CHAPTER 3

Renewable Energy

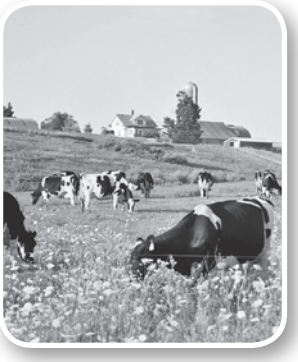
A Quick Guide to Renewable Energy

Renewable energy resources play a key role in Wisconsin's efforts to achieve the Governor's 25 x '25 goal, and to reduce dependence on imported fuels. According to Wisconsin Statutes 196.374(1)(j), a renewable resource "derives energy from any source other than coal, petroleum products, nuclear power, or …natural gas."

Biomass is organic matter (plant material, vegetation, agriculture waste, forestry waste) used as a fuel or source of energy. Use of biomass as an energy source results in little net production of carbon dioxide because the CO_2 generated during combustion of plant material equals the CO_2 consumed during the lifecycle of the plant. A map of biomass density across the United States can be found in the Map Appendix.

Wind power uses turbines to generate electricity for distribution on the electric grid and/or to displace energy normally purchased from the grid. A map of wind production sites and wind energy potential across Wisconsin can be found in the Map Appendix.

Biogas is produced from the state's landfills and agricultural manure digesters. Often, biogas is included under the heading biomass. In this statistics book, we break out biogas from biomass to provide further definition and detail about these resources in the state.



Solar thermal uses sunlight to generate heat for applications such as water heating without fossil fuels.

Hydro power uses the kinetic energy of moving water to generate electricity for distribution on the electric grid. A map of hydroelectric sites in Wisconsin can be found in the Map Appendix.

Solar photovoltaic uses sunlight to generate electricity to displace energy normally purchased from the electric grid, or to add energy to the electric grid. A map of solar intensity across the United States Wisconsin can be found in the Map Appendix.

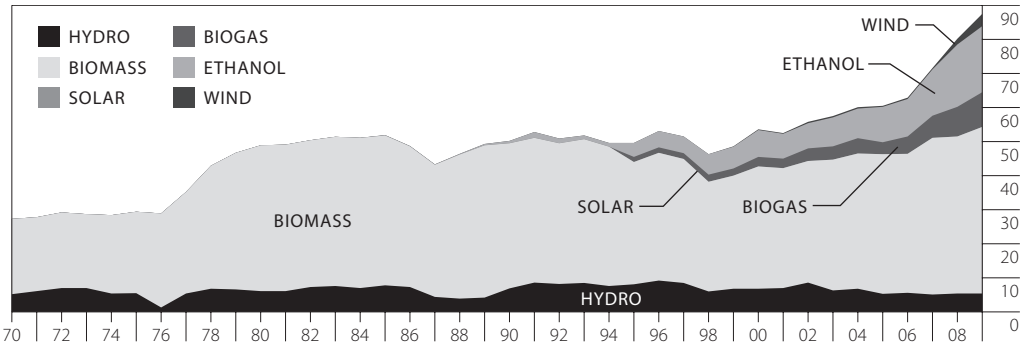
Ethanol is a renewable transportation fuel primarily made from corn. It is used as the oxygenate in reformulated gasoline sold in southeastern Wisconsin and as E10 and E85 throughout the state. A listing of ethanol facilities is on the OEI website at: http://energyindependence.wi.gov/docview.asp?docid=11272&locid=160.

Wisconsin Renewable Energy Production, by Type of Fuel

This table includes all renewable energy used in Wisconsin for generating electricity and for other applications that displace fossil fuels (e.g., space heating, transportation fuel).

All the figures for solar energy, biomass and biogas were historically revised in 2007 to more accurately represent a revision to methodology and data sources. For example, this table does not include estimated passive solar, municipal solid waste or other refuse derived fuels, (e.g., railroad ties, tires) except where defined by law as a renewable fuel.

1970-2009 TRILLIONS OF BTU



1970-2009 TRILLIONS OF BTU AND PERCENT OF TOTAL

Year	Hydro		Biomass		Solar		Biogas		Ethanol[a]		Wind		Total
1970	5.2	*19.0%*	22.1	*81.0%*	0.0	*0.0%*	0.0	*0.0%*	0.0	*0.0%*	0.00	*0.0%*	27.3
1975	5.5	*18.7%*	23.9	*81.3%*	0.0	*0.0%*	0.0	*0.0%*	0.0	*0.0%*	0.00	*0.0%*	29.4
1980	6.1	*12.5%*	42.8	*87.5%*	0.0	*0.0%*	0.0	*0.0%*	0.0	*0.0%*	0.00	*0.0%*	48.9
1985[r]	7.8	*15.0%*	44.0	*84.7%*	0.0	*0.0%*	0.0	*0.0%*	0.1	*0.2%*	0.00	*0.0%*	51.9
1990[r]	6.9	*13.7%*	42.6	*84.9%*	0.0	*0.0%*	0.0	*0.0%*	0.7	*1.4%*	0.00	*0.0%*	50.2
1995[r]	8.1	*16.4%*	35.9	*72.3%*	0.0	*0.0%*	1.5	*3.1%*	4.1	*8.3%*	0.00	*0.0%*	49.6
2000[r]	6.8	*12.7%*	35.9	*67.1%*	0.0	*0.0%*	2.8	*5.2%*	7.9	*14.8%*	0.16	*0.3%*	53.6
2005[r]	5.3	*8.8%*	41.0	*67.7%*	0.00652	*0.0%*	3.5	*5.8%*	10.4	*17.1%*	0.32	*0.5%*	60.5
2006[r]	5.6	*8.9%*	40.8	*64.9%*	0.01227	*0.0%*	5.1	*8.1%*	11.0	*17.5%*	0.35	*0.6%*	62.8
2007[r]	5.1	*7.1%*	46.0	*64.3%*	0.01674	*0.0%*	6.5	*9.1%*	13.6	*19.0%*	0.37	*0.5%*	71.5
2008[r]	5.4	*6.8%*	46.1	*57.5%*	0.02728	*0.0%*	8.7	*10.9%*	18.3	*22.8%*	1.66	*2.1%*	80.3
2009[p]	**5.4**	***6.1%***	**48.9**	***55.9%***	**0.03528**	***0.0%***	**10.2**	***11.7%***	**19.4**	***22.2%***	**3.59**	***4.1%***	**87.4**

