **5** | **0** |
| Electricity Generation | 0 | 0 | 0 | 0 | 0 | 0 | 4 | **4** | **10** |
| Other [b] | * | 0 | 0 | * | 0 | 2 | 0 | **2** | **1** |
| **Total** | **8,152** | **11** | **84** | **328** | **2** | **2** | **4** | **8,583** | **7,756** |

[a]Other market sector include shipments of solar thermal collectors to sectors such as government, including some military, but excluding space applications.

[b]Other end use includes shipments of solar thermal collectors for other uses such as cooking, water pumping, water purification, desalinization, distillation, etc.

* = Less than 500 square feet.

ICS= Integral Collector Storage.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 17. Shipments of Complete Solar Thermal Collector Systems, 1998 and 1999

| Shipment Information | 1998 | 1999 |
|---|---|---|
| Complete Collector Systems | | |
| Shipped | 15,025 | 23,839 |
| Thousand Square Feet | 2,602 | 3,528 |
| Percent of Total Shipments | 34 | 41 |
| Number of Companies | 28 | 29 |
| Value of Systems (Thousand Dollars) | 15,242 | 17,854 |

Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 18. Number of Companies Expecting To Introduce New Solar Thermal Collector Products in 2000

| New Product Type | Number of Companies |
|---|---|
| Low-Temperature Collectors | 1 |
| Medium-Temperature Collectors | 3 |
| High-Temperature Collectors | 2 |
| Noncollector Components | 4 |

Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 19. Percent of Solar Collector Shipments by the 10 Largest Companies, 1993-1999

| Year | Company Rank | Shipments (Thousand Square Feet) | Percent of Total Shipments |
|---|---|---|---|
| 1993 | 1-5 | 6,135 | 88 |
| | 6-10 | 551 | 8 |
| 1994 | 1-5 | 6,401 | 84 |
| | 6-10 | 861 | 12 |
| 1995 | 1-5 | 6,525 | 85 |
| | 6-10 | 806 | 11 |
| 1996 | 1-5 | 6,452 | 85 |
| | 6-10 | 910 | 12 |
| 1997 | 1-5 | 7,183 | 88 |
| | 6-10 | 731 | 9 |
| 1998 | 1-5 | 6,938 | 89 |
| | 6-10 | 613 | 8 |
| 1999 | 1-5 | 7,813 | 91 |
| | 6-10 | 563 | 7 |

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration: Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 20. Employment in the Solar Thermal Industry, 1993-1999

| Year | Person Years |
|---|---|
| 1993 | 392 |
| 1994 | 402 |
| 1995 | 386 |
| 1996 | 239 |
| 1997 | 184 |
| 1998 | 207 |
| 1999 | 289 |

Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 21. Companies Involved in Solar Thermal Activities by Type, 1998 and 1999

| Type of Activity | 1998 | 1999 |
|---|---|---|
| Collector or System Design | 22 | 23 |
| Prototype Collector Development | 12 | 12 |
| Protype System Development | 10 | 11 |
| Wholesale Distribution | 20 | 16 |
| Retail Distribution | 16 | 18 |
| Installation | 12 | 12 |
| Noncollector System Component Manufacture | 9 | 7 |

Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 22. Solar-Related Sales as a Percentage of Total Sales, 1998 and 1999

| Percent of Total Sales | Number of Companies | |
|---|---|---|
| | 1998 | 1999 |
| 90-100 | 19 | 20 |
| 50-89 | 4 | 4 |
| 10-49 | 0 | 0 |
| Less than 10 | 5 | 5 |
| **Total** | **28** | **29** |

Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

## Table 23. Annual Shipments of Photovoltaic Cells and Modules, 1997-1999

(Peak Kilowatts)

| Item | 1997 | 1998 | 1999 |
|---|---|---|---|
| Cells | 12,709 | 18,249 | 33,714 |
| Modules | 33,645 | 32,313 | 43,073 |
| **Total** | **46,354** | **50,562** | **76,787** |

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 24. Annual Shipments of Photovoltaic Cells and Modules, 1993-1999

| Year | Number of Companies | Photovoltaic Cell and Module Shipments [a] (Peak Kilowatts) | | |
|---|---|---|---|---|
| | | Total | Imports | Exports |
| 1993 | 19 | 20,951 | 1,767 | 14,814 |
| 1994 | 22 | 26,077 | 1,960 | 17,714 |
| 1995 | 24 | 31,059 | 1,337 | 19,871 |
| 1996 | 25 | 35,464 | 1,864 | 22,448 |
| 1997 | 21 | 46,354 | 1,853 | 33,793 |
| 1998 | 21 | 50,562 | 1,931 | 35,493 |
| 1999 | 19 | 76,787 | 4,784 | R55,562 |

[a] Does not include shipments of cells and modules for space/satellite applications.

R = Revised data.

Note: Total shipments as reported by respondents include all domestic and export shipments and may include imported collectors that subsequently were shipped to domestic or foreign customers.

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 25. Distribution of Photovoltaic Cells and Modules, 1997-1999

| Recipient | Shipments (Peak Kilowatts) | | |
|---|---|---|---|
| | 1997 | 1998 | 1999 |
| Wholesale Distributers | 31,385 | 26,664 | 39,629 |
| Retail Distributers | 424 | 1,621 | 6,605 |
| Exporters | 4,081 | 7,002 | 11,152 |
| Installers | 1,236 | 3,993 | 1,054 |
| End-Users | 1,522 | 313 | 425 |
| Module manufacturers | 5,247 | 8,278 | 16,302 |
| Other [a] | 2,459 | 2,691 | 1,619 |
| **Total** | **46,354** | **50,562** | **76,787** |

[a] Other includes categories not identified by reporting companies.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-63B, " Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 26. Photovoltaic Cell and Module Shipments by Type, 1997-1999

| Type | Shipments (Peak Kilowatts) | | | Percent of Total | | |
|---|---|---|---|---|---|---|
| | 1997 | 1998 | 1999 | 1997 | 1998 | 1999 |
| Crystalline Silicon | | | | | | |
| Single Crystal | 29,977 | 30,758 | 47,220 | 65 | 61 | 61 |
| Cast and Ribbon | 14,317 | 16,428 | 26,241 | 31 | 32 | 34 |
| Subtotal | 44,313 | 47,186 | 73,461 | 96 | 93 | 96 |
| Thin-Film Silicon | 1,886 | 3,318 | 3,269 | 4 | 7 | 4 |
| Concentrator Silicon | 154 | 58 | 57 | * | * | * |
| **Total** | **46,354** | **50,562** | **76,787** | **100** | **100** | **100** |

* = Less than 0.5 percent.

Notes: Data do not include shipments of cells and modules for space/satellite applications. Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 27. Photovoltaic Cell and Module Shipment Values by Type, 1998 and 1999

| Type | Value (Thousand Dollars) | 1998 Average Price (Dollars per Peak Watt) | | Value (Thousand Dollars) | 1999 Average Price (Dollars per Peak Watt) | |
|---|---|---|---|---|---|---|
| | | Module | Cells | | Modules | Cells |
| Crystalline Silicon | | | | | | |
| Single-Crystal | 108,914 | 4.29 | 2.87 | 139,021 | 3.69 | 2.37 |
| Cast and Ribbon | 62,099 | 3.56 | 5.43 | R82,980 | 3.56 | R2.10 |
| Subtotal | 171,013 | 3.93 | 3.14 | R222,002 | 3.63 | 2.00 |
| Thin-Film Silicon | W | W | W | W | W | W |
| Concentrator Silicon | W | W | W | W | W | W |
| Other [a] | 0 | -- | -- | 0 | -- | -- |
| **Total** | **185,007** | **3.94** | **3.15** | **R234,163** | **3.62** | **R2.32** |

[a] Includes categories not identified by reporting companies.

R = Revised data.

W = Data withheld to avoid disclosure of proprietary company data.

-- = Does not apply.

Notes: Data do not include shipments of cells and modules for space/satellite applications. Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 28. Shipments of Photovoltaic Cells and Modules by Market Sector, End Use, and Type, 1998 and 1999

(Peak Kilowatts)

| Sector and End Use | Crystalline Silicon [a] | Thin-Film Silicon | Concentrator Silicon | Other | 1999 Total | 1998 Total |
|---|---|---|---|---|---|---|
| **Market** | | | | | | |
| Industrial | 24,150 | 822 | 0 | 0 | 24,972 | 13,232 |
| Residential | 18,403 | 1,408 | 6 | 0 | 19,817 | 15,936 |
| Commercial | 16,850 | 433 | 0 | 0 | 17,283 | 8,460 |
| Transportation | 4,281 | 60 | 0 | 0 | 4,341 | 3,440 |
| Utility | 5,283 | 551 | 42 | 0 | 5,876 | 3,965 |
| Government [b] | 3,041 | 66 | 0 | 0 | 3,107 | 2,808 |
| Other [c] | 1,383 | 0 | 9 | 0 | 1,392 | 2,720 |
| **Total** | **73,390** | **3,340** | **57** | **0** | **76,787** | **50,562** |
| **End Use** | | | | | | |
| Electricity Generation | | | | | | |
| Grid Interactive | 23,756 | 978 | 48 | 0 | 24,782 | 14,193 |
| Remote | 9,923 | 907 | 0 | 0 | 10,829 | 8,634 |
| Communications | 11,526 | 620 | 0 | 0 | 12,147 | 8,280 |
| Consumer Goods | 2,072 | 220 | 0 | 0 | 2,292 | 1,198 |
| Transportation | 8,458 | 27 | 0 | 0 | 8,486 | 6,356 |
| Water Pumping | 3,965 | 98 | 0 | 0 | 4,063 | 4,306 |
| Cells/Modules To OEM [d] | 11,915 | 485 | 0 | 0 | 12,400 | 5,044 |
| Health | 1,466 | 0 | 0 | 0 | 1,466 | 1,061 |
| Other [e] | 309 | 4 | 9 | 0 | 322 | 1,491 |
| **Total** | **73,390** | **3,340** | **57** | **0** | **76,787** | **50,562** |

[a] Includes single-crystal and cast and ribbon types.
[b] Includes Federal, State, local governments, excluding military.
[c] Other includes shipments that are manufactured for private contractors for research.
[d] Original equipment manufacturer.
[e] Other uses include shipments of photovoltaic and modules for other uses, such as cooking food, desalinization, distillation, etc.
Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 29. Export Shipments of Photovoltaic Cells and Modules by Type, 1998 and 1999

(Peak Kilowatts)

| | Type | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Crystalline | | Thin-Film Silicon | | Concentrator Silicon | | Total | |
| Item | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 | 1998 | 1999 |
| Cells | 16,430 | R31,008 | 0 | 0 | 48 | 9 | 16,478 | R31,017 |
| Modules | 17,765 | 23,587 | 1,249 | 958 | 1 | 0 | 19,015 | 24,545 |
| **Total** | **34,195** | **R54,595** | **1,249** | **958** | **49** | **9** | **35,493** | **R55,562** |

R = Revised data.
Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 30. Destination of U.S. Photovoltaic Cell and Module Export Shipments by Country, 1999

| Country | Peak Kilowatts | Percent of U.S. Exports |
|---|---|---|
| **Africa** | | |
| Angola | 0.2 | * |
| Burkina Faso | 0.3 | * |
| Egypt | 111.3 | 0.2 |
| Kenya | 22.8 | * |
| Mali | 36.5 | 0.1 |
| Morocco | 549.5 | 1.0 |
| Nigeria | 0.7 | * |
| Rwanda | 11.4 | * |
| South Africa, Rep of | 1,886.7 | 3.4 |
| Tanzania | 11.1 | * |
| Uganda | 0.1 | * |
| Zimbabwe | 11.4 | * |
| **Total** | **2,641.7** | **4.8** |
| **Asia and the Middle East** | | |
| Bangladesh | 35.4 | 0.1 |
| China | 258.5 | 0.5 |
| Hong Kong | 1,820.6 | 3.3 |
| India | 2,012.8 | 3.6 |
| Israel | 152.8 | 0.3 |
| Japan | 14,953.2 | 26.9 |
| Korea, Republic of | 193.8 | 0.3 |
| Mongolia | 8.8 | * |
| Nepal | 11.4 | * |
| Philippines | 34.2 | 0.1 |
| Saudi Arabia | 145.8 | 0.3 |
| Singapore | 743.5 | 1.3 |
| Taiwan | 707.0 | 1.3 |
| Thailand | 88.4 | 0.2 |
| United Arab Emirates | 268.6 | 0.5 |
| Yemen (Aden) | 22.8 | * |
| **Total** | **R21,457.5** | **38.6** |
| **Australia** | | |
| Australia | 262.2 | 0.5 |
| **Total** | **262.2** | **0.5** |
| **Europe** | | |
| Austria | 102.6 | 0.2 |
| Denmark | 11.4 | * |
| France | 179.4 | 0.3 |
| Germany | 20,046.7 | 36.1 |
| Greece | 11.4 | * |
| Ireland | 773.3 | 1.4 |
| Italy | 208.5 | 0.4 |
| Norway | 182.4 | 0.3 |
| Portugal | 11.4 | * |
| Spain | 1,899.9 | 3.4 |
| Sweden | 341.9 | 0.6 |
| Switzerland | 1,364.2 | 2.5 |
| United Kingdom | 203.1 | 0.4 |
| **Total** | **25,336.2** | **45.6** |

## Table 30. Destination of U.S. Photovoltaic Cell and Module Export Shipments by Country, 1999 (Continued)

| Country | Peak Kilowatts | Percent of U.S. Exports |
|---|---|---|
| **North America** | | |
| Bermuda | 0.1 | * |
| Canada | 958.9 | 1.7 |
| Costa Rica | 4.4 | * |
| Dominican Republic | 18.1 | * |
| El Salvador | 8.8 | * |
| Guatemala | 123.7 | 0.2 |
| Haiti | 17.7 | * |
| Honduras | 38.7 | 0.1 |
| Jamaica | 11.4 | * |
| Mexico | 830.1 | 1.5 |
| Netherlands Antilles | 68.4 | 0.1 |
| Nicaragua | 18.0 | * |
| Panama | 9.2 | * |
| Trinidad & Tobago | 20.2 | * |
| **Total** | **2,127.7** | **3.8** |
| **South America** | | |
| Argentina | 788.8 | 1.4 |
| Bolivia | 189.9 | 0.3 |
| Brazil | 1,881.2 | 3.4 |
| Chile | 93.5 | 0.2 |
| Colombia | 221.1 | 0.4 |
| Ecuador | 18.0 | * |
| Guadeloupe | 35.4 | 0.1 |
| Guyana | 0.1 | * |
| Other Latin America | 130.2 | 0.2 |
| Peru | 233.7 | 0.4 |
| Uruguay | 17.7 | * |
| Venezuela | 5.5 | * |
| **Total** | **R3,615.1** | **6.5** |
| **Other** | 121.8 | 0.2 |
| **Total U.S. Exports** | **R55,562.2** | **100.0** |

Notes: "Other" represents shipments to countries not disaggregated by companies on Form EIA-63B. Totals may not equal sum of component due to independent rounding.

R = Revised data.

* = Value less than 0.05 percent.

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 31. Shipments of Complete Photovoltaic Module Systems, 1997-1999

| Shipment Information | 1997 | 1998 | 1999 |
|---|---|---|---|
| Complete Photovoltaic Module Systems Shipped | 3,926 | 3,680 | 6,317 |
| Peak Kilowatts | 202 | 382 | 3,221 |
| Percent of Total Module Shipments | 1 | 1 | 7 |
| Value of Systems (Thousand Dollars) | 4,061 | 6,198 | 23,299 |

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 32. Employment in the Photovoltaic Manufacturing Industry,1993-1999

| Year | Number of Companies | Number of Person-Years |
|---|---|---|
| 1993 | 19 | 1,431 |
| 1994 | 22 | 1,312 |
| 1995 | 24 | 1,578 |
| 1996 | 25 | 1,280 |
| 1997 | 21 | 1,736 |
| 1998 | 21 | 1,988 |
| 1999 | 19 | 2,013 |

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 33. Companies Expecting to Introduce New Photovoltaic Products in 2000

| New Product Type | Number of Companies |
|---|---|
| Crystalline Silicon | |
| Single-Crystal Silicon Modules | 4 |
| Cast Silicon Modules | 2 |
| Ribbon Silicon Modules | 3 |
| Thin-Film | |
| Amorphous Silicon Modules | 2 |
| Other (Thin-Film) | 4 |
| Other (Flat Plate) | 0 |
| Concentrators | 1 |
| NonModule System Components | 1 |

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

## Table 34. Number of Companies Involved in Photovoltaic-Related Activities, 1998 and 1999

| Type of Activity | Number of Companies | |
|---|---|---|
| | 1998 | 1999 |
| Cell Manufacturing | 13 | 11 |
| Module or System Design | 18 | 15 |
| Prototype Module Development | 16 | 14 |
| Prototype Systems Development | 14 | 11 |
| Wholesale Distribution | 17 | 12 |
| Retail Distribution | 5 | 6 |
| Installation | 6 | 6 |
| Noncollector System Component Manufacturing | 6 | 5 |

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

# 3. Survey of Geothermal Heat Pump Shipments

Geothermal heat pump manufacturers shipped 49,162 geothermal heat pumps in 1999, an increase of 28 percent from the 1998 total of 38,266. Of those shipped in 1999, 13,236 were ARI-320 rated, an increase of 26 percent from 1998.[9] The total shipments of ARI-325 and ARI-330 were 34,271 in 1998, an increase of 32 percent. Non-ARI-rated units shipped in 1999 numbered 1,655, a decrease of 3 percent from 1998 (Table 35).

The total rated capacity of heat pumps shipped in 1999 was 188,536 tons, compared to 141,446 tons in 1998 (Table 36). The average capacity of heat pumps shipped in 1999, 3.8 tons, remained essentially unchanged from 1997 and 1998 levels.

Information on geothermal heat pump shipments is based on the Energy Information Administration's Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey." The proportion of geothermal heat pumps shipped to each Census Region in 1999 was as follows: the South (43 percent), the Midwest (27 percent), Export (13 percent), the Northeast (12 percent), and the West (6 percent) (Table 37).

Fifty-one percent of geothermal heat pumps were shipped to installers, 19 percent to wholesale distributors, 5 percent to retail distributors, and 13 percent to exporters (Table 38).

**Table 35. Geothermal Heat Pump Shipments by Model Type, 1995-1999**
(Number of Units)

| Model | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| ARI-320 | 4,696 | 4,697 | 7,772 | 10,510 | 13,236 |
| ARI-325/330 | 26,800 | 25,697 | 28,335 | 26,042 | 34,271 |
| Other Non-ARI Rated | 838 | 991 | 1,327 | 1,714 | 1,655 |
| **Totals** | 32,334 | 31,385 | 37,434 | 38,266 | 49,162 |

Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

**Table 36. Capacity of Geothermal Heat Pump Shipments by Model Type, 1995-1999**
(Total Rated Capacity Tons)

| Model | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|
| ARI-320 | 13,120 | 15,060 | 24,708 | 35,776 | 33,163 |
| ARI-325/330 | 113,925 | 92,819 | 110,186 | 98,912 | 149,303 |
| Other Non-ARI Rated | 3,935 | 5,091 | 6,662 | 6,758 | 6,070 |
| **Totals** | 130,980 | 112,970 | 141,556 | 141,446 | 188,536 |

Note: One ton of capacity is equal to 12,000 Btu's.
Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

[9] See Appendices A and B for an explanation of geothermal heat pump models.

**Table 37. Geothermal Heat Pump Shipments by Export, Census Region, and Model Type, 1999**
(Number of Units)

| Export and Census Region | ARI-320 | ARI-325/330 | Other Non-ARI Rated GHPs | Total |
|---|---|---|---|---|
| Export | 480 | 5,768 | 55 | 6,303 |
| Midwest | 3,175 | 9,419 | 518 | 13,112 |
| Northeast | 1,180 | 4,548 | 316 | 6,044 |
| South | 7,813 | 12,445 | 677 | 20,935 |
| West | 588 | 2,091 | 89 | 2,768 |
| **Total** | 13,236 | 34,271 | 1,655 | 49,162 |

GHPs = Geothermal heat pumps.

Notes: The Midwest Census region consists of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. The Northeast Census region consists of Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. The South Census region consists of Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, and West Virginia. The West Census region consists of Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. "Export" in Table 37 and "Exporter" in Table 38 are different—"Export" refers to where the geothermal heat pumps are shipped, while "Exporter" is the type of customer.

Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

**Table 38. Geothermal Heat Pump Shipments by Customer Type and Model Type, 1999**
(Number of Units)

| Customer Type | ARI-320 | ARI-325/330 | Other Non-ARI Rated GHPs | Total |
|---|---|---|---|---|
| Exporter | 480 | 5,637 | 55 | 6,172 |
| Wholesale Distributor | 1,042 | 8,109 | 42 | 9,193 |
| Retail Distributor | 0 | 1,405 | 1,150 | 2,555 |
| Installer | 6,242 | 18,468 | 207 | 24,917 |
| End-User | 0 | 0 | 66 | 66 |
| Others | 5,472 | 652 | 135 | 6,259 |
| **Total** | **13,236** | **34,271** | **1,655** | **49,162** |

GHPs = Geothermal heat pumps.

Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

## Appendix A

# EIA Renewable Energy Data Sources

The Energy Information Administration (EIA) develops renewable energy information from a wide variety of sources, cutting across different parts of the organization. This appendix provides a list of all sources that EIA uses to obtain renewable energy information. While most data come from EIA data collection forms, some are derived from secondary sources. For EIA data collections, additional information is available in the EIA publication *Directory of Energy Data Collection Forms 1996*, DOE/EIA-0249(96), December 1996, or through the EIA home page and on the EIA website:

http://www.eia.doe.gov/oss/forms.html
(January 18, 2001).

