

2010

ALTERNATIVE ENERGY DEVICES: WIND ENERGY, SOLAR ENERGY & GEOTHERMAL ENERGY

A Resource Guide for Common Questions and Concerns



Devon Bank in Wheeling (LEED Gold and going Platinum)

ALTERNATIVE ENERGY
TASK FORCE OF LAKE
COUNTY COMMUNITIES

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ALTERNATIVE ENERGY TASK FORCE OF LAKE COUNTY COMMUNITIES

The Alternative Energy Task Force (AETF) of Lake County Communities consists of officials, managers and staff from the County, municipalities, and local private planning and engineering firms, who are committed to promoting responsible wind, solar and geothermal energy policies.

The AETF is a collaborative effort drawing upon the collective resources of the participating Communities to develop comprehensive educational and regulatory materials to be shared to anyone interested in the energy topics. This handout is intended to be a supplemental document to the Model Ordinance for Wind Energy Systems & Solar/Geothermal Energy Systems that was developed by the AETF for the County and municipalities to use as a template or starting point when proposing to create their own Wind, Solar or Geothermal Energy regulations.

This document is intended for informational purposes only, and is not intended to be entirely comprehensive.

SPECIAL THANKS TO THE FOLLOWING TASK FORCE MEMBERS AND THEIR RESPECTIVE COMMUNITIES FOR THEIR TIME AND EFFORT DEDICATED TO THIS DOCUMENT:

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ADDITIONALLY, THE AETF WOULD LIKE TO THANK THE FOLLOWING COMMUNITIES FOR THEIR VALUABLE INPUT:

Village of Libertyville
City of Lake Forest
City of Highwood

WIND ENERGY SYSTEMS

While windmills conjure up images of our agricultural heritage, Wind Energy Systems are a practical and renewable source of electricity for modern life. Moving air causes the turbine to rotate, which generates clean, emissions-free energy that can be used to power a home, farm, school, or small business. Wind Energy Systems include a turbine that is technologically advanced but mechanically simple, with only two or three moving parts. The Wind Energy Systems available to consumers include: Building Mounted, Small, and Large Wind Energy Systems¹. These systems will generally be one of two types: Horizontal Axis Wind Turbine and Vertical Axis Wind Turbine.



Building Mounted Wind Energy System (BWES)

Specifically refers to Wind Energy Systems that are structurally attached either onto the roof of or to the side of a building. A BWES typically has less than 1 kilowatt (kW) in nameplate capacity. Some sources include BWES in the same classification with Small Wind Energy Systems. The WETF created this as a separate category due to its different regulatory considerations. Since they require less space, BWES may be more appropriate for more developed residential areas. The adjacent picture is an example of two (2) BWES turbines attached to a single-family home.



Some additional examples of current BWES applications in Illinois:

- Hyacinth Place, Highland Park [Contains GALE T1 Vertical Access Wind Turbine, 1.02 kW]
- Magee, Negele and Associates, Round Lake [Hybrid Aeroturbines, 1 kW each]

Small Wind Energy System (SWES)

A SWES includes any tower-mounted turbine up to 175 feet in height to the top of the blade, typically producing between 1 kW to 100 kW of energy. A SWES is generally used to produce power primarily on-site for a single-user. They are ideally suited for individual homes, small businesses, farms, and similar small-scale establishments.

Some examples of current SWES applications in Illinois:

- Prairie Crossing Farm, Grayslake as seen to the right [Apex. 100 feet tall, 20 kW]
- Devon Bank, Wheeling [Windspire turbines (apx. 30' tall), 1.2 kW each]
- Chipotle, Gurnee [Proven WT6000 turbine (58' tall), 6 kW]

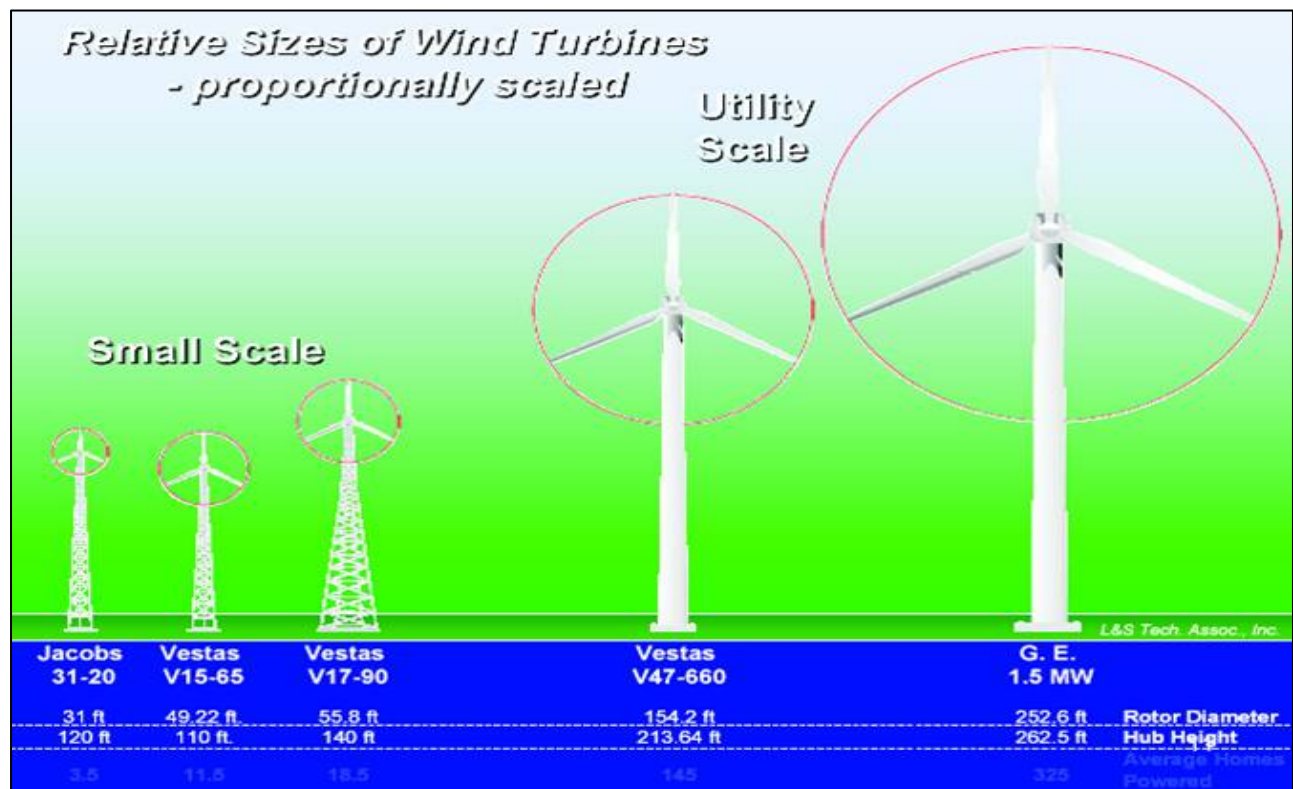


Large Wind Energy System (LWES)

Typically include turbines with a capacity ranging from 100 kilowatts (kW) to 2.5 megawatts (MW) in the largest models that are currently available. The overall height of a LWES can range from 175 to 450 feet and are sometimes referenced as “utility scale”, as referenced in the figure below. The LWES is typically a commercial wind project, since it is capable of producing enough electricity for commercial sale. LWES projects can be a large wind farm with as many as 700 turbines but may also be as small as a single turbine large enough to power a school, which in turn sells off the excess electricity. Please note that this report is primarily designed for reference to smaller residential turbines (BWES & SWES). While the LWES have similar concerns and questions, they are at a larger scale and intensity than the smaller residential turbines.

Some examples of current LWES “wind farms” in Illinois and around the country include:

- 396 MW total capacity Twin Groves I & II wind farm near Bloomington, Illinois [240 total turbines of 1.65 MW each].
- 781 MW total capacity Roscoe Wind Complex in Roscoe, Texas [627 total turbines] (this is currently the largest wind farm in the world & can power 230,000 homes).²
- 200 MW total capacity Meadow Lake I wind farm, White & Benton County (NE Indiana – off of I-65) [124 total turbines of 1.65 MW each - The gear box and slowly rotating, three-bladed rotor are perched atop towers that are 262 feet in height. The three-bladed rotor spans 269 feet in diameter and turns at about 14 revolutions per minute (rpm).] The potential full build out capacity is estimated at 1,000 MW which would amount to approximately 606 turbines at 1.65 MW each.



The Horizontal Axis Wind Turbine

A wind energy system will generally be one of two types: Horizontal Axis Wind Turbine and Vertical Axis Wind Turbine. The Horizontal Axis Wind Turbine (HAWT) is the more conventional model. As illustrated on page 9 below, the rotor shaft and generator are located at the top of the tower, and the blades are angled into the wind for optimal efficiency. Smaller HAWT's often include a wind vane (or tail) to help direct the blades into the prevailing wind. Most HAWT's have a gearbox, which adjusts the rotational speed of the blade to help drive the generator when the wind is too light and when the wind is too strong.

HAWT blades are always perpendicular to the wind. As a result, they maintain much higher efficiency levels than other Vertical Axis wind turbine models.

Since HAWT blades, gearboxes, and generators can become fairly heavy, taller and more visible towers need to be built to support the weight, which increases installation costs as the height of the tower increases. While HAWT's can be installed on rooftops, they tend to be much smaller and maintain a capacity of only a few kilowatts.

6 kW Proven WT6000 turbine at
Chipotle, Gurnee, IL



The Vertical Axis Wind Turbine

The Vertical Axis Wind Turbine (VAWT) is more ideally suited for urban and suburban settings. In this model, the rotor shaft is arranged vertically, which means that a VAWT does not need to be pointed into the wind to produce energy. They can be installed on rooftops of buildings and private homes as well as on towers (which also tend to be smaller than HAWT's on average). VAWTs come in two forms: *lift-* and *drag-* based designs. Some examples of the VAWT include, the cup anemometer, stacked savonis rotor, Darrieus Lift-Type Vertical Axis Machines, among others³. *The image to the right is of a Vertical Axis Wind Turbine at Magee, Negele and Associates, Round Lake [Hybrid Aeroturbines, 1 kW each].*



Since VAWT's can take advantage of any wind direction, they do not require pitched blades or yaws to capture wind energy. No efficiency is lost due to a change in wind direction; however, overall a VAWT tends to be less efficient than HAWT's because there is increased drag with the blades. For more information regarding the variety of VAWT's available, refer to the American Wind Energy Association's webpage: <http://www.awea.org/faq/vawt.html>.

Type of Wind Energy System Support Towers

There are a number of towers available for supporting a wind turbine, with the monopole, lattice tower or guyed tower being the most common free standing structures. The monopole tower generally has a "tidier" appearance than a lattice tower (which looks like a radio tower) or guyed tower (which looks like a flag pole with wire supports); however, they can cost several thousands of dollars more and should not be considered equal economic substitutes. All towers on the market are professionally engineered for safety and reliability, leaving appearance and cost the only significant differences among them. These support towers are described further below:



Monopole Towers

Monopole Towers are the most common design, using a tapered cylindrical structure and look like a flag pole. Climbing pegs are often included to allow for regular maintenance. Installation costs increase significantly with height, but the footprint is the smallest/least of any of the tower types and has a "tidier" appearance when compared to a lattice or guyed tower. Generally this is the most expensive of the towers. (The picture to the left is a turbine located in Cleveland, OH)

Tilt-Up Towers

On Tilt-Up Towers, a gin pole is fastened to the base of the tower, and the entire structure is then pulled into an upright position by a winch. This makes installation and maintenance a much easier processes. They can also be lowered during "hurricane-force" winds to prevent damage. Tilt-up towers do require ample horizontal clearance when being installed and many models also include guy wires, which further increase the footprint of the tower.



Lattice Towers

Lattice Towers utilize three or four legged lattice structures without guy wires and can be compared to the older radio and cellular towers that still might be located in your community. They are less expensive than monopoles and tilt-up towers, and also have a smaller footprint than guyed wire towers. They lack the "tidy" appearance of the monopole. (The picture to the left is a lattice tower turbine located in Downers Grove, IL)

Guyed Wire Towers

Guyed Wire Towers require the most land of any of the design types and are like a flag pole with wire supports. Metal cables are attached to the tower and the ground to provide greater support when the turbine experiences higher wind speeds. Guy-wire cable can also compliment any of the previous three designs in necessary.



Rooftop Turbines (aka BWES)

Rooftop Turbines have become increasingly popular in suburban and urban areas. VAWT and Building Mounted Horizontal Axis Wind Turbines are ideal for this type of situation, since they do not require the same amount of clearing space on the ground as does a small wind energy system. (The picture to the left is the Hyacinth 1.02 kW BWES Turbine on a residential building in Highland Park.)

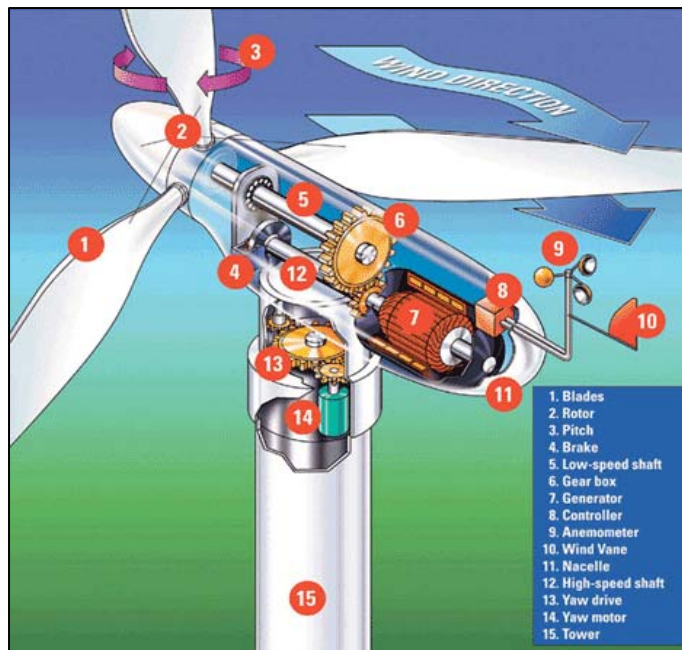
TECHNICAL ASPECTS OF WIND ENERGY SYSTEMS

Why Wind Energy Systems?

In light of the growing concerns about climate change, the rising cost of energy, and other forms of pollution caused by carbon emissions, more Americans than ever are considering wind energy as a clean alternative to other energy sources. According to the United States Department of Energy's National Renewable Energy Laboratory, the majority of Lake County enjoys average wind speeds of 12 to 14.5 miles per hour at 50 meters (~164 feet) in height (See Figure A on page 21).⁴ The Illinois Institute for Rural Affairs, on the other hand, estimated average wind speeds of 18 to 20 miles per hour in 2007 at the same altitude.⁵ These reported wind speeds are adequate wind speeds to generate electricity; however, they may still not be strong enough to fully maximize the energy output of the turbine. Refer to the turbine manufacturer specifications provided with your turbine for details on what wind speed the turbine is rated at (or the maximum capacity of the turbine). The blades of most Small Wind Energy Systems must be propelled by winds of at least 10 miles per hour in order to maintain a high level of efficiency.⁶ Lastly, Figure C at the end of this document (page 21) illustrates the wind speeds and the potential for wind energy production within the entire United States.