a Ethanol is blended with a petroleum-based fuel to produce reformulated gasoline, E10 and E85.

p Preliminary estimates.

r Revised.

Source: Public Service Commission of Wisconsin, unpublished data compiled from annual reports (2007-2009); Focus on Energy, aggregated data (2005-2009); survey data from conversations and emails with utilities, independent operators of landfills and/or waste water treatment plants, and public schools (2007-2009); Department of Revenue *Monthly Motor Fuel Consumption Report* (2000-2009); Energy Center of Wisconsin, *Wisconsin Agricultural Biogas* Casebook (2008); Wisconsin Department of Natural Resources, Annual Survey of Point Source Emissions, unpublished (1972-2009); Wisconsin Department of Administration, Division of Energy, "Wisconsin Residential Wood Energy Model," unpublished (1981-2009); Public Service Commission of Wisconsin, Focus on Energy Evaluation *Semiannual Report (Second Half of 2009)*, April 23, 2010 (2009) http://www.focusonenergy.com/files/Document_Management_System/Evaluation/semiannualsecondhalf2009_evaluationreport.pdf; U.S. Department of Energy, Energy Information Administration, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981* (August 1983); Compiled from renewable energy tables in this publication.

OVERALL RENEWABLE ENERGY USE
8.9%

Overall renewable energy use in Wisconsin increased 8.9 percent in 2009. Ethanol use in the transportation sector increased 5.8 percent. Hydro generation includes electricity generation by Wisconsin utilities and dams owned by industrial users (e.g., paper mills). Solar and wind energy figures include distributed energy sold to utilities by residential and commercial users.

Maps of Wisconsin's hydroelectric sites, wind installations ("wind farms") and U.S. potential for biomass and solar can be found in the Map Appendix in the back of this book.

Wisconsin Renewable Energy Production, by Economic Sector

TOTAL END-USE ENERGY
6.4%

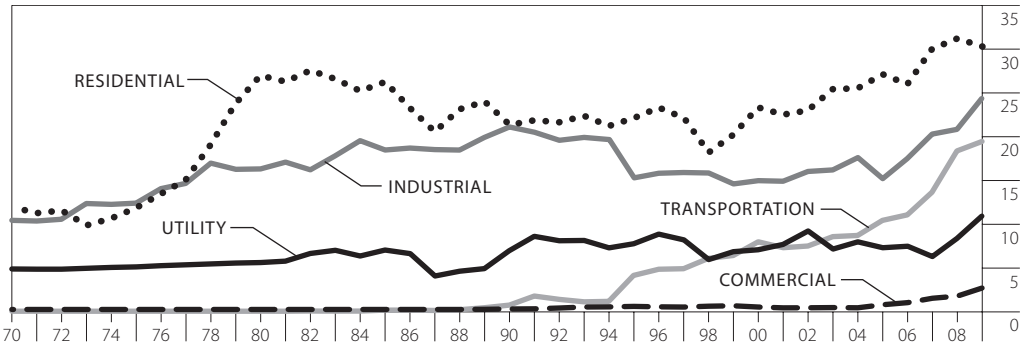
Wisconsin's total end-use energy increased by 6.4 percent. The residential and industrial sectors use the most renewable energy, primarily due to woodburning in these sectors. Residential data also include solar hot water and photovoltaic systems, and wind power. Data reported in the electric sector represents resource energy, meaning that the renewable fuels are used to generate electricity which is sold through the grid. Transportation sector renewable energy measures use of ethanol blended with gasoline and sold as E10 and E85.

Maps of Wisconsin's hydroelectric sites, wind installations ("wind farms") and U.S. potential for biomass and solar can be found in the Map Appendix in the back of this book.

This table includes all renewable energy used in Wisconsin for generating electricity and for other applications that displace fossil fuels (e.g., space heating, transportation fuel).

In 2007, the figures in this table were revised to remove non-metered resources such as passive solar energy and resources not considered renewable under Wisconsin law (e.g., municipal solid waste and refuse derived fuel such as railroad ties and tires). This impacted all sectors when compared to previous versions of this publication.

