ZONING FOR WIND MACHINES

A Guide for Minnesota Communities

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*formerly: Energy Division ■ Minnesota Department of Energy, Planning and Development

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Statement of Purpose

The purpose of this guide is to provide information on wind machines and related zoning issues to enable planners, zoning administrators, county commissioners, city councils, and other staff and elected officials to make informed decisions on how small wind machines will be addressed in community plans and zoning ordinances. Large wind machines and wind farms are not considered in this document.

Many possible community concerns about wind machines can be addressed in a zoning ordinance. For example, should wind machines be considered a permitted accessory use or a conditional use, what height limits are appropriate, and how should wind machines be considered with regard to lot coverage and setback requirements? How these questions are resolved depends on the community's assessment of the safety of wind machines and of the aesthetic and nuisance effects of the machines.

These zoning issues are discussed in Chapter 3. Recommendations and model language that could be adopted in a Minnesota community are included. The model language is offered as guidelines and should be modified as necessary in individual communities. If time is short, read this chapter first. Communities with little or no planning capacity may also want to focus on Chapter 3.

Chapter 1 provides background information on wind machines—what they are, how they work, and the conditions required for most effective operation. Chapter 2 considers goals and policies on wind machines that can be integrated into a comprehensive plan or other planning documents. Developing goals and policies provides planning support for the zoning amendments and reduces the likelihood of successful legal challenge to zoning changes. Chapter 4 discusses amendments to subdivision and planned unit development regulations to encourage the use of wind machines. Chapter 5 summarizes sample language from the text into model wind machine zoning provisions. This chapter is cross referenced with portions of the text in which the model language is discussed listed next to each item. Review of this chapter would give a good overview of the guidebook.

The model language in this guidebook attempts to strike a reasonable balance between the public health, safety, and general welfare concerns of planning and zoning officials, the interest of individuals in using wind energy, and the interest of the wind industry in providing a product and earning a living. The use of wind power is not new, but many people are unfamiliar with this technology. Planners and zoning officials need to learn more about wind machines and the wind industry in order to develop reasonable regulations. It is for this reason that background information and discussions of zoning issues concerning wind machines are provided in this guidebook. Representatives of the wind industry may also find this guidebook helpful in gaining a perspective on planning and zoning concerns and why local officials are concerned about wind machines.

Zoning revisions concerning wind machines could be made at any time. Amendments could also be made when the rest of the zoning ordinance is being reviewed and revised. If a zoning revision has recently been completed, then it would be appropriate to make the zoning changes concerning wind machines as soon as possible rather than waiting for another review period.

Another option is to revise the zoning ordinance concerning wind machines as part of a comprehensive energy planning effort. The following resources could be useful in such a project:

- *Energy: A Planning Guide for Minnesota Communities*
- *Zoning for Earth Sheltered Buildings: A Guide for Minnesota Communities*
- *Planning and Zoning for Solar Access: A Guide for Minnesota Communities*
- *Energy Accounting for Local Governments and School Districts*

To obtain these documents contact: Energy Division, Department of Energy, Planning and Development, 980 American Center Building, 150 East Kellogg Boulevard, St. Paul, MN 55101. ■ 296-5175 in the Twin Cities or toll free 1-800-652-9747 outside the Metro area.

1 WHAT ARE WIND MACHINES?

Wind energy

Wind energy is a form of solar power. Winds are generated by uneven heating of the atmosphere by the sun, the irregularities of the earth's surface, and rotation of the earth. Wind flow patterns are modified by the shape of the land surface, bodies of water, and vegetative cover. Hills and valleys channel wind flow. Ground roughness caused by hills, trees, and buildings disrupts and slows wind flow.

Wind can be "harvested" by wind machines and used to pump water, produce heat, or generate electricity to run lights and appliances. Much of the electricity consumed in rural Minnesota in the 1930's and 1940's was produced by wind electric systems. But as cheap electricity produced from fossil fuels became available through the federally subsidized Rural Electrification Administration, wind energy use declined.

The Minnesota countryside is dotted with retired windmills from another era. In the past few years, however, a variety of new wind machines have also sprung up. As energy costs skyrocket, wind power in Minnesota is becoming more and more attractive economically. The use of renewable, nonpolluting energy sources such as wind also helps conserve our dwindling supplies of coal, oil, and natural gas.

Wind machines

Wind machines or wind energy conversion systems (WECS) are available in a variety of types and sizes. A large machine such as the 200 kilowatt (kW) MOD-OA has rotors that are 124 feet in diameter. The 2-megawatt (Mw) MOD-1 machine has a rotor that is 200 feet in diameter. The focus of this guidebook is on considerably smaller machines that would be suitable for home, farm, or business energy production. Small wind energy conversion systems come in a variety of sizes and types. Donald Marier in his book, *Wind Power for the Homeowner,* groups wind systems into three size classifications. Discussion of these classifications is useful to get an idea of the size of wind machine that will likely need to be addressed in local zoning ordinances. The first group is cabin-size systems that have rotors from 6-12 feet in diameter. Machines of this size would be suitable in small homes that are remote from utility power and use a minimal amount of energy. Cabin-size machines produce in the range of 25 to 350 kWh (1kWh=1 kilowatt of electricity used or produced for one hour) of electricity per month (depending on wind speeds) which is less than what is typically used in most homes.

Home-sized wind systems have rotors between 12 to 16 feet in diameter and are capable of producing 300 to 500 kWh per month at an average wind speed of 12 mph. This could make a significant contribution to the electrical needs of most households.

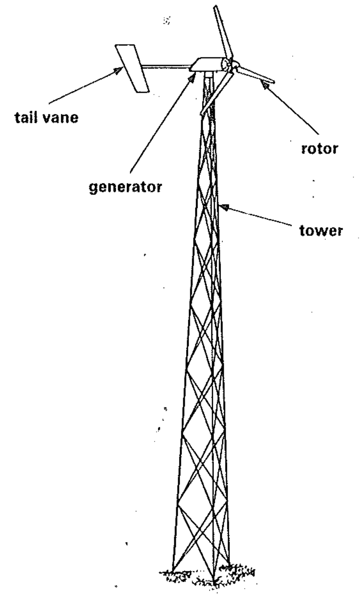
Mr. Marier's final classification is all-electric size systems. This grouping includes machines with rotors over 16 feet and up to 40 feet in diameter. Machines of this size are large enough to supply the power needs of an all-electric home, including space heating, or a small business and typically produce from 500 to 5,000 kWh per month at an average wind speed of 12 mph.

Though these classifications are helpful, it is important to remember that the wind industry is rapidly changing and many more wind machines of a variety of sizes are entering the market. As the industry changes it may be necessary to revise zoning regulations.

Wind machines may also be described by their power or nameplate rating. Power rating refers to the amount of power that a wind machine will produce at a certain wind speed. Power ratings are presently calculated at whatever wind speed the manufacturer chooses though this may change as the industry begins to set standards. For example, one machine may be able to produce 1.2 kW at a wind speed of 27 mph. During 1 hour of wind speeds of 27 mph, the energy output would be 1.2 kWh. Since wind speeds of 27 mph are not likely over one full hour, the average hourly energy output will be less than the machine's rated power. Another machine may have a power rating of 2.0 kW at 28 mph. The diversity in how power ratings are calculated reduces the usefulness of describing wind machines in zoning language in this way. Also, power ratings don't necessarily correlate with blade size. For example, one machine with rotors 12 feet in diameter has a power rating of 2.0 kW at 26 mph, while another WECS with 12 foot rotors has a power rating of 1.0 kW at 23 mph. In the model zoning language in Chapter 3, wind machine size is defined by rotor or blade diameter. This type of definition is recommended instead of power rating designations or other size characteristics for two reasons. The first is that blade size is easily determined and is a standard measurement that doesn't vary with different wind speeds. The second reason is that it is blade size that influences visual impact, how setbacks are determined, and other zoning concerns.

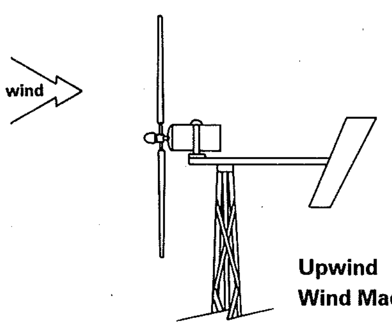
Wind energy conversion systems (WECS) are comprised of a few basic components. The rotor or, as it is also called, the blade or turbine is the part that is actually rotated by the wind. Rotors may be made of wood, aluminum, steel, or of a composite of urethane foam inside a fiberglass shell.

The rotation of the rotor turns the shaft on an electrical generator or provides power to a mechanical device. The rotor and generator are either connected to the local utility or have a battery bank for storage. These basic components are summarized in the accompanying drawing.

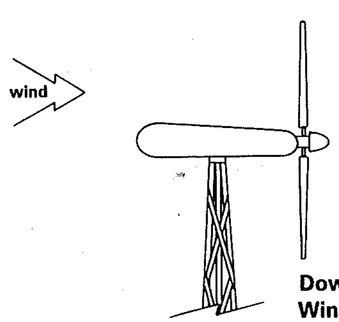


Wind Machine Components

Wind machines can be divided into two categories, horizontal axis and vertical axis machines. In horizontal axis machines, the rotor shaft or the axis of rotation is parallel to the horizon. In vertical axis machines, the axis of rotation is perpendicular to the horizon. Most horizontal axis machines have two, three, or four blades, but some designs have more blades. Machines with six and eight blades are produced and one manufacturer produces a machine with forty eight blades. Another characteristic of horizontal axis machines is that they are either downwind or upwind machines. In an upwind machine, the wind passes the rotor first and then flows past the tower. Most upwind machines have tail vanes that keep the rotor facing the wind. Upwind designs are the most common type of WECS. Wind machines of downwind design typically don't have a tail vane, and the wind passes over the tower first and then reaches the rotor. Differences between upwind and downwind designs are illustrated in the accompanying drawing.



Upwind Wind Machine



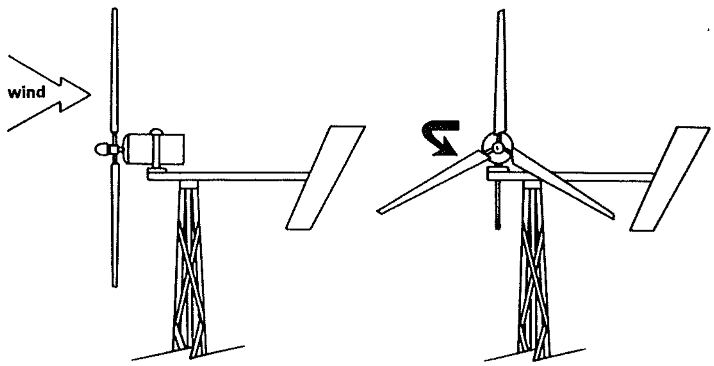
Downwind Wind Machine

All wind machine rotors have a speed control system to ensure that overspeeding or operation at speeds that could cause damage to the WECS does not occur during high winds. Wind machines do not operate at all wind speeds. The cut-in wind speed is the speed at which the rotor is turning fast enough for the generator to produce a reasonable amount of power. The cut-out speed is the speed at which the machine will stop generating power. Common cut-in speeds are 8 - 10 mph while cut-out speeds range around 40 - 50 mph. Some machines are designed to produce electricity at high wind speeds and do not have a cut-out speed.

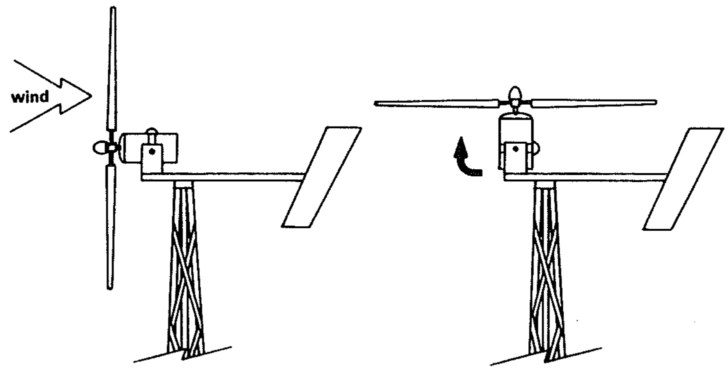
There are many different types of speed control systems. On some upwind machines, the rotor turns to the side or upward away from the wind at high speeds. The movement away from the wind reduces the area of the rotor facing the wind and, hence, the speed of the rotor. Spoiler flaps control wind speed by extending at high wind speeds and causing drag that slows down the blades. Blade pitch controls slow the rotors to safe speeds because the pitch of the blades or the angle of attack increases at high wind speeds increasing drag. With coning speed controls, the blades actually bend away from the wind as the wind speed increases. This type of speed control is mainly used on downwind machines because in an upwind design the blades could hit the tower. Brakes can also be used for speed controls. A variety of overspeed controls are illustrated in the accompanying drawings.

In addition to an overspeed control, some machines have fail-safe shutdown systems. If part of the machine fails, the shutdown system turns the blades out of the wind or puts on brakes.