How do turbines work?

Wind Energy Systems (horizontal & vertical) use the power of the wind to rotate blades and convert the kinetic energy from the wind into electricity, without any carbon emissions. The wind spins the turbine's blades, which creates a rotary motion to drive the generator and produce electrical power. That power can be used on site or transmitted to an electric transmission grid. The picture to the right illustrates the inner components of a typical *Horizontal Small Wind Energy System*.



What size Wind Energy System do I need?

The size of the wind turbine you need depends on how much energy you wish/prefer/want/desire to generate, the physical location where the turbine is proposed, and the average wind speeds in your area. For residential applications, before you even consider a wind turbine, you should establish an energy budget (<http://www.paystolivegreen.com/2008/09/energy-savings-calculator/>) to help define your energy usage and thereafter, the size of turbine you will need. Because energy efficiency is usually less expensive than energy production, making your house more energy efficient first will probably be more cost effective and could reduce the size of the wind turbine you need. Additionally, wind turbine manufacturers can help you size your system based on your electricity needs (i.e., they can provide you direction on turbine products that *at maximum*

efficiency produces “X” kWh per day), the specifics of local wind patterns, and the property location of the proposed turbine.

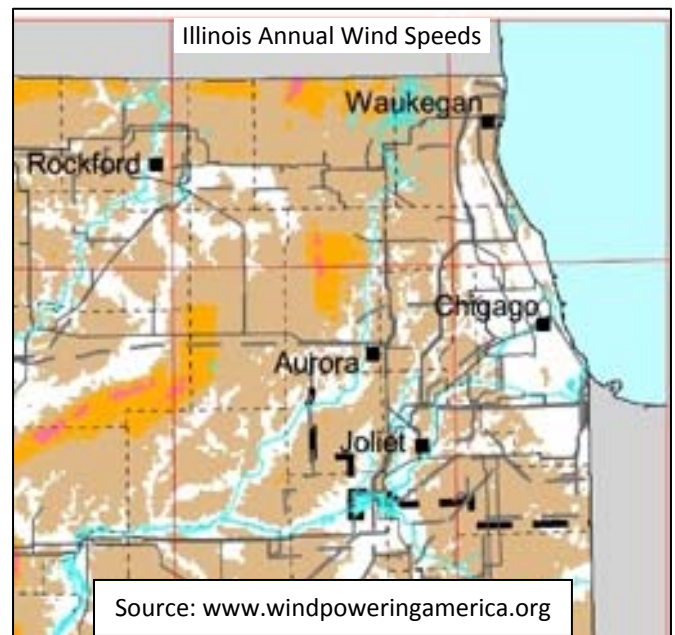
Turbines used in residential applications can range in size from 400 watts to 100 kW (100 kW for very large loads), depending on the amount of electricity you want to generate. A typical home uses approximately 10,000 kilowatt-hours (kWh) of electricity per year (about 830 kWh per month). Depending on the average wind speed in the area (check your local wind speed maps), and the location of the turbine relative to objects that may break up a strong and sustained wind (this is discussed in the following sections), a wind turbine rated in the range of 5 to 15 kW would be required to make a significant contribution to the full demand of a home’s electricity usage. A 1.5- kW wind turbine will meet the needs of a home requiring 300 kWh per month in a location with a 14-mile-per-hour (6.26-meters-per-second) annual average wind speed (which is equal to producing 36% of the electricity of a typical home). The manufacturer can provide you with the expected annual energy output of the turbine as a function of annual average wind speed. It must be noted that the “expected annual energy output” is not a concrete number and can vary drastically if the winds you utilize are not performing per the manufacturers’ standards. This information, along with your local wind speed, your energy budget, and how much capital you are willing to invest in the technology will help you decide which size turbine will best meet your electricity needs.⁷

How Do I Choose the Best Site for My Wind Turbine?

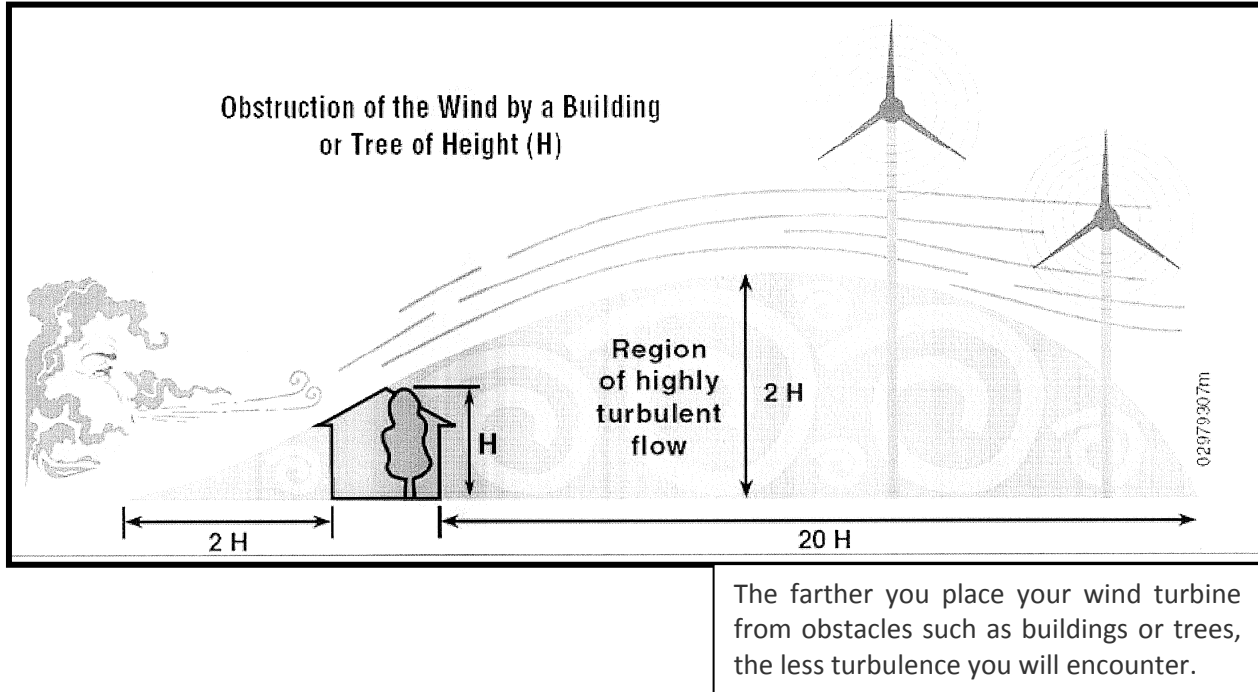
The first step is to find out the annual wind speeds through historical maps (see picture of the annual wind speeds below for northeastern Illinois or refer to Figure A below for the full state of Illinois wind map) or have a wind study performed on your site for more precise wind speeds. Maps on wind speed can be found by going to the website: [www.http://renewableenergy.illinoisstate.edu/wind/](http://renewableenergy.illinoisstate.edu/wind/).

You also need to know about the prevailing wind directions at your site and whether there are geologic features or other manmade structures in the area that can cause a varied wind speed within the same property. For instance, if you live in complex terrain, take care in selecting the installation site. If you site your wind turbine on the top of or on the windy side of a hill, for example, you will have more access to prevailing winds. However if you

site your wind turbine in a gully (depression) or on the leeward (sheltered) side of a hill your turbine will lose the strong prevailing winds and will also lose the maximum efficiency of the wind turbine. In addition to geologic formations, you also need to consider existing obstacles such as trees, houses, and sheds as these can affect the prevailing wind speed. Lastly, you need to do your best to plan for future obstructions such as new buildings or trees that have not reached their full height because they could also affect the strength of your wind speed.



In order for free standing small wind energy system to have maximum efficiency, your turbine should be sited at least 300 feet upwind and 30 feet above any buildings, trees, or other tall obstacles. The picture below illustrates this concept in more detail.



In addition to the previously mentioned obstructions, you also need enough room to raise and lower the tower for maintenance, and if your tower is guyed, you must allow room for the support guy wires that extend beyond the tower. If your wind energy system is off-grid or grid-connected (connect to the utility grid), you will also need to take the length of the wire run between the turbine and the load (house, batteries, water pumps, etc.) into consideration. This is because a substantial amount of electricity can be lost as a result of the wire resistance—the longer the wire run, the more electricity is lost. Using more or larger wire to reduce the electricity loss caused by the longer wire run will also increase your installation cost. Your wire run losses are greater when you have direct current (DC) instead of alternating current (AC). Therefore, if you have a long wire run, it is advisable to invert DC to AC.⁸ It is advised that you consult a certified electrician for more information or recommendation for the type of wire to use, connecting to the utility grid, or other issues that are beyond the scope of this resource guide.

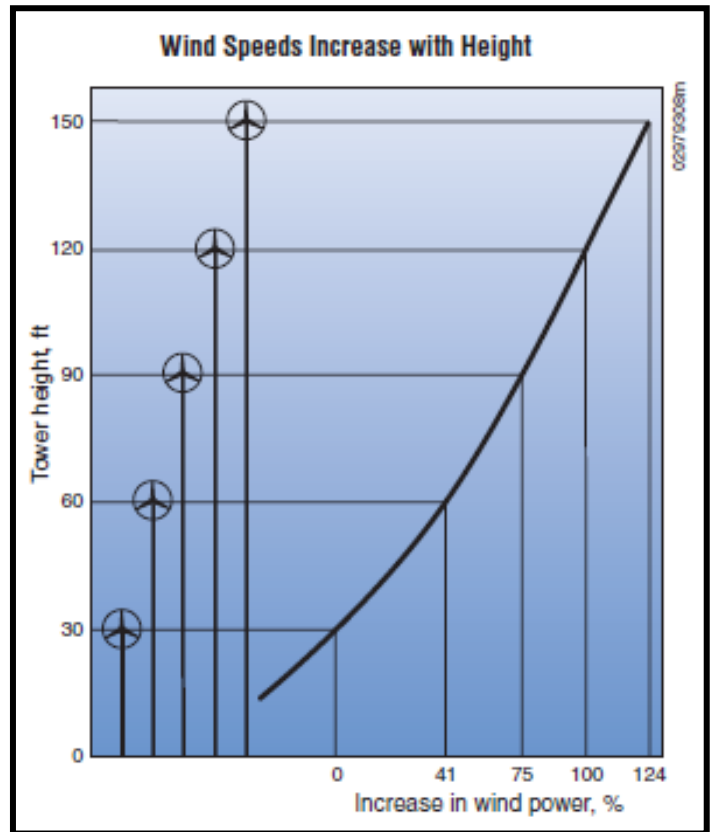
The Importance of Height & Wind Energy Systems

In order to harness the optimal higher wind velocities, wind turbines' heights must be adjusted according to the geography of the property in question as previously discussed in the section titled *How do I choose the best site for my wind turbine*. The height of your system is so important because the higher you turbine is the more powerful the wind becomes. Wind speed has an exponent of 3 applied to it, which means that even a small increase in wind speed results in a large increase in power.⁹ Therefore, a taller tower will generate exponentially more wind energy as is illustrated in diagram below for Small Wind Energy Systems from 30 to 150 feet in height.¹⁰

Wind speeds increase with height.¹¹ Note, the following:

- a. From a 30' to a 60' tall tower, there is a 41% increase in wind power.
- b. From a 30' to a 90' tall tower, there is a 75% increase in wind power.
- c. From a 30' to a 120' tall tower, there is a 100% increase in wind power.
- d. From a 30' to a 150' tall tower, there is a 124% increase in wind power.

Please note that there is no direct correlation between generator size (kW produced) and the tower height. Both factors (tower height & generator size) are independently determined on a case-by-case basis according to surrounding terrain, average wind velocities, and property location.¹² See Figure B at the end of the document (page 21) titled “Power from the Wind” for an additional figure which re-illustrates the importance of wind speed (and therefore height) when placing a turbine.



COST TO CONSTRUCT WIND ENERGY SYSTEMS

A 2007 market study by the American Wind Energy Association acknowledges “roughly 7,000 Americans purchased small wind systems in 2006 and that these systems are still far too expensive for most consumers.”¹³ The Daily Herald estimates that standard Residential Wind Turbines generally range from \$23,000 to \$35,000 in installation costs.¹⁴ Another example on cost comes from Entegrity Wind Systems, Inc., which offers a larger 50 kW tower at approximately 126 feet tall and costs in excess of \$200,000 to install. Lastly, with the popularity of turbines, they are becoming more available to consumers at prices that are more reasonable. Specifically, Ace Hardware will begin selling a small turbine in their store in 2010, which is currently available on the web for approximately \$6,000.¹⁵ Per Ace Hardware’s website, this turbine model is the Honeywell Wind Turbine (WT6500) and can generate a maximum of 2,500 kWh per year under optimal wind conditions.

In addition to cost, the time it takes to “recoup” the original homeowner costs to install your turbine, as stated in the New York Times, can take up to twenty years.¹⁶ To put this in perspective, if a homeowner purchased a turbine that cost \$25,000 (including installation) and had an average yearly electric bill of \$2,000, it would take 12.5 years for the homeowner to “re-coup”

the capital costs involved with the purchase and installation of the turbine. As stated many times within this document, the time it takes to recoup the overall cost of the turbine depends on the turbine (power it is capable of producing), the residence (high or low in topography), and the surrounding environment (open fields or large woodlands). While they are still fairly expensive and they may take years to recoup the original installation cost, according to the American Wind Energy Association, wind turbines can lower electric bills by 50 to 90 percent, depending upon how much energy is used at the residence and how much energy the wind turbine produces.¹⁷ Many residents may instead be looking at the installation of the wind turbine as an investment in a healthier future.

The WETF should note that there is some evidence that citizens who have installed residential wind turbines have reported that their models have consistently underperformed compared to the manufacturers' claim of ultimate efficiency of the turbine. The Commissioner of the Massachusetts Department of Energy Resources reports that 19 turbines tested averaged about 25% of the manufacturers' estimated energy production.¹⁸ Individual residences will experience differing results depending on the size and geographic location of the home, air conditioning use, lighting usage, and other factors as previously discussed. Please refer back to the section *How do I choose the best site for my wind turbine* for discussion on where you will lose efficiency in your wind turbine's output.

Tax Incentives

The following incentives are provided for informational purposes only and are not all inclusive. Homeowners may claim a Federal income tax credit of 30% of qualified expenditures for small wind energy systems on a property that serves as a residence by the taxpayer. *The Energy Improvement and Extension Act of 2008* extended the tax credit to until December 31, 2016. The maximum credit is \$500 per half kilowatt, not to exceed \$4,000, for systems placed in service after 2008.

The State of Illinois provides an additional tax credit of 30% of installation and labor costs for private businesses and residences and 50% of installation and labor costs for public sector and non-profit businesses. Customer must pay for at least 25% of the overall project costs. Please refer to the Database of State Incentives for Renewable Energy (www.dsireusa.org) to stay afoot of the most current available incentives.

