CHAPTER 3

Renewable Energy

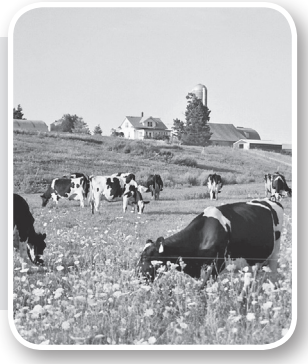
A Quick Guide to Renewable Energy

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 back of this publication.

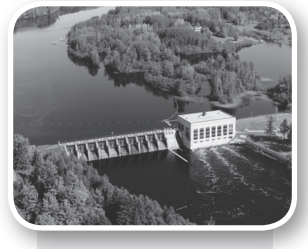
Renewable energy resources play a key role in Wisconsin's efforts to reduce dependence on imported fuels. According to Wisconsin Statutes 196.374(1)(j), a renewable resource "derives energy from any source other than coal, petroleum products, nuclear power, or …natural gas." This energy statistics publication looks at the primary renewable resources used in Wisconsin: solar, wind, water, biomas/biogas, and ethanol.

Wind power uses turbines—residential and commercial or utility sized—to generate electricity for distribution on the electric grid. A map of wind production sites, and wind energy potential across Wisconsin can be found in the back of this publication.

Biogas is produced from the state's landfills and agricultural manure digesters. In Wisconsin statutes and in data from U.S. Energy Information Administration, biogas is included in the definition of 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 back of this publication.

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 back of this publication.

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 State Energy Office website at: http://www.stateenergyoffice.wi.gov/docview.asp?docid=11272&locid=160.

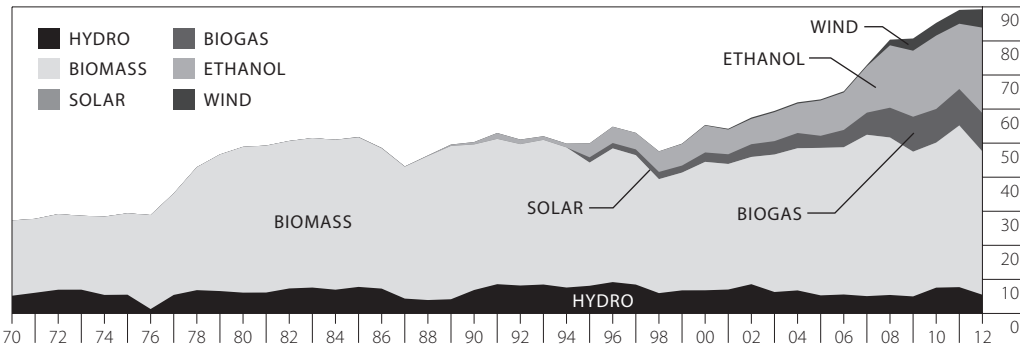
Wisconsin Total Renewable Energy Use, by Type of Fuel

OVERALL RENEWABLE ENERGY END-USE 0.2%

Overall renewable energy resource use in Wisconsin increased 0.2 percent in 2012. Ethanol use in the transportation sector increased 31.0 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.

This table includes all renewable energy used in Wisconsin for all applications, including space heating, electricity generation, transportation fuels, and for other applications that displace fossil fuels.

