DOE/EIA

Renewable Energy Annual, 2006

April 2008

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

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

Contacts

This report was prepared by the staff of the Renewable Information Team, Coal, Nuclear, and Renewables Division, Office of Coal, Nuclear, Electric and Alternate Fuels. Questions about the general preparation and content of this report may be directed to Fred Mayes, Team Leader, Renewable Information Team at e-mail fred.mayes@eia.doe.gov, (202) 586-1508 or Louise Guey-Lee at e-mail louise.guey-lee@eia.doe.gov, (202) 586-1293.

Energy Specific Contacts

Renewable Energy General	Fred Mayes	202/586-1508 Fred.mayes@eia.doe.gov
	Louise Guey-Lee	202-586-1293 Louise.guey-lee@eia.doe.gov
Biodiesel	Marie LaRiviere	202/586-1475 Marie.lariviere@eia.doe.gov
Biomass Energy	Fred Mayes	202/586-1508 Fred.mayes@eia.doe.gov
Geothermal Energy	Mark Gielecki	202/586-1264 Mark.gielecki@eia.doe.gov
Geothermal Heat Pumps	Fred Mayes	202/586-1508 Fred.mayes@eia.doe.gov
	Susan Henry	202/586/1427 Susan.henry@eia.doe.gov
Hydroelectric Power	Mark Gielecki	202/586-1264 Mark.gielecki@eia.doe.gov
Solar Thermal and Photovoltaic	Peter Wong	202/586-7574 Peter.wong@eia.doe.gov
Wave and Tidal Energy	Mark Gielecki	202/586-1264 Mark.gielecki@eia.doe.gov
Wind Energy	Louise Guey-Lee	202-586-1293 Louise.guey-lee@eia.doe.gov

Preface

The *Renewable Energy Annual (REA) 2006* is the twelfth in a series of annual publications on renewable energy by the Energy Information Administration (EIA). The 2006 edition presents four chapters, accompanied with data tables, text and graphics covering various aspects of the renewable energy marketplace:

- Renewable Energy Trends in Consumption and Electricity
- Solar Thermal and Photovoltaic Collector Manufacturing Activities
- Survey of Geothermal Heat Pump Shipments
- Green Pricing and Net Metering Programs

These chapters correspond to chapters published in previous releases of the Renewable Energy Annual.

The renewable energy sources included are biomass (wood, wood waste, municipal solid waste, landfill gas, ethanol, biodiesel and other biomass); geothermal; wind; solar (solar thermal and photovoltaic); and conventional hydropower.

Hydroelectric pumped storage facilities are excluded, because they usually use non-renewable energy sources for their operation. Since the EIA collects data only on terrestrial (land-based) solar energy systems, satellite and some military applications are also excluded.

Definitions for terms used in this report can be found in EIA's Energy Glossary: http://www.eia.doe.gov/glossary/index.html. General information about all the EIA surveys with data related to renewable energy and referenced in this report can be found here: http://www.eia.doe.gov/oss/forms.html.

Table of Contents

Page

Tables

Renewable Energy Trends in Consumption and Electricity, 2006

Solar Thermal and Photovoltaic Collector Manufacturing Activities, 2006

Survey of Geothermal Heat Pump Shipments, 2006

Green Pricing and Net Metering Programs, 2006

Figures

Renewable Energy Trends in Consumption and Electricity, 2006

Solar Thermal and Photovoltaic Collector Manufacturing Activities 2006

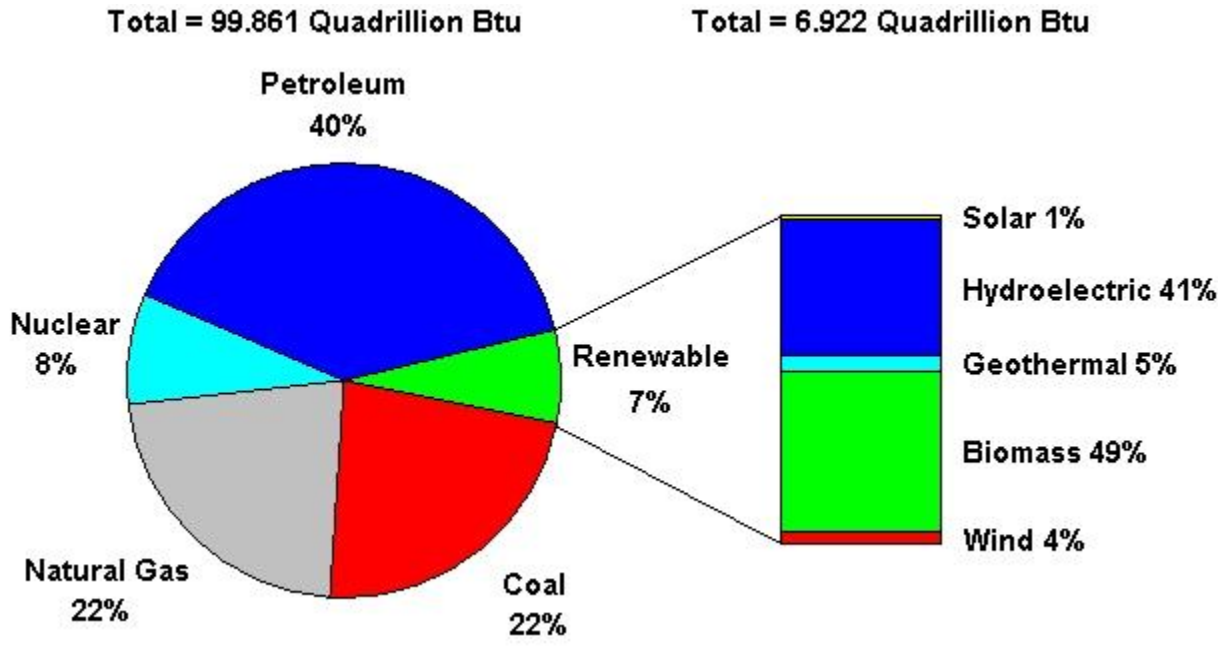
1. Renewable Energy Trends in Consumption and Electricity

Highlights 2006

Consumption

Total renewable energy consumption increased by 478 trillion Btu or 7 percent between 2005 and 2006 to 6,922 trillion Btu (Table 1.1). At the same time total US energy consumption decreased 1 percent largely due to decreases across the board in fossil fuel energy consumption. The combination of these trends resulted in moving renewable energy's share of total US energy to nearly 7 percent, up from over 6 percent in 2005 (Figure 1.1).

Figure 1.1 The Role of Renewable Energy Consumption in the Nation's Energy Supply, 2006



Source: Table 1.1 of this report.

During 2006 renewable energy consumption reached its highest level since 1997, which was a record year for hydropower due to water availability (Table 1.5a and Table 1.5b). Hydropower is the second largest source of renewable energy consumption.

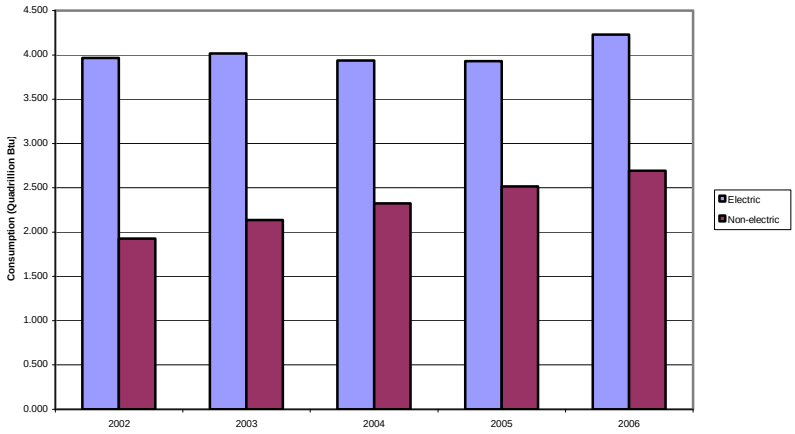
Biomass and conventional hydroelectric power had the largest volumetric increases at 220 and 166 trillion Btu respectively, while wind energy consumption had the fastest annual rate of growth at almost 50 percent.

The electric power sector continued to be the largest consumer of renewable energy in 2006 (55 percent of total), primarily due to the very large contribution of conventional hydroelectric power (Table 1.2). The industrial sector was second (29 percent of the total), due to that sector's major consumption of wood and derived fuels. Geothermal and conventional hydropower played only minor roles in the industrial sector. The residential sector also consumed wood for space heating and solar energy for water heating and electricity. The commercial sector accounted for just 2 percent of total renewable energy consumption. The transportation sector was the fastest growing sector, consuming 40 percent more renewable fuel between 2005 and 2006. This is mainly due to increased ethanol consumption, by far the larger component of biofuels during those years.

Renewable energy used to produce electricity contributed 4.229 quadrillion Btu or 61 percent of total renewable energy consumption in 2006 (Table 1.2 and Table 1.3). Ninety percent of this energy was consumed in the electric power sector, which includes traditional electric utilities and independent power producers whose primary purpose is to sell electricity, or electricity and heat, to the public. Almost all of the remainder is used by the industrial sector. Nonhydro renewable electricity energy consumption expanded slowly from 1,278 to 1,360 trillion Btu between 2002 and 2006. Increases in wind consumption were partially offset by decreases in biomass.

Nonelectric uses of renewable energy made up the balance (2,693 trillion Btu or 39 percent) of renewable energy consumption (Table 1.2 and Table 1.4). Nonelectric uses include applications such as wood for space heating, noncentral station solar, process heat from biomass for manufacturers, geothermal heat pumps and direct use of geothermal, biofuels for transportation and losses and coproducts from the production of biofuels. Over the last five years the share of renewable energy consumed for nonelectric use expanded from 33 to 39 percent (Figure 1.2).

Figure 1.2 Renewable Energy Consumption, 2002-2006



Source: Table 1.3 and Table 1.4 of this report.

A major portion (over 65 percent) of the 745 trillion Btu increase in nonelectric biomass energy consumption from 2002 to 2006 was in biofuels. Table 1.6 (included for the first time in this report) presents an overview of biofuels, showing that a considerable amount of biomass energy is lost or goes to coproducts during production of ethanol. Ethanol production increased about 25 percent from 3.9 billion gallons in 2005 to 4.9 billion gallons in 2006.[1] A number of factors contributed to this growth:

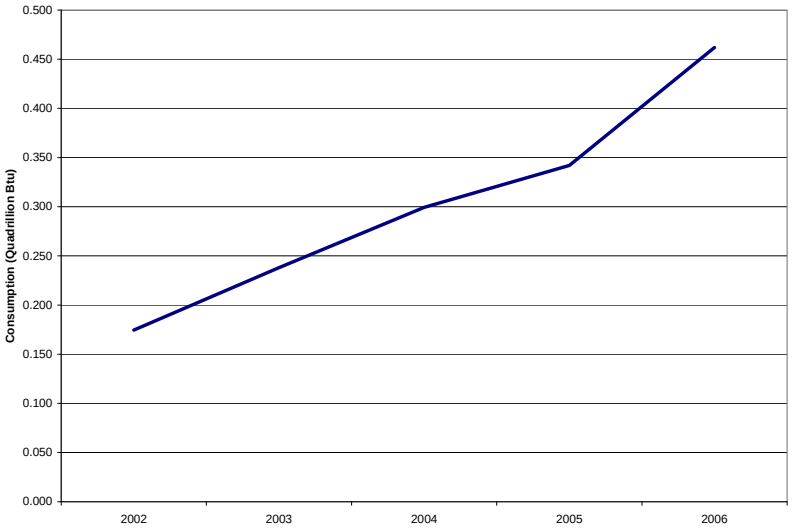
- Continued replacement of methyl tertiary butyl ether (MTBE) by ethanol as a gasoline additive.
- Strong world oil demand and higher crude oil prices, which have raised the price of gasoline and thus the demand for, and price of, ethanol as a substitute.
- Tax laws that provide incentives, such as the 51 cent per gallon Federal tax credit available to blenders for each gallon of ethanol blended into gasoline.
- The Energy Policy Act of 2005, which mandated annual renewable fuel use in gasoline at 5.4 billion gallons by 2008.

At 2006 production levels, ethanol accounted for nearly 4 percent of U.S. finished motor gasoline production.[2]

Ethanol consumption, when compared to production, increased at an even faster rate, 35 percent.[3] The difference between production and consumption was largely made up of increased imports (principally from Brazil) and stock withdrawals. So total consumption for 2006 was 462 trillion Btu, up from just 175 trillion Btu in 2002 (Figure 1.3).

[1] Energy Information Administration, Form EIA-819, "Monthly Oxygenate Report."
[2] Energy Information Administration, *Petroleum Supply Monthly*, February 2007 (Washington, DC, February 2007) Table 2.
[3] Ethanol consumption is calculated as the sum of production, net imports, and stock changes.

Figure 1.3 Ethanol Consumption, 2002-2006



Source: Table 1.2 of this report.

Biodiesel production also was in a period of growth and more than doubled between 2005 and 2006. A later section of this report on renewable issues presents general information to familiarize readers with the biodiesel industry.

In December 2007 the Energy Independence and Security Act (EISA) of 2007 was signed into law.[4] This boosted the renewable fuel standard to 9 billion gallons of renewable fuels by 2008 and 36 billion gallons in 2022. Assuming the targets are achieved, biofuels consumption (ethanol and biodiesel) will increase substantially from current levels.

Waste energy consumption stood at 407 trillion Btu in 2006 and was little changed from the previous few years. More than half of the waste energy was consumed by independent power producers (Table 1.7). MSW biogenic provided the most energy (42 percent) followed by landfill gas (37 percent).

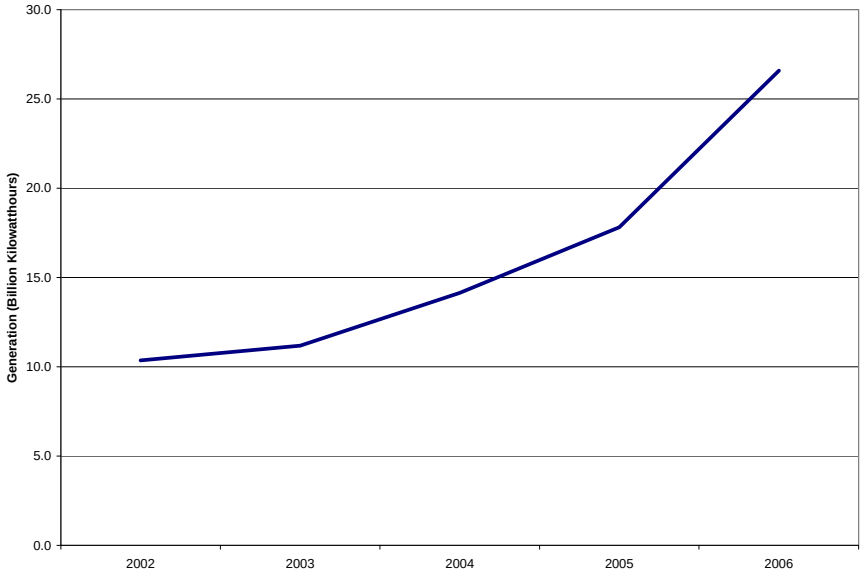
Industrial biomass energy consumption increased about 6 percent between 2005 and 2006 (Table 1.2). The paper and allied products industries dominated biomass consumption in the industrial sector with 64 percent of the total (Table 1.8). Most of this was useful thermal output and a much smaller share was used to produce electricity. Biorefineries, which produce biodiesel and ethanol, and the lumber industry had the next largest shares with 15 and 13 percent of the total, respectively. In addition, fifty-two power plants in 23 states with total generating capacity of 6,317 megawatts reported having generators with biomass/coal cofiring capacity that totaled 3,569 megawatts (Table 1.9).

[4] See EISA 2007 Title II here: http://thomas.loc.gov/cgi-bin/bdquery/z?d110:h6:

Electricity

Renewable energy provided almost 386 billion kilowatt hours of electricity generated in 2006 of a U.S. total of 4,065 billion kilowatthours. [5] While total U.S. electricity generation increased by 0.2 percent in 2006, conventional hydroelectric generation grew 7 percent and wind generation increased by nearly 50 percent, though from a much smaller base (Table 1.11 and Figure 1.4).

Figure 1.4 Wind Electricity Net Generation, 2002-2006



Source: Table 1.11 of this report.

Most of the electricity produced using renewable energy during 2006 was in the electric power sector, which accounted for 91 percent of the market; the industrial sector accounted for just 8 percent. In the same year, results were mixed for nonrenewable electricity. Nuclear- and coal-fired electricity generation stayed fairly steady, while electricity from petroleum plunged and natural gas rose 7 percent.

As a result of expanded government-sponsored renewable energy programs, total renewable electric capacity stood at 101,934 megawatts by the end of 2006, up from 98,746 megawatts in 2005 (Table 1.12). With an increase of 2,622 megawatts between 2005 and 2006 wind energy accounted for the largest increase in renewable capacity and the second largest increase in capacity nationwide.[6] Natural gas capacity was first nationwide with an increase of over 5,000 megawatts. A later section of this report discusses wind electricity developments in detail.

[5] Energy Information Administration, *Monthly Energy Review December 2007* (Washington, DC, December 2007), Table 7.2a

[6] Energy Information Administration, *Electric Power Annual 2006* (Washington, DC, October 2007), Table 2.1.

Table 1.13 shows that conventional hydroelectric generation was concentrated in the Pacific Contiguous Census Division where it accounts for a major portion of electricity supplied to that market (Figure 1.6). Electricity from geothermal and solar/ photovoltaic (PV) energy was found mainly in the Pacific Contiguous and Mountain Divisions, while electricity from the remaining renewable energy sources tended to be scattered geographically. Nearly 98 percent of industrial biomass generation was provided by wood and wood derived fuels (principally, black liquor, wood/wood waste liquids and solids) mainly in the southern Census Divisions of the U.S. (Table 1.14).

State Electricity

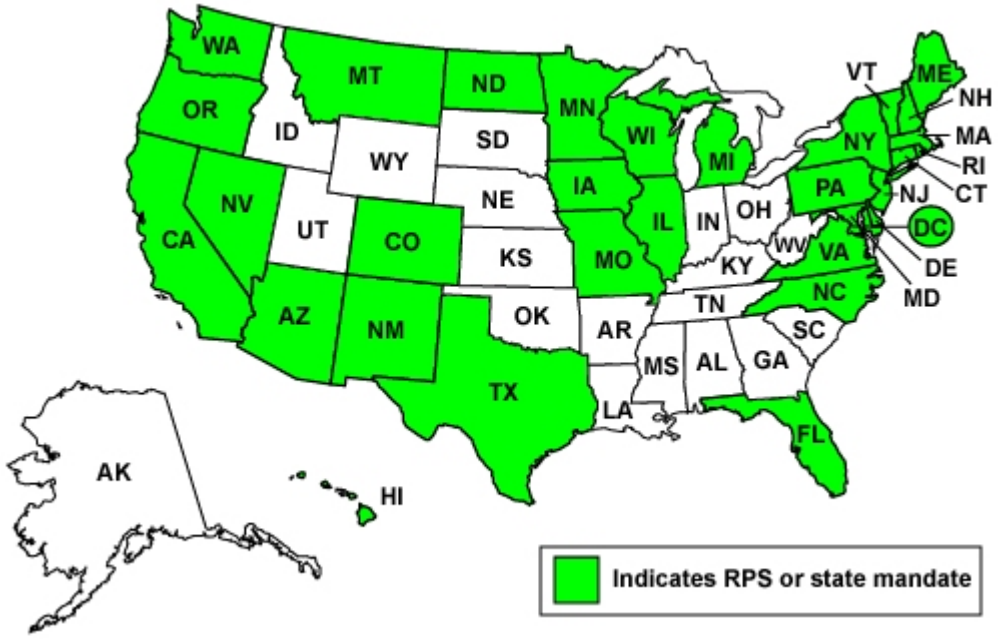
Renewable electricity generation increased by 28 billion kilowatthours between 2005 and 2006. The largest increases were for conventional hydroelectric power in Washington, California, Oregon, Idaho and New York and for wind in California, Iowa, Oklahoma, and Texas (Table 1.17 and Table 1.20).

Renewable electric capacity increased by 3,189 megawatts between 2005 and 2006. Eighty-two percent of this increase was wind capacity. Texas, Washington, and California led that growth (Table 1.23 and Table 1.26). Most of the remainder of the capacity increase was for landfill gas/MSW biogenic (111 megawatts), wood and derived fuels (179 megawatts), and conventional hydroelectric (281 megawatts).

In 2006 renewable electricity generation captured 9.5 percent of the U.S. electricity market, while nonhydro renewable electricity took just 2.4 percent (Table 1.27). Some States had little or no renewable generation, while others had shares as high as 89 percent for Idaho, 78 percent for Washington, and 75 percent for Oregon. Maine had the largest share of nonhydro renewable electricity generation at 24 percent. In terms of volume, California had the most nonhydro renewable generation with 24 billion kilowatthours due to its diverse supply of renewable energy sources, which includes the majority of the nation's geothermal and solar power.

Although there is considerable variation in objectives and standards for enforcement, many States continue to expand their efforts to incorporate more renewable energy in their electric supply. By the end of 2007 32 states had enacted renewable portfolio standards (RPS) or state renewable mandates (Table 1.28 and Figure 1.5).

Figure 1.5 Renewable Portfolio Standards and State Mandates by State, 2007



Note: In Florida, Michigan and Missouri the RPS is not statewide. In some states, including Illinois, Michigan, Missouri, North Dakota, Virginia and Vermont, the renewable portfolio standard (RPS) is voluntary. Source: North Carolina Solar Center, Database of State Incentives for Renewable Energy (DSIRE) website: http://www.dsireusa.org (January 8, 2008).

These include the following states that were new on the list in 2007:

Michigan. Early in 2007, the Lansing Board of Power and Light (LBPL) established a series of voluntary goals for meeting its customers' electricity demand with renewable energy. The goal for 2016 is 7 percent of retail sales.

Missouri. In mid-2007, Missouri created a renewable energy and energy-efficiency objective for its investor owned utilities. Each utility must make a "good-faith effort" to generate or procure electricity generated by renewable energy equal to 11 percent of its retail electric sales by 2020. Credit towards the objective also may be achieved through energy efficiency that includes utility and consumer efforts to reduce consumption of electricity.

New Hampshire. In mid-2007, New Hampshire enacted a renewable portfolio standard that requires electricity providers to acquire renewable energy certificates (RECs). equivalent to 23.8 percent of retail electricity sold to end-use customers by 2025. Class I and II eligible new renewable sources (in operation after January 1, 2006) will provide 16.3 percent of retail electricity sold, while Class III and IV eligible existing renewable sources will provide 7.5 percent.[7]

[7] For a detailed explanation of eligible energy sources, see the New Hampshire Code of Administrative Rules, Chapter Puc 2500 Electric Renewable Portfolio Standard, here: http://www.puc.state.nh.us/Regulatory/Rules/Puc2500%20Interim%20Rules%20-%20January%2010%202008.pdf

North Carolina. In mid-2007, North Carolina enacted a Renewable Energy and Energy Efficiency Portfolio Standard. Basically, this requires investor owned utilities to supply electricity equivalent to 12.5 percent of their 2020 sales using renewable energy or eligible alternatives by 2021. Up to 25 percent of the requirement can be met through energy efficiency technologies, including combined heat and power systems powered by nonrenewable energy sources. Municipal utilities and electric cooperatives must meet a target of 10 percent of their sales coming from renewables by 2018 but using slightly different rules.

North Dakota. Early in 2007, North Dakota enacted legislation establishing a goal that 10 percent of all retail electricity sold in the state is to be obtained from renewable energy and recycled energy by 2015. The goal is voluntary.

Oregon. At about the same time in 2007 that Oregon's governor signed the Western Climate Initiative, the state enacted its renewable portfolio standard.[8] In summary the standard is stepped in over the years from 2011 to 2025 and it varies by the size of the utility's load. In practice this means that the three large utilities (each with three percent or more of Oregon's total retail sales) will meet a target of 5 percent of electricity sold from renewable energy by 2011 and 25 percent by 2025, while smaller utilities will have lower targets.[9]

Virginia. As part of its legislation to reregulate the state's electricity industry, Virginia enacted a voluntary renewable energy portfolio goal. The goal for investor owned utilities is to have 12 percent of base load sales in 2007 in Virginia (less the average annual percentage of power supplied from nuclear generators between 2004 and 2006) to come from renewable energy sources by 2022.

A number of other states including Arizona, Colorado, Delaware, Maryland, Minnesota, Montana, New Mexico, and Pennsylvania expanded the provisions of their renewable portfolio standards in 2007.

---

[8] The agreement establishing the Western Climate Initiative was signed in February 2007. Targets to lower greenhouse gases to 15 percent below 2005 levels by 2020 were announced in August. Oregon enacted the renewable portfolio standard that would support that mission in June 2007.

[9] For details such as the list of eligible sources, the matrix of RPS targets, implementation plans, and possible exemptions and modifications to the targets, etc., see the Oregon Department of Energy website, here: http://www.oregon.gov/ENERGY/RENEW/docs/Oregon_RPS_Summary_Oct2007.pdf .

Data Revisions

Estimates of residential wood consumption were revised upward for 2005 and 2006 to reflect a higher number of households reported as having wood burning units in the preliminary data from the EIA Residential Energy Consumption Survey 2005. Renewable electricity data for 2006 is now final.

Also a new source of data was found for feedstocks consumed to produce inedible methyl esters (biodiesel).[10] This was used to estimate biodiesel production and apparent consumption starting in 2006 after the U.S. Department of Agriculture's Commodity Credit Corporation ended its biodiesel program.

[10] Refer to the U.S. Department of Commerce, Census Bureau series of Current Industrial Reports: *Fats and Oils – Production, Consumption, and Stocks.*

Issue in Focus: Wind Energy Developments

Introduction

Although wind power has developed rapidly in the United States since 2000, it still did not provide a substantial amount of electricity until 2006, when wind energy produced 27 billion kWh. This represents half the amount provided by biomass, but nearly 83 percent more than the amount provided by geothermal. The fact that wind provided 7 percent of renewable-based electricity during 2006 -- and 28 percent of non-hydro renewable generation--is due to the large amount of new wind capacity which has come on line since the turn of the century. In particular, total installed wind capacity increased from 4,417 MW in 2002 to 11,329 MW in 2006, with 2,600 MW of the increase coming during 2006 alone (Table 1.H1).

The top five states for wind capacity in 2006 were Texas, California, Iowa, Minnesota and Washington. In 2006, Texas overtook California, which had been the leading wind capacity state since the inception of the modern wind power industry in the 1980's. The biggest single project in 2006 was the expansion of Buffalo Mountain Energy Center (also known as the Horse Hollow Wind Energy Center) in Texas. In 2006 it was considered to be the largest wind plant in the world at 736 MW.[11]

Not only has total wind capacity expanded rapidly, but since 2002 wind projects have also been built in 9 additional states: Alaska, Idaho, Illinois, Montana, New Jersey, New Mexico, North Dakota, Ohio and Oklahoma.[12] This makes a total of 28 states with wind capacity of 1 megawatt or more. Oklahoma now has almost 600 MW of wind, and New Mexico has 500 MW.

The major factors driving this growth include the Federal Production Tax Credit (PTC) and state policies to encourage renewable energy. These topics are discussed in the materials that follow, in the context of the underlying issues of global warming, the cost of natural gas, and limits on the electricity transmission infrastructure.

Federal Production Tax Credit

The Federal production tax credit, originally enacted as part of the Energy Policy Act of 1992 (EPACT 92), was set at 1.5 cents per kilowatthour for all electricity generated in the first ten years of the life of the project. According to EPACT 92, the credit is to be adjusted for inflation, and in 2008 it was set at two cents per kilowatthour for all wind projects in operation before the current expiration date (December 31, 2008) for the first

[11] See http://www.fplenergy.com/news/contents/101906.shtml .
[12] Some states, such as Alaska, may have had some small wind plants in operation before 2006 that were not included in EIA estimates, because power plants must be 1 megawatt or more in capacity to be included in EIA reported data.

Table 1.H1. Wind Net Summer Capacity by State, 2002-2006 (Megawatts)

State	2002	2005	2006
Alabama	-	-	-
Alaska	-	10	3
Arizona	-	-	-
Arkansas	-	-	-
California	1,701	2,052	2,255
Colorado	37	228	289
Connecticut	-	-	-
Delaware	-	-	-
District of Columbia	-	-	-
Florida	-	-	-
Georgia	-	-	-
Hawaii	11	11	43
Idaho	-	11	75
Illinois	-	105	105
Indiana	-	-	-
Iowa	416	820	921
Kansas	112	263	363
Kentucky	-	-	-
Louisiana	-	-	-
Maine	-	-	-
Maryland	-	-	-
Massachusetts	-	-	-
Michigan	1	1	2
Minnesota	312	687	827
Mississippi	-	-	-
Missouri	-	-	-
Montana	-	135	145
Nebraska	3	73	73
Nevada	-	-	-
New Hampshire	-	-	-
New Jersey	-	-	8
New Mexico	-	404	494
New York	48	185	370
North Carolina	-	-	-
North Dakota	-	96	164
Ohio	-	7	7
Oklahoma	-	474	594
Oregon	182	298	399
Pennsylvania	34	223	150
Rhode Island	-	-	-
South Carolina	-	-	-
South Dakota	3	43	43
Tennessee	2	29	29
Texas	1,085	1,755	2,738
Utah	-	-	-
Vermont	1	5	5
Virginia	-	-	-
Washington	225	393	821
West Virginia	66	66	66
Wisconsin	36	45	53
Wyoming	141	287	287
Total	4,417	8,706	11,329

*** =Less than 500 kilowatts.**
Note: Dash indicates the state has no data to report for wind capacity. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-860,"Annual Electric Generator Report."

ten years of the project's life.[13,14] This tax credit in some regions/localities may make wind power competitive with electricity generated by more conventional sources.[15,16] In the past there has been uncertainty over the availability of the PTC. Twice recently (at the end of 2001 and again in October 2004) the PTC expired, and there was a gap between the expiration and the time it was reinstated. During each of these gaps, little additional wind capacity came on line. Currently, the wind industry is in a period of relative stability, because the credit was renewed without a break in 2005 and again in 2006 and will not expire until the end of 2008. The flow of new projects and expansion has been steady compared to earlier years, when there were bursts of activity followed by periods of little activity. The debate on continuing the PTC is ongoing.[17]

Texas

In 2006 Texas was first among states in the Nation in total electrical capacity, net generation and total retail sales.[18] Forty- nine percent of its generation in 2006 was from natural gas, and the average delivered price of natural gas to the electric power industry in Texas has almost doubled since 2002. Although Texas is still the leading state in U.S. crude oil production, output is off nearly 60 percent since 1981. Therefore, Texas is turning its attention to developing new energy sources as its oil production continues to decline. [19]

In 1999, the Public Utility Commission of Texas (PUCT) adopted rules for the state's Renewable Energy Mandate, calling for 2,000 MW of new renewable capacity to be installed in Texas by 2009 and for a system of renewable energy credits to be established.[20] The ten-year goal was achieved within just six years, mainly with additions of wind capacity. After that success, the state legislature passed Senate Bill 20 in 2005, which increased the state's goal to 5,880 MW by 2015, of which 500 MW must come from non-wind resources. In 2006 alone, Texas added 460 MW at new wind plants

---

[13] Technologies that qualify are wind, solar, geothermal and "closed-loop" dedicated bioenergy facilities. Other technologies such as "open-loop" biomass, incremental hydropower, small irrigation systems, landfill gas, and municipal solid waste receive a lesser credit.

[14] The December 2008 expiration is the latest in a series of expiration dates, which started with the original sunset date of June 30, 1999.

[15] Tax-excempt entities clearly cannot take advantage of this provision. However, they are eligible for another credit, known as the Renewable Energy Production Incentive (REPI).

[16] Ryan Wiser and Mark Bolinger, Lawrence Berkeley National Laboratory, *Annual Report on U.S. Wind Power Installation, Cost, and Performance Trends: 2006,* LBNL-62702 (Washington, DC, 2007).

[17] Ryan Wiser, Mark Bolinger, and Galen Barbose, Lawrence Berkeley National Laboratory, *Using the Federal Production Tax Credit to Build a Durable Market for Wind Power in the United States* (November 2007). See website here: http://eetd.lbl.gov/EA/emp/reports/63583.pdf .

[18] See Energy Information Administration, State Electricity Profiles 2006 Edition, here: http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html .

[19] In recent years starting in 1999 through 2006, Federal Offshore (PADD 3) crude oil production was greater than production in Texas. See the EIA Petroleum Navigator here: http://tonto.eia.doe.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_m.htm .

[20] Texas State Energy Conservation Office, Renewable Portfolio Standard, here: http://www.seco.cpa.state.tx.us/re_rps-portfolio.htm . Qualifying renewable sources include solar, wind, geothermal, hydroelectric, tidal energy, and biomass, including landfill gas.

and 523 MW to an existing plant. Also, Texas reported the largest number of green pricing customers in any single state for 2006 – 100,950.[21]

Some of the best wind resources and sites for development in the state are distant from areas of demand, so Texas has had to resolve transmission congestion issues that forced periodic curtailment in some of the early wind projects and could hamper deliveries of future electricity supplies to market. For example, state Senate Bill 20 required that competitive renewable energy zones (CREZ) be designated in the best areas in the state and that electric transmission infrastructure be constructed to move renewable energy from those zones to markets where people use the electricity.[22] This mechanism is designed to get transmission out to prime wind energy areas in advance of wind development, rather than trying to catch up to development as happened in Texas during the first part of this decade. In early October 2007, the PUCT issued an Interim Final Order that designated five CREZ in West Texas and the Texas Panhandle and authorized development of the necessary transmission lines.[23] The final order is expected in early 2008. Since 85 percent of Texas transmission does not cross state lines, it is not subject to Federal Regulatory Energy Commission (FERC) regulation, so the state can act on its own in those areas and thus potentially expedite the process.