COMMONLY DISCUSSED CONCERNS

Abandonment/Decommissioning

Like any other piece of machinery, defunct turbines will inevitably fall into disrepair, and removal will be necessary. Some communities require assurance that any non-functioning turbine will be removed after a period of time to prevent unnecessary clutter in a community. Abandonment due to malfunction has become particularly rare due to today's improved technology; though a community should be entitled to recourse should an abandoned turbine present a nuisance¹⁹. However, when the wind turbine does stop operating, the removal cost will be substantial, especially for taller Horizontal Axis Wind Turbines. The WETF of Lake County and the American Wind Energy Association recommends that if small wind turbine owners have inoperable equipment for at least six continuous months, the local government should notify them that they have six more months to make the system fully operable. After that time, the structure should be removed for safety reasons.²⁰

Aesthetics

While in many cases, wind systems can evoke images of Illinois' rural history, for neighbors of properties that maintain wind turbines, the primary concern has consistently been the visual impact of these devices. Capturing the strongest prevailing winds may necessitate that wind turbines are situated in more sensitive locations, which may affect sight lines from neighboring properties. This problem becomes particularly acute in areas where there are few surrounding features for the wind turbine to blend into.

While the previously mentioned tower heights may seem exaggerated, in a September, 2008, report published by the American Wind Energy Association stated “[p]utting a turbine on too short of a tower is like placing a solar panel in the shade.”²¹ Wind turbines operate most efficiently when there are few or no obstructions to prevent them from harnessing the faster and stronger prevailing winds that exist above tree lines and buildings. If people try to 'conceal' wind turbines from neighbors' views, they inevitably compromise the efficiency of the wind turbines.

Complaints have arisen in the past about the lighting on wind farms and individual turbines. While currently an unresolved issue for most residential and small-business purposes, the Federal Aviation Administration mandates lighting for structures more than 200 feet in height for aviation safety. Ordinances such as the WETF Model Ordinance limit lighting from WES facilities unless they are required by the FAA or other agencies.

Birds and Bats

The National Wind Coordinating Committee compared wind turbine bird kill with bird mortality caused by other man-made structures in the United States. It concluded that birds killed by collisions with wind turbines comprise 0.01% to 0.02% of all birds killed by collisions with man-made structures.²² While this estimate is based on commercial turbines and wind farms, isolated residential wind turbines, which generally are smaller according to local government ordinances currently in place, do not present a significant danger to birds or bats.

A study conducted by the University of Wisconsin-Green Bay concluded that “while bird collisions do occur ... the impacts on global populations appear to be relatively minor, especially in comparison with other human-related causes of mortality such as communication towers, collisions with buildings, and vehicle collisions. This is especially true for small facilities.”²³ With regard to bats, studies performed at Minnesota's Buffalo Ridge Wind Resource Area concluded that the 2.45 to 3.21 bat fatalities per turbine were not sufficient to severely impact overall bat populations. The data also indicated that the overwhelming proportion of deaths occurred among migrant bats, not resident populations.²⁴ According to these studies, it appears that birds and bats do not perceive or respond to wind turbines any differently than other man-made structures. While the reports could not distinguish between collisions with the blades or the towers themselves, the distinction may be irrelevant for residential wind turbines.

Connecting to the Utility Grid

It will be important that a consumer proposing to install a wind turbine in Lake County contact Commonwealth Edison Utility (power company) to obtain the proper procedure for connecting to the electricity grid. Consumers have only recently started to connect individual wind turbines to electricity grids.²⁵ Any excess energy produced by the wind turbine could be sold back to the utility (get approval from utility company). For example, if a resident installs a 1 kW Small Wind Turbine, all energy produced after the 1 kW capacity has been reached will be sold to the grid. However, not every utility will permit grid-connected wind turbines.²⁶ For contact information, you should utilize Commonwealth Edison's website (www.comed.com).

Electrical Signal Interference

Electromagnetic interference can occur due to scattering, reflection, diffraction, or other near-field effects. Satellite TV reception will be compromised if the turbine is directly in the way of the signal as well as any other permanent structure; however cable TV is not affected. Wind turbines can potentially interfere with television reception or other electrical signals per the AWEA.²⁷ Lastly, it should be noted that small wind turbine blades are made from materials that are "invisible" to radio frequency transmissions and cannot cause interference problems and turbines less than 200 feet will not affect civilian or military radar.

Icing

Wind turbines tend not to accumulate ice while they are moving. Turbines are designed to slow down to a stop when ice does build up on the blades. Melting ice will fall downward from stopped or slowly moving blades. Some blades are designed to flex in the wind in such a way as to resist ice accumulation, while others are heated to keep ice from forming.

A study in Switzerland²⁸ demonstrated that ice can be thrown from moving blades of a Large Wind Energy System (approximately 286 feet in height). Distance of falling ice depended on the wind speed and rotational velocity. The Swiss study identified 40% of ice fragments falling within the distance of a blade's length and 95% of ice fragments falling within two blades' length. The largest ice fragments noted by the study were a length of 39 inches and a weight of up to 4 pounds. The maximum range of ice thrown from the rotating blades was roughly the system height of the turbine.

While conditions in the Swiss Alps are considerably different than here in Lake County, and the chance of being hit by ice throw from a turbine remains small, this and other studies suggest that personal property and safety would be protected if automobile and pedestrian traffic were restricted during periods of winter weather within a distance of the system height of the **Large Wind** Energy System.

Research has not identified a risk of ice throw from smaller sized horizontal or vertical axis wind turbines. As is recommended with street lights, trees, and buildings, caution should also be exercised when parking or walking near or under Small Wind Energy Systems during icing or melting weather conditions.

Lightning Strikes

All wind turbines and guy wires are “grounded”, which means that wind turbines – while made of metal – do not build up an electric charge in the tower, but rather disperse it into the ground. However, while a turbine is not “appealing” to lightning strikes, they are still possible which is why turbines incorporate back-up technologies like surge and lightning arrestors and metal oxide varistors which are also used to protect home computers from electrical surges.²⁹

Potential for Structural or Electrical Failure

Instances of electrical or structural failures have become increasingly rare in the past decade as renewable energy machinery is more reliable and subject to more safety precautions.³⁰ Wind turbines are regularly equipped with gearboxes that ensure that the blades rotate within a controlled range of speed. They are also designed to automatically shut down during power outages with built-in breaking systems. These breaking systems are the system that limits the blades from rotating at speeds above manufacturer specification.

Property Values of Surrounding Neighbors

On December 2009, the US Dept. of Energy’s Lawrence Berkeley National Laboratory released a technical analysis of wind energy facilities’ impacts on the property values of nearby residences. The research is the most comprehensive and data-rich analysis on the subject to date. Using a combination of different analytic approaches, the investigation finds no evidence that prices of homes surrounding wind facilities are consistently, measurably, and significantly affected by either the view of wind facilities or the distance of the home to those facilities. Though the analysis cannot dismiss the possibility that individual homes or small numbers of homes have been or could be negatively impacted, it finds that if these impacts do exist, their frequency is too small to result in any widespread, statistically observable impact. The entire document can be accessed through the following US Dept. of Energy website:

http://apps1.eere.energy.gov/news/progress_alerts.cfm/pa_id=277 (accessed 12-11-09)

Shadow Flicker

Shadow Flicker is the on-and-off strobe light effect caused by the shadow of moving blades cast by the sun passing above the turbine. Shadow flicker is a function of several factors, including the location of people relative to the turbine, the wind speed and direction, the diurnal variation of sunlight, the geographic latitude of the location, the local topography, and the presence of any obstructions³¹. The American Wind Energy Association claims that Shadow Flicker is not an issue and can be mitigated by setbacks, since the optical effects of the flicker dissipate with distance.³² Per the Committee on Environmental Impacts of Wind Energy Projects, National Research Council, “a typical result (shadow flicker) might indicate, that a house 300 meters (984 feet) from a 600 kW wind turbine with a rotor diameter of 40 meters (131 feet) will be exposed to moving shadows for approximately 17-18 hours annually, out of a total of 8,760 hours in a year”³³. This accounts to a total of approximately 0.2% of the year and does not take into account whether or not the day is cloudy; thereby blocking any light from the sun which creates shadow flicker.

While some sources say shadow flicker is not an issue, the Sangamon County (Illinois) Ordinance concerning wind turbines requires the applicant to conduct a study on potential shadow flicker where it would interfere with neighboring residences more than 1 hour per year. This requirement is for wind farms of 40 or more acres in size, and does not apply to 35’ to 80’ tall facilities.³⁴ It should be noted that there is no one set requirement for shadow flicker at the current time, therefore, if a community does believe shadow flicker to be an issue, they may create restrictions that regulate this phenomenon.

Sound, Frequency, and Vibration

Depending on size and location, wind turbines have been reported to produce less than 40 (dB) decibels, equivalent to the noise produced by a refrigerator or a standard office environment.³⁵ Decibels measure the intensity of sound emitted from a given object.

The United States Department of Energy states that noise problems have been greatly reduced in recent years through stricter zoning policies and technological developments.³⁶ Since sound decreases in intensity with distance, noise pollution can be decreased by appropriate setback policies instituted by local governments. Appropriate setbacks help to ensure that whatever noise is generated can be largely confined to the properties on which the turbines are situated. Different setback requirements can exist depending on tower height and the location of the turbine on the property. All noise-emitting devices, including wind energy systems, must comply with Illinois Pollution Control Board regulations for noise.³⁷

In a probable attempt to meet lower noise standards, manufacturers have decreased the blades' rotational speeds, improved insulation, and eliminated many of the moving parts (including gearboxes) to create small wind turbines for residential use that operate at “near-ambient” levels.³⁸ The British Wind Energy Association reported in February, 2005, that turbine noise frequencies and vibrations have no “direct health effects,” and are emitted at very low levels.³⁹ The figure on the next page from NetWell Noise Control illustrates the decibel levels of a number of common noises that we hear everyday.

Noise Charts of Common Noises and their respective decibels

[Source: www.esoundproof.com; Accessed 8-12-2009]

Decibel Level Comparison Chart			
Commercial	Industrial	Residential	dB Level
Threshold For Hearing			0
Good Recording Studio		Breathing	10
		Rustling Leaves	15
		Whisper, Mosquito	20
Library		Living / Dining Room	30
Refrigerator Hum		Kitchen / Bathroom	40
Quiet Office	Power Lawn Mower	Home Office	50
		Birds at 10'	55
Conversational Speech			60
Piano Practice		Electric Shaver	60
Business Office		Piano Practice	65
Noisy Restaurant	Inplant Office	Street Traffic	70
Chamber Music		Barking Dog	75
Classroom		Alarm Clock	75
		Television / Dishwasher	75
Airplane at 1 mile	Manual Machines	Vacuum Cleaner	80
Reception / Lobby Area	Handsaw	Garbage Disposal	85
Motor Bus		Telephone Dial Tone	85
Applause in Auditorium		Lawn Mower	85
OSHA Required Hearing Protection in Factory			85
Teleconference Room		Train at 100'	90
Subway	Farm Tractor	Teenage Stereo	90
Sustained Exposure May Cause Hearing Loss			90
Music Practice Room	Electric Drill	Walkman at 5/10	94
French Horn	Average Factory Noise	Blender	100
Orchestra	Diesel Truck	Motorcycle	105
Computer Room	Printing Press	Train	105

Bass Drum	Heavy Truck	Power Saw	110
Dog Kennel	Power Mower	Baby Crying	110
Symphony Orchestra	Punch Press	Squeaky Toy to Ear	110
Pain Begins			120
Disco	Sandblasting	Shot Gun	120
Cymbal Crash	Pneumatic Clipper	Air Raid Siren	130
Drag car Racing	Military Jet	Shotgun	140
Rock Concert	Aircraft Carrier Deck	Jet Takeoff	140
Chest Wall Begins to Vibrate			150
Ear Drum Breaks Instantly			160
Death of Hearing Tissue			180
Loudest Possible Sound			194

To help municipalities determine whether sound from a Wind Energy System exceeds the sound limits created by municipalities, the *Environmental Sound Measurement Worksheet* (ESMW) was developed by Dr. Tom Thunder, AuD of Acoustics Associates, with the assistance of the Wind Energy Task Force of Lake County Communities. This document is attached in its full form near the end of this document [before the footnotes]. The purpose of the ESMW is to allow the municipalities to determine the average sound level from operating Wind Energy Systems by correcting for the ambient sound levels and adjusting for adverse characteristics.

Stray Voltage

Stray voltage describes the event when there is voltage between two objects that should normally not have any voltage difference. Per the AWEA, this unusual phenomenon, primarily affecting farm livestock, is the result of faulty wiring on any number of electrical systems (not just wind turbines) and easily prevented by industry-standard practices. It is also a strictly localized issue that will not affect off-site parties or properties. Large voltages do occur around electrical equipment due to poor insulation systems or some induced voltage from another source. Most small wind turbine inverters - those that are IEEE 1547 or UL1741 compliant - can detect faulty grounding and automatically shut down current flow.

Sun Glint

Sun Glint is the reflection of sunlight off any surface of the blades, tower, or other component of the wind energy system. Sun Glint off of the surface of the wind turbine, depending on the height of the tower, can be seen from miles away.⁴⁰ While some materials do reflect sunlight more harshly than others, manufacturers can provide non-reflective paint, such as matte finish paint, that minimizes this effect.

Turbine's Lifespan

Estimates for a turbine's lifespan range from one to a few decades. However, most studies focus on the installation while the everyday operation of the turbine, and the timetables for the removal and recycling of wind turbines have been largely ignored.⁴¹ If the wind turbine is built high enough to reach the more stable winds above tree lines and buildings, less strain will be placed on the overall structure. This can help reduce long-term maintenance costs and prolong the lifespan of the turbine.⁴² Many communities require a decommissioning plan for turbines that become inoperable or abandoned which defines how the turbine will be removed by the property owner.

REGULATIONS

State of Illinois Statutes

Non home rule of counties in Illinois must comply with state statutes regarding siting and zoning requirements related to wind farms. According to Municipal Code 65 ILCS 5/11-13-26: "A municipality may regulate wind farms and electric-generating wind devices within its zoning jurisdiction and within the 1.5 mile radius surrounding its zoning jurisdiction. There shall be at least one public hearing not more than 30 days prior to a sitting decision by the corporate authorities of a municipality. Notice of the hearing shall be published in a newspaper of general circulation in the municipality. A municipality may allow test wind towers to be sited without formal approval of the corporate authorities of the municipality. Test wind towers must be dismantled within 3 years of installation."⁴³ As the wind energy technology becomes more prevalent, additional state statutes related to this technology will most certainly be developed.

Certification Requirements

Wind turbine manufacturers must demonstrate that any given wind turbine meets standards for elements including labeling and identification, design, power performance, noise emissions, and structural integrity. Certification does not constitute a warranty, but an assurance of quality by the certification agent. A Type Certification confirms that a specific type of wind turbine (according to size, form, and function) meets standards that are specific to that type.⁴⁴

The WETF of Lake County Communities recommends that each WES shall conform to applicable industry standards, including those of the American National Standards Institute (ANSI). Applicants shall submit certificates of design compliance that equipment manufacturers have obtained from Underwriters Laboratories (UL), National Renewable Energy Laboratories (NREL), Det Norske Veritas (DNV), Germanischer Lloyd Wind Energie (GL), or an equivalent third party.

