Renewable Energy Resources

This Public Service Commission (PSC or Commission) publication contains information that will be useful to people who have an interest in the role of renewable energy resources in Wisconsin's electrical generation mix.

Renewable Energy

Renewable energy refers to energy from a source that is continuously replenished by natural processes. State law (Wis. Stat. §196.378(1)) defines the following as renewable resources when used to create electricity:

- **Wind energy**
- **Solar thermal energy:** using heat from the sun to create electric power
- **Photovoltaic energy:** a system that directly converts sunlight into electric power
- **Biomass:** defined as wood or plant material or residue, biological waste, crops grown for use as a resource or landfill gases. Biomass does not include garbage or nonvegetation-based industrial, commercial or household waste.
- **Geothermal technology**
- **Hydroelectric with a capacity of less than 60 megawatts**
- **Tidal or Wave Action**
- **Fuel Cell:** using a renewable fuel as determined by the Commission

Advantages and Disadvantages of Renewable Resources

The advantages of electric production from renewable resources include:

- The potential for low or no fuel cost (except for some biomass)
- The possibility of shorter lead-times for planning and construction as compared to conventional power plants
- The potential to utilize relatively small, modular plant sizes
- Significantly reduced environmental effects compared to fossil fuels
- For many renewable resources, a non-depletable resource base
- Public support for use of renewable resources
- The potential for use in distributed generation applications

The disadvantages of electric production from renewable resources include:

- Public concern for land use, biodiversity, birds and aesthetics in siting a facility
- Relatively high capital cost to construct a renewable facility
- Uneven geographic distribution of renewable resources
- Intermittent availability of some renewable resources for electric production
- Lack of maturity or commercial availability of some technologies
- For some biomass resources, the need to consider environmental implications of the fuel supply

Utilities and independent power producers are researching ways to expand the use of renewable resources. One of the most important benefits of renewable resources is their long-term availability. Another important benefit is their minimal impact to the atmosphere. These technologies have not been associated with mercury emissions or the causes of acid rain and have little or no negative impact on climate change.

As of 1994, Wisconsin state law (Wis. Stat. § 1.12(3)(b)) mandates that, "It is the goal of the state that, to the extent that is cost-effective and technically feasible, all new installed capacity for electric generation in the state be based on renewable energy resources, including hydroelectric, wood, wind, solar, refuse, agricultural and biomass energy resources."

As part of 2005 Wisconsin Act 141, the Wisconsin Legislature established the current renewable portfolio standard (RPS), requiring each investor-owned electric utility, municipal electric utility and rural electric cooperative (electric providers) to meet a gradually increasing percentage of their retail sales with qualified renewable resources. The current RPS establishes the goal that by the end of 2015, 10 percent of all electric energy consumed in the state will be renewable energy.

Wind Energy

Wind energy is converted to electricity when wind passes by blades mounted on a rotating shaft. As the wind moves the blades, the rotation of the shaft turns a generator which converts the rotational movement into electricity.

Three main factors affect wind machine power: the length and design of the blades, the density of the air and wind velocity. Longer blades produce more power output. Cold air is denser than warm air, which means it produces more force, or ability to turn the blades. Also, in general, as elevations increase wind turbines will encounter greater wind velocities.

A consortium of Wisconsin utilities conducted a statewide wind resource assessment study in conjunction with the Wisconsin Energy Bureau, the Commission and the National Renewable Energy Laboratory. The purpose of the Wisconsin Wind Resource Assessment Program (WRAP) was to identify potential areas for wind energy project development and to obtain wind data from a geographically diverse sample of the state of Wisconsin. A 3 year study was conducted and the final report was completed in 2002 and is available from Focus on Energy at www.focusonenergy.com.

As of 2009, there are approximately 450 MW of utility-sized wind generation in operation and numerous other projects are under consideration in Wisconsin.

Utility-sized wind energy project in Fond du Lac County

There is great interest in customer-owned small wind projects of 100 kW or less. However property limitations such as trees and buildings can greatly affect wind turbine performance. As of the end of 2008, 49 small wind projects in the state have been co-funded by the Focus on Energy program, Wisconsin's statewide energy efficiency and renewable energy program.

Residential wind system

Using wind energy to create electricity can have both positive and negative impacts on the environment. One of the major benefits of this technology is that it does not create air pollution. Unlike power plants that burn coal or natural gas, wind turbines do not emit sulfur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2), particulates or heavy metals into the atmosphere. These emissions from fossil fuel-burning power plants contribute to acid rain which damages lakes, streams, forests and ozone which affects human health and climate change.