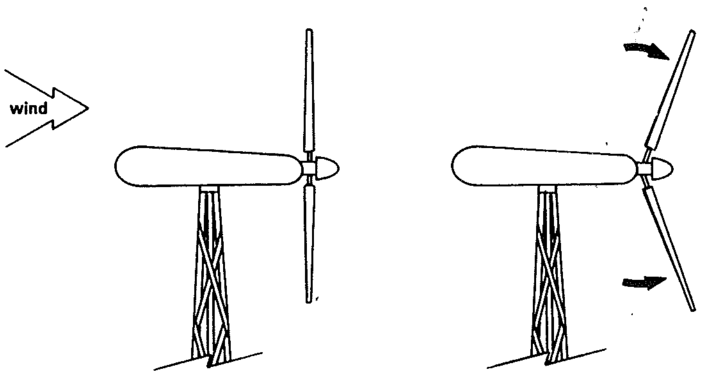
Vertical axis wind machines are not as common as horizontal axis wind systems. Savonius and Darrieus machines are probably the best known vertical axis machines. Savonius machines are not as efficient as horizontal axis machines and may not be very effective for electrical generation but are useful for water pumping. Darrius machines are about as efficient as horizontal axis machines and can be used for generating electricity as well as for pumping water and other uses. Another vertical axis machine is known by its trade name, Cycloturbine.



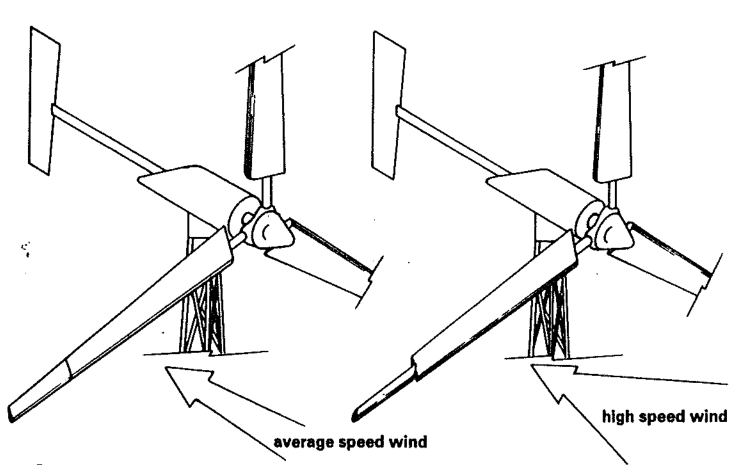
Sideways speed control



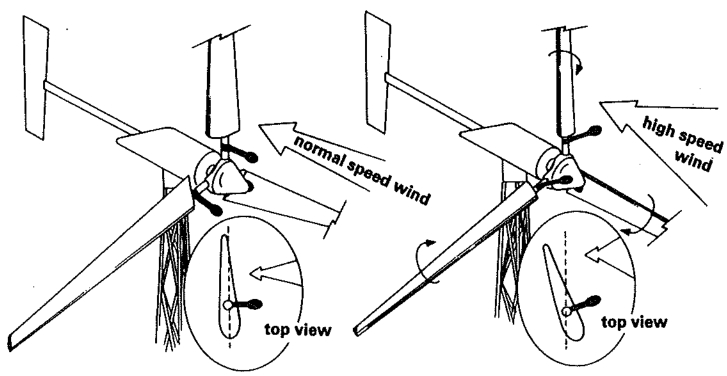
Upwards speed control



Coning blade control



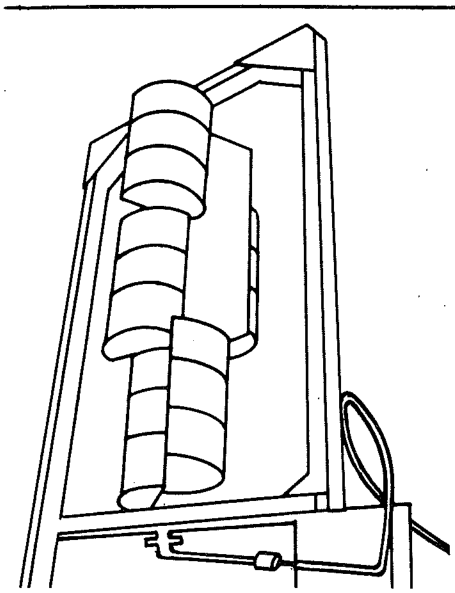
Tip flaps speed control



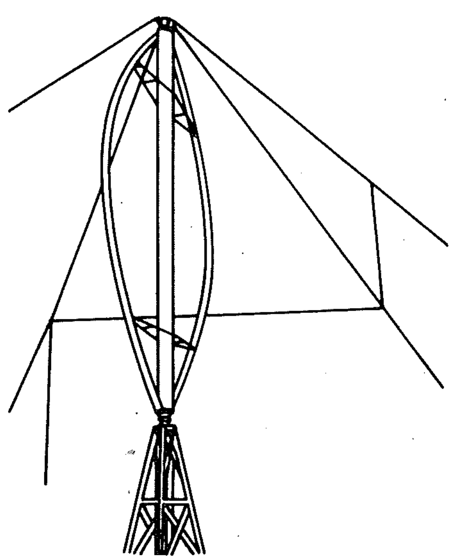
Blade-pitch speed control

Overspeed Controls

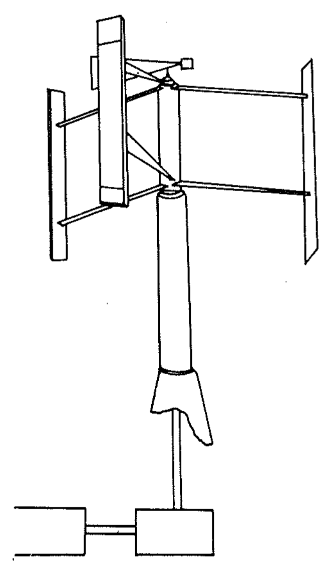
In the sideways and upwards speed controls, gyroscopic controls tilt the rotor to the side or up, away from the wind. In coning speed control, the blades bend away from the wind. Tip flap brakes extend from the blade tips to create drag that slows down the rotor at high wind speeds. With blade-pitch controls, the rotor speed is controlled by the action of weights that change the pitch of the rotor during high-speed winds.



Savonius Vertical Axis Wind Machine

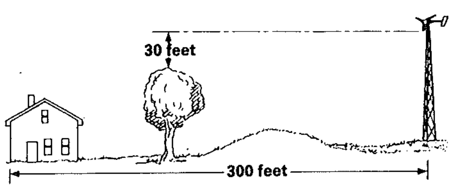


Darrieus Vertical Axis Wind Machine



Cycloturbine Vertical Axis Wind Machine

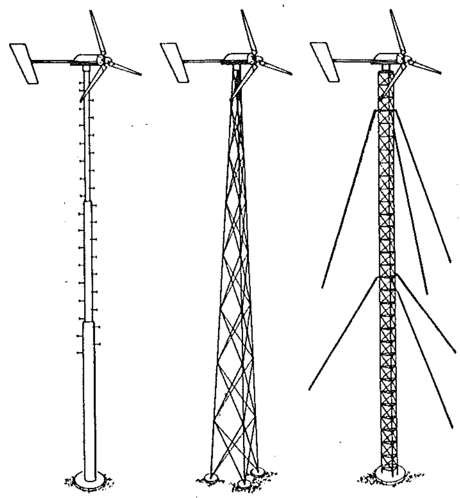
Towers are a component of wind machines that communities may be particularly concerned about because of their height and possible safety concerns. Towers need to be tall enough to lift the wind rotors above any turbulence caused by nearby trees or buildings. If the tower is not tall enough, the wind system will not operate safely and efficiently. A general rule of thumb is that the wind system should, at a minimum, be on a tower that is high enough so that the lowest extent of the blades is at least 30 feet above any buildings, trees, or other obstacles within 300 feet. The tower height rule of thumb is illustrated in the accompanying drawing. Towers must also be strong enough to support the wind system, withstand the wind, and withstand the pressure and vibrations created by the movement of the rotor.



Tower Height Rule of Thumb

Install a wind system so that the lowest extent of the blades is 30 feet above any obstacle within 300 feet.

Self-supporting towers and guyed towers are the two basic types of towers. There are two types of self-supporting towers: lattice and pole towers. These towers are illustrated in the accompanying drawing. An advantage of these types of towers is that they take up a small area without the need for space for guy wire anchors. Self-supporting towers, however, are more expensive. Guyed towers are more efficient in their use of materials. A guyed lattice tower uses approximately 50 percent less steel and 90 percent less concrete to perform the same function as a self-supporting tower. For this reason, guyed towers are cheaper and can increase the cost effectiveness of a WECS purchase. An individual may be willing to accept the possible inconvenience of guy wire anchors taking up yard space because of the lower cost of guyed towers. Guyed towers have several levels of guy wires that extend out to about 40 to 80 percent of the tower height. This feature of guyed towers is shown in the accompanying drawing.



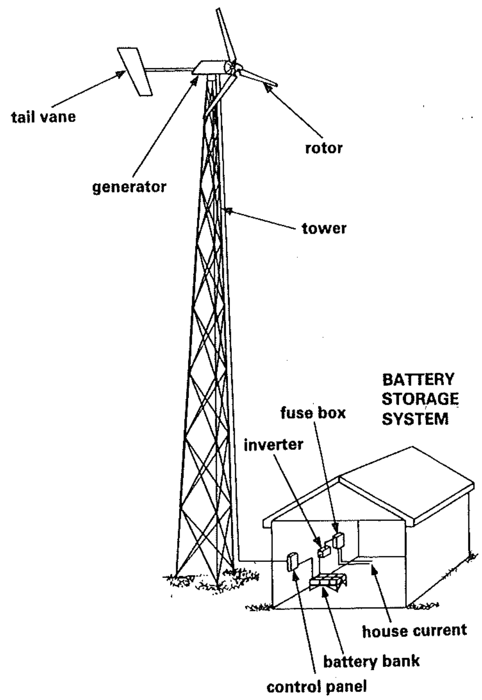
Pole Tower **Lattice Tower** **Guyed Tower**

Many wind machine manufacturers sell or recommend towers suitable for use with their machines. Towers must be designed for compatibility with wind machines. Aluminum TV antenna towers, for example, should not be used. Tower and rotor designs need to be selected to avoid vibration problems.

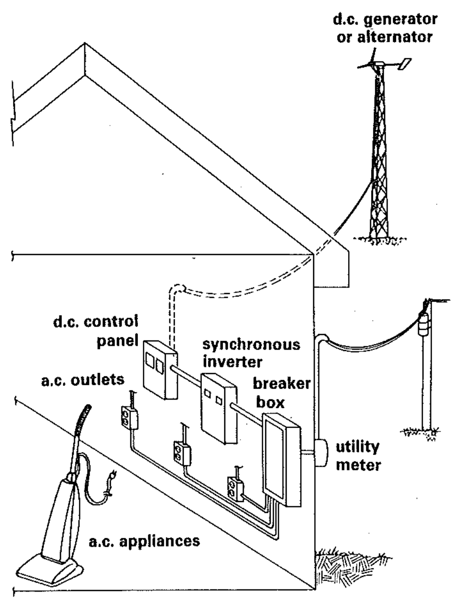
Another way to mount a wind machine is to place it on a building. This is not recommended because many roofs cannot withstand the vibrations created by the rotor's movement and the weight of the system. Vibrations and the resulting stress may be transmitted throughout the building. Portions of the state building code are applicable to a load like wind machines on top of buildings and should be adopted to address wind machines on buildings. (See Chapter 3)

Wind applications

Wind machines can be used to generate electricity for heating and running appliances or for mechanical uses such as pumping water. Wind machines that produce electricity are usually either connected to local utility lines or to battery storage. In most areas under zoning jurisdiction, wind machines will likely be connected to the utility. Battery storage systems are more common in remote settings. Utility connection or battery storage is necessary because, depending on the wind speed, a wind system will produce varying amounts of power. Sometimes the wind is strong enough to produce more electricity than is needed, sometimes less. A home that is connected to an electric utility as well as a wind machine can draw on the utility power lines when power is needed. The WECS can supply excess electricity back to the utility when more is produced than can be used in the home. Battery systems charge up when excess electricity is produced and help supply power when the wind system output is not sufficient to meet immediate load requirements. Accompanying drawings illustrate interconnection with utilities and a battery storage system.



Interconnection with Battery Storage System



Interconnection with a Utility

Federal and state law now requires utilities to allow interconnection of wind machines (and other renewable energy systems producing electrical power) and to sell electricity and buy back excess power at reasonable rates. The federal legislation is titled the Public Utility Regulatory Policies Act of 1978 (PURPA). The intent of PURPA is to encourage the use of wind power and other renewable energy sources and to encourage the implementation of conservation measures. Minnesota has adopted legislation similar to the federal PURPA that also encourages conservation and the use of renewable energy. The Minnesota Public Utilities Commission is developing rules concerning utility interconnections in this state. The rules will include rate schedules for the utility's purchase of power produced by renewable energy resources including wind machines. Check with the Public Utilities Commission on the status of the rules: Public Utilities Commission, Room 780 American Center Building, 160 East Kellogg Boulevard, St. Paul, MN 55101■ (612) 296-7124.

Wind machines can be interconnected to utility lines through an electronic device called a synchronous inverter that integrates with the alternating current electricity from public utility lines. With such a system, the wind machine owner is provided standard A.C. power that is generated both by the WECS and by the utility. If the wind system produces more energy than is needed at a given time, the excess electricity is sold to the utility. Another option for utility interconnection is to choose a wind system with an induction generator that produces A.C. electricity synchronous with utility power. In this case, a synchronous inverter would not be needed.

The concept of utility interconnection is still a new one, but the number of applications in Minnesota is growing. Its advantages are the availability of standard A.C. current that can be used in modern appliances, the elimination of the need for a storage capacity, and the potential for selling excess power. A major question regarding the economic feasibility of interconnection for the WECS owner is the utility buy-back rate which will be determined by the Minnesota Public Utility Commission rules.