Delays for certification of future wind turbines will be inevitable. National standards for certification of small wind turbines have only been established in the past few months, and the process of certification takes several months to complete for individual installations.⁴⁵

ADDITIONAL USEFUL FIGURES

Figure A -ILLINOIS WIND RESOURCE MAP (2010)

Source: National Renewable Energy Laboratory

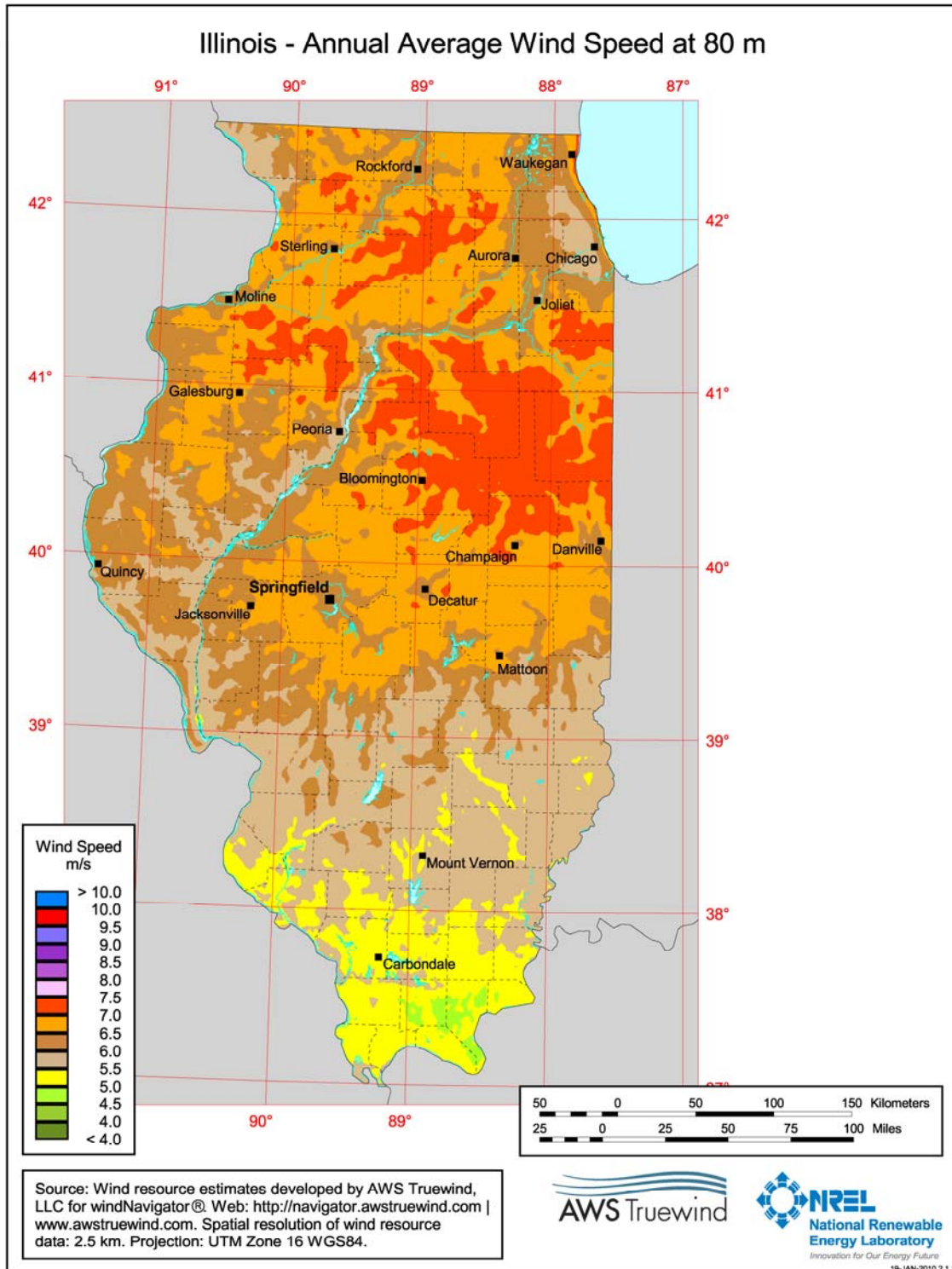


Figure B – INCREASE IN POWER FROM THE WIND

Source: American Wind Energy Association (AWEA)

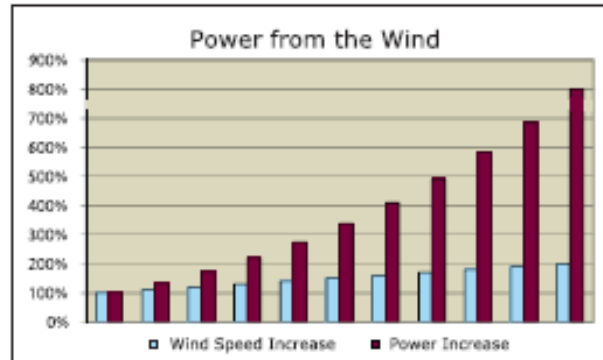
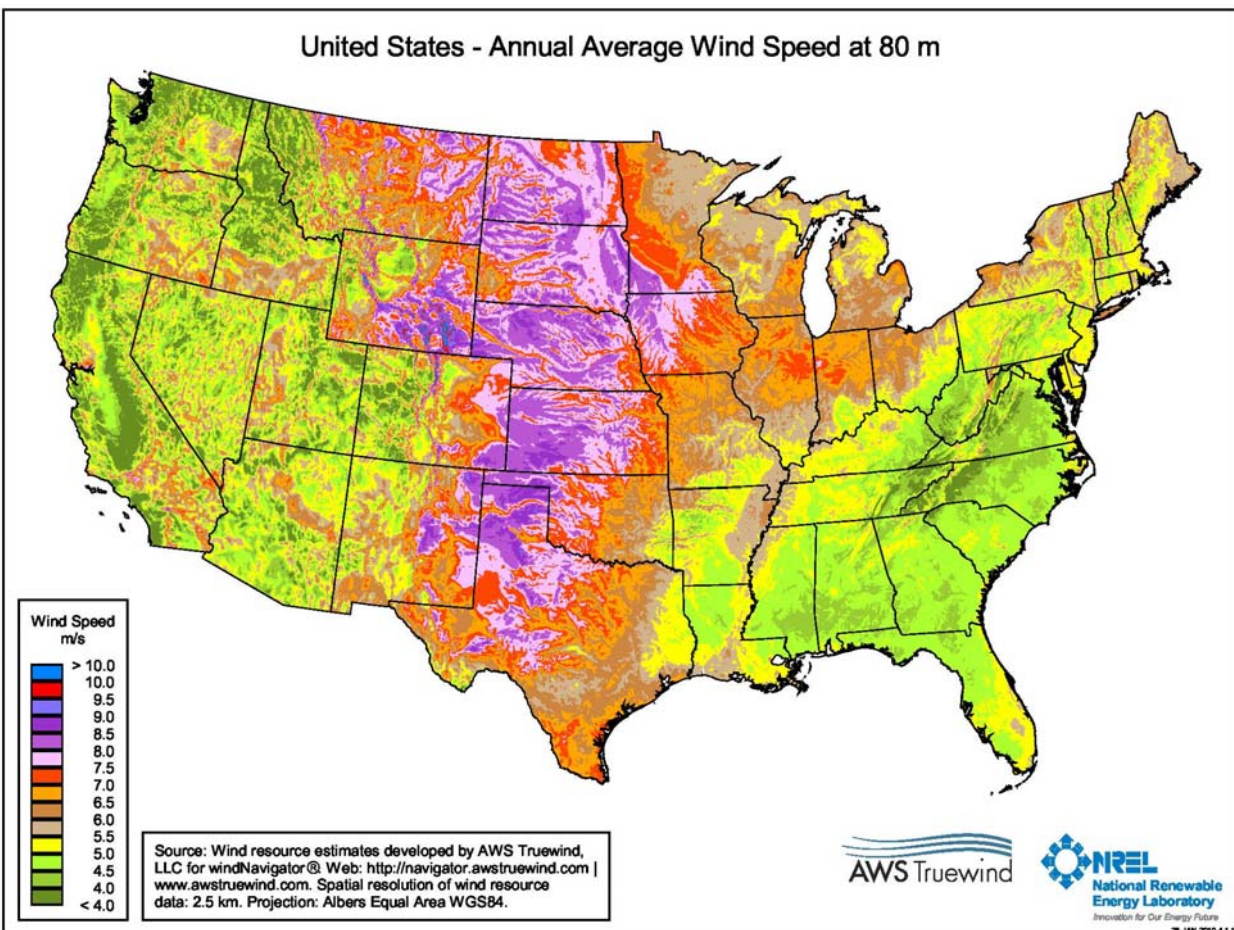


Figure C – UNITED STATES WIND POWER CLASSIFICATION MAP

Source: US Dept. of Energy National Renewable Energy Laboratory



HELPFUL WEBSITE LINKS

A majority of the links below are courtesy of the Illinois Wind Working Group
(<http://renewableenergy.illinoisstate.edu/wind/links>)

- [Wind News Stories](http://windforillinois.blogspot.com/) (<http://windforillinois.blogspot.com/>) - a useful link to archived news stories from across the state of Illinois.
- [Community Wind Info](http://www.windustry.org/community/default.htm) (www.windustry.org/community/default.htm) - Community Wind Resources and Links from Windustry.org
- [Wind Guide for Illinois](http://www.windustry.org/illinois/default.htm) (www.windustry.org/illinois/default.htm) - Information and resources specifically related to wind energy developments in Illinois and opportunities for Illinois farmers and communities to get involved with this emerging market.
- [Illinoiswind.org](http://www.illinoiswind.org) (www.illinoiswind.org) - Illinois Wind is a website dedicated to information for Illinois residents interested in wind as a source of renewable energy.
- [Small Wind in Illinois](http://www.awea.org/smallwind/illinois.html) (www.awea.org/smallwind/illinois.html) - This page provides information specific to public policies, incentive programs, wind resources, and organizational resources for installing and operating a small wind turbine in Illinois.
- [Small Wind Electric Systems: An Illinois Consumer's Guide](http://www.windpoweringamerica.gov/filter_detail.asp?itemid=310) (www.windpoweringamerica.gov/filter_detail.asp?itemid=310) - The purpose of this guide is to provide you with the basic information about small wind electric systems to help you decide if wind energy will work for you.
- [Wind Resource Maps](http://www.windpoweringamerica.gov/wind_maps.asp) (www.windpoweringamerica.gov/wind_maps.asp) - One of Wind Powering America's key activities is to provide validated, high-resolution state wind maps.
- [Opportunities in Illinois](http://www.illinoiswind.org/resources/small/faq05.asp) (www.illinoiswind.org/resources/small/faq05.asp) - This site includes incentive programs for renewable energy, including state policies, utility initiatives, state tax incentives, and other financial incentives and funding programs.
- [Gob Nob Wind Turbine](http://66.116.12.173:8085/) (<http://66.116.12.173:8085/>) - this turbine can now be viewed online through a webcam located at the nearby Farmersville Substation.
- [Wind Monitoring Program](http://www.illinoiswind.org/program/index.asp) (www.illinoiswind.org/program/index.asp) - It is essential to measure wind velocity for at least one year in order to forecast how much electricity might be generated at a particular site. Western Illinois University and its Illinois Institute for Rural Affairs and Department of Geography are offering organizations and landowners throughout the state the opportunity to assess the wind at a site under consideration for wind power.
- [How Wind Turbines Work](http://www1.eere.energy.gov/windandhydro/wind_how.html) (www1.eere.energy.gov/windandhydro/wind_how.html) - Learn more about wind energy technology, including topics such as how turbines work, types of wind turbines, sizes of wind turbines, and a look inside the wind turbine.
- [Wind Energy Applications Guide](http://www.awea.org/pubs/documents/appguideformatWeb.pdf) (www.awea.org/pubs/documents/appguideformatWeb.pdf) - This guide provided by the AWEA is designed to briefly explain the applications for which wind power is currently best suited in international applications and provide some contact numbers for further research.

- [Small Wind for Homeowners, Ranchers, and Small Businesses](http://www.eere.energy.gov/windandhydro/windpoweringamerica/small_wind.asp) (www.eere.energy.gov/windandhydro/windpoweringamerica/small_wind.asp) - The National Renewable Energy Laboratory produced Small Wind Electric Systems Consumer's Guides to help homeowners, ranchers, and small businesses decide if wind energy will work for them.
- [Financial Incentives](http://www.windpoweringamerica.gov/ne_policy_federalgrants.asp) (www.windpoweringamerica.gov/ne_policy_federalgrants.asp) - This is a link to some financial incentives, other than the most well known Production Tax Credit, for eligible renewable resources.
- [Small Wind - AWEA](http://www.awea.org/smallwind/) (www.awea.org/smallwind/) - This page on the AWEA website shares a wide variety of information on small wind, including details for installing and promoting small wind.
- [Small Wind - US DOE](http://www1.eere.energy.gov/windandhydro/small_wind_system_faqs.html) (www1.eere.energy.gov/windandhydro/small_wind_system_faqs.html) - This page includes many Frequently Asked Questions regarding small wind, from the U.S. Department of Energy.
- [Small Wind - Appalachian State University](http://www.wind.appstate.edu/swiwind/smallwindrdsite.php) (www.wind.appstate.edu/swiwind/smallwindrdsite.php) - This webpage features small wind research and demonstration.
- [Large Wind/Wind Farms](http://www.eere.energy.gov/windandhydro/windpoweringamerica/large_wind.asp) (www.eere.energy.gov/windandhydro/windpoweringamerica/large_wind.asp) - This site includes publications such as Wind Project Development Process, 10 Steps in Building a Wind Farm, and Permitting of Wind Energy Facilities: A Handbook
- [Wind Farmers Network](http://www.windfarmersnetwork.org/) (www.windfarmersnetwork.org/) - The Wind Farmers Network is a discussion forum for those interested in wind power to exchange ideas and information about wind power resources, economics, technology, and how to develop a wind project.
- [Wind energy policy, transmission & regulation](http://www.awea.org/policy/) (www.awea.org/policy/) - Resources on wind and other renewable energy sources for regulators and policymakers.
- [Farm Bill](http://www.eere.energy.gov/windandhydro/windpoweringamerica/ag_farm_bill.asp) (www.eere.energy.gov/windandhydro/windpoweringamerica/ag_farm_bill.asp) - The "Farm Security and Rural Investment Act of 2002," better known as the 2002 Farm Bill, includes a number of provisions for renewable energy, especially in the Energy Title of the bill. Several items directly fund or benefit wind energy systems. At this site you can find programs that are funded or enabled by the bill.
- [Illinois Incentives for Renewables and Efficiency](http://www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=IL&RE=1&EE=1) (www.dsireusa.org/library/includes/map2.cfm?CurrentPageID=1&State=IL&RE=1&EE=1) - DSIRE is a comprehensive source of information on state, local, utility, and federal incentives that promote renewable energy and energy efficiency.
- [Fat Spaniel Technologies](http://www.fatspaniel.com/) (www.fatspaniel.com/) - Fat Spaniel is the leading provider of critical information services for the renewable energy industry. It provides hosted data monitoring, management and control services that OEMs, installers, and distributed utilities can use to optimize performance and ensure investment returns for all types of renewable energy systems.
- [Al E Educational Videos on Wind Energy](http://www.altestore.com/store/Books-Classes-Educational-Videos/Educational-Videos/c1138/) (www.altestore.com/store/Books-Classes-Educational-Videos/Educational-Videos/c1138/) - This website features free online videos about Renewable Energy Basics.