1970-2012 TRILLIONS OF BTU



1970-2012 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%*	0.00000	*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%*	0.00000	*0.0%*	0.0	*0.0%*	0.0	*0.0%*	0.00	*0.0%*	29.4
1980[r]	6.1	*12.5%*	42.8	*87.5%*	0.00000	*0.0%*	0.0	*0.0%*	0.0	*0.0%*	0.00	*0.0%*	48.9
1985[r]	7.8	*15.0%*	43.9	*84.7%*	0.00000	*0.0%*	0.0	*0.0%*	0.1	*0.2%*	0.00	*0.0%*	51.8
1990[r]	6.9	*13.7%*	42.7	*84.9%*	0.00000	*0.0%*	0.0	*0.0%*	0.7	*1.4%*	0.00	*0.0%*	50.3
1995[r]	8.1	*16.3%*	36.2	*72.5%*	0.00000	*0.0%*	1.5	*3.1%*	4.1	*8.2%*	0.00	*0.0%*	49.9
2000[r]	6.8	*12.3%*	37.7	*68.1%*	0.00000	*0.0%*	2.8	*5.0%*	7.9	*14.3%*	0.16	*0.3%*	55.3
2005[r]	5.3	*8.4%*	43.3	*68.9%*	0.00652	*0.0%*	3.5	*5.6%*	10.4	*16.5%*	0.32	*0.5%*	62.8
2006[r]	5.6	*8.5%*	43.2	*66.3%*	0.01227	*0.0%*	5.1	*7.8%*	11.0	*16.9%*	0.35	*0.5%*	65.2
2007[b,r]	5.1	*7.0%*	47.4	*64.9%*	0.01674	*0.0%*	6.5	*8.9%*	13.6	*18.7%*	0.38	*0.5%*	72.9
2008[r]	5.4	*6.7%*	46.2	*57.5%*	0.02728	*0.0%*	8.7	*10.9%*	18.3	*22.8%*	1.67	*2.1%*	80.4
2009[r]	5.0	*6.2%*	42.5	*52.6%*	0.03528	*0.0%*	10.2	*12.7%*	19.4	*24.0%*	3.59	*4.4%*	80.7
2010[r]	7.6	*8.9%*	42.6	*49.9%*	0.04930	*0.1%*	9.8	*11.5%*	21.6	*25.3%*	3.73	*4.4%*	85.3
2011[r]	7.7	*8.7%*	47.4	*53.2%*	0.07449	*0.1%*	10.6	*12.0%*	19.2	*21.5%*	4.06	*4.6%*	89.1
2012[p]	**5.5**	***6.1%***	**42.0**	***47.1%***	**0.09600**	***0.1%***	**11.2**	***12.5%***	**25.1**	***28.1%***	**5.41**	***6.1%***	**89.3**

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

b All 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.

p Preliminary estimates.

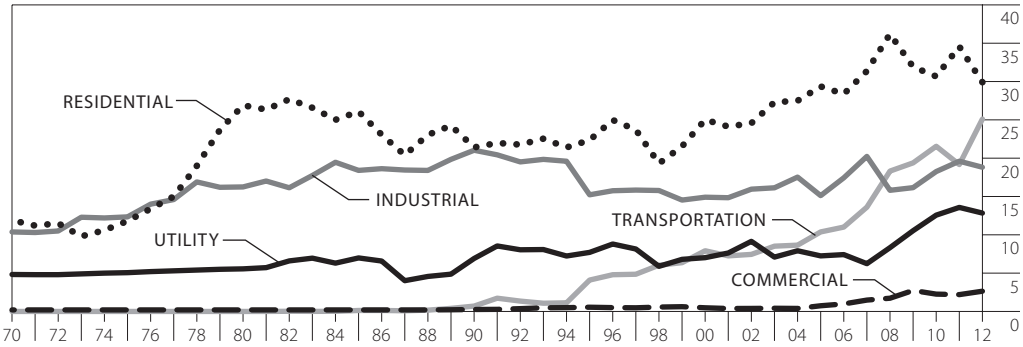
r Revised.

Source: U.S. Department of Energy, Energy Information Administration, *Estimates of U.S. Wood Energy Consumption from 1949 to 1981* (August 1983); Public Service Commission of Wisconsin, unpublished data compiled from annual reports (2007-2012); Focus on Energy, aggregated data (2005-2012); survey data from conversations and emails with utilities, independent operators of landfills and/or waste water treatment plants, and public schools (2007-2012); Department of Revenue *Monthly Motor Fuel Consumption Report* (2000-2012); Energy Center of Wisconsin, *Wisconsin Agricultural Biogas* Casebook (2008); Wisconsin Department of Natural Resources, Annual Survey of Point Source Emissions, unpublished (1972-2012); Wisconsin Department of Administration, Division of Energy, "Wisconsin Residential Wood Energy Model," unpublished (1981-2012); Compiled from renewable energy tables in this publication.