Because the process of generating electricity from wind does not use water, potential negative impacts sometimes associated with producing electricity such as thermal pollution of water bodies and impacts to surface waters and groundwater are avoided. Wind energy does not create waste byproducts, avoiding issues connected with the transportation, treatment and storage of these wastes. Additionally, because wind power requires no fuel, the cost of wind-generated electricity is not affected by volatility in fuel prices.

The risk of avian and bat mortality is an environmental concern associated with wind energy. Bird collisions with turbine blades and towers have been reported in the U.S. and in other countries. In the past, with older, smaller turbines hawks, falcons and eagles were identified in the scientific literature as being susceptible to mortality from collision with wind turbines. Recent studies identify some risk to smaller birds; however mortality to bats is causing increased concerns among state and federal agencies. Investigations are on-going regarding the best methods to mitigate impacts to bats.

Additional issues that are associated with the operation of wind turbines pertain to interference with radar and television signals, noise, shadow flicker and aesthetics. Some of these impacts may be partially mitigated with proper siting and setbacks of turbines from residences, radar facilities and other land uses.

Biomass/Biogas Energy

Biomass energy is the release of energy stored in wood, herbaceous plants, or other biological materials. Biomass can be burned (like coal) to produce steam. Common biomass fuels include waste wood and dedicated crops. Waste wood may come from construction projects, demolition projects, or as a waste from wood product manufacturing and is the most available source of biomass in Wisconsin.

Biomass can be burned in a generating plant to produce steam for both electric energy and industrial processes. This dual use of the steam is known as "cogeneration." In some cases, the biomass is burned along with another fuel to reduce emissions, in a process known as co-firing. The amount of biomass that can be co-fired with coal varies for different types of coal plants. Conversion of a coal plant to co-firing with biomass requires changes to that plant's boiler and its fuel handling process. Other biomass technologies exist, including power plants that burn chipped wood alone or that co-fire the chips with natural gas. A newer biomass technology converts biomass to a gas for burning. One of the challenges for all biomass technologies is assuring a reliable biomass fuel supply. The biomass supply for facilities burning only biomass would need to be much greater than the supply needed for co-firing.

To minimize impacts to the environment, potential biomass supplies should be used in the following order of priority:

1. Wood industry residues—e.g., lumber mill residues and sawdust, furniture manufacturing wastes, pallets, etc.

2. Urban, forest, or agricultural residues—residues resulting from logging cropping, or city tree trimming. Enough logging or cropping residue must be left on the ground to ensure stable soil conditions and appropriate plant nutrient cycling.
3. Woody or herbaceous energy crops—grown sustainably on cropland or in plantations and dedicated to be converted to electricity. Crops showing the most promise in Wisconsin include hybrid poplars, willows, and switchgrass.
4. Natural woodlands—harvesting trees for fuel. This option is the least preferable and most complicated environmentally.

As costs associated with fossil fuel electric generation increase, a wider variety of biomass resources become more attractive to use for electric generation. Table 1 compares some of the main environmental impacts of several different biomass fuel types. All of the listed biomass types are available in Wisconsin, but the amount of generation that could be supported by each is unknown.