1970-2009 TRILLIONS OF BTU



1970-2009 TRILLIONS OF BTU AND PERCENT OF TOTAL

Year	Residential		Commercial		Industrial		Electric Utility		Transportation		Total Resources	Total End Use
1970	11.9	*43.6%*	0.2	*0.7%*	10.4	*38.0%*	4.8	*17.7%*	0.0	*0.0%*	27.3	22.5
1975	11.8	*40.1%*	0.2	*0.7%*	12.3	*42.0%*	5.1	*17.2%*	0.0	*0.0%*	29.4	24.3
1980[r]	26.9	*55.0%*	0.2	*0.4%*	16.2	*33.2%*	5.6	*11.4%*	0.0	*0.0%*	48.9	43.4
1985[r]	26.2	*50.4%*	0.2	*0.4%*	18.4	*35.5%*	7.0	*13.5%*	0.1	*0.2%*	51.9	44.9
1990[r]	21.3	*42.4%*	0.3	*0.5%*	21.0	*41.9%*	6.9	*13.8%*	0.7	*1.4%*	50.2	43.3
1995[r]	22.0	*44.4%*	0.6	*1.1%*	15.2	*30.7%*	7.7	*15.5%*	4.1	*8.3%*	49.6	41.9
2000[r]	23.3	*43.4%*	0.5	*0.9%*	14.9	*27.8%*	7.0	*13.1%*	7.9	*14.8%*	53.6	46.6
2005[r]	27.0	*44.7%*	0.7	*1.2%*	15.1	*25.0%*	7.2	*12.0%*	10.4	*17.1%*	60.5	53.3
2006[r]	25.9	*41.3%*	1.0	*1.6%*	17.4	*27.8%*	7.4	*11.8%*	11.0	*17.5%*	62.7	55.3
2007[r]	30.0	*41.9%*	1.5	*2.1%*	20.2	*28.3%*	6.2	*8.7%*	13.6	*19.0%*	71.5	65.3
2008[r]	31.1	*38.8%*	1.7	*2.1%*	20.8	*25.9%*	8.3	*10.4%*	18.3	*22.8%*	80.3	71.9
2009[p]	**30.2**	***34.6%***	**2.7**	***3.0%***	**24.3**	***27.8%***	**10.9**	***12.4%***	**19.4**	***22.2%***	**87.4**	**76.6**

p Preliminary estimates.

r Revised.

Source: Focus on Energy via the Wisconsin Energy Conservation Corporation, unpublished, aggregated data (2005-2009); survey data from conversations and emails with utilities, independent operators of landfills and/or waste water treatment plants, and public schools (2007-2009); Department of Revenue *Monthly Motor Fuel Consumption Report* (2000-2009); Energy Center of Wisconsin *Wisconsin Agricultural Biogas Casebook* (2008); Public Service Commission of Wisconsin, unpublished data complied from utility annual reports (1970-2009), http://psc.wi.gov/apps/annlreport/default.

Wisconsin Wood Use, by Economic Sector

In previous versions of this book, the electric sector was included in this table. Electric sector data is included in tables elsewhere in this chapter.

1970-2009 TRILLIONS OF BTU AND PERCENT OF TOTAL

Year	Residential[a]		Commercial[b]		Industrial		Total
1970	11.9	*53.8%*	0.20	*0.9%*	10.0	*45.2%*	22.1
1975	11.8	*49.4%*	0.20	*0.8%*	11.9	*49.8%*	23.9
1980	26.9	*62.9%*	0.20	*0.5%*	15.7	*36.7%*	42.8
1985[r]	26.2	*59.5%*	0.20	*0.5%*	17.6	*40.0%*	44.0
1990[r]	21.3	*51.2%*	0.26	*0.6%*	20.0	*48.2%*	41.5
1995[r]	22.0	*62.5%*	0.55	*1.6%*	12.7	*35.9%*	35.3
1996[r]	23.2	*63.1%*	0.50	*1.4%*	13.1	*35.6%*	36.9
1997[r]	22.1	*62.0%*	0.48	*1.3%*	13.1	*36.7%*	35.6
1998[r]	18.1	*57.5%*	0.57	*1.8%*	12.8	*40.7%*	31.5
1999[r]	20.1	*62.4%*	0.62	*1.9%*	11.5	*35.7%*	32.3
2000[r]	23.3	*66.5%*	0.48	*1.4%*	11.2	*32.1%*	35.0
2001[r]	22.4	*65.7%*	0.38	*1.1%*	11.3	*33.2%*	34.2
2002[r]	22.9	*65.9%*	0.37	*1.1%*	11.5	*33.1%*	34.8
2003[r]	25.3	*67.8%*	0.36	*1.0%*	11.7	*31.3%*	37.4
2004[r]	25.4	*66.2%*	0.32	*0.8%*	12.7	*33.0%*	38.5
2005[r]	27.0	*68.5%*	0.27	*0.7%*	12.2	*30.8%*	39.5
2006[r]	25.9	*69.6%*	0.24	*0.7%*	11.0	*29.7%*	37.2
2007[r]	29.9	*70.3%*	0.44	*1.0%*	12.2	*28.6%*	42.6
2008[r]	31.1	*71.7%*	0.54	*1.2%*	11.7	*27.0%*	43.4
2009[p]	**30.2**	***66.9%***	**0.80**	***1.8%***	**14.2**	***31.4%***	**45.2**

a Revisions by the federal Bureau of Economic Activity, shifting the baseline year from 2000 to 2005, resulted in changes in the GDP, which impacted estimates of residential woodburning.

b Commercial sector figures are revised to reflect data incorrectly assigned to the electric production sector which are now correctly categorized with wood/biomass for non-electric production.

p Preliminary estimates.

r Revised.