## EIA-63A/B, "Annual Solar Thermal Collector Manufacturers Survey" and "Annual Photovoltaic Module/Cell Manufacturers Survey"

**Energy Sources:** Solar energy.
**Energy Functions:** Disposition.
**Frequency of Collection:** Annually.
**Respondent Categories:** Solar thermal collector manufacturers and/or importers; photovoltaic module/cell manufacturers and/or importers;
**Reporting Requirement:** Mandatory.
**Description:** Forms EIA-63A/B are designed to gather for publication data on shipments of solar thermal collectors and photovoltaic modules. Data are collected by end use and market sector. Collector types include low-temperature, medium-temperature air, medium-temperature liquid, thermosiphon, flat plate, concentrator, integral collector storage, and evacuated tube and concentrators. Respondents are manufacturers, importers, and exporters of solar thermal collectors and photovoltaic modules. These forms were formerly known as CE-63A/B.

## EIA-457A/H, "Residential Energy Consumption Survey"

**Energy Sources:** Coal and coal products; electricity; natural gas; petroleum and petroleum products; wood.
**Energy Functions:** Consumption costs and/or prices.
Frequency of Collection: Quadrennially.
Respondent Categories: Electric utilities; natural gas distributors (including importers/exporters); petroleum and petroleum product distributors; institutions (nonprofit); individuals/households.
**Reporting Requirement:** Voluntary and mandatory.
**Description:** Forms EIA-457A through G are used to collect comprehensive national and regional data on both the consumption of and expenditures for energy in the residential sector of the economy. Data are used for analyzing and forecasting residential energy consumption. Housing, appliance, and demographic characteristics data are collected via personal interviews with households, and consumption and expenditure billing data are collected from the energy suppliers. End-use intensities are produced for space heating, water heating, air conditioning, refrigerators, and appliances. Rental agents are contacted by telephone to check on fuels used in rented apartments. Surveys were conducted in 1978, 1979, 1980, 1981, 1982, 1984, 1987, 1990, 1993, and 1997. Form EIA-457H is used to collect detailed lighting usage information for a subsample.

## EIA-819M, "Monthly Oxygenate Telephone Report"

**Energy Sources:** Petroleum and petroleum products.
**Energy Functions:** Production, Supply.
**Frequency of Collection:** Monthly.
**Respondent Categories:** Oxygenate producers; petroleum and petroleum product distributors; petroleum and petroleum product processors; petroleum and petroleum product storers.
**Reporting Requirement:** Mandatory.
**Legal Citation:** Public Law 93-275 (FEAA), 13(b), 5(a), 5(b), 52.
**Description:** Form EIA-819M is designed to obtain information on oxygenate production, imports, and end-of-month stocks. Data was previously collected using the EIA-819, Monthly Oxygenate Telephone Survey Data are reported by oxygenate type and PAD District. Respondents are a sample of: operators of facilities that produce oxygenates; operators of petroleum refineries; operators of bulk terminals, bulk stations, blending plants, and other non-refinery facilities that store or blend oxygenates; and importers of oxygenates.

## EIA-846 (A,B,C), "Manufacturing Energy Consumption Survey"

**Energy Sources:** Coal and coal products; electricity; natural gas; petroleum and petroleum products; wood.
**Energy Functions:** Consumption; disposition; financial; and/or management; production; research and development; other energy functions.
**Frequency of Collection:** Quadrennially.
**Respondent Categories:** Manufacturing.
**Reporting Requirement:** Mandatory.
**Description:** Forms EIA-846A through D are used to collect information on energy consumption, energy usage patterns, and fuel-switching capabilities of the manufacturing sector of the U.S. economy. The information from this survey is used to publish aggregate statistics on the consumption of energy for fuel and nonfuel purposes, fuel-switching capabilities, and certain energy-related issues such as energy prices, on-site electricity generation, and purchases of electricity from nonutilities. Since 1991, the survey has also collected information on end users of energy, participation in energy management programs, and penetration of new technology. Respondents are a sample of manufacturing establishments. Surveys were conducted for 1985, 1988, 1991, 1994, and 1998 although data for 1998 was not ready to be included in the preparation of this report.

## EIA-860, "Annual Electric Generator Report"

**Energy Sources:** Electricity.
**Energy Functions:** Financial and/or management; production.
**Frequency of Collection:** Annually through 1997.
**Respondent Categories:** Electric utilities.
**Reporting Requirement:** Mandatory.
**Description:** Form EIA-860 is used to collect data on the status of electric generating plants and associated equipment in operation and those scheduled to be in operation in the United States within 10 years of filing of the report. These data are used to maintain and update EIA's electric power plant frame data base. Data are collected on power plant sites, and the design data of electric generators. Respondents include each electric utility that operates, or plans to operate, a power plant in the United States within 10 years of the report.

## EIA-860A, "Annual Electric Generator Report – Utility"

**Energy Sources:** Electricity.
**Energy Functions:** Financial and/or management, Production.
**Frequency of Collection:** Annually since 1998.
**Respondent Categories**: Electric utilities.
**Reporting Requirement:** Mandatory.
**Description:** Form EIA-860A is used to collect data on the status of electric generating plants and associated equipment in operation and those scheduled to be in operation in the United States within 5 years of filing of the report. These data are used to maintain and update EIA's electric power plant frame data base. Data are collected on power plant sites, and the design data of electric generators. Respondents include each electric utility that operates, or plans to operate, a power plant in the United States within 5 years of the report.

## EIA-860B, "Annual Electric Generator Report – Nonutility"

**Energy Sources:** Electricity.
**Energy Functions:** Production.
**Frequency of Collection:** Annually since 1998.
**Respondent Categories:** Nonutility power producers.
**Reporting Requirement:** Mandatory.
**Description:** EIA-860B collects data annually from nonutility power producers who own or plan on installing electric generation equipment with a total capacity of 1 megawatt or more at an existing or proposed site. Electricity generation, installed capacity, and energy consumption data are collected. These data are used to augment existing electric utility data and for electric power forecasts and analyses.

## EIA-861, "Annual Electric Utility Report"

**Energy Sources:** Electricity.
**Energy Functions:** Disposition; financial and/or management; production.
**Frequency of Collection:** Annually.
**Respondent Categories:** Electric utilities.
**Reporting Requirement:** Mandatory.
**Description:** Form EIA-861 is a mandatory collection of data filed annually by each electric utility in the United States, its territories, and Puerto Rico. The survey collects data on generation, wholesale purchases, and sales and revenue by class of consumer and State. These data are used to maintain and update EIA's electric utility frame data base. This data base provides information to answer questions from the Executive Branch, Congress, other public agencies, and the general public. Respondents include each electric utility that is a corporation, person, agency, authority, or other legal entity or instrumentality that owns or operates facilities within the United States, its territories, or Puerto Rico for the generation, transmission, distribution, or sale of electric energy primarily for use by the public.

## EIA-867, "Annual Nonutility Power Producer Report"

**Energy Sources:** Electricity.
**Energy Functions:** Production.
**Frequency of Collection:** Annually through 1997.
**Respondent Categories:** Nonutility power producers.
**Reporting Requirement:** Mandatory.
**Description:** Form EIA-867 is used to collect data annually from nonutility power producers who own or plan on installing electric generation equipment with a total capacity of 1 megawatt or more at an existing or proposed site. Electricity generation, installed capacity, and energy consumption data are collected. These data will be used to augment existing electric utility data and for electric power forecasts and analyses.

## EIA-871A/F, "Commercial Buildings Energy Consumption Survey"

**Energy Sources:** Electricity; natural gas; natural gas products; petroleum and petroleum products; wood; other energy sources.
**Energy Functions:** Consumption; costs and / or prices.
**Frequency of Collection:** Quadrennially.
**Respondent Categories:** Commercial buildings; electric utilities; natural gas distributors (including importers / exporters); petroleum and petroleum product distributors; other (industry); Federal government institutions (nonprofit).
**Reporting Requirement:** Voluntary and mandatory.
**Description:** Forms EIA-871A through F are used to collect information for the Commercial Buildings Energy Consumption Survey (CBECS). The survey provides comprehensive national and regional information on the consumption of, and expenditures for, energy in the commercial sector of the economy. Data are used in EIA models and published in statistical and analytical reports. Physical characteristics information for commercial buildings is collected by personal interviews with building owners and managers using Form EIA-871A. Billing and consumption data for the buildings are collected by mail from individual energy suppliers by using Forms EIA-871C through F (depending upon the energy source). Supplemental information on construction improvements, maintenance, and repairs is collected for the Bureau of the Census by using Form EIA-871G. This survey was renamed the CBECS in 1989. Previously it was conducted under the name of Nonresidential Buildings Energy Consumption Survey.

## EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey"

**Energy Sources:** Geothermal.
**Energy Functions:** Disposition.
**Frequency of Collection:** Annually.
**Respondent Categories:** Geothermal heat pump manufacturers and importers.
**Reporting Requirement:** Mandatory.
**Description:** The Form EIA-902 collects information on shipments of geothermal heat pumps. The survey tracks shipments of the following three main types of geothermal heat pumps, as classified by the Air Conditioning & Refrigeration Institute (ARI), and the much smaller shipped volume of non-ARI rated systems. A brief description of the ARI-classified system is as follows:

**ARI 320—Water-Source Heat Pumps** (WSHP)—These systems are installed in commercial buildings, where a central chiller or boiler supplies chilled or heated water, respectively, to heat pumps installed in series. The heat pumps transfer building heat to chilled water during the cooling season and, during the heating season, remove heat from boiler water.

**ARI 325—Ground Water-Source Heat Pumps** (GWHP)—The GWHP is an open-loop system in which ground water is drawn from an aquifer or other natural body of water into piping. At the heat pump, heat is drawn from or dumped to the water through a heat exchanger to the refrigerant in the heat pump. The heated or cooled water returns to its source.

**ARI 330—Ground Source Closed-Loop Heat Pumps** (GSHP)—A water or water / glycol (antifreeze) solution flows continuously through a closed loop of pipe buried underground. Ground heat is absorbed into or rejected from the solution flowing in the closed loop. At the heat pump, heat is drawn from or dumped to the closed loop solution via heat transfer through a heat exchanger, which passes heat to or removes heat from the refrigerant in the heat pump. Depending on the type of ground and land area, systems can either be installed horizontally or vertically.

Data are collected by model type, heat pump capacity, region of destination, customer type, and economic sector. Respondents are manufacturers and importers.

## Appendix B

# Renewable Energy Data Limitations

This appendix provides information about the quality of renewable energy data presented in this report. Information pertinent to renewable energy source data quality, in general, is presented first, followed by discussion of electric and non-electric data sources by fuel type.

Renewable energy projects pose special challenges when attempting to collect complete information on them. One challenge is the dispersed nature of many renewable energy forms, such as a photovoltaic (PV) system for generating electricity that may operate in a stand-alone fashion in a remote location. If the facility is not connected to an electricity grid, there is no Federal regulatory requirement to report its operating information. Tracking down hundreds or thousands of such facilities, each with a small power output, can be extremely challenging.

Another challenge involves tracking renewable energy supplies. Conventional energy supplies, such as petroleum, are easily tracked because the distribution networks (usually pipelines) are limited and well-defined. This permits one to make reasonable assumptions about fuel consumption, assuming stocks can be reasonably estimated.[10] The same cannot be said for many renewable energy supplies. Often a large number of energy consumers must be surveyed in order to make reasonable inferences about renewable energy consumption. Wood, for example, is gathered by tens of thousands of entities—millions if residential use is considered—for fuel uses not reportable for regulatory purposes. Thus, obtaining accurate data on wood energy consumption would entail conducting large end use consumption surveys.

Finally, some renewable energy sources are byproducts (such as pulping liquor) of non-energy processes. To track such uses, information must be solicited from respondents not generally in the energy supply chain.

## Electricity[11]

As noted in Chapter 1, 60 percent of renewable energy consumption measured by EIA is used to produce electric power. It is, therefore, important to examine the coverage quality of EIA renewable electricity data. EIA renewable electricity generation is derived from two principal sources: Form EIA-759, "Monthly Power Plant Report," and Form-EIA-860B, "Annual Electric Generator Report-Nonutility."[12] Form EIA-759 is sent to all utilities, while the EIA-860B is required of all nonutility generating facilities exceeding 1 megawatt capacity. (This includes facilities which meet Federal Energy Regulatory Commission [FERC] standards as a "qualifying facility" [QF], as well as independent power producers [IPPs]). Because of the difficulty in surveying off-grid electric applications, not all of them are captured here (although they may be covered in EIA's Manufacturing Energy Consumption Survey[13]).

Because electric utilities are easily identified and have mandatory regulatory reporting requirements, complete coverage of utility-generated electricity is usually assured. As part of the electric power industry restructuring, some utilities are selling off generating assets. Every effort is made to assure that the new owner picks up reporting on the appropriate EIA survey. In contrast, nonutilities (i.e., QFs and IPPs) are required only to file regulatory reports at the time of their intention to become a grid electricity-producing facility. Over time, QF ownerships and locations change frequently. These factors, combined with the large number of QF applications, make tracking these facilities difficult.

[10] Even if stock data are only approximate, conventional energy stocks are normally a small percentage of production.

[11] Information in this section is based on the report, "Renewable Energy Frame Review Updated Report: Survey Sampling Frame and Electricity Discrepancy Estimates," by Decision Analysis Corporation of Virginia (Vienna, Virginia, August 1993).

[12] Before 1998 this report was called the Form EIA-867, "Annual Nonutility Power Producer Report."

[13] Because the MECS is based on the Bureau of the Census' Annual Survey of Manufacturers, EIA does not know the identity of MECS respondents.

Accordingly, EIA has developed a threshold below which nonutility units are not surveyed. The Form EIA-860B is a mandatory survey of all existing and planned nonutility electric generating facilities in the United States with a total generator nameplate capacity of 1 megawatt or more.

An analysis of the Form EIA-867 (the predecessor to Form EIA-860B) universe indicates that the survey's capacity under coverage varies between 3 and 10 percent, depending on the fuel source (Table B1). Capacity and unit coverage are the most difficult for wind, where numerous small units exist. EIA has analyzed the differences between capacities reported for identical renewable units on Form EIA-867 and alternative sources. Capacity discrepancies were found to result from these factors:

- Obsolete information
- Facility versus generator reporting: A non-EIA source may cite capacity figures for an entire facility, not taking into account individual generators that use conventional fuels or a mixture of conventional and renewable fuels. Because EIA assigns capability to the major energy source, when two or more sources are reported, renewable capability may be understated when another energy source is more important.
- Capacity definition differences: Form EIA-867 requests respondents to report nameplate electric capacity. However, alternative capacity measures are being reported on non-EIA data sources.
- Numerical rounding practices: This has the greatest effect on small units.

In a follow-up study of capacity discrepancies, the EIA-867 was over four times more likely to have the correct value than the alternative source, which covered units of all sizes.

# Non-Electric Renewable Energy Consumption

## Overview

The primary application for renewable energy other than making electricity is creating heat for industrial processes, buildings, or water. Most non-electric consumption data are gathered on two EIA consumption surveys: the Manufacturing Energy Consumption Survey (MECS), and the Residential Energy Consumption Survey (RECS). MECS is based on the U.S. Bureau of the Census' Census of Manufacturing. As far as renewable energy is concerned, MECS provides consumption estimates of total industrial energy and various categories of biomass, including wood. MECS data was available for 1991 and 1994. Data for 1998 has been collected and is being compiled. RECS is based on an area probability sample of households selected by EIA. For renewable energy, it provides estimates of residential wood energy consumption. RECS data was available for 1990, 1993, and 1997. During intervening years, EIA estimated energy consumption by assessing industry trends, housing developments, and changes in weather conditions.

There are three other non-electric applications for renewable energy: solar heating, alcohol transportation

**Table B1. Evaluation of EIA's Undercoverage of Nonutility Electricity Data**

| Fuel | Source | Number of Facilities[a] | Capacity (megawatts) |
|---|---|---|---|
| Biomass | EIA-867[b] (≥ 1 MW) | 471 | 14,090 |
| | "Electricity Discrepancy Estimates"[c] | 759 | 15,037 |
| Geothermal | EIA-867 | 48 | 1,551 |
| | "Electricity Discrepancy Estimates" | 57 | 1,590 |
| Wind | EIA-867 | 82 | 1,803 |
| | "Electricity Discrepancy Estimates" | 739 | 1,992 |
| Solar | EIA-867 | 11 | 365 |
| | "Electricity Discrepancy Estimates" | 152 | 374 |

[a] Excludes some EIA-867 facilities that could not be matched with facilities contained in non-EIA data sources.
[b] Based upon the 1991 survey year. Excludes *some* EIA-867 facilities that could not be matched with facilities contained in non-EIA data sources. The 1991 EIA-867 survey did not indicate what nonutility facilities under 5 megawatts are renewable.
[c] "Renewable Energy Frame Review Updated Report: Survey Sampling Frame and Electricity Discrepancy Estimates," by Decision Analysis Corporation of Virginia, August 2, 1993.
Source: Energy Information Administration, Form EIA-867, "Annual Nonutility Power Producer Report."

fuels, and geothermal energy. Solar energy for non-electric applications is derived from the EIA Solar Collector Manufacturing Survey, Form EIA-63A/B (formerly CE-63A/B). The survey does not collect energy "consumption" data, but rather production statistics on various types of solar and photovoltaic energy units. EIA applies additional assumptions regarding their application to estimate the amount of heat energy derived from installed solar/PV panels. Alcohol fuel consumption information is provided by the Form EIA-819M, "Monthly Oxygenate Telephone Report." Geothermal non-electric energy information is taken from data provided by the Oregon Institute of Technology, Geo-Heat Center.

## Biomass

Wood is the principal component of biomass energy. Information on non-electric wood energy consumption is derived from the MECS and RECS sample surveys.

Although some questions about MECS coverage have been raised, no formal analysis of current data exists to support this concern. According to 1983 U.S. Forest Service statistics on wood harvested for fuelwood, the Pulp and Paper Industry subgroup of the Forest Products Industry group consumed only 42 percent of total sector wood energy, not including black liquor (a byproduct fuel). MECS surveys the smaller-populated Pulp and Paper Industry intensively but only randomly samples the larger-populated remainder of the Forest Products Industry. For a variety of reasons, it is difficult to trace wood energy supply to wood consumed for energy. RECS covers wood consumption only for the primary residence of those surveyed; thus, wood consumption by second homes is omitted. This could cause residential wood energy consumption to be understated by about 5 percent, but EIA has adjusted the data presented in this report to avoid the undercount.

Of the 3.208 quads of biomass energy estimated to have been consumed in 1999, roughly three-fourths represents estimates from RECS and MECS. For MECS, 1998 estimated consumption of 2.093 quads has an appropriate relative standard error of 3 percent.[14] The RECS estimate of 0.404 quads of biomass energy consumption has a relative standard error of 10.3 percent.[15]

Cross-checks of Form EIA-819M information on alcohol fuels with data from the Bureau of Alcohol, Tobacco, and Firearms and the U.S. Department of Transportation have not revealed any major deficiencies in the Form EIA-819M data.

## Geothermal

EIA does not collect data on non-electric applications of geothermal energy such as crop drying and ground-water heat pumps. A study prepared for the U.S. Department of Energy by the Oregon Institute of Technology, Geo-Heat Center, indicates that non-electric uses of geothermal energy amounted to nearly 19.3 trillion Btu in 1999 (Table B2). Sixty-five percent of this energy was provided by geothermal heat pumps.

**Table B2. Geothermal Direct Use of Energy and Heat Pumps, 1990-1999**
(Quadrillion Btu)

| | Direct Use | Heat Pumps | Total |
|---|---|---|---|
| 1990 | 0.0048 | 0.0054 | 0.0102 |
| 1991 | 0.0050 | 0.0060 | 0.0110 |
| 1992 | 0.0051 | 0.0067 | 0.0118 |
| 1993 | 0.0053 | 0.0072 | 0.0125 |
| 1994 | 0.0056 | 0.0076 | 0.0132 |
| 1995 | 0.0058 | 0.0083 | 0.0141 |
| 1996 | 0.0059 | 0.0093 | 0.0152 |
| 1997 | 0.0061 | 0.0101 | 0.0162 |
| 1998 | 0.0063 | 0.0115 | 0.0178 |
| 1999 | 0.0079 | 0.0114 | 0.0193 |

Source: John Lund, Oregon Institute of Technology, Geo-Heat Center (Klamath Falls, Oregon, March 2000), unpublished data.

## Wind, Solar, and Photovoltaics

EIA does not collect information on direct energy uses of wind (e.g., water-pumping). No comprehensive source of such information is known.

The data collected on Forms EIA-63A and EIA-63B are subject to various limitations including: (1) coverage (the list of respondents may not be complete or, on the other hand, there may be double counting); (2) nonresponse (some of those surveyed may not respond, or they may not provide all the information requested); and (3) adjustments (errors may be made in estimating values for missing data).

[14] Energy Information Administration, *Manufacturing Consumption of Energy 1994*, DOE/EIA-0512(94) (Washington, DC, December 1997).

[15] Energy Information Administration, *Residential Energy Consumption Survey*, DOE/EIA-0632(97) (Washington, DC, November 1997).

EIA collects solar data only on terrestrial systems; it does not collect data on satellite and military applications. The total value of U.S. photovoltaic shipments in 1999 according to the Forms EIA-63A and EIA-63B was $234 million. Based on anecdotal information for 2000, shipments ranging from about $195 million to $215 million went for satellite applications. Military applications cannot be estimated due to classified information and budgetary accounting. These figures do not include possible inventories held by distributors, retailers, and installers.