Wisconsin Total Renewable Energy Production and Use, by Economic Sector

This table includes all renewable energy used in Wisconsin for all applications, including space heating, electricity generation, transportation fuels, and for other applications that displace fossil fuels.

1970-2012 TRILLIONS OF BTU



1970-2012 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	43.3
1985[r]	26.1	*50.4%*	0.2	*0.4%*	18.4	*35.5%*	7.0	*13.5%*	0.1	*0.2%*	51.8	44.8
1990[r]	21.4	*42.6%*	0.3	*0.5%*	21.0	*41.8%*	6.9	*13.7%*	0.7	*1.4%*	50.3	43.4
1995[r]	22.4	*44.8%*	0.6	*1.1%*	15.2	*30.5%*	7.7	*15.4%*	4.1	*8.2%*	49.9	42.2
2000[r]	25.0	*45.2%*	0.5	*0.9%*	14.9	*26.9%*	7.0	*12.7%*	7.9	*14.3%*	55.3	48.3
2005[r]	29.4	*46.7%*	0.7	*1.2%*	15.1	*24.0%*	7.2	*11.5%*	10.4	*16.5%*	62.8	55.6
2006[r]	28.4	*43.5%*	1.0	*1.5%*	17.4	*26.7%*	7.4	*11.4%*	11.0	*16.9%*	65.2	57.8
2007[a,r]	31.4	*43.0%*	1.5	*2.0%*	20.2	*27.7%*	6.2	*8.5%*	13.6	*18.7%*	72.9	66.7
2008[r]	36.2	*45.0%*	1.7	*2.1%*	15.8	*19.7%*	8.3	*10.4%*	18.3	*22.8%*	80.4	72.1
2009[r]	31.9	*39.5%*	2.7	*3.4%*	16.2	*20.0%*	10.5	*13.1%*	19.4	*24.0%*	80.7	70.2
2010[r]	30.7	*36.0%*	2.3	*2.6%*	18.3	*21.4%*	12.6	*14.7%*	21.6	*25.3%*	85.3	72.7
2011[r]	34.6	*38.8%*	2.2	*2.5%*	19.6	*22.0%*	13.6	*15.2%*	19.2	*21.5%*	89.1	75.5
2012[p]	**29.9**	***33.5%***	**2.6**	***3.0%***	**18.8**	***21.1%***	**12.8**	***14.4%***	**25.1**	***28.1%***	**89.3**	**76.5**

a 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.

p Preliminary estimates.

r Revised.

Source: Focus on Energy aggregated and verified savings data (2005-2012); survey data from conversations and emails with utilities, independent operators of landfills and/or waste water treatment plants, and public schools (2007-2012); Department of Revenue *Monthly Motor Fuel Consumption Report* (2000-2012); Energy Center of Wisconsin, *Wisconsin Agricultural Biogas* Casebook (2008); Public Service Commission of Wisconsin, unpublished data compiled from utility annual reports (1970-2012). http://psc.wi.gov/apps40/annlreport/default.aspx

TOTAL RENEWABLE END-USE ENERGY 1.2%

Wisconsin's total, renewable end use energy increased by 1.2 percent. The residential and industrial sectors use the most renewable energy, primarily due to woodburning in these sectors. Residential and commercial data also include solar hot water, photovoltaic systems and wind power. Data reported in the electric sector represents resource energy, meaning that the renewable fuels are used to generate electricity—by the utilities and through distributed generation—sold through the grid. Transportation sector renewable energy measures use of ethanol blended with gasoline and sold as reformulated gasoline, 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.

Wisconsin Renewable Energy Electricity Generated and Purchased

RENEWABLE ELECTRICITY GENERATION
4.8%

In 2012, Wisconsin's electric utilities and non-utilities, such as paper mills, decreased their generation of electricity generated from renewable energy sources by 4.8 percent. The primary renewable energy source used was hydropower, which represents 32.1 percent of Wisconsin's renewable electricity generation. Hydropower is followed closely by wind, representing 31.7 percent of Wisconsin's renewable electricity.