Washington

Washington was second in wind capacity additions for 2006, with 428 MW coming on line. This included the Wild Horse Wind Facility (229 MW) by Puget Sound Energy, a regulated electric utility. As part of its least cost resource plan, Puget Sound Energy considered the anticipated cost of various resources, as well as the cost of carbon dioxide emissions in the future and the risk of fossil fuel price spikes.[24] As early as September 2003, Washington's governor joined the governors of California and Oregon to announce the West Coast Governors' Global Warming Initiative. By 2004, the governors had issued detailed recommendations on how this might be accomplished. In August 2007, members of the Western Climate Initiative, including Washington state, announced a regional, economy-wide greenhouse gas emissions target of 15 percent below 2005 levels by 2020.[25]

In response to these and other concerns, in November 2006 Washington voters passed ballot Initiative 937, which included a renewable portfolio standard.[26] But Washington is

[21] Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report."
[22] Texas State Energy Conservation Office, Wind Energy Transmission, here: http://www.seco.cpa.state.tx.us/re_wind-transmission.htm .
[23] The Wind Coalition article, "Texas Decision Opens Door to Double Wind Power Capacity in the United States," October 2, 2007, here: http://www.windcoalition.org/PDFs/crez_pr_100207.pdf .
[24] Puget Sound Energy August 22, 2006 press release, "Puget Sound Energy Selects Seven Projects to Increase Power Supplies by 25 percent to Meet Customers' Growing Need," see website here: http://www.pse.com/insidePSE/newsSevenProjects.aspx .
[25] In August 2007 members included: Washington state, Arizona, California, New Mexico, Oregon, Utah, and in Canada the provinces of British Columbia and Manitoba.
[26] See North Carolina Solar Center DSIRE database here: http://www.dsireusa.org/library/includes/tabsrch.cfm?state=WA&type=RPS&back=regtab&Sector=S&CurrentPageID=7&EE=1&RE=1 .

no newcomer to renewable energy. In 2006, over three-fourths of its generation was sourced to conventional hydroelectric power and 2.3 percent to other renewable energy.[27] The new standard calls for all electric utilities that serve more than 25,000 customers to obtain 15 percent of their electricity from new renewable energy resources by 2020 and to undertake all cost-effective energy conservation. Most conventional hydroelectric generation is excluded.

Eligible renewable electricity includes electricity produced from:

- eligible water;
- wind;
- solar energy;
- geothermal energy;
- landfill gas;
- wave, ocean, or tidal power;
- gas from sewage treatment facilities;
- eligible biodiesel fuel (must meet specified standards); and
- eligible biomass energy.

Electricity from biomass must be derived from animal waste or solid organic fuels from wood, forest, field residues, or dedicated energy crops. Specifically excluded from the definition are wood pieces that have been treated with chemical preservatives such as creosote (e.g., utility poles), pentachlorophenol, or copper-chrome arsenic; black liquor byproduct from paper production; wood from old growth forests; and municipal solid waste (MSW).

Electricity from renewable resources other than fresh water is eligible for compliance if the generation facility began operation after March 31, 1999. The facility must be located in the Pacific Northwest, or the electricity from the facility must be delivered into Washington State on a real-time basis. Hydroelectric generation projects are eligible if incremental electricity produced as a result of efficiency improvements completed after March 31, 1999, are made to:

- hydroelectric projects owned by a utility subject to the renewable portfolio standard and located in the Pacific Northwest; or to
- hydroelectric generation in irrigation pipes and canals located in the Pacific Northwest, where the additional generation in either case does not result in new water diversions or impoundments.

In the future, new wind projects proposed for Washington State may further contribute to meeting its commitments to increase renewable electricity production. For example, Puget Sound Energy's 2007 Integrated Resource Plan includes plans for more wind.[28]

---

[27] Energy Information Administration, State Electricity Profiles 2006 Edition, see website here: http://www.eia.doe.gov/cneaf/electricity/st_profiles/washington.html .

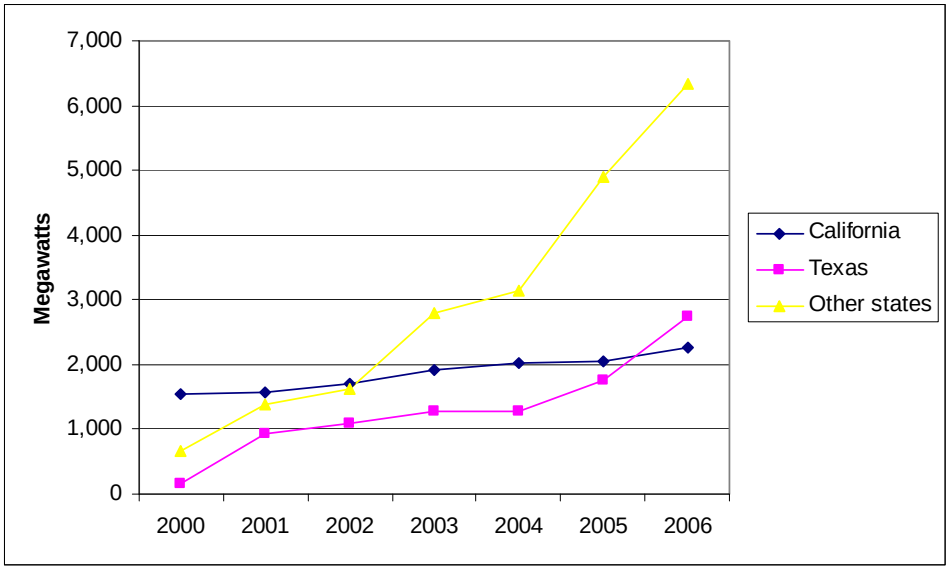
[28] Puget Sound Energy press release for May 31, 2007, "Conservation, wind power, natural gas drive 20-year resource plan for Puget Sound Energy," here http://www.pse.com/insidePSE/news2007IRP.aspx .

However, Washington's electric power industry is operating in a regional context. For instance, the other project for 2006, the Rock River I LLC wind facility (a 199 MW plant also known by the name Big Horn) was developed to provide electricity to a joint power authority in California that includes the Modesto Irrigation District, Silicon Valley Power (Santa Clara), and the City of Redding.

California

California has long been a leader in renewable energy in the U.S., beginning after the world oil crisis of the late 1970's. As late as 2000, California had nearly two-thirds of U.S. wind capacity. Since then, however, wind energy growth in California has been slower than in other states, despite adding 203 MW in 2006 and having public policies in place to support wind energy development (Figure 1.5). Thus, Texas was able to surpass California in 2006 as the state with the most wind capacity. To understand why this has occurred, it is instructive to examine California's recent efforts to promote renewable energy.

Figure 1.7 Wind Capacity by State, 2000-2006



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

In 2002, California Senate Bill 1078 established a renewable portfolio standard with the goal of increasing to 20 percent (by 2017) the percentage of the state's electricity from renewable energy that is sold to retail customers. The 2003 Energy Action Plan adopted by the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC) accelerated that target date to 2010.

Eligible renewable resources generally include:

- Biodiesel
- Biomass
- Conduit hydroelectric
- Fuel cells using renewable fuels
- Digester gas
- Geothermal
- Landfill gas
- Municipal solid waste
- Ocean wave, ocean thermal, and tidal current
- Photovoltaic
- Small Hydroelectric (30 Megawatt)
- Solar thermal electric
- Wind.[29]

Eligibility of renewable facilities varies by type of technology and date that the facility became operational.[30] Most facilities in operation after September 1996 are eligible as are certain ones before then, but there are exceptions. Most, but not all, MSW combustion is excluded.[31]

Out-of-state generation that is delivered into California also counts towards meeting the RPS. The Western Region Electricity Generation Information System (WREGIS) will be used to ensure that renewable energy output is counted only once for the purpose of meeting the RPS in California or any other state, and for verifying retail product claims.[32]

In addition, California has commitments to reduce global warming. In September 2006, the governor signed Assembly Bill 32, the Global Warming Solution Act. This Act caps California's greenhouse gas emissions at 1990 levels in 2020. California is also a party to the Western Climate Initiative. Development of renewable energy is expected to be part of the solution.

However in the CEC's *2007 Integrated Energy Policy Report* of November 2007, the CEC reports that California is not on track to meet its RPS goals:

> "Renewable generation in 2006, for all entities serving retail load, was at 10.9 percent, just below the percentage in 2002 before the RPS began. While delivered

[29] Specific details may be found in California Energy Commission, *Renewable Portfolio Standard Eligibility – Guidebook Second Edition* (March 2007). See website here: http://www.energy.ca.gov/2007publications/CEC-300-2007-006/CEC-300-2007-006-CMF.PDF

[30] Specific details may be found in California Energy Commission, *Renewable Portfolio Standard Eligibility – Guidebook Second Edition* (March 2007). See website here: http://www.energy.ca.gov/2007publications/CEC-300-2007-006/CEC-300-2007-006-CMF.PDF

[31] For example, MSW combustion located in Stanislaus county and operational prior to September 26, 1996 is allowed.

[32] WREGIS is an independent, renewable energy tracking system for the region covered by the Western Electricity Coordinating Council (WECC). WREGIS tracks renewable energy generation from units that register in the system using verifiable data and creates renewable energy certificates (RECs) for this generation.

renewable energy has grown, load has also continued to grow, and delivered energy has essentially kept even, rather than increasing in percentage terms as required."[33]

As for the near term,, the report states:

"Although the percentage of renewable deliveries has been flat, there is a large amount of contracted renewable energy that is likely to come on line in the next 2 to 5 years as new transmission to the Tehachapi and Imperial Valley becomes available."

Thus, it is likely California will miss meeting the 2010 target by at least several years. By inference, the slowdown in recent renewable energy capacity additions, especially wind, appears to be due in sizable measure to lack of sufficient electricity transmission capability.

Conclusion

Clearly, Federal incentives for renewable energy have had a major impact on wind energy development. Equally clear, however, is that progress in leading wind energy states is also heavily influenced by state programs promoting renewable energy, as well as state regulatory policies, regional considerations, and electricity infrastructure issues.

As markets evolve in the states and regions, pending Federal actions may have important implications for future wind energy development in the future. Among them: the renewal of the production tax credit (set to expire at the end of 2008); Federal Energy Regulatory Commission (FERC) facilitation of transmission capabilities for renewable energy; the passage of a Federal renewable portfolio standard; and changes in U.S. policy on global warming to limit carbon emissions. As important as these may be to long-term growth of wind energy, the primary issue affecting the short-term wind energy market in the two major wind energy states (Texas and California) is sufficient transmission capacity.

[33] California Energy Commission, *2007 Integrated Energy Policy Report – IEPR Committee Final* (November 2007), pp. 148-149. See website here: http://www.energy.ca.gov/2007_energypolicy/index.html .

Issue in Focus: Central Station Solar Thermal Electricity
Concentrating Solar Power Comes of Age

Introduction

Although solar energy provided only a miniscule portion of the Nation's power supply in 2006, the recent addition of central station solar capacity to the grid may be the beginning of a new wave of large solar power plants over the next four years. The following summarizes recent history, solar power technologies, and provides a short-term assessment of possible capacity increases.

The U.S. Southwest region is an ideal setting for solar thermal power. The deserts of Arizona, California, New Mexico, and Nevada have abundant sunshine and scarce rainfall. However, efforts to build utility-scale solar thermal power plants have been limited to 9 units built during the 1980's in the Mojave Desert of California, due to cost and performance issues (see Appendix). Known as the "Solar Energy Generating System" (SEGS), these units used parabolic troughs to capture the thermal energy from the sun directly to develop steam for producing electricity. (See: http://www.flagsol.com/SEGS_tech.htm.)

Concentrating Solar Power—Background

Concentrating Solar Power (CSP) plants like SEGS are power plants that produce electricity from steam heated by the Sun's energy. Although the CSP concept has been around for decades, it was not considered economic and by the late 1990's was virtually ignored as a feasible electricity technology.

Recently, however, several factors have caused a resurgence of interest in CSP:

- The high cost of fossil fuels;
- Environmental concerns;
- Government incentives and mandates for renewable energy sources, such as renewable portfolio standards (RPS), which require electricity suppliers to source a certain percentage of electricity from renewable energy;
- Technological advances in CSP; and
- Short construction lead time.

Since the last SEGS unit was built in 1990, CSP technologies have been quietly attracting new attention. The Arizona Public Service's (APS) 1-megawatt (MW) Saguaro solar thermal power plant came online in December 2005, and the 64-MW Nevada Solar One went online in June 2007, demonstrating that utilities and investors are becoming interested in developing large-scale CSP plants.

Concentrating Solar Power—Technology

Concentrating solar power technologies, that utilize different kinds of mirror configurations to convert the Sun's energy into high-temperature heat, are used in CSP plants. The heat energy is then used to generate electricity in a steam generator. There are three main types of concentrating solar power technologies:

- **Parabolic Trough:** A parabolic trough system uses parabolic mirrors that line up in long rows to concentrate sunlight onto an absorber tube (receiver). The receiver contains a fluid that is heated and circulated, and the heat is released to generate steam. The steam powers a conventional steam generator to produce electricity (Figure 1.7).

Figure 1.8. Parabolic Trough System

Source: National Renewable Energy Laboratory (NREL)

- **Dish/Engine:** A dish/engine system uses a mirrored dish to collect and concentrate sunlight onto a receiver. The receiver absorbs the sun's heat and transfers it to a gas or fluid in an engine. The heat causes the gas or fluid to expand and drive a piston, which is connected to a generator to produce electricity (Figure 1.8).

Figure 1.9. Dish/Engine System

Source: National Renewable Energy Laboratory (NREL)

- **Power Tower:** A power tower system utilizes a field of mirrors to concentrate and reflect sunlight to a receiver on the top of a centrally located tower. The receiver absorbs the sun's heat through molten salt, and the heat is released to generate steam. The steam powers a conventional steam generator to produce electricity (Figure 1.9).

Figure 1.10. Power Tower System

Source: National Renewable Energy Laboratory (NREL)

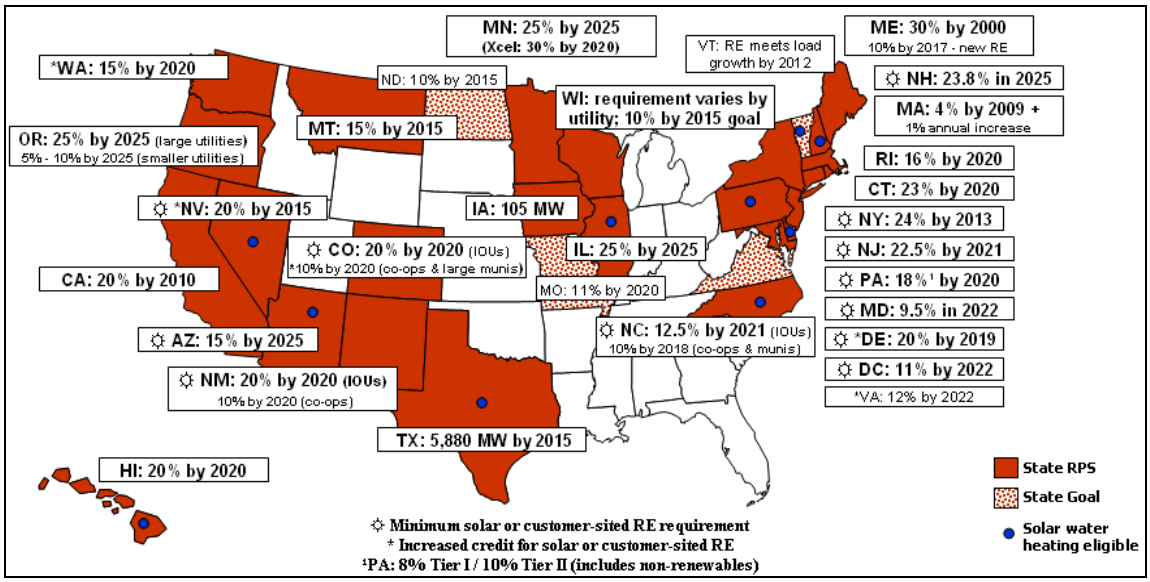
Concentrating Solar Power—Short-Term Outlook

CSP may be on the brink of significant growth. One sign for its potential growth is that utilities are mandated to increase their renewable portfolios (Figure 1.10). For example, the California RPS establishes a goal of 20 percent renewable generation by 2010. In addition, California Senate Bill SB1368 set a new standard for any new long-term financial contracts for electricity used in California. This standard prohibits California

utilities from building coal-fired power plants and/or procuring coal-produced electricity in and/or outside the state of California unless carbon capture and sequestration (CCS) technology is used. This standard will likely encourage the development of clean electricity generation technologies, which may include CSP technology. In addition, some states, such as Nevada and Arizona, have an RPS that requires a certain percentage of the renewables requirement to be fulfilled by solar resources.

Although California utilities are making progress toward meeting their 2010 RPS goals through the long-term power purchasing agreement process, a number of analysts in the country believe that California utilities will not achieve full compliance with their RPS requirements of 20 percent by 2010. However, California lawmakers nonetheless believe there is value in renewable energy technologies and are explicitly focusing on the new statutes and rules (such as RPS) that they believe will protect the environment and prevent future energy shortages.[34] Further, the state's electric entities are making significant commitments to new sources of renewable energy such as CSP.

Figure 1.11. Renewables Portfolio Standards



Source: The Database of State Incentives for Renewables and Efficiency (DSIRE), November 7, 2007. See www.dsireusa.org .

Currently, California is considering an even higher goal of 33 percent RPS by 2020 as advocated by Governor Schwarzenegger.[35] All energy suppliers, including municipal utilities, energy service providers and community choice aggregators would meet the same renewable energy goals required of the investor-owned utilities. Achieving the 33 percent goal could have tremendous implications throughout California over the next ten

[34] Section 387 of the California Public Utility code requires the PUC to implement and enforce the RPS, "while taking into consideration the effect of the standard on rates, reliability, and financial resources and the goal of environmental improvement."
[35] See http://docs.cpuc.ca.gov/word_pdf/misc/Achieving_33_Percent_RPS_Report.pdf.

years. Under the Governor's directive, the California Public Utilities Commission and the California Energy Commission are now developing plans to address the goal of 33 percent RPS by 2020.

Concentrating Solar Power--Projects

Several energy companies that have acquired the proven CSP technology have indicated their intention to enter the CSP market. These companies have unveiled plans for utility-scale solar thermal projects in California and other areas. If constructed as planned, these plants could deliver more than 3,000 megawatts of renewable power to the energy-hungry Southwest region within approximately four years.

The following provides an overview of the completed and proposed CSP projects over the past few years. [36]

Completed CSP Projects

Saguaro Solar Thermal Power Plant (April 2006)

- **Who**: Arizona Public Service Company (APS)
- **What and When:** In 2002, APS contracted with Solargenix Inc. to construct and provide the solar thermal technology for a one megawatt parabolic trough plant. Construction began in June 2004 and was completed 15 months later. The plant has been generating electricity since December 2005.
- **Where:** The plant was built on a patch of desert in Red Rock, next to the existing Saguaro Power Plant, about 30 miles north of Tucson.
- **Why:** APS had to meet the goals of the Arizona Corporation Commission's Environmental Portfolio Standard, which, at the time, required APS to generate 1.1 percent of its energy through renewable sources by 2007 – with 60 percent of this through solar resources.

Nevada Solar One (June 2007)

- **Who**: Acciona Energy
- **What:** Acciona Energy announced that Nevada Solar One, a 64-megawatt solar thermal power plant near Boulder City, Nevada, is now online. The new facility is the largest of its type to be built in the world since 1991. The electricity generated by the plant will be purchased by Nevada Power Company and Sierra Pacific Power under a 20-year power purchase agreement.
- **When:** Groundbreaking took place in February 2006. The plant was constructed rapidly and on schedule and was completed in just over a year.

[36] "Proposed" refers as projects that have been publicly announced in the news media. It does not necessarily mean a CSP plant will actually be built. In some cases, proposed plants have received regulatory approval and/or secured financing.

- **Where:** The plant is located in the Nevada desert on a site directly adjacent to the existing 480 MW El Dorado Energy combined cycle natural gas power plant. It covers 400 acres and consists of 760 parabolic trough concentrators.
- **Why:** Support by Nevada Power Company and Sierra Pacific Power Company needed to meet part of their renewable energy portfolio standard requirement.

Proposed CSP Projects

Proposed Stirling Solar Thermal One (October 2005)

- **Who**: Stirling Energy Systems, Inc.
- **What:** The California Public Utilities Commission has approved a renewable contract for Southern California Edison. The 20-year power purchase agreement calls for the development of a 500 MW solar power project using Stirling dish technology. The agreement includes an option to expand the project to 850 MW and will count toward Southern California Edison's Renewable Portfolio Standard (RPS) requirements.
- **When:** Stirling will build a one megawatt test facility using 40 of the company's 37-foot diameter dish assemblies. Subsequently, a 20,000-dish array is planned to be constructed from January 2009 to December 2012.
- **Where:** A 4,500-acre site in San Bernardino County, California.
- **Why:** This helps to fulfill the RPS requirement for utilities to get 20 percent of their electricity from renewable sources by 2010.

Proposed Stirling Solar Thermal Two (December 2005)

- **Who**: Stirling Energy Systems, Inc.
- **What:** San Diego Gas and Electric Company has announced that the California Public Utilities Commission has approved its contracts to purchase 300 megawatts of solar power, with the potential to grow to 900 MW from Stirling's Solar Thermal Two facility.
- **When:** To be announced.
- **Where:** Stirling plans to build an array of Stirling solar dishes on a 1,920-acre site in California's Imperial Valley.
- **Why:** California RPS.

Proposed Victorville 2 Hybrid Power Project (February 2007)

- **Who**: City of Victorville, CA
- **What:** The City of Victorville has filed an application with the California Energy Commission to construct and operate the Victorville 2 Hybrid Power Project, including 513 MW from natural gas and 50 MW from solar thermal.
- **When:** Construction of the project was scheduled to start in the summer of 2008, and full commercial operation is expected to begin by late summer 2010.
- **Where:** City of Victorville in San Bernardino County, California.

- **Why:** California RPS.

Proposed Mojave Solar Park 1 (July 2007)

- **Who**: Solel Inc.
- **What:** Pacific Gas and Electric Company has entered into a 25-year renewable energy agreement with Solel to purchase renewable energy from the Mojave Solar Park. The 553 MW solar plant, estimated to cost $2 billon, will use solar thermal parabolic trough technology.
- **When:** Construction will begin in 2009 and the plant will start generating electricity in 2011.
- **Where:** It is to be located on a 6,000-acre site in the Mojave Desert.
- **Why:** California RPS.

Proposed Ivanpah Solar Project (September 2007)

- **Who**: BrightSource Energy
- **What:** BrightSource Energy Inc. has filed an application with the California Energy Commission to develop a 400 MW solar power project in the Mojave Desert. The project consists of three solar plants that use Distributed Power Tower (DPT) solar field technology developed by Luz II, a wholly-owned subsidiary of BrightSource Energy.
- **When:** The plants are proposed to be built in three phases. Construction of the first, a 100-MW plant, will begin in the first quarter of 2009, with commercial operations starting in the fourth quarter of 2010. The second 100-MW plant will break ground in 2010 and is expected to begin commercial operations in 2011. Construction of the third, a 200-MW plant, will begin in 2011 with commercial operation expected by the end of 2012.
- **Where:** Three separate locations in Southern California's Mojave Desert, near the Nevada border.
- **Why:** California RPS.

Proposed Solar Power Plant (September 2007)

- **Who**: FPL Group
- **What:** A $2.4 billion investment, including $1.5 billion for a 300 MW solar thermal plant in Florida and an additional 200 MW solar thermal plant tentatively slated for California.
- **When:** Construction of a 10-MW solar power plant with Ausra's solar thermal technology is proposed to begin in 2008. If it meets performance expectations, the remaining 290 megawatts will follow within three years. A total of 300 megawatts capacity could be available by 2011.
- **Where:** The specific locations have not been chosen.
- **Why:** The plant is part of FPL's stated goal to add at least 600 MW of new solar generating capacity by 2015.

Proposed Carrizo Energy Solar Farm (September 2007)

- **Who**: Carrizo Energy, LLC
- **What:** Carrizo Energy, LLC has proposed to build the Carrizo Energy Solar Farm with production up to a nominal capacity of 177 MW.[37]
- **When:** Construction from site preparation to full commercial operation is expected to take approximately 35 months. If site construction activities commence in the first quarter of 2009, the entire project could be completed by the first quarter of 2012.
- **Where:** The site is located in eastern San Luis Obispo County, California.
- **Why:** California RPS.

Proposed Kern Solar Plant (October 2007)

- **Who**: Solar MW Energy Inc. (SME) and affiliate Ecosystem Solar Electric Corp. (ESE)
- **What:** ESE has commenced the development of a solar thermal electric combined cycle hybrid power plant (nominal capacity of 109.4 MW). The proposed plant utilizing solar energy as well as hybrid combined cycle co-fired and gas-fired superior systems will cost $100 million to build. The latest design of improved tried-and-true CSP technology for solar energy, consisting of twin parabolic collectors with twin parabolic tubes receivers, will be implemented.
- **When:** ESE has sent official notices to Federal, State and local governments involved in the permitting of the proposed plant.
- **Where:** A 40-acre site in Kern County, California.
- **Why:** California RPS.

Proposed Barstow Solar Plant (October 2007)

- **Who**: Solar MW Energy Inc. (SME) and affiliate Ecosystem Solar Electric Corp. (ESE)
- **What:** ESE has proposed the development of another solar thermal electric combined cycle hybrid power plant (nominal capacity of 59.4 MW).
- **When:** The project is still in design stage.
- **Where:** A 54-acre site near Barstow in San Bernardino County, California, is planned.
- **Why:** California RPS.

[37] Nominal capacity of unglazed flat plate collectors is the instantaneous thermal output of the collector under established operating conditions.

Conclusion

California's utilities are under mandate to increase the percentage of their sales from renewable energy resources. To meet California's RPS requirements, California has established standards and guidebooks for utilities in contracting for eligible renewable energy resources, implementing rules for compliance (such as applying excess renewable procurement in one year to a deficit in another year), and imposing penalties for non-compliance. Noticeably, there are hurdles to achieve a 20 percent RPS by 2010 by using CSP, such as:

- Utilities may have signed long-term power purchase agreement with companies that planned to build solar thermal power plant with technologies that are not yet fully commercialized;
- Construction permit issues for large-scale CSP plants; and
- The availability of the funding for above market costs covered by California's Renewable Resource Trust Fund.

As California's utilities move toward the 20 percent RPS goal by 2010, there may be an environment in which solar thermal power plants can reemerge as significant renewable electricity producers. The mandates to increase reliance on renewable energy have changed the utilities' long-term power purchases planning, which in part, is the key factor supporting the recent demand for large-scale solar thermal power plants. This key factor is similar to the driving force behind the demand for the initial SEGS units in 1983 discussed below, when Luz International, Ltd. negotiated a 30-year contract with Southern California Edison to sell electricity from its plants (See Appendix). Just as with the ups and downs of the CSP industry two decades ago, it is likely that the rebirth of the CSP industry will depend as much on the actions of utilities and state regulators as on development of industry technology.

Appendix: Early History

In the 1980's, Luz International, Ltd., began to build a series of Solar Energy Generating Systems (SEGS) in California's Mojave Desert. A total of nine separate SEGS plants have been constructed by Luz. The first plant was commissioned in 1984 and the last was commissioned in 1990 (Table 1.H2). Under Federal guidelines, the SEGS plants can rely on natural gas for up to 25 percent of their power supply and still qualify as a renewable resource.

In 1991, Luz ran into financial trouble and filed for Chapter 7 bankruptcy after failing to secure construction financing for its tenth SEGS plant. The operation of the SEGS plants was taken over by an investor group. Luz failed largely due to natural gas prices and electricity costs not rising as much as expected. The problem was compounded by operating and maintenance costs for the station not declining as rapidly as had been expected, and uncertainty about, or expiration of, key tax incentives. The tenth SEGS plant was never constructed.

Table 1.H2 U.S. Operating Solar Electric Generating Systems (SEGS)

Plant Name	SEGS I	SEGS II	SEGS III	SEGS IV	SEGS V	SEGS VI	SEGS VII	SEGS VIII	SEGS IX
State	CA	CA	CA	CA	CA	CA	CA	CA	CA
Prime Mover	Steam Turbine	Steam Turbine	Steam Turbine	Steam Turbine	Steam Turbine	Steam Turbine	Steam Turbine	Steam Turbine	Steam Turbine
Nameplate Capacity (MW)	13.8	30.0	34.2	34.2	34.2	35.0	35.0	92.0	92.0
Summer Capacity (MW)	13.8	30.0	36.0	36.0	36.0	36.0	36.0	88.0	88.0
Winter Capacity (MW)	13.8	30.0	34.0	34.0	34.0	35.0	35.0	64.0	64.0
Status	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating
In-Service Year	1984	1985	1986	1986	1987	1988	1988	1989	1990
Primary Energy Source	Solar (Thermal)	Solar (Thermal)	Solar (Thermal)	Solar (Thermal)	Solar (Thermal)	Solar (Thermal)	Solar (Thermal)	Solar (Thermal)	Solar (Thermal)
Secondary Energy Source	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas

Source: Energy Information Administration (EIA)

These SEGS plants reliably generate electricity in the Mojave Desert. The development of the SEGS project occurred between 1984 and 1990 following a decade which witnessed two major increases in petroleum prices and oil shortages. After that time, average energy prices stabilized, supply remained readily available, and the demand for SEGS plants diminished. However, in the last several years, increasing dependence on foreign oil, environmental issues, and rising energy prices have sparked a rapidly growing interest in alternate energy sources, including solar.

Issue in Focus: Biodiesel in the Energy Supply

Introduction

While the effort to reduce dependency on foreign oil in the transportation sector has focused on a replacement for gasoline, efforts have also been underway to find a suitable replacement for diesel fuel. In 1999, the United States began commercial production of a diesel fuel substitute, generally made from soybean and canola oil, known as biodiesel.

Though biodiesel currently represents only a small fraction of the diesel fuel market, it is of great interest as a diesel replacement because of two specific fuel characteristics. First, biodiesel can be used in any diesel engine and therefore its usage usually does not require modifications to the on-board fuel system.[38] Second, the combustion of biodiesel emits lower levels of several pollutants compared with traditional diesel.

From a marketing perspective, getting biodiesel into the mainstream distribution system is likely to be much easier than getting E85 into the gasoline distribution system. There are far fewer major retail diesel facilities (mainly truck stops), and unlike branded service stations for motor gasoline, retail diesel facilities are usually not restricted in the non-branded fuels they can sell, thus making biodiesel marketing easier.[39]

What is Biodiesel?

Biodiesel is a renewable-based diesel fuel substitute, made from vegetable oils or animal fats, which meets the requirements of American Society for Testing & Materials (ASTM) Standard D 6751.[40] Because biodiesel has the properties of petroleum-based diesel, it can be used as a substitute for diesel, either pure or blended with petroleum diesel in any percentage.[41] When biodiesel and petroleum diesel are combined, the resultant blend is named by its volume percentage of biodiesel. For example, a blend of 20 percent biodiesel with 80 percent petroleum diesel is known as B20. Pure or straight biodiesel is known as B100 or neat biodiesel.

How is Biodiesel Produced?

---

[38] If biodiesel blends of greater than 20 percent biodiesel are used, then minor adjustments to the engine may be required.

[39] Recently, however, Section 241 of The Energy Independence and Security Act of 2007 (P.L. 110-140) amended the Petroleum Marketing Practices Act to prohibit a franchisor (i.e. oil company) from restrict ing a franchisee from installing E85 infrastructure through a franchise agreement.

[40] Some entities include so-called "renewable" or "green" diesel in their definition of biodiesel. "Renewable" or "green" diesel includes processed raw vegetable oils or fats that have not been chemically transformed into esters. EPACT05 distinguishes between "biodiesel" and "renewable diesel." See http://www.biodiesel.org/resources/definitions/default.shtm for further explanation.

[41] Some alterations may need to be made to older engines in order to run on blends with high percentages of biodiesel.

Biodiesel is produced by a trans-esterification process in which oils or fats are mixed with a catalyst and an alcohol. This chemical reaction produces trigylcerides[42], which are then split apart and recombined to make methyl esters[43] (biodiesel) and crude glycerin[44] as a co-product. The glycerin is generally further distilled to a higher purity and then sold for use in the pharmaceutical and cosmetics industries.

The oil or fat from which biodiesel is made can come from many sources, including but not limited to the following: canola oil, palm oil, sunflower oil, soybean oil, animal tallow, lard and yellow grease (recycled grease).

Currently, soybean oil is the dominant feedstock in the United States due to its availability and historically low cost. However, in recent years an increasing amount of biodiesel has been produced from waste grease or rendered animal fat due to increasing prices of soybean oil. Biodiesel can also be made from the trans-esterification of hydrocarbons which are derived from agricultural products such as rice hulls or other carbonaceous stock.

What are the Characteristics of Biodiesel?

Biodiesel contains approximately 86 percent the heat content of Ultra Low Sulfur Diesel (ULSD), meaning that customers can use low level blends of biodiesel without noticing a significant decrease in mileage (Table 1.H3). The flash point (the temperature which a liquid needs to exceed in order to self-ignite) of biodiesel is substantially higher than ULSD, meaning that biodiesel is much less hazardous to contain and transport than is ULSD. The pour point of a liquid is the lowest temperature at which it is still a low-viscosity "pourable" liquid, and the cloud point is the temperature at which dissolved solids begin to precipitate out of the liquid. Because biodiesel is produced from fatty acids, any incompletely reacted materials left in the solution cause it to have both a higher pour and cloud point than ULSD. High cloud and pour points only become an issue in extremely low temperatures, as the fuel may become viscous and need to be warmed before usage.

One final point of comparison between biodiesel and ULSD is the sulfur content - biodiesel that meets ASTM Spec D 6751 has 0 parts per million (ppm) sulfur by definition; however, it may pick up miniscule amounts of sulfur while it is being transported and distributed[45]. Because sulfur is considered to be harmful to human health when emitted into the atmosphere, starting in 2006 the Environmental Protection Agency mandated that sulfur levels for all on-road diesel fuel must be reduced from 500 ppm to 15 ppm. Although this mandate reduced the pollution created from ULSD, it has been problematic for large diesel engines because it also reduced the lubricity of the fuel,

[42] Fats composed of three fatty-acid chains linked to a glycerol molecule
[43] Biodiesel produced via a reaction between fatty acids and methanol
[44] A clear, odorless, viscous sugar alcohol that is a by-product of the trans-esterification process for producing biodiesel.
[45] Sometimes biodiesel is transported in vehicles or pipes that previously contained ULSD, and residual sulfur from the prior fuel may be transferred to the biodiesel.

which is important in maintaining an engine's performance. Biodiesel is a natural lubricant, and blending it into ULSD has the effect of both reducing the sulfur content and increasing the lubricity.