Source: U.S. Department of Energy, Energy Information Administration, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981* (August 1983); Wisconsin Department of Natural Resources, Annual Survey of Point Source Emissions, unpublished (1972-2009); USDA Forest Service, *Residential Fuelwood Consumption and Production in Wisconsin* (1994); Wisconsin Department of Administration, Division of Energy, "Wisconsin Residential Wood Energy Model," unpublished (1981-2009), and *Directory of Wisconsin Wood Burning Facilities* (1995).

WOOD ENERGY USE
4.1%

Wood energy use in Wisconsin increased by 4.1 percent in 2009. This table shows wood used in Wisconsin for applications that displace the use of fossil fuels, such as space heating or water heating. Wood used in this table does not represent wood used to generate electricity.

Residential wood use is estimated using a variety of factors including heating degree days, cost of other winter fuels and gross domestic product, the efficiency factor of wood, and the number of households in Wisconsin. The Commercial sector wood use includes schools, hospitals, wholesalers and retailers, and construction.

A map of biomass potential distribution across the United States can be found in the Map Appendix in the back of this book

Wisconsin Manufacturing Industry Use of Wood Fuel, by Industry Group

The use of wood and wood products as fuel by Wisconsin industries is concentrated among businesses that use or produce a wood product. Lumber mills burn sawdust, bark and scrap wood as a boiler fuel and for kiln drying boards. Furniture and paper companies use scrap wood and wood byproducts for process steam, heating and generating electricity. Wood in Wisconsin is a renewable resource for heating as well as electricity generation.

A map of biomass potential distribution across the United States can be found in the Map Appendix in the back of the book.

1972-2009 THOUSANDS OF TONS AND TRILLIONS OF BTU[a]

	Lumber		Furniture		Paper & Allied		Other Manufacturing		Total	
Year	(Tons)	(Btu)	(Tons)	(Btu)	(Tons)	(Btu)	(Tons)	(Btu)	(Tons)	(Btu)
1972	391.2	4.42	13.2	0.15	508.5	5.75	16.1	0.18	929.0	10.50
1975	437.2	4.94	24.5	0.28	575.6	6.50	17.1	0.19	1,054.4	11.91
1980	447.5	5.06	56.9	0.64	872.8	9.86	12.0	0.14	1,389.2	15.70
1985	427.3	4.83	53.9	0.61	1,046.7	11.83	33.5	0.38	1,561.4	17.64
1990	490.9	5.55	64.0	0.72	1,186.5	13.41	30.0	0.34	1,771.4	20.02
1995	480.6	5.43	29.3	0.33	592.3	6.69	19.9	0.22	1,122.1	12.68
1996	435.9	4.93	29.9	0.34	676.8	7.65	18.6	0.21	1,161.2	13.12
1997	402.2	4.54	23.2	0.26	712.3	8.05	17.6	0.20	1,155.2	13.05
1998	408.1	4.61	22.1	0.25	693.2	7.83	10.9	0.12	1,134.2	12.82
1999	455.4	5.15	22.7	0.26	535.1	6.05	7.9	0.09	1,021.1	11.54
2000	432.3	4.89	20.1	0.23	534.5	6.04	7.5	0.08	994.4	11.24
2001	419.9	4.74	19.0	0.21	554.5	6.27	8.9	0.10	1,002.3	11.33
2002	415.2	4.69	17.2	0.19	577.5	6.53	9.0	0.10	1,019.0	11.51
2003	384.3	4.34	15.3	0.17	626.9	7.08	8.2	0.09	1,034.7	11.69
2004	434.5	4.91	13.5	0.15	665.5	7.52	10.5	0.12	1,124.0	12.70
2005	421.8	4.77	10.8	0.12	633.4	7.16	10.5	0.12	1,076.5	12.16
2006	356.1	4.02	7.6	0.09	597.3	6.75	16.5	0.19	977.4	11.05
2007	361.3	4.08	7.5	0.08	690.4	7.80	19.3	0.22	1,078.5	12.19
2008	300.0	3.39	5.6	0.06	712.1	8.05	20.7	0.23	1,038.4	11.73
2009[p]	**256.7**	**2.90**	**4.0**	**0.05**	**971.6**	**10.98**	**21.8**	**0.25**	**1,254.1**	**14.17**

a Gross heating values of wood range from 8 MMBtu per ton to 17 MMBtu per ton, due in part to differences in moisture content. In this table, 11.3 MMBtu per ton is used, based on estimates of moisture content and type of wood used in Wisconsin.

p Preliminary.

Source: Estimates by the Wisconsin Office of Energy Independence, based on Wisconsin Department of Natural Resources, Annual Survey of Point Source Emissions, unpublished (1972-2009); Employment Research Associates, *Biomass Resources: Generating Jobs and Energy*, Technical Papers (January 1986); Department of Administration, Division of Energy, Directory of Wisconsin Wood Burning Facilities (1995).

Wisconsin Electric Utility Use of Wood Fuel

1970-2009

Year	Tons	Billions of Btu
1970-1975	0	0
1980	76,282	740
1985	155,717	1,666
1990	299,464	3,112
1995	327,201	3,506
1996	339,803	3,837
1997	304,618	3,326
1998	334,231	3,871
1999	330,491	3,765
2000	296,739	3,430
2001	301,580	3,484
2002	283,774	3,260
2003	267,446	3,154
2004	242,973	2,877
2005	253,638	2,961
2006	288,907	3,482
2007	315,811	3,437
2008	342,684	3,735
2009	**362,471**	**3,868**

Source: Wisconsin Department of Natural Resources, Annual Survey of Point Source Emissions, unpublished (1972-1994); annual reports of various Wisconsin electric generating utilities (1995-2009). http://psc.wi.gov/apps/annlreport/default

WOOD ENERGY USED FOR ELECTRICITY

In the utility sector, Northern States Power (NSP)/Xcel Energy uses wood for their electricity-generation fuel at the Bay Front and French Island generating plants.