Batteries provide direct current, D.C., electricity. Lead-acid "marine" or "golf-cart" batteries are presently the least expensive and most practical means of storing electrical energy. Battery storage capacity to meet electricity needs for three to five days is recommended. Batteries can be recharged with a backup generator. Some appliances and lights are designed for use with D.C. batteries. To power most A.C. appliances with a battery storage system, however, a D.C. to A.C. inverter is necessary.

Battery storage wind systems are generally the most expensive application of wind machines. In addition, they are not as efficient; much power is lost during battery storage and through D.C. - A.C. conversion. These problems limit the economic feasibility of battery storage systems. However, in remote locations where bringing in utility lines would be very costly, battery storage wind systems can be a practical alternative.

In addition to running appliances, power generated by wind systems can also be used for space and water heating. Most commercially available wind machines are readily adaptable to thermal or heat energy delivery, and several have been designed specifically for this application. Electricity generated by these systems is fed into electric resistance heating elements that deliver heat into the area or storage medium to be heated. Concrete, stone, and water are good heat storage mediums.

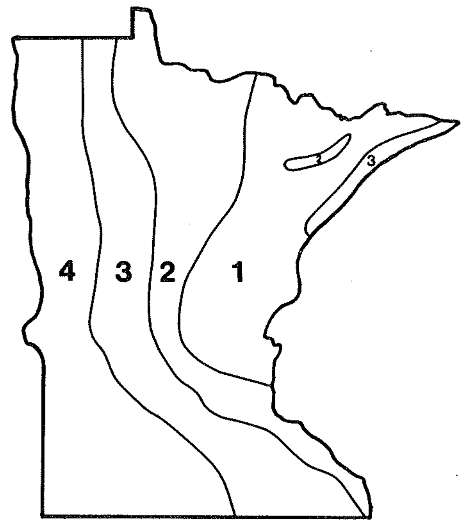
Properly designed wind powered thermal systems are highly efficient in using energy from the wind generator. In addition, wind speeds tend to be greater in the winter when the heating demand is also greater. If wind generated electricity is used primarily for space heating during the winter, another use for this power, such as heating water or drying grain, could be found to use the available wind energy during the rest of the year.

Another possible application of wind machines is larger scale generation of electricity. Instead of small wind machines producing electricity for individual homes and businesses, larger WECS could produce energy for a neighborhood. Larger scale electrical generation may be more feasible in communities with existing municipal electrical generating facilities.

A final note with regard to wind applications is that energy conservation efforts should accompany the use of wind power. If the amount of electricity that is required can be reduced then presumably the size of WECS required can be reduced. Conservation efforts seem particularly appropriate if electricity is used for space heating.

Wind speed requirements

A wind machine will not operate economically unless there is an adequate wind resource at the proposed site. In general, at the present installed cost per kilowatt of most WECS, an average annual wind speed of 10 to 14 mph is necessary to economically run a small wind machine. The accompanying map gives a general indication of average annual wind speeds at heights of 33 and 164 feet above ground level based on available state monitoring data. The data that



Minnesota Annual Average Wind Power Regions

Wind-speed Region	Av. Annual Wind Speed (mph) at 33 Ft.	Av. Annual Wind Speed (mph) at 164 Ft.
1	0 - 9.8	0 - 12.5
2	9.9 - 11.5	12.6 - 14.3
3	11.6 - 12.5	14.4 - 15.7
4	12.6 - 13.4	15.8 - 16.8

Source: *Wind Energy Resource Atlas: Volume 2 - The North Central Region*, Pacific Northwest Laboratory, February, 1981, p. 68

the map is based on, however, is not very extensive. The map should only be used as a general guideline and should be supplemented by wind speed monitoring at any potential site. Though the plains areas of western and southern Minnesota and North Shore locations exposed to Lake Superior winds have the greatest potential as wind energy sites, the potential at any individual site in these areas should also be monitored. Heavily wooded sites or sites in a valley may not have adequate wind speeds, even though they are in an area with good wind potential. Similarly, sites in open areas or on hills may be good wind sites even though they are in an area that is generally considered to have poor or only fair wind potential. Wind speed monitoring prior to WECS installation is essential for buyers to ensure that the use of a wind machine at a particular site is not a poor investment.

Ultimately, wind monitoring is the responsibility of the individual consumer. However, planners, zoning administrators, building inspectors, and other local staff can play a role in educating individuals in their community about wind machines and the importance of monitoring wind speeds. The following information on wind characteristics and how to monitor wind speed should help staff play this educational role. This infromation should also be helpful in illustrating the importance of proper wind machine siting and can be used in developing zoning language on WECS that does not hinder efficient siting. Finally, if there is a great deal of interest in wind machines in the community, it may be appropriate for the city or county engineer or planning department to undertake a wind monitoring project to increase the amount of local wind speed data that is available.

Local wind patterns are specific to a site because they are affected by contours of the local landscape. The effect of obstructions and ground roughness is reduced at greater distances from the ground. Therefore, wind speed typically increases with altitude. For instance, a site on a rolling plain with wind speeds of 10 mph at 20 feet above ground theoretically has an approximate wind speed of 12.8 mph at 60 feet above ground. Also wind speeds at greater distances above the ground are steadier and less turbulent. Tables summarizing the wind speed at higher altitudes based on wind speed monitoring closer to the ground can be found in many books on wind power. For example, such a table is included in Appendix C of Don Marier's *Wind Power for the Homeowner.*

Small differences in wind speed mean a big difference in the amount of available power. The power available for a given area is proportional to the cube of wind velocity. A wind speed of 20 mph, for example, has eight times the power per unit of area as a 10 mph wind.

Wind patterns vary by time of day and time of year. They can be roughly characterized by close observation but never exactly predicted. However, careful observation and data collection over a period of time will provide a good idea of the available wind resource.

The first step in wind monitoring is to simply observe the wind at the proposed site. Wind speeds of 8-12 mph cause constant motion of leaves and small twigs and make flags or streamers extend downwind. Be aware of the prevailing wind direction. Consider calm days as well as the breezier ones.

Examine the local topography for obstacles such as trees, buildings, and hills which slow the wind from certain directions. An open flat area or a ridge or hilltop exposed to prevailing winds may be especially suited for wind machines. Low areas, ravines, and river bottoms are generally not feasible locations for wind systems. In wooded areas a taller tower will usually be required to ensure adequate performance.

If there is a nearby airport or weather station, check for any wind speed data it can provide. Data from an airport or weather station will only be useful if the topography at those sites are similar to the proposed WECS site.

If these preliminary indications are favorable, the next step is to use a wind speed measurement instrument called an anemometer to get actual site readings.

Anemometers should be read as often as possible. Monthly readings will give rough data but weekly or daily readings are much more useful. Readings should be taken at the same time several times a day for a minimum of three months and, ideally, for six to twelve months. The longer the wind speed is measured the better will be the estimate of the wind resource. Longer measuring periods will also give a better idea of seasonal variations in wind speed.

Some wind machine dealers lease anemometers for $10 - 20 per month. They may also be purchased from some WECS manufacturers. Some anemometers do not operate in extreme cold; in Minnesota it is a good idea to use an anemometer that is rated for -40° F. The instruments are considered easy to install by following the manufacturer's instructions.

Other resources

This discussion on wind machines, what they can do and their siting requirements, is not exhaustive. The following resources may be helpful in answering additional questions or to give as references to individuals in your community interested in wind machines.

- *Wind Power for the Homeowner,* Donald Marier, Rodale Press, Emmaus, PA, 1981.
- *The Wind Power Book,* Jack Park, Chesire Books, Palo Alto, CA, 1981.

Check with your local library on the availability of these and other books.

Four fact sheets on wind machines are available from the Energy Division of the Department of Energy, Planning and Development:

- *Wind Energy in Minnesota*
- *Wind Economics*
- *Wind Energy Applications*
- *Wind Site Monitoring*

The fact sheets are available by contacting: Minnesota Energy Information Center, 980 American Center Building, 150 E. Kellogg Boulevard, St. Paul, MN 55101 ■ 296-5175 in the Twin Cities or toll free 1-800-652-9747 outside the Metro area.

2 GOALS AND POLICIES

Introduction

Establishing goals and policies on wind energy and wind energy conversion systems will help ensure development of zoning language on WECS that reflects community concerns. Also zoning amendments that are supported by planning documents are less susceptible to successful legal challenge. Goals and policies could be included in an energy element of a comprehensive plan or some other appropriate section of the plan. If there is no comprehensive plan, planning documentation could take the form of a WECS goals and policies paper. Goals and policies should be based on the findings of any planning studies done on wind energy in your community.

Findings

A statement of findings does not have to be extensive. It can include general information on Minnesota's energy situation and the role wind machines can play. The availability of wind machines and federal and state policies in support of wind energy use could be included. Information on wind speed data and the availability of suitable sites for wind machines would also be useful. Results of any local wind speed monitoring programs should be mentioned. A planning study of wind speeds and site suitability is not necessary, though it could provide valuable information for individuals who are interested in wind energy. The findings could suggest that a wind speed monitoring program be completed. To ensure that the WECS is cost effective and efficient, however, wind speed monitoring by individuals at the site of each proposed wind machine is still recommended. A sample of a statement of findings is as follows:

> **Wind energy is a plentiful and nonpolluting renewable energy resource. Minnesota does not have conventional fossil fuel resources, and payments for fossil fuels from elsewhere in the United States and foreign sources represents a drain of money away from the state and local economies. The use of wind energy will reduce dependence on nonrenewable energy resources and contribute to economic stability and growth.** *(If a community energy planning effort has been undertaken, more specific figures on the economic impacts of energy payments on your community and the advantages of local resources like wind energy can be added.)*
>
> **Local support of wind energy conversion systems (WECS) is consistent with state and federal energy policies. Minnesota and federal tax credits for WECS, the Public Utility Regulatory Policies Act of 1978 (PURPA), state legislation, and promulgation of rules by the Minnesota Public Utilities Commission are indications of federal and state support for wind energy.**
>
> **Wind energy conversion systems are available from manufacturers both within and outside Minnesota. Properly sited WECS can generate electricity in a cost-effective manner. The city** *(or county or township)* **of** *(insert name of community)* **is in an area of the state that has an average annual wind speed at 33 feet of ______ mph.** *(Fill this in from the map summarizing average wind speeds on p. 7. Add more specific wind speed data, if available, from local airports or weather stations.)* **Suitable sites for WECS are available.** *(Mention any specific areas that seem especially suitable for WECS such*

as ridges or hills. It would also be helpful to note any areas that may not be suitable like a ravine.) **Individuals interested in installing a WECS are encouraged to undertake wind speed monitoring at the proposed site. The summary of general wind speed data and of sites that may be suitable for WECS included here should not replace individual wind speed monitoring at specific sites.**

Regulation of the siting, design, and installation of wind energy conversion systems is necessary to protect the health, safety, and general welfare of neighbors and the general public.

Wind machine zoning language adopted in *(insert name of community)* **will attempt to be a reasonable balance among safety concerns, nuisance factors, aesthetic effects, and siting factors that enables efficient WECS operation and encouragement of the use of wind energy.**

Goals

A basic goal based on the findings outlined above might be:

> **To encourage the use of wind energy and to ensure the safe installation and operation of effective wind energy conversion systems (WECS) in** *(insert name of community).*

Additional goals could be developed if desired. For example, if there is a site with steady high winds, a specific goal encouraging the use of wind energy in that area may be appropriate.

Policies

Policies to implement the goal outlined above could take a variety of forms. Policy issues that a community may want to address are the use designation for WECS; what steps, if any, will be taken to assure wind access; and whether local government staff will play a role in providing information on WECS.

Use designation

This discussion of the appropriate use designation for WECS begins with the assumption that WECS can be installed safely at most locations. There are some aspects of wind machines, such as size, siting, installation, and design, that many communities would like to regulate. Chapter 3 discusses regulatory language in detail. The extent of regulation may vary depending on community development patterns and concerns. What use designation allows communities to best regulate those aspects of WECS that are of concern? What use designation will present a reasonable burden on the potential WECS owner and the wind machine industry? These two questions should guide local decisions on the use designation for WECS.

The three possible use designations for WECS are permitted use, permitted accessory use, and conditional use. The permitted use designation is not recommended because it typically refers to the primary use on a lot, and a WECS would be installed in relation to the primary use. Some communities, however, include fences, telephone and power lines and poles, and other structures in the permitted use category. In communities with this type of language a WECS could be included as a permitted use. In most cases, however, designating a WECS as either a permitted accessory use or a conditional use would be most appropriate.

An accessory use or an auxillary use, as it may be called in some communities, is a use or structure that serves the principal use. Garages, driveways, and recreational equipment are examples of structures that are commonly designated as permitted accessory uses in residential zoning districts.

A conditional use is a permitted use that must meet certain conditions before it can be constructed or installed. A conditional use is considered appropriate for a specified district but requires special approval because it may cause problems such as traffic congestion or excessive visual impact unless it is carefully located or designed. Some examples of conditional uses are churches, schools, and home occupations. For the sake of clarity, conditional uses should be named in the zoning ordinance. The conditions to be met before these uses are allowed should also be specified in the ordinance. For example, if a home occupation is a conditional use, an individual interested in putting a business in his home would apply for a conditional use permit and comply with the conditions specified in the ordinance such as parking requirements and limits to the number and size of signs. If the proposed use is in compliance, the conditional use permit should be issued. Counties and some municipalities also require demonstration of compatibility with the neighborhood and the comprehensive plan. Public hearings must be held concerning conditional use permits in counties and municipalities (see Minnesota Statutes, Section 394.26, subdivision 1a and Section 462.3595, subdivision 2).