Table 1.H3 Physical Characteristics of Biodiesel vs. Ultra Low Sulfur Diesel (ULSD)

	Biodiesel (soybean)	Ultra Low Sulfur Diesel
Heat Content (Btu/gallon)	118,952	139,000
Flash point (°C)	93	>52
Pour Point (°C)	0	-27
Cloud Point (°C)	2	-23
Sulfur (ppm)	0-2	<15

Sources: Heat contents: (Biodiesel) Energy Information Administration, Monthly Annual Energy Review (November 2007),. Table A3. http://www.eia.doe.gov/emeu/mer/pdf/pages/sec12_3.pdf. (Diesel) Energy Information Administration. http://www.eia.doe.gov/basics/conversion_basics.html. Flash point (Diesel) McCormick, Bob. National Renewable Energy Lab. Renewable Diesel Fuels: Status of Technology and R&D Needs. http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2002/session4/2002_deer_mccormick.pdf August 2003. Flash Point (Biodiesel) Cloud Point (Diesel and Biodiesel) and Pour Point (Diesel and Biodiesel): National Biodiesel Board, Biodiesel Cold Weather Blending Study. http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20050728_gen-354.pdf. Sulfur (Biodiesel): ASTM Specification 6751-07b. http://biodiesel.org/pdf_files/fuelfactsheets/BDSpec.PDF. (Diesel) Environmental Protection Agency, Program Update: Introduction of Cleaner-burning Diesel Fuel Enables Advanced Pollution Control for Cars, Trucks and Buses EPA420-F-06-064, October 2006. http://www.epa.gov/otaq/highway-diesel/regs/420f06064.htm

Who Produces Biodiesel?

The biodiesel production industry spans the spectrum from small seasonal operations to plants operated by large multinational conglomerates. Plant sizes (measured in gallons per year of capacity) range from 300,000 to 100,000,000 gallons per year. Because biodiesel can be made from multiple feedstocks, the production industry is not as geographically constrained as other biofuels industries, which are limited to fewer locations. Pockets of concentrated biodiesel plants exist in the Midwest, the South and Texas, but in general production is dispersed throughout the country.

Just as production facilities vary in size, biodiesel companies also vary in their business models and how they market their product. All biodiesel plants necessarily produce pure biodiesel (B100), but some plants sell only this product, while others sell a wide range of biodiesel blends for the transportation fuels market. Due to the complicated nature of the petroleum diesel distribution market, producers have many options in how they move their product. For example, producers can co-locate a biodiesel pump with their production facility to allow consumers to directly fuel their vehicles on-site. Some producers sell strictly to wholesalers or distributors, while other producers sell to fleets and school districts. Biodiesel is even sold outside the transportation sector, notably to home heating oil companies.

Biodiesel can leave the plant by individual vehicle, tanker truck, train or barge, depending on both the location of the plant and the destination of the product. In addition to local domestic markets, anecdotal evidence suggests that biodiesel is being exported to Europe in response to demand created by renewable fuels blending mandates in certain European countries. Partially due to high demand caused by European subsidies, U.S. biofuels command a higher price in European markets than they do in domestic markets. Federal biodiesel blending credits (which can be taken regardless of the biofuel's end destination) combined with high prices in Europe means that producers and distributors can increase their revenues by selling the biodiesel into European markets rather than domestic ones.

How is Biodiesel Used?

Biodiesel's primary use is as a fuel for onroad vehicles (principally trucks), but it also has several uses in other markets. It is used in offroad transportation and industrial applications, such as marine engines, mining equipment, agricultural equipment, and stationary diesel engines and generators. Additionally, biodiesel has properties of a mild solvent and is sometimes sold as such; for example, it can be used in distributing pesticides through agricultural irrigation systems. Biodiesel has excellent lubricating properties and virtually no sulfur content, which makes it a popular additive for new low and ultra-low sulfur diesel fuels.[46] Biodiesel can also be blended into home heating oil or used as substitute heating oil at the B100 level.

What Factors Have Influenced the Biodiesel Industry in Recent Years?

The biodiesel industry has undergone massive growth in the last five years and is poised to continue to grow into the foreseeable future. Production has grown from 204 thousand barrels in 2001 to 5,963 thousand barrels in 2006.[47] One important driver of this growth has been Federal incentives to producers and blenders of biodiesel. In 2004, The American Jobs Creation Act established tax credits of $1.00 per gallon produced for agri-biodiesel and renewable diesel, and $.50 per gallon for waste-grease biodiesel.[48] If the fuel is used in a mixture, the credit is 1 cent per percentage point of agri-biodiesel used or 1/2 cent per percentage point of waste-grease biodiesel. Additionally, the Energy Policy Act of 2005 (EPACT2005) created the Small Biodiesel Producer Tax Credit, which allows for an additional production credit equal to $.10 per gallon on the first 15 million gallons of agri-biodiesel produced at facilities with annual capacity not exceeding 60 million gallons per year.

Another piece of legislation affecting the growth of the biodiesel industry is the Renewable Fuels Standard Program established by EPACT2005. This program

[46] Regulations limiting the sulfur content of diesel fuel became effective in 2006. The lubricity of petroleum diesel has been reduced due to the processes used to reduce sulfur and aromatic compounds in the fuel (http://www.cleanairfleets.org/altfuels.html)

[47] Energy Information Administration, Monthly Energy Review April 2008 (Washington, D.C. April 2008, Table 10.4, http://tonto.eia.doe.gov/FTPROOT/multifuel/mer/00350804.pdf

[48] Energy Policy Act of 2005 (Section 1344) extended the tax credit for biodiesel blenders through 2008.

mandated a certain level of renewable fuels to be blended into the gasoline and diesel fuels sold in the U.S[49]. In 2004, this level was approximately 4 billion gallons and in 2012 it was to reach 7.5 billion gallons. After 2012, the blending requirement was to grow at a rate equal to the growth of gasoline consumption. The renewable fuels considered under this mandate are ethanol and biodiesel. It is left up to the individual refiners to use whichever renewable fuel makes the most economic sense in their particular operations, as long as the overall standards are met yearly.

Other factors influencing the market have been higher petroleum prices and continued Federal support for alternative fuels, shown in recently enacted Federal legislation. Also, EPA's mandate that diesel consumed in the U.S. be ultra-low sulfur diesel (ULSD) as of October 15, 2006 has been an additional driver of biodiesel consumption. Because of biodiesel's extremely low[50] sulfur content, blends of biodiesel with petroleum diesel have been instrumental in the transition from low sulfur diesel to ULSD, which has also helped create a biodiesel distribution network that is necessary for continued expansion of the industry. Two other mandated-purchasing programs helping to create demand for biodiesel are Federal fleet purchases, and state-level fuel pool blending requirements, such as those recently enacted in Minnesota and Washington. Finally, foreign demand for biodiesel continues to increase because of country-specific biofuels usage requirements. There is currently no statistical data on the amount of biodiesel exported by the United States, but anecdotal evidence suggests a fair amount of U.S. production is being exported to Europe.

What is the Outlook for Biodiesel?

EIA's Annual Energy Outlook 2008 reference case predicts that consumption of biodiesel will continue to grow over time due to continued and increasing demand for the fuel, both in its pure form and in its many blend levels. The Energy Independence and Security Act (EISA) of 2007 is an important new factor in biodiesel's demand equation. It was enacted in December 2007 and affects the biodiesel industry in two significant ways. First, the bill seeks to promote increased consumer confidence in biodiesel fuel quality by requiring more stringent fuel labeling requirements. Second, Section 202 of the EISA 2007 expands the mandatory usage of biodiesel under the Renewable Fuel Standard. By calendar year, the bill requires the introduction of the following amounts of biodiesel into the transportation fuel stream:

2009— 500,000,000 gallons
2010— 650,000,000 gallons
2011— 800,000,000 gallons
2012—1,000,000,000 gallons

[49] EPACT2005 blending levels have been superseded by new blending levels mandated by the Energy Independence and Security Act of 2007.
[50] Biodiesel by definition has sulfur content of less than 0.02%. If the finished fuel contains any additional sulfur, it is most likely a product of the transportation process.

Issue In Focus: Wave and Tidal Energy

Introduction

The United States has abundant ocean wave and tidal energy resources. It is estimated that if one-quarter of the U.S. wave resource were harnessed at 50 percent efficiency, the electricity produced would be roughly equivalent to electricity produced from hydropower in 2003.[51] This translates to about 6.8 percent of the total amount of net electricity generated in the United States in 2006.[52]

Research and development (R&D) funding for Ocean Energy Systems was included in the Department of Energy's initial year of operation, fiscal year (FY) 1978, and continued through FY 1994. The budget for Ocean Energy Systems was then zeroed out through FY 2008. The Department of Energy Hydropower Program was closed out in FY 2006 and resurrected in FY 2008 as the Water Power Program.[53] The mission of the program is to "explore, test and develop (as appropriate) innovative and effective technologies capable of harnessing hydrokinetic (i.e., energy from the motion of fluids) energy resources, including ocean wave and current (ocean and tidal) energy)."[54] Encouraged by the Energy Policy Act of 2005 (EPACT) and the Energy Independence and Security Act of 2007, much of this activity has been spawned by the adoption of Renewable Portfolio Standards (RPS). [55] In fact, 17 of the 22 coastal states have an RPS and each one that does includes tidal energy and wave energy technologies as eligible for meeting the state's renewable standard or goal.[56]

Given the demonstration and pilot projects that are beginning or already in operation, and the significant amount of the resource and power potential, identifying and following this market is important to our understanding of the overall energy picture.

---

[51] Electric Power Research Institute, "Overview: EPRI Ocean Energy Program," September 14, 2006, http://archive.epri.com/oceanenergy/attachments/ocean/briefing/Duke_Sep_14.pdf,

[52] Energy Information Administration, *Electric Power Annual with data for 2006* (Washington, DC, October 2007), http://www.eia.doe.gov/cneaf/electricity/epa/epat1p1.html.

[53] For Fiscal Years 1978 through 1999, see U.S. Department of Energy, Office of Budget, "Department of Energy Historical R&D Budget," April 1998, http://www.eia.doe.gov/cneaf/solar.renewables/rea_issues/reatabp1.html; for Fiscal Years 2000 through 2008, see Office of the Chief Financial Officer, Budget Justifications and Supporting Documents, http://www.cfo.doe.gov/crorg/cf30.htm.

[54] U.S. Department of Energy, Office of the Chief Financial Officer, FY 2009 Budget Request to Congress, "Water Power," http://www.cfo.doe.gov/budget/09budget/Content/Volumes/Volume3a.pdf.

[55] Energy Policy Act of 2005, Title IX, Section 931 (E), http://www.fedcenter.gov/_kd/Items/actions.cfm?action=Show&item_id=2969&destination=ShowItem and Energy Independence and Security Act of 2007, Title VI, Subtitle C – Marine and Hydrokinetic Renewable Energy Technologies, http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=110_cong_public_laws&docid=f:publ140.110.pdf.

[56] Database of State Incentives for Renewables & Efficiency as of November 6, 2007, http://www.dsireusa.org/.

Jurisdictional Issues[57]

The Federal Energy Regulatory Commission (FERC) is responsible for regulating nonfederal development of hydropower and hydrokinetics, which it defines as "hydroelectric generation from ocean waves, tides, and currents and from free-flowing rivers."[58] There is some ambiguity over regulatory jurisdiction since the Energy Policy Act of 2005 gave the Department of Interior Minerals Management Service (MMS) oversight authority for renewable energy projects on the Outer Continental Shelf (OCS).[59] The OCS begins three miles off shore, except for Texas and the Gulf Coast of Florida, where it begins 10 miles off shore. Therefore, inside these limits there is no ambiguity about FERC's jurisdiction.[60]

As part of its regulatory function, the commission issues preliminary permits and licenses to hydrokinetic project developers. A preliminary permit, issued for up to three years, holds a place in the licensing queue while the project site is being studied; it does not authorize construction. In fact, a permit is not a prerequisite for a license. A license is for a 30 to 50 year period and conveys the right of eminent domain, that is, the project developer owns the rights to the land or waterway on which the project is being developed. In November 2007, FERC released a policy statement which allows it to issue conditioned licenses. A conditioned license can be awarded even though certain authorization required from other entities may be outstanding. It assists the developer in obtaining project financing even though it does not allow construction.[61] As of January 24, 2008, 49 permits had been issued and 26 were pending.[62] As of December 31, 2007, one license had been issued, and none were pending.[63]

Technologies

Water is a very good energy source due to its wide availability and has high energy potential because of its comparatively high density. It is also renewable and emission-free when used in electricity generation. While tides are intermittent, they are very dependable, running in one direction for hours and then reversing. Waves are fairly predictable days in advance, making system supply planning somewhat easier than with

---

[57] For a discussion of jurisdictional and environmental issues, see, CRS Report for Congress: Issues Affecting Tidal, Wave and In-Stream Generation Projects, Updated June 28, 2007, http://ncseonline.org/NLE/CRSreports/07Jul/RL33883.pdf.
[58] Federal Energy Regulatory Commission, "Hydropower – Industry Activities," http://www.ferc.gov/industries/hydropower/indus-act/hydrokinetics.asp, as of November 5, 2007.
[59] OCS Alternative Energy and Alternate Use Programmatic EIS Information Center, http://www.ocsenergy.anl.gov/, accessed November 6, 2007.
[60] Law Offices of Carolyn Elefant, "MMS FERC Jurisdictional Smackdown!" February 18, 2007, http://carolynelefant1.typepad.com/renewablesoffshore/2007/02/mmsferc_jurisdi.html, November 7, 2007.
[61] FERC News Release: November 30, 2007, http://www.ferc.gov/news/news-releases/2007/2007-4/11-30-07.asp.
[62] FERC: Hydrokinetics – Issued and Pending Permits, http://www.ferc.gov/industries/hydropower/indus-act/hydrokinetics/permits.asp.
[63] FERC: Hydrokinetics – Issued and Pending Licenses, http://www.ferc.gov/industries/hydropower/indus-act/hydrokinetics/licences.asp,.

wind power - another intermittent renewable technology.[64] However, the ocean environment is very stressful on equipment and until recently very few projects had been undertaken.

There are a number of different wave and tidal energy devices either being used or in the planning stages. They can be grouped into two broad categories: surface devices and in-stream turbines.

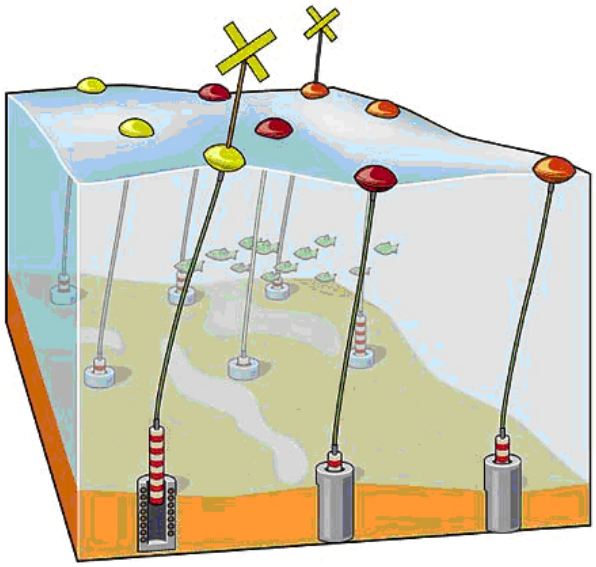
Wave Energy Technologies[65,66]

The primary wave energy technologies are:

- Terminator device: a structure that extends perpendicular to the direction of wave travel. An example of a terminator is the oscillating water column (OWC). In an OWC, water enters a subsurface chamber with air inside. The action of the waves causes water in the chamber to act as a piston, forcing the air trapped above it through an opening to drive a turbine-generator.
- Attenuators: long, floating structures that extend parallel to the direction of wave travel. The waves cause the device to flex. The flexing motion drives hydraulic pumps or other energy converters.
- Point absorber: a floating structure with components that move relative to each other due to wave action. This relative motion is used to drive electromechanical or hydraulic energy converters.
- Overtopping device: consists of a structure over which waves fall into a reservoir with hydro turbines installed at the bottom. The water turns the turbines as it goes back out to sea. The turbines power generators that produce electricity.
- Wave rotor: a turbine that is turned directly by waves and is coupled to a generator to produce electricity.

[64] Renewable Energy Holdings, plc.; http://www.reh-plc.com/news.asp?type=2&menu=&article=294&keywords=&offset.
[65] Carbon Trust, "Technical overview of wave and tidal stream energy," http://www.thecarbontrust.co.uk/technology/technologyaccelerator/ME_guide.htm.
[66] Argonne National Laboratory, OCS Alternative Energy and Alternate Use Programmatic EIS, "Ocean Wave Energy," http://www.ocsenergy.anl.gov/guide/wave/index.cfm.

Figure 1.12 Artist's Rendition of Point Absorber Wave Energy Farm



Source: U.S. Department of the Interior, Minerals Management Service, website here: http://ocsenergy.anl.gov/includes/dsp_photozoom.cfm?imgname=wave%2Ejpg&caption=Point%20Absorber%20Wave%20Energy%20Farm&callingpage=%2Fguide%2Fwave%2Findex%2Ecfm&callingttl=Wave%20Energy&source=Source%3A%20Minerals%20Management%20Service.

Tidal Energy Technologies[67,68]

Tidal energy technologies include:

- Turbines: submerged horizontal- or vertical-axis devices turned by the power of tides. The turbines are coupled to a generator or other energy converter.
- Reciprocating tidal stream devices: systems in which hydrofoils move perpendicular to the tidal stream. These hydrofoils act as pistons which drive a hydraulic motor and generator to produce electricity.
- Barrage: a dam built with gates and turbines. As tides produce a difference in water levels on either side of the dam, the gates are opened and water flows through the turbines which turn an electric generator to produce electricity.
- Venturi effect device: tidal flow is constricted by being directed through a duct, thereby causing a pressure difference, which, in turn, causes a secondary fluid to flow through a turbine which turns an electric generator to produce electricity.

[67] Op.Cit., Carbon Trust.
[68] U.S. Department of Energy, "Ocean Tidal Power," http://www.eere.energy.gov/consumer/renewable_energy/ocean/index.cfm/mytopic=50008.

Figure 1.13 Artist's Rendition of Ocean Tidal Current Turbines

Source: U.S. Department of the Interior, Minerals Management Service, website here: http://ocsenergy.anl.gov/includes/dsp_photozoom.cfm?imgname=currentturbine%2Ejpg&caption=Figure%201%3A%20Current%20Turbines%20Visualization&callingpage=%2Fguide%2Fcurrent%2Findex%2Ecfm&callingttl=Ocean%20Current%20Energy&source=Source%3A%20Minerals%20Management%20Service.

Environmental Issues

Wave and tidal energy devices produce no greenhouse gases when generating electricity. Also, the devices operate beneath or close to the surface and are, generally, not visible from shore. It is expected that wave energy devices will only minimally affect the size of waves. Similarly, tidal stream devices will only extract a small amount of the energy available, thereby not unduly affecting the nearby environment.[69] However, there are environmental considerations. To that end, in October 2005, the Department of Energy convened a workshop to identify important environmental issues associated with hydrokinetic technologies, as well as mitigation strategies.[70] [71] The environmental issues noted include the following: alteration of river/ocean bottom; suspension of sediments and contaminants; danger that aquatic animals may be struck or entangled; electromagnetic fields may attract, deter, or injure aquatic animals; protection of near-shore vegetative environments; wave and current buffering; potential noise effects.

[69] BWEA Marine Steering Group, "Why Marine?", 2006, http://www.bwea.com/pdf/marine/FINAL%20WHY%20MARINE.pdf, accessed February 5, 2008.
[70] U.S. Department of Energy, Hydrokinetik and Wave Workshop, http://hydropower.inel.gov/hydrokinetic_wave/index.shtml, accessed January 11, 2008.
[71] U.S. Department of Energy, "Proceedings of the Hydrokinetic and Wave Energy Technologies Technical and Environmental Issues Workshop – October 26-28, 2005," (Washington, DC, March 24, 2006), http://hydropower.inel.gov/hydrokinetic_wave/pdfs/hydro_workshop_proceedings.pdf, .

Current Activities in the United States

There are a number of on-going wave and tidal pilot projects in the United States. The Electric Power Research Institute (EPRI) has an active ocean energy program and supports a number of demonstration projects.[72] These include six wave energy projects in states on both coasts and Hawaii and tidal energy projects on both coasts and in Canada. EPRI sees wave power as being a cost competitive power source in the 2020 time period.

The first major tidal project in the United States dates back to 2002, when Verdant Power Company began its Roosevelt Island Tidal Energy (RITE) project in New York City's East River. Using six "Free Flow" turbines (35 kilowatts installed capacity each) to generate electricity, power has been transmitted to an end-use customer.[73] This project requires no impoundment or dams and operates completely underwater. The project expects to receive the necessary permits and licenses for commercial operation by the end of 2008 and to potentially expand to 10 megawatts by 2010, depending on the successful demonstration of its first six turbines.[74] [75]

On December 20, 2007, FERC issued its first license for a hydrokinetic energy project – the Makah Bay Offshore Wave Pilot Project, which will be located in the Pacific Ocean off the coast of Washington. The licensee is Finavera Renewables Ocean Energy, Ltd. The license includes mitigation measures to protect the environment.[76] The project is planned as a 1 megawatt demonstration plant – enough to power about 150 homes.

Obstacles to Development

Hydrokinetic devices are relatively unproven and use new technologies that have not yet established a track record. Investors prefer certainty and until more experience is gained, financing might be problematic or relatively expensive. There are also environmental and land use issues associated with these projects, and demonstration projects don't necessarily foretell what may occur when they are built full scale. In addition, there is the economic obstacle of whether the power from wave and tidal sources will be cost competitive with competing sources of energy.

International Projects

Hydrokinetic power projects are recent and few. Consequently, learning from similar projects is very important from a developmental, operational, economic and environmental perspective. This learning is likely to convey across projects no matter

[72] EPRI Ocean Energy Program, http://archive.epri.com/oceanenergy/oceanenergy.html#projects.
[73] Free Flow Turbine, http://verdantpower.com/what-systemsint.
[74] The RITE Project, http://verdantpower.com/what-initiative2#backtop.
[75] Technology Review, "Tidal Turbines Help Light Up Manhattan," April 23, 2007, http://www.technologyreview.com/Energy/18567/page1/, accessed November 7, 2007.
[76] FERC News Release: "FERC issues first license for Hydrokinetic Energy Project," December 20, 2007, http://www.ferc.gov/news/news-releases/2007/2007-4/12-20-07-H-1.asp.

where they are developed. In order to facilitate the transfer of information across projects, in October 2001, the International Energy Agency (IEA) instituted an Implementing Agreement on Ocean Energy Systems (OES).[77] This is a framework for international collaboration on activities to enhance the commercialization of ocean energy systems which include wave and tidal power. The principal tasks of this agreement are: 1) review, exchange and disseminate information on ocean energy systems; 2) develop recommended practices for testing and evaluating ocean energy systems; and 3) integrate ocean energy plants into transmission and distribution networks.

The world's first tidal power plant was built at La Rance, in northwestern France in 1966 and was connected to the French grid in December 1967.[78] [79] The plant consists of a barrage, or dam, and twenty-four 10 megawatt bulb-type turbines.[80] It has been operating without major incident for over 30 years and produces enough power to supply a city of 300,000 people.

A sampling of other projects being developed worldwide is instructive for the kinds of technologies that are being developed and used and any problems they may be encountering (see below).

- A 27 MW wave energy project in Portland, Victoria, Australia.[81]
- Wave Hub Project in North Cornwall, United Kingdom.[82]
- A 22.5 MW wave park in Agucadoura, Portugal, Power Technology.Com, "Pelamis, World's First Commercial Wave Energy Project, Agucadoura, Portugal."[83]
- Limpet wave project on the Island of Islay, Scotland.[84]
- An 18 MW tidal power station, the Annapolis Royal Generating Station, in the Annapolis River in Nova Scotia, Canada. [85]
- Jiangxia Tidal Plant, China, 1985.[86]

---

[77] IEA/OES, http://www.iea.org/Textbase/techno/technologies/renew.asp.
[78] The Encyclopedia of Earth, http://www.eoearth.org/article/La_Rance,_France.
[79] Wikipedia, "Rance Tidal Power Plant", last updated June 14, 2007, http://en.wikipedia.org/wiki/Rance_tidal_power_plant.
[80] The Encyclopedia of Alternative Energy and Sustainable Living, http://www.daviddarling.info/encyclopedia/B/AE_bulb_turbine.html.
[81] See (http://www.oceanlinx.com/Currentprojects.asp).

[82] See BBC News release, September 17, 2007, "Wave hub gets planning go-ahead," http://news.bbc.co.uk/1/hi/england/cornwall/6998199.stm.
[83] See http://www.power-technology.com/projects/pelamis/.

[84] See Wavegen, http://www.wavegen.co.uk/what_we_offer_limpet.htm.
[85] See: Wikipedia, "Annapolis Royal Generating Station." http://en.wikipedia.org/wiki/Annapolis_Royal_Generating_Station.

[86] See http://www.co-reach.org/input/document/documents/620.ppt

Conclusion

Tidal and wave energy projects are being developed worldwide. Two major organizations – the Electric Power Research Institute and the International Energy Agency – have programs in place to support this emerging industry. At a time when global climate change and sustainable energy are global concerns, these renewable, relatively benign sources of power are potentially important additions to the world's power supply options.

Table 1.H1. Wind Net Summer Capacity by State, 2002-2006
(Megawatts)

State	2002	2005	2006	Wind 2006 Prelim
Alabama	-	-	-	-
Alaska	-	10	3	2
Arizona	-	-	-	-
Arkansas	-	-	-	-
California	1,701	2,052	2,255	2,264
Colorado	37	228	289	288
Connecticut	-	-	-	-
Delaware	-	-	-	-
District of Columbia	-	-	-	-
Florida	-	-	-	-
Georgia	-	-	-	-
Hawaii	11	11	43	43
Idaho	-	11	75	75
Illinois	-	105	105	105
Indiana	-	-	-	-
Iowa	416	820	921	919
Kansas	112	263	363	363
Kentucky	-	-	-	-
Louisiana	-	-	-	-
Maine	-	-	-	-
Maryland	-	-	-	-
Massachusetts	-	-	-	-
Michigan	1	1	2	1
Minnesota	312	687	827	786
Mississippi	-	-	-	-
Missouri	-	-	-	-
Montana	-	135	145	135
Nebraska	3	73	73	73
Nevada	-	-	-	-
New Hampshire	-	-	-	-
New Jersey	-	-	8	8
New Mexico	-	404	494	494
New York	48	185	370	370
North Carolina	-	-	-	-
North Dakota	-	96	164	164
Ohio	-	7	7	7
Oklahoma	-	474	594	480
Oregon	182	298	399	399
Pennsylvania	34	223	150	150
Rhode Island	-	-	-	-
South Carolina	-	-	-	-
South Dakota	3	43	43	43
Tennessee	2	29	29	29
Texas	1,085	1,755	2,738	2,698
Utah	-	-	-	-
Vermont	1	5	5	5
Virginia	-	-	-	-
Washington	225	393	821	821
West Virginia	66	66	66	66
Wisconsin	36	45	53	45
Wyoming	141	287	287	287
Total	4,417	8,706	11,329	11,119

*** =Less than 500 kilowatts.**
Note: Dash indicates the state has no data to report for that energy source.
Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-860,"Annual Electric Generator Report."

Table 1.H2 U.S. Operating Solar Electric Generating Systems (SEGS)

Plant Name	SEGS I	SEGS II	SEGS III	SEGS IV	SEGS V	SEGS VI	SEGS VII	SEGS VIII	SEGS IX
State	CA	CA	CA	CA	CA	CA	CA	CA	CA
Nameplate Capacity(MW)	13.8	30	34.2	34.2	34.2	35	35	92	92
Summer Capacity(MW)	13.8	30	36	36	36	36	36	88	88
Winter Capacity(MW)	13.8	30	34	34	34	35	35	64	64
Status	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating	Operating
In-Service Year	1984	1985	1986	1986	1987	1988	1988	1989	1990
Primary Energy Source	Solar Thermal	Solar Thermal	Solar Thermal	Solar Thermal	Solar Thermal	Solar Thermal	Solar Thermal	Solar Thermal	Solar Thermal
Secondary Energy Source	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas	Natural Gas

Source: Energy Information Administration (EIA)

Table 1.H3 Physical Characteristics of Biodiesel vs. Ultra Low Sulfur Diesel (ULSD)

	Biodiesel (soybean)	Ultra Low Sulfur Diesel
Heat Content (Btu/gallon)	118,952	139,000
Flash Point (oC)	93	>52
Pour Point (oC)	0	-27
Cloud Point (oC)	2	-23
Sulfur (ppm)	0-2	<15

Sources: Heat contents: (Biodiesel) Energy Information Administration, Monthly Annual Energy Review (November 2007),. Table A3. http://www.eia.doe.gov/emeu/mer/pdf/pages/sec12_3.pdf. (Diesel) Energy Information Administration. http://www.eia.doe.gov/basics/conversion_basics.html. Flash point (Diesel) McCormick, Bob. National Renewable Energy Lab. Renewable Diesel Fuels: Status of Technology and R&D Needs. http://www1.eere.energy.gov/vehiclesandfuels/pdfs/deer_2002/session4/2002_deer_mccormick.pdf August 2003. Flash Point (Biodiesel) Cloud Point (Diesel and Biodiesel) and Pour Point (Diesel and Biodiesel): National Biodiesel Board, Biodiesel Cold Weather Blending Study. http://www.biodiesel.org/resources/reportsdatabase/reports/gen/20050728_gen-354.pdf. Sulfur (Biodesel): ASTM Specification 6751-07b. http://biodiesel.org/pdf_files/fuelfactsheets/BDSpec.PDF. (Diesel) Environmental Protection Agency, Program Update: introduction of Cleaner-burning Diesel Fuel Enables Advanced Pollution Control for Cars, Trucks and Buses EPA420-F-06-064, October 2006 http://www.epa.gov/otaq/highway-diesel/regs/420f06064.htm

Table 1.1. U.S. Energy Consumption by Energy Source, 2002-2006
(Quadrillion Btu)

Energy Source	2002	2003	2004	2005	2006
Total	97.858	98.209	100.351	100.503	99.861
Fossil Fuels	83.750	84.078	85.830	85.816	84.662
Coal	21.904	22.321	22.466	22.795	22.452
Coal Coke Net Imports	0.061	0.051	0.138	0.044	0.061
Natural Gas [a]	23.558	22.897	22.931	22.583	22.191
Petroleum[b]	38.227	38.809	40.294	40.393	39.958
Electricity Net Imports	0.072	0.022	0.039	0.084	0.063
Nuclear	8.143	7.959	8.222	8.160	8.214
Renewable	5.893	6.150	6.261	6.444	6.922
Biomass [c]	2.706	2.817	3.023	3.154	3.374
Biofuels	0.309	0.414	0.513	0.595	0.795
Waste	0.402	0.401	0.389	0.403	0.407
Wood Derived Fuels	1.995	2.002	2.121	2.156	2.172
Geothermal	0.328	0.331	0.341	0.343	0.343
Hydroelectric Conventional	2.689	2.825	2.690	2.703	2.869
Solar/PV	0.064	0.064	0.065	0.066	0.072
Wind	0.105	0.115	0.142	0.178	0.264

[a] Includes supplemental gaseous fuels.
[b] Petroleum products supplied, including natural gas plant liquids and crude oil burned as fuel.
[c] Biomass includes: biofuels, waste (landfill gas, MSW biogenic, and other biomass), wood and wood-derived fuels.
MSW=Municipal Solid Waste.
Note: Ethanol is included only in biofuels. In earlier issues of this report, ethanol was included in both petroleum and biofuels, but counted only once in total energy consumption. Totals may not equal sum of components due to independent rounding.
Sources: Non-renewable energy: Energy Information Administration (EIA), Monthly Energy Review (MER) March 2008, DOE/EIA-0035 (2008/3) (Washington, DC, March 2008,) Tables 1.3, 1.4a and 1.4b. Renewable Energy: Table 1.2 of this report.

