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Preface

This report, the Renewable Energy Annual 1997, Volume 1, is the third in a series of annual reports published by the Energy Information Administration (EIA) to provide current information on renewable energy. In doing so, this report provides detailed explanations of summary renewable energy information originally published in EIA's *Annual Energy Review 1996,* released in July 1997. It also constitutes an annual update of renewable energy data presented in the *Renewable Energy Annual 1996.*

The publication of this report marks a change in the publication format of the *Renewable Energy Annual.* The prior two issues contained both renewable data and analytical material. This year, EIA has split the *Renewable Energy Annual* into two volumes in order to make data available more quickly (the electronic version of the report was available in October 1997). Volume 1 includes renewable energy consumption, capacity, and generation data, along with brief descriptive text. It also includes a chapter on solar (thermal and photovoltaic) manufacturing activity, and an appendix on the direct uses of geothermal energy. The *Renewable Energy Annual 1997,* Volume 2, a topical issues analysis report, is scheduled to be published in Summer 1998.

This report covers the following energy sources: biomass, geothermal, wind, and solar. While hydropower is a renewable energy resource, it is also regarded as a "conventional" energy source because it has furnished a significant amount of electricity for more than a century. Therefore, this report discusses hydropower as it contributes to total renewable energy consumption but does not address hydropower as an individual energy source. Also, EIA collects data only on terrestrial systems. Satellite and military applications are not included in this report. See Appendix A, "EIA Renewable Energy Data Sources," and Appendix B, "Renewable Data Limitations," for more detail.

The Energy Information Administration 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 determining its mission and the data and analyses it chooses to present.

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Introduction

This report presents information on renewable energy consumption, capacity, and electricity generation data, as well as data on U.S. solar thermal and photovoltaic collector manufacturing activities. The renewable energy resources included in the report are: biomass (wood, ethanol, and biodiesel); municipal solid waste; geothermal; wind; and solar (solar thermal and photovoltaic).

The first chapter of the report provides an overview of renewable energy use and capability from 1992 through 1996. It contains renewable energy consumption, capacity, and electricity generation data, as well as descriptive text. Chapter 2 presents current (through 1996) information on the United States solar energy industry. This information was collected on the Energy Information Administration's (EIA) Forms EIA-63 A and B, "Annual Survey of Solar Collector Manufacturers," and "Annual Survey of Photovoltaic Module/Cell Manufacturers," covering the 1996 calendar year.

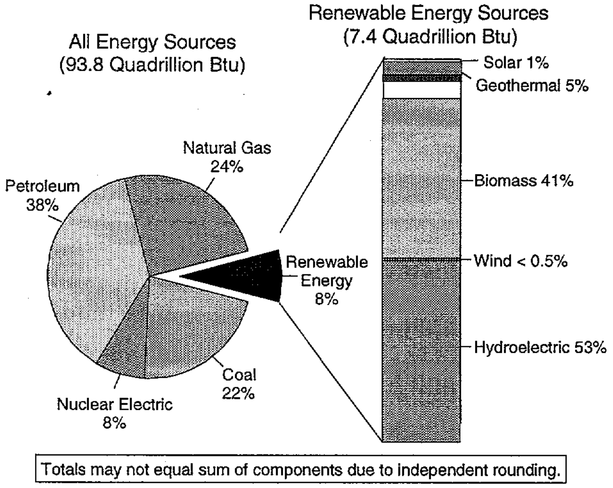
Appendix A describes EIA surveys that include information on renewable energy sources. Appendix B discusses renewable energy data and its limitations. Appendix C provides non-EIA information on direct-use geothermal applications. Appendix D provides a list of Internet addresses for web sites that include 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.

Highlights

Renewable Energy Consumption

Renewable energy consumption amounted to 7.4 quadrillion Btu's in 1996—up 8 percent over 1995 levels (Figure H1 and Table H1). Most of the change resulted from conventional hydropower generation. Increased water availability permitted hydropower generation to contribute 3.9 quadrillion Btu's—a hefty rise of 37 percent from 1992 levels. Some improvements in efficiency also contributed to increased hydroelectric output.

Figure H1. U.S. Energy Consumption by Source, 1996



Sources: **1992-1996:** Energy Information Administration (EIA), *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC, July 1997), Table 1.3. **1996 Renewable Energy:** Consumption values based on the sum of electricity consumption from EIA, *Electric Power Monthly March 1997*, DOE/EIA-0226(97/03) (Washington, DC, March 1997), and non-electricity consumption based on analysis by the Office of Coal, Nuclear, Electric and Alternate Fuels.

Of the remaining renewables, biomass had the largest share—about 3 quadrillion Btu's of energy consumed in 1996. Wood dominated this source, which also includes alcohol fuels and waste energy. Production at the Geysers field reversed a ten year decline so geothermal energy was up 9 percent over 1995 levels. Although still small sources, both solar and wind energy experienced modest growth.

Renewable energy consumed to generate electricity in 1996 increased more than 10 percent. Hydro- and nonhydro-generated electricity increased by similar amounts. Renewable electric generating capacity in 1996 was essentially unchanged from 1995 levels, at about 94,000 megawatts.

Solar Manufacturing Activity[1]

Solar thermal collectors provide nearly all the solar energy in the United States. Although the number of manufacturers declined from 36 to 28, production of collector panels was stable at around 7.6 million square feet in 1996 compared to 1995. Most of the manufacturers who left the business had other product lines besides solar collector panels.

Nearly 90 percent of shipments were low-temperature collectors for heating swimming pools, mainly in the residential sector. California was the biggest shipper, while Florida was the most popular destination. Total value of shipments rose to nearly $30 million, reflecting a steady volume of business and an 18-percent increase in prices.

In contrast, the photovoltaics industry supplied a very small, but rapidly growing, portion of solar energy. In 1996, the United States shipped 35 peak megawatts of solar photovoltaic modules and cells. This is more than double the 16 peak megawatts shipped in 1992. Most of the shipments (about 22 peak megawatts in 1996) were exported. Germany alone took 8 peak megawatts in 1996, while Japan imported nearly 3 megawatts. The remainder went to continents around the world. For any number of developing countries, solar photovoltaic technology is an appealing source of electricity where grid electricity is not available.

[1] Information on solar manufacturing activity is based on Energy Information Administration Form EIA-63A, "Annual Solar Thermal Collector Manufacturers' Survey" and Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers' Survey" data.

Table H1. U.S. Renewable Energy Consumption by Energy Source, 1992-1996
(Quadrillion Btu)

Energy Source	1992	1993	1994	1995	1996
Conventional Hydroelectric Power[a]	2.852	3.138	2.958	R3.471	3.911
Geothermal Energy	0.367	0.381	0.381	0.325	0.354
Biomass[b]	2.788	2.784	R2.838	R2.946	3.017
Solar Energy[c]	0.068	R0.071	R0.072	0.073	0.075
Wind Energy	0.030	0.031	0.036	0.033	0.036
Total Renewable Energy[d]	**6.106**	**R6.404**	**R6.285**	**R6.847**	**7.393**

[a]Hydroelectricity generated by pumped storage is not included in renewable energy.

[b]Includes wood, wood waste, peat, wood sludge, municipal solid waste, agricultural waste, straw, tires, landfill gases, fish oils, and/or other waste.

[c]Includes solar thermal and photovoltaic.

[d]Includes photovoltaic electricity; therefore, totals do not match those in Table 1.3 of the *Annual Energy Review 1996*.

R = Revised data.

Notes: See "Data Characteristics and Caveats" section for a detailed explanation. Totals may not equal sum of components due to independent rounding.

Sources: **1992-1996:** Energy Information Administration (EIA), *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC, July 1997), Table 1.3. **1996 Renewable Energy:** Consumption values based on the sum of electricity consumption from EIA, *Electric Power Monthly March 1997*, DOE/EIA-0226(97/03) (Washington, DC, March 1997), and non-electricity consumption based on analysis by the Office of Coal, Nuclear, Electric and Alternate Fuels.

The total value of solar photovoltaic shipments was up to $131 million in 1996 or about 11 percent, even though module prices were down. The average price of crystalline-silicon modules was down 10 percent to $3.95 per peak kilowatt. The number of companies was up 1 to 25 in 1996.

1. Renewable Data Overview[2]

1996 In Review

Renewable energy consumption in 1996 jumped 8.0 percent from 1995 levels (Table 1).[3] At 7.4 quadrillion Btu (quads), renewable energy contributed 7.9 percent of the Nation's energy supply, up from 7.6 percent in 1995 (Table 2). Renewable energy includes biomass (i.e., wood, waste, and alcohol fuels), hydropower, wind, solar, photovoltaic, and geothermal sources.

Much of the gain in 1996 was due to increased hydropower generation, which in turn was due to increased water availability and generation efficiency improvements. (Hydroelectric generating capacity actually

Table 1. U.S. Energy Consumption by Energy Source, 1992-1996
(Quadrillion Btu)

Energy Source	1992	1993	1994	1995	1996
Fossil Fuels					
Coal	R19.209	R19.829	R20.018	R20.085	20.988
Coking Coal (Net Imports)	0.027	0.017	0.024	0.026	s
Natural Gas[a]	20.131	20.827	R21.288	R22.163	22.587
Petroleum[b]	33.527	33.841	34.735	R34.663	35.717
Total Fossil Fuels	**R72.893**	**R74.514**	**R76.064**	**R76.938**	**79.292**
Nuclear Electric Power	**6.607**	**6.519**	**6.837**	**R7.177**	**7.168**
Hydroelectric Pumped Storage[c]	**-0.043**	**-0.041**	**-0.035**	**R-0.028**	**-0.032**
Renewable Energy					
Conventional Hydroelectric Power[d]	2.852	3.138	2.958	R3.471	3.911
Geothermal Energy	0.367	0.381	0.381	0.325	0.354
Biomass[e]	2.788	2.784	R2.838	R2.946	3.017
Solar Energy[f, g]	0.068	R0.071	R0.072	0.073	0.075
Wind Energy	0.030	0.031	0.036	0.033	0.036
Total Renewable Energy	**6.106**	**R6.404**	**R6.285**	**R6.847**	**7.393**
Total Energy Consumption[g]	**R85.523**	**R87.338**	**R89.217**	**R90.943**	**93.813**

[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 wood, wood waste, peat, wood sludge, municipal solid waste, agricultural waste, straw, tires, landfill gases, fish oils, and/or other waste.
[f]Includes solar thermal and photovoltaic.
[g]Includes off-grid photovoltaic electricity not included in Table 1.3 of the *Annual Energy Review 1996*.
R = Revised data.
s = value less than 0.005 quadrillion Btu.
Notes: See Appendix B, "Renewable Data Limitations," for a detailed explanation. Totals may not equal sum of components due to independent rounding.
Sources: **1992-1996:** Energy Information Administration (EIA), *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC, July 1997), Table 1.3. **1996 Renewable Energy:** Consumption values based on the sum of electricity consumption from EIA, *Electric Power Monthly March 1997*, DOE/EIA-0226(97/03) (Washington, DC, March 1997), and non-electricity consumption based on analysis by the Office of Coal, Nuclear, Electric and Alternate Fuels.

[2] Calculated statistics in this chapter are based upon unrounded data. In contrast, data presented in tables may be rounded.
[3] All renewable consumption and production information shown in this chapter was derived from the Integrated Renewable Energy Database System (IREDS). The data values in IREDS are more precise than those shown in the tables of this report.

Table 2. Renewable Energy Consumption by Sector and Energy Source, 1992-1996
(Quadrillion Btu)

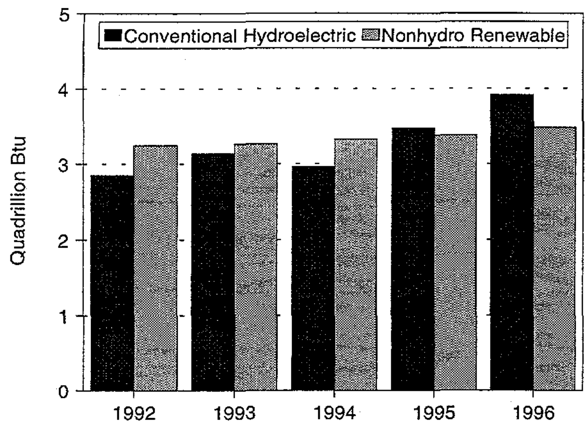
Sector and Source	1992	1993	1994	1995	1996
Residential/Commercial					
Biomass	0.645	0.592	0.582	0.641	0.644
Solar	0.060	R0.062	R0.064	R0.065	0.066
Total	**0.705**	**R0.654**	**R0.646**	**R0.706**	**0.709**
Industrial[a]					
Biomass	2.042	2.084	R2.138	R2.184	2.279
Geothermal	0.179	0.204	0.212	0.207	0.231
Conventional Hydroelectric[b]	0.097	0.118	0.136	0.152	0.172
Solar	0.008	0.009	0.008	0.008	0.009
Wind	0.030	0.031	0.036	0.033	0.036
Total	**2.357**	**2.446**	**R2.530**	**R2.584**	**2.727**
Transportation					
Biomass[c]	**0.079**	**0.088**	**R0.097**	**R0.104**	**0.074**
Electric Utility					
Biomass	0.022	0.020	0.020	0.017	0.020
Geothermal	0.169	0.158	0.145	0.099	0.110
Conventional Hydroelectric[b]	2.511	2.766	R2.538	R3.053	3.419
Solar and Wind	*	*	*	*	*
Net Renewable Energy Imports[d]	0.263	0.271	0.309	R0.284	0.333
Total	**2.965**	**3.217**	**R3.012**	**R3.453**	**3.883**
Total Renewable Energy Consumption	**6.106**	**R6.404**	**R6.285**	**R6.847**	**7.393**

*Less than 0.5 trillion Btu.
[a]Includes generation of electricity by cogenerators, independent power producers, and small power producers.
[b]Hydroelectricity generated by pumped storage is not included in renewable energy.
[c]Ethanol blended into gasoline.
[d]Includes only net imports of electricity known to be from renewable resources (geothermal and hydroelectric).
R= Revised data.
Note: Totals may not equal sum of components due to independent rounding.
Sources: **1992-1995:** Energy Information Administration (EIA), *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC, July 1997), Table 10.1. **1996:** Electricity Consumption—EIA, *Electric Power Monthly March 1997*, DOE/EIA-0226(97/03) (Washington, DC, March 1997). Non-electricity Consumption (except imports)—Based on analysis by the Office of Coal, Nuclear, Electric and Alternate Fuels. **Net Renewable Energy Imports, 1992-1996:** Based on analysis by the Office of Coal, Nuclear, Electric and Alternate Fuels.

actually decreased in 1996.) Hydropower energy consumption rose 12.7 percent over 1995 levels, which were, in turn, 17.3 percent higher than in 1994. Excluding hydropower, renewable energy consumption rose just 3.1 percent (Figure 1).

Biomass energy consumption amounted to 3.0 quads in 1996 and accounted for 87 percent of non-hydro renewable energy consumption. Only 22 percent of biomass energy consumption was for electricity generation. The remainder was used to provide industrial process heat. In contrast, all or nearly all of renewable energy consumption for the other fuels was used to generate electricity. Consumption of the remaining renewables—geothermal, solar/photovoltaic, and wind—increased 7.9 percent in 1996. Geothermal and hydroelectric consumption include net imports of electricity. Excluding imports, geothermal energy consumption rose 11.1 percent to 0.341 quads (Table 3), as production from The Geysers field reversed a 10-year decline. Solar energy consumption increased 2.4 percent, while wind energy consumption rose about 10 percent. Net renewable energy imports increased 17 percent, from 0.284 quads in 1995 to 0.333 quads in 1996. Greater hydro imports and lower hydro exports were the principal reasons for the increase.

Figure 1. Renewable Energy Consumption by Source, 1992-1996



Sources: **1992-1996:** Energy Information Administration (EIA), *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC, July 1997), Table 1.3. **1996 Renewable Energy:** Consumption values based on the sum of electricity consumption from EIA, *Electric Power Monthly March 1997*, DOE/EIA-0226(97/03) (Washington, DC, March 1997), and non-electricity consumption based on analysis by the Office of Coal, Nuclear, Electric and Alternate Fuels.

Renewable Energy in the 1990's

Since 1990, non-hydro renewable energy consumption has risen at a 2.2-percent annualized rate. By comparison, non-renewable energy has grown at a 1.6-percent rate over the same period. Biomass has provided the biggest increase in non-hydro renewable energy since 1990, from 2.6 quads to 3.0 quads in 1996. Wind energy consumption has shown the greatest percentage increase—over 50 percent—but from a very low base of 0.023 quads in 1990.

Renewable Energy Consumption by Sector

Utilities consumed over half of total renewable energy provided (including net imports) in 1996 (Table 2). Nearly 90 percent of utility renewable energy consumption was hydropower, with another 8.5 percent of utility renewable energy "consumption" coming from net imports of electricity. Thus, utilities currently produce very little electricity from non-hydro renewable sources. In addition, utilities account for only 12 percent of non-hydro renewable energy consumption.