Info on Wind Energy

- www.awea.org - The American Wind Energy Association (AWEA) promotes wind energy as a clean source of electricity for consumers around the world.
- www.dsireusa.org - The Database of State Incentives for Renewables and Efficiency (DSIRE) is a comprehensive source of information on state, local, utility, and federal incentives that promote renewable energy and energy efficiency.
- www.nationalwind.org - A U.S. consensus-based collaborative formed in 1994, the National Wind Coordinating Collaborative (NWCC) identifies issues that affect the use of wind power, establishes dialogue among key stakeholders, and catalyzes appropriate activities to support the development of environmentally, economically, and politically sustainable commercial markets for wind power.
- www.nrel.gov - The National Renewable Energy Laboratory (NREL) is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by Midwest Research Institute.
- www.eere.energy.gov - Energy Efficiency and Renewable Energy, U.S. Department of Energy
- www.windustry.org - Windustry works to increase wind energy opportunities for rural landowners and communities. Windustry promotes wind energy through outreach, educational materials, and technical assistance to rural landowners, local communities and utilities, and state, regional, and nonprofit collaborations.
- <http://www.eere.energy.gov/windandhydro/windpoweringamerica/> - Wind Powering America is a commitment to dramatically increase the use of wind energy in the United States. This initiative will establish new sources of income for American farmers, Native Americans, and other rural landowners, and meet the growing demand for clean sources of electricity.

USEFUL DEFINITIONS

(From FINAL WETF Ordinance – 1-29-10 Version)

Abandonment: Any Wind Energy System (WES) that has not been repaired to operating condition within the reasonable timeframe identified by [the Lake County Community], as provided in this ordinance.

Ambient Sound: The all-encompassing sound at a given location, usually a composite of sounds from many sources near and far. For the purpose of this ordinance, the “ambient sound level” shall mean the quiescent background level, that is, the quietest of ten 10-second average sound levels measured when there are no nearby or distinctly audible sound sources (e.g., dogs, cars in line-of-sight, or jets). Daytime ambient measurements should be made during mid-morning, weekday hours while nighttime measurements should be made after midnight.

Applicant: The Owner, who is in the process of submitting or has submitted an application to install a Wind Energy System project in [the Lake County Community].

Building-Mounted Wind Energy Systems (BWES): Wind Energy Systems that are structurally attached either onto the roof of or to the side of a building.

Day time hours: The hours of the day from 7:00 am to 10:00 pm, local time.

Decibel (dB): The unit of sound level based on a reference where 0 dB represents the threshold of hearing at 1000 Hz for a healthy young adult.

Decommissioning: Once a WES has been deemed inoperable or abandoned its components must be disassembled and removed from the premises, including the foundation. Upon removal, the site shall be restored to its original pre-construction condition.

FAA: The Federal Aviation Administration of the United States Department of Transportation.

FCC: The Federal Communications Commission.

Financial Assurance: A reasonable assurance from a credit worthy party, examples of which include a surety bond, trust instrument, cash escrow, or irrevocable letter of credit.

Grid-Intertie WES System: A system that converts wind energy to electrical energy that is connected to an electric circuit served by an electric utility company.

High Quality Aquatic Resource: Waters of the United States or Isolated Waters of Lake County that are determined to be critical due to their uniqueness, scarcity, function and/or value.

Horizontal Axis Wind Turbine (HAWT): This is the most typical type of turbine used. They have the main rotor shaft and generator at the top of the tower, and must be pointed into the wind.

Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator.

IDNR: The Illinois State Department of Natural Resources.

Large Wind Energy Systems (LWES): Wind Energy Systems with turbine towers and fully extended blades measuring taller than 175 ft. from the ground. LWES include one or more wind turbines, electronic conversion and distribution systems. They typically produce energy to be sold commercially and have a nameplate capacity of 750 kW to 2.5 MW.

Met Tower: A meteorological tower with an anemometer, used for the measurement of wind speed.

Nacelle: The part containing the shaft, gear box, and generator in a typical horizontal axis turbine.

Nameplate Wattage: The amount of energy produced from a Wind Energy System at maximum or optimum wind speeds within one hour, as indicated by the manufacturer.

Neighboring Property: Any property within 500 feet of a BWES or SWES, or within 1 mile of a LWES.

Nighttime hours: The time of the day after 10:00 pm until 7:00 am, local time.

Noise: Sound that adversely affects the psychological or physiological well-being of people.

Nonparticipating Property: A property that is not owned by the Owner of the property on which the WES is proposed or installed.

Operational condition: WES facilities being capable of operating at full capacity while meeting all sound, shadow flicker and other permit conditions.

Operator: The entity responsible for the day-to-day operation and maintenance of the WES, including any third party subcontractors.

Owner:

- The person(s), who hold(s) title of the property on which a BWES or SWES facility is installed.
- The entity or entities with an equity interest in the LWES facilities, including their respective successors and assigns.

Participating Property: A property that is owned by the Owner of the property on which the WES is proposed or installed.

Professional Engineer: A qualified individual who is licensed as a professional engineer in the State of Illinois.

Shadow Flicker: The on-and-off strobe light effect caused by the shadow of moving blades cast by the sun passing above the turbine. Shadow flicker intensity is defined as the difference or variation in brightness at a given location in the presence and absence of a shadow.

Silhouette: The area covered by moving blades of WES turbine, as viewed from the front elevation, described in square feet.

Small Wind Energy Systems (SWES): Free-standing, tower-mounted Wind Energy Systems with a system height measuring less than 175 ft. from the ground. SWES facilities are accessory structures that generate power for local distribution and consumption. Generators typically range from 1 kW to 100 kW in nameplate wattage.

Sound: A disturbance or oscillation that propagates outwardly as acoustic waves through the air.

Sound Frequency: The number of oscillations per second expressed in hertz (Hz). How we perceive sound is partly dependant on frequency. High frequency sound has more oscillations per second, whereas low frequency sound has fewer.

- **Audible or tonal sound:** Sound frequencies between 20-20,000 Hz. With WES, this may include mechanical sounds from rotating machinery experienced as "hum" or "pitch" occurring at distinct frequencies.
- **Broadband:** A wide range of frequencies above 100 Hz. With WES, the aerodynamics from the displacement of air from the turning blades of a wind turbine creates a "swishing" or "whooshing" sensation.
- **Low-frequency:** Sound with frequencies below 100 Hz, including audible sound and infrasound.
- **Infrasound:** Sound frequencies below 20 Hz, which if sufficiently intense, can be perceived by many individuals.

Sound Level: The A-weighted sound pressure level in decibels (dB) (or the C-weighted level if specified) as measured using a sound level meter that meets the requirements of a Type 2 or better precision instrument according to ANSI S1.4. The "average" sound level is time-averaged over a suitable period (say 1-minute) using an integrating sound level meter that meets the requirements of ANSI S12.43.

Structural Engineer: An Engineer who is licensed and registered to practice structural engineering in the State of Illinois under the Illinois Structural Engineering Act and whose principal professional practice is in the field of structural engineering.

Structural Weight: The combined weight of the tower, wind turbine generator, and any other component(s) otherwise supported by the base foundation.

Substation: The apparatus that connects the electrical collection system of the WES facilities and increases the voltage for connection with the utility's transmission lines.

Sun Glint: The reflection of sunlight off of a surface of the blades, tower, or other component of the wind energy system.

System Height: The distance from the ground to the highest point of the WES, including the highest reach of the blades. See local zoning code to see how measurement from the ground is determined.

Vertical Axis Wind Turbine (VAWT): A small scale wind turbine, in which the main rotor shaft is arranged vertically creating an "egg beater" appearance. The generator and gearbox are located near the ground so the tower does not have to support it and it is more accessible for maintenance.

Watt: (Symbol: W) A derived unit of power in the International System of Units (SI). It measures rate of energy conversion. One watt is equivalent to 1 joule (J) of energy per second. The kilowatt (symbol: kW) is equal to one thousand watts. The megawatt (symbol: MW) is equal to one million watts.

Wind Energy System (WES): A wind energy production, conversion and distribution system consisting of a wind turbine, tower, and associated electronics equipment. In other publications this is known as Wind Energy Conversion System (WECS).

Wind Farm: More than one Large Wind Energy Systems (LWES) on a given site, constructed for the commercial generation of electrical power.

Tower: The structure on which the wind system is mounted.

Turbine: The parts of a WES including the blades, nacelle and tail.

ENVIRONMENTAL SOUND MEASUREMENT WORKSHEET

[See following pages for document – 4 pages total]

Wind Energy Systems Sound Measurement Worksheet

Source Property: _____

___ Residential ___ Nonresidential ___ Industrial

Receiving Property: _____

___ Residential ___ Nonresidential ___ Industrial

Nature of Sound: _____

Location of instruments: _____

Wind Speed and Direction: _____

Equipment: _____

Date:

Time:

Examiner:

Calibration Check:

Sound level with calibrator in place:

Before	Cal. Level	After
_____ dB	94.0 dB	_____ dB

Measured Sound Levels:

1 **Total Sound Level** (*source on*):

Sample 1	Sample 2	Average
_____ dB(A)	_____ dB(A)	_____ dB(A)
_____ dB(C)	_____ dB(C)	_____ dB(C)

2 **Ambient Sound Level** (*quiescent level with source off*):

_____ dB(A)	_____ dB(A)	_____ dB(A)
_____ dB(C)	_____ dB(C)	_____ dB(C)

3 **Correction** for the ambient background sound

3a. Enter the difference between lines 1 and 2:

_____ dB(C)	_____ dB(A)
-------------	-------------

If Line 3a = 0 or 1 dB the source level cannot be determined

3b. If Line 3a = 2 dB → enter 4 dB; 3 dB → enter 3 dB

_____ dB(C)	_____ dB(A)
-------------	-------------

= 4-5 dB → enter 2 dB; 6-9 dB → enter 1 dB

= 10 dB or more → enter 0 dB

4 **Source Sound Level** (*line 1 minus line 3b*):

_____ dB(C)	_____ dB(A)
-------------	-------------

5 **Increase Above Ambient Sound** (*A-wtd level in line 4 minus A-wtd level in line 2*):

_____ dB(A)

Measured within 100 ft of residential dwelling

6 **Low Frequency** = $C_{\text{source}} - A_{\text{ambient}}$ (*C-wtd level of line 4 minus A-wtd level of line 2*):

_____ dB

Sound Limits (dB) on Receiving Properties:

	Industrial	Nonresidential	Residential Day / Night
Source Sound Level (A-wtd) - Line 4	65	60	50 / 40
Increase Above Ambient Sound (A-wtd) - Line 5			5
Low Frequency, $C_{\text{source}} - A_{\text{ambient}}$ - Line 6	20	20	20

Wind Energy Systems Sound Measurement Worksheet Instructions (ver. 7)

Wind Energy Task Force of Lake County Communities

The **Environmental Sound Measurement Worksheet** is intended to determine the average sound level (i.e. **Effective Source Sound Level**) from operating Wind Energy Systems (WES) by correcting for the ambient sound levels and adjusting for adverse characteristics. This measurement will determine whether the sound exceeds the limits stipulated in the ordinance of Lake County or the appropriate municipality.

Sound Level Meters (SLM) must meet the Type 2 grade or better per the latest revision of ANSI S1.4 *American National Standard Specification for Sound Level Meters* and must have an integrating feature that meets ANSI S1.43 *American National Standard Specifications for Integrating Averaging Sound Level Meters*.

The **procedures** outlined here are based in essence on applicable portions of ANSI S12.9 *American National Standard Quantities and Procedures for Description and Measurement of Environmental Sound* and Part 910 of Title 35: Environmental Protection, Subtitle H: Noise, Chapter 1: Illinois Pollution Control Board.

Frequency measurement

- The A-weighted scale is most often utilized for the measurement of tonal or audible sound levels. These are sounds that range from 20 to 20,000 Hz. and that the human ear can typically hear.
- The C-weighted scale is utilized especially for measurement of low frequency sound, i.e. more bass tones or infrasound, which may or may not be audible to the human ear. Low frequency sounds can travel farther and may be enhanced in different locations such as in buildings.

Instrumentation Set-up:

- Ensure the battery is in good condition.
- Measurements may be taken at any position, provided the location is not within:
 - 5 feet of small surfaces (e.g., trees, posts, etc),
 - 25 feet of a large reflective surface (e.g., shed, building, etc), or
 - 50 feet of a large reflective surface if the sound is tonal in nature.
- A tripod for the microphone or SLM is required if the sound is high-pitched. If the sound is low frequency in nature, a hand-held meter is acceptable as long as the arm is extended.
- The microphone on the SLM must be aimed toward the noise source and oriented at an angle recommended by the manufacturer (usually 45-70° off the ground).

Sound Level Limit Regulations for Wind Energy Systems (WES):

- The average sound level from a WES shall not exceed fifty (50) dB(A) during daytime hours or forty (40) dB(A) during nighttime hours at any point within neighboring, residentially zoned or used property. The different limits for daytime and nighttime sound levels are consistent with standards established by the Illinois Noise Pollution Board. These sound level limits on residential properties are stricter than those established by the Illinois Noise Pollution Board, because of the typical tonal, modulating and/or bass sounds experienced with WES. The average sound level from a WES shall not exceed sixty-five (65) dB(A) on neighboring industrial properties and sixty (60) dB(A) on other neighboring nonresidential properties, at any time of the day.
- No WES shall operate with an average sound level that is more than 5 dB(A) above the non-operational ambient level, as measured within 100 ft. of any neighboring residential dwelling.
- To limit the level of low-frequency sound, the average C-weighted sound level during WES operation shall not exceed the A-weighted ambient sound level by more than twenty (20) dB.

Wind Energy Systems Sound Measurement Worksheet Instructions (ver. 7)

Wind Energy Task Force of Lake County Communities

WORKSHEET INSTRUCTIONS

Source and Receiver Location:

Identify the types of property from which the sound is coming (Source) and on which the sound is being measured (Receiver).

Nature of Sound:

Identify what is the Source of the sound being measured.

Weather Conditions:

- Measurements should not be made when ground level winds exceed 10 mph.
- Use an anemometer and compass to measure **wind speed** and **direction** and identify them on the Worksheet.
- Use a thermometer to determine **temperature** and a hygrometer to measure **relative humidity** to identify any adverse conditions. All instruments must be used in accordance with the manufacturer's recommended procedures.
- As an alternative, weather conditions can be obtained from an airport or weather station reporting local conditions through an internet site such as WeatherBug.com.