Table 1.2. Renewable Energy Consumption by Energy Use Sector and Energy Source, 2002-2006
(Quadrillion Btu)

Sector and Source	2002	2003	2004	2005	2006
Total	5.893	6.150	6.261	6.444	6.922
Biomass	2.706	2.817	3.023	3.154	3.374
Biofuels	0.309	0.414	0.513	0.595	0.795
Biodiesel [a]	0.001	0.002	0.004	0.012	0.032
Biodiesel Feedstock [b]	*	*	*	*	*
Ethanol [c]	0.175	0.238	0.299	0.342	0.462
Ethanol Feedstock [d]	0.133	0.174	0.210	0.241	0.301
Waste	0.402	0.401	0.389	0.403	0.407
Landfill Gas	0.142	0.141	0.144	0.148	0.150
MSW Biogenic [e]	0.182	0.165	0.164	0.168	0.171
Other Biomass [f]	0.078	0.096	0.081	0.088	0.086
Wood and Derived Fuels	1.995	2.002	2.121	2.156	2.172
Geothermal	0.328	0.331	0.341	0.343	0.343
Hydroelectric Conventional	2.689	2.825	2.690	2.703	2.869
Solar/PV	0.064	0.064	0.065	0.066	0.072
Wind	0.105	0.115	0.142	0.178	0.264
Residential	0.449	0.471	0.483	0.527	0.495
Biomass	0.380	0.400	0.410	0.450	0.410
Wood and Derived Fuels [g]	0.380	0.400	0.410	0.450	0.410
Geothermal	0.010	0.013	0.014	0.016	0.018
Solar/PV [h]	0.059	0.058	0.059	0.061	0.067
Commercial	0.104	0.113	0.118	0.119	0.117
Biomass	0.095	0.101	0.105	0.105	0.102
Biofuels	*	0.001	0.001	0.001	0.001
Ethanol [c]	*	0.001	0.001	0.001	0.001
Waste	0.026	0.029	0.034	0.034	0.036
Landfill Gas	0.002	0.002	0.002	0.003	0.004
MSW Biogenic	0.020	0.022	0.025	0.025	0.026
Other Biomass [f]	0.004	0.005	0.007	0.007	0.007
Wood and Derived Fuels [i]	0.069	0.071	0.070	0.070	0.065
Geothermal	0.009	0.011	0.012	0.014	0.014
Hydroelectric Conventional	*	0.001	0.001	0.001	0.001
Industrial	1.723	1.731	1.861	1.884	1.999
Biomass	1.679	1.684	1.824	1.848	1.966
Biofuels	0.136	0.178	0.217	0.248	0.311
Ethanol [c]	0.003	0.005	0.006	0.007	0.009
Losses and Coproducts	0.133	0.174	0.210	0.241	0.301
Biodiesel Feedstock [b]	*	*	*	*	*
Ethanol Feedstock [d]	0.133	0.174	0.210	0.241	0.301
Waste	0.146	0.142	0.132	0.148	0.140
Landfill Gas	0.079	0.076	0.075	0.081	0.074
MSW Biogenic [e]	0.005	0.005	0.006	0.007	0.006
Other Biomass [f]	0.063	0.062	0.050	0.061	0.061
Wood and Derived Fuels [i]	1.396	1.363	1.476	1.452	1.515
Geothermal	0.005	0.003	0.004	0.004	0.004
Hydroelectric Conventional	0.039	0.043	0.033	0.032	0.029
Transportation	0.172	0.235	0.296	0.346	0.483
Biofuels	0.172	0.235	0.296	0.346	0.483
Biodiesel [a]	0.001	0.002	0.004	0.012	0.032
Ethanol [c]	0.171	0.233	0.292	0.334	0.451
Electric Power [j]	3.445	3.601	3.503	3.568	3.827
Biomass	0.380	0.397	0.388	0.406	0.412
Waste	0.230	0.230	0.223	0.221	0.231
Landfill Gas	0.062	0.063	0.066	0.065	0.073
MSW Biogenic	0.157	0.138	0.133	0.136	0.139
Other Biomass [f]	0.010	0.029	0.023	0.020	0.019
Wood and Derived Fuels [i]	0.150	0.167	0.165	0.185	0.182
Geothermal	0.305	0.303	0.311	0.309	0.306
Hydroelectric Conventional	2.650	2.781	2.656	2.670	2.839

Table 1.2. Renewable Energy Consumption by Energy Use Sector and Energy Source, 2002-2006
(Quadrillion Btu)

Sector and Source	2002	2003	2004	2005	2006
Solar/PV	0.006	0.005	0.006	0.006	0.005
Wind	0.105	0.115	0.142	0.178	0.264

[a] Biodiesel primarily derived from soy bean oil.
[b] Difference between the energy in biodiesel feedstocks (principally soy bean oil) and the energy in biodiesel consumed in the transportation sector.
[c] Ethanol primarily derived from corn.
[d] Difference between energy in ethanol feedstocks (primarily corn) and its coproducts (wet and dry distiller grains), and the energy in ethanol consumed in the transportation sector.
[e] Includes paper and paper board, wood, food, leather, textiles and yard trimmings.
[f] Agriculture byproducts/crops, sludge waste, and other biomass solids, liquids and gases.
[g] Wood and wood pellet fuels.
[h] Includes small amounts of distributed solar thermal and photovoltaic energy used in the commercial, industrial and electric power sectors.
[i] Black liquor, and wood/woodwaste solids and liquids.
[j] The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public.
PV=Photovoltaic.
MSW=Municipal Solid Waste.
***=Less than 500 billion Btu.**
NA=Not Applicable.
Note: Data revisions are discussed in the Highlights section. Revisions to biomass removed MSW non-biogenic and tires from renewable waste energy. Totals may not equal sum of components due to independent rounding.
Sources: Analysis conducted by Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels and specific sources described as follows. Residential: Energy Information Administration, Form EIA-457A/G, "Residential Energy Consumption Survey;" Oregon Institute of Technology, Geo-Heat Center; and Energy Information Administration, Form EIA-63-A, "Annual Solar Thermal Collector Manufacturers Survey" and Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey." Commercial: Energy Information Administration, Form EIA-906, "Power Plant Report", Form EIA-920, "Combined Heat and Power Plant Report;" and Oregon Institute of Technology, Geo-Heat Center. Industrial: Energy Information Administration, Form EIA-846 (A, B, C) "Manufacturing Energy Consumption Survey," Form EIA-906, "Power Plant Report" and Form EIA-920, "Combined Heat and Power Plant Report;" Oregon Institute of Technology, Geo-Heat Center; Government Advisory Associates, Resource Recovery Yearbook and Methane Recovery Yearbook; U.S. Environmental Protection Agency, Landfill Methane Outreach Program estimates; and losses and coproducts from the production of biodiesel and ethanol calculated as the difference between energy in feedstocks and production. Biofuels for Transportation: Biodiesel: 2001-2005: U.S. Department of Agriculture, Commodity Credit Corporation, Bioenergy Program estimates of production assigned to consumption and 2006 and forward: U.S. Department of Commerce, Bureau of Census, Current Industrial Reports, Fats and Oils - Production, Consumption and Stocks, and Ethanol: 2001-2004: EIA, Petroleum Supply Annual, Tables 2 and 16. Calculated as ten percent of oxygenated finished motor gasoline field production (Table 2) plus fuel ethanol refinery input (Table 16). 2005: EIA Petroleum Supply Annual 2005, Tables 1 and 15. Calculated as motor gasoline blending components adustments (Table 1), plus finished motor gasoline adjustments (Table 1), plus fuel ethanol refinery and blender net inputs (Table 15). 2006: EIA Petroleum Supply Monthly, monthly reports, Tables 1 and 27. Calculated as motor gasoline blending components adjustments (Table 1), plus finished motor gasoline adjustments (Table 1), plus fuel ethanol refinery and blender net inputs (Table 27). Small amounts of ethanol consumption are distributed to the commercial and industrial sectors according to those sector's shares of U.S. motor gasoline supplied. Electric Power: Energy Information Administration, Form EIA-906, "Power Plant Report" and Form EIA-920, "Combined Heat and Power Plant Report."

Table 1.3. Renewable Energy Consumption for Electricity Generation by Energy Use Sector and Energy Source, 2002-2006 (Quadrillion Btu)

Sector/Source	2002	2003	2004	2005	2006
Total	3.967	4.016	3.936	3.929	4.229
Biomass	0.862	0.768	0.787	0.733	0.785
Waste	0.257	0.249	0.254	0.252	0.262
Landfill Gas	0.064	0.066	0.070	0.069	0.077
MSW Biogenic [a]	0.166	0.148	0.150	0.152	0.155
Other Biomass [b]	0.027	0.035	0.034	0.031	0.031
Wood and Derived Fuels [c]	0.605	0.519	0.534	0.482	0.523
Geothermal	0.305	0.303	0.311	0.309	0.306
Hydroelectric Conventional	2.689	2.825	2.690	2.703	2.869
Solar/PV	0.006	0.005	0.006	0.006	0.005
Wind	0.105	0.115	0.142	0.178	0.264
Commercial	0.019	0.021	0.024	0.026	0.028
Biomass	0.018	0.020	0.023	0.025	0.027
Waste	0.018	0.019	0.022	0.025	0.026
Landfill Gas	0.002	0.002	0.002	0.002	0.004
MSW Biogenic [a]	0.013	0.013	0.016	0.017	0.017
Other Biomass [b]	0.004	0.005	0.004	0.006	0.005
Wood and Derived Fuels [c]	*	*	0.001	0.001	0.001
Hydroelectric Conventional	*	0.001	0.001	0.001	0.001
Industrial	0.518	0.419	0.419	0.347	0.386
Biomass	0.479	0.376	0.387	0.315	0.358
Waste	0.015	0.013	0.011	0.009	0.008
Landfill Gas	0.001	0.001	0.001	0.001	*
MSW Biogenic [a]	*	*	0.001	0.001	*
Other Biomass [b]	0.014	0.012	0.008	0.007	0.007
Wood and Derived Fuels [c]	0.464	0.362	0.376	0.306	0.350
Hydroelectric Conventional	0.039	0.043	0.033	0.032	0.029
Electric Power [d]	3.430	3.576	3.493	3.556	3.815
Biomass	0.364	0.372	0.378	0.393	0.400
Waste	0.224	0.216	0.220	0.217	0.228
Landfill Gas	0.062	0.063	0.066	0.065	0.073
MSW Biogenic [a]	0.153	0.135	0.133	0.134	0.137
Other Biomass [b]	0.009	0.018	0.021	0.018	0.018
Wood and Derived Fuels [c]	0.141	0.156	0.157	0.176	0.172
Geothermal	0.305	0.303	0.311	0.309	0.306
Hydroelectric Conventional	2.650	2.781	2.656	2.670	2.839
Solar/PV	0.006	0.005	0.006	0.006	0.005
Wind	0.105	0.115	0.142	0.178	0.264

[a] Includes paper and paper board, wood, food, leather, textiles and yard trimmings.
[b] Agriculture byproducts/crops, sludge waste, tires, and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
[d] The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public.
PV=Photovoltaic.
MSW=Municipal Solid Waste.
*** =Less than 500 billion Btu.**
Note: Data revisions are discussed in the Highlights section. Totals may not add due to independent rounding.
Sources: Analysis conducted by Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels and the following specific sources: Energy Information Administration, Form EIA-906, "Power Plant Report," and Form EIA-920, "Combined Heat and Power Plant Report."

Table 1.4. Renewable Energy Consumption for Nonelectric Use by Energy Use Sector and Energy Source, 2002-2006 (Quadrillion Btu)

Sector/Source	2002	2003	2004	2005	2006
Total	1.927	2.135	2.325	2.515	2.693
Biomass	1.844	2.049	2.236	2.421	2.589
Biofuels	0.309	0.414	0.513	0.595	0.795
Biodiesel [a]	0.001	0.002	0.004	0.012	0.032
Biodiesel Feedstock [b]	*	*	*	*	*
Ethanol [c]	0.175	0.238	0.299	0.342	0.462
Ethanol Feedstock [d]	0.133	0.174	0.210	0.241	0.301
Waste	0.145	0.153	0.135	0.152	0.145
Landfill Gas	0.078	0.075	0.074	0.079	0.073
MSW Biogenic [e]	0.016	0.016	0.014	0.016	0.016
Other Biomass [f]	0.050	0.061	0.047	0.056	0.055
Wood and Derived Fuels	1.390	1.483	1.588	1.674	1.649
Geothermal	0.024	0.027	0.030	0.034	0.037
Solar/PV	0.059	0.058	0.059	0.061	0.067
Residential	0.449	0.471	0.483	0.527	0.495
Biomass	0.380	0.400	0.410	0.450	0.410
Wood and Derived Fuels [g]	0.380	0.400	0.410	0.450	0.410
Geothermal	0.010	0.013	0.014	0.016	0.018
Solar/PV [h]	0.059	0.058	0.059	0.061	0.067
Commercial	0.085	0.092	0.095	0.093	0.089
Biomass	0.077	0.081	0.083	0.079	0.075
Biofuels	*	0.001	0.001	0.001	0.001
Ethanol [c]	*	0.001	0.001	0.001	0.001
Waste	0.008	0.010	0.012	0.009	0.010
Landfill Gas	-	-	-	*	*
MSW Biogenic [e]	0.007	0.009	0.009	0.008	0.008
Other Biomass [f]	0.001	0.001	0.002	0.001	0.001
Wood and Derived Fuels [i]	0.068	0.071	0.070	0.069	0.064
Geothermal	0.009	0.011	0.012	0.014	0.014
Industrial	1.204	1.312	1.442	1.537	1.613
Biomass	1.200	1.308	1.438	1.533	1.608
Biofuels	0.136	0.178	0.217	0.248	0.311
Ethanol [c]	0.003	0.005	0.006	0.007	0.009
Losses and Coproducts	0.133	0.174	0.210	0.241	0.301
Biodiesel Feedstock [b]	*	*	*	*	*
Ethanol Feedstock [d]	0.133	0.174	0.210	0.241	0.301
Waste	0.131	0.129	0.121	0.139	0.133
Landfill Gas	0.078	0.075	0.074	0.079	0.073
MSW Biogenic [e]	0.004	0.004	0.004	0.006	0.006
Other Biomass [f]	0.049	0.050	0.042	0.053	0.054
Wood and Derived Fuels [i]	0.932	1.001	1.100	1.146	1.165
Geothermal	0.005	0.003	0.004	0.004	0.004
Transportation	0.172	0.235	0.296	0.346	0.483
Biofuels	0.172	0.235	0.296	0.346	0.483
Biodiesel [a]	0.001	0.002	0.004	0.012	0.032
Ethanol [c]	0.171	0.233	0.292	0.334	0.451
Electric Power [j]	0.016	0.025	0.010	0.013	0.012
Biomass	0.016	0.025	0.010	0.013	0.012
Waste	0.006	0.014	0.003	0.003	0.003
Landfill Gas	*	*	-	*	-
MSW Biogenic [e]	0.005	0.003	*	0.002	0.002
Other Biomass [f]	0.001	0.011	0.002	0.002	*
Wood and Derived Fuels [i]	0.010	0.011	0.008	0.009	0.010

Table 1.4. Renewable Energy Consumption for Nonelectric Use by Energy Use Sector and Energy Source, 2002-2006 (Quadrillion Btu)

Sector/Source	2002	2003	2004	2005	2006

[a] Biodiesel primarily derived from soy bean oil.
[b] Difference between the energy in biodiesel feedstocks (principally soy bean oil) and the energy in biodiesel consumed in the transportation sector.
[c] Ethanol primarily derived from corn.
[d] Difference between energy in ethanol feedstocks (primarily corn) and its coproducts (wet and dry distiller grains), and the energy in ethanol consumed in the transportation sector.
[e] Includes paper and paper board, wood, food, leather, textiles and yard trimmings.
[f] Agriculture byproducts/crops, sludge waste, tires, and other biomass solids, liquids and gases.
[g] Wood and wood pellet fuels.
[h] Includes small amounts of distributed solar thermal and photovoltaic energy used in the commercial, industrial and electric power sectors.
[i] Black liquor, and wood/woodwaste solids and liquids.
[j] The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public.

PV=Photovoltaic.
MSW=Municipal Solid Waste.
*=Less than 500 billion Btu.
NA=Not Applicable.
Note: Data revisions are discussed in the Highlights section. Revisions to biomass removed MSW non-biogenic and tires from renewable waste energy. Dash indicates the sector has no data to report for the energy source for that year. Totals may not equal sum of components due to independent rounding.
Sources: Analysis conducted by Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels and specific sources described as follows. Residential: Energy Information Administration, Form EIA-457A/G, "Residential Energy Consumption Survey;" Oregon Institute of Technology, Geo-Heat Center; and Energy Information Administration, Form EIA-63-A, "Annual Solar Thermal Collector Manufacturers Survey" and Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey." Commercial: Energy Information Administration, "Form EIA-920, "Combined Heat and Power Plant Report;" and Oregon Institute of Technology, Geo-Heat Center. Industrial: Energy Information Administration, Form EIA-846 (A, B, C) "Manufacturing Energy Consumption Survey," Form EIA-920, "Combined Heat and Power Plant Report;" Oregon Institute of Technology, Geo-Heat Center; Government Advisory Associates, Resource Recovery Yearbook and Methane Recovery Yearbook; U.S. Environmental Protection Agency, Landfill Methane Outreach Program estimates; and losses and coproducts from the production of biodiesel and ethanol calculated as the difference between energy in feedstocks and production. Biofuels for Transportation: Biodiesel: 2001-2005: U.S. Department of Agriculture, Commodity Credit Corporation, Bioenergy Program estimates of production assigned to consumption and 2006 and forward: U.S. Department of Commerce, Bureau of Census, Current Industrial Reports, Fats and Oils - Production, Consumption and Stocks, and Ethanol: 2001-2004: EIA, Petroleum Supply Annual, Tables 2 and 16. Calculated as ten percent of oxygenated finished motor gasoline field production (Table 2) plus fuel ethanol refinery input (Table 16). 2005: EIA Petroleum Supply Annual 2005, Tables 1 and 15. Calculated as motor gasoline blending components adustments (Table 1), plus finished motor gasoline adjustments (Table 1), plus fuel ethanol refinery and blender net inputs (Table 15). 2006: EIA Petroleum Supply Monthly, monthly reports, Tables 1 and 27. Calculated as motor gasoline blending components adjustments (Table 1), plus finished motor gasoline adjustments (Table 1 adjustments (Table 1), plus finished motor gasoline adjustments (Table 1), plus fuel ethanol refinery and blender net inputs (Table 27). Small amounts of ethanol consumption are distributed to the commercial and industrial sectors according to those sector's shares of U.S. motor gasoline supplied. Electric Power: Energy Information Administration, Form EIA-920, "Combined Heat and Power Plant Report."

Table 1.5a. Historical Renewable Energy Consumption by Sector and Energy Source, 1989-1999
(Quadrillion Btu)

Sector and Energy Source	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Total	6.391	6.206	6.238	5.993	6.262	6.155	6.705	7.168	7.178	6.657	6.681
Biomass	3.160	2.735	2.782	2.933	2.910	3.030	3.104	3.159	3.108	2.931	2.967
Biofuels [a]	0.126	0.111	0.129	0.146	0.171	0.190	0.202	0.145	0.187	0.205	0.213
Waste [b]	0.354	0.408	0.440	0.473	0.479	0.515	0.531	0.577	0.551	0.542	0.540
Wood and Derived Fuels	2.680	2.216	2.214	2.313	2.260	2.324	2.370	2.437	2.371	2.184	2.214
Geothermal	0.317	0.336	0.346	0.349	0.364	0.338	0.294	0.316	0.325	0.328	0.331
Hydroelectric Conventional	2.837	3.046	3.016	2.617	2.892	2.683	3.205	3.590	3.640	3.297	3.268
Solar/PV	0.055	0.060	0.063	0.064	0.066	0.069	0.070	0.071	0.070	0.070	0.069
Wind	0.022	0.029	0.031	0.030	0.031	0.036	0.033	0.033	0.034	0.031	0.046
Residential	0.978	0.641	0.674	0.706	0.618	0.590	0.591	0.612	0.503	0.452	0.462
Biomass	0.920	0.580	0.610	0.640	0.550	0.520	0.520	0.540	0.430	0.380	0.390
Wood and Derived Fuels [c]	0.920	0.580	0.610	0.640	0.550	0.520	0.520	0.540	0.430	0.380	0.390
Geothermal	0.005	0.006	0.006	0.006	0.007	0.006	0.007	0.007	0.008	0.008	0.009
Solar/PV [d]	0.053	0.056	0.058	0.060	0.062	0.064	0.065	0.065	0.065	0.065	0.064
Commercial	0.102	0.098	0.100	0.109	0.114	0.112	0.118	0.135	0.138	0.127	0.129
Biomass	0.099	0.094	0.095	0.105	0.109	0.106	0.113	0.129	0.131	0.118	0.121
Biofuels [e]	0.001	0.001	*	*	*	*	*	*	*	*	*
Waste [b]	0.022	0.028	0.026	0.032	0.033	0.035	0.040	0.053	0.058	0.054	0.054
Wood and Derived Fuels [f]	0.076	0.066	0.068	0.072	0.076	0.072	0.072	0.076	0.073	0.064	0.067
Geothermal	0.003	0.003	0.003	0.003	0.003	0.004	0.005	0.005	0.006	0.007	0.007
Hydroelectric Conventional	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Industrial	1.870	1.716	1.683	1.737	1.772	1.927	1.992	2.033	2.058	1.931	1.936
Biomass	1.840	1.683	1.651	1.704	1.740	1.862	1.935	1.970	1.997	1.873	1.883
Biofuels [g]	0.056	0.049	0.057	0.064	0.075	0.083	0.087	0.062	0.082	0.090	0.093
Waste [b]	0.200	0.192	0.185	0.179	0.181	0.199	0.195	0.224	0.184	0.180	0.171
Wood and Derived Fuels [f]	1.584	1.442	1.410	1.461	1.484	1.580	1.652	1.683	1.731	1.603	1.620
Geothermal	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.004
Hydroelectric Conventional	0.028	0.031	0.030	0.031	0.030	0.062	0.055	0.061	0.058	0.055	0.049
Transportation	0.069	0.062	0.072	0.081	0.096	0.107	0.115	0.082	0.104	0.115	0.120
Biofuels [h]	0.069	0.062	0.072	0.081	0.096	0.107	0.115	0.082	0.104	0.115	0.120
Electric Power Sector [i]	3.372	3.689	3.710	3.360	3.662	3.420	3.889	4.305	4.375	4.032	4.034
Electric Utilities	2.983	3.151	3.114	2.712	2.953	2.714	3.173	3.553	3.620	3.279	3.123
Biomass	0.020	0.022	0.021	0.022	0.021	0.021	0.017	0.020	0.020	0.021	0.020
Waste [b]	0.010	0.013	0.014	0.013	0.011	0.013	0.010	0.012	0.013	0.013	0.013
Wood and Derived Fuels [f]	0.010	0.008	0.008	0.008	0.009	0.008	0.007	0.008	0.008	0.007	0.007
Geothermal	0.197	0.181	0.170	0.169	0.158	0.145	0.099	0.110	0.115	0.109	0.036
Hydroelectric Conventional	2.765	2.948	2.923	2.521	2.774	2.549	3.056	3.423	3.485	3.149	3.067
Solar/PV	*	*	*	*	*	*	*	*	*	*	*
Wind	*	*	*	*	*	*	*	*	*	*	*
Independent Power Producer	0.389	0.538	0.596	0.648	0.709	0.705	0.716	0.752	0.754	0.753	0.910
Biomass	0.211	0.295	0.333	0.381	0.394	0.413	0.405	0.418	0.426	0.424	0.433
Waste [b]	0.122	0.175	0.215	0.249	0.253	0.269	0.286	0.288	0.296	0.294	0.302
Wood and Derived Fuels [f]	0.089	0.120	0.118	0.132	0.141	0.144	0.119	0.130	0.129	0.129	0.131
Geothermal	0.111	0.145	0.165	0.168	0.193	0.180	0.181	0.191	0.194	0.202	0.276
Hydroelectric Conventional	0.043	0.066	0.062	0.065	0.087	0.072	0.093	0.104	0.096	0.092	0.151
Solar/PV	0.003	0.004	0.005	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005
Wind	0.022	0.029	0.031	0.030	0.031	0.036	0.033	0.033	0.034	0.031	0.046

Table 1.5b. Historical Renewable Energy Consumption by Sector and Energy Source, 2000-2006 (Continued)
(Quadrillion Btu)

Sector and Energy Source	2000	2001	2002	2003	2004	2005	2006
Total	6.264	5.316	5.893	6.150	6.261	6.444	6.922
Biomass	3.013	2.627	2.706	2.817	3.023	3.154	3.374
Biofuels [a]	0.241	0.258	0.309	0.414	0.513	0.595	0.795
Waste [b]	0.511	0.364	0.402	0.401	0.389	0.403	0.407
Wood and Derived Fuels	2.262	2.006	1.995	2.002	2.121	2.156	2.172
Geothermal	0.317	0.311	0.328	0.331	0.341	0.343	0.343
Hydroelectric Conventional	2.811	2.242	2.689	2.825	2.690	2.703	2.869
Solar/PV	0.066	0.065	0.064	0.064	0.065	0.066	0.072
Wind	0.057	0.070	0.105	0.115	0.142	0.178	0.264
Residential	0.490	0.439	0.449	0.471	0.483	0.527	0.495
Biomass	0.420	0.370	0.380	0.400	0.410	0.450	0.410
Wood and Derived Fuels [c]	0.420	0.370	0.380	0.400	0.410	0.450	0.410
Geothermal	0.009	0.009	0.010	0.013	0.014	0.016	0.018
Solar/PV [d]	0.061	0.060	0.059	0.058	0.059	0.061	0.067
Commercial	0.128	0.101	0.104	0.113	0.118	0.119	0.117
Biomass	0.119	0.092	0.095	0.101	0.105	0.105	0.102
Biofuels [e]	*	*	*	0.001	0.001	0.001	0.001
Waste [b]	0.047	0.025	0.026	0.029	0.034	0.034	0.036
Wood and Derived Fuels [f]	0.071	0.067	0.069	0.071	0.070	0.070	0.065
Geothermal	0.008	0.008	0.009	0.011	0.012	0.014	0.014
Hydroelectric Conventional	0.001	0.001	*	0.001	0.001	0.001	0.001
Industrial	1.930	1.721	1.723	1.731	1.861	1.884	1.999
Biomass	1.884	1.684	1.679	1.684	1.824	1.848	1.966
Biofuels [g]	0.102	0.112	0.136	0.178	0.217	0.248	0.311
Waste [b]	0.145	0.129	0.146	0.142	0.132	0.148	0.140
Wood and Derived Fuels [f]	1.636	1.443	1.396	1.363	1.476	1.452	1.515
Geothermal	0.004	0.005	0.005	0.003	0.004	0.004	0.004
Hydroelectric Conventional	0.042	0.033	0.039	0.043	0.033	0.032	0.029
Transportation	0.138	0.145	0.172	0.235	0.296	0.346	0.483
Biofuels [h]	0.138	0.145	0.172	0.235	0.296	0.346	0.483
Electric Power Sector [i]	3.579	2.910	3.445	3.601	3.503	3.568	3.827
Electric Utilities	2.607	2.063	2.529	2.615	2.522	2.530	2.688
Biomass	0.021	0.014	0.033	0.029	0.031	0.040	0.042
Waste [b]	0.014	0.008	0.022	0.012	0.011	0.013	0.015
Wood and Derived Fuels [f]	0.007	0.006	0.011	0.017	0.020	0.027	0.027
Geothermal	0.003	0.003	0.029	0.026	0.026	0.024	0.024
Hydroelectric Conventional	2.582	2.044	2.465	2.556	2.461	2.455	2.598
Solar/PV	*	*	*	*	*	*	*
Wind	*	0.001	0.002	0.004	0.004	0.010	0.023
Independent Power Producer	0.972	0.847	0.916	0.986	0.981	1.038	1.139
Biomass	0.432	0.323	0.347	0.368	0.357	0.365	0.370
Waste [b]	0.305	0.202	0.208	0.218	0.212	0.208	0.216
Wood and Derived Fuels [f]	0.127	0.121	0.140	0.151	0.145	0.158	0.154
Geothermal	0.293	0.286	0.275	0.277	0.285	0.285	0.282
Hydroelectric Conventional	0.185	0.165	0.185	0.224	0.196	0.215	0.242
Solar/PV	0.005	0.006	0.006	0.005	0.006	0.005	0.005
Wind	0.057	0.068	0.103	0.111	0.138	0.168	0.240

Notes and Sources

[a] Biofuels and biofuel losses and coproducts.
[b] Municipal solid waste biogenic, landfill gases, agriculture byproducts/crops, sludge waste, and other biomass solids, liquids and gases. Includes municipal solid waste nonbiogenic and tires for 1989-2000.
[c] Wood and wood pellet fuel
[d] Includes small amounts of distributed solar thermal and photovoltaic energy used in the commercial, industrial and electric power sectors.
[e] Ethanol primarily derived from corn.
[f] Black liquor, and wood/woodwaste solids and liquids.
[g] Ethanol primarily derived from corn and losses and coproducts from production of biodiesel and ethanol.
[h] Biodiesel primarily derived from soy bean oil and ethanol primarily derived from corn
[i] The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public
***=Less than 500 billion Btu.**
PV=Photovoltaic.
Note: Revised data are in italics. Totals may not equal sum of components due to independent rounding.
Sources: Analysis conducted by Energy Information Administration, Office of Coal, Nuclear, Electric, and Alternate Fuels and Specific sources described as follows. Residential: Energy Information Administration, Form EIA-457A/G, "Residential Energy Consumption Survey;"Oregon Institute of Technology, Geo-Heat Center and Energy Information Administration, Form EIA-63-A, "Annual Solar Thermal Collector Manufacturers Survey" and Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey." Commercial: Energy Information Administration, Form EIA-867, "Annual Nonutility Power Producer Report," Form EIA-860B, " Annual Electric Generator Report - Nonutility," Form EIA-906, "Power Plant Report," Form EIA-920, "Combined Heat and Power Plant Report," and Oregon Institute of Technology, Geo-Heat Center.Industrial: Energy Information Administration, Form EIA-846 (A,B,C) "Manufacturing Energy Consumption Survey," Form EIA-867, "Annual Nonutility Power Producer Report," Form EIA-860B, "Annual Electric Generator Report - Nonutility," Form EIA-906, "Power Plant Report", and Form EIA-902, "Combined Heat and Power Plant Report," Oregon Institute of Technology, Geo-Heat Center; Government Advisory Associates, Resource Recovery Yearbook and Methane Recovery Yearbook; U.S. Environmental Protection Agency, Landfill Methane Outreach Program estimates; and losses and coproducts from the production of biodiesel and ethanol calculated as the difference between energy in feedstocks and production. Biofuels for Transportation: Biodiesel: 2001-2005: U.S. Department of Agriculture, Commodity Credit Corporation, Bioenergy Program estimates of production assigned to consumption and 2006 and forward: U.S. Department of Commerce, Bureau of Census, Current Industrial Reports, Fats and Oils - Production, Consumption and Stocks, and Ethanol: 1989: EIA, Estimates of U.S. Biofuels Consumption 1990, Table 10, 1990-1992: EIA, Estimates of U.S. Biomass Energy Consumption 1992, Table D2, 1993-2004: EIA, Petroleum Supply Monthly, Tables 2 and 16. Calculated as ten percent of oxygenated finished motor gasoline field production (Table 2) plus fuel ethanol refinery input (Table 16).2005: EIA Petroleum Supply Annual 2005, Tables 1 and 15. Calculated as motor gasoline blending components adustments (Table 1), plus finished motor gasoline adjustments (Table 1), plus fuel ethanol refinery and blender net inputs (Table 15).2006: EIA Petroleum Supply Monthly, monthly reports, Tables 1 and 27. Calculated as motor gaoline blending components adjustments (Table 1), plus finished motor gaosline adjustments (Table 1), plus fuel ethanol refinery and blender net inputs (Table 27). Small amounts of ethanol consumption are distributed to the commercial and industrial sectors according to those sector's shares of U.S. motor gasoline supplied. Electric Power: Energy Information Administration, Form EIA-759, "Monthly Power Plant Report, "Form EIA-867, "Annual Nonutility Power Producer Report, "Form EIA-860B, " Annual Electric Generator Report - Nonutility," and Form EIA-906 "Monthly Power Plant Report," and Form EIA-920, "Combined Heat and Power Plant Report."

Table 1.6. Biofuels Overview, 2002-2006
(Trillion Btu)

Type	2002	2003	2004	2005	2006
Ethanol					
Feedstock [a]	313	410	497	570	712
Losses and Coproducts [b]	133	174	210	241	301
Production [c]	180	236	287	329	412
Net Imports [d]	1	1	13	11	62
Stock Change [e]	7	-1	0	-2	11
Consumption [f]	175	238	299	342	462
Biodiesel					
Feedstock [g]	1	2	4	12	32
Losses and Coproducts [h]	*	*	*	*	*
Production [i]	1	2	4	12	32

[a] Total corn and other biomass inputs to the production of fuel ethanol.
[b] Losses and co-products from the production of fuel ethanol. Does not include natural gas, electricity, and other non-biomass energy used in the production of fuel ethanol.
[c] Fuel ethanol production.
[d] Fuel ethanol imports. There are no exports.
[e] Fuel ethanol stock change. A negative number indicates a decrease in stocks and a positive number indicates an increase.
[f] Fuel ethanol consumption equals fuel ethanol production, plus fuel ethanol net imports, minus fuel ethanol stock change.
[g] Total soy bean oil and other biomass inputs to the production of biodiesel.
[h] Losses and co-products from the production of biodiesel. Does not include natural gas, electricity, and other non-biomass energy used in the production of biodiesel.
[i] Production of biofuels for use as diesel fuel substitutes or additives. Biodiesel consumption equals biodiesel production.
NA=Not available.
***=Less than 0.5 trillion Btu.**
Note: Totals may not equal sum of components due to independent rounding.
Sources: (Note: For ethanol and biodiesel heat contents, see Table 10.) Ethanol Feedstock: Calculated as fuel ethanol production multiplied by the approximate heat content of the corn and other biomass inputs to the production of fuel ethanol. Ethanol Losses and Co-products: Calculated as ethanol feedstock minus fuel ethanol production. Ethanol Production: 2002 and forward: Energy Information Administration (EIA), Form EIA-819, "Monthly Oxygenate Report," and predescessor form. Ethanol Net Imports, Stocks and Stock Change: 2002-2005: EIA, Petroleum Supply Annual (PSA), annual reports. 2006: EIA, Petroleum Supply Monthly (PSM), monthly reports. Ethanol Consumption: 2002-2004: EIA, PSA, annual reports, Tables 2 and 16. Calculated as ten percent of oxygentated finished motor gasoline field production (Table 2), plus fuel ethanol refinery input (Table 16). 2005: EIA, PSA 2005, Tables 1 and 15. Calculated as motor gasoline blending components adjustments (Table 1), plus finished motor gasoline adjustments adjustments (Table 1), plus fuel ethanol refinery blender net inputs (Table 15). 2006: EIA, PSM, monthly reports, Tables 1 and 27. Calculated as motor gasoline blending components adjustments (Table 1), plus finished motor gasoline adjustments (Table 1), plus fuel ethanol refinery and blender net inputs (Table 27). Biodiesel Feedstock: Calcualted as biodiesel production multiplied by the approximate heat content of the vegetable oil and other biomass inputs to the production of biodiesel. Biodiesel Losses and Co-products: Calculated as biodiesel feedstock minus biodiesel production. Biodiesel Production: 2001-2005 U.S. Department of Agriculture, Commodity Credit Corporation, Bioenergy Program records and 2006 and forward: U.S. Department of Commerce, Bureau of Census, Current Industrial Reports, Fats and Oils - Production, Consumption and Stocks, and analysis conducted by Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.

Table 1.7. Waste Energy Consumption by Type of Waste and Energy Use Sector, 2006
(Trillion Btu)

Type	Sector				
			Electric Power		
	Commercial	Industrial	Electric Utilities	Independent Power Producers	Total
Total	36	140	15	216	407
Landfill Gas	4	74	8	64	150
MSW Biogenic [a]	26	6	4	135	171
Other Biomass [b]	7	61	3	16	86

[a] Includes paper and paper board, wood, food, leather, textiles and yard trimmings.
[b] Agriculture byproducts/crops, sludge waste, and other biomass solids, liquids and gases.
MSW = Municipal Solid Waste
Note: Totals may not equal sum of components due to independent rounding.
Sources: Energy Information Administration, Form EIA-906, "Power Plant Report," Form EIA-920, "Combined Heat and Power Plant Report," and Government Advisory Associates, Resource Recovery Yearbook and Methane Recovery Yearbook; U.S. Environmental Protection Agency, Landfill Methane Outreach Program estimates; and analysis conducted by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.