Wood energy used for electricity in Wisconsin increased in 2009 when NSP increased wood usage at its Bay Front plant.

These figures represent resource energy, before conversion of wood fuel to electricity.

NSP began using wood fuel at Bay Front in 1976 and at its French Island facility in 1980. These are the only electric utility generation sites in Wisconsin using significant amounts of wood.

A map of biomass potential distribution across the United States can be found in the Map Appendix.

Wisconsin Electric Utility and Non-Utility Hydroelectric Generation

ELECTRIC UTILITY HYDROELECTRIC PRODUCTION
7.9%

Total Wisconsin hydroelectric production — utility and non-utility — decreased 7.9 percent from 2008 to 2009. Because hydroelectric production is impacted by rainfall, among other factors, precipitation inches are provided in this table. In 2009, total precipitation in Wisconsin fell by 11.7 percent from 2008.

A map of Wisconsin's hydroelectric sites can be found in the Map Appendix in the back of the book.

1970-2009 MILLIONS OF kWh

Year	Wisconsin Operated Utility Plant Location		Total Utility	Wisconsin Non-Utility	Total Wisconsin	Total Wisconsin Precipitation (inches per year)
	Wisconsin[a,b]	MIchigan				
1970	1,413.2	448.1	1,861.3	110.0	1,523.2	32.0
1975	1,482.9	450.3	1,933.2	129.4	1,612.3	32.4
1980	1,628.3	488.9	2,117.2	160.4	1,788.7	32.5
1985	2,046.3	543.6	2,589.9	235.9	2,282.2	37.0
1990	1,791.0	340.2	2,131.2	223.4	2,014.4	36.2
1995	2,097.1	440.1	2,537.2	281.4	2,378.5	32.9
1996	2,401.9	500.7	2,902.6	294.1	2,696.0	32.8
1997	2,182.2	458.5	2,640.7	301.1	2,483.3	28.6
1998	1,517.8	324.0	1,841.8	229.6	1,747.4	32.7
1999	1,734.0	416.1	2,150.1	250.6	1,984.6	34.0
2000	1,749.4	369.6	2,119.0	241.4	1,990.8	34.8
2001	1,887.6	383.3	2,270.9	168.6	2,056.2	35.5
2002	2,282.9	485.8	2,768.7	232.1	2,515.0	35.2
2003	1,623.4	373.4	1,996.8	219.9	1,843.3	28.4
2004	1,748.4	401.0	2,149.4	232.3	1,980.7	35.3
2005[r]	1,499.0	338.6	1,837.6	51.7	1,550.7	29.2
2006[r]	1,446.0	326.3	1,772.3	180.9	1,626.9	30.7
2007[r]	1,314.0	272.6	1,586.6	169.2	1,483.2	34.0
2008[r]	1,428.0	272.6	1,700.6	157.6	1,585.6	33.6
2009[p]	**1,352.7**	**251.2**	**1,603.9**	**108.2**	**1,460.9**	**29.7**

a Including Wisconsin power cooperatives.

b From 1970 to 1989, data were sourced from the Public Service Commission bulletins; from 1990 to 2008, data are sourced from the federal Energy Information Administration (EIA). Beginning in 2009, data are from the Wisconsin Public Service Commission. Totals here may not match other hydroelectric totals in the book due to different data sources.

p Preliminary estimates.

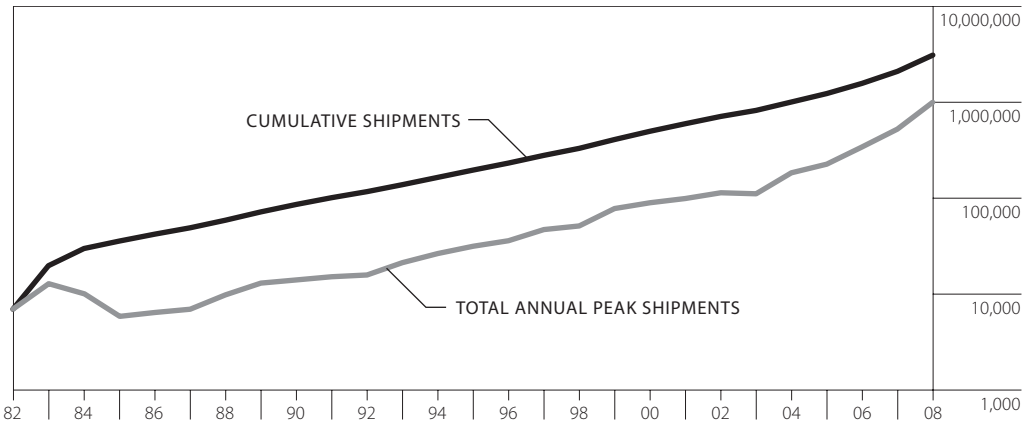
r Revised.