Table 3. Renewable Energy Consumption for Electricity Generation by Energy Source, 1992-1996
(Quadrillion Btu)

Source	1992	1993	1994	1995	1996
Industrial Sector[a]					
Biomass	0.552	0.573	0.590	R0.587	0.640
Geothermal	0.179	0.204	0.212	0.207	0.231
Hydroelectric	0.097	0.118	0.136	0.152	0.172
Solar	0.008	0.009	0.008	0.008	0.009
Wind	0.030	0.031	0.036	0.033	0.036
Total	**0.867**	**0.936**	**R0.981**	**R0.988**	**1.088**
Electric Utility Sector[b]					
Biomass	0.022	0.020	0.020	0.017	0.020
Geothermal	0.169	0.158	0.145	0.099	0.110
Conventional Hydroelectric	2.511	2.766	R2.538	R3.053	3.419
Solar and Wind	*	*	*	*	*
Total	**2.702**	**2.945**	**R2.704**	**R3.169**	**3.549**
Imports and Exports					
Geothermal (Imports)	0.019	0.018	0.025	0.019	0.014
Conventional Hydroelectric (Imports)	0.278	0.294	0.313	R0.297	0.344
Conventional Hydroelectric (Exports)	0.034	0.040	0.029	R0.032	0.024
Total Net Renewable Energy Imports	**0.263**	**0.271**	**0.309**	**R0.284**	**0.333**
Total	**3.831**	**4.152**	**R3.994**	**R4.441**	**4.971**

*Less than 0.5 trillion Btu.

[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," and Form EIA-867, "Annual Nonutility Power Producer Report," personal communication with Dave Walker of Natural Resources Canada (Ottawa, Canada, March 1997). Federal Energy Regulatory Commission, Form FE-781R, "Annual Report of International Electricity Export/Import Data."

By far, industrial and "nonutility" facilities[4] (i.e., the "Industrial" category) consume most of non-hydro renewable energy—two-thirds, in fact, in 1996. Of the 3.8 quads of non-hydro renewable energy consumed in 1996, 60 percent (2.3 quads) was provided by biomass in the Industrial sector. Unlike other renewable fuels, a substantial portion of Industrial biomass energy is used for process heating and not to make electricity. In 1996, 1.639 quads of biomass energy were used to make process heat, over 70 percent of total Industrial biomass energy consumption.

In the Residential/Commercial sector, biomass accounts for over 90 percent of renewable energy consumed. This is almost entirely wood for space heating. Solar energy provides the balance of renewable energy in this sector, largely as a result of solar panels used to heat swimming pools.

Renewable Energy Consumption for Electricity

Renewable energy consumed to generate electricity jumped from 4.441 quads in 1995 to 4.971 quads in 1996 (Table 3). Both hydro- and nonhydro-generated electricity increased somewhat over 10 percent. Excluding imported renewable-based electricity, renewable electricity generation of 433 billion kilowatt-hours (kWh) (Table 4) represented 12 percent of total electricity generation in

Table 4. Electricity Generation From Renewable Energy by Energy Source, 1992-1996
(Thousand Kilowatthours)

Source	1992	1993	1994	1995	1996
Industrial Sector (Gross Generation)[a]					
Biomass	R53,606,891	R55,745,782	R57,391,594	R56,975,276	62,107,065
Geothermal	R8,577,891	R9,748,634	R10,122,228	9,911,659	11,014,788
Hydroelectric	R9,446,439	R11,510,786	R13,226,934	14,773,801	16,711,809
Solar	R746,277	R896,796	R823,973	824,193	908,126
Wind	R2,916,379	R3,052,416	R3,481,616	3,185,006	3,507,335
Total	**R75,293,877**	**R80,954,414**	**R85,046,345**	**R85,669,935**	**94,249,123**
Electric Utility Sector (Net Generation)[b]					
Biomass	2,092,945	1,990,407	1,988,257	1,649,178	1,967,057
Geothermal	8,103,809	7,570,999	6,940,637	4,744,804	5,233,927
Conventional Hydroelectric	243,736,029	269,098,329	247,070,938	R296,377,840	331,935,592
Solar	3,169	3,802	3,472	3,909	3,169
Wind	308	243	309	11,097	10,123
Total	**253,936,260**	**278,663,780**	**256,003,613**	**R302,786,828**	**339,149,868**
Imports and Exports					
Geothermal (Imports)	889,864	877,058	1,172,117	884,950	649,514
Conventional Hydroelectric (Imports)	26,948,408	28,558,134	30,478,863	28,823,244	33,359,983
Conventional Hydroelectric (Exports)	3,254,289	3,938,973	2,806,712	3,059,261	2,336,340
Total Net Imports	**24,583,983**	**25,496,219**	**28,844,268**	**26,648,933**	**31,673,157**
Total Renewable Electricity Generation	**R353,814,120**	**R385,114,413**	**R369,894,226**	**R415,105,696**	**465,072,148**

[a]Includes generation of electricity by cogenerators, independent power producers, and small power producers.
[b]Excludes imports.
R = Revised data.
Notes: 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 *Electric Power Monthly March 1997*, DOE/EIA-0226(97/03) (Washington, DC, March 1997). Personal communication with Dave Walker of Natural Resources Canada (Ottawa, Canada, March 1997). U.S. Department of Energy, Office of Fossil Energy, Form FE-781R, "Annual Report of International Electricity Export/Import Data."

[4] Although the category "Industrial" is used, there are actually two subcategories, not easily distinguishable. A pure industrial facility may loosely be described as one designed principally to provide energy for a manufacturing or other product-making use, while a nonutility is a special category of facility which are usually designed to generate electric power and connect to the grid. Nonutilities are often those designated by the Federal Energy Regulatory Commission as "qualifying facilities," so-called because they meet certain criteria set forth by PURPA. However, a "pure industrial" facility may sell power to the grid, and a nonutility can generate energy for the entity's own use.

1996.[5] When conventional hydropower is eliminated, the percentage drops to 2 percent.

Biomass-generated power increased from 58,624 million kWh in 1995 to 64,074 kWh in 1996. Industrial biomass power has increased steadily during the 1990's—nearly 50 percent—while electric utility biomass generation has remained flat over the decade.

Nonutilities produce virtually all of the solar and wind electricity. Estimated 1996 electricity production exceeded 1995 levels by about 10 percent in both categories. (See Appendix B, "Data Description and Limitations" for an explanation of potential estimation errors in nonutility data.) Because information which EIA collects from nonutilities on the Form EIA-867, "Annual Nonutility Power Producer Report," is confidential, it is not possible to make any statements about individual plant operations.

In the utility sector, there are 6 or fewer plants in each category (solar and wind). In the case of wind, the Solano plant operated by Sacramento Municipal Utility District, generates about 99 percent of total utility wind generation. For solar, the number of plants is about the same, with the output of a single plant, Solar 2, providing about 60 percent of the output. Despite the fact that output from three of the four other generating plants increased output in 1996, Solar 2's output decreased by 50 percent, leading to a decline in overall utility solar/PV generation.

Resource accessibility largely determines where renewable electricity is generated. Access to water power makes Washington the leading producer of renewable energy, accounting for 27 percent of total renewable electricity produced by utilities in 1995 (Table 5). State level data for 1996 were not available when this report was published.

A second major factor influencing the use of renewables is State policies promoting renewable energy. The combined effect of resource availability and energy policy makes California the second-largest producer of renewable electricity generation. In 1995,[6] sixteen percent of utility renewable generation nationwide occurred in California. California's share of nonutility renewable electricity was even larger—almost 25 percent (Table 6). California promoted renewable energy strongly in the 1980's with renewable tax credits. In addition, California has the vast majority of the Nation's developed geothermal energy resources, as well as significant wind, solar, biomass (wood and waste), and hydroelectric resources.

Utilities in Oregon, which also has sizable water power resources, produced the second-largest amount of electricity from renewables—13 percent. No other State contributed more than 4 percent of total utility renewable generation.

Nonutility renewable generation outside California is more evenly spread. One reason is that nonutility plants are usually smaller than utility plants, having been built in many instances to service a single facility (e.g., pulp and paper manufacturing plant). Thus, many more resource locations—particularly for biomass and hydropower—are available. After California, the States with the most nonutility electricity generation in 1995 were Florida, Maine, Alabama, Louisiana, New York, and North Carolina.

The nonutility sector produces virtually all of the biomass, wind, and solar powered electricity generation. Florida leads the Nation in both nonutility and total biomass-generated power. California produces the most total wind, solar, and geothermal electricity.

Renewable Generating Capacity

Renewable electric generating capacity remained basically unchanged at 93,931 megawatts (Table 7) during 1996. Overall, renewable electric plants operated at a 52.5-percent capacity factor. Excluding hydroelectric capacity, renewable plants operated at a 62.7-percent capacity factor, due largely to operating availabilities for biomass (70 percent) and geothermal plants (65 percent).[7]

Biomass capacity rose just over 1 percent in 1996. Growth has essentially stagnated since 1993. Because biomass electricity plants often cogenerate and provide process steam for manufacturing operations, biomass generating facilities generally operate at a high availability.

Solar electric generating capacity has for the last 3 years remained constant at 333 megawatts (Table 4). Much of the use of solar energy has been off grid and in remote areas, especially when access to the electric transmission lines is unavailable.

[5] EIA estimates total electricity generation in 1996 to be 3,481 billion kilowatthours. See Energy Information Administration, *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC, July 1997).

[6] State level electricity data by renewable fuel category were not available when this publication was prepared.

[7] However, plants which co-fire biomass have their capacity counted with the principal fuel, while the generation is apportioned by fuel usage. Thus, the biomass capacity factor is overstated by an indeterminate amount.

Table 5. Renewable Electric Utility Net Generation, 1995
(Million Kilowatthours)

	Hydro-electric	Geothermal	Solar/ PV	Wind	MSW Landfill Gas	Wood and Wood Waste	Total	Percent
Alabama	9,501,510	--	--	--	--	--	9,501,510	3.1
Alaska	1,372,115	--	--	--	--	--	1,372,115	0.5
Arizona	8,288,419	--	--	--	--	--	8,288,419	2.7
Arkansas	3,217,714	--	--	--	--	--	3,217,714	1.1
California	44,928,985	4,605,062	3,653	10,917	1,931	--	49,550,548	16.4
Colorado	2,008,902	--	--	--	--	--	2,008,902	0.7
Connecticut	305,401	--	--	--	403,726	--	709,127	0.2
Delaware	--	--	--	--	--	--	--	--
Dist. of Col.	--	--	--	--	--	--	--	--
Florida	230,480	--	--	--	--	--	230,480	0.1
Georgia	4,057,223	--	--	--	--	--	4,057,223	1.3
Hawaii	15,957	--	--	--	--	--	15,957	*
Idaho	10,067,322	--	--	--	--	--	10,067,322	3.3
Illinois	32,205	--	--	--	67,053	853	100,111	*
Indiana	467,261	--	--	--	--	--	467,261	0.2
Iowa	1,006,582	--	--	117	19,578	--	1,026,277	0.3
Kansas	--	--	--	26	--	--	26	*
Kentucky	3,100,018	--	--	--	--	--	3,100,018	1.0
Louisiana	--	--	--	--	--	--	--	--
Maine	1,658,481	--	--	--	--	299	1,658,780	0.5
Maryland	1,442,006	--	--	--	--	--	1,442,006	0.5
Massachusetts	650,277	--	--	--	--	--	650,277	0.2
Michigan	1,475,594	--	--	--	--	--	1,475,594	0.5
Minnesota	822,599	--	--	37	406,971	21,618	1,251,225	0.4
Mississippi	--	--	--	--	--	--	--	--
Missouri	1,918,507	--	--	--	24,979	--	1,943,486	0.6
Montana	10,698,465	--	--	--	--	--	10,698,465	3.5
Nebraska	657,024	--	--	--	16,268	--	673,292	0.2
Nevada	1,922,441	--	--	--	--	--	1,922,441	0.6
New Hampshire	693,659	--	--	--	--	--	693,659	0.2
New Jersey	--	--	--	--	--	--	--	--
New Mexico	263,920	--	--	--	--	--	263,920	0.1
New York	24,782,142	--	--	--	--	12,234	24,794,376	8.2
North Carolina	3,846,840	--	--	--	--	--	3,846,840	1.3
North Dakota	2,457,401	--	--	--	--	--	2,457,401	0.8
Ohio	550,919	--	--	--	--	--	550,919	0.2
Oklahoma	2,779,920	--	--	--	--	--	2,779,920	0.9
Oregon	40,415,006	--	--	--	--	--	40,415,006	13.3
Pennsylvania	1,683,697	--	--	--	--	--	1,683,697	0.6
Rhode Island	--	--	--	--	--	--	--	--
South Carolina	3,481,379	--	--	--	--	--	3,481,379	1.1
South Dakota	6,778,905	--	--	--	--	--	6,778,905	2.2
Tennessee	8,801,848	--	--	--	--	--	8,801,848	2.9
Texas	1,703,348	--	253	--	--	--	1,703,601	0.6
Utah	921,557	139,742	--	--	--	--	1,061,299	0.4
Vermont	1,124,500	--	--	--	--	127,168	1,251,668	0.4
Virginia	1,175,350	--	3	--	--	--	1,175,353	0.4
Washington	82,028,297	--	--	--	--	261,094	82,289,391	27.2
West Virginia	136,755	--	--	--	--	--	136,755	*
Wisconsin	2,108,046	--	--	--	75,478	209,928	2,393,452	0.8
Wyoming	798,503	--	--	--	--	--	798,503	0.3
Total	**296,377,480**	**4,744,804**	**3,909**	**11,097**	**1,015,984**	**633,194**	**302,786,468**	

* = Less than 0.5 million kilowatthours.

Note: Sum of components may not add up to the total due to independent rounding.

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

Table 6. Nonutility Gross Generation From Renewables, 1995
(Million Kilowatthours)

	Hydro-electric	Geothermal	Solar/PV	Wind	MSW Landfill Gas	Wood and Wood Waste	Total	Percent
Alabama	--	--	--	--	W	W	4,317,773	5.0
Alaska	--	--	--	--	W	W	W	W
Arizona	--	--	--	--	--	W	W	W
Arkansas	--	--	--	--	W	W	1,634,035	1.9
California	3,154,895	8,011,286	824,193	3,106,909	2,513,747	2,738,999	20,350,029	23.8
Colorado	W	--	--	--	W	--	128,100	0.1
Connecticut	58,992	--	--	--	1,607,935	--	1,666,927	1.9
Delaware	--	--	--	--	--	--	--	--
Dist. of Col.	--	--	--	--	--	--	--	--
Florida	--	--	--	--	3,533,923	2,304,818	5,838,741	6.8
Georgia	51,044	--	--	--	90,383	3,042,766	3,184,193	3.7
Hawaii	W	241,774	--	20,562	691,929	W	1,038,126	1.2
Idaho	W	--	--	--	W	557,211	1,506,887	1.8
Illinois	W	W	--	--	279,539	W	358,056	0.4
Indiana	--	--	--	--	86,469	--	86,469	0.1
Iowa	12,006	--	--	--	W	W	61,141	0.1
Kansas	11,328	--	--	--	--	--	11,328	*
Kentucky	--	--	--	--	--	W	W	W
Louisiana	961,762	--	--	--	127,869	2,786,905	3,876,536	4.5
Maine	1,726,605	--	--	--	591,943	3,148,766	5,467,314	6.4
Maryland	--	--	--	--	W	W	708,064	0.8
Massachusetts	W	--	--	--	2,016,133	W	2,376,535	2.8
Michigan	129,826	--	--	--	709,516	1,984,760	2,824,103	3.3
Minnesota	279,883	--	--	57,535	327,106	508,018	1,172,542	1.4
Mississippi	--	--	--	--	W	W	2,047,829	2.4
Missouri	--	--	--	--	W	--	W	W
Montana	W	--	--	--	--	W	W	W
Nebraska	--	--	--	--	--	--	--	--
Nevada	W	W	--	--	--	--	1,677,886	2.0
New Hampshire	405,802	--	--	--	181,212	881,016	1,468,030	1.7
New Jersey	W	--	--	--	W	--	1,331,387	1.6
New Mexico	--	--	--	--	W	--	W	W
New York	1,223,288	--	--	--	1,901,263	495,384	3,619,935	4.2
North Carolina	W	--	--	--	W	1,729,782	3,583,178	4.2
North Dakota	--	--	--	--	W	--	W	W
Ohio	W	--	--	--	W	W	407,590	0.5
Oklahoma	--	--	--	--	W	W	W	W
Oregon	W	--	--	--	W	570,739	1,008,754	1.2
Pennsylvania	350,108	--	--	--	1,762,250	750,840	2,863,197	3.3
Rhode Island	W	--	--	--	W	--	90,618	0.1
South Carolina	W	--	--	--	W	1,662,833	1,803,392	2.1
South Dakota	--	--	--	--	--	--	--	--
Tennessee	835,054	--	--	--	60,321	599,778	1,495,153	1.7
Texas	--	--	--	--	88,795	955,134	1,043,929	1.2
Utah	42,835	--	--	--	--	--	42,835	0.1
Vermont	W	--	--	--	--	W	346,642	0.4
Virginia	78,154	--	--	--	742,948	1,535,635	2,356,737	2.8
Washington	W	--	--	--	W	589,338	1,267,065	1.5
West Virginia	W	--	--	--	W	--	810,205	0.9
Wisconsin	276,500	--	--	--	182,045	658,427	1,116,972	1.3
Wyoming	--	--	--	--	--	--	--	--
Total	**14,773,801**	**9,911,659**	**824,193**	**3,185,006**	**20,014,222**	**36,961,054**	**85,669,935**	

* = Less than 0.5 million kilowatthours.
W = Data withheld to avoid disclosure of proprietary company data.
Note: Sum of components do not add up to the total due to independent rounding.
Source: Energy Information Administration, Form EIA-867, "Annual Nonutility Power Producer Report."