Table 1.8. Industrial Biomass Energy Consumption and Electricity Net Generation by Industry and Energy Sources, 2006

Industry	Energy Source	Biomass Energy Consumption (Trillon Btus)			Net Generation (Million Kilowatthours)
		Total	For Electricity	For Useful Thermal Output	
Total	Total	1,966.043	357.655	1,608.388	28,897
Agriculture, Forestry and Mining	Total	13.199	2.888	10.310	181
	Agricultural Byproducts/Crops	13.199	2.888	10.310	181
Manufacturing	Total	1,868.156	354.767	1,513.389	28,716
Food and Kindred Products	Total	38.034	1.325	36.708	98
	Agricultural Byproducts/Crops	34.687	0.937	33.750	29
	Other Biomass Gases	0.610	0.042	0.568	8
	Other Biomass Liquids	0.069	0.069	0.000	6
	Wood/Wood Waste Solids	2.668	0.278	2.390	56
Lumber	Total	251.939	16.839	235.099	1,327
	Sludge Waste	0.073	0.015	0.058	2
	Wood/Wood Waste Solids	251.865	16.824	235.041	1,326
Paper and Allied Products	Total	1,256.298	334.917	921.381	27,190
	Agricultural Byproducts/Crops	1.381	0.065	1.316	6
	Black Liquor	853.151	220.683	632.467	17,949
	Landfill Gas	0.046	0.007	0.039	1
	Municipal Solid Waste Biogenic [a]	1.362	0.272	1.089	24
	Other Biomass Gases	0.267	0.031	0.237	4
	Other Biomass Liquids	0.004	0.001	0.003	0
	Other Biomass Solids	4.319	0.570	3.749	112
	Sludge Waste	5.331	2.275	3.056	171
	Wood/Wood Waste Liquids	26.976	3.831	23.146	154
	Wood/Wood Waste Solids	363.462	107.182	256.280	8,768
Chemicals and Allied Products	Total	4.521	0.860	3.661	34
	Landfill Gas	0.160	0.078	0.082	4
	Municipal Solid Waste Biogenic [a]	0.790	0.079	0.711	10
	Other Biomass Liquids	0.161	0.014	0.146	3
	Other Biomass Solids	0.005	0.000	0.005	0
	Sludge Waste	0.389	0.000	0.389	0
	Wood/Wood Waste Solids	3.016	0.689	2.328	17
Biorefineries	Total	301.177	0.000	301.177	0
	Biofuel Losses and Coproducts [b]	301.177	0.000	301.177	0
	Biodiesel Feedstock	0.441	0.000	0.441	0
	Ethanol Feedstock	300.736	0.000	300.736	0
Other [c]	Total	16.187	0.824	15.363	66
Nonspecified [d]	Total	84.688	0.000	84.688	0
	Ethanol	9.429	0.000	9.429	0
	Landfill Gas	72.996	0.000	72.996	0
	Municipal Solid Waste Biogenic [a]	2.263	0.000	2.263	0

[a] Includes paper and paper board, wood, food, leather, textiles and yard trimmings
[b] Losses and coproducts from production of biodiesel and ethanol calculated as the difference between energy in feedstocks and production.
[c] Other includes Apparel; Petroleum Refining; Rubber and Misc. Plastic Products; Transportation Equipment; Stone, Clay, Glass, and Concrete Products; Furniture and Fixtures; and related industries.
[d] Primary purpose of business is not specified.
- = Not Applicable.
Note: Totals may not equal sum of components due to independent rounding.
Sources: Energy Information Administration, Form EIA-906, "Power Plant Report," and Form-920, "Combined Heat and Power Plant Report;" Government Advisory Associates, Resource Recovery Yearbook and Methane Recovery Yearbook; U.S. Environmental Protection Agency, Landfill Methane Outreach Program estimates; Ethanol and biofuel losses and coproducts: Table 2 of this report; and analysis conducted by the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.

Table 1.9. Net Summer Capacity of Plants Cofiring Biomass and Coal, 2006
(Megawatts)

State	Company Name	Plant I.D.	Plant Name	County	Biomass/ Coal Cofiring Capacity	Total Plant Capacity
AL	DTE Energy Services	50407	Mobile Energy Services LLC	Mobile	91	91
AL	Georgia-Pacific Corp	10699	Georgia Pacific Naheola Mill	Choctaw	31	78
AL	International Paper Co	52140	International Paper Prattville Mill	Autauga	49	90
AR	Domtar Industries Inc	54104	Ashdown	Little River	47	156
AZ	Tucson Electric Power Co	126	H Wilson Sundt Generating Station	Pima	173	558
CT	Covanta Mid-Connecticut Inc	54945	Covanta Mid-Connecticut Energy	Hartford	90	90
DE	Conectiv Delmarva Gen Inc	593	Edge Moor	New Castle	252	710
FL	International Paper Co-Pensacola	50250	International Paper Pensacola	Escambia	83	83
FL	Jefferson Smurfit Corp	10202	Jefferson Smurfit Fernandina Beach	Nassau	74	128
FL	Stone Container Corp-Panama Ci	50807	Stone Container Panama City Mill	Bay	20	34
GA	Georgia Pacific CSO LLC	54101	Georgia Pacific Cedar Springs	Early	101	101
GA	International Paper Co-Augusta	54358	International Paper Augusta Mill	Richmond	85	85
GA	SP Newsprint Company	54004	SP Newsprint	Laurens	45	82
HI	Hawaiian Com & Sugar Co Ltd	10604	Hawaiian Comm & Sugar Puunene Mill	Maui	46	62
IA	Ag Processing Inc	10223	AG Processing Inc	Wright	8	8
IA	University of Iowa	54775	University of Iowa Main Power Plant	Johnson	21	23
KY	East Kentucky Power Coop, Inc	6041	H L Spurlock	Mason	329	1,279
LA	International Paper Co	54090	International Paper Louisiana Mill	Morehouse	59	59
MD	NewPage Corporation	50282	Luke Mill	Allegany	65	65
ME	NewPage Corporation	10495	Rumford Cogeneration	Oxford	103	103
ME	S D Warren Co.- Westbrook	50447	S D Warren Westbrook	Cumberland	62	81
MI	Decorative Panels International, Inc.	10149	Decorative Panels Intl	Alpena	8	8
MI	MeadWestvaco Corp.	10208	Escanaba Paper Company	Delta	81	103
MI	TES Filer City Station LP	50835	TES Filer City Station	Manistee	70	70
MN	Minnesota Power Inc	1897	M L Hibbard	St Louis	73	123
MN	Minnesota Power Inc	10686	Rapids Energy Center	Itasca	26	28
MS	Weyerhaeuser Co	50184	Weyerhaeuser Columbus MS	Lowndes	123	123
NC	Corn Products Intl Inc	54618	Corn Products Winston Salem	Forsyth	8	8
NC	Primary Energy of North Carolina LLC	10379	Primary Energy Roxboro	Person	68	68
NC	Weyerhaeuser Co	50189	Weyerhaeuser Plymouth NC	Martin	162	162
NY	AES Greenidge	2527	AES Greenidge LLC	Yates	112	162
NY	AES Hickling LLC	2529	AES Hickling LLC	Steuben	70	70
NY	AES Jennison LLC	2531	AES Jennison LLC	Chenango	60	60
NY	Black River Generation LLC	10464	Black River Generation	Jefferson	56	56
SC	International Paper Co-Eastovr	52151	International Paper Eastover Facility	Richland	48	110
SC	Smurfit-Stone Container Enterprises Inc	50806	Stone Container Florence Mill	Florence	79	108
SC	South Carolina Electric&Gas Co	7737	Cogen South	Charleston	99	99
UT	Desert Power LP	55858	Desert Power LP	Tooele	43	135
VA	Bassett Furniture Industries Inc	50911	Bassett Table	Henry	2	2
VA	GP Big Island LLC	50479	Georgia Pacific Big Island	Bedford	8	8
VA	International Paper	52152	International Paper Franklin Mill	Isle of Wight	96	155
VA	Westvaco Corp	50900	Covington Facility	Covington	105	105
WA	Tacoma City of	3920	Steam plant	Pierce	50	50
WI	Madison Gas & Electric Co	3992	Blount Street	Dane	100	188
WI	Manitowoc Public Utilities	4125	Manitowoc	Manitowoc	10	90
WI	Minergy Neenah LLC	56037	Fox Valley Energy Center	Winnebago	6	6
WI	Mosinee Paper Corp	50614	Mosinee Paper	Marathon	20	23
WI	Northern States Power Co	3982	Bay Front	Ashland	40	68
WI	Stora Enso North America	10234	Biron Mill	Wood	22	62
WI	Stora Enso North America	10476	Whiting Mill	Portage	4	4
WI	Stora Enso North America	10477	Wisconsin Rapids Pulp Mill	Wood	72	72
WI	Stora Enso North America	54857	Niagara Mill	Marinette	12	24
Total					3,569	6,317

Note: State abbreviations are documented on the United States Postal Service website: http://www.usps.com/ncsc/lookups/usps_abbreviations.htm.
Source: Energy Information Administration, Form EIA-860,"Annual Electric Generator Report," Schedule 3, Part B.

Table 1.10. Average Heat Content of Selected Biomass Fuels

Fuel Type	Heat Content	Units
Agricultural Byproducts	8.248	Million Btu/Short Ton
Biodiesel	5.359	Million Btu/Barrel
Black Liquor	11.758	Million Btu/Short Ton
Digester Gas	0.619	Million Btu/Thousand Cubic Feet
Ethanol	3.539	Million Btu/Barrel
Landfill Gas	0.490	Million Btu/Thousand Cubic Feet
MSW Biogenic	9.696	Million Btu/Short Ton
Methane	0.841	Million Btu/Thousand Cubic Feet
Paper Pellets	13.029	Million Btu/Short Ton
Peat	8.000	Million Btu/Short Ton
Railroad Ties	12.618	Million Btu/Short Ton
Sludge Waste	7.512	Million Btu/Short Ton
Sludge Wood	10.071	Million Btu/Short Ton
Solid Byproducts	25.830	Million Btu/Short Ton
Spent Sulfite Liquor	12.720	Million Btu/Short Ton
Utility Poles	12.500	Million Btu/Short Ton
Waste Alcohol	3.800	Million Btu/Barrel
Wood/Wood Waste	9.961	Million Btu/Short Ton

MSW=Municipal Solid Waste.
Note: For detailed characteristics of biomass feedstocks, see the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, website here: http://www1.eere.energy.gov/biomass/for_researchers.html .
Sources: Biodiesel and ethanol: Energy Information Administration, Monthly Energy Review October 2007, DOE/EIA-0035 (2007/10) (Washington, DC, October 2007), Table A3; MSW Biogenic: Energy Information Administration, Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenic Energy (Washington, DC, May 2007); and all other fuel types: Energy Information Administration, Form EIA-860B (1999), "Annual Electric Generator Report - Nonutility 1999."

Table 1.11. Electricity Net Generation From Renewable Energy by Energy Use Sector and Energy Source, 2002-2006 (Thousand Kilowatthours)

Sector/Source	2002	2003	2004	2005	2006
Total	343,438,006	355,293,117	351,020,906	357,533,995	385,669,799
Biomass	53,708,755	53,341,090	53,073,730	54,160,152	54,758,512
Waste	15,043,717	15,811,993	15,497,309	15,479,005	16,109,652
Landfill Gas	4,759,765	5,077,451	5,128,416	5,135,256	5,677,253
MSW Biogenic [a]	8,637,916	8,306,065	8,153,230	8,334,720	8,476,478
Other Biomass [b]	1,646,034	2,428,477	2,215,664	2,009,029	1,955,921
Wood and Derived Fuels [c]	38,665,038	37,529,097	37,576,421	38,681,147	38,648,859
Geothermal	14,491,310	14,424,231	14,810,974	14,691,745	14,568,029
Hydroelectric Conventional	264,328,831	275,806,328	268,417,306	270,321,255	289,246,416
Solar/PV	554,831	534,001	575,155	550,294	507,706
Wind	10,354,279	11,187,467	14,143,741	17,810,549	26,589,137
Commercial	1,078,019	1,374,208	1,645,981	1,752,519	1,688,360
Biomass	1,065,222	1,301,964	1,541,015	1,666,483	1,594,915
Waste	1,052,717	1,288,914	1,527,371	1,650,485	1,574,314
Landfill Gas	99,761	151,801	172,029	210,824	171,979
MSW Biogenic [a]	653,997	716,921	945,812	953,591	956,337
Other Biomass [b]	298,957	420,192	409,530	486,070	445,999
Wood and Derived Fuels [c]	12,505	13,049	13,644	15,998	20,600
Hydroelectric Conventional	12,797	72,245	104,966	86,037	93,446
Industrial	34,313,831	32,926,240	31,923,526	32,082,295	31,796,137
Biomass	30,489,184	28,703,816	28,675,032	28,886,854	28,897,089
Waste	845,979	715,445	839,555	789,325	600,979
Landfill Gas	70,882	96,018	120,014	113,082	28,785
MSW Biogenic [a]	73,543	35,997	31,333	37,463	33,689
Other Biomass [b]	701,554	583,431	688,209	638,781	538,504
Wood and Derived Fuels [c]	29,643,205	27,988,371	27,835,477	28,097,529	28,296,111
Hydroelectric Conventional	3,824,647	4,222,424	3,248,494	3,195,441	2,899,048
Electric Power [d]	308,046,156	320,992,669	317,451,398	323,699,182	352,185,302
Biomass	22,154,349	23,335,310	22,857,682	23,606,816	24,266,508
Waste	13,145,021	13,807,633	13,130,382	13,039,195	13,934,359
Landfill Gas	4,589,122	4,829,632	4,836,372	4,811,350	5,476,488
MSW Biogenic [a]	7,910,375	7,553,146	7,176,084	7,343,666	7,486,452
Other Biomass [b]	645,523	1,424,854	1,117,925	884,178	971,419
Wood and Derived Fuels [c]	9,009,328	9,527,677	9,727,300	10,567,621	10,332,148
Geothermal	14,491,310	14,424,231	14,810,974	14,691,745	14,568,029
Hydroelectric Conventional	260,491,387	271,511,659	265,063,846	267,039,777	286,253,922
Solar/PV	554,831	534,001	575,155	550,294	507,706
Wind	10,354,279	11,187,467	14,143,741	17,810,549	26,589,137

[a] Includes paper and paper board, wood, food, leather, textiles and yard trimmings.
[b] Agriculture byproducts/crops, sludge waste, and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
[d] The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public.
PV=Photovoltaic
MSW=Municipal Solid Waste.
Note: Data revisions are discussed in Highlights section. Revisions to biomass removed MSW non-biogenic and tires from renewable waste energy. Totals may not add due to independent rounding.
Sources: Energy Information Administration, Form EIA-906, "Power Plant Report," and Form EIA-920, "Combined Heat and Power Plant Report."

Table 1.12. U.S. Electric Net Summer Capacity, 2002-2006
(Megawatts)

Source	2002	2003	2004	2005	2006
Total	905,301	948,446	962,942	978,020	986,215
Renewable Total	96,066	96,847	96,357	98,746	101,934
Biomass	9,644	9,628	9,711	9,802	10,100
Waste	3,800	3,758	3,529	3,609	3,727
Landfill Gas	838	863	859	887	978
MSW [a]	2,492	2,442	2,196	2,167	2,188
Other Biomass [b]	470	453	474	554	561
Wood and Derived Fuels [c]	5,844	5,871	6,182	6,193	6,372
Geothermal	2,252	2,133	2,152	2,285	2,274
Hydroelectric Conventional	79,356	78,694	77,641	77,541	77,821
Solar/PV	397	397	398	411	411
Wind	4,417	5,995	6,456	8,706	11,329
Nonrenewable Total	809,236	851,599	866,585	879,274	884,281

[a] Includes total capacity whose primary energy source is MSW.
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases. Does not include tires.
[c] Black liquor, and wood/woodwaste solids and liquids.
MSW=Municipal Solid Waste.
Note: Data revisions are discussed in Highlights section. Revisions to biomass capacity removed tires from renewable waste energy.
Totals may not add due to independent rounding.
Sources: Energy Information Administration, Form EIA-860, "Annual Electric Generator Report."

Table 1.13. Renewable Electricity Net Generation by Energy Source and Census Division, 2006
(Thousand Kilowattthours)

Census Division	Biomass				Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste								
	Landfill Gas	MSW Biogenic [a]	Other Biomass [b]	Wood and Derived Fuels [c]					
Total	5,677,253	8,476,478	1,955,921	38,648,859	14,568,029	289,246,416	507,706	26,589,137	385,669,799
New England	385,863	2,035,095	75,575	4,854,236	-	9,388,153	-	10,688	16,749,610
Middle Atlantic	1,001,612	2,622,271	126,203	1,218,585	-	30,224,233	-	1,032,470	36,225,374
East North Central	1,683,595	252,492	59,315	2,900,838	-	4,493,674	-	372,560	9,762,474
West North Central	216,954	347,695	66,795	586,447	-	7,501,194	-	6,144,355	14,863,441
South Atlantic	453,800	2,659,809	610,339	10,874,453	-	13,446,121	-	173,757	28,218,279
East South Central	115,325	-	30,207	6,231,208	-	17,592,137	-	54,598	24,023,475
West South Central	226,220	-	150,824	5,819,482	-	3,549,323	-	8,382,956	18,128,805
Mountain	36,639	6,179	56,841	625,957	1,534,319	33,802,580	13,134	3,485,620	39,561,269
Pacific Contiguous	1,557,245	363,775	637,143	5,537,139	12,821,434	167,905,306	494,572	6,851,671	196,168,284
Pacific Noncontiguous	-	189,162	142,679	514	212,276	1,343,694	-	80,462	1,968,788

[a] Includes paper and paper board, wood, food, leather, textiles and yard trimmings.
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
PV=Photovoltaic
MSW=Municipal Solid Waste
***=Less than 500 kilowatthours**
Note: Dash indicates the division has no data to report for that energy source. Totals may not add due to independent rounding.
Source: Energy Information Administration, Form EIA-906, "Power Plant Report."

Table 1.14. Industrial Biomass Electricity Net Generation by Census Division and Energy Sources, 2006
(Thousand Kilowattthours)

Energy Source	Census Division										
	New England	Middle Atlantic	East North Central	West North Central	South Atlantic	East South Central	West South Central	Mountain	Pacific Contiguous	Pacific Noncontiguous	Total
Total	1,901,010	739,035	1,695,714	506,688	9,473,607	6,067,872	5,844,973	541,791	2,112,812	13,588	28,897,089
Agricultural Byproducts/Crops	-	-	-	3,544	167,202	6,480	18,203	-	-	7,439	202,868
Black Liquor	791,866	545,067	828,049	149,056	6,702,807	4,241,271	3,796,751	262,087	632,342	-	17,949,296
Landfill Gases	-	-	23,894	-	954	3,937	-	-	-	-	28,785
MSW Biogenic	-	-	-	-	33,689	-	-	-	-	-	33,689
Other Biomass Gases	-	-	2,367	7,612	2,027	-	-	-	-	-	12,007
Other Biomass Liquids	129	2,889	-	-	-	-	-	-	-	6,149	9,167
Other Biomass Solids	-	-	30,507	-	111,057	-	-	-	-	-	141,564
Sludge Waste	39,863	3,467	12,395	4,398	52,065	22,441	7,288	-	30,982	-	172,899
Wood/Wood Waste Liquids	-	76,395	-	-	-	-	-	-	77,843	-	154,237
Wood/Wood Waste Solids	1,069,153	111,217	798,501	342,077	2,403,805	1,793,743	2,022,731	279,704	1,371,645	-	10,192,577

MSW=Municipal Solid Waste.
***=Less than 500 kilowatthours**
Note: Dash indicates the division has no data to report for that energy source. Totals may not add due to independent rounding.
Source: Energy Information Administration, Form EIA-906, "Power Plant Report."

Table 1.15. Renewable Electric Power Sector Net Generation by Energy Source and State, 2005
(Thousand Kilowattthours)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	-	-	202,010	-	10,144,581	-	-	10,346,591
Alaska	-	-	-	-	1,463,942	-	589	1,464,531
Arizona	44,690	-	12,058	-	6,410,064	13,581	-	6,480,393
Arkansas	-	22,770	-	-	3,082,516	-	-	3,105,286
California	1,455,822	259,668	2,748,429	13,022,639	39,626,441	536,713	4,262,229	61,911,941
Colorado	-	33,879	*	-	1,415,296	-	776,234	2,225,857
Connecticut	746,021	-	7,314	-	478,199	-	-	1,231,534
Delaware	-	-	-	-	-	-	-	-
District of Columbia	-	-	-	-	-	-	-	-
Florida	1,773,489	242,555	479,219	-	266,159	-	-	2,761,421
Georgia	16,247	-	-	-	4,012,283	-	-	4,028,530
Hawaii	-	134,783	-	221,597	62,321	-	6,632	425,333
Idaho	-	-	87,703	-	8,542,121	-	-	8,629,824
Illinois	516,661	47,805	-	-	129,037	-	141,146	834,649
Indiana	20,022	-	-	-	438,282	-	-	458,304
Iowa	81,991	-	-	-	959,526	-	1,647,134	2,688,651
Kansas	-	-	-	-	11,337	-	425,823	437,160
Kentucky	62,098	-	-	-	2,961,193	-	-	3,023,291
Louisiana	-	75,961	-	-	810,948	-	-	886,909
Maine	136,078	6,479	1,875,102	-	3,465,890	-	-	5,483,548
Maryland	376,258	-	-	-	1,703,639	-	-	2,079,897
Massachusetts	1,113,754	*	120,027	-	1,041,455	-	-	2,275,248
Michigan	566,219	-	1,064,194	-	1,432,730	-	1,848	3,064,991
Minnesota	398,226	-	102,799	-	645,120	-	1,582,477	2,728,622
Mississippi	-	-	-	-	-	-	-	-
Missouri	-	-	-	-	1,159,326	-	-	1,159,326
Montana	-	-	-	-	9,587,349	-	-	9,587,349
Nebraska	24,566	7,449	-	-	871,473	-	96,608	1,000,096
Nevada	-	-	-	1,262,707	1,702,380	-	-	2,965,087
New Hampshire	156,166	-	661,530	-	1,790,729	-	-	2,608,425
New Jersey	872,481	-	-	-	29,392	-	-	901,873
New Mexico	-	4,644	-	-	164,993	-	794,630	964,267
New York	1,213,349	13,809	286,416	-	25,719,915	-	102,990	27,336,479
North Carolina	87,015	-	388,115	-	4,656,454	-	-	5,131,584
North Dakota	-	-	-	-	1,341,824	-	220,345	1,562,169
Ohio	22,526	-	44,273	-	515,744	-	13,268	595,811
Oklahoma	-	-	-	-	2,630,361	-	847,773	3,478,134
Oregon	70,693	13,319	311,132	-	30,948,345	-	734,274	32,077,763
Pennsylvania	1,232,516	1,672	199,107	-	2,232,179	-	284,241	3,949,715
Rhode Island	-	-	-	-	6,734	-	-	6,734
South Carolina	44,159	-	272,908	-	2,935,642	-	-	3,252,709
South Dakota	-	-	-	-	3,074,566	-	158,104	3,232,670
Tennessee	27,265	-	-	-	8,537,997	-	3,339	8,568,601
Texas	192,377	9,045	-	-	1,332,560	-	4,237,209	5,771,191
Utah	3,948	-	-	184,802	784,463	-	-	973,213
Vermont	-	-	401,638	-	1,189,668	-	11,486	1,602,792
Virginia	434,043	-	540,332	-	1,471,118	-	-	2,445,493
Washington	170,700	5,889	620,298	-	72,022,983	-	498,470	73,318,340
West Virginia	-	*	*	-	891,891	-	153,892	1,046,496
Wisconsin	295,638	4,188	142,108	-	1,530,237	-	92,544	2,064,715
Wyoming	-	-	-	-	808,375	-	717,264	1,525,639
Total	12,155,016	884,178	10,567,621	14,691,745	267,039,777	550,294	17,810,549	323,699,181

[a] Includes landfill gas and MSW biogenic (Paper and paper board, wood, food, leather, textiles and yard trimmings.).
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
***=Less than 500 kilowatthours**
PV=Photovoltaic.
MSW=Municipal Solid Waste.
Note: Revisions to biomass removed MSW non-biogenic and tires from renewable waste energy. The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-906,"Power Plant Report," and Form EIA-920, " Combined Heat and Power Plant Report."

Table 1.16. Renewable Commercial and Industrial Sector Net Generation by Energy Source and State, 2005 (Thousand Kilowattthours)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	3,494	17,342	3,536,410	-	-	-	-	3,557,246
Alaska	-	4,873	*	-	-	-	-	5,254
Arizona	-	3,666	-	-	-	-	-	3,666
Arkansas	-	4,923	1,706,996	-	-	-	-	1,711,920
California	131,675	369,568	861,668	-	5,426	-	-	1,368,336
Colorado	-	-	-	-	-	-	-	-
Connecticut	-	-	-	-	-	-	-	-
Delaware	-	-	-	-	-	-	-	-
District of Columbia	-	-	-	-	-	-	-	-
Florida	1,783	340,090	1,526,718	-	-	-	-	1,868,592
Georgia	12,424	48,711	3,148,749	-	19,770	-	-	3,229,654
Hawaii	163,003	12,932	-	-	33,867	-	-	209,802
Idaho	-	-	489,337	-	-	-	-	489,337
Illinois	76,664	646	-	-	-	-	-	77,310
Indiana	47,757	-	-	-	-	-	-	47,757
Iowa	-	34,852	-	-	-	-	-	34,852
Kansas	-	-	-	-	-	-	-	-
Kentucky	-	1,222	359,065	-	-	-	-	360,287
Louisiana	-	4,546	2,643,987	-	-	-	-	2,648,533
Maine	97,726	48,075	1,911,531	-	625,036	-	-	2,682,368
Maryland	41,147	-	195,466	-	-	-	-	236,613
Massachusetts	-	24,498	-	-	*	-	-	24,993
Michigan	147,849	3,021	737,136	-	28,978	-	-	916,984
Minnesota	11,028	6,476	546,617	-	129,609	-	-	693,728
Mississippi	-	5,344	1,519,941	-	-	-	-	1,525,285
Missouri	-	9,249	-	-	-	-	-	9,249
Montana	-	-	65,245	-	-	-	-	65,245
Nebraska	-	10,631	-	-	-	-	-	10,631
Nevada	-	-	-	-	-	-	-	-
New Hampshire	-	-	124,203	-	8,174	-	-	132,377
New Jersey	-	2,425	-	-	1,721	-	-	4,145
New Mexico	-	-	-	-	-	-	-	-
New York	130,800	-	251,094	-	62,603	-	-	444,497
North Carolina	-	11,770	1,351,468	-	740,048	-	-	2,103,286
North Dakota	-	9,989	-	-	-	-	-	9,989
Ohio	-	4,279	314,741	-	-	-	-	319,020
Oklahoma	-	-	289,217	-	-	-	-	289,217
Oregon	-	14,031	498,174	-	-	-	-	512,205
Pennsylvania	119,519	4,023	488,389	-	-	-	-	611,931
Rhode Island	-	-	-	-	-	-	-	-
South Carolina	43,592	-	1,424,557	-	2,505	-	-	1,470,654
South Dakota	-	-	-	-	-	-	-	-
Tennessee	-	-	528,281	-	771,544	-	-	1,299,825
Texas	14,421	37,569	843,789	-	-	-	-	895,778
Utah	-	-	-	-	-	-	-	-
Vermont	-	-	8,853	-	21,143	-	-	29,997
Virginia	242,699	20,820	1,259,530	-	13,235	-	-	1,536,285
Washington	-	21,447	799,096	-	51,666	-	-	872,210
West Virginia	-	-	-	-	555,675	-	-	555,675
Wisconsin	29,381	47,830	682,888	-	209,982	-	-	970,081
Wyoming	-	-	-	-	-	-	-	-
Total	1,314,959	1,124,850	28,113,526	-	3,281,478	-	-	33,834,814

[a] Includes landfill gas and MSW biogenic (Paper and paper board, wood, food, leather, textiles and yard trimmings.).
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
***=Less than 500 kilowatthours**
PV=Photovoltaic.
MSW=Municipal Solid Waste.
Note: Revisions to biomass removed MSW non-biogenic and tires from renewable waste energy. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-906,"Power Plant Report," and Form EIA-920, " Combined Heat and Power Plant Report."

Table 1.17. Total Renewable Net Generation by Energy Source and State, 2005
(Thousand Kilowattthours)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	3,494	17,342	3,738,421	-	10,144,581	-	-	13,903,838
Alaska	-	4,873	*	-	1,463,942	-	589	1,469,785
Arizona	44,690	3,666	12,058	-	6,410,064	13,581	-	6,484,059
Arkansas	-	27,693	1,706,996	-	3,082,516	-	-	4,817,205
California	1,587,497	629,236	3,610,097	13,022,639	39,631,867	536,713	4,262,229	63,280,278
Colorado	-	33,879	*	-	1,415,296	-	776,234	2,225,857
Connecticut	746,021	-	7,314	-	478,199	-	-	1,231,534
Delaware	-	-	-	-	-	-	-	-
District of Columbia	-	-	-	-	-	-	-	-
Florida	1,775,272	582,645	2,005,937	-	266,159	-	-	4,630,013
Georgia	28,671	48,711	3,148,749	-	4,032,053	-	-	7,258,184
Hawaii	163,003	147,715	-	221,597	96,188	-	6,632	635,135
Idaho	-	-	577,040	-	8,542,121	-	-	9,119,161
Illinois	593,325	48,452	-	-	129,037	-	141,146	911,960
Indiana	67,779	-	-	-	438,282	-	-	506,061
Iowa	81,991	34,852	-	-	959,526	-	1,647,134	2,723,503
Kansas	-	-	-	-	11,337	-	425,823	437,160
Kentucky	62,098	1,222	359,065	-	2,961,193	-	-	3,383,578
Louisiana	-	80,507	2,643,987	-	810,948	-	-	3,535,442
Maine	233,803	54,554	3,786,633	-	4,090,926	-	-	8,165,916
Maryland	417,405	-	195,466	-	1,703,639	-	-	2,316,510
Massachusetts	1,113,754	24,510	120,027	-	1,041,950	-	-	2,300,240
Michigan	714,068	3,021	1,801,330	-	1,461,708	-	1,848	3,981,975
Minnesota	409,254	6,476	649,415	-	774,729	-	1,582,477	3,422,350
Mississippi	-	5,344	1,519,941	-	-	-	-	1,525,285
Missouri	-	9,249	-	-	1,159,326	-	-	1,168,575
Montana	-	-	65,245	-	9,587,349	-	-	9,652,594
Nebraska	24,566	18,080	-	-	871,473	-	96,608	1,010,727
Nevada	-	-	-	1,262,707	1,702,380	-	-	2,965,087
New Hampshire	156,166	-	785,733	-	1,798,903	-	-	2,740,802
New Jersey	872,481	2,425	-	-	31,113	-	-	906,018
New Mexico	-	4,644	-	-	164,993	-	794,630	964,267
New York	1,344,149	13,809	537,510	-	25,782,518	-	102,990	27,780,976
North Carolina	87,015	11,770	1,739,583	-	5,396,502	-	-	7,234,871
North Dakota	-	9,989	-	-	1,341,824	-	220,345	1,572,158
Ohio	22,526	4,279	359,014	-	515,744	-	13,268	914,831
Oklahoma	-	-	289,217	-	2,630,361	-	847,773	3,767,351
Oregon	70,693	27,350	809,306	-	30,948,345	-	734,274	32,589,968
Pennsylvania	1,352,035	5,695	687,496	-	2,232,179	-	284,241	4,561,646
Rhode Island	-	-	-	-	6,734	-	-	6,734
South Carolina	87,751	-	1,697,465	-	2,938,147	-	-	4,723,363
South Dakota	-	-	-	-	3,074,566	-	158,104	3,232,670
Tennessee	27,265	-	528,281	-	9,309,541	-	3,339	9,868,426
Texas	206,798	46,614	843,789	-	1,332,560	-	4,237,209	6,666,969
Utah	3,948	-	-	184,802	784,463	-	-	973,213
Vermont	-	-	410,491	-	1,210,811	-	11,486	1,632,789
Virginia	676,742	20,820	1,799,862	-	1,484,353	-	-	3,981,778
Washington	170,700	27,336	1,419,394	-	72,074,649	-	498,470	74,190,549
West Virginia	-	*	*	-	1,447,566	-	153,892	1,602,171
Wisconsin	325,019	52,018	824,996	-	1,740,219	-	92,544	3,034,797
Wyoming	-	-	-	-	808,375	-	717,264	1,525,639
Total	13,469,976	2,009,029	38,681,147	14,691,745	270,321,255	550,294	17,810,549	357,533,995

[a] Includes landfill gas and MSW biogenic (Paper and paper board, wood, food, leather, textiles and yard trimmings.).
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
***=Less than 500 kilowatthours**
PV=Photovoltaic.
MSW=Municipal Solid Waste.
Note: Revisions to biomass removed MSW non-biogenic and tires from renewable waste energy. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-906,"Power Plant Report," and Form EIA-920, " Combined Heat and Power Plant Report."