The universe of solar / PV survey respondents is a census of those U.S.-based companies involved in manufacturing and / or importing solar collectors and photovoltaic cells and modules. Care has been taken to establish the survey frames accurately. The frames of potential respondents are compiled from previous surveys and from information in the public domain. However, because the solar collector and photovoltaic cell and module industries are subject to sporadic entry and exit of manufacturers and importers, the frame may exclude some small companies that have recently entered or reentered the industry. From 1993 through 1999, EIA received reports from all known potential respondents.

## Geothermal Heat Pump Manufacturing Activity

In 1997, the EIA began collecting information on geothermal heat pumps using its new survey the Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey." The principal data collected are the number and type of heat pumps shipped and their capacity ratings.

The data collected on Form EIA-902 are subject to various sources of error. These sources are: (1) coverage (the list of respondents may not be complete or, on the other hand, there may be double counting); (2) nonresponse (all that are surveyed may not respond or may not provide all information requested); (3) respondents (respondents may commit errors in reporting the data); (4) processing (the data collection agency may omit or incorrectly transcribe a submission); (5) concept (the data collection elements may not measure the items they were intended to measure); and (6) estimation (errors may be made in estimating values for missing data). Because the survey is a census survey, the estimates shown in this report are not subject to sampling error. Although it is not possible to present estimates of nonsampling error, precautionary steps were taken at each stage of the survey design to minimize the possible occurrence of these errors.

In order to improve accuracy and the quality of data collected from U.S. geothermal heat pump manufacturers in 1999, EIA modified the Form EIA-902 by adding a new data element which requested respondents to report all ARI-320 heat pumps that were shipped in 1999, as well as the number of ARI-320 geothermal heat pump units that were manufactured to be connected to ground, ground water, or surface water connection for heat exchange. This modification clarifies for the manufacturer the type of ARI-320 applications manufacturers should report as geothermal and would separate out units that would be connected to a boiler / cooling tower. Respondents were asked to report the total number of heat pumps shipped and the number of only the ARI-320 geothermal heat pumps shipped. ARI-320 units may be connected either to a "boiler / cooling tower"configuration or ground / ground water. Ground / ground water connections are geothermal applications, while boiler / cooling tower configurations are traditional water-to-water exchange uses.

An additional modification to the Form EIA-902 was to combine both the ARI-325 and ARI-330 units into one reporting category. Many ARI-325 geothermal heat pumps are dual-rated to qualify as ARI-330 units. Which rating is appropriate depends on the installed application, information not necessarily known when the manufacturer shipped the unit. Therefore, the sum of ARI-325 and ARI-330 units may be regarded as an accurate total, whereas manufacturers would estimate the number of units in each category based upon heuristic information.

## Appendix C

# Renewable Electric Generation, Capability, and Market Share by State for 1998 and 1999

Tables C1-14 present renewable electric generation and net summer capability by State and the District of Columbia for 1998 and 1999. The four leading States for renewable electric utility net generation and net summer capability in 1999 were Washington, Oregon, California, and New York. Idaho was fifth for utility generation, while Alabama was fifth for capability. The leading States for utility hydroelectric generation were the same as for total generation. The high proportion of hydroelectric generation reflects the fact that utilities have long had sizeable hydroelectric generating operations. California also dominated utility generation from geothermal (91 percent) and solar (97 percent), although solar generation was minimal. Vermont had the lead for utility wind generation (59 percent) and Connecticut was first for biomass generation (23 percent). All but six States (Delaware, Kansas, Louisiana, Mississippi, New Jersey, and Rhode Island) and the District of Columbia had utility renewable generation in 1999.

California also was a major player in the nonutility market. It was first for renewable nonutility net generation and net summer capability, followed by Maine, New York and Florida. Alabama was fifth for nonutility generation and Illinois was fifth for capability. The top five States produced 49 percent of total nonutility renewable electricity in 1999. California produced 89 percent of nonutility geothermal generation, 72 percent of wind generation, and all of the nonutility solar generation. Florida accounted for 17 percent of nonutility generation from municipal solid waste (MSW) and landfill gas (LFG). The leading States for nonutility generation from wood and wood waste are States with large volumes of biomass waste from industrial production. Forty-seven States (all but Alaska, Delaware, and South Dakota) and the District of Columbia had nonutility renewable electric operations in 1999.

The renewable market share of total electric power industry generation in different states ranged from a high of 97 percent to a low of less than 1 percent in 1998 (Table C15). States with higher percentages of renewable electricity had higher levels of hydroelectric/biomass generation.

## C1. Renewable Electric Utility Net Generation by State, 1998

(Thousand Kilowatthours)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas | Wood/ Wood Waste | Other Waste[a] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | 10,564,857 | -- | -- | -- | -- | -- | -- | 10,564,857 |
| Alaska | 1,113,332 | -- | -- | -- | -- | -- | -- | 1,113,332 |
| Arizona | 10,970,189 | -- | -- | -- | -- | -- | -- | 10,970,189 |
| Arkansas | 3,113,643 | -- | -- | -- | -- | -- | -- | 3,113,643 |
| California | 47,475,341 | 5,016,223 | 2,384 | 2,556 | -- | -- | 119,865 | 52,616,369 |
| Colorado | 1,346,170 | -- | -- | -- | -- | -- | -- | 1,346,170 |
| Connecticut | 384,447 | -- | -- | -- | 427,389 | -- | -- | 811,836 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | 198,505 | -- | -- | -- | -- | -- | -- | 198,505 |
| Georgia | 5,198,370 | -- | -- | -- | -- | -- | -- | 5,198,370 |
| Hawaii | 13,750 | -- | -- | 312 | -- | -- | -- | 14,062 |
| Idaho | 11,977,826 | -- | -- | -- | -- | -- | -- | 11,977,826 |
| Illinois | 50,731 | -- | -- | -- | -- | -- | -- | 50,731 |
| Indiana | 478,668 | -- | -- | -- | -- | -- | -- | 478,668 |
| Iowa | 893,219 | -- | -- | 89 | 19,076 | -- | -- | 912,384 |
| Kansas | -- | -- | -- | -- | -- | -- | -- | -- |
| Kentucky | 3,116,018 | -- | -- | -- | -- | -- | -- | 3,116,018 |
| Louisiana | -- | -- | -- | -- | -- | -- | -- | -- |
| Maine | 1,820,306 | -- | -- | -- | -- | -- | -- | 1,820,306 |
| Maryland | 1,739,737 | -- | -- | -- | -- | -- | -- | 1,739,737 |
| Massachusetts | 760,785 | -- | -- | -- | -- | -- | -- | 760,785 |
| Michigan | 1,282,471 | -- | -- | -- | -- | -- | -- | 1,282,471 |
| Minnesota | 694,836 | -- | -- | -- | 451,293 | -- | -- | 1,146,129 |
| Mississippi | -- | -- | -- | -- | -- | -- | -- | -- |
| Missouri | 2,346,585 | -- | -- | -- | 77,787 | -- | -- | 2,424,372 |
| Montana | 11,053,648 | -- | -- | -- | -- | -- | -- | 11,053,648 |
| Nebraska | 1,682,834 | -- | -- | -- | -- | -- | 707 | 1,683,541 |
| Nevada | 3,151,415 | -- | -- | -- | -- | -- | -- | 3,151,415 |
| New Hampshire | 975,057 | -- | -- | -- | -- | -- | -- | 975,057 |
| New Jersey | -- | -- | -- | -- | -- | -- | -- | -- |
| New Mexico | 236,412 | -- | -- | -- | -- | -- | -- | 236,412 |
| New York | 27,739,454 | -- | -- | -- | -- | 4,603 | -- | 27,744,057 |
| North Carolina | 4,045,503 | -- | -- | -- | -- | -- | -- | 4,045,503 |
| North Dakota | 2,295,948 | -- | -- | -- | -- | -- | -- | 2,295,948 |
| Ohio | 406,427 | -- | -- | -- | -- | -- | -- | 406,427 |
| Oklahoma | 3,508,748 | -- | -- | -- | -- | -- | -- | 3,508,748 |
| Oregon | 39,504,178 | -- | -- | -- | -- | -- | -- | 39,504,178 |
| Pennsylvania | 2,027,827 | -- | -- | -- | -- | -- | -- | 2,027,827 |
| Rhode Island | -- | -- | -- | -- | -- | -- | -- | -- |
| South Carolina | 3,503,249 | -- | -- | -- | -- | -- | -- | 3,503,249 |
| South Dakota | 5,757,600 | -- | -- | -- | -- | -- | -- | 5,757,600 |
| Tennessee | 10,007,358 | -- | -- | -- | -- | -- | -- | 10,007,358 |
| Texas | 1,418,903 | -- | 134 | -- | -- | -- | -- | 1,419,037 |
| Utah | 1,299,052 | 160,057 | -- | -- | -- | -- | -- | 1,459,109 |
| Vermont | 848,291 | -- | -- | -- | -- | 145,458 | -- | 993,749 |
| Virginia | 1,210,984 | -- | -- | -- | -- | -- | -- | 1,210,984 |
| Washington | 79,409,678 | -- | -- | -- | -- | 337,444 | -- | 79,747,122 |
| West Virginia | 361,331 | -- | -- | -- | -- | -- | -- | 361,331 |
| Wisconsin | 1,517,765 | -- | -- | -- | 14,730 | 231,802 | 194,088 | 1,958,385 |
| Wyoming | 1,342,322 | -- | -- | -- | -- | -- | -- | 1,342,322 |
| **Total** | **308,843,770** | **5,176,280** | **2,518** | **2,957** | **990,275** | **719,307** | **314,660** | **316,049,767** |

[a]Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

## C2. Renewable Nonutility Net Generation by State, 1998

(Thousand Kilowatthours)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas | Wood/ Wood Waste | Other Waste[a] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | -- | -- | -- | -- | -- | 4,020,578 | 6,456 | 4,027,034 |
| Alaska | -- | -- | -- | -- | -- | 877 | -- | 877 |
| Arizona | -- | -- | -- | -- | -- | -- | -- | -- |
| Arkansas | 3,100 | -- | -- | -- | -- | 1,042,174 | 978 | 1,046,253 |
| California | 2,072,859 | 7,792,875 | 853,742 | 2,717,916 | 1,637,233 | 2,779,072 | 367,061 | 18,220,759 |
| Colorado | 115,791 | -- | -- | -- | -- | -- | -- | 115,791 |
| Connecticut | 63,838 | -- | -- | -- | 1,409,956 | -- | 223,734 | 1,697,528 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | -- | -- | -- | -- | 2,793,852 | 1,905,487 | 556,835 | 5,256,174 |
| Georgia | 35,342 | -- | -- | -- | 18,923 | 2,887,277 | 30,916 | 2,972,457 |
| Hawaii | 107,523 | 237,083 | -- | 18,969 | 356,322 | 2,071 | 146,511 | 868,479 |
| Idaho | 901,618 | -- | -- | -- | -- | 503,662 | 50 | 1,405,330 |
| Illinois | 89,514 | -- | -- | -- | 467,644 | 110,906 | 60,729 | 728,794 |
| Indiana | -- | -- | -- | -- | 124,111 | -- | -- | 124,111 |
| Iowa | 19,696 | -- | -- | -- | 47,854 | 385 | 7,473 | 75,407 |
| Kansas | 11,425 | -- | -- | -- | -- | -- | -- | 11,425 |
| Kentucky | -- | -- | -- | -- | -- | 15,652 | -- | 15,652 |
| Louisiana | 1,062,824 | -- | -- | -- | -- | 1,837,023 | 64,307 | 2,964,154 |
| Maine | 1,895,661 | -- | -- | -- | 284,132 | 2,025,813 | 226,347 | 4,431,954 |
| Maryland | -- | -- | -- | -- | 603,869 | 156,008 | 1,177 | 761,054 |
| Massachusetts | 342,702 | -- | -- | -- | 1,853,449 | 118,028 | 81,642 | 2,395,820 |
| Michigan | 129,880 | -- | -- | -- | 935,355 | 1,840,392 | 64,452 | 2,970,079 |
| Minnesota | 257,989 | -- | -- | 146,852 | 318,744 | 357,710 | -- | 1,081,295 |
| Mississippi | -- | -- | -- | -- | -- | 1,060,717 | -- | 1,060,717 |
| Missouri | -- | -- | -- | -- | -- | -- | 3,316 | 3,316 |
| Montana | 64,292 | -- | -- | -- | -- | 43,811 | -- | 108,103 |
| Nebraska | -- | -- | -- | -- | -- | -- | -- | -- |
| Nevada | 14,910 | 1,519,580 | -- | -- | -- | -- | -- | 1,534,491 |
| New Hampshire | 621,690 | -- | -- | -- | 233,805 | 864,198 | -- | 1,719,693 |
| New Jersey | 20,670 | -- | -- | -- | 1,285,734 | -- | -- | 1,306,404 |
| New Mexico | -- | -- | -- | -- | -- | -- | -- | -- |
| New York | 1,569,647 | -- | -- | -- | 1,063,605 | 399,793 | 842,835 | 3,875,881 |
| North Carolina | 1,692,704 | -- | -- | -- | 76,459 | 1,333,461 | 11,963 | 3,114,588 |
| North Dakota | -- | -- | -- | -- | -- | -- | 1,524 | 1,524 |
| Ohio | -- | -- | -- | -- | -- | 698,307 | 91 | 698,399 |
| Oklahoma | -- | -- | -- | -- | -- | 218,091 | -- | 218,091 |
| Oregon | 397,989 | -- | -- | 19,523 | 91,115 | 339,128 | -- | 847,756 |
| Pennsylvania | 353,525 | -- | -- | -- | 1,863,724 | 532,845 | 20,845 | 2,770,939 |
| Rhode Island | 8,676 | -- | -- | -- | 111,155 | -- | -- | 119,831 |
| South Carolina | 66,167 | -- | -- | -- | 57,349 | 1,553,940 | 4,983 | 1,682,439 |
| South Dakota | -- | -- | -- | -- | -- | -- | -- | -- |
| Tennessee | 798,670 | -- | -- | -- | 40,714 | 464,758 | 13,003 | 1,317,144 |
| Texas | 5,918 | -- | -- | 80,036 | 45,108 | 754,851 | 26,408 | 912,321 |
| Utah | 15,659 | -- | -- | -- | -- | -- | -- | 15,659 |
| Vermont | 329,193 | -- | -- | -- | -- | 185,249 | -- | 514,442 |
| Virginia | 72,312 | -- | -- | -- | 1,054,900 | 1,544,220 | 6,562 | 2,677,993 |
| Washington | 404,973 | -- | -- | -- | 183,273 | 796,791 | 21,719 | 1,406,755 |
| West Virginia | 725,014 | -- | -- | -- | -- | -- | -- | 725,014 |
| Wisconsin | 214,426 | -- | -- | -- | 142,326 | 676,245 | 25,358 | 1,058,355 |
| Wyoming | -- | -- | -- | 2,045 | -- | -- | -- | 2,045 |
| **Total** | **14,486,196** | **9,549,539** | **853,742** | **2,985,342** | **17,100,709** | **31,069,521** | **2,817,275** | **78,862,325** |

[a]Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-860B, "Annual Electric Generator Report – Nonutility."

## C3. Renewable Electric Power Industry Net Generation by State, 1998

(Thousand Kilowatthours)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas | Wood/ Wood Waste | Other Waste[a] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | 10,564,857 | -- | -- | -- | -- | 4,020,578 | 6,456 | 14,591,891 |
| Alaska | 1,113,332 | -- | -- | -- | -- | 877 | -- | 1,114,209 |
| Arizona | 10,970,189 | -- | -- | -- | -- | -- | -- | 10,970,189 |
| Arkansas | 3,116,743 | -- | -- | -- | -- | 1,042,174 | 978 | 4,159,896 |
| California | 49,548,200 | 12,809,098 | 856,126 | 2,720,472 | 1,637,233 | 2,779,072 | 486,926 | 70,837,128 |
| Colorado | 1,461,961 | -- | -- | -- | -- | -- | -- | 1,461,961 |
| Connecticut | 448,285 | -- | -- | -- | 1,837,345 | -- | 223,734 | 2,509,364 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | 198,505 | -- | -- | -- | 2,793,852 | 1,905,487 | 556,835 | 5,454,679 |
| Georgia | 5,233,712 | -- | -- | -- | 18,923 | 2,887,277 | 30,916 | 8,170,827 |
| Hawaii | 121,273 | 237,083 | -- | 19,281 | 356,322 | 2,071 | 146,511 | 882,541 |
| Idaho | 12,879,444 | -- | -- | -- | -- | 503,662 | 50 | 13,383,156 |
| Illinois | 140,245 | -- | -- | -- | 467,644 | 110,906 | 60,729 | 779,525 |
| Indiana | 478,668 | -- | -- | -- | 124,111 | -- | -- | 602,779 |
| Iowa | 912,915 | -- | -- | 89 | 66,930 | 385 | 7,473 | 987,791 |
| Kansas | 11,425 | -- | -- | -- | -- | -- | -- | 11,425 |
| Kentucky | 3,116,018 | -- | -- | -- | -- | 15,652 | -- | 3,131,670 |
| Louisiana | 1,062,824 | -- | -- | -- | -- | 1,837,023 | 64,307 | 2,964,154 |
| Maine | 3,715,967 | -- | -- | -- | 284,132 | 2,025,813 | 226,347 | 6,252,260 |
| Maryland | 1,739,737 | -- | -- | -- | 603,869 | 156,008 | 1,177 | 2,500,791 |
| Massachusetts | 1,103,487 | -- | -- | -- | 1,853,449 | 118,028 | 81,642 | 3,156,605 |
| Michigan | 1,412,351 | -- | -- | -- | 935,355 | 1,840,392 | 64,452 | 4,252,550 |
| Minnesota | 952,825 | -- | -- | 146,852 | 770,037 | 357,710 | -- | 2,227,424 |
| Mississippi | -- | -- | -- | -- | -- | 1,060,717 | -- | 1,060,717 |
| Missouri | 2,346,585 | -- | -- | -- | 77,787 | -- | 3,316 | 2,427,688 |
| Montana | 11,117,940 | -- | -- | -- | -- | 43,811 | -- | 11,161,751 |
| Nebraska | 1,682,834 | -- | -- | -- | -- | -- | 707 | 1,683,541 |
| Nevada | 3,166,325 | 1,519,580 | -- | -- | -- | -- | -- | 4,685,906 |
| New Hampshire | 1,596,747 | -- | -- | -- | 233,805 | 864,198 | -- | 2,694,750 |
| New Jersey | 20,670 | -- | -- | -- | 1,285,734 | -- | -- | 1,306,404 |
| New Mexico | 236,412 | -- | -- | -- | -- | -- | -- | 236,412 |
| New York | 29,309,101 | -- | -- | -- | 1,063,605 | 404,396 | 842,835 | 31,619,938 |
| North Carolina | 5,738,207 | -- | -- | -- | 76,459 | 1,333,461 | 11,963 | 7,160,091 |
| North Dakota | 2,295,948 | -- | -- | -- | -- | -- | 1,524 | 2,297,472 |
| Ohio | 406,427 | -- | -- | -- | -- | 698,307 | 91 | 1,104,826 |
| Oklahoma | 3,508,748 | -- | -- | -- | -- | 218,091 | -- | 3,726,839 |
| Oregon | 39,902,167 | -- | -- | 19,523 | 91,115 | 339,128 | -- | 40,351,934 |
| Pennsylvania | 2,381,352 | -- | -- | -- | 1,863,724 | 532,845 | 20,845 | 4,798,766 |
| Rhode Island | 8,676 | -- | -- | -- | 111,155 | -- | -- | 119,831 |
| South Carolina | 3,569,416 | -- | -- | -- | 57,349 | 1,553,940 | 4,983 | 5,185,688 |
| South Dakota | 5,757,600 | -- | -- | -- | -- | -- | -- | 5,757,600 |
| Tennessee | 10,806,028 | -- | -- | -- | 40,714 | 464,758 | 13,003 | 11,324,502 |
| Texas | 1,424,821 | -- | 134 | 80,036 | 45,108 | 754,851 | 26,408 | 2,331,358 |
| Utah | 1,314,711 | 160,057 | -- | -- | -- | -- | -- | 1,474,768 |
| Vermont | 1,177,484 | -- | -- | -- | -- | 330,707 | -- | 1,508,191 |
| Virginia | 1,283,296 | -- | -- | -- | 1,054,900 | 1,544,220 | 6,562 | 3,888,977 |
| Washington | 79,814,651 | -- | -- | -- | 183,273 | 1,134,235 | 21,719 | 81,153,877 |
| West Virginia | 1,086,345 | -- | -- | -- | -- | -- | -- | 1,086,345 |
| Wisconsin | 1,732,191 | -- | -- | -- | 157,056 | 908,047 | 219,446 | 3,016,740 |
| Wyoming | 1,342,322 | -- | -- | 2,045 | -- | -- | -- | 1,344,367 |
| **Total** | **323,329,966** | **14,725,819** | **856,260** | **2,988,299** | **18,090,984** | **31,788,828** | **3,131,935** | **394,912,092** |

[a] Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Energy Information Administration, Form EIA-759, "Monthly Power Plant Report," and Form EIA-860B, "Annual Electric Generator Report – Nonutility."