Table 7. U.S. Electric Generating Capacity, 1992-1996
(Megawatts)

Source	1992	1993	1994	1995	1996
Hydroelectric[a]	74,580	77,181	78,041	78,563	78,536
Geothermal	2,910	2,978	3,006	2,968	2,842
Biomass	9,701	10,045	10,465	10,292	10,419
Solar/Photovoltaic	339	340	333	333	333
Wind	1,823	1,813	1,745	[b]1,731	1,801
Total Renewables	**89,353**	**92,357**	**93,590**	**93,887**	**93,931**
Nonrenewables[c]	656,563	661,222	668,819	675,643	681,737
Total	**745,916**	**753,579**	**762,409**	**769,530**	**775,668**

[a]Excludes pumped storage, which is included in "Nonrenewables."
[b]Excludes 6.6 megawatts of utility capacity and 35 megawatts of nonutility capacity that were not captured by EIA sources.
[c]Includes hydrogen, sulfur, batteries, chemicals, spent sulfite liquor, and hydroelectric pumped storage.
Note: 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 Power Plants in the United States as of January 1, 1996*, DOE/EIA-0095(96), p. 262.
Sources: Energy Information Administration, Form EIA-860, "Annual Electric Generator Report," and Form EIA-867, "Annual Nonutility Power Producer Report."

Wind capacity increased 4 percent after declines during the past two years. Wind and solar plants, due to the intermittent nature of the resource and comparatively untested technologies, operated at much lower capacity factors (22 and 31 percent, respectively) during 1996.

EIA plans to publish extensive detailed data on renewable electricity in a subsequent report.[8] This information will include a State-by-State profile of renewable-generated electricity and capacity, by fuel source, as well as individual generator data where EIA disclosure rules permit.

Biomass Energy Highlights

Biomass energy consumption increased by 2.4 percent in 1996 (Table 8), slightly faster than the 2.3-percent average growth rate for the 1990-1995 period (Figure 2). Consumption growth remained moderate during 1996 in part as a result of winter weather conditions. Total U.S. Heating Degree Days in 1996 were largely unchanged compared to 1995. Thus, there was no climate-induced change in residential biomass consumption.

The Industrial Sector was the largest consumer of biomass energy during the period 1990-1996, continuing a trend of several decades. Almost all the increase in total usage can be attributed to the Industrial Sector (Figure 3). Biomass energy consumption remained flat in the Residential Sector.

Sales of pellet fuel, used primarily by residential customers, ran counter to the trend, however, growing recently in most regions during most of the comparison period (Figure 4).

Recent declines in the consumption of pellet fuel in the Mountain and Pacific marketing regions have been attributed to milder winters there. Statistics for the Northeast indicate a strong growth trend in recent fuel sales in that region. However, sales of pellet fuel appliances (stoves, fireplace inserts, pellet furnaces, etc.), nationwide, have decreased over the past two heating seasons (Figure 5).

In the wake of the oil crisis of the 1970's, sales of all wood burning appliances exceeded 1,000,000 units per year. As oil prices dropped and concerns arose in some regions over environmental pollution from wood burning, woodstoves sales dropped to fewer than 400,000 units per year.[9] Since then, significant improvements have been made in the combustion profile and efficiency of these appliances and all manufactured today conform to strict EPA standards.

[8] *Renewable Energy Annual 1997, Volume 2*. The anticipated publication date is June 1998.
[9] Great Lakes Regional Biomass Energy Program, *Wood Pelletization Sourcebook: A Sample Business Plan for the Potential Pellet Manufacturer*, prepared by NEOS Corporation, March 1995, p. 7.

Table 8. Biomass Energy Consumption by Sector and Census Region, 1992-1996
(Trillion Btu)

Energy Source	1992	1993	1994	1995	1996
Wood Energy[a]	**2,249**	**2,228**	**2,266**	**2,350**	**2,440**
Sector					
Residential	645	548	537	596	595
Commercial	[b]	44	45	45	49
Industrial	1,593	1,625	1,673	1,698	1,784
Electric Utility	11	11	11	11	12
Census Region					
Northwest	264	277	278	354	359
Midwest	286	222	223	277	278
South	1,234	1,405	1,437	1,075	1,128
West	466	324	328	644	675
Waste Energy[c]	**460**	**468**	**475**	**492**	**503**
Source					
Municipal Solid Waste	383	390	394	408	421
Combustion	311	318	323	333	333
Landfill Gas	72	72	71	75	88
Manufacturing	77	78	81	81	82
Census Region					
Northwest	148	151	171	173	176
Midwest	84	85	76	88	77
South	128	130	134	134	149
West	100	102	95	96	101
Alcohol Fuels (Ethanol)	**79**	**88**	**97**	**104**	**74**
Census Region					
Northwest	*	*	*	3	2
Midwest	55	61	68	74	53
South	13	14	16	10	7
West	10	11	12	17	12
Biofuel Energy Consumption	**2,788**	**2,784**	**2,838**	**2,946**	**3,017**

[a]Assuming an average energy yield of 17 million Btu per ton.

[b]Commercial wood energy use for 1990-1992 is not included because there are no accurate data sources to provide reliable estimates. However, from the "1986 Nonresidential Energy Consumption Survey," conducted by the Energy Information Administration, it is estimated that commercial sector use is about 20 to 40 trillion Btu.

[c]Municipal solid waste, manufacturing waste, refuse-derived fuel, and methane recovered from landfills.

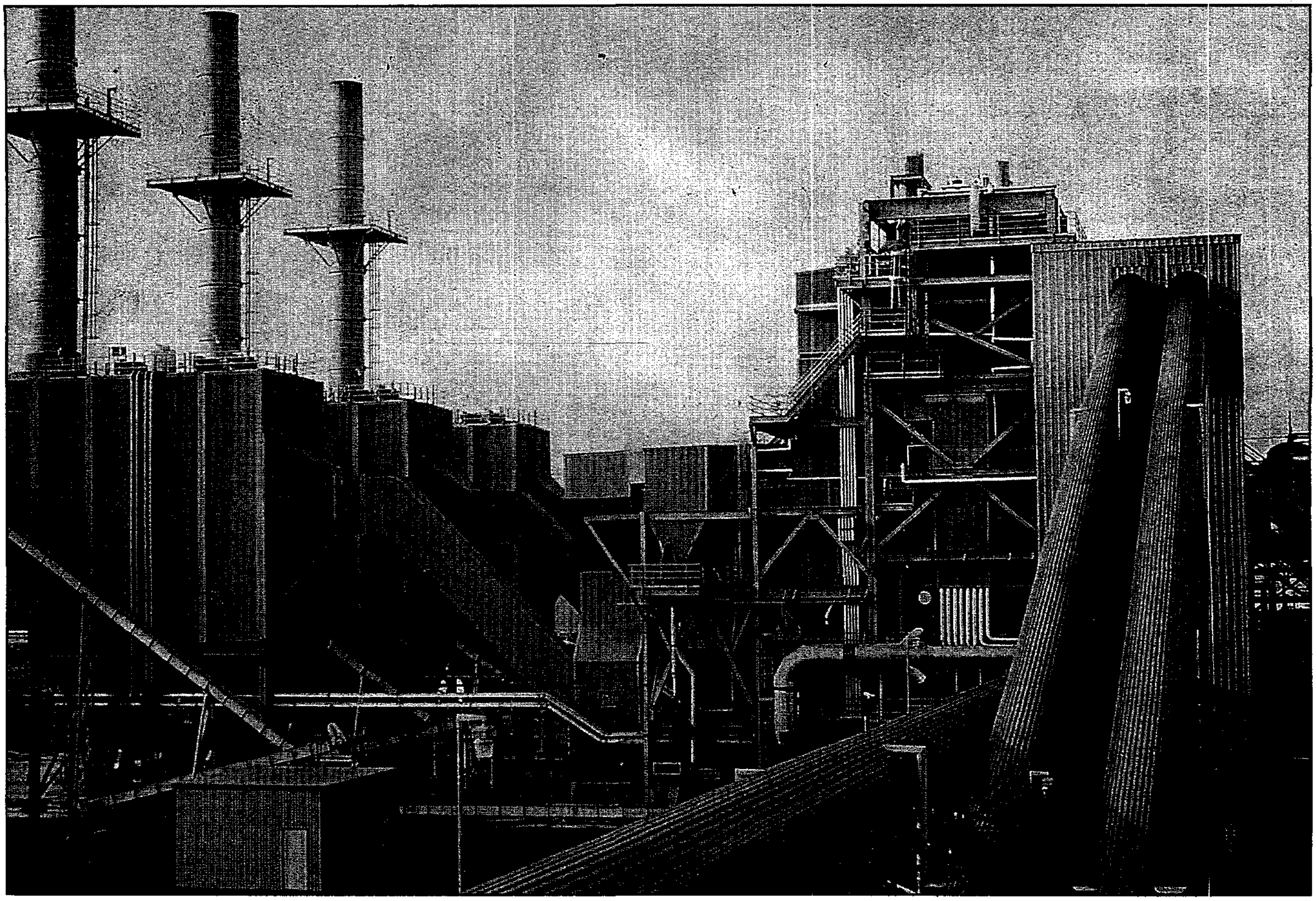
* = Less than 0.5 trillion Btu.

Note: The annual season runs from April 1 through March 31.

Source: Energy Information Administration, *Annual Energy Review 1996*, DOE/EIA-0384(96) (Washington, DC, July 1997).

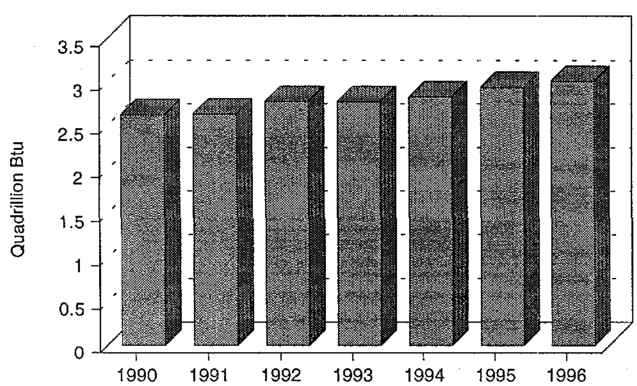
The broad components of biomass energy (wood, waste fuels, and alcohol fuels) consumption totaled 3,017 trillion Btu in 1996. Wood continues a long historical trend as the most employed biomass fuel (Figure 6 illustrates recent years). Woodfuel consumption grew at average annual rate of 2.1 percent during the 1990-1996 period, or an average annual rate of 47.5 trillion Btu. The mixed rate of growth reflected a cyclical downturn in the Pulp and Paper Industry during the first part of the period, followed by a subsequent period of recovery. Waste, including municipal solid waste, experienced positive growth during the period, increasing by an average 18 trillion Btu annually. U.S. ethanol production was in a growth mode for the 1990-1996 period until high corn prices during 1996 dealt a major blow to the ethanol industry by boosting feedstock costs to well above manufacturers' breakeven levels. Corn is used in the production of ethanol, yielding about 2.5 gallons per bushel.

Biodiesel, a renewable fuel which can substitute for petroleum diesel, is now being consumed in commercial



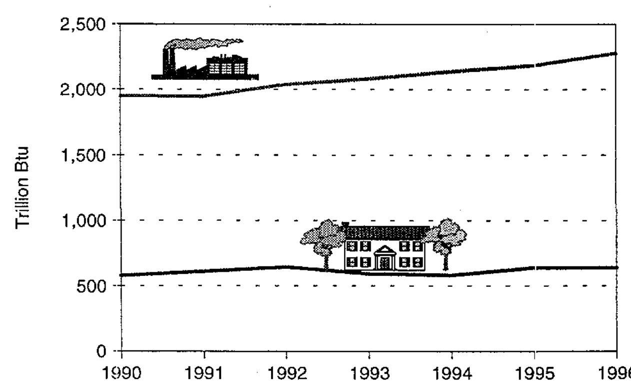
Wheelabrator Shasta Energy Company converts biomass to electricity.

Figure 2. Biomass Energy Consumption, 1990-1996



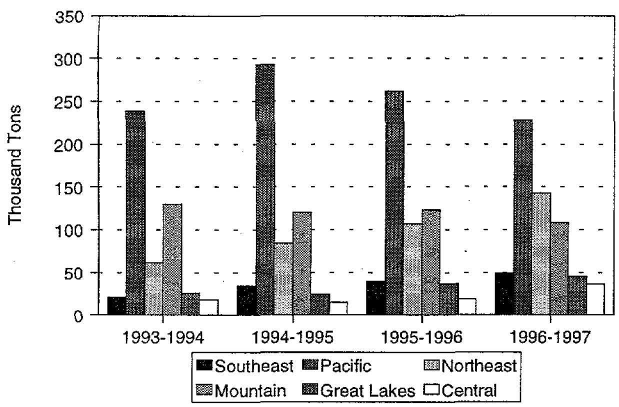
Source: Energy Information Administration (EIA), Form EIA-759, "Monthly Power Plant Report"; and EIA, *Annual Energy Review, 1996*, DOE/EIA-0384(96) (Washington, DC, July 1997), Table 10.2.

Figure 3. Residential/Commercial and Industrial Consumption of Biomass Energy, 1990-1996



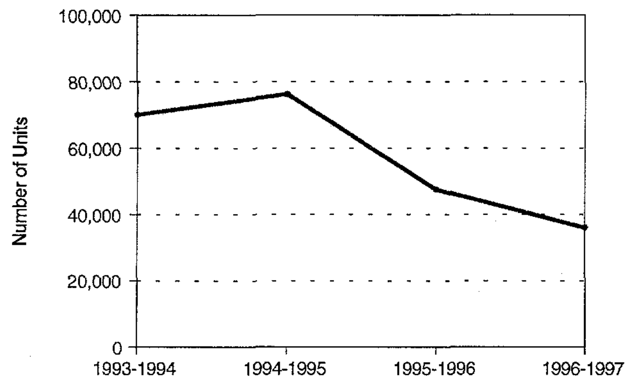
Source: Energy Information Administration (EIA), Form EIA-759, "Monthly Power Plant Report"; and EIA, *Annual Energy Review, 1996*, DOE/EIA-0384(96) (Washington, DC, July 1997), Table 10.2.

Figure 4. Regional Pellet Fuel Sales by Heating Season, 1993-1997



Source: Personal communication between Robert Lowe and Leslie Wheeler of the Pellet Fuels Institute, May 1, 1997.

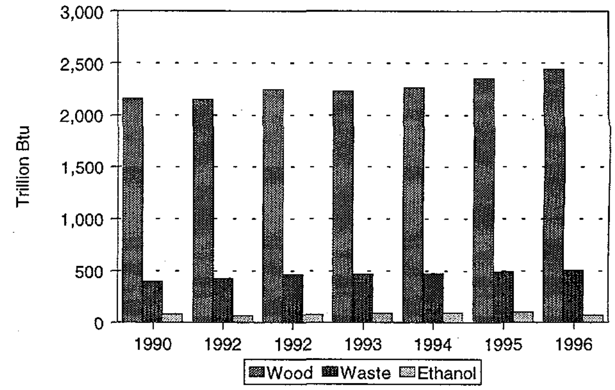
Figure 5. Pellet Fuel Appliance Sales, 1993-1997



Source: Personal communication between Robert Lowe and Leslie Wheeler of the Pellet Fuels Institute, May 1, 1997.

applications in small quantities. Total consumption in 1996 was about one million gallons. Biodiesel can be manufactured from soy beans, animal tallow, or used cooking oil. One bushel of soybeans will yield about 1.5 gallons of biodiesel[10] (7.3 lbs./gal.). About one billion pounds of animal tallow are produced annually in Nebraska alone. Sixty-five percent modified tallow mixed with 35 percent fuel ethanol has been shown to result in a blend which can be used as a blending agent with No.2 diesel. A mix of 20 percent of this blend with 80 percent No. 2 diesel yields a fuel having a viscosity identical to diesel alone.[11]

Figure 6. Primary Components of Biomass Energy Consumption, 1990-1996



Source: Energy Information Administration (EIA), Form EIA-759, "Monthly Power Plant Report"; and EIA, *Annual Energy Review, 1996,* DOE/EIA-0384(96) (Washington, DC, July 1997), Table 10.2.