Source: Public Service Commission of Wisconsin, Accounts and Finance Division, *Generating Plants Operated by Wisconsin Electric Utilities*, Bulletin #46 (1971-1994); U.S. Department of Agriculture, Rural Electrification Administration, *Annual Statistical Report*, REA Bulletin 1-1 (1971-1994); Wisconsin Department of Administration, Division of Energy, Wisconsin Hydroelectric Generation Model, unpublished (1994); National Oceanic and Atmospheric Administration, *Monthly State Heating Degree Days, Historical Climatology Series 5-1* (April 2004); U.S. Department of Energy, Energy Information Administration, *Electric Power Monthly* [DOE/EIA-0226 (2010/03)] (March 2010), http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html; Public Service Commission of Wisconsin, unpublished electrical production data (2005-2009).

U. S. Photovoltaic Modules and Cell Shipments and Conversion Efficiency

1982-2008 PHOTOVOLTAIC SHIPMENTS (KILOWATTS)

The table also includes information about conversion efficiency, which measures the fraction of solar energy that is converted into electrical energy. PV modules average a conversion efficiency of about 15 percent for Crystalline Silicon and about 10 percent for Amorphous Silicon.



	Photovoltaic Shipments[a]		Average Energy Conversion Efficiency Photovoltaic					
			Crystalline Silicon			Thin-Film Silicon		Concentrator
Year	Shipments Total Annual Peak Kilowatts	Cumulative Kilowatts	Single Crystal	Cast	Ribbon	Amorphous Silicon	Other	Silicon
1982	6,897	6,897						
1985	5,769	35,198						
1990	13,837	84,719						
1995	31,059	193,328						
1996	35,464	228,792						
1997	46,354	275,146						
1998	50,562	325,708						
1999	76,787	402,495						
2000	88,221	490,716						
2001	97,666	588,382						
2002	112,090	700,472						
2003	109,357	809,829						
2004	181,116	990,945						
2005	222,916	1,213,861						
2006	337,268	1,551,129						
2007	517,684	2,068,813	17	14	12	8	12	35
2008[p]	**986,504**	**3,055,317**	**19**	**14**	**13**	**8**	**12**	**34**

a Total shipments in the table represent shipment from outside and within the United States, and do not include export shipments to other counties.

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review* [DOE/EIA-0384(2009) (August 2010)], table 10.8 (2009) www.eia.doe.gov/aer; U. S. Department of Energy, Energy Information Administration, December 2009, Form EIA-63B, *Annual Photovoltaic Module/Cell Manufacturers Survey*, Table 3.8, "Average Energy Conversion Efficiency of Photovoltaic Cells and Modules Shipped", 2007-2008 (2009).

Shipments of photovoltaic (PV) modules and cells are measured in peak kilowatts (KW), also known as the rated capacity (how much power can be produced under standardized test conditions). Data in the table show KWs of shipments for each year, as well as cumulative shipments since the Energy Information Administration (EIA) began collecting these data.

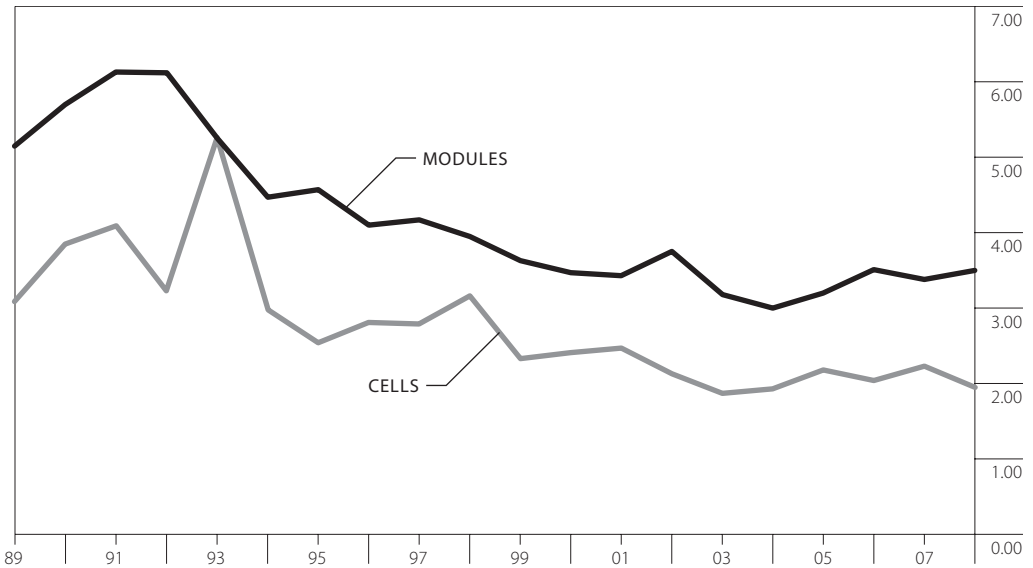
Since 1982 total shipments of PV systems have exceeded 3,000 Megawatts (MW). Since 2003 annual shipments of PV systems have been doubling every 18 months, an annual average growth of nearly 60 percent. The volume of shipments is a good proxy for the growth of PV in the commercial, industrial and residential sectors and demonstrates a steady growth in the purchase and installation of PV in the United States.

U. S. Photovoltaic Modules and Cell Prices

Growth in photovoltaic (PV) is demonstrated by falling prices. From 1990 to 2008, PV systems shipment prices fell by a factor of two. A PV module is an integrated assembly of PV cells that generate direct current power for PV systems. The price per watt of a module (about $3/watt) is about 55 percent higher than the cost of PV cells (about $2/watt).