Table 1.18. Renewable Electric Power Sector Net Generation by Energy Source and State, 2006
(Thousand Kilowattthours)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	-	-	196,194	-	7,251,786	-	-	7,447,980
Alaska	-	-	-	-	1,223,607	-	788	1,224,395
Arizona	27,929	-	8,240	-	6,792,904	13,134	-	6,842,207
Arkansas	7,407	20,439	-	-	1,550,558	-	-	1,578,404
California	1,561,782	275,651	2,564,861	12,821,434	48,039,986	494,572	4,882,801	70,641,086
Colorado	-	30,692	-	-	1,791,207	-	865,536	2,687,435
Connecticut	754,776	-	8,544	-	543,892	-	-	1,307,212
Delaware	*	-	-	-	-	-	-	*
District of Columbia	-	-	-	-	-	-	-	-
Florida	1,824,337	242,575	471,773	-	203,422	-	-	2,742,107
Georgia	14,908	-	-	-	2,545,504	-	-	2,560,412
Hawaii	-	129,092	-	212,276	81,792	-	79,674	502,834
Idaho	-	-	75,926	-	11,242,372	-	169,617	11,487,915
Illinois	581,899	11,993	-	-	173,272	-	254,571	1,021,735
Indiana	173,991	-	-	-	489,515	-	-	663,506
Iowa	100,268	-	-	-	909,348	-	2,317,821	3,327,437
Kansas	-	-	-	-	9,649	-	991,890	1,001,539
Kentucky	87,713	-	-	-	2,591,701	-	-	2,679,414
Louisiana	-	76,304	-	-	713,215	-	-	789,519
Maine	139,382	8,142	1,843,355	-	3,499,336	-	-	5,490,215
Maryland	392,949	-	-	-	2,104,275	-	-	2,497,224
Massachusetts	1,126,129	*	125,258	-	1,504,072	-	-	2,755,819
Michigan	583,412	-	1,065,409	-	1,488,242	-	2,212	3,139,275
Minnesota	400,307	-	95,218	-	475,342	-	2,054,947	3,025,814
Mississippi	-	-	-	-	-	-	-	-
Missouri	15,195	-	*	-	199,214	-	-	214,505
Montana	-	-	-	-	10,130,161	-	435,970	10,566,131
Nebraska	37,404	3,137	-	-	893,386	-	261,247	1,195,174
Nevada	-	-	-	1,343,711	2,057,626	-	-	3,401,337
New Hampshire	156,399	-	580,433	-	1,523,637	-	-	2,260,469
New Jersey	803,245	94,659	-	-	34,076	-	15,991	947,971
New Mexico	-	21,885	-	-	198,211	-	1,255,436	1,475,532
New York	1,276,264	10,840	292,404	-	27,252,046	-	655,371	29,486,925
North Carolina	88,110	-	447,665	-	3,333,173	-	-	3,868,948
North Dakota	-	-	-	-	1,521,034	-	369,485	1,890,519
Ohio	23,653	-	37,883	-	631,936	-	14,401	707,873
Oklahoma	-	-	-	-	623,579	-	1,712,441	2,336,020
Oregon	71,203	13,926	290,225	-	37,850,297	-	931,219	39,156,871
Pennsylvania	1,297,255	14,348	193,502	-	2,844,142	-	361,108	4,710,354
Rhode Island	148,913	-	-	-	5,909	-	-	154,822
South Carolina	61,042	-	348,887	-	1,805,295	-	-	2,215,224
South Dakota	-	-	-	-	3,396,833	-	148,965	3,545,798
Tennessee	23,675	1,286	-	-	7,167,342	-	54,598	7,246,901
Texas	201,073	7,585	-	-	661,971	-	6,670,515	7,541,144
Utah	6,179	-	-	190,608	746,783	-	-	943,570
Vermont	-	-	435,628	-	1,497,064	-	10,688	1,943,380
Virginia	443,218	-	482,711	-	1,344,890	-	-	2,270,819
Washington	165,496	6,843	600,223	-	81,943,845	-	1,037,651	83,754,058
West Virginia	-	-	-	-	1,048,467	-	173,757	1,222,224
Wisconsin	367,010	1,662	167,715	-	1,474,692	-	101,376	2,112,455
Wyoming	-	-	-	-	843,316	-	759,061	1,602,377
Total	12,962,940	971,419	10,332,148	14,568,029	286,253,922	507,706	26,589,137	352,185,302

[a] Includes landfill gas and MSW biogenic (Paper and paper board, wood, food, leather, textiles and yard trimmings.).
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
***=Less than 500 kilowatthours**
PV=Photovoltaic.
MSW=Municipal Solid Waste.
Note: Revisions to biomass removed MSW non-biogenic and tires from renewable waste energy. The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-906,"Power Plant Report," and Form EIA-920, " Combined Heat and Power Plant Report."

Table 1.19. Renewable Commercial and Industrial Sector Net Generation by Energy Source and State, 2006
(Thousand Kilowattthours)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	3,937	20,750	3,684,860	-	-	-	-	3,709,548
Alaska	-	6,149	514	-	-	-	-	6,663
Arizona	-	4,264	-	-	-	-	-	4,264
Arkansas	-	5,441	1,668,515	-	-	-	-	1,673,956
California	122,539	309,741	857,233	-	7,394	-	-	1,296,907
Colorado	-	-	-	-	-	-	-	-
Connecticut	-	-	-	-	-	-	-	-
Delaware	-	-	-	-	-	-	-	-
District of Columbia	-	-	-	-	-	-	-	-
Florida	954	309,355	1,523,481	-	-	-	-	1,833,791
Georgia	9,841	36,984	3,381,260	-	23,333	-	-	3,451,418
Hawaii	189,162	7,439	-	-	38,295	-	-	234,896
Idaho	-	-	453,672	-	-	-	-	453,672
Illinois	-	*	-	-	-	-	-	*
Indiana	46,323	-	-	-	-	-	-	46,323
Iowa	-	36,631	-	-	-	-	-	36,631
Kansas	-	-	-	-	-	-	-	-
Kentucky	-	1,691	369,986	-	-	-	-	371,677
Louisiana	-	5,124	2,949,599	-	-	-	-	2,954,723
Maine	95,359	39,992	1,847,855	-	778,796	-	-	2,762,002
Maryland	15,152	-	221,140	-	-	-	-	236,293
Massachusetts	-	27,082	-	-	8,573	-	-	35,654
Michigan	151,930	1,743	647,321	-	32,111	-	-	833,106
Minnesota	11,475	4,398	491,133	-	96,388	-	-	603,394
Mississippi	-	6,480	1,534,603	-	-	-	-	1,541,083
Missouri	-	7,612	-	-	-	-	-	7,612
Montana	-	-	88,119	-	-	-	-	88,119
Nebraska	-	11,472	-	-	-	-	-	11,472
Nevada	-	-	-	-	-	-	-	-
New Hampshire	-	-	9,570	-	5,273	-	-	14,842
New Jersey	-	2,889	-	-	1,360	-	-	4,249
New Mexico	-	-	-	-	-	-	-	-
New York	133,778	-	237,830	-	92,609	-	-	464,218
North Carolina	-	3,744	1,295,384	-	505,839	-	-	1,804,966
North Dakota	-	3,544	-	-	-	-	-	3,544
Ohio	-	10,205	312,753	-	-	-	-	322,958
Oklahoma	-	-	300,480	-	-	-	-	300,480
Oregon	-	13,524	549,758	-	-	-	-	563,283
Pennsylvania	113,341	3,467	494,849	-	-	-	-	611,657
Rhode Island	-	-	-	-	-	-	-	-
South Carolina	45,051	-	1,381,894	-	1,653	-	-	1,428,598
South Dakota	-	-	-	-	-	-	-	-
Tennessee	-	-	445,565	-	581,308	-	-	1,026,873
Texas	17,740	35,931	900,888	-	-	-	-	954,559
Utah	8,710	-	-	-	-	-	-	8,710
Vermont	-	-	3,594	-	21,601	-	-	25,195
Virginia	217,629	17,681	1,320,259	-	6,304	-	-	1,561,873
Washington	-	17,457	674,839	-	63,784	-	-	756,080
West Virginia	-	-	-	-	523,966	-	-	523,966
Wisconsin	7,868	33,322	669,756	-	203,906	-	-	914,852
Wyoming	-	-	-	-	-	-	-	-
Total	1,190,791	984,502	28,316,711	-	2,992,493	-	-	33,484,497

[a] Includes landfill gas and MSW biogenic (Paper and paper board, wood, food, leather, textiles and yard trimmings.).
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
***=Less than 500 kilowatthours**
PV=Photovoltaic.
MSW=Municipal Solid Waste.
Note: Revisions to biomass removed MSW non-biogenic and tires from renewable waste energy. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-906,"Power Plant Report," and Form EIA-920, " Combined Heat and Power Plant Report."

Table 1.20. Total Renewable Net Generation by Energy Source and State, 2006
(Thousand Kilowattthours)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	3,937	20,750	3,881,054	-	7,251,786	-	-	11,157,527
Alaska	-	6,149	514	-	1,223,607	-	788	1,231,058
Arizona	27,929	4,264	8,240	-	6,792,904	13,134	-	6,846,471
Arkansas	7,407	25,880	1,668,515	-	1,550,558	-	-	3,252,360
California	1,684,321	585,392	3,422,093	12,821,434	48,047,380	494,572	4,882,801	71,937,993
Colorado	-	30,692	-	-	1,791,207	-	865,536	2,687,435
Connecticut	754,776	-	8,544	-	543,892	-	-	1,307,212
Delaware	*	-	-	-	-	-	-	*
District of Columbia	-	-	-	-	-	-	-	-
Florida	1,825,292	551,930	1,995,254	-	203,422	-	-	4,575,897
Georgia	24,749	36,984	3,381,260	-	2,568,837	-	-	6,011,830
Hawaii	189,162	136,530	-	212,276	120,087	-	79,674	737,729
Idaho	-	-	529,598	-	11,242,372	-	169,617	11,941,587
Illinois	581,899	12,383	-	-	173,272	-	254,571	1,022,125
Indiana	220,314	-	-	-	489,515	-	-	709,829
Iowa	100,268	36,631	-	-	909,348	-	2,317,821	3,364,068
Kansas	-	-	-	-	9,649	-	991,890	1,001,539
Kentucky	87,713	1,691	369,986	-	2,591,701	-	-	3,051,091
Louisiana	-	81,428	2,949,599	-	713,215	-	-	3,744,242
Maine	234,741	48,133	3,691,210	-	4,278,132	-	-	8,252,216
Maryland	408,102	-	221,140	-	2,104,275	-	-	2,733,517
Massachusetts	1,126,129	27,442	125,258	-	1,512,645	-	-	2,791,473
Michigan	735,343	1,743	1,712,730	-	1,520,353	-	2,212	3,972,381
Minnesota	411,782	4,398	586,351	-	571,730	-	2,054,947	3,629,208
Mississippi	-	6,480	1,534,603	-	-	-	-	1,541,083
Missouri	15,195	7,612	*	-	199,214	-	-	222,117
Montana	-	-	88,119	-	10,130,161	-	435,970	10,654,250
Nebraska	37,404	14,610	-	-	893,386	-	261,247	1,206,647
Nevada	-	-	-	1,343,711	2,057,626	-	-	3,401,337
New Hampshire	156,399	-	590,003	-	1,528,910	-	-	2,275,311
New Jersey	803,245	97,548	-	-	35,436	-	15,991	952,220
New Mexico	-	21,885	-	-	198,211	-	1,255,436	1,475,532
New York	1,410,042	10,840	530,234	-	27,344,655	-	655,371	29,951,143
North Carolina	88,110	3,744	1,743,048	-	3,839,012	-	-	5,673,914
North Dakota	-	3,544	-	-	1,521,034	-	369,485	1,894,063
Ohio	23,653	10,205	350,637	-	631,936	-	14,401	1,030,831
Oklahoma	-	-	300,480	-	623,579	-	1,712,441	2,636,500
Oregon	71,203	27,450	839,984	-	37,850,297	-	931,219	39,720,153
Pennsylvania	1,410,596	17,815	688,351	-	2,844,142	-	361,108	5,322,011
Rhode Island	148,913	-	-	-	5,909	-	-	154,822
South Carolina	106,093	-	1,730,781	-	1,806,948	-	-	3,643,822
South Dakota	-	-	-	-	3,396,833	-	148,965	3,545,798
Tennessee	23,675	1,286	445,565	-	7,748,650	-	54,598	8,273,774
Texas	218,813	43,516	900,888	-	661,971	-	6,670,515	8,495,704
Utah	14,889	-	-	190,608	746,783	-	-	952,280
Vermont	-	-	439,222	-	1,518,665	-	10,688	1,968,575
Virginia	660,847	17,681	1,802,970	-	1,351,194	-	-	3,832,692
Washington	165,496	24,301	1,275,062	-	82,007,629	-	1,037,651	84,510,138
West Virginia	-	-	-	-	1,572,433	-	173,757	1,746,190
Wisconsin	374,878	34,984	837,471	-	1,678,598	-	101,376	3,027,307
Wyoming	-	-	-	-	843,316	-	759,061	1,602,377
Total	14,153,731	1,955,921	38,648,859	14,568,029	289,246,416	507,706	26,589,137	385,669,799

[a] Includes landfill gas and MSW biogenic (Paper and paper board, wood, food, leather, textiles and yard trimmings.).
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
***=Less than 500 kilowatthours**
PV=Photovoltaic.
MSW=Municipal Solid Waste.
Note: Revisions to biomass removed MSW non-biogenic and tires from renewable waste energy. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-906,"Power Plant Report," and Form EIA-920, " Combined Heat and Power Plant Report."

Table 1.21. Renewable Electric Power Sector Net Summer Capacity by Energy Source and State, 2005 (Megawatts)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	-	-	-	-	3,240	-	-	3,240
Alaska	-	-	-	-	397	-	10	406
Arizona	4	-	3	-	2,720	9	-	2,736
Arkansas	-	4	-	-	1,388	-	-	1,392
California	245	49	429	2,046	10,082	402	2,052	15,305
Colorado	-	10	-	-	652	-	228	889
Connecticut	166	-	-	-	146	-	-	313
Delaware	-	-	-	-	-	-	-	-
District of Columbia	-	-	-	-	-	-	-	-
Florida	442	75	67	-	55	-	-	639
Georgia	2	-	-	-	2,007	-	-	2,010
Hawaii	-	46	-	31	18	-	11	107
Idaho	-	-	12	-	2,390	-	11	2,412
Illinois	88	25	-	-	32	-	105	250
Indiana	10	-	-	-	60	-	-	69
Iowa	6	-	-	-	131	-	820	958
Kansas	-	-	-	-	3	-	263	266
Kentucky	10	-	-	-	817	-	-	827
Louisiana	-	12	-	-	192	-	-	204
Maine	30	35	217	-	620	-	-	901
Maryland	118	-	-	-	566	-	-	684
Massachusetts	261	-	26	-	253	-	-	540
Michigan	90	-	158	-	249	-	1	498
Minnesota	133	-	76	-	147	-	687	1,043
Mississippi	-	-	-	-	-	-	-	-
Missouri	-	-	-	-	552	-	-	552
Montana	-	-	-	-	2,619	-	135	2,754
Nebraska	3	1	-	-	269	-	73	346
Nevada	-	-	-	185	1,047	-	-	1,233
New Hampshire	31	-	91	-	507	-	-	629
New Jersey	181	19	-	-	3	-	-	203
New Mexico	-	6	-	-	82	-	404	492
New York	270	-	37	-	4,192	-	185	4,683
North Carolina	14	-	79	-	1,785	-	-	1,879
North Dakota	-	-	-	-	432	-	96	528
Ohio	4	-	7	-	101	-	7	119
Oklahoma	-	-	-	-	800	-	474	1,274
Oregon	14	3	56	-	8,336	-	298	8,708
Pennsylvania	310	-	28	-	748	-	223	1,309
Rhode Island	24	-	-	-	4	-	-	28
South Carolina	9	-	-	-	1,347	-	-	1,356
South Dakota	-	-	-	-	1,500	-	43	1,543
Tennessee	5	2	12	-	2,415	-	29	2,463
Texas	41	-	-	-	673	-	1,755	2,469
Utah	1	-	-	23	255	-	-	279
Vermont	-	-	72	-	304	-	5	381
Virginia	93	-	83	-	669	-	-	844
Washington	35	4	136	-	21,138	-	393	21,707
West Virginia	-	-	-	-	163	-	66	229
Wisconsin	46	1	73	-	444	-	45	610
Wyoming	-	-	-	-	303	-	287	590
Total	2,685	293	1,662	2,285	76,852	411	8,706	92,895

[a] Total capacity whose primary energy source is landfill gas or MSW.
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
PV=Photovoltaic.
MSW=Municipal Solid Waste.
*** =Less than 500 kilowatts.**
Note: Revisions to biomass capacity removed tires from renewable waste energy. The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-860,"Annual Electric Generator Report."

Table 1.22. Renewable Commercial and Industrial Sector Net Summer Capacity by Energy Source and State, 2005 (Megawatts)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	-	-	553	-	-	-	-	553
Alaska	-	-	-	-	-	-	-	-
Arizona	-	-	-	-	-	-	-	-
Arkansas	-	2	292	-	-	-	-	293
California	13	96	147	-	6	-	-	262
Colorado	-	-	-	-	-	-	-	-
Connecticut	-	-	-	-	-	-	-	-
Delaware	-	-	-	-	-	-	-	-
Florida	-	70	276	-	-	-	-	346
Georgia	2	44	450	-	7	-	-	504
Hawaii	60	3	-	-	5	-	-	68
Idaho	-	-	66	-	-	-	-	66
Illinois	12	3	-	-	1	-	-	15
Indiana	9	-	-	-	-	-	-	9
Iowa	-	3	-	-	-	-	-	3
Kansas	-	-	-	-	-	-	-	-
Kentucky	-	-	43	-	-	-	-	43
Louisiana	-	3	318	-	-	-	-	321
Maine	24	-	388	-	100	-	-	512
Maryland	7	-	2	-	-	-	-	9
Massachusetts	-	9	-	-	7	-	-	16
Michigan	67	-	52	-	4	-	-	122
Minnesota	4	-	60	-	29	-	-	93
Mississippi	-	-	229	-	-	-	-	229
Missouri	-	-	-	-	-	-	-	-
Montana	-	-	17	-	-	-	-	17
Nebraska	-	3	-	-	-	-	-	3
New Hampshire	-	-	14	-	-	-	-	14
New Jersey	-	1	-	-	-	-	-	1
New Mexico	-	-	-	-	-	-	-	-
New York	33	-	-	-	15	-	-	48
North Carolina	-	-	211	-	160	-	-	371
North Dakota	-	10	-	-	-	-	-	10
Ohio	-	-	17	-	-	-	-	17
Oklahoma	16	-	63	-	-	-	-	78
Oregon	-	-	136	-	-	-	-	136
Pennsylvania	34	-	80	-	-	-	-	114
Rhode Island	-	-	-	-	-	-	-	-
South Carolina	10	-	217	-	1	-	-	228
Tennessee	-	-	100	-	193	-	-	293
Texas	-	16	130	-	-	-	-	145
Utah	-	-	-	-	-	-	-	-
Vermont	-	-	4	-	5	-	-	8
Virginia	76	-	326	-	4	-	-	405
Washington	-	-	192	-	8	-	-	200
West Virginia	-	-	-	-	101	-	-	101
Wisconsin	4	-	148	-	43	-	-	195
Wyoming	-	-	-	-	-	-	-	-
Total	369	261	4,532	-	688	-	-	5,850

[a] Total capacity whose primary energy source is landfill gas or MSW.
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
PV=Photovoltaic.
MSW=Municipal Solid Waste.
*** =Less than 500 kilowatts.**
Note: Revisions to biomass capacity removed tires from renewable waste energy. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-860,"Annual Electric Generator Report."

Table 1.23. Total Renewable Net Summer Capacity by Energy Source and State, 2005 (Megawatts)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	-	-	553	-	3,240	-	-	3,793
Alaska	-	-	-	-	397	-	10	406
Arizona	4	-	3	-	2,720	9	-	2,736
Arkansas	-	6	292	-	1,388	-	-	1,686
California	258	145	577	2,046	10,087	402	2,052	15,567
Colorado	-	10	-	-	652	-	228	889
Connecticut	166	-	-	-	146	-	-	313
Delaware	-	-	-	-	-	-	-	-
District of Columbia	-	-	-	-	-	-	-	-
Florida	442	145	343	-	55	-	-	985
Georgia	5	44	450	-	2,014	-	-	2,513
Hawaii	60	49	-	31	24	-	11	175
Idaho	-	-	78	-	2,390	-	11	2,478
Illinois	100	28	-	-	33	-	105	265
Indiana	19	-	-	-	60	-	-	78
Iowa	6	3	-	-	131	-	820	961
Kansas	-	-	-	-	3	-	263	266
Kentucky	10	-	43	-	817	-	-	870
Louisiana	-	15	318	-	192	-	-	525
Maine	53	35	605	-	720	-	-	1,413
Maryland	125	-	2	-	566	-	-	693
Massachusetts	261	9	26	-	260	-	-	556
Michigan	157	-	210	-	253	-	1	620
Minnesota	137	-	136	-	176	-	687	1,136
Mississippi	-	-	229	-	-	-	-	229
Missouri	-	-	-	-	552	-	-	552
Montana	-	-	17	-	2,619	-	135	2,772
Nebraska	3	4	-	-	269	-	73	349
Nevada	-	-	-	185	1,047	-	-	1,233
New Hampshire	31	-	104	-	507	-	-	643
New Jersey	181	20	-	-	3	-	-	204
New Mexico	-	6	-	-	82	-	404	492
New York	303	-	37	-	4,207	-	185	4,732
North Carolina	14	-	291	-	1,945	-	-	2,250
North Dakota	-	10	-	-	432	-	96	537
Ohio	4	-	24	-	101	-	7	135
Oklahoma	16	-	63	-	800	-	474	1,353
Oregon	14	3	193	-	8,336	-	298	8,844
Pennsylvania	344	-	108	-	748	-	223	1,423
Rhode Island	24	-	-	-	4	-	-	28
South Carolina	19	-	217	-	1,348	-	-	1,583
South Dakota	-	-	-	-	1,500	-	43	1,543
Tennessee	5	2	113	-	2,608	-	29	2,756
Texas	41	16	130	-	673	-	1,755	2,614
Utah	1	-	-	23	255	-	-	279
Vermont	-	-	76	-	309	-	5	389
Virginia	168	-	409	-	672	-	-	1,249
Washington	35	4	328	-	21,146	-	393	21,907
West Virginia	-	-	-	-	264	-	66	330
Wisconsin	50	1	221	-	487	-	45	805
Wyoming	-	-	-	-	303	-	287	590
Total	3,055	554	6,193	2,285	77,540	411	8,706	98,745

[a] Total capacity whose primary energy source is landfill gas or MSW.
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
PV=Photovoltaic.
MSW=Municipal Solid Waste.
*** =Less than 500 kilowatts.**
Note: Revisions to biomass capacity removed tires from renewable waste energy. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-860,"Annual Electric Generator Report."

Table 1.24. Renewable Electric Power Sector Net Capacity by Energy Source and State, 2006 (Megawatts)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	-	-	-	-	3,271	-	-	3,271
Alaska	-	-	-	-	397	-	3	400
Arizona	4	-	3	-	2,720	9	-	2,736
Arkansas	5	4	-	-	1,389	-	-	1,397
California	263	49	436	2,032	10,077	402	2,255	15,514
Colorado	-	10	-	-	652	-	289	950
Connecticut	170	-	-	-	147	-	-	316
Delaware	7	-	-	-	-	-	-	7
District of Columbia	-	-	-	-	-	-	-	-
Florida	447	75	67	-	55	-	-	643
Georgia	2	-	-	-	2,020	-	-	2,022
Hawaii	-	46	-	31	18	-	43	138
Idaho	-	-	12	-	2,378	-	75	2,464
Illinois	111	13	-	-	32	-	105	261
Indiana	22	-	-	-	60	-	-	82
Iowa	11	-	-	-	131	-	921	1,064
Kansas	-	-	-	-	3	-	363	366
Kentucky	12	-	-	-	815	-	-	827
Louisiana	-	12	-	-	192	-	-	204
Maine	30	36	220	-	602	-	-	888
Maryland	118	-	-	-	566	-	-	684
Massachusetts	261	-	26	-	253	-	-	540
Michigan	83	-	158	-	253	-	2	496
Minnesota	123	-	79	-	147	-	827	1,176
Mississippi	-	-	-	-	-	-	-	-
Missouri	3	-	-	-	552	-	-	555
Montana	-	-	-	-	2,604	-	145	2,749
Nebraska	6	1	-	-	272	-	73	352
Nevada	-	-	-	188	1,047	-	-	1,236
New Hampshire	31	-	128	-	512	-	-	671
New Jersey	181	19	-	-	5	-	8	212
New Mexico	-	6	-	-	82	-	494	582
New York	280	-	37	-	4,292	-	370	4,979
North Carolina	14	-	80	-	1,794	-	-	1,889
North Dakota	-	-	-	-	443	-	164	607
Ohio	4	-	7	-	101	-	7	119
Oklahoma	-	-	-	-	851	-	594	1,446
Oregon	14	3	58	-	8,374	-	399	8,848
Pennsylvania	331	-	28	-	748	-	150	1,257
Rhode Island	24	-	-	-	4	-	-	28
South Carolina	20	-	-	-	1,344	-	-	1,364
South Dakota	-	-	-	-	1,516	-	43	1,559
Tennessee	5	2	-	-	2,429	-	29	2,465
Texas	42	-	-	-	681	-	2,738	3,461
Utah	1	-	-	23	255	-	-	279
Vermont	-	-	72	-	304	-	5	381
Virginia	95	-	80	-	669	-	-	843
Washington	35	4	136	-	21,148	-	821	22,145
West Virginia	-	-	-	-	163	-	66	229
Wisconsin	58	1	73	-	433	-	53	618
Wyoming	-	-	-	-	303	-	287	590
Total	2,812	282	1,699	2,274	77,102	411	11,329	95,909

[a] Total capacity whose primary energy source is landfill gas or MSW.
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
PV=Photovoltaic.
MSW=Municipal Solid Waste.
*** =Less than 500 kilowatts.**
Note: Revisions to biomass capacity removed tires from renewable waste energy. The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-860,"Annual Electric Generator Report."

Table 1.25. Renewable Commercial and Industrial Sector Net Summer Capacity by Energy Source and State, 2006 (Megawatts)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	-	-	581	-	-	-	-	581
Alaska	-	-	-	-	-	-	-	-
Arizona	-	-	-	-	-	-	-	-
Arkansas	-	2	292	-	-	-	-	293
California	12	96	148	-	6	-	-	262
Colorado	-	-	-	-	-	-	-	-
Connecticut	-	-	-	-	-	-	-	-
Delaware	-	-	-	-	-	-	-	-
Florida	-	89	276	-	-	-	-	365
Georgia	2	44	450	-	7	-	-	504
Hawaii	60	3	-	-	5	-	-	68
Idaho	-	-	64	-	-	-	-	64
Illinois	-	3	-	-	1	-	-	4
Indiana	9	-	-	-	-	-	-	9
Iowa	-	3	-	-	-	-	-	3
Kansas	-	-	-	-	-	-	-	-
Kentucky	-	-	43	-	-	-	-	43
Louisiana	-	3	318	-	-	-	-	321
Maine	24	-	389	-	117	-	-	530
Maryland	7	-	2	-	-	-	-	9
Massachusetts	-	9	-	-	5	-	-	14
Michigan	67	-	52	-	4	-	-	122
Minnesota	4	-	49	-	29	-	-	82
Mississippi	-	-	229	-	-	-	-	229
Missouri	-	-	-	-	-	-	-	-
Montana	-	-	17	-	-	-	-	17
Nebraska	-	3	-	-	-	-	-	3
Nevada	-	-	-	-	-	-	-	-
New Hampshire	-	-	14	-	-	-	-	14
New Jersey	-	1	-	-	-	-	-	1
New Mexico	-	-	-	-	-	-	-	-
New York	33	-	-	-	15	-	-	48
North Carolina	-	-	244	-	160	-	-	403
North Dakota	-	10	-	-	-	-	-	10
Ohio	-	-	57	-	-	-	-	57
Oklahoma	16	-	63	-	-	-	-	78
Oregon	-	-	136	-	-	-	-	136
Pennsylvania	28	-	80	-	-	-	-	108
Rhode Island	-	-	-	-	-	-	-	-
South Carolina	10	-	220	-	1	-	-	231
Tennessee	-	-	147	-	209	-	-	356
Texas	-	16	130	-	-	-	-	145
Utah	3	-	-	-	-	-	-	3
Vermont	-	-	4	-	5	-	-	8
Virginia	76	-	330	-	2	-	-	408
Washington	-	-	190	-	8	-	-	198
West Virginia	-	-	-	-	101	-	-	101
Wisconsin	4	-	147	-	43	-	-	195
Wyoming	-	-	-	-	-	-	-	-
Total	354	280	4,673	-	719	-	-	6,025

[a] Total capacity whose primary energy source is landfill gas or MSW.
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
PV=Photovoltaic.
MSW=Municipal Solid Waste.
*** =Less than 500 kilowatts.**
Note: Revisions to biomass capacity removed tires from renewable waste energy. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-860,"Annual Electric Generator Report."

Table 1.26. Total Renewable Net Summer Capacity by Energy Source and State, 2006 (Megawatts)

State	Biomass			Geothermal	Hydroelectric Conventional	Solar/PV	Wind	Total
	Waste		Wood and Derived Fuels [c]					
	Landfill Gas / MSW Biogenic [a]	Other Biomass [b]						
Alabama	-	-	581	-	3,271	-	-	3,852
Alaska	-	-	-	-	397	-	3	400
Arizona	4	-	3	-	2,720	9	-	2,736
Arkansas	5	6	292	-	1,389	-	-	1,691
California	275	145	584	2,032	10,083	402	2,255	15,776
Colorado	-	10	-	-	652	-	289	950
Connecticut	170	-	-	-	147	-	-	316
Delaware	7	-	-	-	-	-	-	7
District of Columbia	-	-	-	-	-	-	-	-
Florida	447	163	343	-	55	-	-	1,008
Georgia	5	44	450	-	2,027	-	-	2,526
Hawaii	60	49	-	31	24	-	43	206
Idaho	-	-	75	-	2,378	-	75	2,528
Illinois	111	15	-	-	33	-	105	264
Indiana	31	-	-	-	60	-	-	91
Iowa	11	3	-	-	131	-	921	1,067
Kansas	-	-	-	-	3	-	363	366
Kentucky	12	-	43	-	815	-	-	871
Louisiana	-	15	318	-	192	-	-	525
Maine	53	36	609	-	719	-	-	1,418
Maryland	126	-	2	-	566	-	-	693
Massachusetts	261	9	26	-	259	-	-	554
Michigan	149	-	210	-	257	-	2	618
Minnesota	127	-	129	-	175	-	827	1,259
Mississippi	-	-	229	-	-	-	-	229
Missouri	3	-	-	-	552	-	-	555
Montana	-	-	17	-	2,604	-	145	2,766
Nebraska	6	4	-	-	272	-	73	355
Nevada	-	-	-	188	1,047	-	-	1,236
New Hampshire	31	-	141	-	512	-	-	685
New Jersey	181	20	-	-	5	-	8	212
New Mexico	-	6	-	-	82	-	494	582
New York	313	-	37	-	4,307	-	370	5,027
North Carolina	14	-	324	-	1,954	-	-	2,292
North Dakota	-	10	-	-	443	-	164	617
Ohio	4	-	64	-	101	-	7	175
Oklahoma	16	-	63	-	851	-	594	1,524
Oregon	14	3	195	-	8,374	-	399	8,984
Pennsylvania	359	-	108	-	748	-	150	1,365
Rhode Island	24	-	-	-	4	-	-	28
South Carolina	29	-	220	-	1,345	-	-	1,594
South Dakota	-	-	-	-	1,516	-	43	1,559
Tennessee	5	2	147	-	2,638	-	29	2,821
Texas	42	16	130	-	681	-	2,738	3,607
Utah	4	-	-	23	255	-	-	282
Vermont	-	-	76	-	309	-	5	390
Virginia	170	-	410	-	671	-	-	1,251
Washington	35	4	326	-	21,156	-	821	22,343
West Virginia	-	-	-	-	264	-	66	330
Wisconsin	62	1	220	-	476	-	53	813
Wyoming	-	-	-	-	303	-	287	590
Total	3,166	561	6,372	2,274	77,821	411	11,329	101,934

[a] Total capacity whose primary energy source is landfill gas or MSW.
[b] Agriculture byproducts/crops, sludge waste and other biomass solids, liquids and gases.
[c] Black liquor, and wood/woodwaste solids and liquids.
PV=Photovoltaic.
MSW=Municipal Solid Waste.
*** =Less than 500 kilowatts.**
Note: Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-860,"Annual Electric Generator Report."

Table 1.27. Renewable Market Share of Net Generation by State, 2005 and 2006
(Thousand Kilowatthours)

	2005			2006		
	Total State Generation	Percent Renewable	Percent NonHydro Renewable	Total State Generation	Percent Renewable	Percent NonHydro Renewable
Alabama	137,948,581	10.0	2.7	140,895,441	7.9	2.8
Alaska	6,576,659	22.3	0.1	6,674,197	18.5	0.1
Arizona	101,478,654	6.3	0.1	104,392,528	6.6	0.1
Arkansas	47,794,509	10.0	3.6	52,168,703	6.2	3.3
California	200,292,818	31.5	11.8	216,798,688	33.2	11.0
Colorado	49,616,694	4.4	1.6	50,698,353	5.3	1.8
Connecticut	33,549,747	3.6	2.3	34,681,736	3.8	2.2
Delaware	8,136,568	-	-	7,182,179	*	*
District of Columbia	226,042	-	-	81,467	-	-
Florida	220,256,412	2.1	2.0	223,751,621	2.1	2.0
Georgia	136,667,892	5.3	2.4	138,010,208	4.4	2.5
Hawaii	11,522,805	5.5	4.7	11,559,174	6.4	5.3
Idaho	10,824,984	84.2	5.3	13,386,085	89.2	5.2
Illinois	194,120,146	0.4	0.4	192,426,958	0.5	0.4
Indiana	130,371,573	0.3	0.1	130,489,788	0.5	0.2
Iowa	44,156,160	6.1	4.0	45,483,462	7.4	5.4
Kansas	45,862,696	0.9	0.9	45,523,736	2.2	2.2
Kentucky	97,822,419	3.4	0.4	98,792,014	3.1	0.5
Louisiana	92,616,878	3.8	2.9	90,921,829	4.1	3.3
Maine	18,843,978	43.3	21.6	16,816,173	49.1	23.6
Maryland	52,661,600	4.4	1.2	48,956,880	5.6	1.3
Massachusetts	47,515,443	4.8	2.7	45,597,775	6.1	2.8
Michigan	121,619,771	3.2	2.1	112,556,738	3.5	2.2
Minnesota	53,018,995	6.4	5.0	53,237,789	6.8	5.7
Mississippi	45,067,453	3.3	3.4	46,228,847	3.3	3.3
Missouri	90,828,230	1.2	*	91,686,343	0.2	*
Montana	27,938,778	34.5	0.2	28,243,536	37.7	1.9
Nebraska	31,464,734	3.2	0.4	31,669,969	3.8	1.0
Nevada	40,213,752	7.3	3.1	31,860,022	10.7	4.2
New Hampshire	24,470,013	11.2	3.9	22,063,695	10.3	3.4
New Jersey	60,549,583	1.5	1.4	60,700,139	1.6	1.5
New Mexico	35,135,642	2.7	2.3	37,265,625	4.0	3.4
New York	146,887,419	18.9	1.4	142,265,432	21.1	1.8
North Carolina	129,748,578	5.5	1.4	125,214,784	4.5	1.5
North Dakota	31,932,615	4.9	0.7	30,881,137	6.1	1.2
Ohio	156,976,323	0.5	0.3	155,434,075	0.7	0.3
Oklahoma	68,607,827	5.4	1.7	70,614,880	3.7	2.9
Oregon	49,325,003	66.0	3.3	53,340,695	74.5	3.5
Pennsylvania	218,091,125	2.0	1.1	218,811,595	2.4	1.1
Rhode Island	6,053,294	0.1	*	5,967,725	2.6	2.5
South Carolina	102,514,665	4.6	1.7	99,267,606	3.7	1.9
South Dakota	6,520,769	49.5	2.4	7,132,243	49.7	2.1
Tennessee	97,117,165	10.1	0.6	93,911,102	8.8	0.6
Texas	396,668,722	1.6	1.3	400,582,878	2.1	2.0
Utah	38,165,131	2.5	0.5	41,263,324	2.3	0.5
Vermont	5,716,755	28.5	7.4	7,084,344	27.8	6.4
Virginia	78,943,045	5.0	3.2	73,069,537	5.3	3.4
Washington	101,965,850	72.7	2.1	108,203,155	78.1	2.3
West Virginia	93,626,285	1.7	0.2	93,815,804	1.9	0.2
Wisconsin	61,824,664	4.9	2.1	61,639,843	4.9	2.2
Wyoming	45,567,307	3.3	1.6	45,400,370	3.5	1.7
Total	4,055,422,750	8.8	2.2	4,064,702,227	9.5	2.4

*** = Less than .05 percent.**
- = Not applicable.
Note: Revisions to biomass capacity removed tires from renewable waste energy. Dash indicates the state has no data to report for that energy source. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-906, "Power Plant Report."