MSW Highlights

Energy from municipal solid waste (MSW) is composed of waste that is combusted and landfill gas recovery. Energy consumed using MSW grew from 394 trillion Btu in 1994 to 408 trillion Btu in 1995 (Table 8). For 1996, MSW energy consumption is estimated to be 421 trillion Btu. As of the Fall of 1996, there were 102 waste-to-energy (WTE) facilities with a capacity of 99,000 tons per day marketing energy in the United States. In addition, there are 133 landfill sites in the business of converting landfill gas into energy.

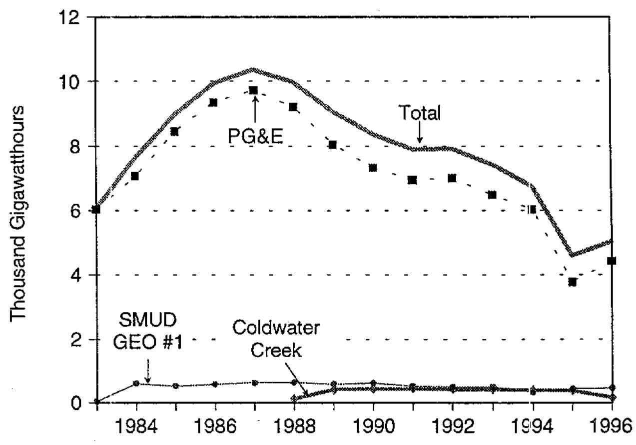
The production of energy from municipal waste supplies grew very rapidly during the 1980s largely as a result of public policy at the federal, State, and local level that promoted the construction of waste-to-energy facilities. This growth has been dramatically curtailed during the 1990s. Today, environmental policies are encouraging recycling and requiring costly pollution control at waste-to-energy facilities. Federal tax policy no longer favors investments in capital intensive products and limits the amount of municipal bonds States can issue for the construction of facilities that are privately owned. As is the case with many industries in the United States, the waste-to-energy industry is also feeling the competitive pressures of deregulation. Electricity prices are dropping, resulting in waste streams going to the cheapest disposal option—often out-of-State landfills.

[10] National Biodiesel Board, *Biodiesel Report,* July 1997, p.5.

[11] The Industrial Agricultural Products Center, University of Nebraska, Website http://ianrwww.unl.edu/ianr/iapc/tallow.htm, July 1, 1997.

As the electric utility industry is anticipating the affects of legislatively driven deregulation scenarios, the municipal solid waste industry is already adjusting to the affects of judicially driven deregulation decisions that have created much uncertainty about their ability to control their waste streams and protect their capital investments in waste-to-energy facilities. Two Supreme Court decisions (Fort Gratiot Landfill v. Michigan Department of Natural Resources, and C&A Carbone, Inc. v. Town of Clarkstown, New York) have outlawed waste management practices in many municipalities throughout the country. However, recent decisions by lower courts, in interpretation of the key Supreme Court guidance, have provided legally acceptable paths for municipalities to follow in developing waste management systems. Judicial systems currently uphold the "municipalization" of waste disposal practices especially if the activities are contracted-out using a competitive bidding process where out-of-State parties are given fair and equal opportunities to compete.

Figure 7. Annual Net Generation from The Geysers, 1983-1996



PG&E = Pacific Gas and Electric Company.
SMUD = Sacramento Municipal Utility District.
Source: Energy Information Administration, Form EIA-759, "Monthly Power Plant Report."

Geothermal Energy Highlights

Geothermal electricity generation reversed its two-year decline, rising to 16,249 million kWh in 1996. Industrial (nonutility) geothermal generation increased to record levels, and utility generation rose for the first time in 3 years. Production from The Geysers reversed a severe 10-year decline, rising from 4,606 million kWh in 1995 to 5,043 million kWh in 1996 (Figure 7). This was the principal reason for a 10-percent increase in electric utility geothermal generation.

The Newberry Geothermal Pilot Project in the Deschutes National Forest was canceled because insufficient geothermal resources were found at the Newberry site. The project developer requested a contract amendment with Bonneville Power Administration (BPA) to relocate the project to the Glass Mountain Area in the Modoc National Forest in northern California.

With the decision to end resource exploration at the Newberry Geothermal Pilot Project, the focus of geothermal resource evaluation has shifted to Glass Mountain, near Mount Shasta. The Bureau of Land Management is preparing an Environmental Impact Statement (EIS No. 970266) on a proposed 33-megawatt (MW) geothermal power plant.[12]

The Four-Mile Hill (a.k.a. Glass Mountain) Geothermal Project, located in Siskiyou County, CA, would have 33 megawatts of capacity.[13] While a contract with the BPA has not yet been signed, the anticipated participants would be the Calpine Siskiyou Geothermal Partners and Springfield Utility Board. The project area consists of 13,725 acres of federal geothermal leases. Approximately three years of environmental baseline data have been collected, some exploratory drilling has been done and an environmental impact statement for the power plant and transmission line is being prepared by the Bureau of Land Management (BLM). If all aspects go well, the project could go on-line in October 1999.

Wind Energy Highlights

Overview

Last year was a slow year for the development of wind energy. While 1996 generating capacity was up modestly over 1995 levels, it was no higher than in earlier years. Two small projects—one in Sibley, Iowa, and the other in Traverse City, Michigan, came on-line in 1996 bringing total wind capacity up to 1,800 megawatts (Table 7).[14]

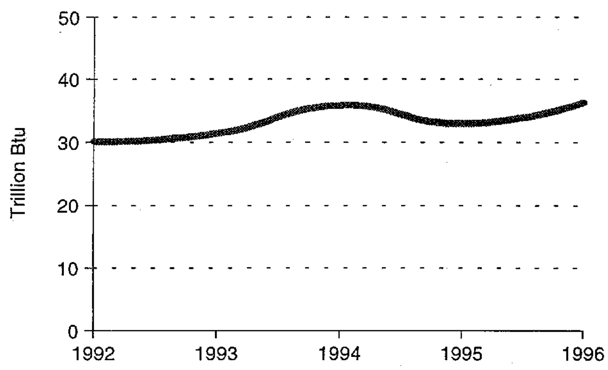
[12] Bureau of Land Management, EIS No. 970266, DRAFT EIS, Fourmile Hill Geothermal Development Project, Construction, Operation and Maintenance of a Geothermal Power Plant on land from Federal Geothermal Leases CA-21924 and CA-21926, Glass Mountain Known Geothermal Resource Area, Klamath and Modoc National Forests, Siskiyou and Modoc Counties, CA, Due: September 16, 1997, Contact: Randall Sharp (916)233-5811, 8/12/97.

[13] Bonneville Power Administration, http://www.bpa.gov/Corporate/ACS/kc/kcconx.htm, 8/12/97.

[14] U.S. Dept. Of Energy, *Wind Energy Data Monthly Summary Report* (Washington, DC, February 1997).

Gross generation from wind increased by 10 percent between 1995 and 1996; nonutility generators dominated this market, although electric utilities contributed a small amount (Table 4). Over the 5 years since 1992, gross generation and wind energy consumption were up 20 percent (Figure 8).

Figure 8. Wind Energy Consumption, 1992-1996



Sources: Energy Information Administration, Form EIA-759, "Monthly Power Plant Report"; Form EIA-867, "Annual Nonutility Power Producer Report"; and *Electric Power Monthly March 1997*, DOE/EIA-0226(97/03) (Washington, DC, March 1997).

Company Activities

In recent months, markets for wind energy have been characterized by turbulence as one U.S. manufacturer went bankrupt and another merged. In 1995 the largest U.S. manufacturer of turbines, Kenetech Windpower, a subsidiary of Kenetech Corp., posted losses of $250 million.[15] According to the company's 10-K filing with the U.S. SEC, these losses were attributed to unexpected problems with its KVS-33 turbine and uncertainty surrounding utility restructuring. Later, on May 29, 1996, Kenetech announced it had filed for Chapter 11 bankruptcy protection. When plans for California to go forward with construction of an additional 1,000 megawatts of capacity folded, the outlook for Kenetech dimmed.[16] By early Spring of 1997 more than half of Kenetech's assets had been auctioned off with the remainder scheduled to go soon.[17]

On a brighter note, in the beginning of 1997 Enron, the largest natural gas supplier in the United States, announced its acquisition of Zond Corp. and formation of Enron Renewable Energy Corporation.[18] The merger is expected to be mutually beneficial. Enron will get Zond's expertise in wind technology development (Zond is the number two U.S. producer) and Zond will have access to Enron's needed financial resources.

Future Prospects

Despite low electricity prices and uncertainty regarding the outcome of electric utility deregulation, U.S. wind markets have some degree of promise. Zond is committed to the development of two large projects in the Midwest. The first is with Minnesota's Northern States Power (NSP) to develop 100 megawatts of wind capacity in exchange for NSP's being allowed to store nuclear waste on site. The second project is to build 112.5 megawatts of wind capacity for Iowa's Mid-American Energy Company.[19] This project will permit the company to meet the state's requirement that a certain percentage of generation is from alternative energy sources.

Solar Energy Highlights

Solar energy consumption increased from .073 quads in 1995 to .075 quads in 1996 (Table 1). Eighty-eight percent of solar energy consumption can be attributed to the residential and commercial sectors and 12 percent to the industrial sector in 1996 (Table 2). Table 3 shows a very small percentage of solar electricity is generated in the electric utility sector as a percentage of total renewable generated net electricity.

U.S. electric utilities reported 2.7 million kilowatthours of net electricity generation from photovoltaic modules in 1996 (Table 9).[20] Of this total, 90 percent was generated in California.

[15] American Wind Energy Association, *Wind Energy Weekly*, April 22, 1996.

[16] Gipe, Paul, "Domestic Doldrums," *Independent Energy*, November 1996.

[17] U.S. Dept of Energy, *Wind Energy Data Monthly Summary Report* (Washington, DC, February 1997).

[18] American Wind Energy Association, http://www.econet.org/awea/news for January 6, 1997. Also, *New York Times*, January 7, 1997.

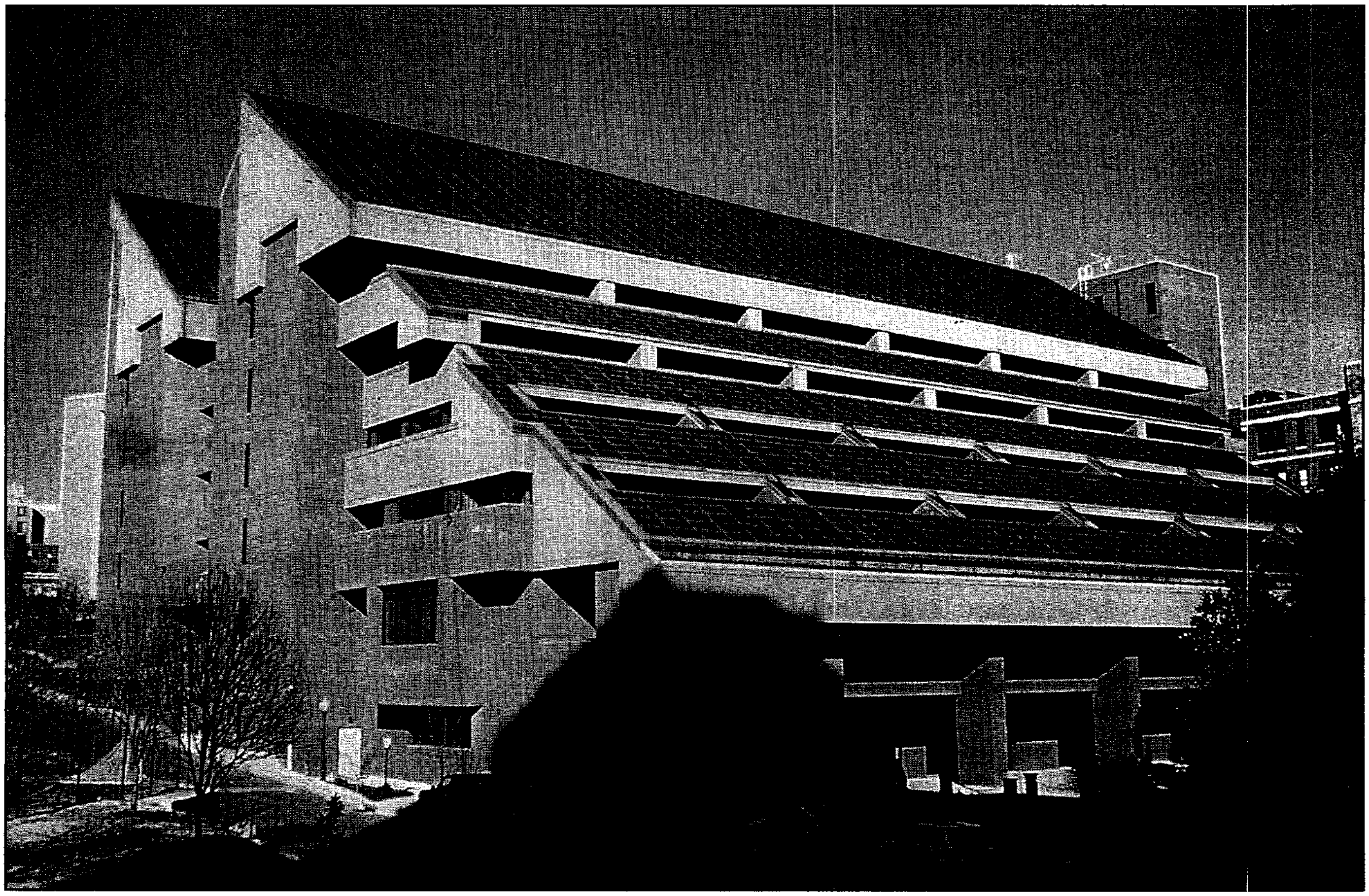
[19] *The Electricity Journal, Volume 10,* May 1997 and the *New York Times*, March 20, 1997.

[20] Net generation is gross generation minus plant use.

Table 9. U.S. Utility Net Electric Generation from Solar Energy, 1996
(Thousand Kilowatthours)

Utility	Plant (State)	Net Generation
Sacramento Municipal Utility District	Solar (California)	1,172
Austin Electric	Decker Creek (Texas)	260
Pacific Gas & Electric	PVUSA 1 (California)	1,304
Total		**2,736**

Note: Net generation is gross generation minus plant use.
Source: Energy Information Administration, *Electric Power Monthly August 1997,* DOE/EIA-0226(97/08) (Washington, DC, August 1997), Table 58.



View of Georgetown University's Intercultural Center. Its roof supports a 300-kilowatt photovoltaic power system.

2. Solar Thermal and Photovoltaic Collector Manufacturing Activities

Introduction

This chapter presents national and State-level data on the United States solar thermal collector and photovoltaic module and cell manufacturing industry. The data are reported to the EIA by U.S.-based manufacturers and importers of solar equipment on Forms EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey," and EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey." Historical data for comparison are presented for annual domestic shipments of solar thermal collectors for the years 1977 through 1996 and of photovoltaic modules and cells for the years 1982 through 1996 (Table 10). Since 1977, the total number of domestic shipments in square feet of solar thermal collectors is 229,730 thousand square feet. The total number of domestic shipments in peak kilowatts of photovoltaic cells and modules is 102,297 peak kilowatts. An estimate of the useful life of solar collectors has been calculated at 20 years. Throughout the chapter, the unit of measure is square feet of collector surface for solar thermal collectors and peak kilowatts for photovoltaic modules and cells.

Solar Thermal Activities

Shipments

Solar thermal collector shipments totaled 7.6 million square feet in 1996, virtually unchanged from the 1995 level of 7.7 million square feet (Table 11). Import shipments totaled 1.9 million square feet, while export shipments were 0.5 million square feet in 1996 (Figure 9). Shipments of low-temperature solar thermal collectors remained constant at 6.8 million square feet in 1996 compared to 1995 (Table 12). Shipments of medium-temperature collectors decreased 7 percent to 0.79 million square feet in 1996 from 0.84 million square feet in 1995. Shipments of high-temperature collectors decreased 3,000 square feet in 1996 to 10,000 square feet from 13,000 square feet in 1995.

Table 10. Annual Photovoltaic and Solar Thermal Shipments, 1977-1996

Year	Domestic Shipments[a]	
	Photovoltaic Modules and Cells (Peak Kilowatts)	Solar Thermal Collectors (Thousand Square Feet)
1977	—	10,312
1978	—	10,020
1979	—	13,396
1980	—	18,283
1981	—	19,362
1982	6,897	18,166
1983	10,717	16,669
1984	7,759	16,843
1985	4,099	[b]19,166
1986	3,224	9,136
1987	3,029	7,087
1988	4,318	8,016
1989	5,462	11,021
1990	6,293	11,164
1991	6,035	6,242
1992	5,760	6,770
1993	6,137	6,557
1994	8,363	7,222
1995	11,188	7,136
1996	13,016	7,162
Total	**102,297**	**229,730**

[a]Total shipments minus export shipments.
[b]Estimated data.
— = Not available.