Sales of renewable energy generated in Wisconsin comprise approximately 7.3 percent of total electric sales in Wisconsin, a decrease of 5.1 percent over 2011.

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.

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.

1990-2012 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	1,550.7	*76.9%*	148.2	*7.3%*	224.3	*11.1%*	93.5	*4.6%*	0.46	*0.0%*	2,017.1
2006	1,626.9	*56.7%*	815.8	*28.4%*	322.2	*11.2%*	102.7	*3.6%*	0.91	*0.0%*	2,868.6
2007[a]	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	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	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
2010	2,217.0	*45.4%*	913.0	*18.7%*	655.3	*13.4%*	1,092.3	*22.4%*	7.54	*0.2%*	4,885.1
2011	2,258.9	*43.0%*	1,080.3	*20.6%*	710.0	*13.5%*	1,190.5	*22.7%*	13.20	*0.3%*	5,253.0
2012[p]	**1,608.2**	***32.2%***	**1,053.3**	***21.1%***	**737.7**	***14.7%***	**1,583.7**	***31.7%***	**19.28**	***0.4%***	**5,002.2**

a 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).

p Preliminary estimates.

Source: Public Service Commission of Wisconsin, unpublished data compiled from annual reports (2007-2012); Focus on Energy aggregated and verified savings data (2005-2012); survey data from conversations and emails with utilities, independent operators of landfills and/or waste water treatment plants, and public schools (2007-2012); Department of Revenue *Monthly Motor Fuel Consumption Report* (2000-2012); Energy Center of Wisconsin *Wisconsin Agricultural Biogas* Casebook (2008).

Wisconsin Electric Utility and Non-Utility Hydroelectric Generation

1970-2012 MILLIONS OF kWh

Year	Wisconsin Operated Utility Plant Location: Wisconsin[a,b]	Wisconsin Operated Utility Plant Location: Michigan	Total Utility	Wisconsin Non-Utility	Total Wisconsin	Total Wisconsin Precipitation (inches per year)
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	1,499.0	338.6	1,837.6	51.7	1,550.7	29.3
2006	1,446.0	326.3	1,772.3	180.9	1,626.9	30.7
2007	1,314.0	272.6	1,586.6	169.2	1,483.2	34.0
2008	1,428.0	272.6	1,700.6	157.6	1,585.6	33.6
2009	1,352.7	251.2	1,603.9	108.2	1,460.9	30.3
2010	2,026.7	330.3	2,357.0	190.3	2,217.0	39.7
2011	2,048.1	339.6	2,387.7	210.8	2,258.9	30.7
2012[p]	**1,455.0**	**257.4**	**1,712.4**	**153.2**	**1,608.2**	**28.0**

a Including Wisconsin power cooperatives and Independent Power Producers.

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.

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) (1990-2008), http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html;
Public Service Commission of Wisconsin, unpublished electrical production data (2005-2012).

ELECTRIC UTILITY HYDROELECTRIC PRODUCTION

28.3%

Total Wisconsin hydroelectric production—utility and non-utility—decreased 28.3 percent from 2011 to 2012. Because hydroelectric production is impacted by rainfall, among other factors, precipitation inches are provided in this table. In 2012, total precipitation in Wisconsin fell by 8.8 percent from 2011.

Beginning in 2009, the utility figure includes production by Independent Power Producers who are required under law to sell their power to regulated utilities. Non-utility figures represent hydroelectric generation from the industrial sector, such as paper companies.

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

Wisconsin Wood Use, by Economic Sector

WOOD ENERGY USE 12.4%

Wood energy use in Wisconsin decreased by 12.4 percent in 2012. 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.

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.

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

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.