Table 1.28. Renewable Portfolio Standards and State Mandates by State, 2007

State	RPS or Mandate
Alabama	
Alaska	
Arizona	X
Arkansas	
California	X
Colorado	X
Connecticut	X
Delaware	X
District of Columbia	X
Florida [a]	X
Georgia	
Hawaii	X
Idaho	
Illinois	X
Indiana	
Iowa	X
Kansas	
Kentucky	
Lousiana	
Maine	X
Maryland	X
Massachusetts	X
Michigan [a]	X
Minnesota	X
Mississippi	
Missouri [a]	X
Montana	X
Nebraska	
Nevada	X
New Hampshire	X
New Jersey	X
New Mexico	X
New York	X
North Carolina	X
North Dakota	X
Ohio	
Oklahoma	
Oregon	X
Pennsylvania	X
Rhode Island	X
South Carolina	
South Dakota	
Tennessee	
Texas	X
Utah	
Vermont	X
Virginia	X
Washington	X
West Virginia	
Wisconsin	X
Wyoming	

[a] In Florida, Michigan and Missouri the RPS is not statewide.
Note: In some states, including Illinois, Michigan, Missouri, North Dakota, Virginia and Vermont the renewable portfolio standard (RPS) is voluntary. Blank cell indicates there is no RPS or state mandate for that state.
Source: North Carolina Solar Center, Database of State Incentives for Renewable Energy (DSIRE) website: http://www.dsireusa.org (January 8, 2008).

Table 1.A1. Other Non-Renewable Energy Consumption by Energy Use Sector and Energy Source, 2002-2006 (Quadrillion Btu)

Sector and Source	2002	2003	2004	2005	2006
Total	0.266	0.280	0.245	0.234	0.236
Commercial	0.017	0.018	0.021	0.020	0.021
MSW Non-Biogenic [a]	0.016	0.018	0.021	0.020	0.020
Other Non-Renewable [b]	0.001	0.001	0.001	0.000	0.000
Industrial	0.106	0.121	0.086	0.091	0.091
MSW Non-Biogenic [a]	0.004	0.004	0.005	0.005	0.005
Other Non-Renewable [b]	0.103	0.117	0.081	0.086	0.086
Electric Power [c]	0.143	0.140	0.138	0.123	0.125
MSW Non-Biogenic [a]	0.124	0.113	0.109	0.107	0.109
Other Non-Renewable [b]	0.019	0.028	0.029	0.016	0.015

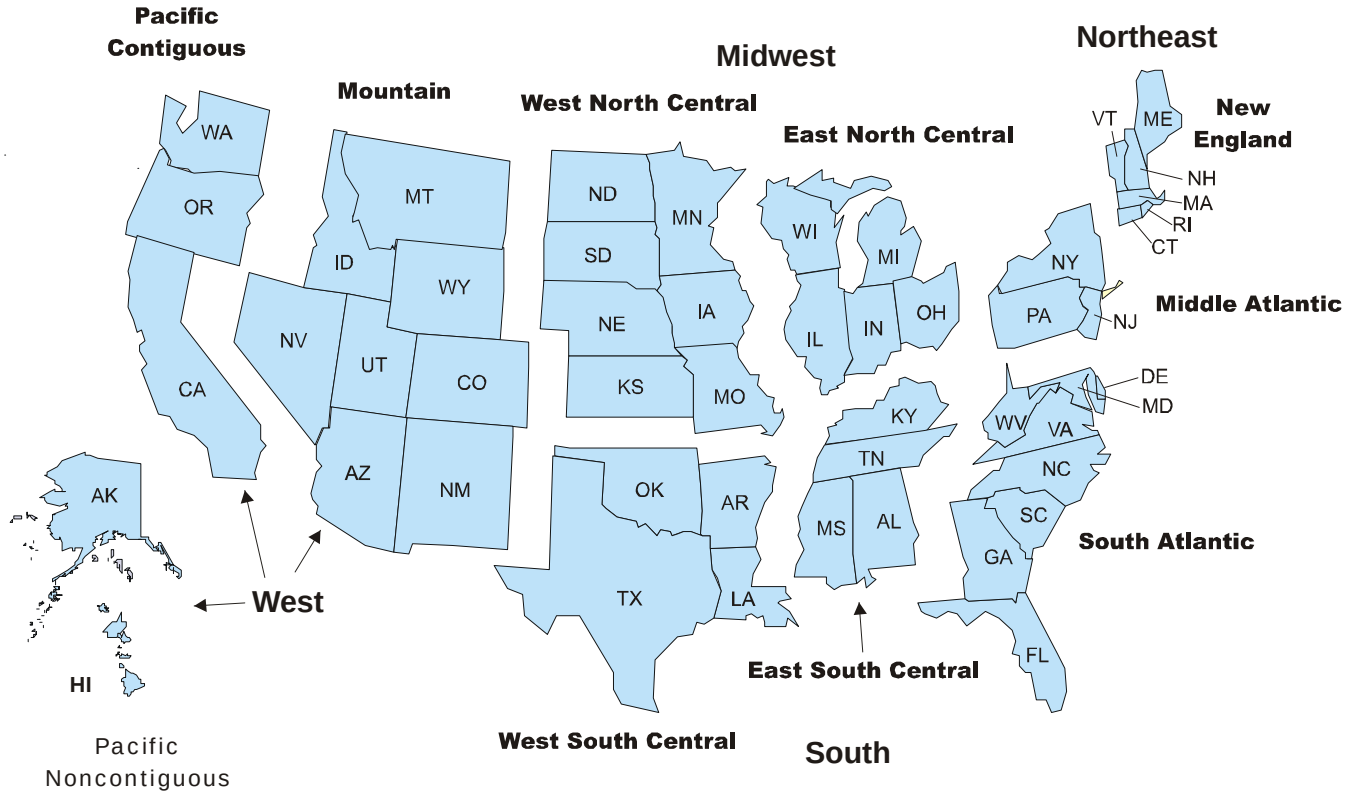
[a] Includes glass, steel, aluminum, other nonferous metals, plastic, rubber, other materials, and miscellaneuos inorganic wastes.
[b] Tires and other (nonspecified).
[c] The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public.
***=Less than 500 billion Btu.**
MSW=Municipal solid waste.
Note: Totals may not equal sum of components due to independent rounding. Details of EIA's analysis that revised MSW consumption are found in the Energy Information Administration (EIA) report, Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenenic Energy (Washington, DC, May 2007). After 2003 small amounts of other non-renewable energy consumption in the industrial sector for certain plants, including those that capture energy from exothermic chemical and manufacturing processes, are no longer included due to a change in EIA survey reporting requirements.
Sources: Analysis conducted by Energy Information Administration (EIA), Office of Coal, Nuclear, Electric, and Alternate Fuels and

Table 1.A2. Other Non-Renewable Net Electricity Generation by Energy Use Sector and Energy Source, 2002-2006 (Thousand Kilowatthours)

Sector and Source	2002	2003	2004	2005	2006
Total	13,526,909	14,044,507	14,483,429	12,468,282	13,977,436
Commercial	603,377	593,868	781,136	756,334	783,056
MSW Non-Biogenic [a]	513,855	586,572	773,846	749,250	751,407
Other Non-Renewable [b]	89,522	7,296	7,290	7,084	31,648
Industrial	3,832,069	4,843,169	5,138,985	4,750,563	6,049,257
MSW Non-Biogenic [a]	57,784	29,452	25,636	29,435	26,470
Other Non-Renewable [b]	3,774,285	4,813,717	5,113,349	4,721,128	6,022,787
Electric Power [c]	9,091,464	8,607,470	8,563,308	6,961,385	7,145,123
MSW Non-Biogenic [a]	6,215,295	6,179,847	5,871,342	5,770,023	5,882,212
Other Non-Renewable [b]	2,876,169	2,427,623	2,691,966	1,191,362	1,262,911

[a] Includes glass, steel, aluminum, other nonferous metals, plastic, rubber, other materials, and miscellaneuos inorganic wastes.
[b] Tires and other (nonspecified).
[c] The electric power sector comprises electricity-only and combined-heat-power (CHP) plants within North American Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public.
***=Less than 500 billion Btu.**
MSW=Municipal solid waste.
Note: Totals may not equal sum of components due to independent rounding. Details of EIA's analysis that revised MSW consumption are found in the Energy Information Administration (EIA) report, Methodology for Allocating Municipal Solid Waste to Biogenic and Non-Biogenenic Energy (Washington, DC, May 2007).
Sources: EIA, Form EIA-906, "Power Plant Report," and Form EIA-920, "Combined Heat and Power Plant Report."

Figure 1.6 U.S. Census Regions and Divisions



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

2. Solar Thermal and Photovoltaic Collector Manufacturing Activities 2006

Overview

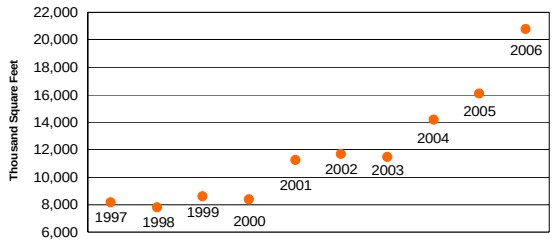
The U.S. solar energy industry continued its double-digit annual growth rate in 2006. Fueling this growth were record high energy prices, the impact of state Renewable Portfolio Standards, increased focus on global warming, and the Energy Policy Act of 2005 (EPAct) which took effect in January 2006, providing tax credits for solar installations.

As demand for solar energy continued to grow, the solar energy industry was shadowed by the steep increases in the cost of raw materials like copper and high-grade silicon. Also putting upward cost pressure on solar energy equipment was the shortage of trained workers, as several new firms began competing with major manufacturers for the same work force. Also during 2006, solar companies from China and Germany exhibited a strong interest in entering the U.S. solar energy market.

Solar Thermal Collectors

Total solar collector shipments surged 29 percent in 2006 to 20.7 million square feet (Figure 2.1). Domestic shipments of solar thermal collectors rose more than 33 percent to 19.5 million square feet during the year (Table 2.1). Forty-four companies were actively involved in shipping solar thermal collectors, an increase of 76 percent from 2005 (Table 2.2).

Figure 2.1 Total Solar Thermal Collector Shipments, 1997-2006



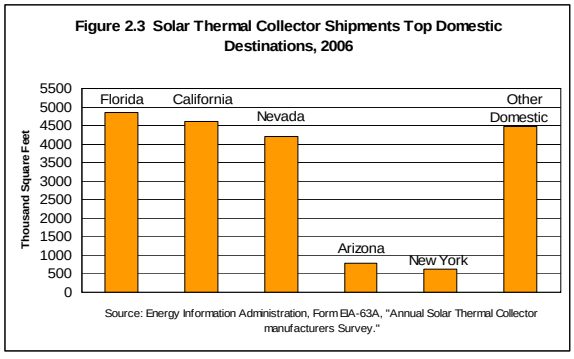
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Low-temperature solar collectors continued to dominate the market in 2006, contributing 75 percent of total shipments (Table 2.3). Medium-temperature collectors were responsible for approximately 6.5 percent of total shipments, increasing its market share substantially over 2005. But the largest gain in market share occurred in high-temperature collectors, which garnered an 18.5 percent share in 2006 after decades of negligible shipments. The rapid growth included the collectors shipped to the Nevada Solar One solar thermal plant, whose 64 megawatts (MW) capacity makes it the largest solar plant to be built in the world in the last 16 years.[1] The Nevada Solar One plant covers 400 acres in the El Dorado Valley (near Las Vegas, Nevada) and was built directly adjacent to the existing 480 MW El Dorado Energy combined cycle gas power plant. It has 760 parabolic cylinder concentrators with almost 219,000 mirrors that concentrate the sun's rays onto over 18,000 receiver tubes to enable heat transfer from the sun's rays to ultimately generate up to 134 million kilowatthours (Kwh) of electricity per year, enough to power 15,000 households annually (Figure 2.2).

Figure 2.2
Nevada Solar One Solar Thermal Plant
Courtesy of Solargenix Energy

In 2006, 78 percent of all collectors were produced in five states: New Jersey, California, Nevada, Florida, and Tennessee (Table 2.4), with 53 percent of the total shipped from New Jersey and California alone. About 20 percent of collectors shipped were imported, mostly from Israel.

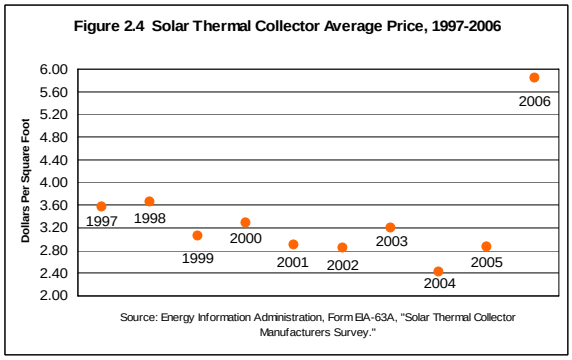
More than 73 percent of all collectors were shipped to the top five destinations: Florida, California, Nevada, Arizona, and New York (Table 2.4 and Figure 2.3). Florida and California accounted for nearly 46 percent of total shipments. (Table 2.5 shows these data for 2005.)



During 2005, 19.5 million square feet of domestic solar thermal shipments were sent to all 50 States within the U.S., plus the District of Columbia, Puerto Rico, and the Virgin Islands (Table 2.6). The export market accounted for 6 percent of total shipments and was dominated by sales to Canada (42 percent of exports), Mexico (17 percent), and France (12 percent) (Table 2.7).

Forty-seven percent of total shipments were sent directly to wholesale distributors, more than 26 percent to retail distributors, 3 percent to exporters, 4 percent to installers, and about 20 percent to other end users (Table 2.8). This closely mirrors the end-use distribution of shipments in 2005.

Total shipment revenue increased to $121.1 million in 2006, up sharply from $45.8 million in 2005 (Table 2.9). Average price per square foot for low-temperature collectors decreased slightly to $1.95 from $2.00 in 2005. The average price for medium- and high-temperature collectors also decreased from $18.77 to $17.47 per square foot (Table 2.9 and Figure 2.4). However, the overall average price for total shipments increased more than 100 percent, from $2.86 per square foot in 2005 to $5.84 per square foot in 2006. The most significant cause of the rise was the surge in high-temperature collectors to the Nevada Solar One project. Shipments of high-temperature collectors surged from 115,000 square feet in 2005 to 3,852,000 in 2006. These collectors are designed for limited, specialized applications. As a result, their average prices are much higher and subject to wide fluctuations.



The residential sector continues to be the prime market for solar thermal collectors, totaling 15.1 million square feet, approximately 73 percent of the total shipments (Table 2.10). 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. In 2006, collectors shipped to the residential sector increased 3 percent, compared to 2005. A significant shift occurred between the commercial and utility sectors due to the Nevada Solar One plant. As a result, the utility sector became the second-largest market for solar thermal collectors in 2006, with 18.5 percent of total shipments. There is growing interest for utility-scale solar thermal power plants in the West (beyond the Nevada Solar One plant), where power supply is tight and prices are high.

There are other notable changes between 2005 and 2006 solar thermal collector shipments by end use sector. Although the pool heating sector maintains its position as the largest end use sector for solar thermal collectors, its 2006 market share declined to 74 percent from 94 percent of total shipment in 2005. The quantity of pool heating shipments remained relatively unchanged during 2006 at 15 million square feet. Despite the increase in shipments for the hot water end use sector to 1.1 million square feet in 2006 from 0.6 million square feet in 2005, the Nevada Solar One project resulted in the electricity generation sector replacing the hot water sector as the second-largest end use for solar thermal collectors shipped in 2006. Shipments to this end use sector totaled 3.8 million square feet, nearly 19 percent of total shipments in 2006 (Table 2.10).

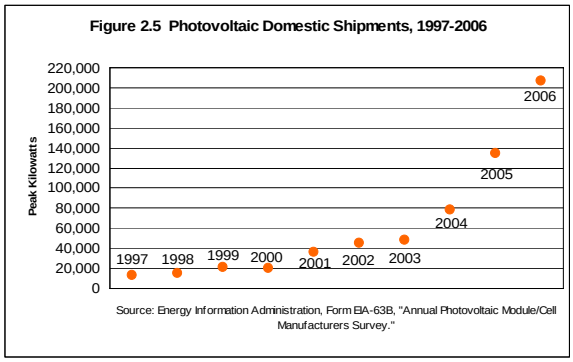
In 2006, twenty-nine companies reported shipping 79,903 complete solar thermal collector systems, a 56 percent shipment increase compared with 2005. A completed system is a unit with a collector and all the necessary functional components, except for installation materials. It includes thermosiphon systems, integral collector storage systems, packaged systems, and system kits. This increase coincides with the increase in revenue from complete systems, slightly over 53 percent. Total revenue for the systems shipped in 2006 was $31.3 million compared with $20.4 million in 2005 (Table 2.11).

In 2006, there were 44 companies active in solar-related activities (manufacturing, importing, and/or exporting), a significant increase from the 25 operating in 2005. Of the 44 active companies shipping solar thermal collectors, 5 are planning to introduce new low-temperature collectors, 14 are planning new medium-temperature collectors, and 5 expect to introduce new high-temperature collectors in 2007 (Table 2.12). In 2006, the industry remained highly concentrated, with the 5 largest companies accounting for 89 percent of total shipments. However, this percentage of the concentration was the lowest since 1998 (Table 2.13). Employment tripled during the year 2006, in part due to the construction of the Nevada Solar One project, the first concentrated solar power facility built in the U.S. in more than 15 years (Table 2.14). A total of 37 companies were involved in the design of collectors or systems, 19 were involved in prototype collector development, and 19 were active in prototype system development (Table 2.15). Twenty-seven companies had 90 percent or more of their total company-wide revenues in solar collectors, seven companies had 50 to 89 percent, four companies had 10 to 49 percent, and six companies had less than 10 percent (Table 2.16).

Photovoltaic Cells and Modules

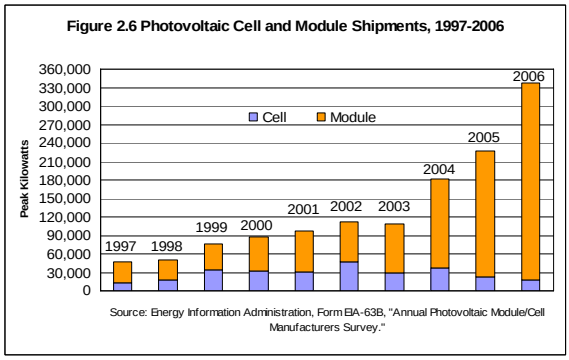
Photovoltaic (PV) cell and module domestic shipments continued their rapid expansion in 2006, in part caused by the new Federal incentive providing tax credits to homes and businesses that install solar systems. The tax credit went into effect in January 2006 as part of the Energy Policy Act of 2005. The Federal tax credit will reduce taxes for qualifying taxpayers by the full amount of the per Kwh credit and is not based on income. Also affecting PV cell and module domestic shipments were the same factors that impacted growth in solar thermal panel shipments.

During 2006, domestic shipments reached 206,511 peak kilowatts, nearly 54 percent above the 2005 domestic shipments of 134,465 peak kilowatts (Table 2.17 and Figure 2.5).

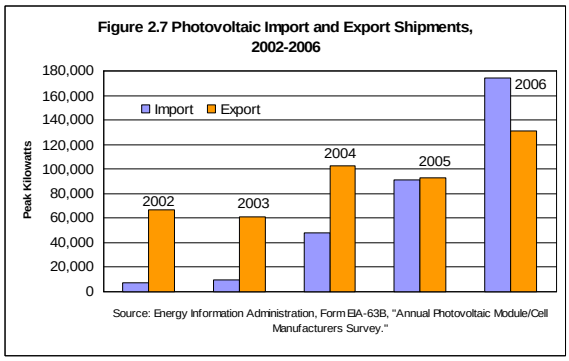


Total shipments of PV cells and modules reached a new high of 337,268 peak kilowatts, nearly a 50 percent increase from 226,916 peak kilowatts in 2005. Module shipments increased 56 percent to 320,208 peak kilowatts in 2006, while cell shipments decreased to 17,060 peak kilowatts from 21,920 peak kilowatts (Table 2.18 and Figure 2.6).

The number of active companies shipping PV cells and modules jumped to 41 in 2006 from 29 in 2005, an increase of 41 percent (Table 2.19) and the largest by far in a decade. This may be a sign of confidence from investors as well as the solar energy industry itself about the future of the solar energy market. This outlook is supported by the Renewable Portfolio Standard (RPS) policies of some western states (e.g., Arizona) requiring that a certain portion of the RPS be solar-based.



Solar energy companies raced to import PV modules/cells to meet soaring demand. Between 2005 and 2006, imports surged from 90,981 to 173,977 peak kilowatts. Exports also rose sharply, from 92,451 to 130,757 peak kilowatts (Table 2.19 and Figure 2.7).



In a dramatic market shift, installers replaced wholesale distributors as the largest business category for PV modules/cells shipped in 2006. Shipments to installers rose approximately 118 percent to 146,948 peak kilowatts, and represented 44 percent of total shipments in 2006 versus 30 percent in 2005. In contrast, shipments to the second-largest category, wholesale distributors, decreased 3 percent to 126,101 peak kilowatts in 2006 from 130,086 peak kilowatts in 2005 (Table 2.20).

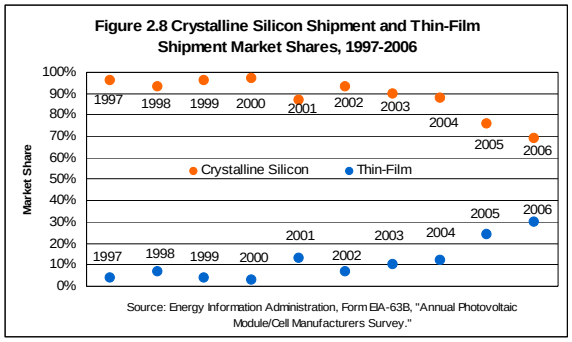
While demand for solar continued to grow in 2006, the supply of high-grade silicon used to make PV cells continued to impact the solar industry. Two types of solar companies are expected to perform well in this market. First

are the silicon-based solar manufacturing companies that have secured stable silicon supplies. Second are the companies that focused on thin-film solar technology (thin film solar modules use either a very thin coating of silicon or other alternative materials with no silicon).

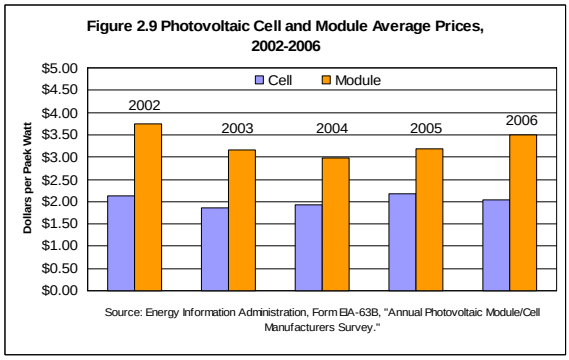
Not surprisingly, thin-film PV cell and module shipments experienced the greatest percentage gain between 2005 and 2006, nearly doubling. Still, conventional crystalline silicon cells and modules shipments continued to dominate all PV technologies with 233,518 peak kilowatts shipped in 2006. However, its market share continued to decline to 69 percent from 76 percent in 2005 and over 95 percent a decade ago (Table 2.21 and Figure 2.8). Within this category, single-crystal shipments rebounded to 85,627 peak kilowatts, or slightly more than 25 percent of total shipments in 2006, compared to 71,901 peak kilowatts in 2005. Cast and ribbon silicon shipments, the predominant PV technology, rose sharply to 147,892 peak kilowatts in 2005, or nearly 44 percent of total shipments, compared to 101,065 peak kilowatts in 2005 (Table 2.21).

Today, thin-film PV modules that use materials such as amorphous silicon (a-Si); cadmium telluride (CdTe); or copper indium gallium selenide (CIGS) are attracting much attention and are growing at an impressive rate, in part due to the shortage of silicon and high manufacturing costs associated with crystalline silicon cells. With the help of lower manufacturing costs and its versatility, thin film technology has ignited the competition with conventional crystalline silicon technology over the past couple of years. However, thin film modules are typically much less efficient than crystalline silicon modules with 7 to 10 percent efficiency compared to silicon's average 15 percent efficiency.

While there are a number of companies that are producing thin-film PV cells, the majority of these companies are small and/or startup. The thin-film shipment market share has steadily increased, from 12 percent of total shipments in 2004 to 24 percent in 2005 to 30 percent of total shipments in 2006 (Table 2.21 and Figure 2.8).



Total revenue from photovoltaic module and cell shipments was $1.16 billion in 2006, nearly a 65-percent increase over the 2005 revenue of $0.70 billion in 2005 (Table 2.22).[2] The average price for PV modules (dollars per peak watt) increased nearly 10 percent, from $3.19 in 2005 to $3.50 in 2006. For photovoltaic cells, the average price decreased 6 percent, from $2.17 in 2005 to $2.03 in 2006 (Table 2.22 and Figure 2.9).



The commercial sector was the largest market for PV modules and cells in 2006, followed by the residential and industrial sectors. Commercial sector shipments totaled 180,852 peak kilowatts and jumped at a rate of 102 percent from 2005 to 2006. The residential sector totaled 95,815 peak kilowatts in 2006, about 28 percent over the previous year (Table 23). Electricity generation, which consists of both grid-interactive (those connected to the electric power grid)[3] and remote applications (those not connected), continues to be the predominant end use for PV cells and modules. In 2006, PV shipments to the electric generation market was about 86 percent of the total shipments, and was 51 percent more than in 2005. Shipments for other uses and into non-

traditional markets also rose substantially in 2006.

Export shipments totaled 130,757 peak kilowatts in 2006, an increase of 41 percent from the 2005 level. The export market previously dominated by crystalline silicon modules/cells has been surpassed by thin-film modules/cells. Thin-film exports increased sharply to 69,718 peak kilowatts in 2006 from 32,000 peak kilowatts in 2005. The export market split was about 47 percent crystalline silicon and 53 percent thin-film modules/cells (Table 2.24). Shipments to Europe represented 83.5 percent of total U.S. exports, with Germany remaining the predominant importer of cells and modules, taking 80,583 peak kilowatts, or 62 percent of U.S. export shipments in 2006 (Table 2.25). Spain has replaced the Netherlands as the second-largest recipient of U.S. PV cells and modules, accounting for 15,241 peak kilowatts, or close to 12 percent of U.S. export shipments in 2006. Strong government financial support programs for renewable energy in these countries, especially Germany, are largely responsible for increased U.S. exports.

Shipments of complete PV systems increased nearly 81 percent from 37,115 systems in 2005 to 67,172 systems in 2005 (Table 2.26). The increase was heavily influenced by the innovative flexible, foldable, portable thin-film system. The total revenue of completed systems surged to $192.9 million, and total peak kilowatts jumped from 6,583 in 2005 to 28,099 in 2005.

Employment in the PV-related activities totaled 4,028 person-years in 2006, an increase of about 26 percent from 2005 (Table 2.27). However, the average employment per company was 98 person-years in 2006, compared with 110 person-years in 2005, as a number of new companies reported shipping PV cells and modules during 2006.

The PV industry is actively promoting new products. Fourteen companies expect to introduce new crystalline silicon products in 2007, and 6 companies plan to introduce new thin-film products to the industry during 2007. Four companies plan to produce new concentrator photovoltaic (CPV) products, three more than the previous year (Table 2.28). Many companies engaged in the manufacture and/or importation of PV modules and cells reported that they are also involved in other photovoltaic-related activities (Table 2.29). Of the 41 total companies, 16 companies were involved in cell manufacturing, 26 companies in module or systems design, and 18 were active in developing module prototypes.

Endnotes:

[1] Acciona Energy (June 7, 2007) "ACCIONA puts the biggest solar thermal power plant built in the world in the last 16 years into service in the USA"

[2] The total revenue includes charges for advertising and warranties, but does not include excise taxes and the cost of freight or transportation for the shipments.

[3] See EIA glossary that defines electric power grid as a system of synchronized power providers and consumers connected by transmission and distribution lines and operated by one or more control centers.

Table 2.1. Annual Solar Thermal Collector Domestic Shipments, 1997-2006

Year	Solar Thermal Collectors[a] (Thousand Square Feet)
1997	7,759
1998	7,396
1999	8,046
2000	7,857
2001	10,349
2002	11,004
2003	10,926
2004	13,301
2005	14,680
2006	19,532
Total	110,852

[a] Total shipments minus export shipments.
Notes: Totals may not equal sum of components due to independent rounding. Total shipments include those made in or shipped to U.S. Territories.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 2.2. Annual Shipments of Solar Thermal Collectors, 1997-2006

Year	Number of Companies	Collector Shipments (Thousand Square Feet)		
		Total [a]	Imports	Export
1997	29	8,138	2,102	379
1998	28	7,756	2,206	360
1999	29	8,583	2,352	537
2000	26	8,354	2,201	496
2001	26	11,189	3,502	840
2002	27	11,663	3,068	659
2003	26	11,444	2,986	518
2004	24	14,114	3,723	813
2005	25	16,041	4,546	1,361
2006	44	20,744	4,244	1,211

[a] Includes shipments of solar thermal collectors to the government, including some military, but excluding space applications.
Note: Total shipments as reported by respondents include all domestic and export shipments and may include imported collectors that subsequently were shipped to domestic or foreign customers.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 2.3. Annual Shipments of Solar Thermal Collectors by Type , 1997-2006
(Thousand Square Feet)

	Low-Temperature		Medium-Temperature		
Year	Total Shipments [a]	Average per Manufacturer	Total Shipments	Average per Manufacturer	High-Temperature Total Shipments [b]
1997	7,524	579	606	29	7
1998	7,292	607	443	23	21
1999	8,152	627	427	21	4
2000	7,948	723	400	25	5
2001	10,919	1,092	268	16	2
2002	11,126	856	535	31	2
2003	10,877	906	560	33	7
2004	13,608	1,512	506	30	0
2005	15,224	1,522	702	41	115
2006	15,546	1,413	1,346	38	3,852

[a] Includes shipments of solar thermal collectors to the government, including some military, but excluding space applications.
[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 2.4. Shipments of Solar Thermal Collectors Ranked by Origin and Destination, 2006

Origin/Destination	2006 Shipments	
	Thousand Square Feet	Percent of U.S. Total
Origin		
Top Five States	16,225	78
New Jersey	5,606	27
California	5,442	26
Nevada	3,845	19
Florida	1,041	5
Tennessee	290	1
Other Domestic	275	1
Imported	4,244	20
U.S. Total	20,744	100
Destination		
Top Five States	15,054	73
Florida	4,841	23
California	4,610	22
Nevada	4,215	20
Arizona	780	4
New York	607	3
Other Domestic	4,479	22
Exported	1,211	6
U.S. Total	20,744	100

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

Table 2.5. Shipments of Solar Thermal Collectors Ranked by Origin and Destination, 2005

Origin/Destination	2005 Shipments	
	Thousand Square Feet	Percent of U.S.Total
Origin		
Top Five States	11,328	71
New Jersey	5,130	32
California	4,961	31
Florida	933	6
Tennessee	190	1
Arizona	114	1
Other Domestic	166	1
Imported	4,546	28
U.S. Total	16,041	100
Destination		
Top Five States	11,299	70
Florida	5,408	34
California	4,137	26
Arizona	794	5
New York	499	3
Illinois	461	3
Other Domestic	3,381	21
Exported	1,361	8
U.S. Total	16,041	100

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

Table 2.6. Shipments of Solar Thermal Collectors by Destination, 2006
(Square Feet)

Destination	Shipments
Alabama	55,330
Alaska	75
Arizona	780,175
Arkansas	66,359
California	4,609,807
Colorado	93,347
Connecticut	382,215
Delaware	1,203
District of Columbia	159
Florida	4,841,469
Georgia	50,750
Hawaii	434,650
Idaho	17,867
Illinois	521,528
Indiana	54,074
Iowa	21,152
Kansas	19,590
Kentucky	17,858
Louisiana	24,226
Maine	57,774
Maryland	26,557
Massachusetts	90,741
Michigan	260,001
Minnesota	37,929
Mississippi	560
Missouri	20,314
Montana	762
Nebraska	17,985
Nevada	4,215,471
New Hampshire	25,633
New Jersey	583,468
New Mexico	39,207
New York	606,613
North Carolina	171,552
North Dakota	3,394
Ohio	45,246
Oklahoma	13,305
Oregon	505,860
Pennsylvania	266,645
Puerto Rico	109,666
Rhode Island	16,413
South Carolina	2,729
South Dakota	1,504
Tennessee	2,921
Texas	51,559
Utah	8,460
Vermont	26,287
Virgin Islands of the U.S.	2,431
Virginia	240,857
Washington	5,491
West Virginia	14,529
Wisconsin	67,238
Wyoming	1,468
Shipments to United States/Territories	19,532,404
Exports	1,211,242
Total Shipments	20,743,645

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

Table 2.7. Distribution of U.S. Solar Thermal Collector Exports by Country, 2006

Country	U.S. Export Shipments (Square Feet)	Percent of U.S. Exports
Asia		
Japan	5,000	0.41
Malaysia	2,715	0.22
United Arab Emirates	11,220	0.93
Total	18,935	1.56
Europe		
Belgium	21,577	1.78
Czech Republic	12,000	0.99
Denmark	3,000	0.25
France	148,541	12.26
Germany	75,000	6.19
Italy	15,891	1.31
Spain	64,000	5.28
Sweden	24,894	2.06
United Kingdom	8,090	0.67
Total	372,993	30.79
North & Central America		
Antigua and Barbuda	1,900	0.16
Aruba	217	0.02
Bahamas	3,108	0.26
Bermuda	80	0.01
British Virgin Islands	912	0.08
Canada	513,699	42.41
Cayman Islands	1,136	0.09
Costa Rica	8,416	0.69
Dominican Republic	1,778	0.15
Guatemala	11,144	0.92
Jamaica	620	0.05
Mexico	205,117	16.93
Netherlands Antilles	170	0.01
Nicaragua	40	*
Panama	64	0.01
St Lucia	140	0.01
Trinidad and Tobago	434	0.04
Total	748,975	61.84
Oceania & Australia		
Australia	66,953	5.53
Total	66,953	5.53
South America		
Bolivia	480	0.04
Chile	1,775	0.15
Ecuador	1,131	0.09
Total	3,386	0.28
Total	1,211,242	100.00

*** = Less than 0.01 percent.**
Notes: Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 2.8. Distribution of Solar Thermal Collector Shipments, 2005 and 2006

Recipient	Shipments (Thousand Square Feet)	
	2005	2006
Wholesale Distribution	9,248	9,778
Retail Distributors	5,342	5,492
Exporters	571	599
Installers	633	825
End Users and Other[a]	248	4,050
Total	16,041	20,744

[a] Other includes minimal shipments not explained on form EIA-63A.
Notes: Totals may not equal sum of components due to independent rounding. Total includes U.S. territories.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 2.9. Solar Thermal Collector Shipments by Type, Quantity, Revenue, and Average Price, 2005 and 2006

Type	2005			2006		
	Quantity (Thousand Square Feet)	Revenue (Thousand Dollars)	Average Price (Dollars per Square Foot)	Quantity (Thousand Square Feet)	Revenue (Thousand Dollars)	Average Price (Dollars per Square Foot)
Low-Temperature						
Liquid and Air	15,224	30,513	2.00	15,546	30,324	1.95
Medium/High Temperature	817	15,337	18.77	5,198	90,792	17.47
Medium						
Air	3	W	W	6	W	W
Liquid						
ICS/Thermosiphon	165	4,327	26.23	238	5,793	24.34
Flate Plate	530	8,161	15.38	1,043	16,613	15.93
Evacuated Tube	3	W	W	55	1,422	25.71
Concentrator				4	W	W
High						
Parabolic Dish and Trough	115	W	W	3,852	W	W
Total	16,041	45,850	2.86	20,744	121,116	5.84

ICS = Integral collector storage.
W = Data withheld to avoid disclosure of proprietary company data
Notes: Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 2.10. Shipments of Solar Thermal Collectors by Market Sector, End Use, and Type, 2005 and 2006
(Thousand Square Feet)

Type	Low-Temperature	Medium-Temperature					High-Temperature	2006 Total	2005 Total
	Liquid/Air	Air	Liquid						
	Metallic and Nonmetallic		ICS/Thermo-siphon	Flat-Plate (Pumped)	Evacuated Tube	Concentrator	Parabolic Dish/Trough		
Market Sector									
Residential	13,906	5	225	944	42	0	0	15,123	14,681
Commercial	1,500	*	10	92	14	4	7	1,626	1,160
Industrial	40	0	2	0	0	0	0	42	31
Utility	0	0	0	0	0	0	3,845	3,845	114
Other [a]	100	0	1	7	0	0	0	107	56
Total	15,546	6	238	1,043	55	4	3,852	20,744	16,041
End use									
Pool Heating	15,225	0	0	135	2	0	0	15,362	15,041
Hot Water	10	0	238	854	34	0	0	1,136	640
Space Heating	290	5	0	30	3	2	0	330	228
Space Cooling	0	0	0	0	3	0	0	3	2
Combined Space and Water Heating	21	1	0	24	14	0	7	66	16
Process Heating	0	0	0	0	0	0	0	0	0
Electricty Generation	0	0	0	0	0	2	3,845	3,847	114
Other [b]	0	0	0	0	0	0	0	0	0
Total	15,546	6	238	1,043	55	4	3,852	20,744	16,041

[a] Other market sector includes shipments of solar thermal collectors to 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, distillation, etc.
***=Less than 500 square feet.**
ICS= Integral Collector Storage.
Note: Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-63A, "Annual Solar Thermal Collector Manufacturers Survey."