Sources: **1977:** Federal Energy Administration telephone survey. **1978-1984:** Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1985-1996**: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey," and Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 11. Annual Shipments of Solar Thermal Collectors, 1987-1996

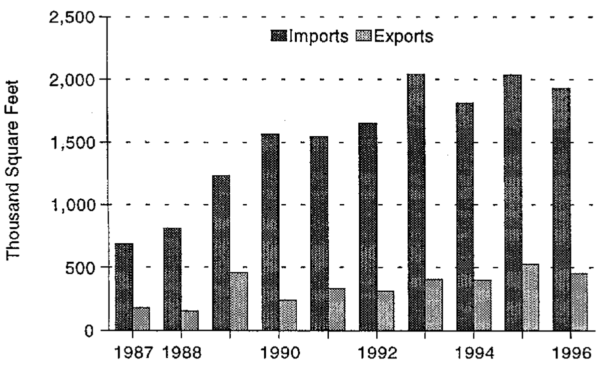
Year	Number of Companies	Collector Shipments (thousand square feet)[a]		
		Total	Imports	Exports
1987	59	7,269	691	182
1988	51	8,174	814	158
1989	44	11,482	1,233	461
1990	51	11,409	1,562	245
1991	48	6,574	1,543	332
1992	45	7,086	1,650	316
1993	41	6,968	2,039	411
1994	41	7,627	1,815	405
1995	36	7,666	2,037	530
1996	28	7,616	1,930	454

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

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."

Figure 9. Import and Export Shipments of Solar Thermal Collectors, 1987-1996



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: **1987-1996:** Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Origins

U.S. manufacturers in California, New York, New Jersey, Florida, and Puerto Rico produced 98 percent of U.S.-manufactured collectors in 1996, which represented the same percentage they produced in 1995. California continued to lead the Nation in 1996 with 33 percent of total domestic shipments, an increase from 16 percent in 1995 (Table 13). New York, New Jersey, Puerto Rico, and Florida shipped a combined 3.6 million square feet in 1996, a decrease of 8 percent.

Distribution

Of total shipments in 1996, 64 percent were sent directly to wholesale distributors and 22 percent were sent to retail distributors (Table 14). Of export shipments, 82 percent were sent directly to exporters. Direct shipments to installers, end users, and others accounted for 10 percent of total shipments in 1996.

Collector Types

Solar thermal collectors are divided into the categories of low-, medium-, and high-temperature collectors. Low-temperature collectors provide heat up to 110° Fahrenheit through either metallic or nonmetallic absorbers and are used in applications such as swimming pool heating, and water, space, and process heating. Medium-temperature collectors provide heat greater than 110° Fahrenheit (usually 140 to 180° Fahrenheit) through either glazed flat-plate collectors that use air or liquid as the heat transfer medium or concentrator collectors that concentrate the heat of incident insolation to greater than "one sun." Evacuated-tube collectors are included in this category. High-temperature collectors are parabolic dish and trough collectors and are used primarily by utilities and nonutility power producers in the generation of electricity for the grid. A high-temperature solar thermal collector operates at temperatures above 180 degrees Fahrenheit - (Figure 10). From 1987 through 1996, annual shipments of low-temperature collectors ranged between 3.2 and 6.8 million square feet. In 1996, medium-temperature collector manufacturers shipped just under 0.8 million square feet, a decrease of 7 percent from 1995.

Table 12. Annual Shipments of Solar Thermal Collectors by Type, 1987-1996
(Thousand Square Feet)

Year	Low-Temperature		Medium-Temperature		High-Temperature Total Shipments[a,b]
	Total Shipments[a]	Average per Manufacturer	Total Shipments[a]	Average per Manufacturer	
1987	3,157	263	957	19	3,155
1988	3,326	416	732	16	4,116
1989	4,283	428	1,989	55	5,209
1990	3,645	304	2,527	62	5,237
1991	5,585	349	989	24	1
1992	6,187	387	897	26	2
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

[a]Includes imputation of shipment data to account for nonrespondents.
[b]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 13. Shipments of Solar Collectors Ranked by Top Five Origins and Destinations, 1995 and 1996

Origin/Destination	1995 Shipments		1996 Shipments	
	Thousand Square Feet	Percent of U.S. Total	Thousand Square Feet	Percent of U.S. Total
Origin[a]				
California	1,575	R28	1,819	33
Florida	R1,075	R19	683	12
New Jersey, New York and Puerto Rico	R2,839	R50	2,905	53
Top Five Total	**R5,489**	**R98**	**5,406**	**98**
Destination[b]				
Florida	3,582	50	3,519	49
California	1,420	20	1,472	21
Arizona	296	4	421	6
Hawaii	219	3	220	3
New York	148	2	219	3
Top Five Total	**5,665**	**79**	**5,850**	**82**

[a]Represents only shipments manufactured in the United States.
[b]Based on the total shipped each year to the United States and Territories.
R = Revised.
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."

Low-temperature collectors dominated the solar thermal industry in 1996, accounting for 90 percent of total shipments (Table 15). Medium-temperature collectors accounted for 10 percent of total collector shipments in 1996. Collectors that constituted subunits of thermosiphon systems or integral collector storage systems (ICS) represented 4.5 percent of total shipments. High-temperature collectors, shipped primarily for research and demonstration projects, represented about 0.1 percent of total shipments in 1996.

Values and Prices

The total value of solar thermal collector shipments was $29.8 million in 1996; a 18-percent increase compared with 1995. The average price of low-temperature collectors increased to $2.67 in 1996 from $2.31 in 1995 (dollars per square foot), and the average price of ICS and thermosiphon collectors increased to $21.63 in 1996 from $19.73 in 1995. This increase was due primarily to increased material costs. The average price for flat-plate

Table 14. Distribution of Solar Thermal Collector Shipments, 1995 and 1996

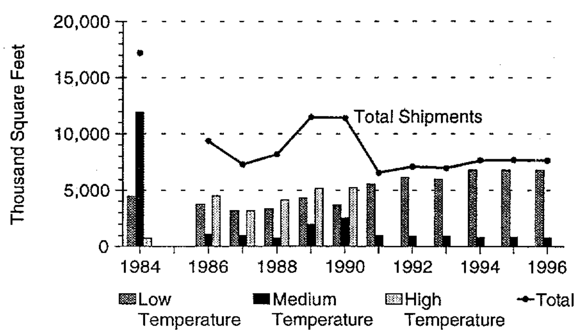
Recipient	Shipments (thousand square feet)	
	1995	1996
Wholesale Distributors	5,271	4,843
Retail Distributors	1,659	1,655
Exporters	279	372
Installers	251	529
End Users and Other[a]	207	217
Total	**7,666**	**7,616**

[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."

Figure 10. Solar Thermal Collector Shipments by Collector Type, 1984-1996



Note: Data for 1985 are incomplete and are not shown.

Sources: **1984:** Energy Information Administration, Form EIA-63, "Annual Solar Thermal Collector and Photovoltaic Module Manufacturers Survey." **1986-1996:** Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

collectors in 1996 increased to $8.57 from the corresponding 1995 level of $8.09 per square foot (Figure 11). The value of shipments includes charges for advertising and warranties. Excluded are excise taxes and the cost of freight or transportation for the shipments.

Markets

In 1996, the residential sector was the largest market for solar thermal collectors. Solar thermal collectors shipped to the residential sector in 1996 totaled 6.9 million square feet, 90 percent of total shipments (Table 16). This market sector primarily involves the use of low-temperature solar collectors for heating swimming pools and medium-temperature collectors for water heating in residential buildings. The second-largest market for solar thermal collectors in 1996 was the commercial sector, which accounted for 9 percent of total shipments.

Uses

The largest end use for solar thermal collectors shipped in 1996 was for heating swimming pools, representing 89 percent of the total square feet shipped. Swimming pools generally use low-temperature collectors. A common low-temperature pool-heating solar collector is a black plastic or rubber-like sheet with tubing through which water is circulated. The heat of the sun is transferred directly from the black absorbing material to the water circulating through the tubing to supply heat to the pool. Shipments for pool heating increased slightly in 1996 from the level reported in 1995.

The second largest end use in 1996 was for domestic hot water systems, which accounted for 10 percent of the total square feet shipped. Typical solar water-heating systems feature flat-plate collectors or collectors installed in an ICS or thermosiphon system. Unlike pool-heating systems, domestic solar water-heating systems nearly always have a conventional backup (i.e., gas or electric). Shipments in 1996 for hot water systems increased also slightly from the 1995 level.

Medium-temperature collectors also were shipped for space heating, and for installation into systems that provide both space and water heating and process heating. High-temperature parabolic dish and trough collectors were shipped for electricity generation and hot water in 1996.

Destinations

Domestic

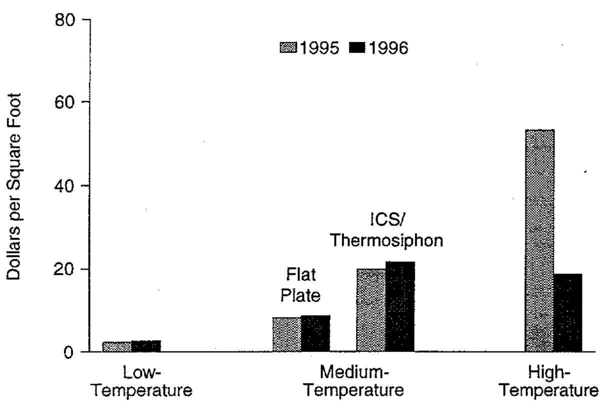
Solar thermal collectors were shipped to 42 States, Puerto Rico, and the U.S. Virgin Islands in 1996 (Table 17). The four States and one U.S. territory that received the largest amounts of solar thermal collectors in 1996 were: Florida (49 percent), California (21 percent), Arizona (6), New York (3 percent), and Hawaii (3 percent) (Table 17). All of the collectors manufactured in Puerto Rico remained on the island. The U.S. market for solar thermal collectors continued to be highly concentrated in a few States and Puerto Rico. Factors favorable for solar energy use that these States and Puerto Rico have in common are: (1) good solar insolation; (2) high electricity costs; (3) solar-promoting incentives, such as tax credits or exemptions;

Table 15. Solar Thermal Collector Shipments by Type, Quantity, Value, and Average Price, 1995 and 1996

Type	1995 Quantity (thousand square feet)	1995 Value (thousand dollars)	1995 Average Price (dollars per square foot)	1996 Quantity (thousand square feet)	1996 Value (thousand dollars)	1996 Average Price (dollars per square foot)
Low-Temperature						
Liquid and Air	6,813	15,756	2.31	6,821	18,227	2.67
Medium-Temperature						
Air	18	271	14.77	9	139	15.83
Liquid						
ICS/Thermosiphon	156	3,079	19.73	343	7,424	21.63
Flat Plate	664	5,369	8.09	431	3,697	8.57
Evacuated Tube	1	79	58.48	1	110	75.10
Concentrator	*	1	43.33	0	0	0
All Medium-Temperature	840	8,799	10.48	785	11,369	14.48
High-Temperature						
Parabolic Dish and Trough	13	694	53.26	10	180	18.75
Total	**7,666**	**25,249**	**3.29**	**7,616**	**29,776**	**3.91**

* = Less than 500 square feet.
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."

Figure 11. Average Price of Solar Thermal Collector Shipments by Collector Type, 1995 and 1996



Note: See Table 15.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

and (4) a demand for low technology solar pool heaters and solar domestic hot water systems.

Export

Exports accounted for 6 percent of total shipments in 1996. A total of 19 companies exported solar thermal collectors in 1996 compared with 16 companies in 1995. Of total 1996 exports, low-temperature collectors accounted for 24 percent and medium-temperature collectors 73 percent. Summed by continents, the largest percentage of shipments were to North and South America (55 percent), followed by Europe (29 percent) and Asia (16 percent) (Table 18). Trading countries that received export shipments were Canada (29 percent), Taiwan (14 percent), Germany (7 percent) and Mexico (8 percent), Bolivia (7 percent), and Norway (6 percent).

Systems

The 28 companies reporting shipments of solar thermal collectors in 1996 reported shipments of 9,013 complete solar thermal collector systems. This was a 36-percent decrease compared with 1995 (Table 19). A complete system is a unit with a collector and all the necessary functional components, except for installation materials. Included are thermosiphon systems, integral collector storage systems, packaged systems, and system kits. The 9,013 complete systems accounted for 2.1 million square feet of collectors, an increase of 35 percent in square feet shipped above the 1995 level. The total value for the systems shipped in 1996 was $10.8 million, compared with $17.8 million in 1995.

Industry Status

In 1996, there were 28 companies active in the solar thermal collector manufacturing industry, a significant

Table 16. Shipments of Solar Collectors by Market Sector, End Use, and Type, 1995 and 1996
(Thousand Square Feet)

Type	Low-Temperature: Liquid/Air: Metallic and Nonmetallic	Medium-Temperature: Air	Medium-Temperature: Liquid: ICS/Thermosiphon	Medium-Temperature: Liquid: Flat-Plate (Pumped)	Medium-Temperature: Liquid: Evacuated Tube	Medium-Temperature: Liquid: Concentrator	High-Temperature: Parabolic Dish/Trough	1996 Total	1995 Total
Market Sector									
Residential	6146	9	315	403	1	0	0	**6,873**	**6,966**
Commercial	625	0	22	28	0	0	7	**682**	**604**
Industrial	51	0	0	1	0	0	2	**54**	**82**
Utility	0	0	0	0	*	0	0	*	**9**
Other[a]	*	0	7	0	0	0	0	**7**	**6**
Total	**6821**	**9**	**343**	**431**	**1**	**0**	**10**	**7,616**	**7,666**
End Use									
Pool Heating	6766	*	*	20	0	0	0	**6,787**	**6,763**
Hot Water	4	2	343	408	1	0	7	**765**	**755**
Space Heating	51	6	0	0	0	0	0	**57**	**132**
Space Cooling	0	0	0	0	0	0	0	**0**	**1**
Combined Space and Water Heating	0	0	0	2	*	0	0	**3**	**2**
Process Heating	0	0	0	1	*	0	2	**4**	*
Electricity Generation	0	0	0	0	*	0	0	*	**10**
Other[b]	0	0	0	0	0	0	0	**0**	**2**
Total	**6821**	**9**	**343**	**431**	**1**	**0**	**10**	**7,616**	**7,666**

*Less than 500 square feet.

[a]Other market sectors include shipments of solar thermal collectors to other sectors such as government, including the 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, distilling, etc.

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."

decrease from the 36 operating in 1995 (Table 11). The decline occurred principally in firms engaged partially in nonsolar-related businesses (Table 15). Despite the decrease, solar thermal collector manufacturers shipped virtually the same quantity as last year—7.6 million square feet during 1996 (Table 11), versus 7.7 million square feet in 1995. Of the 28 active companies, 7 are planning to introduce new low-temperature collectors, 11 are planning new medium-temperature collectors, and 3 expect to introduce new high-temperature collectors in 1997 (Table 20).

The decline from 1995 to 1996 in manufacturing firms reflects a continuation of a decade-long decline. Since 1987, 31 manufacturing companies have left the market (Table 11). This is due in large measure to two factors. First, the 40-percent residential energy tax credit and the 15-percent business energy tax credit expired at the end of 1985. Second, the decline in industry companies intensified with the drop in oil prices in 1986. The reinstatement of the business energy tax credit (at the 15-percent level for 1986, at the 12-percent level for 1987 through 1991, and at the 10-percent level in 1992)—plus increasing oil prices after 1986—appear to have had little effect on drawing companies into manufacturing solar thermal collectors.[21]

[21] In an effort to stimulate domestic energy sources, the Energy Policy Act of 1992, Section 1916, extended the 10-percent business tax credits for solar equipment indefinitely, retroactive to June 30, 1992. Investors in or purchasers of qualified solar energy property can take the credit on up to 10 percent of the investment or purchase price and installment amount. Section 1914 established a 1.5-cent per kilowatthour electricity production incentive for "qualifying facilities."

Table 17. Shipments of Solar Thermal Collectors by Destination, 1996
(Square Feet)

Destination	1996	Destination	1996
Alabama	2,015	Nebraska	32
Alaska	0	Nevada	147,075
Arizona	420,843	New Hampshire	505
Arkansas	6,335	New Jersey	118,243
California	1,471,655	New Mexico	27,984
Colorado	43,736	New York	219,042
Connecticut	118,125	North Carolina	22,395
Delaware	0	North Dakota	2,015
District of Columbia	0	Ohio	12,175
Florida	3,519,196	Oklahoma	900
Georgia	41,240	Oregon	210,446
Hawaii	220,412	Pennsylvania	109,720
Idaho	39	Puerto Rico	110,144
Illinois	27,248	Rhode Island	0
Indiana	25,241	South Carolina	0
Iowa	288	South Dakota	0
Kansas	2,615	Tennessee	6,812
Kentucky	0	Texas	90,187
Louisiana	2,150	Utah	11,611
Maine	2,199	Vermont	10,054
Maryland	2,303	Virgin Islands (U.S.)	6,937
Massachusetts	13,819	Virginia	18,805
Michigan	18,639	Washington	20,058
Minnesota	20,068	West Virginia	25,237
Mississippi	0	Wisconsin	30,709
Missouri	0	Wyoming	88
Montana	2,105		
Shipments to United States/Territories			**7,161,445**
Exports			**454,465**
Total Shipments			**7,615,910**

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

At the end of 1996, 30 States were providing financial incentives for investment in the use of solar thermal collectors and photovoltaic modules and cells. The legislative actions were passed to encourage the use of an environmentally clean source of energy, to promote energy conservation through the use of renewable energy technologies, and to promote energy efficiency. Among the most common incentives were property tax exemptions and income tax credits for both the residential and business sectors.