## C4. Renewable Nonutility Gross Generation by State, 1998

(Thousand Kilowatthours)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas | Wood/ Wood Waste | Other Waste[a] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | -- | -- | -- | -- | -- | 4,207,922 | R6,842 | R4,214,764 |
| Alaska | -- | -- | -- | -- | -- | 941 | -- | 941 |
| Arizona | -- | -- | -- | -- | -- | -- | -- | -- |
| Arkansas | 3,132 | -- | -- | -- | -- | 1,102,344 | R1,019 | R1,106,494 |
| California | 2,093,797 | 8,068,680 | 886,553 | 2,745,370 | 1,693,961 | 2,909,343 | R381,386 | R18,779,090 |
| Colorado | 116,960 | -- | -- | -- | -- | -- | -- | 116,960 |
| Connecticut | 64,483 | -- | -- | -- | 1,496,612 | -- | 240,189 | 1,801,285 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | -- | -- | -- | -- | 2,982,199 | 2,024,819 | R590,370 | R5,597,388 |
| Georgia | 35,699 | -- | -- | -- | 19,309 | 3,031,702 | 32,372 | 3,119,082 |
| Hawaii | 108,609 | 244,416 | -- | 19,161 | 381,464 | 2,135 | 152,655 | 908,439 |
| Idaho | 910,726 | -- | -- | -- | -- | 524,488 | 52 | 1,435,266 |
| Illinois | 90,418 | -- | -- | -- | 484,748 | 119,063 | 64,247 | 758,476 |
| Indiana | -- | -- | -- | -- | 127,027 | -- | -- | 127,027 |
| Iowa | 19,895 | -- | -- | -- | 48,830 | 397 | R7,943 | R77,064 |
| Kansas | 11,541 | -- | -- | -- | -- | -- | -- | 11,541 |
| Kentucky | -- | -- | -- | -- | -- | 16,137 | -- | 16,137 |
| Louisiana | 1,073,560 | -- | -- | -- | -- | 1,917,438 | 68,335 | 3,059,333 |
| Maine | 1,914,809 | -- | -- | -- | 292,920 | 2,135,419 | 242,766 | 4,585,914 |
| Maryland | -- | -- | -- | -- | 646,505 | 162,330 | 1,213 | 810,048 |
| Massachusetts | 346,163 | -- | -- | -- | 1,986,043 | 121,678 | 84,167 | 2,538,052 |
| Michigan | 131,192 | -- | -- | -- | 974,554 | 1,929,321 | 67,381 | 3,102,448 |
| Minnesota | 260,595 | -- | -- | 148,336 | 338,612 | 368,506 | -- | 1,116,048 |
| Mississippi | -- | -- | -- | -- | -- | 1,100,741 | -- | 1,100,741 |
| Missouri | -- | -- | -- | -- | -- | -- | 3,397 | 3,397 |
| Montana | 64,941 | -- | -- | -- | -- | 45,166 | -- | 110,107 |
| Nebraska | -- | -- | -- | -- | -- | -- | -- | -- |
| Nevada | 15,061 | 1,568,861 | -- | -- | -- | -- | -- | 1,583,922 |
| New Hampshire | 627,969 | -- | -- | -- | 243,533 | 898,476 | -- | 1,769,978 |
| New Jersey | 20,879 | -- | -- | -- | 1,368,185 | -- | -- | 1,389,064 |
| New Mexico | -- | -- | -- | -- | -- | -- | -- | -- |
| New York | 1,585,502 | -- | -- | -- | 1,117,131 | 422,965 | 904,824 | 4,030,422 |
| North Carolina | 1,709,802 | -- | -- | -- | 79,895 | 1,416,375 | 12,843 | 3,218,915 |
| North Dakota | -- | -- | -- | -- | -- | -- | 1,571 | 1,571 |
| Ohio | -- | -- | -- | -- | -- | 747,392 | 98 | 747,490 |
| Oklahoma | -- | -- | -- | -- | -- | 233,301 | -- | 233,301 |
| Oregon | 402,009 | -- | -- | 19,721 | 97,816 | 360,783 | -- | 880,329 |
| Pennsylvania | 357,096 | -- | -- | -- | 1,990,163 | 563,930 | 21,932 | 2,933,121 |
| Rhode Island | 8,764 | -- | -- | -- | 113,423 | -- | -- | 122,187 |
| South Carolina | 66,835 | -- | -- | -- | 59,122 | 1,636,088 | 5,349 | 1,767,396 |
| South Dakota | -- | -- | -- | -- | -- | -- | -- | -- |
| Tennessee | 806,737 | -- | -- | -- | 41,756 | 483,098 | 13,816 | 1,345,407 |
| Texas | 5,978 | -- | -- | 80,844 | 46,029 | 784,917 | R27,590 | R945,359 |
| Utah | 15,817 | -- | -- | -- | -- | -- | -- | 15,817 |
| Vermont | 332,518 | -- | -- | -- | -- | 190,979 | -- | 523,497 |
| Virginia | 73,042 | -- | -- | -- | 1,127,137 | 1,605,984 | 6,809 | 2,812,972 |
| Washington | 409,064 | -- | -- | -- | 196,031 | 826,114 | R22,663 | R1,453,872 |
| West Virginia | 732,337 | -- | -- | -- | -- | -- | -- | 732,337 |
| Wisconsin | 216,592 | -- | -- | -- | 145,230 | 706,166 | 25,901 | 1,093,888 |
| Wyoming | -- | -- | -- | 2,066 | -- | -- | -- | 2,066 |
| **Total** | **14,632,521** | **9,881,958** | **886,553** | **3,015,497** | **18,098,236** | **32,596,456** | **R2,987,731** | **R82,098,952** |

[a]Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

R = Revised.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-860B, "Annual Electric Generator Report – Nonutility."

## C5. Renewable Electric Utility Net Generation by State, 1999

(Thousand Kilowatthours)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas | Wood/ Wood Waste | Other Waste[a] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | 7,759,602 | -- | -- | -- | -- | -- | -- | 7,759,602 |
| Alaska | 816,608 | -- | -- | -- | -- | -- | -- | 816,608 |
| Arizona | 9,758,817 | -- | -- | -- | -- | -- | -- | 9,758,817 |
| Arkansas | 2,693,011 | -- | -- | -- | -- | -- | -- | 2,693,011 |
| California | 39,228,603 | 1,542,870 | 2,949 | 3,939 | -- | -- | 141,288 | 40,919,649 |
| Colorado | 1,443,426 | -- | -- | -- | -- | -- | -- | 1,443,426 |
| Connecticut | 365,364 | -- | -- | -- | 467,034 | -- | -- | 832,398 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | 140,175 | -- | -- | -- | -- | -- | 16,428 | 156,603 |
| Georgia | 2,722,553 | -- | -- | -- | -- | -- | -- | 2,722,553 |
| Hawaii | 18,844 | -- | -- | 3,795 | -- | -- | -- | 22,639 |
| Idaho | 12,455,965 | -- | -- | -- | -- | -- | -- | 12,455,965 |
| Illinois | 52,030 | -- | -- | -- | -- | -- | 66,844 | 118,874 |
| Indiana | 406,974 | -- | -- | -- | -- | -- | -- | 406,974 |
| Iowa | 931,073 | -- | -- | 1,663 | 20,101 | -- | -- | 952,837 |
| Kansas | -- | -- | -- | -- | -- | -- | -- | -- |
| Kentucky | 2,556,572 | -- | -- | -- | -- | -- | -- | 2,556,572 |
| Louisiana | -- | -- | -- | -- | -- | -- | -- | -- |
| Maine | 516,242 | -- | -- | -- | -- | -- | -- | 516,242 |
| Maryland | 1,422,418 | -- | -- | -- | -- | -- | -- | 1,422,418 |
| Massachusetts | 544,113 | -- | -- | -- | -- | -- | -- | 544,113 |
| Michigan | 1,367,296 | -- | -- | -- | -- | -- | -- | 1,367,296 |
| Minnesota | 857,323 | -- | -- | -- | 416,933 | -- | -- | 1,274,256 |
| Mississippi | -- | -- | -- | -- | -- | -- | -- | -- |
| Missouri | 1,853,065 | -- | -- | -- | 47,283 | -- | 2,541 | 1,902,889 |
| Montana | 11,580,716 | -- | -- | -- | -- | -- | -- | 11,580,716 |
| Nebraska | 1,719,030 | -- | -- | -- | -- | -- | -- | 1,719,030 |
| Nevada | 2,807,162 | -- | -- | -- | -- | -- | -- | 2,807,162 |
| New Hampshire | 339,216 | -- | -- | -- | -- | -- | -- | 339,216 |
| New Jersey | -- | -- | -- | -- | -- | -- | -- | -- |
| New Mexico | 242,710 | -- | -- | -- | -- | -- | -- | 242,710 |
| New York | 21,232,642 | -- | -- | -- | -- | 129 | -- | 21,232,771 |
| North Carolina | 2,478,485 | -- | -- | -- | -- | -- | -- | 2,478,485 |
| North Dakota | 2,609,159 | -- | -- | -- | -- | -- | -- | 2,609,159 |
| Ohio | 423,031 | -- | -- | -- | -- | -- | -- | 423,031 |
| Oklahoma | 3,175,399 | -- | -- | -- | -- | -- | -- | 3,175,399 |
| Oregon | 45,233,883 | -- | -- | -- | -- | -- | -- | 45,233,883 |
| Pennsylvania | 1,604,351 | -- | -- | -- | -- | -- | -- | 1,604,351 |
| Rhode Island | -- | -- | -- | -- | -- | -- | -- | -- |
| South Carolina | 1,646,643 | -- | -- | -- | -- | -- | -- | 1,646,643 |
| South Dakota | 6,677,303 | -- | -- | -- | -- | -- | -- | 6,677,303 |
| Tennessee | 7,150,413 | -- | -- | -- | -- | -- | -- | 7,150,413 |
| Texas | 1,116,881 | -- | 86 | -- | -- | -- | -- | 1,116,967 |
| Utah | 1,246,727 | 155,530 | -- | -- | -- | -- | -- | 1,402,257 |
| Vermont | 420,685 | -- | -- | 13,604 | -- | 200,476 | -- | 634,765 |
| Virginia | 620,073 | -- | -- | -- | -- | -- | -- | 620,073 |
| Washington | 96,472,455 | -- | -- | -- | -- | 269,964 | -- | 96,742,419 |
| West Virginia | 302,733 | -- | -- | -- | -- | -- | -- | 302,733 |
| Wisconsin | 1,733,959 | -- | -- | -- | 7,702 | 213,590 | 121,222 | 2,076,473 |
| Wyoming | 1,170,225 | -- | -- | -- | -- | -- | -- | 1,170,225 |
| **Total** | **299,913,955** | **1,698,400** | **3,035** | **23,001** | **959,053** | **684,159** | **348,323** | **303,629,926** |

[a]Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

## C6. Renewable Nonutility Net Generation by State, 1999

(Thousand Kilowatthours)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas | Wood/ Wood Waste | Other Waste[a] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | -- | -- | -- | -- | -- | 3,904,945 | 8,427 | 3,913,372 |
| Alaska | -- | -- | -- | -- | -- | -- | -- | -- |
| Arizona | -- | -- | -- | -- | -- | -- | 104,020 | 104,020 |
| Arkansas | 1,323 | -- | -- | -- | -- | 1,306,247 | 7,683 | 1,315,253 |
| California | 1,508,064 | 13,390,201 | 844,920 | 3,226,014 | 1,715,751 | 3,322,930 | 526,074 | 24,533,955 |
| Colorado | 119,059 | -- | -- | -- | -- | -- | 31,772 | 150,832 |
| Connecticut | 56,598 | -- | -- | -- | 1,474,225 | -- | 219,613 | 1,750,436 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | -- | -- | -- | -- | 3,138,988 | 1,745,341 | 641,868 | 5,526,196 |
| Georgia | 28,621 | -- | -- | -- | 16,764 | 3,002,399 | 24,425 | 3,072,209 |
| Hawaii | 98,718 | 210,857 | -- | 12,699 | 364,898 | -- | 200,003 | 887,175 |
| Idaho | 987,081 | -- | -- | -- | -- | 486,756 | -- | 1,473,837 |
| Illinois | 90,064 | -- | -- | -- | 473,337 | 201,876 | 427,752 | 1,193,028 |
| Indiana | -- | -- | -- | -- | 123,139 | -- | -- | 123,139 |
| Iowa | 14,549 | -- | -- | 324,691 | 54,340 | 11 | 16,766 | 410,356 |
| Kansas | 12,367 | -- | -- | -- | -- | -- | -- | 12,367 |
| Kentucky | -- | -- | -- | -- | -- | 12,409 | -- | 12,409 |
| Louisiana | 801,826 | -- | -- | -- | -- | 2,458,967 | 127,102 | 3,387,894 |
| Maine | 3,241,951 | -- | -- | -- | 423,699 | 2,568,527 | 83,163 | 6,317,340 |
| Maryland | 1,779 | -- | -- | -- | 363,586 | 177,638 | 41 | 543,044 |
| Massachusetts | 424,901 | -- | -- | -- | 1,991,057 | 100,463 | 5,011 | 2,521,432 |
| Michigan | 91,037 | -- | -- | -- | 878,734 | 1,773,933 | 172,418 | 2,916,122 |
| Minnesota | 321,610 | -- | -- | 485,692 | 324,342 | 546,569 | 253 | 1,678,465 |
| Mississippi | 5,554 | -- | -- | -- | -- | 1,450,418 | -- | 1,455,972 |
| Missouri | -- | -- | -- | -- | -- | -- | 11,271 | 11,271 |
| Montana | 2,241,346 | -- | -- | -- | -- | 51,491 | -- | 2,292,837 |
| Nebraska | -- | -- | -- | -- | -- | -- | 11,712 | 11,712 |
| Nevada | 20,509 | 1,425,509 | -- | -- | -- | -- | -- | 1,446,017 |
| New Hampshire | 1,072,066 | 87,643 | -- | -- | 244,102 | 810,891 | -- | 2,214,703 |
| New Jersey | 17,303 | -- | -- | -- | 1,374,521 | -- | 17,054 | 1,408,877 |
| New Mexico | -- | -- | -- | -- | -- | -- | 11,013 | 11,013 |
| New York | 3,518,685 | -- | -- | -- | 2,006,154 | 717,423 | 1,057 | 6,243,320 |
| North Carolina | 1,205,701 | -- | -- | -- | 82,473 | 1,483,171 | 12,100 | 2,783,445 |
| North Dakota | -- | -- | -- | -- | -- | -- | 5,736 | 5,736 |
| Ohio | -- | -- | -- | -- | -- | 636,752 | -- | 636,752 |
| Oklahoma | -- | -- | -- | -- | 1,653 | 166,599 | -- | 168,252 |
| Oregon | 405,167 | -- | -- | 84,792 | 94,705 | 358,554 | -- | 943,218 |
| Pennsylvania | 342,247 | -- | -- | -- | 1,982,281 | 544,376 | 41,253 | 2,910,156 |
| Rhode Island | 6,050 | -- | -- | -- | 114,192 | -- | -- | 120,241 |
| South Carolina | 40,708 | -- | -- | -- | 60,577 | 1,484,583 | 2,605 | 1,588,473 |
| South Dakota | -- | -- | -- | -- | -- | -- | -- | -- |
| Tennessee | 651,544 | -- | -- | -- | 35,109 | 616,424 | 4,984 | 1,308,061 |
| Texas | 3,325 | -- | -- | 319,960 | 43,469 | 692,800 | 42,716 | 1,102,270 |
| Utah | 8,415 | -- | -- | -- | 8,169 | -- | -- | 16,584 |
| Vermont | 775,011 | -- | -- | -- | -- | 196,886 | -- | 971,897 |
| Virginia | 61,613 | -- | -- | -- | 1,107,461 | 1,678,127 | 6,317 | 2,853,519 |
| Washington | 516,927 | -- | -- | -- | 231,061 | 825,914 | 19,639 | 1,593,541 |
| West Virginia | 627,523 | -- | -- | -- | -- | -- | -- | 627,523 |
| Wisconsin | 250,634 | -- | -- | -- | 148,638 | 637,982 | 14,880 | 1,052,134 |
| Wyoming | -- | -- | -- | 11,150 | -- | -- | -- | 11,150 |
| **Total** | **19,569,876** | **15,114,210** | **844,920** | **4,464,997** | **18,877,423** | **33,961,400** | **2,798,729** | **95,631,555** |

[a]Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-860B, "Annual Electric Generator Report – Nonutility."

## C7. Renewable Electric Power Industry Net Generation by State, 1999

(Thousand Kilowatthours)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas | Wood/ Wood Waste | Other Waste[a] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | 7,759,602 | -- | -- | -- | -- | 3,904,945 | 8,427 | 11,672,974 |
| Alaska | 816,608 | -- | -- | -- | -- | -- | -- | 816,608 |
| Arizona | 9,758,817 | -- | -- | -- | -- | -- | 104,020 | 9,862,837 |
| Arkansas | 2,694,334 | -- | -- | -- | -- | 1,306,247 | 7,683 | 4,008,264 |
| California | 40,736,667 | 14,933,071 | 847,869 | 3,229,953 | 1,715,751 | 3,322,930 | 667,362 | 65,453,604 |
| Colorado | 1,562,485 | -- | -- | -- | -- | -- | 31,772 | 1,594,258 |
| Connecticut | 421,962 | -- | -- | -- | 1,941,259 | -- | 219,613 | 2,582,834 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | 140,175 | -- | -- | -- | 3,138,988 | 1,745,341 | 658,296 | 5,682,799 |
| Georgia | 2,751,174 | -- | -- | -- | 16,764 | 3,002,399 | 24,425 | 5,794,762 |
| Hawaii | 117,562 | 210,857 | -- | 16,494 | 364,898 | -- | 200,003 | 909,814 |
| Idaho | 13,443,046 | -- | -- | -- | -- | 486,756 | -- | 13,929,802 |
| Illinois | 142,094 | -- | -- | -- | 473,337 | 201,876 | 494,596 | 1,311,902 |
| Indiana | 406,974 | -- | -- | -- | 123,139 | -- | -- | 530,113 |
| Iowa | 945,622 | -- | -- | 326,354 | 74,441 | 11 | 16,766 | 1,363,193 |
| Kansas | 12,367 | -- | -- | -- | -- | -- | -- | 12,367 |
| Kentucky | 2,556,572 | -- | -- | -- | -- | 12,409 | -- | 2,568,981 |
| Louisiana | 801,826 | -- | -- | -- | -- | 2,458,967 | 127,102 | 3,387,894 |
| Maine | 3,758,193 | -- | -- | -- | 423,699 | 2,568,527 | 83,163 | 6,833,582 |
| Maryland | 1,424,197 | -- | -- | -- | 363,586 | 177,638 | 41 | 1,965,462 |
| Massachusetts | 969,014 | -- | -- | -- | 1,991,057 | 100,463 | 5,011 | 3,065,545 |
| Michigan | 1,458,333 | -- | -- | -- | 878,734 | 1,773,933 | 172,418 | 4,283,418 |
| Minnesota | 1,178,933 | -- | -- | 485,692 | 741,275 | 546,569 | 253 | 2,952,721 |
| Mississippi | 5,554 | -- | -- | -- | -- | 1,450,418 | -- | 1,455,972 |
| Missouri | 1,853,065 | -- | -- | -- | 47,283 | -- | 13,812 | 1,914,160 |
| Montana | 13,822,062 | -- | -- | -- | -- | 51,491 | -- | 13,873,553 |
| Nebraska | 1,719,030 | -- | -- | -- | -- | -- | 11,712 | 1,730,742 |
| Nevada | 2,827,671 | 1,425,509 | -- | -- | -- | -- | -- | 4,253,179 |
| New Hampshire | 1,411,282 | 87,643 | -- | -- | 244,102 | 810,891 | -- | 2,553,919 |
| New Jersey | 17,303 | -- | -- | -- | 1,374,521 | -- | 17,054 | 1,408,877 |
| New Mexico | 242,710 | -- | -- | -- | -- | -- | 11,013 | 253,723 |
| New York | 24,751,327 | -- | -- | -- | 2,006,154 | 717,552 | 1,057 | 27,476,091 |
| North Carolina | 3,684,186 | -- | -- | -- | 82,473 | 1,483,171 | 12,100 | 5,261,930 |
| North Dakota | 2,609,159 | -- | -- | -- | -- | -- | 5,736 | 2,614,895 |
| Ohio | 423,031 | -- | -- | -- | -- | 636,752 | -- | 1,059,783 |
| Oklahoma | 3,175,399 | -- | -- | -- | 1,653 | 166,599 | -- | 3,343,651 |
| Oregon | 45,639,050 | -- | -- | 84,792 | 94,705 | 358,554 | -- | 46,177,101 |
| Pennsylvania | 1,946,598 | -- | -- | -- | 1,982,281 | 544,376 | 41,253 | 4,514,507 |
| Rhode Island | 6,050 | -- | -- | -- | 114,192 | -- | -- | 120,241 |
| South Carolina | 1,687,351 | -- | -- | -- | 60,577 | 1,484,583 | 2,605 | 3,235,116 |
| South Dakota | 6,677,303 | -- | -- | -- | -- | -- | -- | 6,677,303 |
| Tennessee | 7,801,957 | -- | -- | -- | 35,109 | 616,424 | 4,984 | 8,458,474 |
| Texas | 1,120,206 | -- | 86 | 319,960 | 43,469 | 692,800 | 42,716 | 2,219,237 |
| Utah | 1,255,142 | 155,530 | -- | -- | 8,169 | -- | -- | 1,418,841 |
| Vermont | 1,195,696 | -- | -- | 13,604 | -- | 397,362 | -- | 1,606,662 |
| Virginia | 681,686 | -- | -- | -- | 1,107,461 | 1,678,127 | 6,317 | 3,473,592 |
| Washington | 96,989,382 | -- | -- | -- | 231,061 | 1,095,878 | 19,639 | 98,335,960 |
| West Virginia | 930,256 | -- | -- | -- | -- | -- | -- | 930,256 |
| Wisconsin | 1,984,593 | -- | -- | -- | 156,340 | 851,572 | 136,102 | 3,128,607 |
| Wyoming | 1,170,225 | -- | -- | 11,150 | -- | -- | -- | 1,181,375 |
| **Total** | **319,483,831** | **16,812,610** | **847,955** | **4,487,998** | **19,836,476** | **34,645,559** | **3,147,052** | **399,261,481** |

[a]Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Energy Information Administration, Form EIA-759, "Monthly Power Plant Report," and Form EIA-860B, "Annual Electric Generator Report – Nonutility."