What are the pros and cons of designating a WECS as a permitted accessory use or as a conditional use? The conditional use permitting procedure is set up to address uses that are appropriate for specified districts but need to meet certain conditions. Because wind machines should be allowed if they comply with pertinent regulations, the conditional use permitting process seems well suited for this type of regulation. The conditional use permit procedure also seems to give more leeway to local governments to impose regulations or conditions on safety and other aspects of WECS which may go beyond traditional zoning concerns.

There are disadvantages, however, to designating a WECS as a conditional use. Requiring a conditional use permit is not as clear an indication of community support for wind energy as a permitted accessory use designation. Public hearings will also be required before a conditional use permit can be granted. A hearing would probably lengthen the time before a wind machine could be installed which could be an inconvenience and expense to the potential WECS owner and could be a burden to WECS manufacturers and dealers. Public hearings also increase the administrative workload of reviewing a proposed WECS.

Another problem related to a conditional use designation is that to many people such a designation has negative connotations. Many people do not realize that a conditional use is essentially a permitted use with conditions. This misconception can turn public hearings on a controversial conditional use permit into demands that a facility not be allowed even though all the required conditions are met. Misconceptions about conditional uses may be aggravated if the zoning ordinances does not clearly identify the conditions to be met before a conditional use permit can be issued. In other words, there may be a difference between the way zoning decisions are intended to be made and public understanding of the zoning process. This difference can influence the practical reality of how zoning decisions are really made.

Designating a WECS as a permitted accesssory use while still requiring compliance with siting, installation, and design regulations concerning WECS seems to stretch the intent of the accessory use designation. Some communities, however, have decided to allow a facility as a permitted use or permitted accessory use and still establish some regulations on that use. For example, the City of North Mankato amended their zoning ordinance and designated WECS as a permitted use. Part of the motivation for this was that the City Council wanted to promote the use of wind energy systems. A section was added to the general district regulations section of the North Mankato zoning ordinance, however, that outlined several regulations that apply only to WECS. In other words, WECS are a permitted use that must comply with certain regulations. If this type of procedure has been used for other uses in your community then it may be appropriate for wind machines as well. A permitted accessory use designation may be preferred in your community if there is a desire to make a policy statement in favor of wind energy use or if a conditional use designation would represent an unreasonable administrative burden.

A disadvantage of designating WECS as a permitted accessory use is that the community may not be able to regulate WECS as carefully as when a conditional use process is used. Also the opportunity for input at a public hearing is lost.

Another factor to consider in determining a use designation for WECS is the impact that a wind machine would have in different locations. A WECS would have a greater impact in a residential area than in an industrial zone or rural area. It may be appropriate to consider WECS a conditional use in residential areas and a permitted accessory use in industrial and agricultural districts. Regulations on WECS siting, design, and installation in an industrial or agricultural zone may not be as extensive as regulations in a residential district and may more appropriately be included as part of a permitted accessory use designation.

The appropriate use designation needs to be determined at the local level after review of the existing zoning language on accessory and conditional uses, review of the Municipal and County Planning Acts, consideration of the community's development patterns, and the level of interest in and concern about wind machines in the community. Consultation with the city or county attorney on this point is recommended.

Depending on what use designation is chosen, one of the following policy statements could be adopted:

> **Conditional use option Amend the zoning ordinance to allow WECS as a conditional use upon compliance with regulations on size, installation and design, siting, nuisance concerns, and other appropriate concerns.**
>
> *or*
>
> **Permitted accessory use option Amend the zoning ordinance to allow WECS as a permitted accessory use upon compliance with regulations on size, installation and design, siting, nuisance concerns, and other concerns.**

Wind access

Adequacy of the local wind resource is another policy issue that a community may wish to address. As noted in Chapter 1 wind speed monitoring is ultimately the responsibility of the individual interested in purchasing a wind machine. A community could develop a policy that encourages potential WECS owners to monitor wind speeds. The reasoning behind this measure is that the possibly adverse aesthetic and other effects of a WECS justify the community wanting to only encourage wind machines that are reasonably certain to operate efficiently. Such a policy could read as follows:

> **Individuals interested in installing a WECS are encouraged to monitor wind speeds at their proposed site to determine the adequacy of the wind resource for efficient and economical operation of a WECS.**

A community could undertake a wind speed monitoring study in an effort to increase the amount of local wind speed data that is available. Such a study could be done in conjunction with the local utility. The following policy statement could be added to planning documents if a community decides to take this step:

> **The city** *(or county or township)* **of** *(insert name of community)* **will undertake a wind speed monitoring program.**

The protection of wind access is closely related to adequacy of wind speeds. Wind access is the access to adequate wind for efficient and economic operation of a wind machine. Individuals could take steps to ensure that the wind access will not be impaired. They could review the maximum building heights allowed under the zoning in the adjacent area. Checking with adjacent land owners to evaluate their development and tree planting plans would also be helpful. Planners, zoning administrators, or other community staff could assist in this evaluation if it is decided that this is an appropriate role for staff members.

Individual wind machine owners could also make a private agreement or easement with adjoining landowners to assure access to the wind machine. Minnesota Statutes, Section 500.30, clarifies that easements for the purpose of providing wind access are legal and outlines what a wind easement should contain. Solar and wind easements are considered in the same statute. This legislation is set out below:

Chapter 500, Minnesota Statutes (1980)
Estates in Real Property

500.30 Solar or Wind Easements.
Subdivision 1. "Solar easement" means a right, whether or not stated in the form of a restriction, easement, covenant, or condition, in any deed, will, or other instrument executed by or on behalf of any owner of land or solar skyspace for the purpose of ensuring adequate exposure of a solar energy system as defined in section 116J.06, subdivision 9, to solar energy.
Subd. 1a. "Wind easement" means a right, whether or not stated in the form of a restriction, easement, covenant, or condition, in any deed, will, or other instrument executed by or on behalf of any owner of land or air space for the purpose of ensuring adequate exposure of wind power system to the winds.
Subd. 2. Any property owner may grant a solar or wind easement in the same manner and with the same effect as a conveyance of an interest in real property. The easements shall be created in writing and shall be filed, duly recorded, and indexed in the office of the recorder of the county in which the easement is granted. No duly recorded easement shall be unenforceable on account of lack of privity of estate or privity of contract; such easements shall run with the land or lands benefited and burdened and shall constitute a perpetual easement, except that an easement may terminate upon the conditions stated therein or pursuant to the provisions of section 500.20.
Subd. 3. Any deed, will, or other instrument that creates a solar or wind easement shall include, but the contents are not limited to:
(a) a description of the real property subject to the easement and a description of the real property benefiting from the solar or wind easement; and
(b) for solar easements, a description of the vertical and horizontal angles, expressed in degrees and measured from the site of the solar energy system at which the solar easement extends over the real property subject to the easement, or any other description which defines the three dimensional space, or the place and times of day in which an obstruction to direct sunlight is prohibited or limited;
(c) a description of the vertical and horizontal angles, expressed in degrees, and distances from the site of the wind power system in which an obstruction to the winds is prohibited or limited;
(d) any terms or conditions under which the easement is granted or may be terminated;
(e) any provisions for compensation of the owner of the real property benefiting from the easement in the event of interference with the enjoyment of the easement, or compensation of the owner of the real property subject to the easement for maintaining the easement;
(f) any other provisions necessary or desirable to execute the instrument.
Subd. 4. A solar or wind easement may be enforced by injunction or proceedings in equity or other civil action.
Subd. 5. Any depreciation caused by any solar or wind easement which is imposed upon designated property, but not any appreciation caused by any easement which benefits designated property, shall be included in the valuation of the property tax purposes.

Concern about adequate wind access could influence a community's decision on height limits and setback requirements for WECS. Establishing regulations that do not unduly restrict the siting of wind machines increases the ability of a potential WECS owner to install a machine that has adequate wind access. In other words, reasonable height and setback regulations would not by themselves protect wind access but could facilitate adequate access.

Another option is for the community to adopt explicit wind access protection provisions in the zoning code. Wind access could be protected by establishing a permit system that would limit development or vegetative growth that would block the flow of wind to a WECS for which a wind access permit has been obtained. Another option is to modify building heights allowed under zoning to restrict the construction of buildings tall enough to obstruct wind flow to wind machines. Language on allowable tree height to ensure wind access could also be adopted. Wind access protection mechanisms are similar to techniques proposed to protect the access of sunlight to solar systems or solar access.

There are several differences, however, between wind access and solar access. Solar systems are smaller than wind systems and can be more unobtrusively sited. There is also the potential, though it may not be realized, of siting solar systems on virtually all homes and other buildings while wind machines must be sited above and away from obstacles, limiting the widespread use of this energy resource. Finally, solar access is easier to measure than wind access. The rays of the sun follow a set path throughout the day and the year while wind patterns vary from location to location and throughout the year.

Because of these differences, many communities that have adopted provisions to protect solar access may not choose to adopt language that involves the community in wind access protection. Some communities may suggest that individual wind machine owners obtain private agreements to protect wind access. These actions seem appropriate given the difficulty of providing public protection of wind access. The language on wind access in Chapter 3 reflects the discussion above. The following policy statement is an illustration of this position:

Individuals interested in installing a WECS are encouraged to consider the adequacy of wind access to their proposed site and acquire wind access easements to protect their wind resource. Regulations on wind machines will attempt to facilitate the availability of adequate wind access but will not attempt to protect wind access.

Wind machine information

The final policy issue considered here is the role local government staff will play, if any, in providing information on WECS and wind energy use. The sample policy outlined below is one example of actions a planning and zoning office could take to increase the general level of awareness about wind energy use in the community and to assist individuals interested in purchasing a WECS.

Fact sheets on wind energy and WECS from the Energy Division of Department of Energy, Planning and Development will be displayed and distributed in the planning and zoning office *(or other appropriate location).*

Summary of goals and policies

The following is a compilation of the goal and policies developed in this section.

Goal: To encourage the use of wind energy and to ensure the safe installation and operation of effective wind energy conversion systems (WECS) in *(insert name of community)*.

Policy #1a: Conditional use option Amend the zoning ordinance to allow WECS as a conditional use upon compliance with regulations on size, installation and design, siting, nuisance concerns, and other appropriate concerns.

or

Policy #1b: Permitted accessory use option Amend the zoning ordinance to allow WECS as a permitted accessory use upon compliance with regulations on size, installation and design, siting, nuisance concerns, and other appropriate concerns.

Policy #2: Individuals interested in installing a WECS are encouraged to monitor wind speeds at their proposed site to determine the adequacy of the wind resource for efficient and economical operations of a WECS.

Policy #3: The city *(or county or township)* **of** *(insert name of community)* **will undertake a wind speed monitoring program.**

Policy #4: Individuals interested in installing a WECS are encouraged to consider the adequacy of wind access to their proposed site and acquire wind access easements to protect their wind resource. Regulations on wind machines will attempt to facilitate the availability of adequate wind access but will not attempt to protect wind access.

Policy #5: Fact sheets on wind energy and WECS from the Energy Division of DEPD will be displayed and distributed in the planning and zoning office *(or other appropriate location)*.

3 ZONING AMENDMENTS

Why zone for wind machines?

Zoning language on wind machines is necessary to assure the safe design, siting, and installation of wind machines. In addition to addressing safety concerns, zoning language on WECS may also consider nuisance issues such as noise and potential interference with radio, TV, and other communications signals. Finally, aesthetic concerns about wind machines may be addressed.

Amend zoning ordinance or develop separate WECS ordinance?

The intent of this guidebook is to assist local governments in addressing WECS in their zoning ordinance. The information in this Chapter is presented in the context of amendments or additions to existing zoning language. It is possible, though, to develop a separate ordinance to deal with WECS. If a separate ordinance is adopted, however, it seems possible that amendments to existing zoning language on height limits, setbacks, and other provisions may also be necessary. Having language on WECS in different locations could be unwieldy. If your community has a zoning ordinance and has addressed other issues by adopting a separate ordinance, then it may be appropriate to address WECS in a similar fashion. In this case the information in the Chapter could be used as the basis for a separate ordinance. In a community without existing zoning language it does not seem appropriate to single out and control WECS in a separate ordinance.

Different WECS provisions for different zoning districts

The impact of a wind machine will depend on its surroundings. For example, a wind system would likely be less obstrusive in an industrial area or in a residential district with large lots than in a higher density residential neighborhood. For this reason it seems appropriate to consider wind machines differently in different zones. Zoning districts are grouped into three categories for the purposes of this guidebook. These categories are small lot residential districts, large lot residential and commercial districts, and industrial and agricultural districts. Many of the wind machine zoning provisions apply in all districts regardless of their category. Where distinctions are made between the categories, the regulations suggested for small lot residential districts are the most strict while those suggested for industrial and agricultural are least strict. These categories should not be considered ironclad but rather as guidelines for establishing wind machine zoning provisions that are appropriate for your community.

Small lot residential districts means those districts with relatively small lots ranging up to about 15,000 to 20,000 square feet. This would include most lots within towns. Typical zoning classifications are R-1 and R-2.

Large lot residential districts means residential zoning districts with minimum lot sizes greater than 15,000 to 20,000 square feet. This would likely include many zoning districts in surburban areas. Adjustments to these categories or adding other categories may be necessary, however, to ensure equitable treatment of wind machines. If there is a wide range of typical lot sizes in a community, for example, 10,000 square foot lots and 5 acre lots, then one set of regulations may be too restrictive for WECS sited on the larger lots. If this is the case, then different and less restrictive regulations would be appropriate for the very large lots.