Since 1987, the 10 largest U.S. companies that shipped solar thermal collectors have supplied not less than 95 percent of all solar thermal collectors manufactured in or imported into the United States (Table 21). In 1996, 97 percent of the approximately 7.6 million square feet of total shipments were supplied by the 10 largest companies.

Employment in solar-thermal-related activities decreased 147 person-years in 1996 to 239 person-years, a 38 percent drop from the 1995 employment level of 386. Industry employment data for 1993 through 1996 are as follows:

Year	Person Years Expended
1993	392
1994	402
1995	386
1996	239

Table 18. Distribution of U.S. Solar Thermal Collector Exports by Country, 1996

Country	Percent of U.S. Exports
Asia	
India	1.3
Japan	0.3
Taiwan	14.4
Total	**16.0**
Europe	
Czechoslovakia	0.1
Denmark	0.3
France	0.5
Germany	7.4
Netherlands	0.3
Norway	6.0
Spain	4.2
Sweden	5.2
Switzerland	4.7
Turkey	0.2
Total	**28.8**
Africa	
Tunisia	0.1
Total	**0.1**
Australia	**0.5**
The Americas	
Bahamas	0.6
Bermuda	0.2
Bolivia	6.9
Canada	29.0
Cayman Island	0.1
Columbia	4.6
Ecuador	4.2
Mexico	7.6
St. Vincent	0.2
San Salvador	1.0
Trinidad	0.2
U.S. Virgin Islands	0.8
Total	**55.4**
Total	**100.0**

Notes: Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturer Survey."

Most of the 28 reporting companies in 1996 combined manufacturing and related activities with importing of solar thermal collectors:

- A total of 20 companies were involved in the design of collectors or systems, 15 were developing prototype collectors, and 7 were developing prototype systems (Table 22).

Table 19. Shipments of Complete Solar Thermal Collector Systems, 1995 and 1996

Shipment Information	1995	1996
Complete Collector Systems		
Shipped	14,121	9,013
Thousand Square Feet	1,551	2,093
Percent of Total Shipments	20	27
Number of Companies	36	28
Value of Systems (thousand dollars)	17,826	10,754

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

Table 20. Number of Companies Expecting To Introduce New Solar Thermal Collector Products, 1997

New Product Type	Number of Companies
Low-Temperature Collectors	7
Medium-Temperature Collectors	11
High-Temperature Collectors	3
Noncollector Components	4

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

- There were 19 wholesale companies and 12 retail companies. Of the 28 companies, 9 offered installation of their collectors.

Solar-related sales represented 90 to 100 percent of total company sales for 21 companies in 1996 versus 22 companies in 1995 (Table 23). Solar-related sales made up less than 10 percent of total sales for three companies in 1996, compared with four companies in 1995.

Photovoltaic Module and Cell Manufacturing Activities

Shipments

PV module and cell shipments in 1996 amounted to 35.5 peak megawatts. Module shipments accounted for 24.5 peak megawatts, while cell shipments accounted for 10.9 peak megawatts. Modules shipments increased 25 percent in 1996 from 1995, while cell shipments decreased 4 percent (Table 24). Total PV shipments in 1996 were 14 percent above the 1995 level. Total shipments have increased 460 percent since 1986 (Table 25 and Figure 12).

Table 21. Percent of Solar Collector Shipments by the 10 Largest Companies, 1987-1996

Year	Company Rank	Shipments (thousand square feet)	Percent of Total Shipments
1987	1-5	6,371	88
	6-10	499	7
1988	1-5	7,585	93
	6-10	335	4
1989	1-5	9,748	85
	6-10	1,321	12
1990	1-5	9,955	87
	6-10	1,029	9
1991	1-5	5,429	83
	6-10	829	13
1992	1-5	6,110	86
	6-10	609	9
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

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 22. Companies Involved in Solar Thermal Activities by Type, 1995 and 1996

Type of Activity	1995	1996
Collector or System Design	28	20
Prototype Collector Development ..	17	15
Prototype System Development ...	13	7
Wholesale Distribution	24	19
Retail Distribution	16	12
Installation	15	9
Noncollector System Component Manufacture	14	7

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

Table 23. Solar-Related Sales as a Percentage of Total Sales, 1995 and 1996

Solar-Related Sales as a Percent of Total Sales	Number of Companies	
	1995	1996
90-100	22	21
50-89	10	4
10-49	0	0
Less than 10	4	3
Total	**36**	**28**

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

Table 24. Annual Shipments of Photovoltaic Modules and Cells, 1994-1996
(Peak Kilowatthours)

Item	1994	1995	1996
Modules	19,064	19,627	24,534
Cells	7,013	11,432	10,930
Total	**26,077**	**31,059**	**35,464**

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

Data for PV modules and cells for terrestrial use only (i.e., excluding space applications) have been reported each year since 1985.

Imports

Seven companies imported PV modules and cells in 1996 totaling 1.9 peak megawatts, or 5 percent of total shipments (Table 25). The predominant type of imported PV modules and cells was crystalline silicon. These imports originated in Australia, China, and Japan, with Japan accounting for most of the imported PV modules and cells.

Distribution

In 1996, PV module and cell shipments totaling 21.4 peak megawatts (60 percent of total shipments) were sent directly to wholesale distributors (Table 26). Installers and end users combined received 5.9 peak megawatts (17 percent of total shipments).

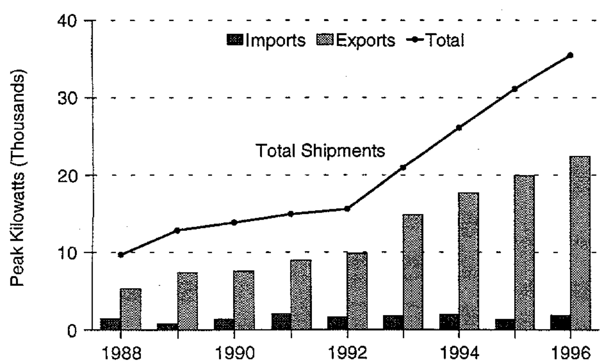
PV cell manufacturers shipped 5.5 peak megawatts (16 percent of total shipments) to other companies that manufacture (assemble) cells into PV modules.

Table 25. Annual Shipments of Photovoltaic Modules and Cells, 1986-1996

Year	Number of Companies	Photovoltaic Module and Cell Shipments (Peak Kilowatts)[a]		
		Total	Imports	Exports
1986	17	6,333	678	3,109
1987	17	6,850	921	3,821
1988	14	9,676	1,453	5,358
1989	17	12,825	826	7,363
1990	[b]19	[b]13,837	1,398	7,544
1991	23	14,939	2,059	8,905
1992	21	15,583	1,602	9,823
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

[a]Does not include shipments of modules and cells for space/satellite applications.
[b]Includes imputed data for one nonrespondent which exited the industry during 1990.
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."

Figure 12. Import and Export Shipments of Photovoltaic Modules and Cells, 1988-1996



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."

Module and Cell Types

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

Crystalline silicon modules and cells continued to dominate the PV industry in 1996, accounting for 96 percent of total shipments (Table 27). In particular, single-crystal silicon shipments totaled 21.7 peak megawatts, an increase of 10 percent compared with corresponding 1995 shipments (Figure 13). Together, cast and ribbon silicon shipments totaled 12.3 peak megawatts in 1996, a 24-percent increase from the corresponding 1995 shipments. From 1995 to 1996, thin-film shipments increased 14 percent (Table 27). Thin-film shipments represented 4 percent of total shipments in 1996.

Values and Prices

The total value of photovoltaic module and cell shipments was $131.1 million in 1996, an 11-percent increase over the 1995 value of $118.4 million (Table 28). The total value includes charges for advertising and warranties, but does not include excise taxes and the cost of freight or transportation for the shipments.

The total value of crystalline silicone (single-crystal, cast, and ribbon) shipments was $121.7 million in 1996, an 11-percent increase compared with the corresponding 1995 value. The average price of crystalline silicon modules in 1996 was $3.95 per peak watt, a decrease of 10 percent from the 1995 price of $4.39 (Figure 14).

Uses

The largest end-use application of PV modules and cells in 1996 was for electricity generation (combined

Table 26. Distribution of Photovoltaic Modules and Cells, 1994-1996

Recipient	Shipments (Peak Kilowatts)		
	1994	1995	1996
Wholesale Distributors	13,248	16,413	21,424
Retail Distributors	1,230	1,181	1,457
Exporters	17	321	367
Installers	2,443	4,098	4,860
End Users	1,892	458	1,048
Module Manufacturers	6,174	5,794	5,528
Other[a]	1,073	2,793	781
Total	**26,077**	**31,059**	**35,464**

[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 27. Photovoltaic Cell and Module Shipments by Type, 1994-1996

Type	Shipments (Peak Kilowatts)			Percent of Total		
	1994	1995	1996	1994	1995	1996
Crystalline Silicon						
Single-Crystal	16,520	19,857	21,742	63	64	61
Cast and Ribbon	8,264	9,883	12,255	32	32	35
Subtotal	24,785	29,740	33,996	95	96	96
Thin-Film Silicon	1,061	1,266	1,445	4	4	4
Concentrator Silicon	231	53	23	1	0	0
Other[a]	0	0	0	0	0	0
Total	**26,077**	**31,059**	**35,464**	**100**	**100**	**100**

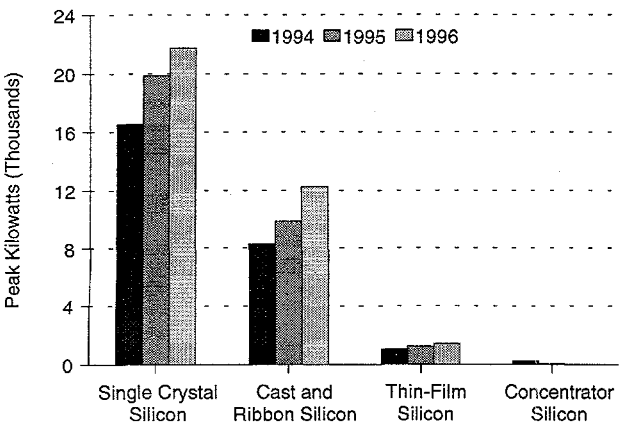
[a]Includes categories not identified by reporting companies.
Notes: Data do not include shipments of modules and cells for space/satellite applications. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

grid-interactive and remote). This represented 44 percent of total shipments (Table 29). Of the 15.7 peak megawatts represented by this end use, 99 percent involved crystalline silicon modules and cells. Grid interactive and remote, i.e., stand-alone, power generation include applications for grid distribution and general remote uses, such as residential power and power for mobile homes. The second largest PV end use in 1996 was in the communication sector, which accounted for 6.0 peak megawatts. An example of use in the commercial sector is the utilization of PV units to power fixed-based communications equipment, such as mountain-top signal-repeater stations. This sector represented 17 percent of total shipments. In 1996, transportation was the third largest PV end-use application, representing 15 percent of total shipments.

End uses related to water pumping and original equipment manufacturers accounted for 3.3 peak megawatts and 2.4 peak megawatts, respectively, in 1996 and involved primarily the use of crystalline silicon cells and modules.

Sales for consumer goods accounted for 1.1 peak megawatts in 1996. PV modules and cells used for health and medical purposes, such as to power refrigerators, medical equipment, and water purifiers, totaled 1.0 peak megawatts in 1996, a 26-percent increase over the 1995 level. End uses reported as "Other" for 1996 totaled 0.8 peak megawatts.

Figure 13. Photovoltaic Module and Cell Shipments by Type, 1994-1996



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

Destinations

Domestic

The residential sector was the largest market for PV modules and cells in 1996, accounting for 24 percent of total shipments (Table 29). The second largest market sector was industrial with 23 percent. In this market, PV modules and cells are used to produce power for industrial applications, including grid and nongrid systems. In 1996, 95.9 percent were crystalline silicon and 4.1 percent were thin-film silicon modules and cells. The commercial sector represented the largest market for PV shipments in 1995, but slipped to third place in 1996 with 15 percent. These modules and cells were shipped to provide power for commercial establishments such as office buildings, retail establishments, private hospitals, and schools (publicly owned hospitals and schools are listed under the government sector).

PV modules and cells for the transportation sector, which were used to produce power on boats, in cars, in recreational vehicles, and to power transportation support systems, amounted to 4.0 megawatts. The transportation sector accounted for 11 percent of total shipments in 1996 compared with 8 percent in 1995.

Shipments to the utility sector, where modules and cells were used to produce power at utility-owned systems including central stations, decentralized systems, and experimental applications, amounted to 4.8 peak megawatts in 1996, a 27-percent increase from 1995.

Shipments of PV modules and cells used to produce power at installations of Federal, State, or local governments (excluding military) totaled 3.1 peak megawatts in 1996. This compares with 2.0 peak megawatts shipped to the government sector in 1995. The "Other" sector (Table 29) in 1996 consisted of 1.6 peak megawatts shipped to foreign governments or used for speciality purposes.

Exports

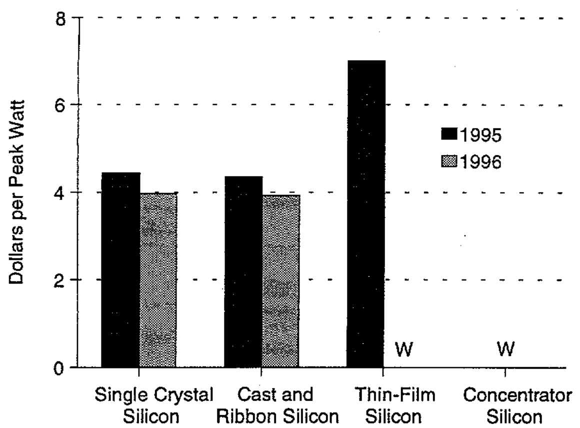
Export shipments totaled 22.4 peak megawatts in 1996 (Table 30), an increase of 13 percent from 1995 levels.

Table 28. Photovoltaic Module and Cell Shipments by Type, 1995 and 1996

Type	1995 Value (Thousand Dollars)	1995 Average Price (Dollars per Peak Watt) Modules	1995 Average Price (Dollars per Peak Watt) Cells	1996 Value (Thousand Dollars)	1996 Average Price (Dollars per Peak Watt) Modules	1996 Average Price (Dollars per Peak Watt) Cells
Crystalline Silicon						
Single-Crystal	67,002	4.44	2.48	75,043	3.97	2.81
Cast and Ribbon	42,527	4.35	3.52	46,646	3.92	2.73
Subtotal	109,529	4.39	2.54	121,689	3.95	2.80
Thin-Film Silicon	8,839	7.00	3.73	W	W	W
Concentrator Silicon	W	W	W	W	W	W
Other[a]	0	0	0	--	--	--
Total	**118,429**	**4.56**	**2.53**	**131,066**	**4.09**	**2.80**

[a]Includes categories not identified by reporting companies.
W = Data withheld to avoid disclosure of proprietary company data.
-- = Does not apply.
Notes: Data do not include shipments of modules and cells 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."

Figure 14. Average Price of Photovoltaic Modules, 1995 and 1996



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

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

Generally, export shipments since 1990 have paralleled total shipments because of the continued search for new PV markets outside the United States (Figure 12). A total of 17 companies reported exports of PV modules and cells in 1996, with exports accounting for 63 percent of total PV shipments. Of all types of modules and cells exported in 1996, 98 percent were crystalline silicon (Table 30). Destinations of PV exports by continent, region, and by country are shown in Table 31.

Systems

Of the 25 companies that reported shipments of PV systems in 1996, 12 reported shipments of 1,615 complete photovoltaic systems, an increase of 50 percent from 1995 (Table 32). A complete photovoltaic 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

Table 29. Shipments of Photovoltaic Modules and Cells by Market Sector, End Use, and Type, 1995 and 1996
(Peak Kilowatts)

Sector and End Use	Crystalline Silicon[a]	Thin-Film Silicon	Concentrator Silicon	Other	1996 Total	1995 Total
Market Sector						
Industrial	8,037	264	0	0	8,300	7,198
Residential	8,225	234	16	0	8,475	6,272
Commercial	5,079	98	0	0	5,176	8,100
Transportation	3,931	64	0	0	3,995	2,383
Utility	4,656	93	4	0	4,753	3,759
Government[b]	2,942	182	3	0	3,126	2,000
Other[c]	1,127	512	0	0	1,639	1,347
Total	**33,996**	**1,445**	**23**	**0**	**35,464**	**31,059**
End Use						
Electricity Generation						
Grid Interactive	4,721	116	7	0	4,844	4,585
Remote	10,390	478	16	0	10,884	8,233
Communications	5,950	91	0	0	6,041	5,154
Consumer Goods	944	119	0	0	1,063	1,025
Transportation	5,135	61	0	0	5,196	4,203
Water Pumping	3,257	4	0	0	3,261	2,727
Cells/Modules to OEM[d]	1,988	422	0	0	2,410	3,188
Health	977	0	0	0	977	776
Other[e]	634	154	0	0	789	1,170
Total	**33,996**	**1,445**	**23**	**0**	**35,464**	**31,059**

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

Table 30. Export Shipments of Photovoltaic Modules and Cells by Type, 1996
(Peak Kilowatts)

Item	Type			
	Crystalline Silicon	Thin-Film Silicon	Concentrator Silicon	Total
Modules	13,690	437	2	**14,128**
Cells	8,312	8	0	**8,320**
Total	**22,002**	**445**	**2**	**22,448**

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

application, wires and other electrical connectors, and sometimes batteries for back-up power supply. Some complex, large-scale PV systems use concentrators to focus incident insolation onto small PV cells and tracking systems to track the sun. In this report, installation materials such as the support frame and concrete foundations are not considered as part of a system. The value of systems reported in Table 32 excludes excise taxes and charges for freight, transportation, and installation. The total value of complete systems shipped in 1996 was $3.5 million. Complete-system shipments in 1996 accounted for 0.6 peak kilowatts, or 6.6 percent of total module shipments.