1970-2012 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[r]	26.9	*62.9%*	0.20	*0.5%*	15.7	*36.7%*	42.8
1985[r]	26.1	*59.4%*	0.20	*0.5%*	17.6	*40.1%*	43.9
1990[r]	21.4	*51.4%*	0.26	*0.6%*	20.0	*48.0%*	41.7
1995[r]	22.4	*62.8%*	0.55	*1.6%*	12.7	*35.6%*	35.6
1996[r]	25.0	*64.7%*	0.50	*1.3%*	13.1	*34.0%*	38.6
1997[r]	23.7	*63.7%*	0.48	*1.3%*	13.1	*35.1%*	37.2
1998[r]	19.3	*59.0%*	0.57	*1.8%*	12.8	*39.2%*	32.7
1999[r]	21.5	*63.9%*	0.62	*1.8%*	11.5	*34.2%*	33.7
2000[r]	25.0	*68.1%*	0.48	*1.3%*	11.2	*30.6%*	36.7
2001[r]	24.1	*67.3%*	0.38	*1.1%*	11.3	*31.6%*	35.8
2002[r]	24.6	*67.4%*	0.37	*1.0%*	11.5	*31.6%*	36.5
2003[r]	27.3	*69.4%*	0.36	*0.9%*	11.7	*29.7%*	39.4
2004[r]	27.5	*67.9%*	0.32	*0.8%*	12.7	*31.4%*	40.5
2005[r]	29.3	*70.2%*	0.27	*0.6%*	12.2	*29.1%*	41.8
2006[r]	28.4	*71.5%*	0.24	*0.6%*	11.0	*27.9%*	39.7
2007[r]	31.4	*71.3%*	0.44	*1.0%*	12.2	*27.7%*	44.0
2008[r]	36.2	*83.2%*	0.54	*1.2%*	6.8	*15.6%*	43.5
2009[r]	31.9	*82.2%*	0.89	*2.3%*	6.0	*15.5%*	38.8
2010[r]	30.6	*78.2%*	0.38	*1.0%*	8.1	*20.8%*	39.2
2011[r]	34.5	*79.4%*	0.28	*0.6%*	8.7	*20.0%*	43.5
2012[p]	**29.9**	***78.4%***	**0.19**	***0.5%***	**8.0**	***21.1%***	**38.1**

a Revisions to the residential sector wood-burn estimates are due to corrections of adjusted pricing figures.

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 (1972-2012); USDA Forest Service, *Residential Fuelwood Consumption and Production in Wisconsin* (1994); Wisconsin Department of Administration, Division of Energy, "Wisconsin Residential Wood Energy Model," unpublished (1981-2012), and *Directory of Wisconsin Wood Burning Facilities* (1995).

Wisconsin Manufacturing Industry Use of Wood Fuel, by Industry Group

1972-2012 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	0.23	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	1,155.3	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	0.09	994.5	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	1,123.9	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[b]	300.0	3.39	5.6	0.06	272.9	3.08	20.7	0.23	599.3	6.77
2009	256.7	2.90	4.0	0.05	249.3	2.82	21.8	0.25	531.8	6.01
2010	314.2	3.55	2.5	0.03	379.1	4.28	24.5	0.28	720.4	8.14
2011	387.9	4.38	3.2	0.04	353.4	3.99	24.8	0.28	769.2	8.69
2012[p]	**369.7**	**4.18**	**2.5**	**0.03**	**321.4**	**3.63**	**17.6**	**0.20**	**711.2**	**8.04**

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 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.

b Drops in Paper and Allied values beginning in 2008 is due to the removal of tonnage associated with electrical generation.

p Preliminary.

Source: Estimates by the Wisconsin State Energy Office, based on Wisconsin Department of Natural Resources, Annual Survey of Point Source Emissions, unpublished (1972-2012); 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

WOOD FUEL
USED FOR
ELECTRICITY
8.4%

Wood energy used for electricity generation in Wisconsin increased by 8.4 percent in 2012.

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 at the back of this book.

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.