Commercial districts are grouped with large lot residential districts because it seems that a similar level of wind machine regulation is appropriate for these two types of districts. Commercial districts, however, can vary a great deal, and it is difficult to make a general statement about how wind machines should be considered in them. For example, the stricter regulations suggested for small lot residential districts may be appropriate for a downtown business district or for small commercial areas within a residential zone. Evaluate your community and make your decisions accordingly.

Industrial districts are those zoned for industrial uses and the least strict WECS zoning regulations seem appropriate in these areas. Again, though, individual evaluation may be necessary in your community. For example, it may be appropriate to treat an older industrial zone next to a high density commercial zone differently than an industrial park at the edge of town. Another option that would be especially appropriate in some large industrial zones is to exempt wind machines from special WECS zoning provisions.

Agricultural zones are grouped with industrial districts because the least strict WECS zoning regulations also seem appropriate in these areas. As with industrial zones, it may be appropriate to exempt wind machines from special WECS zoning in agricultural areas. This would be the case if the agricultural area was composed of fairly sizable farms. In this case the great distances possible between a wind machine and any other structure are such that WECS regulations aren't necessary. Some level of regulation may be suitable in areas of small, hobby farms. Again, specific evaluation in your community is necessary.

Homebuilt, experimental, prototype, and production phase WECS

Like many products, wind machines go through many developmental stages before they are widely available on the market. Experimental and homebuilt machines are WECS which are the first of their kind. These terms overlap, but experimental typically refers to the first stage of development of a machine produced by a WECS company while homebuilt refers to home designed, backyard, do-it-yourself efforts.

Prototypes are machines built by a wind company after the experimental phase. Usually a limited number of prototype machines are built to be tested under field conditions. After the prototypes have been tested a company goes into the final production phase of the development process. A production phase WECS is a machine which is produced in significant numbers on a continuing basis.

Another option is wind machines that are constructed from professionally designed kits. Though these would be built by individuals, they are not home designed and should be considered production phase WECS. The following definitions summarize these stages of development:

> **Production phase WECS are professionally designed wind machines that are built in significant numbers on a continuing basis after testing. Wind machines made from professionally designed kits will be considered production phase WECS.**
>
> **Experimental and homebuilt WECS are wind machines that are one of a kind, first attempt machines built by a wind power company or individual.**
>
> **Prototype WECS are wind machines built after the experimental design stage in limited numbers for the purpose of testing.**

It may be difficult to tell the difference between a prototype and production phase wind machine especially with machines made by newer and smaller companies in the wind industry. Some questions that can guide local decisions about how a particular wind machine will be defined are:

- How many other wind machines of the same model under consideration has the company built and installed?
- How long have other wind machines of the same model been operating?
- Has operation of other wind machines of the same model been successful and safe?
- Have any machines built by the company failed? If yes, how is the proposed WECS different from any machine the company has had problems with?

Wind machines that are not yet in production phase stage of development will not have the testing and operating record of a production phase WECS and may not be as safe. There is no reason, however, to believe that these types of WECS will automatically be more hazardous or potentially hazardous than production phase wind machines. Also the number of homebuilt, experimental, and prototype WECS should be very small relative to production phase machines. But since the prototype, experimental, and homebuilt WECS have not stood the test of time and experience, these machines will be considered differently in the zoning amendments discussion that follows.

Wind machine zoning amendments

This section presents model zoning language and discussion on the following topics concerning zoning for wind machines.

Statement of purpose

Definitions

Use designation

Homebuilt, experimental, and prototype WECS

Permit application

Size regulations
Rotor size
Minimum height
Maximum height
Height and aviation concerns
Tower base

Installation and design
Tower safety
Rotor safety
Rotor and tower compatibility
Electrical safety
Utility notification
Battery storage safety
Reconditioned and modified WECS
Warning sign
Tower access
WECS on top of building

Siting
Setbacks
Siting and aesthetics
Clearance from electrical lines

Nuisance concerns
Noise

Radio frequency or electrical interference
Signal interference

Other regulations

Insurance
Joint use of electricity
Ornamental wind machines
Wind access
Abatement and removal of abandoned towers
Partial invalidity
Interpretation

Explanations of why certain approaches are recommended or discouraged are included in the discussions of these topics. Not all of these topics need to be considered in each community. If a topic discussed in this chapter is not a concern in the community, then it doesn't need to be included in an ordinance. A model ordinance that summarizes the sample language in this section is included in Chapter 5.

Statement of purpose

Including a purpose statement on WECS in the zoning ordinance may be helpful in clarifying why WECS are being considered in the ordinance.

> **The city** *(or county or town ship)* **of** *(insert name of community)* **promotes the effective and efficient use of wind energy conversion systems (WECS) with appropriate regulations on the siting, design, and installation of WECS so that the public health, safety, and welfare of neighboring property owners or occupants will not be jeopardized.**

Definitions

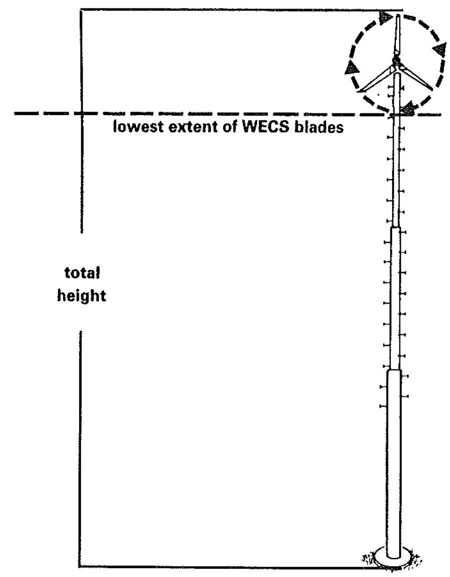
In 1982, the Minnesota Legislature adopted the following definition of wind machines:

> Wind energy conversion system (WECS) means any device such as a wind charger, windmill, or wind turbine which converts wind energy to a form of useable energy.

This definition is in Minnesota Statute 116J.06, subdivision 13 and seems suitable for use in local zoning ordinances. Other definitions that may be useful to include are as follows:

> **Overspeed controls are mechanisms to limit the speed of blade rotation to below the design limits of the wind energy conversion system (WECS).**
>
> **Total height means the distance between ground level and the tallest vertical extension of the WECS.**
>
> **Lowest extension of WECS blades means the lowest point of the arc created by the rotation of the WECS rotor.**
>
> **Production phase WECS are professionally designed wind machines that are built in significant numbers on a continuing basis after testing. Wind machines made from professionally designed kits will be considered production phase WECS.**
>
> **Experimental and homebuilt WECS are wind machines that are one of a kind, first attempt machines built by a wind power company or individual.**
>
> **Prototype WECS are wind machines built after the experimental design stage in limited numbers for the purpose of testing.**

Total height and the lowest extent of WECS blades are graphically represented in the accompanying drawing. If questions come up about the differences between production phase and prototype WECS, refer back to the section entitled homebuilt, experimental, and prototype WECS. That section includes questions that can be used to provide guidance in drawing distinctions between prototype and production phase machines.



Definitions: Total Height and Lowest Extent of WECS Blades

Use designation

The next step is to give a use designation to WECS. The two possible designations are permitted accessory use or conditional use. The pros and cons of each option and some guidelines for determining the appropriate designation are discussed in Chapter 2. If you are reading this Chapter first, it would be helpful to review the part of Chapter 2 that discusses this issue. The policy decision made in Chapter 2 will determine which option discussed in this section is taken.

If the decision is to consider WECS as a permitted accessory use, the suggested procedure to ensure that WECS comply with any regulations that are developed is to require that a WECS installation and operation permit be obtained. A WECS permit would only be issued if the proposed installation complies with the WECS regulations that are adopted. If the WECS is not operating properly and actions aren't taken to correct problems, then the permit can be revoked.

If the decision is to consider wind machines a conditional use, the conditional use permit application would serve to notify government staff of the proposed WECS and to ensure compliance with all conditions outlined in the ordinance. The conditional use permitting procedure could be used to ensure compliance with regulations on both installation and operation of a WECS. If a WECS is not operating properly and actions aren't taken to correct operating problems, than the conditional use permit could be revoked.

A different use designation may be appropriate in different zoning districts. For this reason six options are outlined below for use designations for the three categories of zoning districts. (See section above entitled different WECS provisions for different zoning districts for explanation of the three categories.)

In small lot residential districts, one of the following two options should suffice. The first option is the permitted accessory use designation while the second option is the conditional use designation. Which option is chosen is a decision that needs to be made at the local level.

Production phase WECS shall be a permitted accessory use in small lot residential districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(Fill in the blank with the appropriate district title or titles.)*

or

Production phase WECS shall be a conditional use in small lot residential districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(Fill in the blank with appropriate district title or titles.)*

The following two use designation options are for large lot residential districts and commercial districts. Because there is probably less likelihood of adverse impacts associated with WECS in these districts, it may be more appropriate to select the permitted accessory use option. Choosing the appropriate use designation, however, depends on community conditions, and this decision must be made based on local evaluation.

Production phase WECS shall be a permitted accessory use in large lot residential districts and in commercial districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(Fill in the blank with the appropriate district titles.)*

or

Production phase WECS shall be a conditional use in large lot residential districts and in commercial districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(Fill in the blank with the appropriate district titles.)*

The following two options apply to industrial and agricultural districts. The permitted accessory use designation seems the most appropriate because the effects of wind machines in such districts would likely be minimal. Again, however, individual community evaluation may be necessary.

Production phase WECS shall be a permitted accessory use in industrial and agricultural districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(Fill in the blank with the appropriate district titles.)*

or

Production phase WECS shall be a conditional use in industrial and agricultural districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(Fill in the blank with the appropriate district titles.)*

In the sample language throughout the rest of the guidebook both conditional use and permitted accessory use designation options will be considered. Model language pertinent to the conditional use option will be given in parentheses after language pertaining to permitted accessory use. If the conditional use option is chosen, than use the language in parentheses and delete the references to permitted accessory use.

Homebuilt, experimental, and prototype WECS

The definitions and the earlier section on homebuilt, experimental, and prototype definitions explain the differences between these machines and production phase WECS. This discussion focuses on how these machines should be treated differently in zoning provisions applicable to different zoning districts.

It seems appropriate to not allow homebuilt, experimental, and prototype WECS in small lot residential districts because of the density of development. The following language should suffice:

Homebuilt, experimental, and prototype WECS shall not be allowed in small lot residential districts, ________. *(Fill in the blank with the appropriate zoning district or districts title.)*

For large lot residential and commercial districts three options are presented though other possibilities are certainly available. One option is that if the permitted accessory use option has been chosen for production phase machines then experimental, homebuilt, and prototype machines could be considered a conditional use. All the requirements necessary to get a WECS permit would apply and in addition a public hearing would be held. The following language summarizes this option.

Homebuilt, experimental, and prototype WECS shall be allowed as a conditional use in large lot residential and commercial districts, ________, if the proposed WECS complies with all regulations imposed on WECS allowed as permitted accessory uses. *(Fill in the blank with the appropriate district titles.)*

The second option would be to allow homebuilt, experimental, and prototype WECS as a conditional use and impose an additional requirement that liability insurance be obtained. The following language summarizes this option:

Homebuilt, experimental, and prototype WECS shall be allowed as a conditional use in large lot residential and commercial districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. In addition, liability insurance must be obtained by the owner of a prototype, homebuilt, or experimental WECS. The amount of liability insurance deemed adequate will be de-

termined by the WECS owner. *(Fill in the blank with the appropriate district titles.)*

If a liability insurance requirement has been imposed on all wind machines, then this option will not be very effective and option number 3 may be the most appropriate. (See discussion on p. on liability insurance requirements.)

The third option is not allow homebuilt, experimental, and prototype WECS in large lot residential and commercial districts. The following language summarizes this option:

Homebuilt, experimental, and prototype WECS shall not be allowed in large lot residential and commercial districts, __________. *(Fill in the blank with the appropriate district titles.)*

Two options are presented on how to address homebuilt, experimental, and prototype WECS in industrial and agricultural districts. The first option is to treat these types of machines the same as production phase machines. This could be justified by the likely long distance between a WECS in one of these districts and any other structure. The following language summarizes this option:

Homebuilt, experimental, and prototype WECS shall be allowed and treated as production phase WECS in industrial and agricultural districts, __________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(Fill in the blank with the appropriate district titles.)*

The second option would be to treat homebuilt, experimental, and prototype WECS like production phase wind machines but to impose as an additional requirement that liability insurance be obtained. The following language summarizes this option:

Homebuilt, experimental, and prototype WECS shall be allowed and treated like production phase WECS in industrial and agricultural districts, __________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. In addition, liability insurance must be obtained by the owner of a homebuilt, experimental, or prototype WECS. The amount of liability insurance deemed adequate will be determined by the WECS owner. *(Fill in the blank with the appropriate district titles.)*

Permit application

The permit application process is very similar for a WECS permit which would be obtained if a wind machine were considered a permitted accessory use or a conditional use permit if the conditional use designation was chosen. Two options are given below. Which one is chosen will depend on which use designation has been chosen.

Permitted accessory use
No production phase WECS shall be allowed in small lot residential districts, large lot residential and commercial districts, or in industrial and agricultural districts without applying for and obtaining a WECS permit. No homebuilt, experimental, or prototype WECS shall be allowed in industrial and agricultural districts without applying for and obtaining a WECS permit.

A WECS permit also applies to the operation of a WECS. The permit may be revoked if the WECS operation does not comply with all applicable regulations in the zoning ordinance.