A small grid-connected fix-mounted PV system has a retail price of about $7 per watt installed. The PV modules comprise about half of that price. In Wisconsin, the cost of purchasing and installing PV power systems can be offset through the involvement of the Focus on Energy Program, the state's rate-payer funded energy efficiency program.

1989-2008 DOLLARS PER PEAK WATT



Year	Dollars per Peak Watt (nominal[a] dollars) Modules	Cells
1989	5.14	3.08
1990	5.69	3.84
1995	4.56	2.53
1996	4.09	2.80
1997	4.16	2.78
1998	3.94	3.15
1999	3.62	2.32
2000	3.46	2.40
2001	3.42	2.46
2002	3.74	2.12
2003	3.17	1.86
2004	2.99	1.92
2005	3.19	2.17
2006	3.50	2.03
2007	3.37	2.22
2008[p]	**3.49**	**1.94**

a Nominal dollars represent the prices during the year cited, they are not adjusted for inflation.

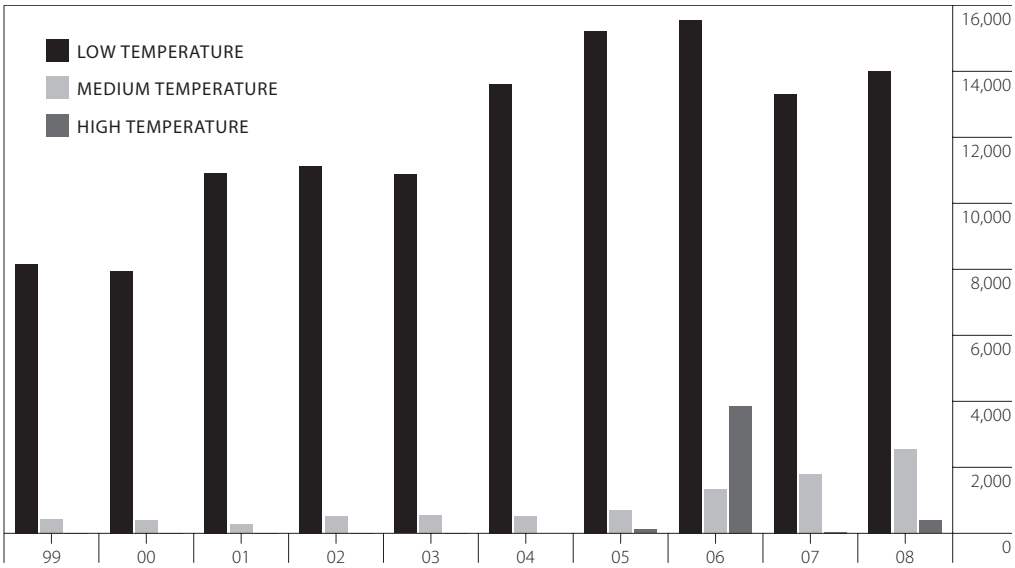
p Preliminary.

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review* [DOE/EIA-0384(2009) (August 2010)], table 10.8 (2009) www.eia.doe.gov/aer; U. S. Department of Energy, Energy Information Administration, December 2009, Form EIA-63B, *Annual Photovoltaic Module/Cell Manufacturers Survey*, Table 3.8, "Average Energy Conversion Efficiency of Photovoltaic Cells and Modules Shipped", 2007-2008 (2009).

U. S. Solar Thermal Collector Shipments and Prices

1999-2008 THOUSANDS OF SQUARE FEET

In Wisconsin medium temperature solar thermal systems can range from $100-$200 per square foot, depending on the size of the system, the quality of the system and the labor involved in the installation. A solar thermal system sized for a residential home is typically 40-64 square feet of collector area, or 1 square foot of medium-temperature solar thermal collector for every gallon of hot water used within the household per day.



1999-2008 THOUSANDS OF SQUARE FEET AND PERCENT OF ALL SHIPMENTS

Year	Low Temperature		Medium Temperature		High Temperature		Total
1999	8,152	*95.0%*	427	*5.0%*	4	*0.0%*	8,583
2000	7,948	*95.2%*	400	*4.8%*	5	*0.1%*	8,353
2001	10,919	*97.6%*	268	*2.4%*	2	*0.0%*	11,189
2002	11,126	*95.4%*	535	*4.6%*	2	*0.0%*	11,663
2003	10,877	*95.0%*	560	*4.9%*	7	*0.1%*	11,444
2004	13,608	*96.4%*	506	*3.6%*		*0.0%*	14,114
2005	15,224	*94.9%*	702	*4.4%*	115	*0.7%*	16,041
2006	15,546	*74.9%*	1,346	*6.5%*	3,852	*18.6%*	20,744
2007	13,323	*87.9%*	1,797	*11.9%*	33	*0.2%*	15,153
2008	**14,015**	***82.6%***	**2,560**	***15.1%***	**388**	***2.3%***	**16,963**

Source: U.S. Department of Energy, Energy Information Administration, *Solar Thermal Collector Manufacturing Activities*, 2008 (2009), table 2.12, http://www.eia.doe.gov/cneaf/solar.renewables/page/solarthermal/solarthermal.html

Solar thermal collectors displace fossil fuels by using solar energy to heat water. Data in the table below represents national solar thermal collector shipments; these figures are not specific to Wisconsin. Solar thermal shipments can be used as a rough proxy for increased national interest in using solar power for water heating.