Environmental Impacts of Biomass Supply Sources

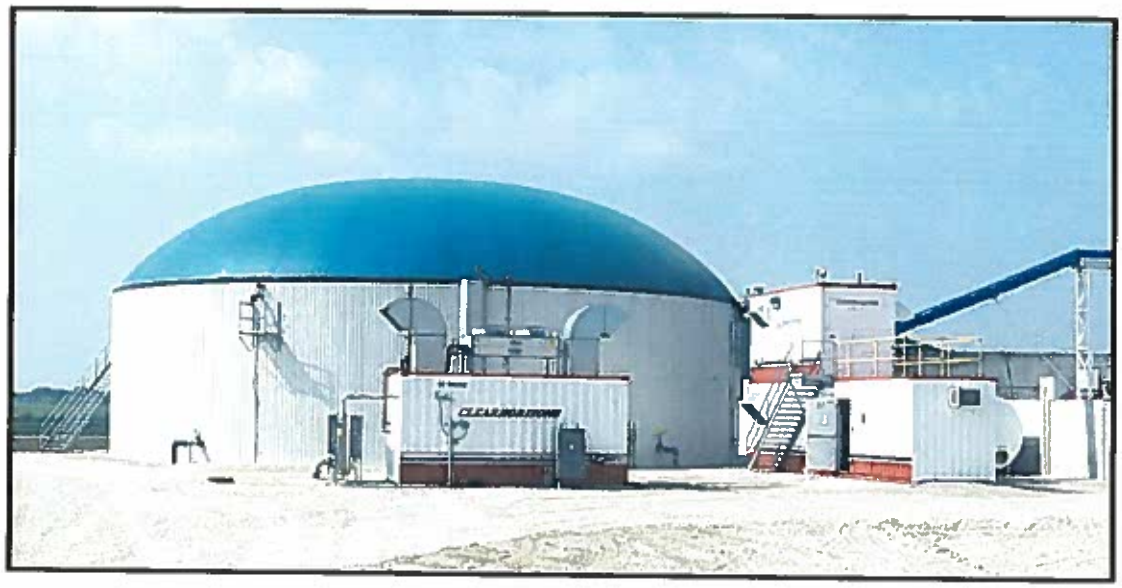
Fuel Source	Environmental Impact of Supply
Primary mill	Reduces land filling.
Industrial	Reduces land filling.
Harvesting residues	Reduces the amount of plant material left behind after harvest that is needed to enhance soil structure and fertility. The effect can be mitigated by leaving behind sufficient material through management practices.
Plantation	May affect soil erosion, water quality and wildlife habitat on farms during establishment and harvest. The effect can be lessened or eliminated by management of harvest methods and timing.
Forest harvest	Affects soil structure and fertility, water quality and wildlife and understory vegetation habitat after harvest. The effect may be lessened by detailed attention to forest structure and species mosaic and through best management and harvest practices.

The environmental effects vary with the type of biomass fuel used, although most fuels will have impacts related to transport (truck or rail) and storage. Air emissions from biomass combustion are generally less than those from coal or natural gas. Like coal or natural gas combustion, biomass combustion produces CO_2, a significant greenhouse gas. However, growing plants to replace the burned plant material can be considered to create a closed-loop system for CO_2, minimizing the overall emission CO_2into the atmosphere. In comparison to coal, biomass can emit lower amounts of NO_x and ash, and release significantly less toxic material such as mercury.

Nonresidential customer-owned biomass combustion systems typically produce process heat or space heating at a site. As natural gas prices rise and fluctuate, there is an increased interest from schools and governments to replace their conventional heating systems with biomass systems.

Often biomass fuel, typically pellets or wood chips, can be bought in bulk, which decreases the risk of month-to-month changes in energy costs. As of the end of 2008, the Focus on Energy program has co-funded 58 customer-owned systems across the state.

Another biological source of energy used to create electricity is biogas. Biogas is created when biological material such as livestock manure or food waste products is processed using a heated, oxygen-free process known as anaerobic digestion to produce a combustible gas. Wisconsin is considered a biogas leader in the nation. As of the end of 2008, the Focus on Energy program has co-funded 20 biogas systems in the state. A majority of these systems are anaerobic digesters at dairy farms; however, there is also a growing interest in the benefits of biogas systems at industrial food-processing plants.



Biogas system at a dairy farm in Jefferson County

Solar Energy

Solar thermal

Heat from the sun can be used to provide energy in multiple ways. One way is to convert the sunlight into heat using a solar collector. The heat can be used for space heating, water heating, or for certain manufacturing processes. When solar energy replaces electricity in these applications, it can reduce the need for generating capacity. Solar water heaters have been commercially available for many years. The use of solar energy for space heating using "passive" methods has also been popular. Heat from the sun can also be used to heat a fluid that drives a turbine or heat engine to provide energy to a conventional electric generator. However, solar thermal electricity is not common in Wisconsin.

In recent years, solar hot water has again become a popular choice for homeowners and businesses that want to decrease their impact on the environment. The Focus on Energy program along with other organizations such as the Midwest Renewable Energy Association and several Wisconsin

Technical Colleges has led an effort to professionalize the industry, offering classes and setting installation standards. From 2002 to the end of 2008, Focus on Energy has co-funded a total of 531 solar hot water projects across the state.