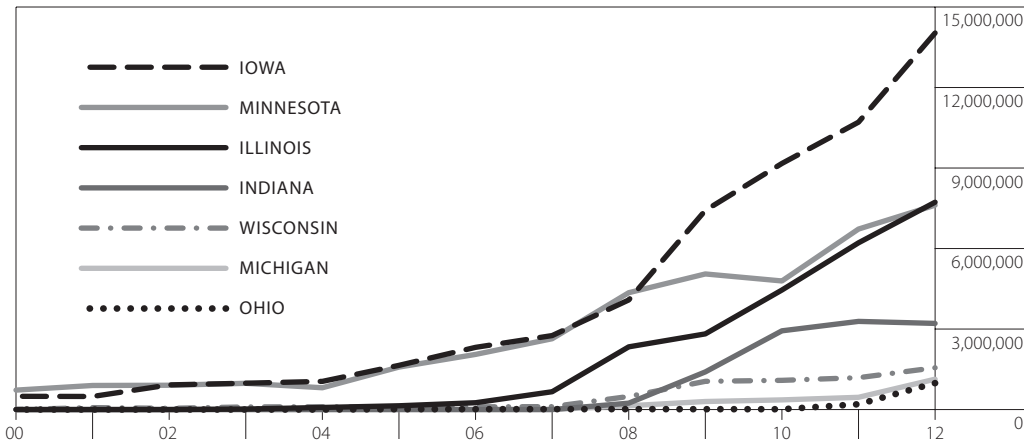
1970-2012

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
2010	380,600	4,333
2011	371,212	4,232
2012	**394,486**	**4,588**

Source: Wisconsin Department of Natural Resources, Annual Survey of Point Source Emissions, unpublished (1972-1994); annual reports of various Wisconsin electric generating utilities (1995-2012). http://psc.wi.gov/apps40/annlreport/default.aspx

Wisconsin, Midwest and U.S. Wind Generation and Capacity

2000-2012 WIND GENERATION BY STATE AND YEAR (MEGAWATT HOURS)



2000-2012 WIND GENERATION BY STATE (MEGAWATT HOURS)

Year	Wisconsin[a]	Illinois	Indiana	Iowa	Michigan	Minnesota	Ohio	Midwest Total	United States
2000	2,728	0	0	493,820	0	724,524	0	1,221,072	5,593,261
2005	92,544	141,146	0	1,647,134	1,848	1,582,477	13,268	3,478,417	17,810,549
2006	101,376	254,571	0	2,317,821	2,212	2,054,947	14,401	4,745,328	26,589,137
2007	109,283	664,427	0	2,756,676	2,723	2,638,812	14,748	6,186,669	34,449,927
2008	487,141	2,336,996	238,356	4,083,787	141,182	4,354,620	15,084	11,657,166	55,363,100
2009	1,051,965	2,819,532	1,403,192	7,420,520	300,172	5,053,022	14,114	18,062,517	73,886,132
2010	1,088,464	4,453,634	2,934,043	9,170,337	360,340	4,791,723	12,576	22,811,117	94,652,246
2011	1,187,730	6,213,132	3,285,411	10,709,177	456,474	6,725,695	198,443	28,776,062	120,176,599
2012	**1,557,578**	**7,726,810**	**3,210,104**	**14,032,491**	**1,131,688**	**7,615,408**	**985,485**	**36,259,564**	**140,821,703**

2000-2012 WIND CAPACITY BY STATE (MEGAWATTS)

Year	Wisconsin[a]	Illinois	Indiana	Iowa	Michigan	Minnesota	Ohio	Midwest Total	United States
2000	23	0	1	197	1	271	0	493	2,394
2005	53	105	1	820	2	687	7	1,675	8,733
2006	53	105	1	921	2	829	7	1,918	11,334
2007	53	740	1	1,170	2	1,139	7	3,112	16,596
2008	365	962	131	2,661	124	1,481	7	5,731	24,980
2009	449	1,596	1,037	3,448	143	1,636	7	8,316	34,683
2010	469	1,946	1,340	3,665	164	2,009	7	9,600	39,516
2011	631	2,737	1,340	4,302	376	2,580	160	12,126	45,982
2012	**370**	**3,520**	**1,540**	**5,005**	**874**	**2,842**	**462**	**14,613**	**59,075**

a Wind generation figures shows for Wisconsin in this table will differ from wind generation figures elsewhere in this publication due to different data sources.