## C8. Renewable Nonutility Gross Generation by State, 1999

(Thousand Kilowatthours)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas | Wood/ Wood Waste | Other Waste[a] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | -- | -- | -- | -- | -- | 4,022,349 | 8,685 | 4,031,034 |
| Alaska | -- | -- | -- | -- | -- | -- | -- | -- |
| Arizona | -- | -- | -- | -- | -- | -- | 106,143 | 106,143 |
| Arkansas | 1,337 | -- | -- | -- | -- | 1,345,698 | 7,865 | 1,354,900 |
| California | 1,523,297 | 13,804,331 | 869,905 | 3,258,600 | 1,762,446 | 3,425,701 | 540,284 | 25,184,564 |
| Colorado | 120,262 | -- | -- | -- | -- | -- | 32,421 | 152,683 |
| Connecticut | 57,170 | -- | -- | -- | 1,519,343 | -- | 226,405 | 1,802,917 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | -- | -- | -- | -- | 3,235,251 | 1,799,321 | 661,356 | 5,695,928 |
| Georgia | 28,910 | -- | -- | -- | 17,107 | 3,094,379 | 25,145 | 3,165,540 |
| Hawaii | 99,715 | 217,378 | -- | 12,827 | 376,000 | -- | 206,188 | 912,109 |
| Idaho | 997,051 | -- | -- | -- | -- | 501,811 | -- | 1,498,862 |
| Illinois | 90,974 | -- | -- | -- | 484,533 | 208,119 | 440,916 | 1,224,542 |
| Indiana | -- | -- | -- | -- | 126,032 | -- | -- | 126,032 |
| Iowa | 14,696 | -- | -- | 327,971 | 55,449 | 11 | 17,127 | 415,253 |
| Kansas | 12,491 | -- | -- | -- | -- | -- | -- | 12,491 |
| Kentucky | -- | -- | -- | -- | -- | 12,793 | -- | 12,793 |
| Louisiana | 809,925 | -- | -- | -- | -- | 2,532,796 | 131,016 | 3,473,738 |
| Maine | 3,274,698 | -- | -- | -- | 436,803 | 2,647,966 | 85,735 | 6,445,201 |
| Maryland | 1,797 | -- | -- | -- | 374,505 | 183,130 | 42 | 559,474 |
| Massachusetts | 429,193 | -- | -- | -- | 2,052,400 | 103,570 | 5,119 | 2,590,282 |
| Michigan | 91,957 | -- | -- | -- | 902,217 | 1,828,797 | 177,750 | 3,000,721 |
| Minnesota | 324,858 | -- | -- | 490,598 | 333,799 | 563,474 | 261 | 1,712,989 |
| Mississippi | 5,610 | -- | -- | -- | -- | 1,495,276 | -- | 1,500,886 |
| Missouri | -- | -- | -- | -- | -- | -- | 11,620 | 11,620 |
| Montana | 2,263,986 | -- | -- | -- | -- | 53,083 | -- | 2,317,069 |
| Nebraska | -- | -- | -- | -- | -- | -- | 11,951 | 11,951 |
| Nevada | 20,716 | 1,469,417 | -- | -- | -- | -- | -- | 1,490,133 |
| New Hampshire | 1,082,895 | 90,354 | -- | -- | 250,633 | 835,971 | -- | 2,259,853 |
| New Jersey | 17,478 | -- | -- | -- | 1,416,166 | -- | 17,433 | 1,451,077 |
| New Mexico | -- | -- | -- | -- | -- | -- | 11,238 | 11,238 |
| New York | 3,554,228 | -- | -- | -- | 2,065,326 | 739,611 | 1,090 | 6,360,255 |
| North Carolina | 1,217,880 | -- | -- | -- | 84,661 | 1,529,042 | 12,474 | 2,844,057 |
| North Dakota | -- | -- | -- | -- | -- | -- | 5,914 | 5,914 |
| Ohio | -- | -- | -- | -- | -- | 656,445 | -- | 656,445 |
| Oklahoma | -- | -- | -- | -- | 1,704 | 171,751 | -- | 173,455 |
| Oregon | 409,260 | -- | -- | 85,649 | 97,634 | 369,643 | -- | 962,186 |
| Pennsylvania | 345,704 | -- | -- | -- | 2,041,690 | 560,767 | 42,448 | 2,990,609 |
| Rhode Island | 6,111 | -- | -- | -- | 116,522 | -- | -- | 122,633 |
| South Carolina | 41,119 | -- | -- | -- | 62,451 | 1,530,498 | 2,686 | 1,636,753 |
| South Dakota | -- | -- | -- | -- | -- | -- | -- | -- |
| Tennessee | 658,125 | -- | -- | -- | 35,993 | 635,489 | 5,138 | 1,334,745 |
| Texas | 3,359 | -- | -- | 323,192 | 44,356 | 713,618 | 43,827 | 1,128,352 |
| Utah | 8,501 | -- | -- | -- | 8,421 | -- | -- | 16,922 |
| Vermont | 782,840 | -- | -- | -- | -- | 202,975 | -- | 985,814 |
| Virginia | 62,236 | -- | -- | -- | 1,140,707 | 1,727,963 | 6,506 | 2,937,412 |
| Washington | 522,148 | -- | -- | -- | 238,013 | 849,250 | 20,169 | 1,629,580 |
| West Virginia | 633,861 | -- | -- | -- | -- | -- | -- | 633,861 |
| Wisconsin | 253,166 | -- | -- | -- | 151,678 | 657,714 | 15,340 | 1,077,898 |
| Wyoming | -- | -- | -- | 11,263 | -- | -- | -- | 11,263 |
| **Total** | **19,767,551** | **15,581,480** | **869,905** | **4,510,098** | **19,431,839** | **34,999,009** | **2,880,293** | **98,040,176** |

[a]Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-860B, "Annual Electric Generator Report – Nonutility."

## C9. Renewable Electric Utility Net Summer Capability by State, 1998

(Megawatts)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas | Wood/ Wood Waste | Other Waste[a] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | 3,009 | -- | -- | -- | -- | -- | -- | 3,009 |
| Alaska | 359 | -- | -- | * | -- | -- | -- | 359 |
| Arizona | 2,708 | -- | * | -- | -- | -- | -- | 2,708 |
| Arkansas | 1,277 | -- | -- | -- | -- | -- | -- | 1,277 |
| California | 9,780 | 1,515 | 4 | 7 | -- | -- | -- | 11,305 |
| Colorado | 614 | -- | -- | -- | -- | -- | -- | 614 |
| Connecticut | 130 | -- | -- | -- | -- | -- | -- | 130 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | 47 | -- | -- | -- | 3 | -- | -- | 50 |
| Georgia | 2,335 | -- | -- | -- | -- | -- | -- | 2,335 |
| Hawaii | 4 | -- | -- | -- | -- | -- | -- | 4 |
| Idaho | 2,435 | -- | -- | -- | -- | -- | -- | 2,435 |
| Illinois | 13 | -- | -- | -- | -- | -- | -- | 13 |
| Indiana | 59 | -- | -- | -- | -- | -- | -- | 59 |
| Iowa | 131 | -- | -- | * | -- | -- | -- | 131 |
| Kansas | -- | -- | -- | -- | -- | -- | -- | -- |
| Kentucky | 808 | -- | -- | -- | -- | -- | -- | 808 |
| Louisiana | -- | -- | -- | -- | -- | -- | -- | -- |
| Maine | 402 | -- | -- | -- | -- | 30 | -- | 432 |
| Maryland | 530 | -- | -- | -- | -- | -- | -- | 530 |
| Massachusetts | 152 | -- | -- | * | -- | -- | -- | 152 |
| Michigan | 241 | -- | -- | 1 | -- | -- | -- | 242 |
| Minnesota | 139 | -- | -- | -- | 84 | 62 | * | 285 |
| Mississippi | -- | -- | -- | -- | -- | -- | -- | -- |
| Missouri | 543 | -- | -- | -- | -- | -- | -- | 543 |
| Montana | 2,587 | -- | -- | -- | -- | -- | -- | 2,587 |
| Nebraska | 167 | -- | -- | -- | -- | -- | -- | 167 |
| Nevada | 1,046 | -- | -- | -- | -- | -- | -- | 1,046 |
| New Hampshire | 64 | -- | -- | -- | -- | -- | -- | 64 |
| New Jersey | -- | -- | -- | -- | -- | -- | -- | -- |
| New Mexico | 81 | -- | -- | -- | -- | -- | -- | 81 |
| New York | 3,787 | -- | -- | -- | -- | -- | -- | 3,787 |
| North Carolina | 1,584 | -- | -- | -- | -- | -- | -- | 1,584 |
| North Dakota | 518 | -- | -- | -- | -- | -- | -- | 518 |
| Ohio | 123 | -- | -- | -- | 90 | -- | -- | 213 |
| Oklahoma | 775 | -- | -- | -- | -- | -- | -- | 775 |
| Oregon | 9,032 | -- | -- | -- | 25 | 12 | 3 | 9,072 |
| Pennsylvania | 621 | -- | -- | -- | -- | -- | -- | 621 |
| Rhode Island | 1 | -- | -- | -- | -- | -- | -- | 1 |
| South Carolina | 1,263 | -- | -- | -- | -- | -- | -- | 1,263 |
| South Dakota | 1,806 | -- | -- | -- | -- | -- | -- | 1,806 |
| Tennessee | 2,230 | -- | -- | -- | -- | -- | -- | 2,230 |
| Texas | 694 | -- | 1 | -- | -- | -- | -- | 695 |
| Utah | 265 | 35 | -- | -- | -- | -- | -- | 300 |
| Vermont | 103 | -- | -- | 1 | -- | 52 | -- | 156 |
| Virginia | 742 | -- | * | -- | -- | -- | -- | 742 |
| Washington | 21,479 | -- | -- | -- | -- | 83 | -- | 21,562 |
| West Virginia | 102 | -- | -- | -- | -- | -- | -- | 102 |
| Wisconsin | 443 | -- | -- | -- | 31 | 30 | -- | 503 |
| Wyoming | 298 | -- | -- | -- | -- | -- | -- | 298 |
| **Total** | **75,525** | **1,550** | **5** | **9** | **232** | **268** | **3** | **77,593** |

[a]Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

* = Capability was less than 0.5 megawatts.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-860A, "Annual Electric Generator Report - Utility."

## C10. Renewable Nonutility Net Summer Capability by State, 1998

(Megawatts)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas[a] | Wood/ Wood Waste[a] | Other Waste[a b] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | -- | -- | -- | -- | -- | 785 | 5 | 789 |
| Alaska | -- | -- | -- | -- | -- | -- | -- | -- |
| Arizona | -- | -- | -- | -- | -- | -- | -- | -- |
| Arkansas | -- | -- | -- | -- | -- | 252 | -- | 252 |
| California | 476 | 1,117 | 330 | 1,480 | 225 | 575 | 104 | 4,306 |
| Colorado | 30 | -- | -- | -- | -- | -- | -- | 30 |
| Connecticut | 19 | -- | -- | -- | 215 | -- | 29 | 263 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | -- | -- | 30 | -- | 433 | 425 | R134 | R1,022 |
| Georgia | 10 | -- | -- | -- | 2 | 528 | 5 | 546 |
| Hawaii | 25 | 33 | -- | 20 | 62 | -- | 93 | 232 |
| Idaho | 232 | -- | -- | -- | -- | 130 | -- | 363 |
| Illinois | 24 | -- | -- | -- | 131 | -- | -- | 154 |
| Indiana | -- | -- | -- | -- | 11 | -- | -- | 11 |
| Iowa | 5 | -- | -- | -- | 5 | -- | -- | 11 |
| Kansas | 2 | -- | -- | -- | -- | -- | -- | 2 |
| Kentucky | -- | -- | -- | -- | -- | 4 | -- | 4 |
| Louisiana | 182 | -- | -- | -- | -- | 478 | 15 | 676 |
| Maine | 355 | -- | -- | -- | 38 | 507 | 48 | 947 |
| Maryland | -- | -- | -- | -- | 124 | 3 | 1 | 128 |
| Massachusetts | 729 | -- | -- | -- | 268 | 25 | 9 | 1,031 |
| Michigan | 24 | -- | -- | -- | 155 | 286 | -- | 465 |
| Minnesota | 64 | -- | -- | 129 | 50 | 128 | -- | 371 |
| Mississippi | -- | -- | -- | -- | -- | 263 | -- | 263 |
| Missouri | -- | -- | -- | -- | -- | -- | -- | -- |
| Montana | 11 | -- | -- | -- | -- | 10 | -- | 21 |
| Nebraska | -- | -- | -- | -- | -- | -- | -- | -- |
| Nevada | 4 | 218 | -- | -- | -- | -- | -- | 222 |
| New Hampshire | 377 | -- | -- | -- | 29 | 115 | -- | 522 |
| New Jersey | 13 | -- | -- | -- | 187 | -- | -- | 199 |
| New Mexico | -- | -- | -- | -- | -- | -- | -- | -- |
| New York | 347 | -- | -- | -- | 158 | 42 | 121 | 669 |
| North Carolina | 406 | -- | -- | -- | 13 | 260 | -- | 679 |
| North Dakota | -- | -- | -- | -- | -- | -- | 9 | 9 |
| Ohio | -- | -- | -- | -- | -- | 120 | -- | 120 |
| Oklahoma | -- | -- | -- | -- | 16 | 60 | -- | 76 |
| Oregon | 96 | -- | -- | 25 | 12 | 158 | -- | 292 |
| Pennsylvania | 70 | -- | -- | -- | 257 | 60 | -- | 387 |
| Rhode Island | 2 | -- | -- | -- | 15 | -- | -- | 17 |
| South Carolina | 18 | -- | -- | -- | 13 | 322 | -- | 353 |
| South Dakota | -- | -- | -- | -- | -- | -- | -- | -- |
| Tennessee | 170 | -- | -- | -- | 10 | 73 | -- | 253 |
| Texas | 2 | -- | -- | 34 | 5 | 174 | 8 | 223 |
| Utah | 2 | -- | -- | -- | -- | -- | -- | 2 |
| Vermont | 167 | -- | -- | -- | -- | 20 | -- | 187 |
| Virginia | 21 | -- | -- | -- | 212 | 424 | -- | 657 |
| Washington | 83 | -- | -- | -- | 5 | 187 | R-- | R275 |
| West Virginia | 36 | -- | -- | -- | -- | -- | -- | 36 |
| Wisconsin | 48 | -- | -- | -- | 19 | 93 | -- | 159 |
| Wyoming | -- | -- | -- | 1 | -- | -- | -- | 1 |
| **Total** | **4,048** | **1,367** | **360** | **1,689** | **2,671** | **6,508** | **R581** | **R17,224** |

[a] There is a discontinuity in capability estimates between 1998 and 1999 due to a change in reporting practices. In 1999 for the first time, respondents self identified the facility's primary energy source resulting in a reclassification compared to earlier years in some cases.

[b] Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

R = Revised.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-860B, "Annual Electric Generator Report – Nonutility."

## C11. Renewable Electric Power Industry Net Summer Capability by State, 1998

(Megawatts)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas[a] | Wood/ Wood Waste[a] | Other Waste[a b] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | 3,009 | -- | -- | -- | -- | 785 | 5 | 3,799 |
| Alaska | 359 | -- | -- | * | -- | -- | -- | 359 |
| Arizona | 2,708 | -- | * | -- | -- | -- | -- | 2,708 |
| Arkansas | 1,277 | -- | -- | -- | -- | 252 | -- | 1,529 |
| California | 10,256 | 2,631 | 334 | 1,487 | 225 | 575 | 104 | 15,611 |
| Colorado | 644 | -- | -- | -- | -- | -- | -- | 644 |
| Connecticut | 148 | -- | -- | -- | 215 | -- | 29 | 392 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | 47 | -- | 30 | -- | 436 | 425 | R134 | R1,072 |
| Georgia | 2,345 | -- | -- | -- | 2 | 528 | 5 | 2,881 |
| Hawaii | 28 | 33 | -- | 20 | 62 | -- | 93 | 236 |
| Idaho | 2,667 | -- | -- | -- | -- | 130 | -- | 2,798 |
| Illinois | 37 | -- | -- | -- | 131 | -- | -- | 167 |
| Indiana | 59 | -- | -- | -- | 11 | -- | -- | 69 |
| Iowa | 136 | -- | -- | * | 5 | -- | -- | 142 |
| Kansas | 2 | -- | -- | -- | -- | -- | -- | 2 |
| Kentucky | 808 | -- | -- | -- | -- | 4 | -- | 812 |
| Louisiana | 182 | -- | -- | -- | -- | 478 | 15 | 676 |
| Maine | 758 | -- | -- | -- | 38 | 536 | 48 | 1,379 |
| Maryland | 530 | -- | -- | -- | 124 | 3 | 1 | 658 |
| Massachusetts | 880 | -- | -- | * | 268 | 25 | 9 | 1,183 |
| Michigan | 265 | -- | -- | 1 | 155 | 286 | -- | 707 |
| Minnesota | 203 | -- | -- | 129 | 133 | 190 | * | 655 |
| Mississippi | -- | -- | -- | -- | -- | 263 | -- | 263 |
| Missouri | 543 | -- | -- | -- | -- | -- | -- | 543 |
| Montana | 2,598 | -- | -- | -- | -- | 10 | -- | 2,608 |
| Nebraska | 167 | -- | -- | -- | -- | -- | -- | 167 |
| Nevada | 1,050 | 218 | -- | -- | -- | -- | -- | 1,268 |
| New Hampshire | 441 | -- | -- | -- | 29 | 115 | -- | 586 |
| New Jersey | 13 | -- | -- | -- | 187 | -- | -- | 199 |
| New Mexico | 81 | -- | -- | -- | -- | -- | -- | 81 |
| New York | 4,134 | -- | -- | -- | 158 | 42 | 121 | 4,455 |
| North Carolina | 1,990 | -- | -- | -- | 13 | 260 | -- | 2,263 |
| North Dakota | 518 | -- | -- | -- | -- | -- | 9 | 527 |
| Ohio | 123 | -- | -- | -- | 90 | 120 | -- | 333 |
| Oklahoma | 775 | -- | -- | -- | 16 | 60 | -- | 851 |
| Oregon | 9,128 | -- | -- | 25 | 37 | 170 | 3 | 9,364 |
| Pennsylvania | 691 | -- | -- | -- | 257 | 60 | -- | 1,008 |
| Rhode Island | 3 | -- | -- | -- | 15 | -- | -- | 18 |
| South Carolina | 1,281 | -- | -- | -- | 13 | 322 | -- | 1,616 |
| South Dakota | 1,806 | -- | -- | -- | -- | -- | -- | 1,806 |
| Tennessee | 2,400 | -- | -- | -- | 10 | 73 | -- | 2,483 |
| Texas | 695 | -- | 1 | 34 | 5 | 174 | 8 | 918 |
| Utah | 266 | 35 | -- | -- | -- | -- | -- | 301 |
| Vermont | 271 | -- | -- | 1 | -- | 72 | -- | 343 |
| Virginia | 763 | -- | * | -- | 212 | 424 | -- | 1,399 |
| Washington | 21,562 | -- | -- | -- | 5 | 270 | R-- | R21,837 |
| West Virginia | 137 | -- | -- | -- | -- | -- | -- | 137 |
| Wisconsin | 490 | -- | -- | -- | 49 | 123 | -- | 662 |
| Wyoming | 298 | -- | -- | 1 | -- | -- | -- | 299 |
| **Total** | **79,573** | **2,917** | **365** | **1,698** | **2,903** | **6,776** | **R585** | **R94,817** |

[a] There is a discontinuity in capability estimates between 1998 and 1999 due to a change in reporting practices. In 1999 for the first time, nonutility respondents self identified the facility's primary energy source resulting in a reclassification compared to earlier years in some cases.

[b] Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

R = Revised.

* = Capability was less than 0.5 megawatts.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Energy Information Administration, Form EIA-860A, "Annual Electric Generator Report - Utility," and Form EIA-860B, "Annual Electric Generator Report – Nonutility."