Application for a WECS permit shall be accompanied by a drawing or drawings that show the following:
- **location of the proposed WECS including guy wires and any other auxilliary equipment,**
- **property lines and physical dimensions of the lot,**
- **clearance distances between the farthest extension of the WECS blades to property lines,**
- **location, dimensions, and types of existing structures and uses on the lot,**
- **location of all above-ground utility lines within a distance equivalent to the total height of the WECS, and**
- **location and size of structures, trees, and other objects within 300 feet which are taller than the lowest extent of the blades of the proposed WECS.**

or

Conditional Use No production phase WECS shall be allowed in small lot residential districts, large lot residential and commercial districts, or in industrial and agricultural districts without applying for and obtaining a conditional use permit. No homebuilt, experimental, or prototype WECS shall be allowed in industrial and agricultural districts without applying for and obtaining a conditional use permit.

A conditional use permit for a WECS also applies to the operation of a WECS. The permit may be revoked if the WECS operation does not comply with all applicable regulations in the zoning ordinance.

Application for a conditional use permit for a WECS shall be accompanied by a drawing or drawings that show the following:
- **location of the proposed WECS including guy wires and any other auxilliary equipment,**
- **property lines and physical dimensions of the lot,**
- **clearance distances between the farthest extension of the WECS blades to property lines,**
- **location, dimensions, and types of existing structures and uses on the lot,**

■ **location of all above-ground utility lines within a distance equivalent to the total height of the WECS, and**
■ **location and size of structures, trees, and other objects within 300 feet which are taller than the lowest extent of the blades of the proposed WECS.**

Size regulations

Regulations on several aspects of the size of wind machines including WECS height and rotor size seem appropriate. Some of the regulations, for example, height limits with regard to aviation concerns, should apply to all WECS regardless of their size or location. The size of wind machines allowed in different districts, however, can be different. The need for size regulations and proposed zoning language are outlined in this section.

Rotor size

The WECS rotor size limit for residential zones should be related both to the amount of electricity required after reasonable conservation measures have been taken and to the expected impacts in lots of different sizes. As noted in Chapter 1 the wind machine size range suitable for most homes without electric heat is a rotor diameter of 12 to 16 feet. All-electric homes could use the amount of electricity produced by large machines with rotors of up to 35 feet in diameter. To provide a little leeway for the development of new wind machines, typical WECS that are currently available, and for the needs of all-electric homes, the suggested rotor size limit for WECS in small lot residential districts is 28 feet in diameter. The following language is suitable:

All WECS in small lot residential districts shall not have rotors that are longer than 28 feet in diameter.

It seems appropriate to allow larger wind machines in large lot residential districts and in commercial zones. The visual impacts of a wind machine will likely be less in an area with large lots and in commercial zones, especially in business areas with lots of signs. The suggested rotor size limit is 35 feet in diameter. The following language should suffice:

All WECS in large lot residential and commercial districts shall not have rotors that are longer than 35 feet in diameter.

Some adjustment to this figure may be necessary depending on what decision is made about what zoning districts in your community are included in the large lot residential and commercial districts categories. One factor to keep in mind when making adjustments is what are the typical sizes of wind machines available. For example, many wind companies are beginning to make a 10 meter or 32 foot machine. Reducing the 35 foot size limit to 30 feet would eliminate the possibility of siting these machines and could significantly limit the number of wind machines available to prospective buyers.

Another factor to consider is the size of lots in large lot residential districts. In an area of very large lots, for example, 5 or more acres, a WECS size limit of 40 or more feet may be more appropriate.

In industrial and agricultural zones the suggested size limit is that rotors be no longer than 50 feet in diameter. The following language should suffice:

A WECS in industrial and agricultural districts shall not have rotors that are longer than 50 feet in diameter.

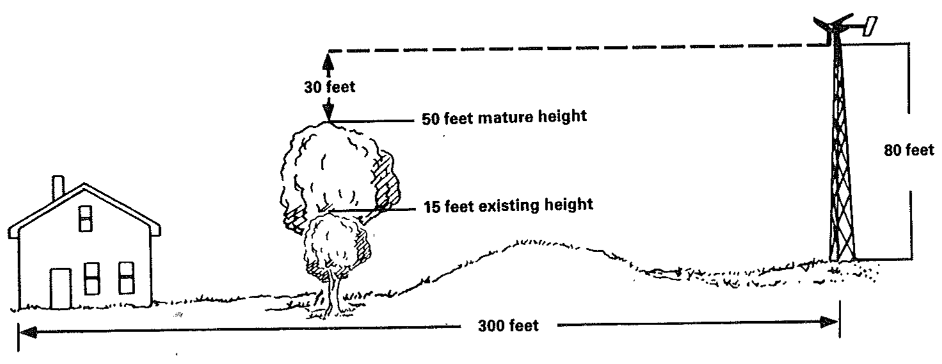
A final note with regard to rotor size limits, especially the 35 and 50 foot limits, is that they should be evaluated periodically. Indeed, all zoning ordinance language should be updated regularly but this point in particular deserves review because the wind industry is changing so rapidly. For example, a 36 foot WECS design could become very popular, and a 35 foot limit could be revised to allow for changes in technology and still achieve a similar level of control.

Minimum height

The safety and efficiency of WECS operation can be impaired if the tower is not tall enough to be above turbulence created by nearby buildings and trees. For this reason a community may want to set a minimum height for a WECS in the ordinance. Minimum height language would help assure safer and more efficient WECS operation, help address wind access concerns, and could be considered a consumer protection device. The rule of thumb on tower height should guide development of any minimum height language. The rule of thumb is that the WECS tower should be tall enough so that the lowest extent of the blades is at least 30 feet above any obstacle within 300 feet. The following language is one way to address this concern:

The minimum height of the lowest extent of the WECS rotor shall be 30 feet above the highest structure allowed under the district zoning requirements or 30 feet above the expected tree height at maturity whichever is higher, that is within 300 feet.

The provision on expected tree height at maturity could be a problem



Minimum Height Above Expected Mature Tree Height

Minimum height of the wind system should be 30 feet above the expected mature tree height of trees within 300 feet even if the existing trees are not yet mature.

in areas with small existing trees. If the existing vegetation is quite small, minimum height language that requires siting at a level above the expected tree height at maturity could mean putting a WECS on a taller tower than is necessary at the time. Indeed a taller tower would be higher than absolutely necessary until the trees did grow to maturity. The efficiency of WECS operation may be increased by the taller height though the increase in efficiency may not warrant the additional cost of a taller tower.

Another option would be to specify that the WECS shall be 30 feet above the tree height expected in 15 years. A concern with this is that it may be difficult to assess the height of a tree after 15 more years of growth while there are fairly standard figures giving the likely mature heights of different tree species.

A final point concerning the minimum height language noted above is that the minimum height appropriate at different sites will depend on the individual characteristics of those sites. For example, the required minimum height at a site close to mature elms of 70 feet would be that the lowest extent of the WECS blade must be 100 feet above the ground. At a site where the predominant tree species was maple, which would likely grow to 50 feet, the appropriate minimum height would be 80 feet above the ground.

If the language above on minimum height seems too cumbersome or if there is little interest in ensuring efficient WECS operation, the following language is recommended to ensure that basic safety is assured.

The minimum height of the lowest extent of the WECS blade shall be 30 feet above the ground.

Maximum height

Many people argue that height limits for wind machine towers are not necessary because tower sizes will be limited by the cost of the tower and are a restriction of an individual's ability to maximize production of electricity from a WECS. The rule of thumb used above in establishing a minimum height limit, 30 feet between the lowest extent of the WECS blade and any obstacle within 300 feet, assures an adequate height but does not assure that the WECS will be at an optimal height. The additional cost of a taller tower may be offset by an increase in electricity production that is worth the increased initial cost. The cost of tall towers should limit WECS height to a level at which increased production of electricity resulting from the taller tower justifies the increased cost.

A machine that is higher than the 30 feet above obstacles rule of thumb will also be safer because there will be even less turbulence caused by buildings and trees. Any sound from a WECS would be less noticeable the higher it is above the ground. A final factor is that the wind machine won't look as imposing on top of a tall tower as on a smaller tower. The relative visual impact of the towers themselves, however, still needs to be evaluated.

All of these factors warrant giving careful consideration to not putting any height limits on WECS except those limits related to aviation. Exempting WECS from height limits would seem particularly appropriate in industrial and agricultural districts and possibly in some commercial zones.

In many residential districts, however, tall WECS towers may not be considered appropriate. If a maximum height limit is considered necessary in your community, then the height limit should be established using a procedure that balances the aesthetic and other concerns of the community with the need to allow for safe and efficient WECS operation. Basically what this means is that a maximum height should not be set any lower than the height necessary to achieve a 30 foot clearance between the lowest extent of the WECS blades and trees and buildings. But to reduce aesthetic impacts the height limit may be set just at the level necessary to achieve a 30 foot clearance and no more. To give more flexibility for increased efficiency and safety in WECS operation, the maximum height limit may be set at 30 feet above any obstacles plus an additional margin.

The first step in determining a suitable maximum height limit is to determine the potential mature height of the tree species in the districts and to review maximum allowable building heights both in and within 300 feet of residential districts. A city forester, agricultural extension agent, or biology or horticulture teacher in a local school may be helpful in determining tree heights. Individual measurement of trees is not necessary; the purpose of this step is to gain a general awareness of the tree species and potential mature heights in the zoning districts. In areas with newly planted trees or trees that are susceptible to disease, such as elms, it may be prudent to consider the potential mature height of likely replacement trees.

In most residential districts trees will be taller than buildings. For example, assume that maple trees are the predominant tree species, the mature height of this species can be up to 50 feet. A suitable maximum height limit measured from the lowest extent of the WECS blade in such a district would be 80 feet, 50 feet (tree height) plus 30 feet (height above obstacles). In areas with elms the height limit would need to be higher. Elms can grow up to 100 feet in Minnesota, though a more typical size range is beetween 60 to 80 feet. An appropriate height limit in areas with elms would be 110 feet, 80 feet (tree height) plus 30 feet (height above obstacles).

Commercial areas bordering a residential district may have a maximum allowable building height that is taller than tree height. Depending on the allowable building heights, maximum height based on the height of existing or future buildings plus 30 feet may not be appropriate. In this case a maximum height limit would mean that a wind machine sited along the border of a residential district near tall buildings would not be able to be high enough for efficient operation. The combination of the maximum height limit and the minimum height language noted earlier would discourage the installation of wind machines in this type of location. In that setting the limit to WECS siting is appropriate.

The next step in setting the maximum height limit is to compare the variety of tree heights and allowable building heights in and near the different residential districts in your community. If tree heights are similar in all the residential districts, then one maximum height limit could be established for all residential zones. If there is a variety of typical tree heights, it may be useful to establish different maximum height limits in different residential districts; however, different limits may be cumbersome. Instead the tallest height limit could be adopted for all districts. In the example noted earlier of two residential districts, one with maximum height limit of 80 feet because of maple trees and the other with a height limit of 110 feet because of the predominance of elms, the 110 foot maximum could be adopted for all residential districts. For the example above, the following language would be appropriate:

The maximum height of the lowest extent of the WECS blades will be 110 feet.

The final step in establishing a maximum height limit is deciding whether or not the height limit will just be based on the minimum clearance of 30 feet above trees and buildings, or if a taller height will be allowed to provide greater opportunity for a WECS to operate more efficiently and with greater safety than is provided by a height based on the minimum clearance of 30 feet. To make this decision the advantages of providing greater flexibility for a potential WECS owner and the possibility of increased operating efficiency and safety need to be weighed against possible aesthetic concerns about tower height. A suggested additional figure to provide more flexibility is 20 feet. This suggestion is based on an assessment that the visual impacts of a tower 130 feet tall will not be significantly different from a tower that is 110 feet tall while the taller tower limit provides more flexibility to a potential WECS owner. The exact figure suitable in your community will be based on individual community characteristics. If the 20 foot figure is chosen, however, the sample language above would be changed from 110 feet to 130 feet and would read as follows:

The maximum height of the lowest extent of the WECS blades will be 130 feet.

A final note concerning height limits is that it may be useful to explicitly exempt WECS from maximum heights established for buildings. Although establishing specific WECS height limits implies that building height limits do not apply to WECS, clarification of this may be helpful. All that is necessary is to include wind energy conversion systems in the list of items such as chimneys, radio towers, water tanks, and other structures to which building height limits do not apply.

Height and aviation concerns

Two sets of regulations concerning aviation could possibly influence the height and location of wind machines. The Federal Aviation Administration regulations are primarily concerned with protecting existing airspace. The other possible influence is local airport zoning. The Minnesota Legislature has enabled local governmental units to adopt airport zoning. A model zoning ordinance prepared by the Minnesota Department of Transportation provides guidance in developing local airport zoning. The model ordinance considers preserving airspace and regulating land use in safety zones around airports.

Federal Aviation Administration regulations require notification of any construction or alteration that is:

- more than 200 feet in height above the ground level at its site or
- of greater height than an imaginary surface extending outward at one of the following slopes:
  - 100 to 1 for a horizontal distance of 20,000 feet from the nearest point of the nearest runway of any public or military airport, or public airport that is under construction, with at least one runway more than 3,200 feet in length.
  - 50 to 1 for a horizontal distance of 10,000 feet from the nearest point of the nearest runway of any public or military airport, or public airport that is under construction, with its longest runway no more than 3,200 feet in length.
  - 25 to 1 for horizontal distance of 5,000 feet from the nearest point of the nearest landing and takeoff area of a heliport.