Table 2.11. Shipments of Complete Solar Thermal Collector Systems, 2005 and 2006

Shipment Information	2005	2006
Complete Collector Systems		
Shipped	51,265	79,903
Thousand Square Feet	5,748	6,587
Percent of Total Shipments	36	32
Number of Companies	18	29
Revenue of Systems (Thousand Dollars)	20,402	31,297

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

Table 2.12. Number of Companies Expecting to Introduce New Solar Thermal Collector Products in 2007

New Product Type	Number of Companies
Low-Temperature Collectors	5
Medium-Temperature Collectors	14
High-Temperature Collectors	5
Noncollector Components	8

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

Table 2.13. Percent of Solar Thermal Collectors Shipments by 10 Largest Companies, 1997-2006

Year	Company Rank	Shipments (Thousand Square Feet)	Percent of Total Shipments
1997	1-5	7,183	88
	6-10	731	9
1998	1-5	6,938	89
	6-10	613	8
1999	1-5	7,813	91
	6-10	563	7
2000	1-5	7,521	90
	6-10	567	7
2001	1-5	10,732	96
	6-10	325	3
2002	1-5	10,755	92
	6-10	670	6
2003	1-5	10,485	92
	6-10	700	6
2004	1-5	13,291	94
	6-10	664	5
2005	1-5	14,801	92
	6-10	934	6
2006	1-5	18,535	89
	6-10	1,484	7

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

Table 2.14. Employment in the Solar Thermal Collector Industry, 1997-2006

Year	Person Years
1997	184
1998	207
1999	289
2000	284
2001	256
2002	356
2003	287
2004	317
2005	353
2006	1,069

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

Table 2.15. Companies Involved in Solar Thermal Collector Activities by Type, 2005 and 2006

Type of Activity	2005	2006
Collector or System Design	22	37
Prototype Collector Development	11	19
Prototype System Development	11	19
Wholesale Distribution	23	38
Retail Distribution	11	20
Installation	9	19
Noncollector System Component Manufacture	10	19

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

Table 2.16. Solar-Related Sales as a Percentage of Total Company Sales, 2005 and 2006

Percent of Total Sales	Number of Companies	
	2005	2006
90-100	16	27
50-89	6	7
10-49	0	4
Less than 10	3	6
Total	25	44

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

Table 2.17. Annual Photovoltaic Domestic Shipments, 1997-2006

Year	Photovoltaic Cells and Modules[a] (Peak Kilowatts)
1997	12,561
1998	15,069
1999	21,225
2000	19,838
2001	36,310
2002	45,313
2003	48,664
2004	78,346
2005	134,465
2006	206,511
Total	618,302

[a] Total shipments minus export shipments.
Notes: Totals may not equal sum of components due to independent rounding. Total shipments include those made in or shipped to U.S. Territories.
Sources: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 2.18. Annual Shipments of Photovoltaic Cells and Modules, 2004-2006
(Peak Kilowatts)

Item	2004	2005	2006
Cells	37,842	21,920	17,060
Modules	143,274	204,996	320,208
Total	181,116	226,916	337,268

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

Table 2.19. Annual Shipments of Photovoltaic Cells and Modules, 1997-2006

Year	Number of Companies	Photovoltaic Cell and Modules Shipments [a] (Peak Kilowatts)		
		Total	Imports	Exports
1997	21	46,354	1,853	33,793
1998	21	50,562	1,931	35,493
1999	19	76,787	4,784	55,562
2000	21	88,221	8,821	68,382
2001	19	97,666	10,204	61,356
2002	19	112,090	7,297	66,778
2003	20	109,357	9,731	60,693
2004	19	181,116	47,703	102,770
2005	29	226,916	90,981	92,451
2006	41	337,268	173,977	130,757

[a] Does not include shipments of cells and modules for space/satellite applications.
Note: Total shipments as reported by respondents include all domestic and export shipments and may include imported cells and modules that subsequently were shipped to domestic or foreign customers.
Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 2.20. Distribution of Photovoltaic Cells and Modules, 2004-2006

Recipient	Shipments (Peak Kilowatts)		
	2004	2005	2006
Wholesale Distributers	106,400	130,086	126,101
Retail Distributers	5,140	2,362	7,086
Exporters	2,354	1,088	4,188
Installers	34,779	67,437	146,948
End-Users	1,029	3,142	3,092
Module Manufacturers	11,868	15,347	9,635
Other [a]	19,546	7,455	40,218
Total	181,116	226,916	337,268

[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 2.21. Photovoltaic Cell and Module Shipments by Type, 2004-2006

Type	Shipments (Peak kilowatts)			Percent of Total		
	2004	2005	2006	2004	2005	2006
Crystalline Silicon						
Single-Crystal	94,899	71,901	85,627	52	32	25
Cast and Ribbon	64,239	101,065	147,892	35	45	44
Subtotal	159,138	172,965	233,518	88	76	69
Thin-Film	21,978	53,826	101,766	12	24	30
Concentrator	0	125	1,984	0	*	1
Other [a]	0	0	0	0	0	0
Total	181,116	226,916	337,268	100	100	100

[a] Includes categories not identified by reporting companies.
*** = Less than 0.5 percent.**
Note: Data do not include shipments of cells and modules for space/satellite applications. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 2.22. Photovoltaic Cell and Module Shipment Revenues by Type, 2005 and 2006

Type	2005			2006		
	Revenue (Thousand Dollars)	Average Price (Dollars per Peak Watt)		Revenue (Thousand Dollars)	Average Price (Dollars per Peak Watt)	
		Modules	Cells		Modules	Cells
Crystalline Sillicon						
Single-Crystal	227,751	3.48	2.20	339,859	4.09	2.09
Cast and Ribbon	318,690	3.20	2.02	529,176	3.66	2.39
Subtotal	546,440	3.30	2.17	869,035	3.82	2.28
Thin-Film Silicon	W	W	W	W	W	W
Concentrator Silicon	W	W	W	W	W	W
Other[a]	0	---	---	0	---	---
Total	701,718	3.19	2.17	1,155,002	3.50	2.03

[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 cells and modules for space/satellite applications. Totals may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Form EIA-63B, "Annual Photovoltaic Module/Cell Manufacturers Survey."

Table 2.23. Shipments of Photovoltaic Cells and Modules by Market Sector, End Use, and Type, 2005 and 2006 (Peak Kilowatts)

Sector and End Use	Crystalline Silicon [a]	Thin-Film Silicon	Concentrator Silicon	Other	2006 Total	2005 Total
Market						
Industrial	22,018	6,600	0	0	28,618	22,199
Residential	84,930	9,801	1,084	0	95,815	75,040
Commercial	97,949	82,603	300	0	180,852	89,459
Transportation	2,455	3	0	0	2,458	1,621
Utility	1,314	2,067	600	0	3,981	143
Government [b]	7,130	558	0	0	7,688	28,683
Other [c]	17,723	134	0	0	17,857	9,772
Total	233,518	101,766	1,984	0	337,268	226,916
End Use						
Electricty Generation						
Grid Interactive	186,894	86,319	984	0	274,197	168,474
Remote	14,360	2,643	1,000	0	18,003	24,958
Communication	6,767	121	0	0	6,888	8,666
Consumer Goods	1,170	2,860	0	0	4,030	5,787
Transportation	2,435	3	0	0	2,438	2,159
Water Pumping	2,093	0	0	0	2,093	1,343
Cells/Modules to OEM [d]	2,644	3,488	0	0	6,132	11,677
Health	0	0	0	0	0	
Other [e]	17,156	6,332	0	0	23,487	3,853
Total	233,518	101,766	1,984	0	337,268	226,916

[a] Includes single-crystal and cast and ribbon types.
[b] Includes Federal, State, local governments, excluding military.
[c] Other includes shipments that are manufactured for private contractors for research.
[d] Original equipment manufacturer.
[e] Other includes shipments of photovoltaic cells and modules for other uses, such as cooking food, desalinization, distillation, etc.
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 2.24. Export Shipments of Photovoltaic Cells and Modules by Type, 2005 and 2006
(Peak Kilowatts)

Item	Type							
	Crystalline		Thin-Film Silicon		Concentrator Silicon		Total	
	2005	2006	2005	2006	2005	2006	2005	2006
Cells	20,434	12,960	0	838	0	400	20,434	14,198
Modules	39,992	47,681	32,000	68,880	25	0	72,017	116,561
Totals	60,426	60,640	32,000	69,718	25	400	92,451	130,757

Notes: 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 2.25. Destination of U.S. Photovoltaic Cell and Module Export Shipments by Country, 2006

Country	Peak Kilowatts	Percent of U.S. Exports
Africa		
Angola	0.5	*
Egypt	307.0	0.2
Kenya	172.0	0.1
Nigeria	5.5	*
South Africa	385.0	0.3
Tanzania	6.0	*
Total	876.0	0.7
Asia		
Afghanistan	83.0	0.1
China	4,403.4	3.4
Hong Kong	2,116.0	1.6
India	1,945.6	1.5
Indonesia	13.0	*
Israel	55.0	*
Malaysia	2.5	*
North Korea	42.0	*
Saudi Arabia	1.0	*
Singapore	2,348.8	1.8
South Korea	4,021.0	3.1
Taiwan	5.0	*
Thailand	45.0	*
United Arab Emirates	11.5	*
Total	15,092.8	11.5
Europe		
Austria	327.5	0.3
Belgium	1.0	*
Denmark	2.6	*
Finland	6.0	*
France	1,447.0	1.1
Germany	80,583.2	61.6
Ireland	27.6	*
Italy	1,475.4	1.1
Luxembourg	324.0	0.2
Netherlands	137.6	0.1
Norway	256.0	0.2
Portugal	6,605.0	5.1
Spain	15,241.5	11.7
Sweden	2,501.0	1.9
Switzerland	22.5	*
United Kingdom	185.6	0.1
Total	109,143.5	83.5
North & Central America		
Bahamas	1.0	*
Bermuda	1.0	*
Canada	1,536.1	1.2
Costa Rica	346.5	0.3
Dominican Republic	1.0	*
El Salvador	1.0	*
Grenada	32.0	*
Guadeloupe	31.0	*
Guatemala	101.0	0.1
Haiti	24.0	*
Honduras	111.0	0.1
Mexico	722.5	0.6
Nicaragua	50.0	*
Panama	85.0	0.1
Trinidad and Tobago	8.0	*
Total	3,051.1	2.3
Oceania & Australia		
Australia	1,562.0	1.2
French Polynesia	93.0	0.1
New Zealand	70.0	0.1
Total	1,725.0	1.3
South America		
Argentina	43.0	*

Table 2.25. Destination of U.S. Photovoltaic Cell and Module Export Shipments by Country, 2006 (Continued)

Country	Peak Kilowatts	Percent of U.S. Exports
Bolivia	89.0	0.1
Brazil	79.0	0.1
Chile	85.0	0.1
Colombia	226.0	0.2
Ecuador	1.0	*
Guyana	60.0	*
Peru	240.0	0.2
Uruguay	45.0	*
Venezuela	1.0	*
Total	869.0	0.7
Total U.S. Export	130,757.4	100.0

*** = Value less than 0.05 percent.**
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 2.26. Shipments of Complete Photovoltaic Module Systems, 2004-2006

Shipment Information	2004	2005	2006
Complete Photovoltaic Module System Shipped	16,990	37,115	67,172
Peak Kilowatts	8,110	6,583	28,099
Percentage of Total Module Shipments	6	3	9
Revenue of Systems (Thousand Dollars)	39,459	43,029	192,928

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

Table 2.27. Employment in the Photovoltaic Manufacturing Industry, 1997-2006

Year	Number of Companies	Number of Person-Years
1997	21	1,736
1998	21	1,988
1999	19	2,013
2000	21	1,913
2001	19	2,666
2002	19	2,696
2003	20	2,590
2004	19	2,916
2005	29	3,198
2006	41	4,028

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

Table 2.28. Companies Expecting to Introduce New Photovoltaic Products in 2007

New Product Type	Number of Companies
Crystalline Silicon	
Single-Crystal Silicon Modules	6
Cast Silicon Modules	7
Ribbon Silicon Modules	1
Thin-Film	
Amorphous Silicon Modules	2
Other (Thin Film)	4
Other (Flat Plate)	1
Concentrators	4
Nonmodule System Components	1

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

Table 2.29. Number of Companies Involved in Photovoltaic-Related Activities, 2005 and 2006

Type of Activity	Number of Companies	
	2005	2006
Cell Manufacturing	12	16
Module or Systems Design	23	26
Prototype Module Development	18	18
Prototype Systems Development	9	10
Wholesale Distribution	19	29
Retail Distribution	7	12
Installation	7	4
Noncollector System Component Manufacturing	3	5

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

3. Survey of Geothermal Heat Pump Shipments, 2006

This report provides information on geothermal heat pump shipments, based on the Energy Information Administration Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey." The survey shows that manufacturers shipped 63,682 geothermal heat pumps (GHP) in 2006, a 33 percent increase over the 2005 total of 47,830. Of those shipped in 2006, 10,968 were ARI-320 rated, and 47, 440 were ARI-325 or ARI-330. ARI-rated shipments increased to 58,408 units in 2006, while the number of other non-ARI-rated units shipped increased to 5,274 in 2006 (Table 3.1).

The total rated capacity of geothermal heat pumps shipped in 2006 was 245,603 tons, compared to 160,402 tons in 2005 (Table 3.2). Geothermal (water and ground-source) heat pumps offer a substantial increase in energy efficiency relative to air-source heat pumps. In 2006, the capacity-weighted average cooling energy efficiency ratio (EER) for geothermal heat shipments was 31 percent greater than the current minimum standard of 13 for air-source heat pumps (based on data in Table 3.2 and Table 3.3).[1] The heating efficiency of ground-source and water-source heat pumps is indicated by their coefficient of performance (COP).[2] In 2006, the capacity-weighted average of COP for geothermal heat shipments was 3.8 (based on data in Table 3.2 and Table 3.4).

The proportion of geothermal heat pumps shipped to each Census Region in 2006 was as follows: the South (29 percent), the Midwest (34 percent), the Northeast (12 percent), and the West (12 percent) (Table 3.5). The proportion of geothermal heat pumps exported was 12 percent. Sixty-one percent of geothermal heat pumps were shipped to wholesale distributors, while 38 percent went to installers. The remaining 1 percent was sold to exporters, retail distributors, or end-users (Table 3.6). The total rated capacity of domestically shipped heat pumps in 2006 was 215,166 tons. Of that total 113,355 tons were shipped to the residential sector and 101,768 tons to commercial sector. (Table 3.7).

Direct use geothermal energy (e.g., low-temperature water from conventional geothermal sources for crop drying) and energy consumed by GHP both increased in 2006. GHP energy consumption increased 15 percent in 2006 to an estimated 28 trillion Btu, while direct use inched upward from 8.8 to 9.1 trillion Btu (Table 3.8).

[1] The energy efficiency ratio (EER) is the ratio of cooling capacity in Btu/hour to the power input in watts under a given set of conditions.
[2] The coefficient of performance (COP) is the ratio of heat provided in Btu/hour to power input in watts.

Table 3.1. Geothermal Heat Pump Shipments by Model Type, 2000-2006
(Number of Units)

Model	2000	2001	2002	2003	2004	2005	2006
ARI-320	7,808	NA	6,445	10,306	9,130	9,411	10,968
ARI-325/330	26,219	NA	26,802	25,211	31,855	34,861	47,440
Other Non-ARI Rated	1,554	NA	3,892	922	2,821	3,558	5,274
Totals	35,581	NA	37,139	36,439	43,806	47,830	63,682

NA=Not Available. No survey was conducted for 2001.
Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

Table 3.2. Capacity of Geothermal Heat Pump Shipments by Model Type, 2000-2006
(Total Rated Capacity Tons)

Model	2000	2001	2002	2003	2004	2005	2006
ARI-320	26,469	NA	16,756	29,238	23,764	28,064	31,198
ARI-325/330	130,132	NA	96,541	89,731	100,317	110,291	155,736
Other Non-ARI Rated	7,590	NA	12,000	5,469	20,220	22,047	58,669
Totals	164,191	NA	125,297	124,438	144,301	160,402	245,603

NA=Not Available. No survey was conducted for 2001.
Note: One ton of capacity is equal to 12,000 Btus per hour.
Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

Table 3.3. Average Cooling Efficiency for Geothermal Heat Pump Shipments, 2006 (Average EER)

Model Type	2006
ARI-320	12.9
ARI-325/330	19.3
Other (Non-ARI Rated)	13.1

EER=Energy Efficiency Ratio
Note: One ton of capacity is equal to 12,000 Btus per hour. Efficiency is expressed as btus of output per watthours of input. The higher the EER the more efficient the unit is.
Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

Table 3.4. Average Heating Efficiency for Geothermal Heat Pump Shipments, 2006 (Average COP)

Model Type	2006
ARI-320	4.4
ARI-325/330	3.9
Other (Non-ARI Rated)	3.4

COP=Coefficient of Performance
Note: One ton of capacity is equal to 12,000 Btus per hour. Efficiency is expressed as Btus of output per watthours of input. The higher the COP the more efficient the unit is.
Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

Table 3.5. Geothermal Heat Pump Shipments by Export, Census Region and Model Type, 2006
(Total Rated Capacity Tons)

Destination	Model Type			
	ARI-320	ARI-325/330	Other Non-ARI Rated GHPs	Total
Exported	882	14,226	15,329	30,437
Midwest	1,449	70,549	12,686	84,684
Northeast	4,306	17,046	8,754	30,106
South	19,893	44,739	6,677	71,309
West	4,665	9,163	15,223	29,051
US Territories	3	13	0	16
Total	31,198	155,736	58,669	245,603

NA=Not Available
Note: The Midwest Census Region consists of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. The Northeast Census Region consists of Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont. The South Census Region consists of Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennesse, Texas, Virginia, and West Virginia. The West Census Region consists of Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. "Export" in Table 3.5 and "Exporter" in Table 3.6 are different. "Export" refers to shipments outside of the country, while "Exporter" is the type of customer.
Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

Table 3.6. Geothermal Heat Pump Domestic Shipments by Customer Type and Model Type, 2006 (Total Rated Capacity Tons)

Customer	Model Type			
	ARI-320	ARI-325/330	Other Non-ARI Rated GHPs	Total
Exporter	6	153	47	206
Wholesale Distributor	10,895	86,402	33,045	130,342
Retail Distributor	0	83	1,483	1,566
Installer	19,415	54,872	8,434	82,721
End-User	0	0	331	331
Total	30,316	141,510	43,340	215,166

NA=Not Available
Note: "Export" in Table 3.5 and "Exporter" in Table 3.6 are different. "Export" refers to shipments outside of the country, while "Exporter" is the type of customer.
Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

Table 3.7. Geothermal Heat Pump Domestic Shipments by Sector and Model Type, 2006
(Total Rated Capacity Tons)

Destination	Model Type			
	ARI-320	ARI-325/330	Other Non-ARI Rated GHPs	Total
Residential	3,205	103,366	6,784	113,355
Commercial [a]	27,111	38,101	36,556	101,768
Industrial	-	43	-	43
Total	30,316	141,510	43,340	215,166

[a] Including government.
Note: Dash indicates the sector has no shipments reported for that model type.
Source: Energy Information Administration, Form EIA-902, "Annual Geothermal Heat Pump Manufacturers Survey."

Table 3.8. Geothermal Direct Use of Energy and Heat Pumps, 1990-2006
(Quadrillion Btu)

Year	Direct Use	Heat Pumps	Total
1990	0.0048	0.0054	0.0102
1991	0.0050	0.0060	0.0110
1992	0.0051	0.0067	0.0118
1993	0.0053	0.0072	0.0125
1994	0.0056	0.0076	0.0132
1995	0.0058	0.0083	0.0141
1996	0.0059	0.0093	0.0152
1997	0.0061	0.0101	0.0162
1998	0.0063	0.0115	0.0178
1999	0.0079	0.0114	0.0193
2000	0.0084	0.0122	0.0206
2001	0.0090	0.0135	0.0225
2002	0.0090	0.0147	0.0237
2003	0.0086	0.0188	0.0274
2004	0.0086	0.0212	0.0298
2005	0.0088	0.0240	0.0328
2006	0.0091	0.0276	0.0367

Note: Direct use includes applications such as: district heating, aquaculture pond and raceway heating, greenhouse heating and agricultural drying.
Source: John Lund, Oregon Institute of Technology, Geo-Heat Center (Klamath Falls, Oregon, March 2007).

4. Green Pricing and Net Metering Programs, 2006

Background

Green pricing/marketing programs allow electricity customers to voluntarily pay the additional costs for renewable energy through direct payments on their monthly bills. In return, the electricity provider guarantees that it will provide either directly or by contract that amount of renewable-based electricity.

The Energy Information Administration (EIA) collects information about green pricing programs on the Form EIA-861, "Annual Electric Power Industry Report," which is a survey of electric industry participants.[1] All respondents, except independent power producers and qualifying facilities, are asked to report their number of customers in green pricing programs by state and customer class.

Net metering programs usually permit customers - typically residential - operating very small generators for some of their needs to purchase extra electricity when needed and to sell back any excess power to the utility. Provisions vary by state and utility and often apply to solar or wind energy. In addition, pricing schemes vary by individual utility and customer circumstance. This system facilitates the ease of operating intermittent generators, such as those using solar and wind energy, and improves their economics. The EIA collects information on net metering on the Form EIA-861 in much the same manner as it does green pricing.

2006 In Review

After three years of gains (2003 through 2005) in which the number of electric industry participants and participating customers in green pricing programs all increased, 2006 was a year of relative decline (Table 4.H1). While the number of electric industry participants increased, the number of participating customers fell.

The total number of electric industry green pricing program participants increased from 442 in 2005 to 484 in 2006. However, the total number of customers enrolled in green pricing programs decreased by almost 32 percent, falling from 942,772 in 2005 to 645,167 in 2006.

The number of participating customers decreased in nine states, most notably in Ohio, which lost over 400,000 customers (Table 4.1). This loss was the result of Green Mountain Energy Co., a green power marketer, discontinuing service in Ohio. Citing regulatory hurdles and unexpected transmission charges, Green Mountain terminated its agreement to supply the Northeast Ohio Public Energy Council program. This program,

[1] "Electric industry participants" include electric utilities, wholesale power marketers, energy service providers, and electric power producers.

which served residential and small commercial customers in northeast Ohio, was the largest retail electric aggregation program in the country.[2]

The state with the biggest increase was Oregon with a net gain of almost 17,000 customers, followed closely by New York, with a net gain of almost 16,000 customers.

Net metering programs have proliferated over the years. Electric industry participants and participating program customers have increased each year during the 2003 through 2006 period (Table 4.H2).

The total number of electric industry participants increased from 188 in 2005 to 232 in 2006. The total number of participating customers was 34,469 in 2006, an increase of 63 percent over 2005. Of this total, 31,323 or 91 percent, were residential customers. Thirty-five states and the District of Columbia reported gains of net metering customers, with the largest gain - 8,705 customers - reported by California (Table 4.2).[3]

[2] Austin Business Journal, http://www.bizjournals.com/austin/stories/2005/10/24/daily30.html?from_rss=1, October 26, 2005. A retail electric aggregation program combines customers in an effort to gain leverage in the deregulated market place. Bulk-buying allows the program to negotiate lower rates.

[3] For details of individual state net metering programs, including some history, see the North Carolina Solar Center DSIRE database on this website: http://www.dsireusa.org/summarytables/reg1.cfm?&CurrentPageID=7&EE=1&RE=1

Table 4.H1. Estimated U.S. Green Pricing Customers by Customer Class, 2002-2006

Year	Electric Industry Participants	Participating Customers		
		Customer Class		
		Residential	Non-residential	Total
2002	212	688,069	23,481	711,550
2003	308	819,579	57,547	877,126
2004	403	864,794	63,539	928,333
2005	442	871,774	70,998	942,772
2006	484	609,213	35,954	645,167

Note: Non-residential may include some customers for whom no customer class is specified.

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

Source: Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report."

Table 4.H2. Estimated U.S. Net Metering Customers by Customer Class, 2002-2006

Year	Electric Industry Participants	Participating Customers		
		Customer Class		
		Residential	Non-residential	Total
2002	96	3,559	913	4,472
2003	127	5,870	943	6,813
2004	166	14,114	1,712	15,826
2005	188	19,244	1,902	21,146
2006	232	31,323	3,146	34,469

Note: Non-residential may include some customers for whom no customer class is specified.

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

Source: Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report."

Table 4.1. Estimated U.S. Green Pricing Customers by State and Customer Class, 2005 and 2006

State	Electric Industry Participants 2006[a]	Participating Customers			
		2006			2005
		Residential	Non-Residential	Total	Total
Alabama	4	157	6	163	975
Alaska	1	351	5	356	325
Arizona	3	1,894	39	1,933	5,896
Arkansas	-	-	-	-	-
California	11	45,557	1,970	47,527	40,436
Colorado	25	46,948	1,145	48,093	40,409
Connecticut	-	-	-	-	-
Delaware	6	1,676	892	2,568	-
District of Columbia	2	2,500	1,216	3,716	7,049
Florida	6	29,269	32	29,301	23,599
Georgia	19	5,846	137	5,983	3,795
Hawaii	3	4,416	50	4,466	4,279
Idaho	6	4,003	127	4,130	3,878
Illinois	7	2,763	7	2,770	1,227
Indiana	11	2,014	25	2,039	1,427
Iowa	47	7,801	761	8,562	8,050
Kansas	-	-	-	-	-
Kentucky	10	873	16	889	809
Louisiana	-	-	-	-	-
Maine	2	1,939	207	2,146	2,019
Maryland	2	30,712	6,336	37,048	32,727
Massachusetts	3	5,448	207	5,655	4,709
Michigan	9	7,833	159	7,992	2,014
Minnesota	99	31,838	504	32,342	24,688
Mississippi	1	3	0	3	3
Missouri	14	453	6	459	451
Montana	7	451	9	460	400
Nebraska	4	4,825	62	4,887	3,768
Nevada	3	379	0	379	384
New Hampshire	-	-	-	-	-
New Jersey	4	96	267	363	1,692
New Mexico	11	14,225	1,352	15,577	9,852
New York	9	21,604	827	22,431	6,577
North Carolina	22	9,124	356	9,480	7,887
North Dakota	12	5,824	22	5,846	6,857
Ohio	3	250	2	252	402,433
Oklahoma	9	10,657	635	11,292	10,754
Oregon	13	78,648	2,085	80,733	63,755
Pennsylvania	4	36,520	835	37,355	29,758
Rhode Island	2	4,410	106	4,516	3,477
South Carolina	13	3,229	306	3,535	2,455
South Dakota	7	620	20	640	715
Tennessee	-	-	-	-	-
Texas	9	88,670	12,280	100,950	87,224
Utah	7	19,716	472	20,188	16,713
Vermont	2	4,297	240	4,537	2,095
Virginia	2	2,661	17	2,678	3,009
Washington	25	35,145	841	35,986	31,351
West Virginia	-	-	-	-	-
Wisconsin	57	30,037	1,298	31,335	39,701
Wyoming	7	3,531	75	3,606	3,150
Total	484	609,213	35,954	645,167	942,772

[a] Includes entities with green pricing programs in more than one state.
Note: Non-residential may include some customers for whom no customer class is specified. Dash indicates no data was reported for the state. Totals may not equal the sum of the components due to independent rounding.
Source: Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report."

Table 4.2. Estimated U.S. Net Metering Customers by State and Customer Class, 2005 and 2006

State	Electric Industry Participants 2006[a]	Participating Customers			
		2006			2005
		Residential	Non-Residential	Total	Total
Alabama	-	-	-	-	13
Alaska	-	-	-	-	-
Arizona	4	185	3	188	152
Arkansas	2	3	1	4	5
California	19	24,160	1,972	26,132	17,427
Colorado	17	380	25	405	145
Connecticut	2	165	16	181	75
Delaware	1	40	10	50	20
District of Columbia	1	1	1	2	-
Florida	5	41	7	48	29
Georgia	1	1	0	1	1
Hawaii	4	184	23	207	98
Idaho	4	28	6	34	21
Illinois	4	4	7	11	8
Indiana	3	11	9	20	16
Iowa	7	10	7	17	16
Kansas	5	15	4	19	11
Kentucky	3	3	2	5	3
Louisiana	-	-	-	-	-
Maine	1	3	0	3	8
Maryland	5	13	0	13	9
Massachusetts	5	454	104	558	246
Michigan	5	9	4	13	7
Minnesota	26	310	19	329	193
Mississippi	-	-	-	-	-
Missouri	4	4	2	6	5
Montana	2	41	5	46	253
Nebraska	-	-	-	-	-
Nevada	2	213	23	236	188
New Hampshire	4	69	28	97	93
New Jersey	5	1,789	203	1,992	604
New Mexico	7	22	2	24	16
New York	5	1,088	119	1,207	130
North Carolina	-	-	-	-	-
North Dakota	2	1	1	2	4
Ohio	8	36	16	52	31
Oklahoma	4	299	153	452	30
Oregon	14	463	77	540	341
Pennsylvania	6	145	29	174	134
Rhode Island	2	81	21	102	81
South Carolina	-	-	-	-	-
South Dakota	-	-	-	-	-
Tennessee	-	-	-	-	-
Texas	9	375	56	431	163
Utah	3	104	7	111	30
Vermont	5	200	32	232	164
Virginia	11	58	2	60	28
Washington	13	124	34	158	96
West Virginia	1			1	1
Wisconsin	12	169	110	279	240
Wyoming	7	22	5	27	11
Total	232	31,323	3,146	34,469	21,146

[a] Includes entities with net metering programs in more than one state.
Note: Non-residential may include some customers for whom no customer class is specified. Dash indicates no data was reported for the state. Totals may not equal the sum of the components due to independent rounding.
Source: Energy Information Administration, Form EIA-861, "Annual Electric Power Industry Report."