Industry Status

Shipments totaling 35.5 peak megawatts were reported by 25 companies in 1996. Eleven companies expect to introduce new crystalline-silicon module products, and seven companies reported plans to introduce new thin-film products to the industry during 1997 (Table 33). One company reported plans to produce new PV concentrator products and three plan new nonmodule system components during 1997.

Employment in PV-related activities totaled 1,280 person-years in 1996 (Table 34), a decrease of 19 percent from the 1995 level of employment. The average employment per company was 51 person-years in 1996, compared with 66 person-years in 1995.

Many companies, engaged in the manufacture and/or importation of PV modules and cells, reported that they also are involved in other PV-related activities. There were 11 companies involved in cell manufacturing, three less than in 1995. There were 19 companies involved in module or system design, 15 were active in developing module prototypes, and 14 developed PV system prototypes (Table 35). There were 19 companies that sold wholesale and 10 companies sold at retail. Nine companies, one more than in 1995, installed PV cells or modules.

Table 31. Destination of U.S. Photovoltaic Module and Cell Export Shipments by Country, 1996

Destination	Peak Kilowatts	Percent of U.S. Exports
Africa		
Algeria	467.2	2.1
Angola	0.4	*
Burkina Faso	0.1	*
Egypt	145.4	0.6
Morocco	471.2	2.1
Nigeria	1.3	*
South Africa	541.2	2.4
Uganda	174.5	0.8
Zimbabwe	231.0	1.0
Total	**2032.2**	**9.1**
Asia and the Middle East		
Bangladesh	0.1	*
Hong Kong	700.8	3.1
India	754.9	3.4
Israel	1.3	*
Japan	2,889.0	12.9
Philippines	78.0	*
Singapore	1,167.9	5.2
Total	**5,514.8**	**24.6**
Australia	**387.0**	**1.8**
Europe		
Belgium	1.6	*
England	51.1	0.2
Finland	7.4	*
France	331.0	1.5
Germany	8,150.3	36.3
Italy	23.0	0.1
Netherlands	5.7	*
Norway	312.2	1.4
Spain	480.9	2.1
Sweden	763.3	3.4
Switzerland	176.9	0.8
Total	**10,303.4**	**45.8**
North America		
Canada	793.4	3.3
Dominican Republic	5.1	*
Mexico	779.5	3.5
Total	**1,578.0**	**7.1**
South America		
Argentina	473.8	2.1
Brazil	268.8	1.2
Chile	350.4	1.6
Columbia	252.0	1.1
Ecuador	84.0	0.4
Nicaragua	0.1	*
Panama	42.0	0.2
Peru	584.0	2.6
Venezuela	1.1	*
Other Latin America	176.0	0.6
Total	**2,182.2**	**9.8**
Other	**450.7**	**2.0**
Total U.S. Exports	**22,448.3**	**100.0**

* = Less than 0.05 percent.

Note: "Other" represents shipments to countries not disaggregated by companies on Form EIA-63B. 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 32. Shipments of Complete Photovoltaic Module Systems, 1994-1996

Shipment Information	1994	1995	1996
Complete Photovoltaic Module Systems Shipped	2,350	1,077	1,615
Peak Kilowatts	1,015	937	647
Percent of Total Shipments	12	6	7
Value of Systems (thousand dollars)	R10,096	6,414	3,489

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

Table 33. Companies Expecting To Introduce New Photovoltaic Products in 1997

New Product Type	Number of Companies
Crystalline Silicon	
Single-Crystal Silicon Modules	6
Cast Silicon Modules	3
Ribbon Silicon Modules	2
Thin Film	
Amorphous Silicon Modules	3
Other (Thin-Film)	4
Other (Flat Plate)	0
Concentrators	1
Nonmodule System Components	3

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

Table 34. Employment in the Photovoltaic Manufacturing Industry, 1991-1996

Year	Number of Companies	Number of Person-Years
1991	23	1,588
1992	21	1,463
1993	19	1,431
1994	22	1,312
1995	24	1,578
1996	25	1,280

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

Table 35. Number of Companies Involved in Photovoltaic-Related Activities, 1995 and 1996

Type of Activity	Number of Companies	
	1995	1996
Cell Manufacturing	14	11
Module or System Design	19	19
Prototype Module Development	17	15
Prototype Systems Development	14	14
Wholesale Distribution	14	19
Retail Distribution	6	10
Installation	8	9
Noncollector System Component Manufacturing	5	6

Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell 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 which the 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*, DOE/EIA-0249(94), December 1994.

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: Photovoltaic module/cell manufacturers and/or importers; solar thermal collector 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: Triennially.
Respondent Categories: Electric utilities; natural gas distributors (including importers/exporters); petroleum and petroleum product distributors; institutions (non-profit); 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, and 1993. Form EIA-457H is used to collect detailed lighting usage information for a subsample.

EIA-819M, Monthly Oxygenate Telephone Report

Previous Forms: EIA819, Monthly Oxygenate Telephone Survey
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
Resulting Publications: *Petroleum Supply Monthly*, DOE/EIA-0109; *Weekly Petroleum Status Report*, DOE/EIA-0208
Collection Manager: Jackie Bachani
Telephone: (202)586-8392
Description: Form EIA-819M is designed to obtain information on oxygenate production, imports, and end-of-month stocks. 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: Triennially.
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 in Standard Industrial Classification categories 20 through 39.

EIA-860, "Annual Electric Generator Report"

Energy Sources: Electricity.
Energy Functions: Financial and/or management; production.
Frequency of Collection: Annually.
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-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 the 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.
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 one 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: Triennially.
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.

Appendix B

Renewable Data Limitations

This appendix provides information about the quality of renewable energy consumption data presented in Section 1 of this report. Information pertinent to renewable energy source data quality, in general, is presented, followed by fuel-specific information.

Obtaining complete information on renewable energy projects poses special challenges due to their nature. 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 "standalone" 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.[22] 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 for fuel uses not reportable for regulatory purposes. Thus, obtaining accurate data on wood energy consumption would entail conducting large 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 considered to be in the energy supply chain.

Electricity[23]

As noted in Chapter 1, 66 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-867, "Annual Nonutility Power Producer Report." Form EIA-759 is sent to all utilities, while the EIA-867 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]). Therefore, off-grid electric applications are not captured here (although they may be covered in EIA's Manufacturing Energy Consumption Survey[24]).

Because electric utilities are easily identified, seldom change business status, and have mandatory regulatory reporting requirements, complete coverage of utility-generated electricity is virtually assured. 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. Accordingly, EIA has developed a threshold below which nonutility units are not surveyed. Form EIA-867 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. In 1992, the reporting threshold for Form EIA-867 was lowered to include all facilities with a combined

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

[23] 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).

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

nameplate capacity of 1 megawatt or more. Previously, data were collected every 3 years from facilities with a nameplate capacity between 1 and 5 megawatts. This has the effect of making the data prior to 1993 slightly less accurate.

Form EIA-867 coverage is particularly weak for facilities producing electricity from municipal solid waste (MSW). Accordingly, EIA uses information provided by Governmental Advisory Associates (GAA) reports, namely, the "Resource Recovery Yearbook" and "Methane Recovery Yearbook," to develop its waste-generated electricity estimates.

An analysis of the Form EIA-867 universe indicates that the survey's capacity undercoverage 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 four 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.
- 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 followup 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.

Industrial (Nonutility) Generation

Industrial (nonutility) generation for 1996 is not based upon complete survey data from the form EIA-867. Instead, it is based upon partial survey data and estimates and should be considered preliminary. Final industrial generation data is not available until around October of each year.

For 1995, the preliminary and final nonutility renewable generation data can be compared in Table B2.

Thus, the preliminary estimate of total renewable nonutility electricity generation (excluding hydroelectric) was 5.4 percent above the final estimate. This had the impact of reversing the direction of change from positive to negative between 1994 and 1995 for biomass, geothermal and wind generation and reduced the strong solar generation increase to virtually no change. It is noteworthy that the preliminary estimation procedure does not use methods which would tend to bias the estimates upward.

EIA has attempted to compare GAA data on MSW with information used by the U.S. Environmental Protection Agency (EPA). However, definitional differences make data quality evaluation difficult.

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

Fuel	Source	Number of Facilities[a]	Capacity
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

Source: Energy Information Administration, Form EIA-867, "Annual Nonutility Power Producer Report."

[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.

Table B2. Preliminary and Final Nonutility Renewable Generation Data Comparison
(Billion Kilowatthours)

Source	1995 Preliminary	1995 Final
Biomass	58,811	56,975
Geothermal	11,309	9,912
Hydroelectric	14,825	14,774
Wind	3,906	3,185
Solar	897	824

Sources: **1995 Preliminary:** Energy Information Administration, *Annual Energy Review 1995*, DOE/EIA-0384(95) (Washington, DC, July 1996); **1995 Final:** Table 4 of this report.

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. RECS is based on an area probability sample of households selected by EIA. For renewable energy, it provides estimates of residential wood energy consumption.

There are two other non-electric applications for renewable energy: solar heating and alcohol transportation fuels. 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," 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 solar/PV panels installed. Alcohol fuel consumption information is provided by the Form EIA-819M, "Monthly Oxygenate Telephone Report."

Biomass

Wood is the principal component of biomass energy. Information on non-electric wood energy consumption is derived from the MECS and RECS 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 causes residential wood energy consumption to be understated by about 5 percent.

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 groundwater heat pumps. A study prepared for the DOE Office of Energy Efficiency and Renewable Energy, Geothermal Division, indicates that direct uses of geothermal energy, expressed in electric equivalents, amounted to nearly 4.2 gigawatthours in 1993 (Table B3). Fifty-seven percent of this energy was provided by geothermal heat pumps.

Wind, Solar and Photovoltaic

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: (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).

Table B3. Geothermal Energy Supplied for Major Direct Use Applications, 1993

Application	Number of Projects	States[a]	Temperature Range (C)	Capacity (MW)	Annual Energy (GWh/yr)
Space & District Heating[b]	123	6	26 to 166	169	386
Geothermal Heat Pumps	[c]168,000	50	6 to 39	1,733	2,403
Greenhouses	38	8	37 to 110	81	197
Aquaculture	27	9	16 to 93	104	574
Resorts & Spas	190	14	24 to 93	71	446
Industrial	12	6	86 to 154	43	176
Total				**2,242**	**4,181**

Source: P.J. Lienau, J.W. Lund, K. Rafferty, and G. Culver, *Reference Book on Geothermal Direct Use*, (August 1994), p. 4.
[a]Number of States where projects are located.
[b]Differs from 1990 inventory (Lund, 1990) because Mammoth Lakes and Bridgeport geothermal district heating systems were not built; therefore, they are not included in the inventory.
[c]Number of equivalent 3-ton geothermal heat pump units.

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 1995 was $118 million. Based on anecdotal information, shipments ranging from about $85 million to $100 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 respondents is a census of those U.S.-based companies involved in manufacturing and/or importing solar collectors and photovoltaic modules and cells. 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 module and cell 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 1991 through 1994, EIA received reports from all known potential respondents. During the 1990 Form EIA-63B survey period, however, one photovoltaic manufacturer that was known to have shipped photovoltaic modules and cells during the first half of the year went out of business during the second half, and no data were acquired. For that company, 1990 shipments were estimated at one-half of the shipments reported for 1989.

During 1986, the solar thermal collector manufacturing industry experienced a substantial slowdown in shipments as a result of lower conventional energy prices and the expiration of the solar tax credit at the end of 1985. Reported shipments declined from 16.4 million square feet in 1984 to 4.9 million square feet in 1986. Many of the 1986 shipments probably occurred during the first quarter, as customers took delivery of materials purchased in late 1985, when solar tax credits were still available. Although reported shipments in 1985 were only 68 percent of those reported in 1984, it is likely that actual shipments were higher in 1985, which was believed to be a banner year because of the impending expiration of the energy tax credit. The number of companies reporting 1985 shipments and, therefore, the reported shipments may have been low because many of the companies had gone out of business by the time the survey was conducted (in early 1987) and could not be located.

Appendix C

Inventory of Known Direct-Use Geothermal Facilities

Background

Geothermal energy[25] (see Table C1) may be used directly, as well as to produce electricity. Geothermal energy systems offer clean, reliable, cost-effective energy for "direct use" applications in industries, businesses, and agriculture. These systems generally provide heat, though occasionally the heat energy is used to augment energy input for cooling.

Direct use applications take water from the ground, extract some of the heat, and re-inject the fluids into the rock formations. Thus, environmental emission regulations are easily achieved. However, this scarce energy esource is tapped lightly by our economy, mostly due to heir remote locations in sparsely populated regions, high capital investment costs, and payback periods in excess of eight years.

Virtually all geothermal resources have temperatures suitable for one or another direct-heating application (see Table C1). The technology for direct use is simple--conventional hot-water and steam-handling equipment. For example, several communities use geothermal energy in district heating systems, circulating hot water through pipes to homes or public buildings. In these systems, the geothermal production field (consisting of wells, pumps, and collection lines) replaces the central boiler facility. A

Table C1. Temperatures of Geothermal Fluids Required for Various Uses
(Degrees Centigrade)

Temperature	State	Uses
180	Saturated Steam	Conventional power production; evaporation of highly concentrated solutions; refrigeration by
170	|	Conventional power production; heavy water via hydrogen sulfide process; drying of diatomaceous earth
160	|	Conventional power production; drying of fish meal; drying of timber
150	|	Conventional power production; alumina via Bayer's process
140	|	Conventional power production; drying of farm products at high rates; canning of food
130	|	Conventional power production; evaporation in sugar refining; extraction of salts by evaporation and crystallization
120	|	Fresh water by distillation; most multiple-effect evaporations; concentration of saline solutions
110	|	Drying and curing of light aggregate cement slabs
100	|	Drying of organic materials (seaweeds, grass, vegetables, etc.)
90	Water	Drying of stock fish; intense de-icing operations
80	|	Space heating; greenhouse space heating
70	|	Refrigeration (lower temperature limit)
60	|	Animal husbandry; greenhouse combined space and hotbed heating
50	|	Mushroom growing; balneological baths
40	|	Soil warming
30	|	Swimming pools; biodegradation; fermentations; warm water for year-round mining in cold climates; de-icing
20	|	Hatching of fish; fish farming

Source: J.S. Rinehart, *Geysers and Geothermal Energy* (New York, NY: Springer-Verlag, 1980), p. 176.

[25] Another form of geothermal energy is found in the earth's thermal capacity, the ability of shallow ground at ambient temperature to serve as a reservoir of heat. Unlike other forms of geothermal energy, thermal capacity is found throughout the United States and the world. This thermal reservoir can be tapped efficiently with geothermal heat pumps, also known as ground-source heat pumps, both for space heating and cooling.

mechanical system—piping, heat exchanger, heating controls—delivers the heat to the building's space or commercial process. A disposal sisytem, such as an injection well, receives the cooled geothermal fluid. Today, over 21 geothermal district heating systems are operating in the United States. Geothermal energy also provides direct heat for commercial processes in greenhouses, fish hatcheries, food-processing plants, and a variety of other applications.

A 1994 survey[26] found that these applications were using nearly 5.7 billion megajoules of geothermal energy—the energy equivalent of nearly 1 million barrels of oil.

Direct-Use Geothermal Resources

A study of possible sites for geothermal direct use identified 271 viable candidates—cities and communities with a population of 7.4 million in the 10 western states (Table C2) that could potentially utilize geothermal energy for district heating and other applications. While over 1,900 thermal wells were identified as having temperatures greater than or equal to 50 C, only 1,496 are co-located with communities. Data[27] was compiled, reflecting the city or community, including: location, population; geothermal resource temperature, flow rate, depth, and water chemistry; current utilization, weather data, and general information about the site.

Direct-Use Applications

The U.S. contains over 600 direct-use geothermal facilities. These applications tend to fall into several distinct categories: produce drying, space heating and cooling, industrial processing and aquaculture. Geothermal resources displace energy that would otherwise come from fossil fuels, saving domestic and foreign fuels from being consumed. This displacement reduced emissions of combustion products, also known as greenhouse gases.