## C12. Renewable Electric Utility Net Summer Capability by State, 1999

(Megawatts)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas | Wood/ Wood Waste | Other Waste[a] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | 3,007 | -- | -- | -- | -- | -- | -- | 3,007 |
| Alaska | 374 | -- | -- | * | -- | -- | -- | 374 |
| Arizona | 2,705 | -- | 1 | -- | -- | -- | -- | 2,706 |
| Arkansas | 1,393 | -- | -- | -- | -- | -- | -- | 1,393 |
| California | 9,838 | 238 | 3 | 7 | -- | -- | -- | 10,086 |
| Colorado | 614 | -- | -- | -- | -- | -- | -- | 614 |
| Connecticut | 129 | -- | -- | -- | -- | -- | -- | 129 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | 47 | -- | -- | -- | 3 | -- | -- | 50 |
| Georgia | 2,365 | -- | -- | -- | -- | -- | -- | 2,365 |
| Hawaii | 4 | -- | -- | -- | -- | -- | -- | 4 |
| Idaho | 2,429 | -- | -- | -- | -- | -- | -- | 2,429 |
| Illinois | 12 | -- | -- | -- | -- | -- | -- | 12 |
| Indiana | 59 | -- | -- | -- | -- | -- | -- | 59 |
| Iowa | 131 | -- | -- | 2 | -- | -- | -- | 133 |
| Kansas | -- | -- | -- | -- | -- | -- | -- | -- |
| Kentucky | 808 | -- | -- | -- | -- | -- | -- | 808 |
| Louisiana | -- | -- | -- | -- | -- | -- | -- | -- |
| Maine | 34 | -- | -- | -- | -- | -- | -- | 34 |
| Maryland | 512 | -- | -- | -- | -- | -- | -- | 512 |
| Massachusetts | 139 | -- | -- | * | -- | -- | -- | 139 |
| Michigan | 243 | -- | -- | 1 | -- | -- | -- | 243 |
| Minnesota | 136 | -- | -- | 1 | 84 | 61 | * | 283 |
| Mississippi | -- | -- | -- | -- | -- | -- | -- | -- |
| Missouri | 543 | -- | -- | -- | -- | -- | -- | 543 |
| Montana | 2,147 | -- | -- | -- | -- | -- | -- | 2,147 |
| Nebraska | 162 | -- | -- | 2 | -- | -- | -- | 164 |
| Nevada | 1,049 | -- | -- | -- | -- | -- | -- | 1,049 |
| New Hampshire | 64 | -- | -- | -- | -- | -- | -- | 64 |
| New Jersey | -- | -- | -- | -- | -- | -- | -- | -- |
| New Mexico | 82 | -- | -- | -- | -- | -- | -- | 82 |
| New York | 3,159 | -- | -- | -- | -- | -- | -- | 3,159 |
| North Carolina | 1,490 | -- | -- | -- | -- | -- | -- | 1,490 |
| North Dakota | 518 | -- | -- | -- | -- | -- | -- | 518 |
| Ohio | 164 | -- | -- | -- | 90 | -- | -- | 254 |
| Oklahoma | 782 | -- | -- | -- | -- | -- | -- | 782 |
| Oregon | 9,017 | -- | -- | -- | 25 | 12 | 3 | 9,057 |
| Pennsylvania | 591 | -- | -- | -- | -- | -- | -- | 591 |
| Rhode Island | 1 | -- | -- | -- | -- | -- | -- | 1 |
| South Carolina | 1,270 | -- | -- | -- | -- | -- | -- | 1,270 |
| South Dakota | 1,806 | -- | -- | -- | -- | -- | -- | 1,806 |
| Tennessee | 2,230 | -- | -- | -- | -- | -- | -- | 2,230 |
| Texas | 691 | -- | 1 | -- | -- | -- | -- | 692 |
| Utah | 265 | 35 | -- | -- | -- | -- | -- | 300 |
| Vermont | 107 | -- | -- | 1 | -- | 52 | -- | 160 |
| Virginia | 738 | -- | * | -- | -- | -- | -- | 738 |
| Washington | 21,420 | -- | -- | -- | 8 | 85 | -- | 21,513 |
| West Virginia | 98 | -- | -- | -- | -- | -- | -- | 98 |
| Wisconsin | 452 | -- | -- | 12 | 29 | 30 | -- | 523 |
| Wyoming | 298 | -- | -- | 5 | -- | -- | -- | 302 |
| **Total** | **74,122** | **273** | **5** | **29** | **240** | **240** | **3** | **74,912** |

[a]Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

* = Capability was less than 0.5 megawatts.

Note: Totals may not equal sum of components due to independent rounding.

Source: Energy Information Administration, Form EIA-860A, "Annual Electric Generator Report - Utility."

## C13. Renewable Nonutility Net Summer Capability by State, 1999

(Megawatts)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas[a] | Wood/ Wood Waste[a] | Other Waste[a b] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | -- | -- | -- | -- | -- | 694 | * | 694 |
| Alaska | -- | -- | -- | -- | -- | -- | -- | -- |
| Arizona | -- | -- | -- | -- | -- | -- | -- | -- |
| Arkansas | 1 | -- | -- | -- | 1 | 261 | 1 | 264 |
| California | 518 | 2,367 | 369 | 1,551 | 251 | 669 | 109 | 5,834 |
| Colorado | 32 | -- | -- | -- | -- | -- | 4 | 37 |
| Connecticut | 20 | -- | -- | -- | 157 | -- | 94 | 272 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | -- | -- | -- | -- | 204 | 421 | 412 | 1,036 |
| Georgia | 12 | -- | -- | -- | 2 | 719 | -- | 733 |
| Hawaii | 25 | 34 | -- | 9 | 64 | -- | 48 | 180 |
| Idaho | 264 | -- | -- | -- | -- | 135 | -- | 399 |
| Illinois | 21 | -- | -- | -- | 690 | -- | 98 | 809 |
| Indiana | -- | -- | -- | -- | 11 | -- | 6 | 18 |
| Iowa | 5 | -- | -- | 193 | 6 | -- | 3 | 207 |
| Kansas | 3 | -- | -- | -- | -- | -- | -- | 3 |
| Kentucky | -- | -- | -- | -- | -- | 4 | -- | 4 |
| Louisiana | 199 | -- | -- | -- | -- | 449 | 18 | 666 |
| Maine | 749 | -- | -- | -- | 39 | 725 | 24 | 1,537 |
| Maryland | 19 | -- | -- | -- | 70 | 3 | 1 | 93 |
| Massachusetts | 121 | -- | -- | -- | 48 | 38 | 231 | 438 |
| Michigan | 27 | -- | -- | -- | 83 | 268 | 66 | 443 |
| Minnesota | 65 | -- | -- | 266 | 50 | 141 | -- | 522 |
| Mississippi | 3 | -- | -- | -- | -- | 272 | -- | 276 |
| Missouri | -- | -- | -- | -- | -- | -- | -- | -- |
| Montana | 577 | -- | -- | -- | -- | 11 | -- | 587 |
| Nebraska | -- | -- | -- | -- | -- | -- | 3 | 3 |
| Nevada | 4 | 209 | -- | -- | -- | -- | -- | 213 |
| New Hampshire | 376 | 15 | -- | -- | 11 | 104 | 18 | 524 |
| New Jersey | 14 | -- | -- | -- | 179 | -- | 23 | 216 |
| New Mexico | -- | -- | -- | -- | -- | -- | 2 | 2 |
| New York | 1,032 | -- | -- | -- | 109 | 109 | 251 | 1,501 |
| North Carolina | 366 | -- | -- | -- | 14 | 186 | -- | 566 |
| North Dakota | -- | -- | -- | -- | -- | -- | 10 | 10 |
| Ohio | -- | -- | -- | -- | -- | 16 | -- | 16 |
| Oklahoma | -- | -- | -- | -- | -- | 63 | 16 | 79 |
| Oregon | 105 | -- | -- | 25 | 13 | 124 | -- | 267 |
| Pennsylvania | 119 | -- | -- | -- | 154 | 29 | 119 | 422 |
| Rhode Island | 3 | -- | -- | -- | 14 | -- | -- | 17 |
| South Carolina | 28 | -- | -- | -- | 13 | 197 | -- | 238 |
| South Dakota | -- | -- | -- | -- | -- | -- | -- | -- |
| Tennessee | 167 | -- | -- | -- | 10 | 11 | -- | 188 |
| Texas | 2 | -- | -- | 173 | 7 | 93 | 8 | 282 |
| Utah | 4 | -- | -- | -- | -- | -- | 2 | 6 |
| Vermont | 185 | -- | -- | -- | -- | 25 | -- | 210 |
| Virginia | 21 | -- | -- | -- | 216 | 443 | -- | 680 |
| Washington | 107 | -- | -- | -- | 5 | 233 | 26 | 371 |
| West Virginia | 143 | -- | -- | -- | -- | -- | -- | 143 |
| Wisconsin | 52 | -- | -- | -- | 21 | 44 | 5 | 121 |
| Wyoming | 1 | -- | -- | 5 | -- | -- | -- | 7 |
| **Total** | **5,389** | **2,625** | **369** | **2,222** | **2,442** | **6,486** | **1,599** | **21,133** |

[a] There is a discontinuity in capability estimates between 1999 and earlier years due to a change in reporting practices. In 1999 for the first time, respondents self identified the facility's primary energy source resulting in a reclassification compared to earlier years in some cases.

[b] Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

* = Capability less than 0.5 megawatts.

Note: Totals may not equal sum of components due to independent rounding.

## C14. Renewable Electric Power Industry Net Summer Capability by State, 1999

(Megawatts)

| | Hydro-electric | Geothermal | Solar/ PV | Wind | MSW/ Landfill Gas[a] | Wood/ Wood Waste[a] | Other Waste[a b] | Total |
|---|---|---|---|---|---|---|---|---|
| Alabama | 3,007 | -- | -- | -- | -- | 694 | -- | 3,702 |
| Alaska | 374 | -- | -- | * | -- | -- | -- | 374 |
| Arizona | 2,705 | -- | 1 | -- | -- | -- | -- | 2,706 |
| Arkansas | 1,394 | -- | -- | -- | 1 | 261 | 1 | 1,657 |
| California | 10,356 | 2,605 | 372 | 1,558 | 251 | 669 | 109 | 15,920 |
| Colorado | 646 | -- | -- | -- | -- | -- | 4 | 651 |
| Connecticut | 150 | -- | -- | -- | 157 | -- | 94 | 402 |
| Delaware | -- | -- | -- | -- | -- | -- | -- | -- |
| Dist. of Col. | -- | -- | -- | -- | -- | -- | -- | -- |
| Florida | 47 | -- | -- | -- | 207 | 421 | 412 | 1,086 |
| Georgia | 2,377 | -- | -- | -- | 2 | 719 | -- | 3,098 |
| Hawaii | 29 | 34 | -- | 9 | 64 | -- | 48 | 183 |
| Idaho | 2,693 | -- | -- | -- | -- | 135 | -- | 2,828 |
| Illinois | 33 | -- | -- | -- | 690 | -- | 98 | 821 |
| Indiana | 59 | -- | -- | -- | 11 | -- | 6 | 76 |
| Iowa | 137 | -- | -- | 194 | 6 | -- | 3 | 340 |
| Kansas | 3 | -- | -- | -- | -- | -- | -- | 3 |
| Kentucky | 808 | -- | -- | -- | -- | 4 | -- | 812 |
| Louisiana | 199 | -- | -- | -- | -- | 449 | 18 | 666 |
| Maine | 782 | -- | -- | -- | 39 | 725 | 24 | 1,571 |
| Maryland | 531 | -- | -- | -- | 70 | 3 | 1 | 605 |
| Massachusetts | 260 | -- | -- | * | 48 | 38 | 231 | 577 |
| Michigan | 269 | -- | -- | 1 | 83 | 268 | 66 | 686 |
| Minnesota | 201 | -- | -- | 267 | 135 | 202 | * | 805 |
| Mississippi | 3 | -- | -- | -- | -- | 272 | -- | 276 |
| Missouri | 543 | -- | -- | -- | -- | -- | -- | 543 |
| Montana | 2,724 | -- | -- | -- | -- | 11 | -- | 2,734 |
| Nebraska | 162 | -- | -- | 2 | -- | -- | 3 | 167 |
| Nevada | 1,053 | 209 | -- | -- | -- | -- | -- | 1,262 |
| New Hampshire | 440 | 15 | -- | -- | 11 | 104 | 18 | 588 |
| New Jersey | 14 | -- | -- | -- | 179 | -- | 23 | 216 |
| New Mexico | 82 | -- | -- | -- | -- | -- | 2 | 84 |
| New York | 4,190 | -- | -- | -- | 109 | 109 | 251 | 4,659 |
| North Carolina | 1,856 | -- | -- | -- | 14 | 186 | -- | 2,057 |
| North Dakota | 518 | -- | -- | -- | -- | -- | 10 | 528 |
| Ohio | 164 | -- | -- | -- | 90 | 16 | -- | 269 |
| Oklahoma | 782 | -- | -- | -- | -- | 63 | 16 | 861 |
| Oregon | 9,122 | -- | -- | 25 | 38 | 136 | 3 | 9,324 |
| Pennsylvania | 710 | -- | -- | -- | 154 | 29 | 119 | 1,013 |
| Rhode Island | 4 | -- | -- | -- | 14 | -- | -- | 19 |
| South Carolina | 1,298 | -- | -- | -- | 13 | 197 | -- | 1,508 |
| South Dakota | 1,806 | -- | -- | -- | -- | -- | -- | 1,806 |
| Tennessee | 2,397 | -- | -- | -- | 10 | 11 | -- | 2,418 |
| Texas | 693 | -- | 1 | 173 | 7 | 93 | 8 | 974 |
| Utah | 269 | 35 | -- | -- | -- | -- | 2 | 306 |
| Vermont | 292 | -- | -- | 1 | -- | 77 | -- | 370 |
| Virginia | 760 | -- | * | -- | 216 | 443 | -- | 1,418 |
| Washington | 21,526 | -- | -- | -- | 14 | 318 | 26 | 21,884 |
| West Virginia | 241 | -- | -- | -- | -- | -- | -- | 241 |
| Wisconsin | 504 | -- | -- | 12 | 50 | 74 | 5 | 644 |
| Wyoming | 299 | -- | -- | 10 | -- | -- | -- | 309 |
| **Total** | **79,511** | **2,898** | **373** | **2,252** | **2,682** | **6,726** | **1,602** | **96,045** |

[a] There is a discontinuity in capability estimates between 1999 and earlier years due to a change in reporting practices. In 1999 for the first time, nonutility respondents self identified the facility's primary energy source resulting in a reclassification compared to earlier years in some cases.

[b] Agricultural waste, straw, tires, fish oils, paper pellets, tall oil, sludge waste, digester gas, methane, and waste alcohol.

-- = Not applicable.

* = Capability was less than 0.5 megawatts.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Energy Information Administration, Form EIA-860A, "Annual Electric Generator Report - Utility," and Form EIA-860B, "Annual Electric Generator Report – Nonutility."

## Table C15. Renewable Market Share of Electric Power Industry Net Generation by State, 1998

(Thousand Kilowatthours)

| State | Total Generation | Renewable Generation | Percent Renewable |
|---|---|---|---|
| Alabama | 120,032,763 | 14,591,891 | 12 |
| Alaska | 5,861,188 | 1,114,209 | 19 |
| Arizona | 82,080,348 | 10,970,189 | 13 |
| Arkansas | 45,661,884 | 4,159,896 | 9 |
| California | 188,757,867 | 70,837,128 | 38 |
| Colorado | 38,851,092 | 1,461,961 | 4 |
| Connecticut | 19,669,157 | 2,509,364 | 13 |
| Delaware | 6,898,584 | -- | -- |
| Dist. of Col. | 243,975 | -- | -- |
| Florida | 189,458,656 | 5,454,679 | 3 |
| Georgia | 115,327,447 | 8,170,827 | 7 |
| Hawaii | 10,226,750 | 882,541 | 9 |
| Idaho | 13,848,749 | 13,383,156 | 97 |
| Illinois | 138,746,800 | 779,525 | 1 |
| Indiana | 117,520,960 | 602,779 | 1 |
| Iowa | 38,205,016 | 987,791 | 3 |
| Kansas | 41,585,227 | 11,425 | * |
| Kentucky | 90,936,825 | 3,131,670 | 3 |
| Louisiana | 89,622,382 | 2,964,154 | 3 |
| Maine | 11,116,096 | 6,252,260 | 56 |
| Maryland | 50,649,541 | 2,500,791 | 5 |
| Massachusetts | 45,817,498 | 3,156,605 | 7 |
| Michigan | 100,566,070 | 4,252,550 | 4 |
| Minnesota | 47,418,129 | 2,227,424 | 5 |
| Mississippi | 34,433,901 | 1,060,717 | 3 |
| Missouri | 75,192,842 | 2,427,688 | 3 |
| Montana | 28,460,516 | 11,161,751 | 39 |
| Nebraska | 28,796,791 | 1,683,541 | 6 |
| Nevada | 30,590,359 | 4,685,906 | 15 |
| New Hampshire | 16,102,737 | 2,694,750 | 17 |
| New Jersey | 53,666,002 | 1,306,404 | 2 |
| New Mexico | 32,341,707 | 236,412 | 1 |
| New York | 144,553,274 | 31,619,938 | 22 |
| North Carolina | 121,371,988 | 7,160,091 | 6 |
| North Dakota | 30,671,950 | 2,297,472 | 7 |
| Ohio | 147,943,088 | 1,104,826 | 1 |
| Oklahoma | 56,190,603 | 3,726,839 | 7 |
| Oregon | 51,142,373 | 40,351,934 | 79 |
| Pennsylvania | 191,134,032 | 4,798,766 | 3 |
| Rhode Island | 7,658,736 | 119,831 | 2 |
| South Carolina | 87,244,314 | 5,185,688 | 6 |
| South Dakota | 9,088,990 | 5,757,600 | 63 |
| Tennessee | 97,730,651 | 11,324,502 | 12 |
| Texas | 354,837,511 | 2,331,358 | 1 |
| Utah | 35,910,429 | 1,474,768 | 4 |
| Vermont | 4,909,009 | 1,508,191 | 31 |
| Virginia | 72,198,147 | 3,888,977 | 5 |
| Washington | 102,074,362 | 81,153,877 | 80 |
| West Virginia | 92,822,187 | 1,086,345 | 1 |
| Wisconsin | 56,355,885 | 3,016,740 | 5 |
| Wyoming | 45,347,670 | 1,344,367 | 3 |
| **U.S . Total** | **3,617,873,059** | **394,912,092** | **11** |

-- = Not applicable.

* = Less than 0.5 percent.

Note: Totals may not equal sum of components due to independent rounding.

Sources: Energy Information Administration, Form EIA-759, "Monthly Power Plant Report," and Form EIA-860-B, "Annual Electric Generator Report – Nonutility." See Energy Information Administration, *State Electricity Profiles 1998* on the website at: http://www.eia.doe.gov/cneaf/electricity/st_profiles/table_a3.html (January 19, 2001) for related information.

## Appendix D

# Selected List of Internet Addresses: Renewable Energy Information by Resource

The list of addresses that follow are current as of winter 2001. This list is abbreviated due to the great increase in Internet sites as well as the growing presence of links to associated web sites over the past few years. Therefore, this list should provide at least a useful start in a search for renewable energy information.