Equipment:

Identify the type of sound level meter being used and whether measurements will be using the A-weighted scale to measure tonal or audible sound (20 to 20,000 Hz) or the C-weighted scale to measure low frequency sound (Below 200 Hz).

Calibration Check:

Place the calibrator on the SLM microphone and adjust the meter as necessary so that it displays the rated output of the calibrator (usually 94.0 dB). This must be repeated before and after each series of measurements to ensure SLM stability.

Measured Sound Levels:

1. **Total Sound Level:** Collect a 1-2 minute sample of the sound with the Wind Energy Systems operating. Wait over one minute collect a 2nd sample. If the samples are within 2 dB, there is repeatability and the two levels can be averaged for a total sound level. If there is more than a 2 dB difference, repeated samples should be taken to determine which levels are most in common and can be averaged. This is repeated for the C scale if low frequency sound is a concern.
2. **Ambient Sound Level:** Ambient Sound represents the background sound level observed when the source is not operating. Collect a 10-15 second sample of the Ambient Sound during a quiescent period, that is, a period when there are no nearby distinct or prominent sounds, such as dogs barking, a plane flying over, or a car passing by. Wait over one minute to collect a 2nd sample. If the samples are within 2 dB, there is repeatability and the two levels can be averaged. This is repeated for the C scale if low frequency sound is a concern.

Wind Energy Systems Sound Measurement Worksheet Instructions (ver. 7)

Wind Energy Task Force of Lake County Communities

3. **Correction:** This figure calculates how to correct the Total Sound Level measurement for Ambient Sound.
 - a. Enter the difference between the Total and Ambient Sound Levels [Line 1 – Line 2]
 - b. If the Ambient sound is not at least 2 dB lower than the Total Level on 3a, a determination of violation cannot be made. If the difference is 2 dB enter a “4”; for a difference of 3, enter a “3”; for a difference of 4-5, enter a “2”; for a difference of 6-9, enter a “1”; and for a difference of 10 or more, enter a “0.”
4. **Source Sound Level Measure:** The average sound level from the operating Wind Energy System (Source) is the Total Sound Level minus the Correction factor. [Line 4 = Line 1 – Line 3b]
5. **Increase above Ambient Sound:** An A-weighted sound level from a sound source that is more than 5 dB above the ambient level represents a significant increase in noise and is an objective indicator of annoyance. This is the difference between Line 4 and Line 2 and is used to assess compliance with the noise ordinance on residential properties. This measurement is intended for use on residential properties and should only be taken within 100 feet of a residential dwelling.
6. **Low Frequency Measurement** (if indicated): Low frequency sound can impact neighbors over a longer distance than more tonal sounds and is possibly perceived indoors. A C-weighted sound level with the turbine(s) operating that is more than 20 dB above the A-weighted ambient sound level is an objective indicator of annoyance due to a significant increase in low frequency noise. If the difference between the C-weighted level of Line 4 and the A-weighted level of Line 2 is less than 20 then Wind Energy System is considered to be in compliance with the noise ordinance.

SOLAR ENERGY SYSTEMS

Solar energy is an abundant renewable resource which is gaining in popularity as utility costs increase. Currently, solar energy is produced primarily through the use of solar cells, also known as photovoltaic cells. The process works by placing the cells in direct sunlight. Sun hits the cells causing a chemical reaction that creates an electric current. The current is then turned into electricity. The different types of systems are described below.



Passive Systems: (Passive and Active Heat and Hot Water Systems)

Passive Solar Design does not involve the use of mechanical and electrical devices, such as pumps, fans, or electrical controls to move solar heat within the house. Rather, a passive solar house is designed to collect, store, and distribute solar energy in the form of heat in the winter and reject solar heat in the summer. The difference between a passive solar home and a conventional home is design. The key is designing a passive solar home to best take advantage of the local climate.

Elements of Passive Solar Design

1. Window location and glazing type
2. Insulation and Air Sealing
3. Auxiliary Heating and Cooling Systems:
4. Direct Gain: Sunlight enters a house through collectors (usually south facing windows with a glazing material made of transparent or translucent glass). When the sunlight strikes masonry dark colored floors and/or walls, the solar heat is absorbed and stored. At night, as the room cools, the heat stored in the thermal mass convects and radiates into the room.
5. Indirect Gain (Trombe Walls): This type of wall distributes or releases heat into a home over a period of several hours. An 8" – 16" thick masonry wall is needed on the south side of a house. A single or double layer of glass is mounted about 1 inch or less in front of the wall's surface. Solar heat is absorbed by the walls dark-colored outside surface and stored in the wall's mass, where it radiates into the living space.
6. Isolated Gain (Sunspaces)
 - A. Also known as a solar room or solarium is the most common isolated gain design. It can be built as part of a new home or as an addition to an existing home.

- B. Most reliable design is to install vertical windows with no overhead glazing, thermal mass (masonry wall or water containers), and low-emissivity windows, vents, doors or fans.

* From the US Dept. of Energy, Energy Efficiency & Renewable Energy, “A Consumer’s Guide”

Thermal Systems (Heat & Hot Water)

[*Source: US Dept. of Energy, Energy Efficiency & Renewable Energy, “A Consumer’s Guide”]

Solar heating harnesses the power of the sun to provide solar thermal energy for solar hot water, solar space heating, and solar pool heaters. Thermal heating systems utilize solar collectors mounted on a roof or the ground to gather the sun’s energy, transform its radiation into heat then transfer that heat to water, solar fluid, or air.

Types of Collectors

There are two types of collectors: flat-plate and evacuated-tube. Additionally, there are two types of active heating systems: fluid and air. If the thermal system can not provide adequate space heating, an auxiliary or back-up system (such as a conventional central heating system, wood stove, etc...) provides the additional heat. To achieve the most economical system, an active solar heating system should provide 40 – 80 percent of the home’s heating needs. Anything less than 40 percent of the home’s heating needs are rarely cost effective.

1. Flat-Plate Collectors

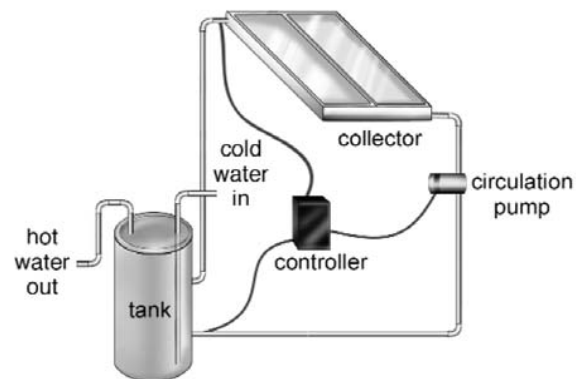
Flat-plate collectors are the most common solar collector for solar water heating systems and solar space heating. A typical flat plate collector is an insulated metal box with a glass or plastic cover (called the glazing) and a dark colored absorber plate. These collectors heat liquid or air at temperatures less than 180 degrees.

2. Evacuated-tube Collectors

Evacuated-tube collectors can achieve extremely high temperatures (170 – 350 degrees), making them more appropriate for cooling applications and commercial & industrial applications. The collectors are usually made of parallel rows of transparent glass tubes. Each tube contains a glass outer tube and metal absorber tube attached to a fin. The fin is covered with a coating that absorbs solar energy well, but which inhibits radiant heat loss. Air is removed, or evacuated, from the space between the two glass tubes to form a vacuum, which eliminates conductive and convective heat loss. This type of collector is more expensive than a flat-plate collector.

3. Fluid Based Heating System [Active System]

For Liquid systems in a flat plate collector, a heat transfer such as water or antifreeze (usually non-toxic propylene glycol) absorbs the solar heat. A controller operates a circulating pump to move the fluid through the collector then into an interior space or



holding tank, from which the heat is distributed for use. Other system components include piping, pumps, valves, an expansion tank, a heat exchanger, a storage tank, and controls.

4. *Air Based Heating System [Active System]*

Solar air heating systems use air as the working fluid for absorbing and transferring solar energy. The absorber plates in air collectors can be metal sheets, layers of screen, or non-metallic materials. The air flows past the absorber by using natural convection or a fan. Solar air collectors can directly heat individual rooms or can potentially pre-heat the air passing into a heat recovery ventilator or through the air coil of an air-source heat pump.

Air collectors produce heat earlier and later in the day than liquid systems, so they may produce more usable energy over a heating season than a liquid system of the same size. Also, unlike liquid systems, air systems do not freeze and minor leaks in the collector or distribution ducts will not cause significant problems, although they will degrade performance. However, air is a less efficient heat transfer medium than liquid so solar air collectors operate at lower efficiencies than solar liquid collectors.

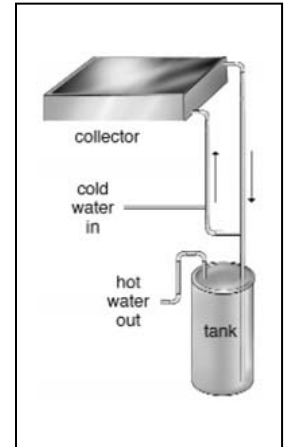
A. Active Solar Hot Water Heaters

Rely on electric pumps and controllers to circulate water or other heat-transfer fluids through the collectors. Three types of active systems:

- I. Direct-circulation systems use pumps to circulate pressurized potable water directly through the collectors. These systems are appropriate in areas that do not freeze for long periods and do not have hard or acidic water. These systems are not approved by the Solar Rating & Certification Corporation if they use recirculation freeze protection (circulating warm tank water during freeze conditions) because that requires electrical power for the protection to be effective.
- II. Indirect-circulation systems pump heat-transfer fluids through collectors. Heat exchangers transfer the heat from the fluid to the potable water. Some indirect systems have “over protection” which is a means to protect the collector and the glycol fluid from becoming super-heated when the load is low and the intensity of incoming solar radiation is high. The two most common indirect systems:
 - (a) Antifreeze. The heat transfer fluid is usually a glycol-water mixture with the glycol concentration depending on the expected minimum temperature. The glycol is usually food-grade propylene glycol because it is non-toxic.
 - (b) Drainback systems. A type of indirect system, use pumps to circulate water through the collectors. The water in the collector loop drains into a reservoir tank when the pumps stop. This makes drainback systems a good choice in colder climates. Drainback systems must be carefully installed to assure that the piping always slopes downward, so that the water will completely drain from the piping. This can be difficult to achieve in some circumstances.

B. Passive Solar Hot Water Heaters

Rely on gravity and the tendency for water to naturally circulate as it is heated. Because they contain no electrical components, passive systems are generally more reliable, easier to maintain, and possibly have a longer work life than active systems. Two most popular systems are:



- I. Integral-collector storage systems consist of one or more storage tanks placed in an insulated box with a glazed side facing the sun. These solar collectors are suited for areas where temperatures rarely go below freezing. They are also good in households with significant daytime and evening hot water needs; but they do not work well in households with predominantly morning draws because they lose most of the collected energy overnight.

- II. Thermosyphon systems are an economical and reliable choice, especially in new homes. These systems rely on the natural convection of warm water rising to circulate water through the collectors and to the tank (located about the collector). As water in the solar collector heats, it becomes lighter and rises naturally into the tank above. Meanwhile, the cooler water flows down the pipes to the bottom of the collector, enhancing the circulation. Some manufacturers place the storage tank in the house's attic, concealing it from view. Indirect thermosyphon's (that use glycol fluid in the collector loop) can be installed in freeze-prone climates if the piping in the unconditioned space is adequately protected.

C. Solar Pool Heating

- I. The existing pool filtration systems pumps pool water through the solar collector and the collected heat is transferred directly to the pool water. Solar pool-heating collectors operate just slightly warmer than the surrounding air temperature and typically use inexpensive, unglazed, low-temperature collectors made from specially formulated plastic materials. Glazed solar collectors are not typically used in pool-heating applications, except for indoor pools, hot tubs, or spas in colder climates.
- II. In residential areas where the goal is usually to extend the swimming season into spring and fall, heating a swimming pool with solar energy requires a solar collector that is 50% to 100% of the surface area of the pool. In general, adding more square footage lengthens the swimming season and allows owners to use the pool in colder weather. A pool cover or blanket significantly reduces heat loss in a cost-effective manner and helps maintain warm temperatures for long periods.

Types of Mounts for Solar Panels*

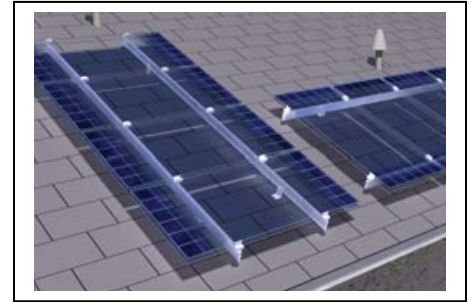
*Source: Northern Arizona Wind & Sun and SPI Renewable Solutions

Flush Mount

This is the simplest type of mount and is commonly used for the single or small quantities of panels. Consist of end brackets or “Z” brackets that mount to the panel frame and then screw or bolt into the roof. The panel must be elevated from the roof, typically 2” – 4” to allow air flow under the unit and keep it cool. If not elevated, the solar unit will rapidly overheat and the functional lifespan will be significantly reduced.

Advantages: Cheap, simple to install, low wind resistance and weight

Disadvantages: Not suitable for large arrays or some types of roofs, no flexibility in tilt or orientation.

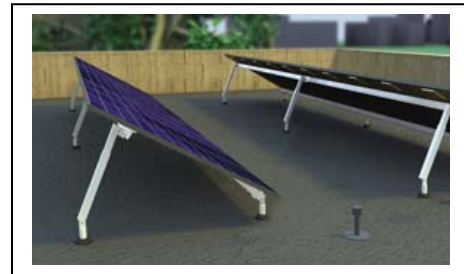


Roof-Ground Mount (also called Universal)

Typically used with larger solar panel systems, can mount on either a roof or ground with little or no change in mount setup, constructed of grid-like systems of supports, provide adjustable or fixed tilt

Advantages: Fits a wide variety of panels, can be used almost everywhere

Disadvantages: more expensive, difficult to install on rooftops due to heavy wind resistance, bulky, aesthetic concerns.



Top & Side of Pole Mount

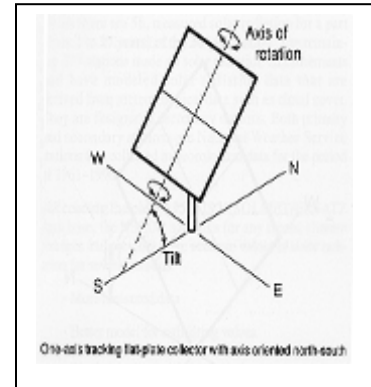
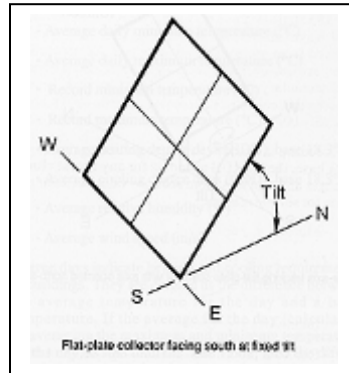
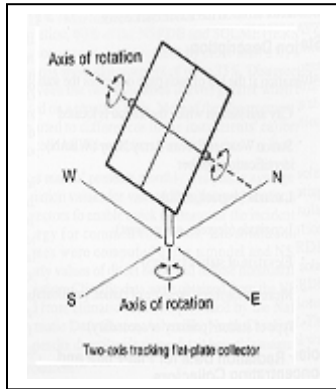
There are three (3) types of pole mounts: Top of Pole; Side of Pole; and Tracking mounts.