Notification to the FAA regional office is required if a proposed wind machine is over 200 feet tall. If the total WECS height is less than 200 feet, notification may still be necessary if it is located near an airport. The Great Lakes Regional Office is at 2300 East Devon Avenue, Des Plaines, IL 60018 ■ (312) 694-4500 ext. 456.

After notification, the FAA will do an aeronautical study and make a determination if the WECS is a hazard to aviation. If it is not considered a hazard, installation of the WECS will be allowed without any stipulations. If it is considered a hazard to navigation, construction may not be allowed or it may be allowed with appropriate warning lights. Notification to the FAA is the responsibility of the individual or business interested in installing a wind machine. The following language, however, may be helpful to ensure that the WECS permit applicant is aware that FAA requirements may apply:

All proposed WECS shall comply with Federal Aviation Administration notification requirements and any other applicable regulations.

Local airport zoning in Minnesota can regulate airspace obstructions to preserve existing airspace and land uses in safety zones around the airport. Depending on the exact zoning language, a WECS could be prohibited if it was proposed for installation in a safety zone or was high enough to be an obstruction. The outermost boundary in which airspace obstruction or land use safety zoning can occur is two miles from the airport boundary. If there is no airport in or within 2 miles of your community, requiring compliance with airport zoning in zoning regulations on wind machines is not necessary. The following language is suggested, however, for cities and townships with or near airports and for counties that have airports:

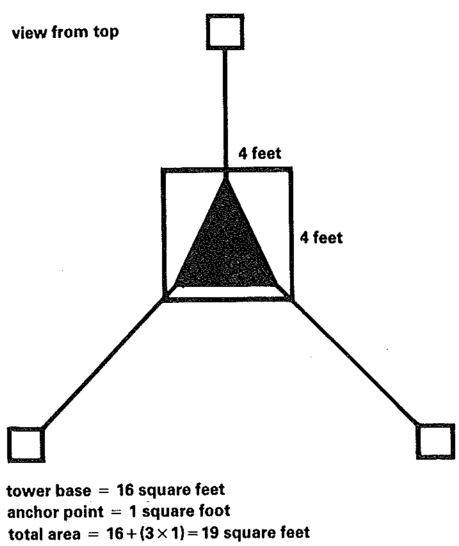
All proposed WECS shall be in compliance with any applicable airport zoning.

Tower base

Some communities have proposed a limit to the size of the base of the WECS tower. Establishing a reasonable size limit may be difficult. Also the concern seems to be how well the tower fits on the lot rather than the absolute size of the tower base. A suggestion, then is to include the tower base in calculations of lot coverage. In this way a large lattice tower could be built on a large lot but not on a smaller lot. The following language outlines this point:

> **The base of a WECS tower shall be included in calculations of lot coverage. In the case of the guyed tower, the area covered by the guy wire anchor points shall also be included in lot coverage calculations.**

For example, a base of a lattice tower with three legs 10 feet apart would cover an area of 43 square feet (area of the triangle equals ½ base times the height), and this area should be added into calculations of lot coverage. A guyed pole tower with 3 guy wire anchors would cover an area of about 19 square feet. The base would be about 16 square feet, and allowing 1 square foot for each guy wire anchor, the total area would equal 19 square feet. If adding the additional footage into the lot coverage calculation exceeds the allowable lot coverage, the WECS would not be allowed. (See accompanying drawing.)



Area of Guyed Tower Base Calculations

Installation and design

Regulations in this section on WECS installation and design focus on safety concerns. The job of local government officials to address the safety and other aspects of WECS will be made much easier when industry standards are established. The American Wind Energy Association (AWEA) is currently developing standards for wind energy conversion systems. The American Society for Testing and Materials (ASTM) plans to review and adopt the standards if they are adequate. The topics the standards would cover are terminology, performance, siting, installation, electric power subsystems, safety, design criteria, and certification and labeling. The standards are expected to be approved in 1983. Once the standards are approved, wind machine manufacturers can have their machines tested for compliance with the standards.

These standards would be very helpful for local governments because the safety of wind machines is difficult to evaluate on the local level. Rather than including the installation and design regulations discussed in this section in a zoning ordinance, the ordinance could adopt the AWEA standards.

Unfortunately, the standards are not completed now. The installation and design regulations in this section are suggested for use until the industry standards are adopted. The Energy Division is monitoring the development of standards and, as staff and budget cuts permit, will keep communities who have received this guidebook informed on the AWEA standards.

Tower safety

The safety of wind machine towers is addressed in the Minnesota State Building Code. Pertinent code provisions are in Chapter 23, section 2311, part g. Chapter 23 covers general design requirements while section 2311 addresses designing for wind pressure and part g concerns open frame towers. Minnesota's State Building Code is the Uniform Building Code adopted by reference and with amendments. The Minnesota amendments include additional language concerning added ice load on the tower. Because of the wind machine on top of the tower, it will likely have to meet part j in section 2311. The building code provisions are summarized below.

Minnesota State Building Code provisions, pertinent to WECS, Uniform Building Code, Chapter 23, Section 2311, part g.
Adopted by reference with amendments in Minnesota at 2 MCAR §1.10111.
(g) Open Frame Towers. Radio towers and other towers of trussed construction shall be designed and constructed to withstand wind pressures specified in this section, multiplied by the shape factors set forth in Table No. 23-H.
Wind pressures shall be applied to the total normal projected area of all the elements of one face (excluding ladders, conduits, lights, elevators, etc., which shall be accounted for separately by using the indicated factor for these individual members).

The effect of one-half inch of radial ice shall be included in the design of open frame towers including all supporting guys. This effect shall include the weight of the ice and the increased profile of each such tower component so coated.

Chapter 23, Section 2311, part j
(j) Combined Wind and Live Loads. For the purpose of determining stresses, all vertical design loads except the roof live load and crane loads shall be considered as acting simutaneously with the wind pressure.

If the Minnesota State Building Code is in effect in the community, the following language could be adopted to address tower safety:

> **All WECS tower structures shall be designed and constructed to be in compliance with pertinent provisions of the Minnesota State Building Code. Indication of compliance may be obtained from the manufacturer's engineering staff or by a Minnesota professional engineer or by an individual with technical training on WECS.**

Not all professional engineers are familiar with wind machine towers while considerable expertise is held by companies that manufacture towers. While an independent appraisal of tower safety may be more satisfactory, the ability of a local government to obtain such an appraisal is limited. It is for this reason that certification of tower safety by the manufacturer is considered acceptable.

An individual trained about wind energy and WECS may also be able to evaluate tower safety. For example, the Red Wing AVTI has a technical wind energy training program. An individual who has completed the Red Wing or a similar course could evaluate the safety of wind towers and the other safety concerns addressed in this section. Deciding whether or not an individual is qualified to evaluate the tower and other safety aspects considered here is up to local government staff and officials. If community staff and officials are not comfortable making such a decision then the provision on safety certification by an individual with technical training on WECS could be removed.

In a community where the State Building Code is not in effect the suggested standard for certification is good engineering practice. The following language should suffice if the Building Code is not in effect:

> **The safety of the design and construction of all WECS towers shall be certified by the manufacturer's engineering staff, by a Minnesota professional engineer, or by an individual with technical training on WECS. The standard for certification shall be good engineering practices.**

One last concern about tower safety applies only to guyed towers. It is usually standard practice to install safety wires on the turnbuckles of guy wires. Safety wires prevent vibration or vandals from loosening the turnbuckle. It would be appropriate to specify in the zoning ordinance that safety wires be installed on turnbuckles. The following language should suffice:

> **Safety wires shall be installed on the turnbuckles on guy wires of guyed WECS towers.**

Rotor safety

Two elements of rotor safety need to be considered. The first is the presence of both manual and automatic overspeed controls. The second element is evidence that the rotor and overspeed controls have been properly designed and constructed to ensure the safety of operation.

An overspeed control system may either slow the rotor down to a safe speed or completely stop the rotor. One possible arrangement is that an automatic overspeed control, like spoiler flaps, would slow down the machine while a manual control could be a brake that completely shuts the machine down. Another arrangement could be to have both the automatic and manual overspeed controls be devices that slow the rotor to a safe speed. There is a wide variety of overspeed controls, and requiring a particular type of automatic and manual overspeed controls is not necessary.

It is more difficult to evaluate the adequacy of rotors and the allowed overspeed controls. The engineering of a WECS is not an exact science. Experimental and prototype machines are built to test the engineering and design of a WECS. A production phase machine should have adequate rotor and overspeed control devices, or presumably the company wouldn't be able to sell very many machines. The wind industry with a few exceptions of companies that have been in the business since the 1930's is in its beginning stages, and problems have been known to occur on production phase machines. The following language includes consideration of the need to analyze certain characteristics of production phase and other WECS.

> **All WECS shall be equipped with manual and automatic overspeed controls. The conformance of rotor and overspeed control design and fabrication with good engineering practices shall be certified by the manufacturer's engineering staff or by a Minnesota professional engineer or by an individual with technical training on WECS.**

It is important to realize that obtaining certification from a professional engineer can be costly. Also many professional engineers do not have any experience with wind machines and will not be able to adequately evaluate a WECS. For these reasons the two other options noted for obtaining certification are included in the model language. To further address the problem of an engineer not being familiar with WECS, it may be helpful to specify that if the individual interested in installing a WECS decides to obtain certification from a professional engineer, then the engineer must be familiar with wind machines or consult with someone who is.

Rotor and tower compatibility

The compatibility of the WECS with the tower on which it is mounted is very important. An improperly matched WECS and tower can begin to vibrate and cause serious fatigue problems and other damage. Certification of tower and WECS compatibility should also be required. The following language summarizes these points.

> **The compatibility of the tower structure with the rotors and other components of the WECS shall be certified by the manufacturer's engineering staff or by a Minnesota professional engineer or by an individual with technical training on WECS.**

Electrical safety

The National Electric Code (NEC) covers all the electrical aspects of a wind machine except for the actual interconnection between the WECS and the utility. The National Electric Code has been adopted in Minnesota. The electrical components of the WECS should be inspected by a qualified electrical inspector for compliance with the NEC.

Proposed rules issued by the Minnesota Public Utilities Commission state that the interconnection between the WECS and the electric utility shall comply with the National Electrical Safety Code (NESC). The NESC applies to utility facilities. Requiring compliance with the National Electrical Safety Code would likely be appropriate in a local zoning ordinance. It would be best, however, to check with the Minnesota Public Utilities Commission to check on the final rules. As budget and staff reductions permit, communities that receive this guide will receive an update on the final PUC rules.

A final area of concern regarding electrical safety is that the wind generating system should automatically disconnect from the utility when there is no power input from the utility lines. This ensures that a WECS will not feed electricity into utility lines that are disconnected due to a storm or accident or for repairs.

The following language is suggested to address these concerns:

> **All electrical components of the WECS shall be in compliance with the applicable requirements of the National Electrical Code as currently adopted by the Minnesota State Building Code Division and shall be inspected by a qualified electrical inspector. The interconnection between the WECS and the electric utility shall be in compliance of the most recent edition of the National Electrical Safety Code. Certification will be supplied in writing that the WECS will automatically disconnect from the utility when there is no power input from the utility. This certification can be supplied by the manufacturer of the WECS.**

Utility notification

The local electrical utility needs to be notified if the WECS is going to be interconnected with the utility. The proposed rules issued by the Minnesota Public Utilities Commission require that a written contract be made between the wind machine owner and the utility. Mention of the Minnesota and federal regulations on the interconnection between utilities and WECS and encouraging advance notice to utilities would be useful in local zoning ordinances. The following language is suggested:

> **The interconnection of the WECS with the local electrical utility shall comply with all applicable federal and Minnesota regulations. Applicants for a WECS permit** *(or a conditional use permit if the conditional use designation is chosen)* **should notify their electrical utility in advance of their installation plans.**

Battery storage safety

Battery storage is most common in rural areas that may not be under zoning jurisdiction. Batteries can be a hazard, however, if improperly stored and connected to a WECS. To address the possibility of battery storage in your area, the following language is recommended:

> **Battery storage units associated with WECS shall be in compliance with the National Electric Code as currently adopted by the Minnesota State Building Code Division and shall be inspected by a qualified electrical inspector.**

Reconditioned and modified WECS

Old wind machines that have been properly rebuilt or reconditioned should operate safely. The skill individuals bring to modifying commercially available WECS, however, can vary and safety problems may result from the modifications. Modification of commercial wind machines is usually not a good idea. Donald Marier in his book, *Wind Power for the Homeowner,* gives an example of a modification to a machine's governing device that resulted in the loss of blades during a violent storm.

Safety concerns about reconditioned and modified wind machines can be addressed by requiring review of the machines by a professional engineer or an individual with technical training on WECS. The following language is suggested:

> **The safety of structural components of reconditioned WECS and the compatibility of the rotors with the towers of reconditioned WECS shall be certified by a Minnesota engineer or individual with technical training on WECS. The safety of electrical components of reconditioned WECS shall be certified by a Minnesota registered electrical engineer or individual with technical training on WECS. The safety of all modifications to any WECS shall be certified by a Minnesota registered professional engineer or individual with technical training on WECS. Certification of safety is required before the WECS permit** *(or conditional use permit if the conditional use designation is chosen)* **is granted for modifications made prior to installation. Certification of the safety of modifications made after the WECS is installed and the permit is granted is also required. Failure to have the safety of modifications certified after the permit has been granted shall result in revocation of the WECS permit** *(or conditional use permit if the conditional use designation is chosen)* **until certification has been obtained.**

Warning sign

A no trespassing sign warning of high voltage should be posted at the base of the tower. The following language should suffice:

> **At least one sign shall be posted at the base of the WECS tower and shall contain the following information:**
> - **notice of no trespassing and**
> - **warning of high voltage**

There may be some concern that requiring a warning sign on a WECS represents unfair treatment because utility and telephone poles and other structures are often not required to have a similar sign. A warning sign requirement for WECS, however, seems appropriate because they are not as familiar to people as other towers and structures. Also the hazards of a WECS aren't known while most people know about dangers relating to a utility line. As an unfamiliar object, a WECS may be more likely to attract people, especially children, who are not likely to know of its possible hazards. A warning sign provides necessary information. In addition, a warning sign is not very costly.