### General: Renewables

U.S. Department of Energy (DOE), Energy Efficiency and Renewable Energy Homepage
http://www.eren.doe.gov/

For information on DOE Renewable Energy Regional Offices
http://www.eren.doe.gov/rso.html

Energy Information Administration Homepage
http://www.eia.doe.gov

North Carolina Solar Center, Renewable Energy State Incentives Database (co-sponsored by DOE)
http://www.ncsc.ncsu.edu

Center for Renewable Energy and Sustainable Technology
http://www.crest.org/renewables/index.html

International Energy Agency
IEA CADDET International Information on Renewable Energy
http://www.caddet.co.uk/re/

International Energy Agency
Key World Energy Statistics
http://www.iea.org/stats/

National Renewable Energy Laboratory
NREL Publications Database
http://www.nrel.gov/cgi-bin/pubspage.cgi

National Association of Regulatory Utility Commissioners (NARUC) Homepage
http://www.naruc.org/

California Energy Commission
http://www.energy.ca.gov/

Green Energy News
http://www.nrglink.com

Renewable Resource Data Center
http://rredc.nrel.gov

U.S. Department of Energy Green Power Network
http://www.eren.doe.gov/greenpower

State Renewable Energy News
http://www.nrel.gov/analysis/emaa/projects/sren

Interstate Renewable Energy Council
http://www.irecusa.org

## Biomass: Wood

Regional Wood Energy Development Programme in Asia
http://www.rwedp.org/

Information for standing woody biomass (TREEDYN3*):
http://www.gsf.de/UFIS/ufis/modell60/grs957.html

Forest Industry Network
World-wide directory of forestry, logging, harvesting, saw milling equipment, etc. companies and related information.
http://www.forestindustry.com

Wood Products Council
http://www.woodinfo.org/

American Forest and Paper Association
http://www.afandpa.org

## Biomass: Biofuels

Biofuels (Federal Government) Resources on the Internet
http://www.nal.usda.gov/ttic/biofuels.htm

DOE BioPower Information Program
http://www.eren.doe.gov/biopower/

American Bioenergy Association
http://www.biomass.org/

DOE Alternative Fuels Data Center
http://www.afdc.doe.gov

National Renewable Energy Laboratories- DOE's National Biofuels Program
http://www.biofuels.nrel.gov/

Short-Rotation Woody Crops (SRWC) Operations Working Group–a private and public partnership between wood products companies, equipment manufacturers, utility companies, the U.S. Forest Service, the U.S. Department of Energy's Oak Ridge National Laboratory (ORNL), the National Council of the Paper Industry for Air and Stream Improvement (NCASI) and university researchers.
http://www.woodycrops.org/

## Municipal Solid Waste

Characterizations of Municipal Solid Waste in the United States 1995 Update
http://rredc.nrel.gov/biomass/epa/msw95/msw95_index.html

U.S. Environmental Protection Agency, Office of Solid Waste
http://www.epa.gov/osw

The Solid Waste Association of North America
http://www.swana.org/

Municipal Solid Waste Factbook
http://www.epa.gov/epaoswer/non-hw/muncpl/factbook

## Waste-to-Energy

Integrated Waste Services Association
http://www.wte.org/

## Geothermal

Geothermal Products Inc. - Energy Star Programs
http://www.geoproducts.com/estar.html

International Geothermal Association - US DOE Sites
http://www.demon.co.uk/geosci/wrusadoe.html

US DOE/Geothermal Energy Technical Site
http://geothermal.id.doe.gov

Geo-Heat Center, Oregon Institute of Technology, Geothermal Information and Technology Transfer
http://www.oit.osshe.edu/~geoheat/

International Geothermal Association
http://www.demon.co.uk/geosci/igahome.html

Geothermal Theory: Introduction
Summary: How Geothermal Systems Form. Geothermal Occurances Today.
http://www.crest.org/renewables/re-kiosk/geothermal/theory/index.shtml

Geothermal Energy in California
http://www.energy.ca.gov/development/geothermal/index.html

Geothermal Institute, The University of Auckland, New Zealand
http://www.auckland.ac.nz/gei/geoener.htm

Geothermal Links
Summary: GEOTHERMAL LABORATORY GEOTHERMAL LINKS.
International Geothermal Association Nappa Valley/Geysers/Geothermal Area Sites/Geyser Resources/ Coso's Geothermal Field/Water Resources of California/Geothermal Resources Council/ World Geothermal Resources Maps.
http://www.geology.smu.edu/~bonner/geothermlinks.html

Geothermal Energy Association
http://www.geotherm.org

Geothermal Resources Council
http://www.geothermal.org

U.S. DOE Geothermal Energy Program
http://www.eren.doe.gov/geothermal/

## Wind

Danish Wind Turbine Manufacturers Association
http://www.windpower.dk/core.htm

Wind Info Resources on the Net
http://www.afm.dtu.dk/wind/bookmark.html

British Wind Energy Association
http://www.bwea.com/

European Wind Energy Association
http://www.ewea.org

German Wind Energy Association
http://www.wind-energie.de

German Wind Energy Institute
Wind Energy Use
http://www.dewi.de/statistics.html

RISO National Laboratory Denmark
Wind Energy & Atmospheric Physics Department
http://www.risoe.dk/vea-wind

American Wind Energy Association. This comprehensive, up-to-date reference includes contact as well as product information.
http://www.awea.org

Windpower Monthly
http://www.wpm.co.nz

U.S. Dept. of Energy, Energy Efficiency and Renewable Energy Network (EREN), Wind Energy Program
http://www.eren.doe.gov/RE/wind.html

National Renewable Energy Laboratory's National Wind Technology Center
http://www.nrel.gov/wind

Wind Powering America
http://www.eren.doe.gov/windpoweringamerica

## Solar Energy

International Solar Energy Society
http://www.ises.org

## Solar Thermal

ASME Solar Energy Division
http://www.asme.org/divisions/solar/index.html

Solar Energy
http://solstice.crest.org/renewables/re-kiosk/solar/index.shtml

Solar Thermal Case Studies
http://solstice.crest.org/renewables/re-kiosk/solar/solar-thermal/case-studies/index.shtml

EREN - Solar Thermal Utilization Energy Efficiency and Renewable Energy Network
http://apollo.osti.gov/html/eren/1409.html

Solar Radiation and Solar Thermal Systems
Optical Engineering Press
http://www.spie.org/web/abstracts/oepress/MS54.html

Sandia National Laboratories
National Solar Thermal Test Facility
http://www.sandia.gov/Renewable_Energy/solarthermal/nsttf.html

Solstice from the Center for Renewable Energy and Sustainable Technology (CREST)
http://www.solstice.crest.org/renewables/index.shtml

## Solar Photovoltaic

NREL National Center For Photovoltaics
http://www.nrel.gov/ncpv

PV WEB SITES
http://www.pvpower.com/pvsites.html

Photovoltaic Module Businesses in the World
http://energy.sourceguides.com/businesses/byP/solar/pvM/pvM.shtml

Siemens Solar
http://www.siemenssolar.com

NASA Photovoltaic and Space Environment Effects Branch
http://powerweb.lerc.nasa.gov/pvsee

Advancing Photovoltaic Technology at NREL's Outdoor Test Facility
http://www.nrel.gov/lab/pao/otf.html

Million Solar Roofs Program
http://www.millionsolarroofs.org

Utility Photovoltaic Group
http://www.ttcorp.com/upvg

Sandia National Laboratories Photovoltaics Program
http://www.sandia.gov/pv

Photovoltaic News/ PV Energy Systems, Inc.
http://www.pvenergy.com

Photovoltaic Insider's Report
http://www.pvinsider.com

### Fuel Cells

U.S. Department of Energy
Office of Fossil Energy
Advanced Power Systems
http://www.fe.doe.gov/coal_power/fuelcells/index.shtml

Hydrogen & Fuel Cell Investor Newsletter
http://www.h2fc.com/tech.html

U.S. Fuel Cell Council
http://www.usfcc.com/

# Appendix E

# State Energy Agencies

The following lists the State Energy Office (or equivalent), the Public Utility Commission (or equivalent), and the State Geologist (when available) for each State, the District of Columbia, Puerto Rico, and Territories.[16]

**Alabama**

**State Energy Office**
Terri Adams, Division Director
Department of Economic and
Community Affairs
Science Technology and Energy Division
P.O. Box 5690
Montgomery, AL 36103-5690
(334) 242-5292
Fax: (334) 242-0552

**State Geologist**
Donald F. Oltz
Geological Survey of Alabama
420 Hackberry Lane
P.O. Box 869999
Tuscaloosa, AL 35486-6999
(205) 349-2852
Fax: (205) 349-2861
URL: http://www.gsa.state.al.us

**Public Service Commission**
Walter L. Thomas, Jr., Secretary
P.O. Box 991
Montgomery, AL 36101-0991
(334) 242-5218
Fax: (304) 242-0509

**Alaska**

**State Energy Office**
Robert Brean
Alaska Housing Finance Corporation
P.O. Box 101020
Anchorage, AK 99510
(907) 338-6100
Fax: (907) 338-1747

**State Geologist and Director**
Milton A. Wiltse
Department of Natural Resources
Division of Alaska Geological and
Geophysical Survey
794 University Avenue, Suite 200
Fairbanks, AK 99709-3645
(907) 451-5005
Fax: (907) 451-5050

**Alaska Public Utilities Commission**
Robert A. Lohr, Executive Director
1016 West 6th Avenue, Suite 400
Anchorage, AK 99501
(907) 276-6222
Fax: (907) 276-0160
E-Mail: bob_lohr@commerce.state.ak.us

**American Samoa**

**State Energy Office**
ASPA/Territorial Energy Office
Samoa Energy House, Tafuna
P.O. Box PPB
Pago Pago, AS 96799
011 (684) 699-1101
Fax: 011 (684) 699-2835

**Arizona**

**State Energy Office**
Amanda Ormond, Director
Arizona Department of Commerce
3800 North Central Avenue, Suite 1200
Phoenix, AZ 85012
(602) 280-1402
Fax: (602) 280-1445

[16] This information was excerpted from, Energy Information Administration, *Energy Information Directory, 1999,* DOE/EIA-0205(99) (Washington, DC, August 2000).

**State Geologist**
Larry D. Fellows
Arizona Geological Survey
416 W. Congress Street, Suite 100
Tucson, AZ 85701-1315
(520) 770-3500
Fax: (520) 770-3505

**Corporation Commission**
Jack Rose, Executive Secretary
Arizona Corporation Commission
1200 W. Washington
Phoenix, AZ 85007-2996
(602) 542-3931
Fax: (602) 542-3977

**Arkansas**

**State Energy Office**
Chris Benson, Team Leader
Arkansas Department of Economic Development
Arkansas Energy Office
One State Capitol Mall
Little Rock, AR 72201
(501) 682-8065
Fax: (501) 682-2703

**State Geologist**
William V. Bush, Director and State Geologist
Arkansas Geological Commission
3815 West Roosevelt Road
Little Rock, AR 72204
(501) 296-1877
Fax: (501) 663-7360

**Public Service Commission**
Sandra Hochstetter, Director
Arkansas Public Service Commission
1000 Center Street
P.O. Box 400
Little Rock, AR 72203-0400
(501) 682-1794
Fax: (501) 682-2572

**California**

**State Energy Commission**
William J. Keese, Chairman
California Energy Commission
1516 9th Street
Sacramento, CA 95814
(916) 654-5000
Fax: (916) 654-4420

**State Geologist**
James F. Davis, State Geologist
Department of Conservation
Division of Mines and Geology
801 K Street, MS 24-01
Sacramento, CA 95814-3529
(916) 445-1923
Fax: (916) 445-5718

**California Public Utilities Commission**
Wesley M. Franklin, Executive Director
505 Van Ness Avenue, Room 5222
San Francisco, CA 94102
(415) 703-3808
Fax: (415) 703-1758

**Colorado**

**State Energy Office**
Rick Grice, Director
Governor's Office of Energy Conservation
1675 Broadway, Suite 1300
Denver, CO 80202-4613
(303) 620-4292
Fax: (303) 620-4288

**State Geologist**
Vicki J. Cowart
Colorado Geological Survey
1313 Sherman Street, Room 715
Denver, CO 80203
(303) 866-2611
Fax: (303) 866-2461
E-Mail: vicki_cowart@state.co.us
URL: http://www.state.co.geosurvey

**Public Utilities Commission**
1580 Logan Street, Level 2
Denver, CO 80203
(303) 894-2000 Ext. 309
Fax: (303) 894-2065

**Connecticut**

**State Energy Office**
Allan Johanson
Policy Development and Planning Division
Energy Unit
450 Capitol Avenue, MS-52ENR
Hartford, CT 06106-1308
(860) 418-6297
Fax: (860) 418-6495

**State Geologist**
Ralph S. Lewis

Connecticut Geological Survey
Department of Environmental Protection
Environmental and Geographic Information Center
79 Elm Street, Store Level
Hartford, CT 06106-5127
(860) 424-3540
Fax: (860) 424-4058

**Department of Public Utility Control**
Steven D. Cadwallader
Chief of Research and Policy Analysis
10 Franklin Square
New Britain, CT 06051
(860) 827-2629
Fax: (860) 827-2613

**Delaware**

**State Energy Office**
Charlie T. Smisson, Jr.
Energy Program Administrator
Division of Facilities Management
149 Transportation Circle
Dover, DE 19901
(302) 739-5644
Fax: (302) 739-6148
E-mail: CSMISSON@STATE.DE.US

**State Geologist**
Robert R. Jordan
Delaware Geological Survey
University of Delaware
DGS Building
Newark, DE 19716-7501
(302) 831-2833
Fax: (302) 831-3579

**Delaware Public Service Commission**
Bruce H. Burcat, Executive Director
861 Silverlake Boulevard
Cannon Building, Suite 100
Dover, DE 19904
(302) 739-4247
Fax: (302) 739-4849

**District of Columbia**

**D.C. Energy Office**
Charles J. Clinton, Director
District of Columbia Energy Office
2000 14th Street, N.W., Suite 300E
Washington, DC 20009
(202) 673-6750
Fax: (202) 673-6725

**Public Service Commission**
Marlene L. Johnson, Esq., Chairperson
717 14th Street, N.W.
Washington, DC 20005
(202) 626-5100
Fax: (202) 393-1389

**Florida**

**State Energy Office**
Alexander Mack, Director
Department of Community Affairs
2555 Shumard Oak Boulevard
Tallahassee, FL 32399-2100
(850) 488-2475
Fax: (850) 488-7688

**State Geologist**
Walter Schmidt, Bureau Chief
Florida Geological Survey
Gunter Building
903 W. Tennessee Street
Tallahassee, FL 32304-0350
(850) 488-4191
Fax: (850) 488-8086

**Public Service Commission**
William D. Talbott, Executive Director
2540 Shumard Oak Boulevard
Tallahassee, FL 32399-0850
(850) 413-6055
Fax: (850) 413-6052

**Georgia**

**State Energy Office**
Paul Burks
Division of Energy
Georgia Environmental Facilities Authority
Equitable Building
100 Peachtree Street, N.W., Suite 2090
Atlanta, GA 30303
(404) 656-0938
Fax: (404) 656-6416
Fax: (404) 656-7970 (Division of Energy)

**State Geologist**
William H. McLemore
Georgia Geologic Survey
19 Martin Luther King Jr. Drive, S.W.
Suite 400
Atlanta, GA 30334
(404) 656-3214
Fax: (404) 657-8379

**Public Service Commission**
B. B. Knowles, Director of Utilities
47 Trinity Avenue
Atlanta, GA 30334-5701
(404) 656-7266
Fax: (404) 656-0980

**Guam**

**Energy Office**
Fred P. Camacho, Director
Guam Energy Office
1504 East Sunset Boulevard
Tiyan, GU 96913
(671) 477-0538
Fax: (671) 477-0589

**Hawaii**

**State Energy Office**
Maurice H. Kaya, Administrator
Energy, Resources, and Technology Division
Department of Business, Economic Development, and Tourism
P.O. Box 2359
Honolulu, HI 96804
(808) 587-3812
Fax: (808) 586-2536

**State Geologist**
Glenn Bauer
Hawaii Geological Survey
Department of Land and Natural Resources
Commission on Water Resource Management
P.O. Box 373
Honolulu, HI 96809
(808) 587-0263
Fax: (808) 587-0219

**Public Utilities Commission**
Dennis R. Yamada, Chairman
465 S. King Street, #103
Honolulu, HI 96813
(808) 586-2020
Fax: (808) 586-2066

**Idaho**

**Energy Division**
Bob Hoppie, Administrator
Idaho Department of Water Resources
1301 North Orchard Street
Boise, ID 83706
(208) 327-7968
Fax: (208) 327-7866

**State Geologist**
Earl H. Bennett
Idaho Geological Survey
Third Floor Morrill Hall
University of Idaho
Moscow, ID 83843-3014
(208) 885-5808
Fax: (208) 885-5826

**Public Utilities Commission**
Stephanie Miller, Administrator
Utilities Division
P.O. Box 83720
Boise, ID 83720-0074
(208) 334-0366
Fax: (208) 334-3762

**Illinois**

**Department of Commerce and Community Affairs**
Mitch Beaver, Deputy Director
Bureau of Energy and Recycling
325 W. Adams Street, #300
Springfield, IL 62704-1892
(217) 785-2800
Fax: (217) 785-2618

**State Geologist**
William W. Shilts, Chief
Illinois State Geological Survey
121 Natural Resources Building
615 East Peabody Drive
Champaign, IL 61820-6964
(217) 333-5111
Fax: (217) 244-7004

**Commerce Commission**
Donna M. Caton, Chief Clerk
527 E. Capitol Avenue
Box 19280
Springfield, IL 62794-9280
(217) 782-7434
Fax: (217) 524-0673

**Indiana**

**Indiana Department of Commerce**
Cheryl L. DeVol-Glowinski, Director
Energy Policy Division
One North Capitol, Suite 700
Indianapolis, IN 46204-2288
(317) 232-8939
Fax: (317) 232-8995

**State Geologist**
John Steinmetz, Director and
State Geologist
Indiana Geological Survey
611 N. Walnut Grove
Bloomington, IN 47405
(812) 855-5067
Fax: (812) 855-2862

**Utility Regulatory Commission**
302 West Washington Street, Suite E-306
Indianapolis, IN 46204
(317) 232-2701
Fax: (317) 232-6758

**Iowa**

**State Energy Office**
Larry Bean, Administrator
Iowa Department of Natural Resources
Energy and Geological Resources Division
502 E. 9th Street
Des Moines, IA 50319
(515) 281-4308
Fax: (515) 281-6794

Sharon A. Tahtinen, Chief
Energy Bureau
Iowa Department of Natural Resources
502 E. 9th Street
Des Moines, IA 50319
(515) 281-7066
Fax: (515) 281-6794

**State Geologist**
Donald L. Koch, State Geologist
Geological Survey Bureau
109 Trowbridge Hall
Iowa City, IA 52242-1319
(319) 335-1575
Fax: (319) 335-2754

**Iowa Utilities Board**
Raymond K. Vawter, Executive Secretary
350 Maple Street
Des Moines, IA 50319-0069
(515) 281-5256
Fax: (515) 281-8821

**Kansas**

**State Energy Office**
Jim Ploger, Energy Program Manager
Energy Programs
Kansas Corporation Commission
1500 S.W. Arrowhead Road
Topeka, KS 66604-4027
(785) 271-3349
Fax: (785) 271-3268

**State Geologist**
M. Lee Allison
Kansas Geological Survey
1930 Constant Avenue
West Campus
The University of Kansas
Lawrence, KS 66047
(785) 864-3965
Fax: (785) 864-5317

**Corporation Commission**
John Wine, Chairman
Kansas Corporation Commission
1500 S.W. Arrowhead Road
Topeka, KS 66604
(785) 271-3100
Fax: (785) 271-3354

**Kentucky**

**State Energy Office**
John M. Stapleton, Director
Kentucky Division of Energy
663 Teton Trail
Frankfort, KY 40601
(502) 564-7192
Fax: (502) 564-7484

**State Geologist**
Donald C. Haney
Kentucky Geological Survey
228 Mining and Mineral Resources Building
University of Kentucky
Lexington, KY 40506-0107
(606) 257-5500
Fax: (606) 257-1147

**Public Service Commission**
Helen Helton, Executive Director
730 Schenkel Lane, Box 615
Frankfort, KY 40602
(502) 564-3940
Fax: (502) 564-3460

**Louisiana**

**State Energy Office**
Paula Ridgeway
Louisiana Department of Natural Resources
P.O. Box 44156

Baton Rouge, LA 70804-4156
(225) 342-1399
Fax: (225) 342-1397

**State Geologist**
Chacko J. John, Director & State Geologist
Louisiana Geological Survey / LSU
P.O. Box G
Baton Rouge, LA 70893
(225) 388-5320
Fax: (225) 388-3662

**Public Service Commission**
Lawrence C. St. Blanc, Secretary
Suite 1630, One American Place
Baton Rouge, LA 70825
(225) 342-4427
Fax: (225) 342-4087

**Mail letters to:**
P.O. Box 91154
Baton Rouge, LA 70821-9154

**Maine**

**State Energy Office**
Brian K. Dancause, Supervisor
Energy Conservation Division
Department of Economic and
Community Development
59 State House Station
Augusta, ME 04333
(207) 287-2656
Fax: (207) 287-5701

**State Geologist**
Robert G. Marvinney
Maine Geological Survey
Natural Resources Information and
Mapping Center
Department of Conservation
22 State House Station
Augusta, ME 04333-0022
(207) 287-2801
Fax: (207) 287-2353

**Public Utilities Commission**
Dennis L. Keschl, Administrative Director
18 State House Station
242 State Street
Augusta, ME 04333
(207) 287-3831
Fax: (207) 287-1039

**Maryland**

**State Energy Office**
Frederick H. Hoover, Jr., Director
Maryland Energy Administration
45 Calvert Street, 4th Floor
Annapolis, MD 21401
(410) 260-7511
Fax: (410) 974-2250

**State Geologist**
Emery T. Cleaves
Maryland Geological Survey
2300 St. Paul Street
Baltimore, MD 21218-5210
(410) 554-5500
Fax: (410) 554-5502
E-Mail: ecleaves@mgs.dnr.md.gov

**State Oil and Gas Resources Agency (Advisory)**
Kenneth A. Schwarz
Maryland Geological Survey
2300 St. Paul Street
Baltimore, MD 21218-5210
(410) 554-5525
Fax: (410) 554-5502

**Public Service Commission**
Felecia L. Greer, Executive Secretary
William Donald Schaefer Tower
6 St. Paul Street, 16th Floor
Baltimore, MD 21202-6806
(410) 767-8067
Fax: (410) 333-6495

**Massachusetts**

**State Energy Office**
David L. O'Connor, Commissioner
Massachusetts Division of Energy
Resources
Leverett Saltonstall Building
100 Cambridge Street, Room 1500
Boston, MA 02202
(617) 727-4732
Fax: (617) 727-0030
E-Mail: energy@state.ma.us
URL: http://www.state.ma.us/doer

**State Geologist**
Richard N. Foster
Massachusetts Geological Survey
Commonwealth of Massachusetts

Executive Office of Environmental Affairs
100 Cambridge Street, 20th Floor
Boston, MA 02202
(617) 626-1026
Fax: (617) 626-1181

**Department of Telecommunications and Energy**
Janet Gail Besser, Chair
One South Station, 2nd Floor
Boston, MA 02110
(617) 305-3500
Fax: (617) 345-9101
URL: http://www.state.ma.us/dpu/

**Michigan**

**Public Service Commission**
John Strand, Chairman
Michigan Public Service Commission
P.O. Box 30221
6545 Mercantile Way
Lansing, MI 48909
(517) 241-6190
Fax: (517) 241-6189

**Minnesota**

**State Energy Office**
Krista L. Sanda, Commissioner
Department of Public Service
121 7th Place East, Suite 200
St. Paul, MN 55101-2145
(651) 296-7107
Fax: (651) 297-1959

**State Geologist**
David L. Southwick, Director
Minnesota Geological Survey
University of Minnesota
2642 University Avenue
St. Paul, MN 55114-1057
(612) 627-4780
Fax: (612) 627-4778
E-Mail: mgs@gold.tc.umn.edu

**Public Utilities Commission**
Burl W. Haar, Executive Secretary
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St. Paul, MN 55101-2147
(651) 296-7124
Fax: (651) 297-7073

**Mississippi**

**State Energy Office**
Chester B. Smith, Director
Mississippi Department of Economic and Community Development
Energy Division
P.O. Box 850
Jackson, MS 39205-0850
(601) 359-6600
Fax: (601) 359-6642