1. Top of Pole – metal rack and rail unit that is bolted to a large sleeve that rests on top of the pole. An existing pole at least 3 – 8” wide with a concrete base is needed, the mount slips over the top of the pole and you can bolt or weld the solar panel unit into place
2. Side of pole – typically fastened and bolted to telephone or utility poles, use smaller solar panel units
3. Tracking Mounts – top of pole mounts with a special function – tracking pole mounts track the motion of the sun in the sky throughout the course of the day – maximizes the operating efficiency of the solar panel unit

A. Specifics on Solar Panel “Trackers” (track mounts)



- I. One-axis tracker - This type of tracker stays at the same vertical angle, which is set manually, and rotates around the post to follow the sun from sunrise to sunset.
- II. Two-axis tracker – This type of tracker adjusts to the sun's vertical angle automatically and rotates around the post to follow the sun from sunrise to sunset.



Flat Plate Panels and Solar Shingles

*Source: EnergyRefuge.com

Solar Shingles: Systems Features

1. Architecturally pleasing systems that do not distract from the natural lines of the home
2. Complete design freedom
3. Fully integrated shingle roof
4. Solar shingles are structurally and aesthetically integrated roofing elements
5. Capable of withstanding 80 mph wind loads
6. No support structures needed
7. UL Listed as prepared roofing cover
8. Modules and inverters UL listed
9. Wind and water tight roof
10. Suitable both for renovation and for new construction
11. 20-year power output and 5-year system warranty
12. Direct nailing on wood decks with fire-resistant underlayment
13. No back-ventilation of solar shingles necessary
14. Easy to transport and install
15. Lightweight shingles are easy to handle and can be placed directly on fire-resistant roofing underlayment



Because of the immense amount of heat absorbed, **solar shingles** usually require an under-decking of ventilated plywood. When they are laid on the roof like regular shingles, they overlap and

provide the same protection and weather shedding effect. The wiring from the shingles runs through the roof deck and to an area where they can be connected to the solar inverter. The shingles are held in place by a heat-activated EVA compound which glues the shingles to each other. This keeps the shingles from shifting or moving in high winds. It can take two months to one year to produce the amount of energy that was required to make them. Once in place, the shingles quickly pay for themselves over their 20 year average lifespan.

Solar Slates (from Atlantis Energy Systems)

With SUNSLATES™ solar electric roofing tiles, you get more than a roof over your head. Each SUNSLATES™ tile begins as an Eternit roofing slate. These slates dominate the European roofing world. We then glue the low glare tempered glass power panel to the exposed surface. Because it is a roofing product it is installed using onsite electrical or certified roofing subs. Ideal for either new construction or re-roofing, the complete SUNSLATES™ system is delivered to the job site. No special trades are necessary. Once trained, the roofer and electrician can handle the installation themselves:



1. SUNSLATES™ are secured with stainless steel storm anchor hooks and anchored to 1x4 nailers resting on 2x2 sleepers. They are rated to Dade County, FL. standard.
2. Each SUNSLATES™ tile comes with a proprietary gas-tight connector that wires each tile to the adjacent tile. With a simple twist of a special screwdriver-like tool (provided), the SUNSLATES™ tile is locked securely within its circuit.
3. At the end of each course, a “homerun” cable is run to a splice box on the underside of the roof deck. On new construction, the low voltage cable is run through wall bays to the inverter. Usually on re-roof construction it is run through conduit on the exterior wall through an eave.
4. The typical size of an energy roof uses about 300 ft. square of SUNSLATES™. (17' x 17'). This size dimension requires one inverter. (Note) Each 100 sq feet of SUNSLATES™ installed is 750 pounds of roofing. This compares to pounds per square for concrete tile and 300 pounds for composition shingles.
5. A single sub-roof penetration (through the plywood sheathing and felt paper, not the tiles) is required per roof plane of SUNSLATES™ installed.
6. The wiring from the roof to the inverter — and from the inverter to the main house panel — can be handled by the on-site electrical contractor who is wiring the rest of the house using standard wiring techniques.



7. The inverter is installed within a cabinet that is built into an exterior or interior location in the house, preferably one that is close to the main house panel.



Commonly Discussed Concerns

Weather Conditions

Clouds

A cloudy day provides sufficient diffuse light by which the panel will produce electricity. Optimum electrical production occurs with bright and sunny weather conditions. Under a light overcast, the modules might produce about half as much as under full sun, ranging down to as little as five to ten percent under a dark overcast day. (Source: <http://www.solarhome.org>)

Cold Weather/Snow

Solar panels work on light not heat, and cold temperatures can actually help solar panels productivity. However, with shorter daylight hours in winter, solar panels produce proportionately less power. If the modules become covered with snow, they stop producing power, but snow generally melts quickly when the sun strikes the modules; if you brush the snow off, they resume operation immediately. (Source: <http://www.solarhome.org>)

Snow on the ground increases a solar panel's production because it increases the amount of diffuse light in the area. (Source: <http://www.glrea.org/articles/howDoSolarPanelsWork.html>)

Optimal solar panel placement

Your panels should be facing as close to south as possible. The optimal angle for your solar panel to be placed at is equivalent to your angle of latitude. In Lake County, Illinois, the optimal latitude is about 42 degrees (Full latitude: 42° 18' 47" N). However, a difference of 15 degrees to either side of this optimum setting will not cause the panel to lose much efficiency.

You can also set your solar panel for optimum performance in summer and winter. In summertime, the solar panel should be at a lower angle because the sun is higher over head. In wintertime, the sun moves across the sky at a lower angle. So by angling your solar panels higher, you will catch more sun rays.

There are tracking devices that follow the sun throughout the day, winter or summer. While these will gather more sunlight, the added expense of the tracking device may not justify the savings from gathering more sun energy.

(Source: <http://www.solartradingpost.com/solar-angle-calculators.html>)



Aesthetics

While solar energy significantly reduces air pollutants and greenhouse gases in the environment, for neighbors of properties that maintain solar panels, the primary concern is often the visual impact of these devices. Solar panels usually offer visual elements that contrast with the environment surrounding them. There are many cases of neighbors complaining about the look of solar panels on adjacent properties. The most common concern of neighbors is that solar panels can damage the character of the neighborhood, and decrease property values.

On the other hand, it can be argued that solar panels are aesthetically pleasing. “Architects have discovered that solar elements can be used to enhance the aesthetic appeal of a building, and their clients have discovered the positive effects of advertising the fact that they are using solar energy... Solar panels are more likely to offer a positive aesthetic impact on modern buildings in comparison to historical buildings.” (Tsoutsos, 5) In the end, it comes down to a matter of taste.

Another option for aesthetic regulations is from the Village of Schaumburg (Illinois) energy code, which partially regulates aesthetics through a “projection” regulation. A projection regulation will limit the distance a solar energy system may project off a roof edge or building façade. This concept is referenced in the figure to the right.

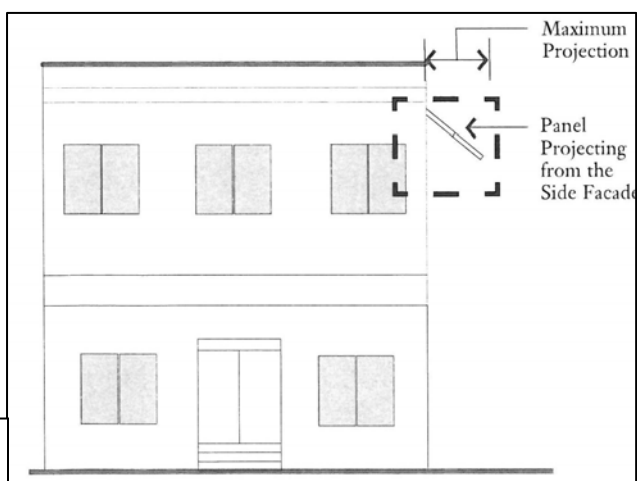


Figure of Solar Projection

For communities that do have additional concerns about the aesthetics of certain solar panels and desire additional legislative review of solar energy projects, an *Architectural Review Commission (ARC)* is a review process that could be utilized for such a purpose.

Safety Issues

Wind Resistance

For solar panels mounted on either ground or rooftop, wind uplift is a primary safety concern. The panels are quite heavy, and if uprooted, they can be quite harmful to any objects or people in their path, especially if uprooted from a roof. For this reason, it is recommended that a qualified contractor install the solar system.

Falling Objects

Because solar panels operate most efficiently in direct sunlight, they are usually installed away from trees or other unwanted shade producers. However, it is wise to trim trees or bushes that begin to grow above the panel. This will not only ensure that the panel produces electricity efficiently, but will also prevent falling branches from breaking the solar panel.

Fire

As with any other electrical system, fire hazard is a concern. The threat comes in the form of faulty wiring or damage to the electrical components of the system. For this reason, an experienced, certified contractor is recommended when installing a solar electric system.

Water Pollution

During operation, coolant liquids may need to be changed every 2 to 3 years, requiring careful handling. There may be the risk of accidental water pollution through leaks of heat transfer fluid. (Tsoutsos, 4)

Air Pollution

While the production of solar panels is rather energy intensive, the emissions associated with operation are quite insignificant. These emissions were only about 0.1% to 1% of manufacturing related emissions. (Tsoutsos, 5) The total emission from both production and the life cycle of the solar panel is significantly lower than emissions avoided by the systems operation – conventional fossil fuel energy emissions.

Decommissioning and Restoration Issues

Solar panels should always be maintained in operational condition. If a solar panel becomes inoperable, the owner will be responsible for removal.

Battery Disposal

In solar panel systems, batteries are responsible for most of the environmental impacts, due to their relatively short life span and their heavy metal content. Furthermore, large amounts of

materials are required for their production. A module-recycling scheme can improve this situation. (Tsoutsos, 6)

It is imperative that batteries are disposed of properly. It is recommended that owners dispose of batteries at stores or recycling centers that accept them. If not treated with caution, harmful elements such as lead can leak into the environment and the drinking water supply.

Recycling

According to the European Photovoltaic Industry Association and PV Cycle, it will take 1/3 of the energy to make a solar panel from a recycled solar panel rather than using new materials, such as silicon, once recycling technologies for reusing silicon from solar cells are commercially available.

(Source: http://www.oregon.gov/ODOT/HWY/OIPP/docs/solar_panel_lifecycle.pdf?ga=t)

Regulations

Building Code

Prior to 2004 the primary energy conservation law in Illinois was the Illinois Public Utilities Act (revised in 1986.) This law required Illinois investor-owned electric utilities to use least-cost energy planning, which required the use of economical energy conservation when new resources for electricity were required. This requirement was implemented by utilities and monitored by the Illinois Commerce Commission through the least-cost energy planning process.

[Public Act 093-0936](#) (Illinois Energy Conservation Code for Commercial Buildings) was signed into law in August, 2004. The Illinois Energy Conservation Code for Commercial Buildings became effective April 8, 2006. This law requires all commercial construction for which a building permit application is received by a municipality or county to follow a comprehensive statewide energy conservation code. The Capital Development Board has the authority to create administrative rules, and its most recent rule amendments mandated that the code for commercial buildings follow 2009 International Energy Conservation Code (IECC) (as of August 2009). Municipalities and counties are required to enforce 2009 IECC.

On May 31, 2009, the Illinois General Assembly approved the Energy Efficient Building Act ([HB 3987](#)), which was signed into law on August 28, 2009. The legislation directed the Illinois Capital Development Board (CDB) to adopt the Illinois Energy Conservation Code, which became effective January 29, 2010. The new statewide code ([71 IAC 600](#)) incorporates the 2009 IECC for residential buildings and privately funded commercial buildings and ASHRAE 90.1-2007 for publicly funded commercial buildings (previously, there was not a mandatory residential statewide energy code based on the IECC). An automatic update provision directs the CDB to adopt each subsequent version of the IECC within nine months of its publication, with an effective date three months afterwards.

The legislation also removed local home rule jurisdiction over residential energy standards. Local governments are allowed to adopt more stringent energy codes for commercial buildings (but not less stringent). These jurisdictions also may not adopt residential codes more or less stringent than the state code (however, exemptions to go above the state residential code are made for

municipalities that adopted at least the 2006 IECC before May 2009 or have more than 1,000,000 residents).

(Source: <http://www.dsireusa.org/incentives/allsummaries.cfm?State=IL&re=1&ee>)

Common problems homeowners have faced with building codes have included exceeding roof load, unacceptable heat exchangers, improper wiring, and unlawful tampering with potable water supplies.

Municipal Zoning and Architectural Review Codes

In conjunction with this resource guide, the AETF has also created the Solar/Geothermal Systems Model Ordinance which municipalities may utilize as a template or starting point for proposing new regulations for Solar Energy Systems. The Model Ordinance contains recommended restrictions in an attempt to promote responsible solar energy policies.

Illinois state law has established that no municipality or county government may require a renewable energy system used for onsite energy generation to be setback more than 1.1 times the height of the system from the end user's property line. (H.B. 3746)

(Source: http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=IL17R&re=1&ee=1)



Example of a Building-Mounted Solar Energy System

Informative Websites

American Solar Energy Society - (<http://www.ases.org/>) - the nation's leading association of solar professionals & advocates.

Battery Information – (<http://www.solar4power.com/solar-power-battery.html>)

Exploring Ways to Use Solar Energy –

(http://www.energysavers.gov/renewable_energy/solar/index.cfm/mytopic=50011) – A useful resource from the U.S. Department of Energy

The Illinois Solar Energy Association – (<http://www.illinoissolar.org/>) - The Illinois Solar Energy Association is a non-profit organization that promotes the use of solar energy.

International Solar Energy Society - (<http://www.ises.org/ises.nsf>) – technical body dealing with the technology and implementation of renewable energy.

Sandia National Laboratories Photovoltaic's Program - (<http://photovoltaics.sandia.gov/>) – Sandia photovoltaic work is centered on developing cost-effective, reliable photovoltaic energy systems produced by US industry and used worldwide.

Solar Angle Calculator – (<http://www.solartradingpost.com/solar-angle-calculators.html>)

Solar Electric Power Association - (<http://www.solarelectricpower.org/>) – SEPA is an unbiased non-profit resource for information about solar technologies, policies, and programs.

Solar Energy Industries Association - (<http://www.seia.org/>) – SEIA works to expand the use of solar technologies, strengthen research and development, remove market barriers, and improve education and outreach for solar.

Solar Home Installers - (<http://www.solarhomeinstallers.com/>) - Solar panel installer directory

Solar Panel Safety Issues - Cal Finder - (<http://solar.calfinder.com/blog/going/how-safe-is-solar-solar-panel-safety-concerns/>) - Cal Finder offers information regarding solar panel safety.