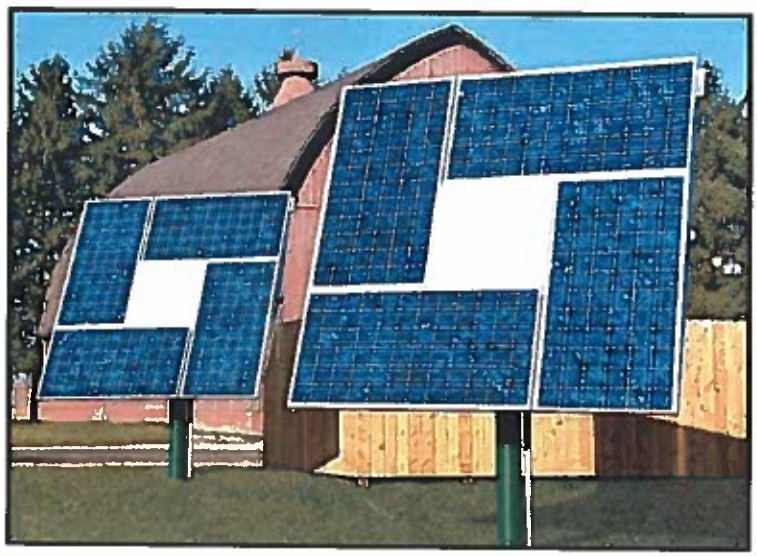
Residential solar hot water collectors

Photovoltaics

Another way to use solar energy is by converting sunlight directly into electricity through the use of photovoltaic cells, which are grouped together to form a panel. Photovoltaic panels can be used in small groups on rooftops or as part of a substantial system for producing large amounts of electrical power. The amount of energy produced by a photovoltaic system depends upon the amount of sunlight available and the size of the system. The intensity of sunlight varies by season of the year, time of day and the degree of cloudiness. Currently, use of PV-generated power can be less expensive than conventional power technologies where the load is small or the area is too difficult to serve by electric utilities.

Further advances in solar photovoltaic technology are likely. As a result of private and government research, photovoltaic systems are expected to become more efficient and affordable in the future. Prices may also decrease as the popularity of photovoltaic systems increases and production increases, producing some economies of scale. Utilities also fund research in these same areas through membership in organizations like the Electric Power Research Institute (EPRI). With continued improvement, photovoltaic technologies may become increasingly cost competitive with conventional generation sources.

Compared to traditional methods of electric generation, photovoltaic systems have few environmental concerns. The primary environmental impact of a large system is visual and can be solved by designing the system to blend with its surroundings.



Solar photovoltaic system installed at a Dane County park

Photovoltaic systems have experienced a high level of popularity in recent years among homeowners and businesses seeking to decrease their impact on the environment. PV systems require little maintenance, making them an attractive renewable energy option. PV arrays can also be installed on building roofs or on pole. As of the end of 2008, Focus on Energy has co-funded a total of 470 photovoltaic systems across the state.

Residential application of a solar photovoltaic flag

Daylighting

The sun can also be used to provide daylighting through appropriate design in residential, commercial and industrial buildings. The use of natural light reduces energy because less energy used for lighting, and the need for summer air conditioning may be also reduced since there is less heat generated by electric lights.

Hydroelectricity

The energy from moving water is converted to electricity when water passes by blades similar to those on a ship's propeller. The blades are connected to a rotating shaft which turns a generator to produce electricity. Hydroelectric power plants in Wisconsin range from large, utility-owned dams on major rivers to small locally-owned dams on small streams.

Although some potential exists for additional hydroelectric development in Wisconsin, public, environmental and recreational concerns limit the potential for new hydro installations. Most sites identified for potential future hydroelectric development in Wisconsin involve installing electric generators at existing dams.

Relicensing existing dams is a significant concern at this time. The Federal Energy Regulatory Commission grants licenses to dam operators for periods of up to 50 years. When a dam is reviewed for relicensing, environmental impacts are examined. Dam operations may be restricted to meet new environmental regulations causing a reduction in the amount of electricity produced by the facility.

Hydroelectric power plants produce no air emissions. Their main environmental impacts are related to the flooding of the landscape upstream, changing flows within the stream banks downstream, dividing the stream into separated pools, and damaging or killing fish. The barriers created by dams constrain fish and other species to specific pools, impacting their ability to survive and reproduce. The turbines have the potential to damage or kill fish if the fish are not filtered aside on the upstream side of the dam.

Grandfather Falls Dam along the Wisconsin River

Additional Information

Additional information regarding renewable sources of energy can be obtained from the Wisconsin Focus on Energy Program at www.focusonenergy.com.

The Public Service Commission of Wisconsin is an independent state agency that oversees more than 1,100 Wisconsin public utilities that provide natural gas, electricity, heat, steam, water and telecommunication services.

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