Different collectors heat water to different temperatures, for different applications. In 2008, low temperature collectors, used primarily for seasonal pool heating, comprise 83 percent of the shipments. Medium temperature collectors, used for domestic water heating, comprise only 15 percent of all shipments in the United States. High temperature solar collectors are used for energy generation applications in the sunniest parts of the country.

Wisconsin Renewable Energy Electricity Generated and Purchased

RENEWABLE ELECTRICITY GENERATION
25.5%

In 2009, Wisconsin's electric utilities and non-utilities, such as paper mills, increased their generation of electricity from renewable energy sources by 25.5 percent. The primary renewable energy source used was hydropower, which represents 34.8 percent of Wisconsin's renewable electricity generation.

Sales of renewable energy generated in Wisconsin comprise approximately 6.4 percent of total electric sales in Wisconsin, an increase of 33.5 percent over 2008.

Wind power in this table represents wind power from in-state wind production facilities, and does not include generation at out-of-state sites owned by, or purchased by, Wisconsin utilities. Increases in wind generation represent efforts of Wisconsin's utilities to add wind power to their overall energy portfolio to meet requirements of the Renewable Portfolio Standard (RPS).

In this table, biomass includes wood, paper pellets and black liquor. Biogas includes methane burned at landfills, waste water treatment facilities, and agricultural manure digesters to generate electricity. Solar generation comes primarily from distributed energy sources such as residences with photovoltaic installations that sell power to the electric utility for distribution on the electric grid.

In 2007 these figures were revised from previous versions of this publication to remove resources that are not considered renewable under Wisconsin law (e.g., municipal solid waste or refuse derived fuels).

Maps of Wisconsin's hydroelectric sites, wind installations ("wind farms") and U.S. potential for biomass and solar can be found in the Map Appendix in the back of the book.

1990-2009 MILLIONS OF KWH AND PERCENT OF TOTAL

Year	Hydro		Biomass		Biogas		Wind		Solar		Total
1990	2,014.4	*96.7%*	68.1	*3.3%*	0.0	*0.0%*	0.0	*0.0%*	0.00	*0.0%*	2,082.5
1995	2,378.5	*93.5%*	54.2	*2.1%*	110.1	*4.3%*	0.0	*0.0%*	0.00	*0.0%*	2,542.8
1996	2,696.0	*94.1%*	56.5	*2.0%*	112.8	*3.9%*	0.0	*0.0%*	0.00	*0.0%*	2,865.3
1997	2,483.3	*93.3%*	57.5	*2.2%*	121.2	*4.6%*	0.0	*0.0%*	0.00	*0.0%*	2,662.0
1998	1,747.4	*89.1%*	60.9	*3.1%*	151.2	*7.7%*	2.2	*0.1%*	0.00	*0.0%*	1,961.7
1999	1,984.6	*89.2%*	68.6	*3.1%*	147.4	*6.6%*	23.7	*1.1%*	0.00	*0.0%*	2,224.3
2000	1,990.8	*86.1%*	78.1	*3.4%*	197.2	*8.5%*	46.6	*2.0%*	0.00	*0.0%*	2,312.7
2001	2,056.2	*85.2%*	83.0	*3.4%*	203.3	*8.4%*	70.2	*2.9%*	0.00	*0.0%*	2,412.7
2002	2,515.0	*84.9%*	70.6	*2.4%*	267.3	*9.0%*	111.1	*3.7%*	0.03	*0.0%*	2,964.0
2003	1,843.3	*79.9%*	79.4	*3.4%*	280.5	*12.2%*	104.0	*4.5%*	0.12	*0.0%*	2,307.3
2004	1,980.7	*79.2%*	98.1	*3.9%*	317.5	*12.7%*	105.3	*4.2%*	0.30	*0.0%*	2,501.9
2005[r]	1,550.7	*76.9%*	148.2	*7.3%*	224.3	*11.1%*	93.5	*4.6%*	0.46	*0.0%*	2,017.2
2006[r]	1,626.9	*56.7%*	815.8	*28.4%*	322.2	*11.2%*	102.7	*3.6%*	0.91	*0.0%*	2,868.5
2007[r]	1,483.2	*50.8%*	914.4	*31.3%*	412.6	*14.1%*	110.4	*3.8%*	1.57	*0.1%*	2,922.2
2008[r]	1,585.6	*47.5%*	698.6	*20.9%*	563.6	*16.9%*	488.4	*14.6%*	3.45	*0.1%*	3,339.6
2009[p]	**1,460.9**	***34.8%***	**1,017.2**	***24.3%***	**657.1**	***15.7%***	**1,051.6**	***25.1%***	**5.31**	***0.1%***	**4,192.2**

p Preliminary estimates.

r Revised.

Source: Public Service Commission of Wisconsin, unpublished data compiled from annual reports (2007-2009); Focus on Energy via the Wisconsin Energy Conservation Corporation, unpublished, aggregated data (2005-2009); survey data from conversations and emails with utilities, independent operators of landfills and/or waste water treatment plants, and public schools (2007-2009); Department of Revenue *Monthly Motor Fuel Consumption Report* (2000-2009); Energy Center of Wisconsin *Wisconsin Agricultural Biogas Casebook* (2008); Public Service Commission of Wisconsin, Focus on Energy Evaluation *Semiannual Report (Second Half of 2009)*, April 23, 2010 (2009) http://www.focusonenergy.com/files/Document_Management_System/Evaluation/semiannualsecondhalf2009_evaluationreport.pdf