Source: U.S. Department of Energy, Energy Information Administration, *State Energy Consumption Estimates*,1960-2012; [DOE/EIA-0214 (2012/06)], June 2013 (2000-2012), Table CT8, http://www.eia.gov/state/seds

WISCONSIN WIND GENERATION 31.1% FROM 2011

In 2012, wind generation in Wisconsin was the third lowest of seven Midwestern states, and increased 31.1 percent over 2011's generation. The installed wind capacity in Wisconsin is the second lowest in the Midwest and is 1.1 percent of the United States installed wind generation capacity.

Wind generation in the Midwest increased 26 percent from 2011 to 2012, and by 17.2 percent across the country. Wind capacity increased 20.5 percent in the Midwest and 28.5 percent in the U.S.

Since 2000, wind generation in the Midwest has increased 2,869.5 percent, making wind one of the fastest growing renewable resources.

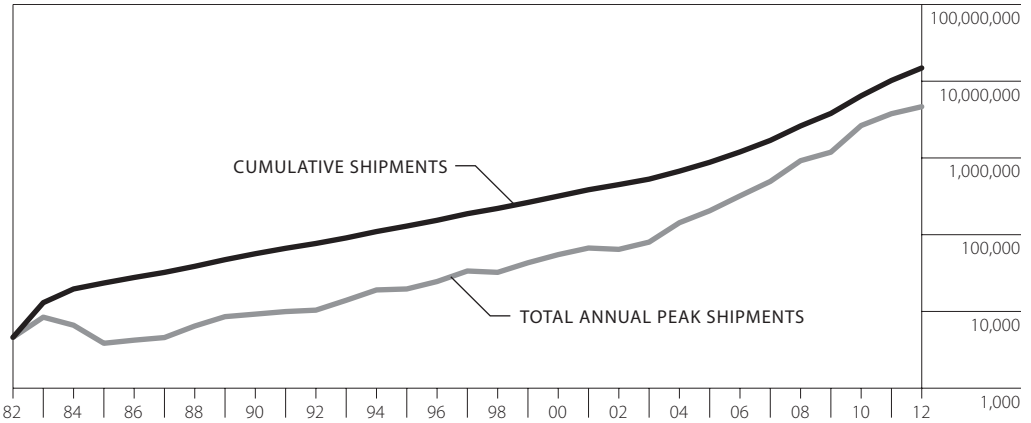
U.S. Photovoltaic Module Shipments and Conversion Efficiency

Shipments of photovoltaic (PV) modules 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 14,000 Megawatts (MW). Since 2003 annual shipments of PV systems have been doubling every 18 months, an annual average growth of 56.1 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.

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 16 percent for Crystalline Silicon and about 11 percent for Amorphous Silicon.

1982-2012 PHOTOVOLTAIC SHIPMENTS (KILOWATTS)



	Photovoltaic Shipments[a]		Average Energy Conversion Efficiency Photovoltaic					
			Crystalline Silicon			Thin-Film Silicon		Concentrator
Year	Shipments Total Annual Peak Kilowatts[b]	Cumulative Kilowatts	Single Crystal	Cast	Ribbon	Amorphous Silicon	Other	Silicon
1982[r]	4,600	4,600						
1985[r]	3,848	23,477						
1990[r]	9,229	56,507						
1995[r]	19,627	129,530						
2000[r]	55,007	318,102						
2005[r]	204,996	877,880						
2006[r]	320,208	1,198,088						
2007[r]	494,148	1,692,236	17	14	12	8	12	35
2008[r]	920,693	2,612,929	19	14	13	8	12	34
2009[r]	1,188,879	3,801,808	20	14	13	8	12	38
2010[r]	2,644,498	6,446,306		16		11		27
2011[r]	3,772,075	10,218,381		16		11		29
2012[p]	**4,655,005**	**14,873,386**		**16**		**13**		**30**

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

b Revisions to these data reflect the shipment of modules only, and do not include cells.