**State Geologist**
S. Cragin Knox
Mississippi Office of Geology
Department of Environmental Quality
P.O. Box 20307
Jackson, MS 39289-1307
(601) 961-5500
Fax: (601) 961-5521

**Mississippi Public Utilities Staff**
Robert G. Waites, Executive Director
Room 1738, Walter Sillers State Office Building
P.O. Box 1174
Jackson, MS 39215-1174
(601) 961-5493
Fax: (601) 961-5804

**Missouri**

**State Energy Office**
Energy Center
P.O. Box 176
Jefferson City, MO 65102-0176
(573) 751-4000
Fax: (573) 751-6860
E-mail: energy@mail.dnr.state.mo.us
URL: http://www.dnr.state.mo.us/de/homede.htm

**State Geologist**
James H. Williams
Department of Natural Resources
Division of Geology and Land Survey
P.O. Box 250
Rolla, MO 65402
(573) 368-2101
Fax: (573) 368-2111

**Public Service Commission**
Gordon Persinger
Acting Executive Director

P.O. Box 360
Jefferson City, MO 65102
(573) 751-3234
Fax: (573) 526-7341

**Montana**

**State Energy Office**
Timothy C. Fox, Acting Administrator
Department of Environmental Quality
Planning, Prevention and Assistance Division
1520 East Sixth Avenue
P.O. Box 200901
Helena, MT 59620-0901
(406) 444-6697
Fax: (406) 444-6836

**State Geologist**
Edmond G. Deal
Montana Bureau of Mines and Geology
Montana Tech of the University of Montana
1300 West Park Street
Main Hall
Butte, MT 59701-8997
(406) 496-4180
Fax: (406) 496-4451

**Public Service Commission**
Kathy Anderson, Commission Secretary
1701 Prospect Avenue
Helena, MT 59620
(406) 444-6170
Fax: (406) 444-7618

**Nebraska**

**State Energy Office**
Nebraska Energy Office
Energy Square
1111 "O" Street, Suite 223
Lincoln, NE 68509
(402) 471-2867
Fax: (402) 471-3064

**State Geologist**
Mark S. Kuzila
Nebraska Geological Survey
Conservation and Survey Division
Institute of Agriculture and Natural Resources
University of Nebraska
113 Nebraska Hall
901 N. 17th Street
Lincoln, NE 68588-0517
(402) 472-3471
Fax: (402) 472-4608

**Public Service Commission**
Rob Logsdon, Executive Director
300 The Atrium
1200 N Street, P. O. Box 94927
Lincoln, NE 68509-4927
(402) 471-3101
Fax: (402) 471-0254

**Nevada**

**State Energy Office**
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Nevada State Energy Office
1050 East William, Suite 435
Carson City, NV 89706
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Fax: (775) 687-4914
E-mail: dparsons@govmail.state.nv.us

**State Geologist**
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Nevada Bureau of Mines and Geology
University of Nevada, Reno
Reno, NV 89557-0088
(775) 784-6691, Ext. 126
Fax: (775) 784-1709
E-mail: jprice@nbmg.unr.edu

**Public Utilities Commission of Nevada**
Donald Soderber, Chairman
1150 E. William Street
Carson City, NV 89701
(775) 775-6007
Fax: (775) 775-6110

**New Hampshire**

**State Energy Office**
Deborah Schachter, Director
Office of Energy and Community Service
57 Regional Drive
Concord, NH 03301-8519
(603) 271-2711
Fax: (603) 271-2615

**State Geologist**
Eugene L. Boudette
New Hampshire Geological Survey
Department of Environmental Services
P.O. Box 95
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(603) 271-3503
Fax: (603) 271-2867

**Public Utilities Commission**
Thomas B. Getz, Executive Director
8 Old Suncook Road
Concord, NH 03301-7319
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Fax: (603) 271-3878

**New Jersey**

**State Geologist**
Haig F. Kasabach
New Jersey Geological Survey
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Fax: (609) 633-1004

**New Jersey Board of Public Utilities**
Herbert Tate, President
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# Glossary

**Alternating Current (AC):** An electric current that reverses its direction at regularly recurring intervals, usually 50 or 60 times per second.

**Amorphous Silicon:** An alloy of silica and hydrogen, with a disordered, noncrystalline internal atomic arrangement, that can be deposited in thin-layers (a few micrometers in thickness) by a number of deposition methods to produce thin-film photovoltaic cells on glass, metal, or plastic substrates.

**Annualized Growth Rates:** Calculated as follows:

$$(x_n / x_1)^{1/n} \quad ,$$

where $x$ is the value under consideration and $n$ is the number of periods.

**Aquifer:** A subsurface rock unit from which water can be produced.

**ARI:** Air-Conditioning and Refrigeration Institute

**Availability Factor:** A percentage representing the number of hours a generating unit is available to produce power (regardless of the amount of power) in a given period, compared to the number of hours in the period.

**Biodiesel:** A renewable fuel synthesized from soy beans, other oil crops, or animal tallow which can substitute for petroleum diesel fuel.

**Biomass:** Organic nonfossil material of biological origin constituting a renewable energy source.

**Black Liquor:** A byproduct of the paper production process that can be used as a source of energy.

**Capacity Factor:** The ratio of the electrical energy produced by a generating unit for the period of time considered to the electrical energy that could have been produced at continuous full-power operation during the same period.

**Capacity, Gross:** The full-load continuous rating of a generator, prime mover, or other electric equipment under specified conditions as designated by the manufacturer. It is usually indicated on a nameplate attached to the equipment.

**Capital Cost:** The cost of field development and plant construction and the equipment required for the generation of electricity.

**Cast Silicon:** Crystalline silicon obtained by pouring pure molten silicon into a vertical mold and adjusting the temperature gradient along the mold volume during cooling to obtain slow, vertically-advancing crystallization of the silicon. The polycrystalline ingot thus formed is composed of large, relatively parallel, interlocking crystals. The cast ingots are sawed into wafers for further fabrication into photovoltaic cells. Cast-silicon wafers and ribbon-silicon sheets fabricated into cells are usually referred to as polycrystalline photovoltaic cells.

**Climate Change (Greenhouse Effect):** The increasing mean global surface temperature of the Earth caused by gases in the atmosphere (including carbon dioxide, methane, nitrous oxide, ozone, and chlorofluorocarbons). The greenhouse effect allows solar radiation to penetrate the Earth's atmosphere but absorbs the infrared radiation returning to space.

**Cogeneration:** The production of electrical energy and another form of useful energy (such as heat or steam) through the sequential use of energy.

**Combined Cycle:** An electric generating technology in which electricity is produced from otherwise lost waste heat exiting from one or more gas (combustion) turbines. The exiting heat is routed to a conventional boiler or to a heat recovery steam generator for utilization by a steam turbine in the production of electricity. Such designs increase the efficiency of the electric generating unit.

**Concentrator:** A reflective or refractive device that focuses incident insolation onto an area smaller than the reflective or refractive surface, resulting in increased insolation at the point of focus.

**Cull Wood:** Wood logs, chips, or wood products that are burned.

**Direct Current (DC):** An electric current that flows in a constant direction. The magnitude of the current does not vary or has a slight variation.

**Electric Utility Restructuring:** With some notable exceptions, the electric power industry historically has been composed primarily of investor-owned utilities. These utilities have been predominantly vertically integrated monopolies (combining electricity generation, transmission, and distribution), whose prices have been regulated by State and Federal government agencies. Restructuring the industry entails the introduction of competition into at least the generation phase of electricity production, with a corresponding decrease in regulatory control. Restructuring may also modify or eliminate other traditional aspects of investor-owned utilities, including their exclusive franchise to serve a given geographical area, assured rates of return, and vertical integration of the production process.

**Emission:** The release or discharge of a substance into the environment; generally refers to the release of gases or particulates into the air.

**Evacuated Tube:** In a solar thermal collector, an absorber tube, which is contained in an evacuated glass cylinder, through which collector fluids flows.

**Exempt Wholesale Generator (EWG):** A nonutility electricity generator that is not a qualifying facility under the Public Utility Regulatory Policies Act of 1978.

**Externalities:** Benefits or costs, generated as a byproduct of an economic activity, that do not accrue to the parties involved in the activity. Environmental externalities are benefits or costs that manifest themselves through changes in the physical or biological environment.

**Flat Plate Pumped:** A medium-temperature solar thermal collector that typically consists of a metal frame, glazing, absorbers (usually metal), and insulation and that uses a pump liquid as the heat-transfer medium: predominant use is in water heating applications.

**Flow Control:** The laws, regulations, and economic incentives or disincentives used by waste managers to direct waste generated in a specific geographic area to a designated landfill, recycling, or waste-to-energy facility.

**Fuel Cells:** One or more cells capable of generating an electrical current by converting the chemical energy of a fuel directly into electrical energy. Fuel cells differ from conventional electrical cells in that the active materials such as fuel and oxygen are not contained within the cell but are supplied from outside.

**Fuelwood:** Wood and wood products, possibly including coppices, scrubs, branches, etc., bought or gathered, and used by direct combustion.

**Fumarole:** A vent from which steam or gases issue; a geyser or spring that emits gases.

**Generation (Electricity):** The process of producing electric energy from other forms of energy; also, the amount of electric energy produced, expressed in watthours (Wh).

*Gross Generation:* The total amount of electric energy produced by the generating units at a generating station or stations, measured at the generator terminals.

*Net Generation:* Gross generation less the electric energy consumed at the generating station for station's use.

**Geopressured:** A type of geothermal resource occurring in deep basins in which the fluid is under very high pressure.

**Geothermal Energy:** As used at electric utilities, hot water or steam extracted from geothermal reservoirs in the Earth's crust that is supplied to steam turbines at electric utilities that drive generators to produce electricity.

**Geothermal Plant:** A plant in which a turbine is driven either from hot water or by natural steam that derives its energy from heat found in rocks or fluids at various depths beneath the surface of the earth. The fluids are extracted by drilling and/or pumping.

**Geyser:** A special type of thermal spring that periodically ejects water with great force.

**Giga:** One billion.

**Green Pricing:** In the case of renewable electricity, green pricing represents a market solution to the various problems associated with regulatory valuation of the nonmarket benefits of renewables. Green pricing programs allow electricity customers to express their willingness to pay for renewable energy development through direct payments on their monthly utility bills.

**Grid:** The layout of an electrical distribution system.

**Groundwater:** Water occurring in the subsurface zone where all spaces are filled with water under pressure greater than that of the atmosphere.

**Heat Pump:** A year-round heating and air-conditioning system employing a refrigeration cycle. In a refrigeration cycle, a refrigerant is compressed (as a liquid) and expanded (as a vapor) to absorb and reject heat. The heat pump transfers heat to a space to be heated during the winter period and by reversing the operation extracts (absorbs) heat from the same space to be cooled during the summer period. The refrigerant within the heat pump in the heating mode absorbs the heat to be supplied to the space to be heated from an outside medium (air, ground or ground water) and in the cooling mode absorbs heat from the space to be cooled to be rejected to the outside medium.

**Heat Pump (Air Source):** An air-source heat pump is the most common type of heat pump. The heat pump absorbs heat from the outside air and transfers the heat to the space to be heated in the heating mode. In the cooling mode the heat pump absorbs heat from the space to be cooled and rejects the heat to the outside air. In the heating mode when the outside air approaches 32° F or less, air-source heat pumps loose efficiency and generally require a back-up (resistance) heating system.

**Heat Pump (Geothermal):** A heat pump in which the refrigerant exchanges heat (in a heat exchanger) with a fluid circulating through an earth connection medium (ground or ground water). The fluid is contained in a variety of loop (pipe) configurations depending on the temperature of the ground and the ground area available. Loops may be installed horizontally or vertically in the ground or submersed in a body of water.

**Heat Pump (efficiency):** The efficiency of a heat pump, that is, the electrical energy to operate it, is directly related to temperatures between which it operates. Geothermal heat pumps are more efficient than conventional heat pumps or air conditioners that use the outdoor air since the ground or ground water a few feet below the earth's surface remains relatively constant throughout the year. It is more efficient in the winter to draw heat from the relatively warm ground than from the atmosphere where the air temperature is much colder, and in summer transfer waste heat to the relatively cool ground than to hotter air. Geothermal heat pumps are generally more expensive ($2,000-$5,000) to install than outside air heat pumps. However, depending on the location geothermal heat pumps can reduce energy consumption (operating cost) and correspondingly, emissions by more than 20 percent compared to high-efficiency outside air heat pumps. Geothermal heat pumps also use the waste heat from air-conditioning to provide free hot water heating in the summer.

**High-Temperature Collector:** A solar thermal collector designed to operate at a temperature of 180 degrees Fahrenheit or higher.

**Hot Dry Rock:** Heat energy residing in impermeable, crystalline rock. Hydraulic fracturing may be used to create permeability to enable circulation of water and removal of the heat.

**Hub Height:** In a horizontal-axis wind turbine, the distance from the turbine platform to the rotor shaft.

**Hydraulic Fracturing:** Fracturing of rock at depth with fluid pressure. Hydraulic fracturing at depth may be accomplished by pumping water into a well at very high pressures. Under natural conditions, vapor pressure may rise high enough to cause fracturing in a process known as hydrothermal brecciation.

**Independent Power Producer (IPP):** A wholesale electricity producer (other than a qualifying facility under the Public Utility Regulatory Policies Act of 1978), that is unaffiliated with franchised utilities in the area in which the IPP is selling power and that lacks significant marketing power. Unlike traditional utilities, IPPs do not possess transmission facilities that are essential to their customers and do not sell power in any retail service territory where they have a franchise.

**Internal Collector Storage (ICS):** A solar thermal collector in which incident solar radiation is absorbed by the storage medium.

**Kilowatt (kW):** One thousand watts of electricity (See Watt).

**Kilowatthour (kWh):** One thousand watthours.

**Levelized Cost:** The present value of the total cost of building and operating a generating plant over its economic life, converted to equal annual payments. Costs are levelized in real dollars (i.e., adjusted to remove the impact of inflation).

**Liquid Collector:** A medium-temperature solar thermal collector, employed predominantly in water heating, which uses pumped liquid as the heat-transfer medium.

**Low-Temperature Collectors:** Metallic or nonmetallic solar thermal collectors that generally operate at temperatures below 110 degrees Fahrenheit and use pumped liquid or air as the heat transfer medium. They usually contain no glazing and no insulation, and they are often made of plastic or rubber, although some are made of metal.

**Magma:** Naturally occurring molten rock, generated within the earth and capable of intrusion and extrusion, from which igneous rocks are thought to have been derived through solidification and related processes. It may or may not contain suspended solids (such as crystals and rock fragments) and/or gas phases.

**Marginal Cost:** The change in cost associated with a unit change in quantity supplied or produced.

**Medium-Temperature Collectors:** Solar thermal collectors designed to operate in the temperature range of 140 degrees to 180 degrees Fahrenheit, but that can also operate at a temperature as low as 110 degrees Fahrenheit. The collector typically consists of a metal frame, metal absorption panels with integral flow channels (attached tubing for liquid collectors or integral ducting for air collectors), and glazing and insulation on the sides and back.

**Megawatt (MW):** One million watts of electricity (See Watt).

**Merchant Facilities:** High-risk, high-profit facilities that operate, at least partially, at the whims of the market, as opposed to those facilities that are constructed with close cooperation of municipalities and have significant amounts of waste supply guaranteed.

**Net Photovoltaic Cell Shipment:** The difference between photovoltaic cell shipments and photovoltaic cell purchases.

**Net Photovoltaic Module Shipment:** The difference between photovoltaic module shipments and photovoltaic module purchases.

**Net Summer Capability:** The steady hourly output, which generating equipment is expected to supply to system load exclusive of auxiliary power, as demonstrated by tests at the time of summer peak demand.

**Nonutility Generation:** Electric generation by nonutility power producers to supply electric power for industrial, commercial, and military operations, or sales to electric utilities. See **Nonutility Power Producer**.

**Nonutility Power Producer:** A corporation, person, agency, authority, or other legal entity or instrumentality that owns electric generating capacity and is not an electric utility. Nonutility power producers include qualifying cogenerators, qualifying small power producers, and other nonutility generators (including independent power producers) without a designated, franchised service area that do not file forms listed in the *Code of Federal Regulations*, Title 18, Part 141.

**Operation and Maintenance (O&M) Cost:** Operating expenses are associated with operating a facility (i.e., supervising and engineering expenses). Maintenance expenses are that portion of expenses consisting of labor, materials, and other direct and indirect expenses incurred for preserving the operating efficiency or physical condition of utility plants that are used for power production, transmission, and distribution of energy.

**Parabolic Dish:** A high-temperature (above 180 degrees Fahrenheit) solar thermal concentrator, generally bowl-shaped, with two-axis tracking.

**Parabolic Trough:** A high-temperature (above 180 degrees Fahrenheit) solar thermal concentrator with the capacity for tracking the sun using one axis of rotation.

**Passive Solar:** A system in which solar energy alone is used for the transfer of thermal energy. Pumps, blowers, or other heat transfer devices that use energy other than solar are not used.

**Peak Watt:** A manufacturer's unit indicating the amount of power a photovoltaic cell or module will produce at standard test conditions (normally 1,000 watts per square meter and 25 degrees Celsius).

**Photovoltaic (PV) Cell:** An electronic device consisting of layers of semiconductor materials fabricated to form a junction (adjacent layers of materials with different electronic characteristics) and electrical contacts and being capable of converting incident light directly into electricity (direct current).

**Photovoltaic (PV) Module:** An integrated assembly of interconnected photovoltaic cells designed to deliver a selected level of working voltage and current at its output terminals, packaged for protection against environment degradation, and suited for incorporation in photovoltaic power systems.

**Public Utility Regulatory Policies Act of 1978 (PURPA):** One part of the National Energy Act, PURPA

contains measures designed to encourage the conservation of energy, more efficient use of resources, and equitable rates. Principal among these were suggested retail rate reforms and new incentives for production of electricity by cogenerators and users of renewable resources.

**Pulpwood:** Roundwood, whole-tree chips, or wood residues.

**Quadrillion Btu:** Equivalent to 10 to the 15th power Btu.

**Qualifying Facility (QF):** A cogeneration or small power production facility that meets certain ownership, operating, and efficiency criteria established by the Federal Energy Regulatory Commission (FERC) pursuant to the Public Utility Regulatory Policies Act of 1978 (PURPA). (See the Code of Federal Regulations, Title 18, Part 292.)

**Refuse-Derived Fuel (RDF):** Fuel processed from municipal solid waste that can be in shredded, fluff, or densified pellet forms.

**Renewable Energy Resources:** Energy resources that are naturally replenishing but flow-limited. They are virtually inexhaustible in duration but limited in the amount of energy that is available per unit of time. Renewable energy resources include: biomass, hydro, geothermal, solar, wind, ocean thermal, wave action, and tidal action.

**Ribbon Silicon:** Single-crystal silicon derived by means of fabricating processes that produce sheets or ribbons of single-crystal silicon. These processes include edge-defined film-fed growth, dendritic web growth, and ribbon-to-ribbon growth.

**Roundwood:** Logs, bolts, and other round timber generated from the harvesting of trees.

**Silicon:** A semiconductor material made from silica, purified for photovoltaic applications.

**Single Crystal Silicon (Czochralski):** An extremely pure form of crystalline silicon produced by the Czochralski method of dipping a single crystal seed into a pool of molten silicon under high vacuum conditions and slowly withdrawing a solidifying single crystal boule rod of silicon. The boule is sawed into thin wafers and fabricated into single-crystal photovoltaic cells.

**Solar Energy:** The radiant energy of the sun, which can be converted into other forms of energy, such as heat or electricity.

**Solar Thermal Collector:** A device designed to receive solar radiation and convert it into thermal energy. Normally, a solar thermal collector includes a frame, glazing, and an absorber, together with the appropriate insulation. The heat collected by the solar thermal collector may be used immediately or stored for later use.

**Solar Thermal Collector, Special:** An evacuated tube collector or a concentrating (focusing) collector. Special collectors operate in the temperature (low concentration for pool heating) to several hundred degrees Fahrenheit (high concentration for air conditioning and specialized industrial processes).

**Thermosiphon System:** A solar collector system for water heating in which circulation of the collection fluid through the storage loop is provided solely by the temperature and density difference between the hot and cold fluids.

**Tipping Fee:** Price charged to deliver municipal solid waste to a landfill, waste-to-energy facility, or recycling facility.

**Transmission System (Electric):** An interconnected group of electric transmission lines and associated equipment for moving or transferring electric energy in bulk between points of supply and points at which it is transformed for delivery over the distribution system lines to consumers, or is delivered to other electric systems.

**Turbine:** A machine for generating rotary mechanical power from the energy of a stream of fluid (such as water, steam, or hot gas). Turbines convert the kinetic energy of fluids to mechanical energy through the principles of impulse and reaction, or a mixture of the two.

**Vapor-Dominated Geothermal System:** A conceptual model of a hydrothermal system where steam pervades the rock and is the pressure-controlling fluid phase.

**Watt (Electric):** The electrical unit of power. The rate of energy transfer equivalent to 1 ampere of electric current flowing under a pressure of 1 volt at unity power factor.

**Watt (Thermal):** A unit of power in the metric system, expressed in terms of energy per second, equal to the work done at a rate of 1 joule per second.

**Watthour (Wh):** The electrical energy unit of measure equal to 1 watt of power supplied to, or taken from, an electric circuit steadily for 1 hour.

**Wheeling:** The use of the transmission facilities of one system to transmit power and energy by agreement of and for, another system with a corresponding wheeling charge (e.g., the transmission of electricity for compensation over a system that is received from one system and delivered to another system).

**Wood Pellets:** Fuel manufactured from finely ground wood fiber and used in pellet stoves.