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Legislation and Grants

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So far, Illinois has been proactive in promoting solar energy. According to the Illinois Solar Energy Association, two bills passed on May 26th by the Illinois General Assembly will bring over 3 million kilowatt hours of solar electricity to Illinois consumers by 2014.

HB 6202, "The Solar Ramp Up bill", sets annual targets for the amount of solar power used in Illinois between 2012 and 2015, encouraging industry to invest in solar power and create new jobs here in Illinois.

Illinois passed a landmark renewable energy standard in 2007 that requires 25% of Illinois' electricity be generated from renewable sources by 2025. The law requires that at least 6% of the state's renewable energy come from solar power by 2015, but it didn't provide a path for Illinois

utilities to meet that goal. HB 6202 establishes those targets and sets Illinois on the path to becoming the leading Midwestern state for solar energy.

HB 5429, “the Homeowners’ Solar Rights Act”, clarifies the rights of homeowners living in homeowner or condominium associations to put solar panels on the property and outlines a process for that to occur. (Source: <http://www.illinoissolar.org/>)

Renewable Energy Credit Aggregation Program

Illinois Solar Energy Association offers this performance-based incentive to local governments, along with commercial, industrial, residential, nonprofit, schools, state government, federal government, and institutional sectors using photovoltaics. The amount is \$0.065/kWh (estimated) and at least 35 megawatt-hours (MWh) will be accepted; only whole MWh RECs will be accepted. The program budget is \$15,000.

RECAP 2010

ISEA and Community Energy, Inc are continuing to offer the Solar REC Aggregation Program for 2010 generated solar electric REC's. This is the only program of its kind in Illinois that provides a financial incentive for REC's attached to small (under 10 kW) grid-tied solar installations. All applicants must be ISEA members. The RECAP application can be found at <http://www.illinoissolar.org/> under “RECAP 2010”.

Special Assessment for Solar Energy Systems

Illinois offers a special assessment of solar energy systems for property-tax purposes. For property owners who register with a chief county assessment officer, solar energy equipment is valued at no more than a conventional energy system. Eligible equipment includes both active and passive solar-energy systems. The exemption is not valid for equipment that is equally usable in a conventional energy system or for components that serve non-solar energy generating (e.g., structural, aesthetic, insulating, etc.) purposes. Those who wish to have their solar energy property valued in this fashion must file property tax form PTAX-330 with their local county assessor's office. Forms are available from the county assessor's office. (Source: http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=IL01F&re=1&ee=1)

Solar Energy Rebate Program

The Illinois Department of Commerce and Economic Opportunity (DECO) offers a Solar Energy Rebate Program which is available to just about everyone, providing rebates up to 30% of the project cost to a maximum of \$50,000. Rebates apply to new solar photovoltaic or solar thermal (hot water) systems.

(Source: http://www.dsireusa.org/solar/incentives/incentive.cfm?Incentive_Code=IL05F&re=1&ee=1)

U.S. Department of Energy Solar Energy Adoption Award

ICMA has received a \$5 million award from the U.S. Department of Energy (DOE) to head a team that will work with local government leaders and stakeholders to accelerate wider adoption of solar energy. ICMA will work with the American Planning Association, the National Association of Regional Councils, and industry experts on this new project. DOE formally announced the award on April 16. (icma.org)

The award will help provide responsive and proactive outreach to local governments to accelerate the implementation of solar technology deployment. ICMA will reach local governments

nationwide by providing a mix of educational workshops, peer-to-peer sharing opportunities, and national Web-based resources.

(Source: http://apps1.eere.energy.gov/news/progress_alerts.cfm/pa_id=315)

Websites Regarding Legislation and Grants

www.dsireusa.org/solar - Directory for solar subsidies currently being offered in your state and utility area.

Online Code Environment & Advocacy Network - (<http://bcap-ocean.org/>)

Status of State Energy Codes - (<http://www.energycodes.gov/states/>)

<http://12.43.67.2/legislation/publicacts/fulltext.asp?Name=095-0420&print=true&write>. – Provisions of Senate Bill 0680 (Public Act 095-0420).

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<http://www.ilga.gov/legislation/billstatus.asp?DocNum=5429&GAID=10&GA=96&DocTypeID=HB&LegID=50469&SessionID=76> – Bill status of HB5429

Definitions

(Source: *Alternative Energy Task Force Model Ordinance*)

Building-Integrated Solar Systems: A solar energy system that is an integral part of a principal or accessory building, rather than a separate mechanical device, replacing or substituting for an architectural or structural part of the building. Building-integrated systems include, but are not limited to, photovoltaic or hot water systems that are contained within roofing materials, windows, skylights, shading devices and similar architectural components.

Building-Mounted Solar Energy System: A solar energy system that is mounted on the façade or roof of either a principal or accessory structure.

Flush-Mounted Solar Energy System: A solar energy system that is mounted flush with a finished surface, at no more than six (6) inches in height above that surface.

Ground-Mounted Solar Energy System: A solar energy system not attached to another structure and is ground mounted.

Photovoltaic Cell: A semiconductor device that converts solar energy into electricity.

Solar Energy System: A system for which the primary purpose is to convert solar energy into thermal, mechanical or electrical energy for storage and use.

Solar Panel: A group of photovoltaic cells are assembled on a panel. Panels are assembled on-site into solar arrays.

Utility Solar Energy System: A solar energy system that is used in order to produce energy for commercial distribution.

GEOHERMAL ENERGY SYSTEMS

COMMON QUESTIONS / INFORMATION

What is geothermal?

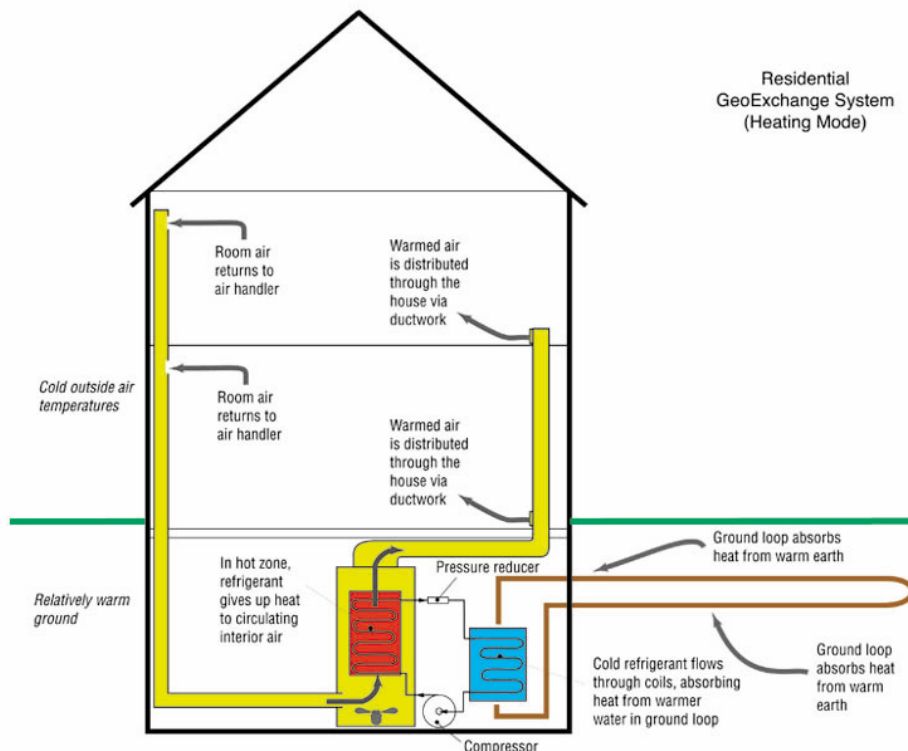
Answer: The word geothermal comes from the Greek words *geo* (earth) and *therme* (heat). Heat from the earth can be accessed by drilling water or steam wells in a process similar to drilling for oil. Ground heat can be found almost everywhere, since the upper 10 feet of Earth's surface maintains a nearly constant temperature between 50°F and 60°F (10°C and 16°C).

Where is geothermal energy available?

Answer: Hydrothermal resources - reservoirs of steam or hot water - are available primarily in the western states, Alaska, and Hawaii. However, the earth's energy can be tapped almost anywhere with geothermal heat pumps and direct-use applications.

How does a geothermal system work?

Answer: In winter, a fluid circulating through pipes buried in the ground absorbs heat from the earth and carries it into the home. The geothermal system inside the home uses a heat pump to concentrate the earth's thermal energy and then to transfer it to the interior space for warmth. In the summer, the process is reversed: heat is extracted from the air in the house and transferred through the heat pump to the ground loop piping. Heat removed during the summer can also be used as no-cost energy to heat water. *Source: GeoExchange.org.*

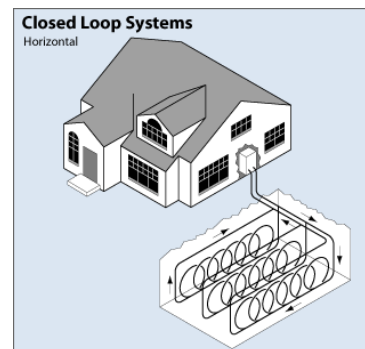


Types of Geothermal Designs

There are four basic types of ground loop (heat pump) systems. Which one is best depends on the climate, soil conditions, available land, and local installation costs at the site. All of these approaches can be used for residential and commercial building applications. [Source: US Department of Energy/EERE]

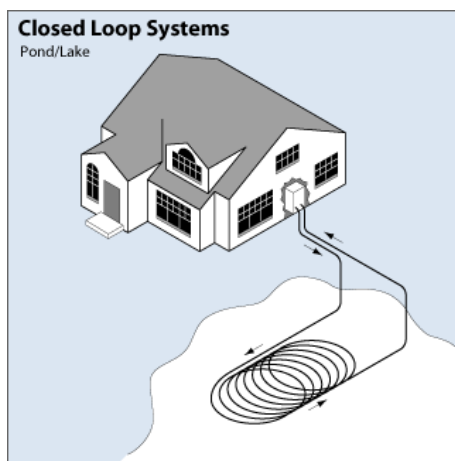
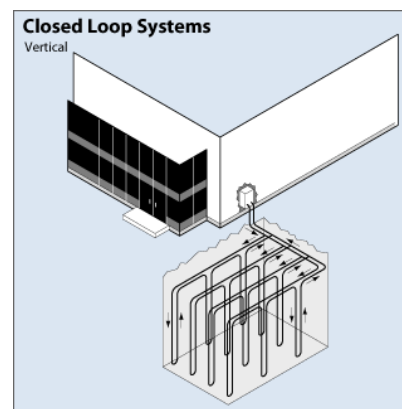
Horizontal

This type of installation is generally the most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least four feet deep. The most common layouts either use two pipes, one buried at six feet, and the other at four feet, or two pipes placed side-by-side at five feet in the ground in a two-foot wide trench. The Slinky™ method of looping pipe allows more pipes in a shorter trench, which cuts down on installation costs and makes horizontal installation possible in areas it would not be with conventional horizontal applications.



Vertical

Large commercial buildings and schools often use vertical systems because the land area required for horizontal loops would be prohibitive. Vertical loops are also used where the soil is too shallow for trenching, and they minimize the disturbance to existing landscaping. For a vertical system, holes (approximately four inches in diameter) are drilled about 20 feet apart and 100–400 feet deep. Into these holes go two pipes that are connected at the bottom with a U-bend to form a loop. The vertical loops are connected with horizontal pipe (i.e., manifold), placed in trenches, and connected to the heat pump in the building.

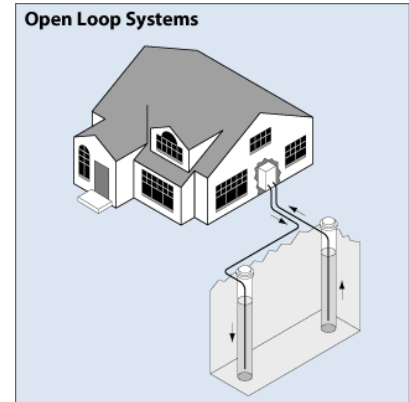


Pond/Lake

If the site has an adequate water body, this may be the lowest cost option. A supply line pipe is run underground from the building to the water and coiled into circles at least eight feet under the surface to prevent freezing. The coils should only be placed in a water source that meets minimum volume, depth, and quality criteria.

Open-Loop System

This type of system uses well or surface body water as the heat exchange fluid that circulates directly through the GHP (geothermal heat pump) system. Once it has circulated through the system, the water returns to the ground through the well, a recharge well, or surface discharge. This option is obviously practical only where there is an adequate supply of relatively clean water, and all local codes and regulations regarding groundwater discharge are met.



Alternative Geothermal System Options

De-centralized (or distributed) systems

In a de-centralized (or distributed) system each geothermal heat pump is installed in close proximity to the zone it serves. The heat pump is easy to service and does not require specialized training. Ease of operation and localized temperature control.

Centralized systems

A centralized system requires very little maintenance because all major pieces of equipment are located in a central location.

Benefits of Geothermal

Why is geothermal energy a renewable resource?

Answer: Its source is the almost unlimited amount of heat generated by the earth's core. Even in geothermal areas dependent on a reservoir of hot water, the volume taken out can be re-injected, making it a sustainable energy source.

What is the visual impact of geothermal technologies?

Answer: Most residential and commercial geothermal systems are invisible since all system components are buried underground, with condensing/exchange units installed inside the building. Larger geothermal power plants where mile-or-more deep wells are drilled into underground reservoirs to tap steam and very hot water to drive turbines and electricity generators are much more visual.

How to address potential geothermal energy concerns

1. Through Municipal Regulations

A. Health Department – will most likely have already have regulations regarding the placement of a geothermal system in place.

B. Building Code Changes and Municipal Zoning and Architectural Review Codes

In conjunction with this resource guide, the AETF has also created the Solar/Geothermal Systems Model Ordinance which municipalities may utilize as a template or starting point for proposing new regulations for Geothermal Energy Systems. The Model Ordinance contains recommended restrictions in an attempt to promote responsible geothermal energy policies.

Helpful Websites

1. Geothermal Education Office – (<http://www.geothermal.marin.org/>) – The Geothermal Education Office (GEO) produces and distributes educational materials about geothermal energy to schools, educators, libraries, industry and the public. GEO collaborates frequently with education and energy organizations with common goals and responds to requests and questions from around the world.
2. GeoExchange – (<http://www.geoexchange.org/>) – Geothermal Exchange Organization offers information on geothermal energy systems along with a directory of GeoExchange heat pump contractors, manufacturers, drilling contractors, ground loop installers, engineers, designers, distributors, architects, builders, utilities, training, financing, software and suppliers.
3. Geothermal Technologies Program – (<http://www1.eere.energy.gov/geothermal/>) – The U.S. Department of Energy's Geothermal Technologies Program works in partnership with industry to establish geothermal energy as an economically competitive contributor to the nation's energy supply.
4. Renewable Energy Policy Project – (<http://repp.org/geothermal/index.html>) – REPP offers information regarding the resources, history, power technology and generation, economics, environmental impacts, policy, and future developments of geothermal energy.

FOOTNOTES

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