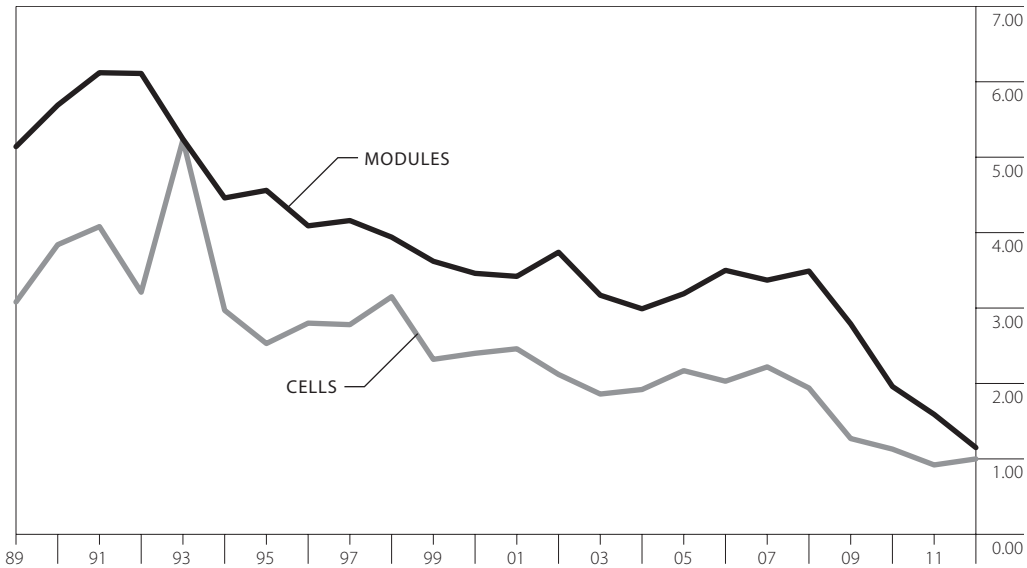
p Preliminary.

r Revised.

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review* [DOE/EIA-0384(2011) (September 2012)], table 10.8 (2011) www.eia.doe.gov/totalenergy/data/annual; 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", 2007-2012 (2013).

U.S. Photovoltaic Modules and Cell Prices

1989-2012 DOLLARS PER PEAK WATT



	Dollars per Peak Watt (nominal[a] dollars)		2012 Dollars[b]	
Year	Modules	Cells	Modules	Cells
1989	5.14	3.08	8.52	5.11
1990	5.69	3.84	9.09	6.13
1995	4.56	2.53	6.45	3.58
2000	3.46	2.40	4.50	3.12
2001	3.42	2.46	4.35	3.13
2002	3.74	2.12	4.68	2.65
2003	3.17	1.86	3.89	2.28
2004	2.99	1.92	3.56	2.29
2005	3.19	2.17	3.68	2.50
2006	3.50	2.03	3.91	2.27
2007	3.37	2.22	3.66	2.41
2008	3.49	1.94	3.71	2.06
2009	2.79	1.27	2.94	1.34
2010	1.96	1.13	2.04	1.17
2011	1.59	0.92	1.62	0.94
2012[p]	**1.15**	**1.00**	**1.15**	**1.00**

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

b 2012 prices indicate the price adjusted for inflation.

p Preliminary estimates.

Source: U.S. Department of Energy, Energy Information Administration, *Annual Energy Review* [DOE/EIA-0384(2011) (August 2012)], table 10.8 (2011) 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", 2007-2012 (2013).

Growth in photovoltaic (PV) is demonstrated by falling prices. From 1990 to 2012, PV module prices fell by 87.3 percent, and the price of cells fell by 83.7 percent.

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 $1.15/watt) is about 15 percent higher than the most of PV cells ($1/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.