Produce drying requires considerable quantities of energy in a steady flow of constant-humidity, constant-temperature air. Onion drying is a good example, because under-dried onions will rot before reaching the ultimate consumer, and over-dried onions do not sell well. Geothermal energy is being used for onion drying at an Idaho facility.

Table C2. States with Co-Located Cities and Direct-Use Geothermal Resources

State	Number of Communities
Arizona	14
California	70
Colorado	15
Idaho	51
Montana	18
Nevada	30
New Mexico	12
Oregon	32
Utah	23
Washington	6

Note: A co-located community is defined as being within 8 kilometers of a geothermal resource with a temperature of at least 50 degrees Centigrade.

Source: John Lund, Oregon Institute of Technology, Geo-Heat Center, 1997.

[26] Oregon Institute of Technology, Geo-heat Center, 1997.

[27] http://www.oit.osshe.edu/~geoheat/colres.htm, November 7, 1996, Oregon Institute of Technology.

Appendix D

List of Internet Addresses: Renewable Energy Information by Resource

Biomass: Wood

Supply of Short Rotation Woody Crop Biomass to the Watts Bar Power Facility This is a brief description of studies that exemplify the methods and approaches that have been developed...
http://www.esd.ornl.gov/iab/iab5-7.htm

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

Chemical Nature of Biomass from Semi-Arid Forest Tree Species S5.01-02 Natural Variations in Wood Quality / P5.01-00 Properties and Utilization of Tropical Woods Theme: ...
http://www.metla.fi/conf/iufro95abs/d5pap22.htm

PCSD Agriculture: Biomass PCSD BRIEFING BOOK Sustainable Agriculture BIOMASS ENERGY INITIATIVES PROJECT HISTORY
http://bertha.chattanooga.net/sustain/pcsd_briefing_book/agriculture_biomass.html
http://www.gsf.de/UFIS/ufis/schlag_groessen/schlagwort419.html

Biomass: Biofuels

Biofuels Information Network
http://www.eren.ornl.gov/biopower/

The Complete Biofuels Internet List
http://www.biomass.org/sites.html

Biofuels Feedstock Development Program. To contact the BFDP management team...
http://www.esd.ornl.gov/BFDP/BFDPMAIN.

Biofuels Resources on the Internet Associations National Biomass Industries Association Bibliographies and Databases Alternative Fuels Data Center...
http://www.ariadne-t.gr/phaethon/biomass/bresource.html

Biofuels: At the Crossroads Biofuels: At the Crossroads. Strategic Plan for the Biofuels Systems Program, United States Departmentof Energy July 1994 Table of Contents.
http://www.esd.ornl.gov/BFDP/DOEOFD/STRATPLA/toc.html

Biofuels Information Network Biofuels Information Network Welcome to the Biofuels Information Network Database Annex Search the ORNL Biofuels
http://dsimd.dsrd.ornl.gov/htmldocs/biofuels/biofuels.htp

Biofuels Program...
http://www.nrel.gov/research/industrial_tech/tmbms.html

Biofuels: A Win-Win Strategy Biofuels: A Win-Win StrategyStabilizing Global Climate Change While Achieving a Sustainable Energy Future.
http://www.esd.ornl.gov/BFDP/doeotd/biowin/toc.html

Re: Targets for biofuels [Prev][Next][Index][Thread] Re: Targets for biofuels To: bioenergy@crest.org Subject: Re: Targets for biofuels.
http://www.crest.org./renewables/index.html

Energy Information on Internet: BIOFUELS INFORMATION NETWORK ECN_logo Energie Informatie via Internet BIOFUELS INFORMATION NETWORK Title Organization: Biofuels System ...
http://blister.ecn.nl/eii/homepgnl/eii_013.html

Renewable Energy: Biomass and Biofuels Renewable Energy: Biomass and Biofuels
http://lacebark.ntu.edu.au/j_mitroy/sid101/energyfacts/re-bioms.html

Biofuels
http://www.enc.org/cd/access/msubs/scieco/m36.htm

Science Classroom
http://www/enc.org/classroom/

Atmospheric Science Curriculum Bookmarks Alternative Fuels Biofuels Information
http://krusty.eecs.umich.edu/people/jreed/weather/ravenbkms.html

1992 BFDP Annual Report BIOFUELS FEEDSTOCK DEVELOPMENT PROGRAM ANNUAL PROGRESS REPORT FOR 1992 L. L. Wright J. H. Cushman A. R. Ehrenshaft (1) S. B. McLaughlin W. A. McNabb S. A. Martin
http://www.esd.ornl.gov/BFDP/doeofd/bsd.html

Alternative Fuel Information
http://www.afdc.doe.gov

Sustainable Energy Energy Agricultural Energy Agricultural Energy Assistance Program, California ALTERNATIVE ENERGY California Energy Commission: Alternative/Renewable Technologies EPA: ...
http://www.netins.net/showcase/s_energy/energy.htm

National Renewable Energy Laboratories- Biofuels Information Center; The Biofuels Information Center, managed by the National Renewable Energy Laboratory;
http://www.biofuels.nrel.gov/

Short-Rotation Woody Crops (SRWC) Operations Working Group
http://www.esd.ornl.gov/bfdp/srwcwgrp/menu.html

Municipal Solid Waste

ENVIRONMENTAL STUDIES 17. TOXIC AND SOLID WASTE Most waste produced by preindustrial societies is biodegradable. In industrial societies, much waste is nondegradable ...
http://www.fcn.org/fcn/ecosystem/wast_po.html

Municipal Solid Waste News News From The World of MSW SWANA Logo Last update on: July 1, 1996
http://www.swana.org/mswweek.htm

Oxygen-Enriched Cocombustion of Sewage Sludge and Municipal Solid Waste
http://es.inel.gov/techinfo/facts/kocmbust.html

Emission Criteria for Municipal Solid Waste Incinerators The Environmental Protection Compendium Emission Criteria for Municipal Solid Waste Incinerators...
http://www.env.gov.bc.ca/~cpr/criteria/icmsw.html

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

Guide to the Preparation of Regional Solid Waste Management Plans by Regional Districts (Part I)
http://www.env.gov.bc.ca/epd/cpr/guidelns/gprswmp1.html

Waste-to-Energy

Energy from Waste Energy from waste Introduction The UK Government's draft waste management strategy maintains that burning waste of one type or another ...
http://www.wrfound.org.uk/

Revised Ash Strategy For Waste-to-energy Facilities
http://pan.cedar.univie.ac.at/arch/enveng-l/95apr/msg00178.html

ECN Bibliotheek: Urban waste generated energy / World Energy Council [WEC] ; team leader S.W.... Uitgegeven/ontvangen publikaties over december 1995 Pub
http://www.ecn.nl/library/aanwinst/aanw1995/a9512114.html

Waste Prevention Saves Energy Waste Prevention Saves Energy H.J.H. Whiffen, J.F.
http://hammock.ifas.ufl.edu/txt/fairs/4133

Geothermal

US DOE/Government
http://DOEGeothermal.inel.gov>U.S. DOE/Government

Domestic Geothermal Organizations
http://www.oit.osshe.edu/~geoheat/

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

Direct Uses Geothermal Energy
http://www.oit.osshe.edu/~geoheat/dusys.htm

Summary: Geothermal Heat Pump Systems user interface. About Apogee e-Mail Return to To Geothermal Home Page
http://www.apogee.net/geoshots.htm

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

Summary: IEA CADDET International Information on Geothermal Energy.
3/95 Demonstration of a 100 kW-class Geothermal Power Generation System - Japan.
http://www.caddet.co.uk/geo.htm

Energy Directory - Geothermal Energy
Summary: Heat Flow and the Structure of the GeoSphere, June 10-16, 1996. Geothermal Heat Pump Initiative in the U.S. Geothermal Resources Council (USA) Library & Information.
http://www.energy.ca.gov/earthtext/other-geothermal.html

Geothermal Workshop
Summary: The New Zealand Geothermal Workshop is a three-day conference held annually in early November. The Workshop provides an international forum where engineers and earth scientists discuss aspects of geothermal development.
http://www.auckland.ac.nz/gei/workshop.htm

Geothermal Links
Summary: GEOTHERMAL LABORATORY GEOTHERMAL LINKS.
Internation 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

IEA
Summary: Geothermal, solar, etc; indigenous production of geothermal, solar, wind, tide and wave energy and the use of these energy forms for electricity generation. The quantity of geothermal energy entering electricity generation is inferred from the electricity production at geothermal plants assuming an average thermal efficiency of 10 per cent.
http://www.iea.org/stats/defs/sources/geo.htm

Geothermal Theory: Geothermal Use Today
Summary: Geothermal power plants now provide more than 2500 megawatts of clean electricity to the U.S., equivalent to three large nuclear power plants. According to the U.S. Energy Information Administration, geothermal has the potential to provide the U.S. with 12,000 megawatts of electricity by the year 2010.
http://www.crest.org/renewables/re-kiosk/geothermal/theory/usetoday.shtml

Geothermal Theory, Geothermal Reservoirs: Fractured Rock (2)
Summary: In most high-temperature reservoirs, much of the porosity and permeability exist in natural rockfractures, although they may be artificially induced. In other reservoirs, the space between sand grains in the rock provides ample porosity and permeability.
http://www.crest.org/renewables/re-kiosk/geothermal/theory/fracturedrock2.shtml

Wind

03/27/95 Talking Points - 25th Annual Conference U. S. Wind Energy Industry Opening Session Monday, March 27, 1995 8:30 a.m. PRESS AVAILABILITY 25th ANNUAL CONFERENCE U.S.
...http://apollo.osti.gov/html/secretry/tp950327.html

American Wind Energy Association. The 1996 AWEA Directory of Industry Members. This comprehensive, up-to-date reference includes contact information as well as product ...
http://www.igc.apc.org/awea/aweapage.html

Alternative Energy Institute Homepage, Wind & Solar Energy Alternative Energy Institute Introduction to AEI:
http://www.wtamu.edu/academic/gradres/aei/

Wind Power 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://nwtc.nrel.gov/

Wind Energy Weekly: Contact: tgray@igc.apc.org (Tom Gray) and http://www.igc.apc.org/awea/aweawew.html

Solar Thermal

FREQUENTLY ASKED QUESTIONS - SOLAR POWER
http://www.greenpeace.org/~uk/solar/faq2.html

MIT Press Books
http://www-mitpress.mit.edu/books-legacy.tcl

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

Solar Thermal Case Studies A solar thermal water heating system provides St. Rose Hospital in San Antonio, TX.
http://solstice.crest.org/renewables/re-kiosk/solar/solar-thermal/case-studies/commercial.shtml

Large Scale Solar Thermal Applications PES operates and maintains Packerland Solar System, the world's largest flat plate...
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Future Solar Thermal concentrators Scientists at the University of Chicago have...
http://solstice.crest.org/renewables/re-kiosk/solar/solar-thermal/future/concentrators.shtml

Solar Thermal Case Studies This 10 megawatt solar thermal central receiver power plant.
http://solstice.crest.org/renewables/re-kiosk/solar/solar-thermal/case-studies/central-receiver.shtml

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

Solar Energy An immense amount of energy from the sun strikes the surface of the earth every day.
http://solstice.crest.org/renewables/re-kiosk/solar/index.shtml

EREN - Solar Thermal Power Systems Energy Efficiency and Renewable Ene
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The National Solar Thermal Test Facility (NSTTF) is operated by Sandia National Laboratories for the U.S. Department of Energy. It...
http://www.sandia.gov/Renewable_Energy/solarthermal/nsttf.html

National Solar Thermal Test Facility Questions Frequently Asked by NSTTF Visitors About Solar Energy How do Central Receiver power plants produce electricity from the heat of...
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Solar Radiation and Solar Thermal Systems
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Thermal Solar Water Heating in the PAC by: Steve Paradine, Tal Schaeffer, Alek Seelemann, Gerald Van Decker Course: http://www.adm.uwaterloo.ca/infowast/watgreen/projects/project_records/80.html

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National Solar Thermal Test Facility Sandia National Laboratories Advantages of Using Molten Salt A variety of fluids was tested to transport the sun's heat, including water, air, ...
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http://www.crest.org/renewables/SJ/solar-thermal/634.html

Solar Photovoltaic

Centre for Photovoltaic Devices and Systems Home Page
http://www.vast.unsw.edu.au/

Power Technology Division PHOTOVOLTAIC GENERATION PHOTOVOLTAIC BRANCH
http://powerweb.lerc.nasa.gov/pv/home.html

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

Photovoltaic(PV) Module Businesses in the World by Name the Source Renewable Energy Businesses by Product Type Solar Related
http://www.mtt.com/theSource/renewableEnergy/businesses/byP/sRP/pvM/byN/byName.html

Appendix E

State Agencies That Provide Energy Information

Table E1. List of State Agencies That Provide Energy Information

State	Office	Telephone Number
Alabama	State Energy Office	205-242-5292
Alaska	State Energy Office	907-269-4640
Alaska	Natural Resources Department 400 Willoughby Ave., 5th Floor Juneau, AK 99801	907-269-7200
Arizona	State Energy Office	602-280-1430
Arkansas	State Energy Office	501-682-1370
California	State Energy Office	916-654-5000
California	Energy Resources, Conservation, and Development Commission 1516 Ninth St. Sacramento, CA 95814	916-654-4942
California	Energy Assessments Office 717 K Street, Suite 409 Sacramento, CA 95814	916-323-8777
Colorado	State Energy Office	303-620-4292
Connecticut	State Energy Office	203-566-1559
Delaware	State Energy Office	302-739-5644
District of Columbia	State Energy Office	202-727-4700
Florida	State Energy Office	904-488-7400
Georgia	State Energy Office	404-656-5176
Hawaii	State Energy Office	808-587-3810
Idaho	State Energy Office	208-327-7910
Illinois	State Energy Office	217-785-2800
Indiana	State Energy Office	317-232-8940
Iowa	State Energy Office	515-281-8518
Kansas	State Energy Office	913-271-3170
Kentucky	State Energy Office	502-564-7192
Louisiana	State Energy Office	504-342-2133
Maine	State Energy Office	207-289-6800
Maryland	State Energy Office	410-974-3755
Massachusetts	State Energy Office	517-727-4732

Table E1. List of State Agencies That Provide Energy Information

State	Office	Telephone Number
Michigan	State Energy Office	517-334-6270
Minnesota	State Energy Office	612-296-5175
Mississippi	State Energy Office	601-359-6600
Missouri	State Energy Office	314-751-4000
Montana	State Energy Office	406-444-6697
Nebraska	State Energy Office	402-471-2867
Nevada	State Energy Office	702-687-4910
New Hampshire	State Energy Office	603-271-2711
New Jersey	State Energy Office	609-292-5383
New Mexico	State Energy Office	505-827-5900
New Mexico	Energy, Minerals, and Natural Resources 2040 South Pacheco Santa Fe, NM 87505	505-827-5950
New York	State Energy Office	518-473-4375
North Carolina	State Energy Office	919-733-2230
North Dakota	State Energy Office	701-224-2094
Ohio	State Energy Office	614-466-6797
Oklahoma	State Energy Office	405-841-9326
Oregon	State Energy Office	503-378-4131
Oregon	Energy Department 625 Marion Street, NE Salem, OR 97310	503-378-4040
Pennsylvania	State Energy Office	717-783-9981
Puerto Rico	State Energy Office	809-724-8774
Rhode Island	State Energy Office	401-277-3370
South Carolina	State Energy Office	803-734-3364
South Dakota	State Energy Office	605-773-3603
Tennessee	State Energy Office	615-741-2994
Texas	State Energy Office	512-463-1931
Texas	General Land Office Energy Resources Department 1700 North Congress Avenue Austin, TX 78701-1495	512-463-5237
Utah	State Energy Office	801-538-5428
Vermont	State Energy Office	802-828-2393
Vermont	Vermont Public Power Supply Authority Route 100, Stowe Road Post Office Box 298 Waterbury Center, VT 05677-0298	802-244-7678

Table E1. List of State Agencies That Provide Energy Information

State	Office	Telephone Number
Virgin Islands	State Energy Office	809-772-2616
Virgin Islands	Directors Office	809-772-2616
Virginia	State Energy Office	804-692-3218
Virginia	State Corporation Commission Energy Regulations Division Tyler Building 1300 East Main Street Richmond, VA 23219	804-371-9611
Washington	State Energy Office	206-956-2000
Washington	Energy Office 925 Plum Street, SE Building #4 Post Office Box 43165 Olympia, WA 98504-3165	360-356-2000
West Virginia	State Energy Office	304-759-0530
Wisconsin	State Energy Office	608-266-8234
Wyoming	State Energy Office	307-777-7284

Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.

Glossary

Alternating Current: 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:

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

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.

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: 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).

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.

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.

Nonutility Generation: Electric generation by end-users, independent power producers, or small power producers under the Public Utility Regulatory Policies Act, to supply electric power for industrial, commercial, and military operations, or sales to electric utilities.

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 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 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 Source: An energy source that is regenerative or virtually inexhaustible. Typical examples are wind, geothermal, and water power.

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.

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