There may be disagreement about what constitutes high voltage levels and whether or not such voltage levels are found at a WECS installation. This phrase could certainly be replaced with other suitable language but is used here because it is familiar to most people and indicates a possibly hazardous situation.

The notice of no trespassing addresses the problem of tower access and people trying to climb a tower. This is more thoroughly discussed below.

Finally, some communities have required that warning signs include information on emergency shutdown procedures and phone numbers. Requiring that emergency shutdown procedures be included on a sign is not recommended. Posting shutdown procedures may facilitate tampering and vandalism. Shutdown procedures can be complicated and possibly dangerous. Posting these procedures could encourage an inexperienced person to try to shutdown a machine which could be dangerous. A difficulty with posting an emergency phone number is whose phone number should be listed? If this question can be satisfactorily resolved, then including an emergency phone number could be added to the warning sign requirements.

Tower access

Wind machine towers, like trees, utility towers, and many other structures, may be attractive to children and others to climb on. Zoning language that limits tower access should be similar to whatever existing requirements are applied to similar structures. If a warning sign on utility towers is considered sufficient in your community, then similar treatment of WECS towers is only fair. If more detailed language is considered necessary, the following is recommended:

> **WECS towers shall either have tower climbing apparatus located not closer than 12 feet to the ground or be unclimbable by design for the first 12 feet.**

Tower access has been a controversial topic in some communities and with the wind industry. Requiring a fence around lattice towers or other towers that are difficult to make unclimbable by design has been a fairly common proposal. There are two problems with such proposals. First, how effective is a fence in keeping someone from the tower? A fence can be climbed by someone determined to climb a WECS tower. The second factor is that requiring a fence increases the cost of the WECS installation and could reduce the cost effectiveness to the point that an individual may not purchase a wind machine. Requirements that are an economic burden on the potential WECS owner could impair increases in the use of wind energy and should not be made without careful consideration of their need and value. In this case, the questionable value of a fence as a deterrent to tower access doesn't seem to justify the added expense that would result from a fencing requirement.

Two other concerns have contributed to fencing requirements around WECS, protection from accidents and vandalism. Protection from car or other types of accidents can best be addressed by siting the WECS tower and anchor points, in the case of a guyed tower, away from a road. This concern is addressed in the siting section.

It is unlikely that a fence would effectively stop vandals. The discussion on tower safety earlier in this section addresses aspects of this issue in its recommendation to include language requiring safety wires on the turnbuckles of guy wires.

WECS on top of buildings

Siting a wind machine on top of a building is not recommended because most roofs are not strong enough to hold up under the weight of the WECS, the wind pressure, and the vibrations created by rotor movement. Often structures on roofs, like billboards, are mounted on supports that go to the edge of the roof to provide enough strength to withstand wind. Portions of the State Building Code apply to WECS sited on top of buildings. The following language is suggested in communities in which the State Building Code applies.

> **WECS sited on top of buildings shall comply with applicable provisions of the Minnesota State Building Code. Certification of compliance by a Minnesota professional engineer is required.**

In communities that have not adopted the State Building Code, the following language is suggested:

> **WECS sited on top of buildings shall be designed and constructed in conformance with good engineering practices. Certification by a Minnesota professional engineer of compliance with good engineering practices is required.**

Siting

Setbacks

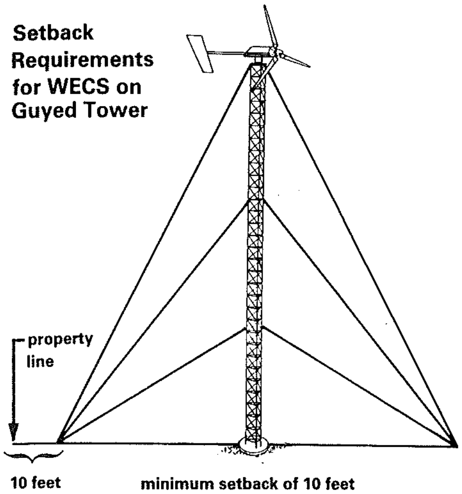
Some communities in the country have proposed to address WECS safety concerns by requiring large setbacks. Large setback requirements are one approach to very valid concerns about wind machine failures. The approach recommended in this guidebook is to address safety concerns directly by requiring compliance with the installation and design requirements discussed above. The setback requirements then can be more consistent with those requirements applicable to other structures. Two options are outlined below on setback requirements:

> *Option 1*
> **No part of a WECS shall be located within or over drainage, utility, or other established easements. No part of a WECS including guy wire anchors shall be located within or over any required minimum front, side or rear yards.**

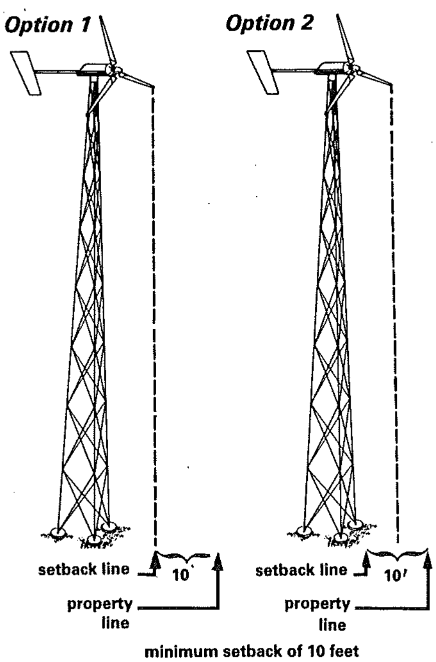
> *Option 2*
> **No part of a WECS shall be located within or over drainage, utility, or other established easements. No part of a WECS shall be located on or over property lines. The base of a WECS or the guy wire anchors of a guyed WECS tower shall not be located in any required minimum front, side, or rear yards.**

Options 1 and 2 have the same effect on guyed towers. (See the accompanying drawing.) Option 1 is more conservative regarding self supporting WECS towers because it requires that even the above ground portions of a wind machine cannot extend over minimum front, side, or rear yard setbacks. The second option allows wind machine rotors, tail vanes, or other above ground parts of a WECS to extend over minimum setbacks to property lines. The base of a self supporting WECS tower or guy

Setback Requirements for WECS on Guyed Tower



wire anchors, however, would not be allowed in the minimum setback area. Options 1 and 2 for self supporting towers are also illustrated. Option 2 is recommended because, it preserves the minimum setback from on-the-ground obstructions to access for fire, utilities, or maintenance and because



Setback Requirements for WECS on Self Supporting Towers

Option 1 doesn't allow any portion of the wind machine, even the above ground portions, to be on or extend over the minimum setback area. Option 2 doesn't allow any portion of the wind machine that is on the ground to extend into the minimum setback area. Option 2 does allow above ground portions of the wind machine to extend over the minimum setback area but not over the property line.

above ground portions of a WECS would not block access in the setback area.

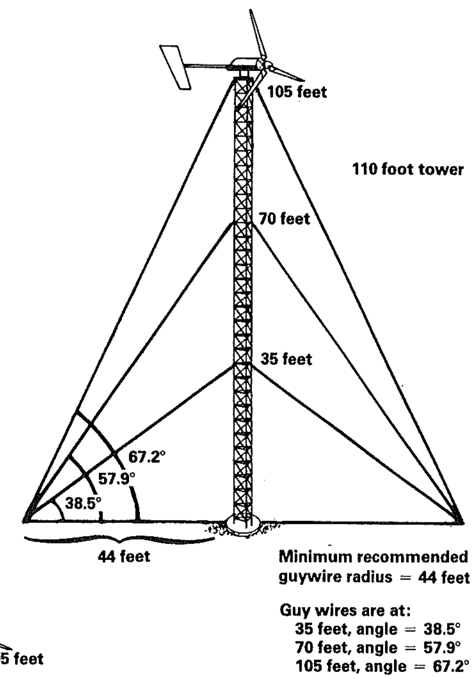
One possible modification of setback requirements would be to allow guy wire anchors on the property line. A property line location could be more convenient and enable greater use of guyed towers. Depending on the distance between a guy wire anchor and the tower, however, the guy wires could go over the minimum setback area at a low angle that could obstruct access. Two guyed tower applications with typical minimum and maximum recommended distances between the anchor and a 110 foot tower are illustrated. Review of this illustration should be helpful in deciding if guy wire anchors will be allowed on property lines.

If a WECS installation is in a location that may be vulnerable to being hit in a car accident, it may be appropriate to require some type of shielding. For example, posts could be installed between the WECS and road. Another option would be to require a minimum clearance of 10 feet between a road and any on ground portion of a WECS. Including some language on this topic may be especially appropriate if guy wire anchors are allowed along the property line where, depending on the exact location, a vehicular accident may be more possible. The sample language below should suffice:

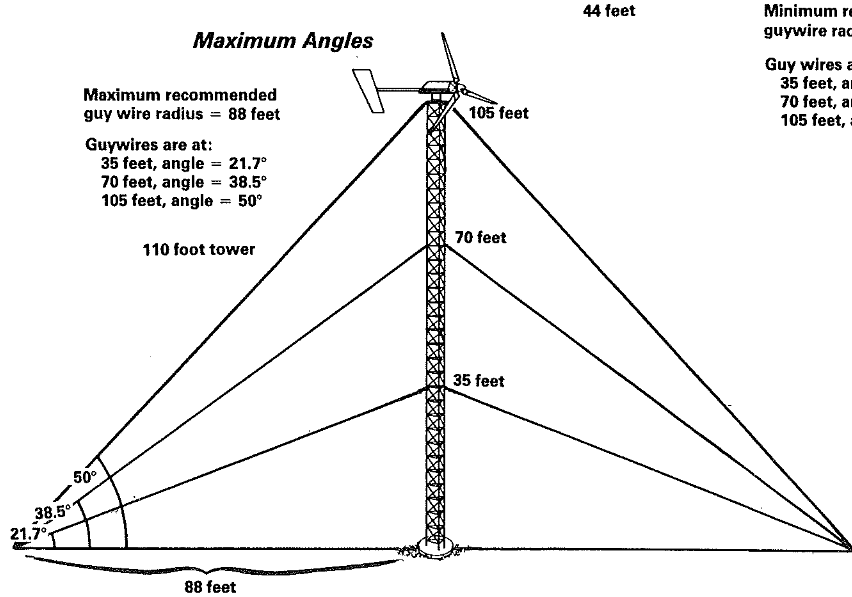
> **Effort should be made when siting a WECS and any related equipment to avoid locations that may be vulnerable to vehicular accidents. It is recommended that WECS towers and guy wire anchors be 10 feet away from any roadway. If the lot configuration does not allow an installation with a 10 foot clearance, then the portion of the WECS within 10 feet of a roadway shall be shielded by posts or a fence.**

Minimum and Maximum Angles of Guy Wires on Guyed Towers

Minimum Angles



Maximum Angles



Siting and aesthetics

Aesthetics is a very subjective and difficult topic to evaluate. Caution is recommended before making any siting requirements based on aesthetic concerns. The following language proposed in North Mankato may be useful: "Wind energy conversion systems shall be placed on the property in a position which shall not unnecessarily obstruct the view from neighboring properties." Wind machine zoning language adopted in Maple Grove also has an aesthetic component. Maple Grove only allows WECS in the rear yards of lots in residential districts. In areas zoned agricultural-residential and large lot residential (5 acres or more), Maple Grove requires that WECS be sited at least 80 feet from the front property line. Other options are to adopt aesthetic standards regarding WECS color and tower design. It is recommended that any proposed aesthetic standards be reviewed by the city or county attorney.

Three factors need to be considered when evaluating the aesthetic effects of wind machines. First is that aesthetic concerns are very subjective. Some people may feel that a wind machine against the sky is very pleasing to the eye while others find a WECS objectionable. Some people may like a pole tower while others like how a lattice tower looks.

A second factor is that new objects are more obvious at first, but then people get used to a new look or design and it becomes part of their routine. For example, many people don't notice power lines or radio towers anymore, though they have visual effects similar to a wind machine. Television antennas were considered objectionable when they first arrived on the scene but are hardly noticed now. A similar process of acclimatization or getting used to something new will probably occur for wind machines as well.

A third factor to consider is the likelihood that a wind machine will be seen. Analysis of the surrounding vegetation, topography, and structures is necessary to evaluate this factor. The relatively thin profile of a wind machine can be more easily shielded by other objects than might be first imagined. A visit to the site may be helpful to analyze this factor. Another analysis tool could be to build a model of the wind tower and its surroundings. Another option is to draw pictures of the area to get an idea of the relative heights of a WECS and surrounding trees and structures and to draw sight lines from eye level to illustrate what somebody on the ground would really see when looking towards a tower. Yet another analysis tool would be to take photographs and superimpose on the photos a scale drawing of the WECS. This type of analysis may take some time, but seems appropriate especially if a zoning decision is boiling down to concerns about aesthetics.

Clearance from electrical lines

Wind machines should be adequately separated from electrical lines. Clearance requirements are outlined in the National Electrical Safety Code. The following language is recommended:

> **Clearance between WECS and electrical lines shall be in compliance with the requirements outlined in the most recent edition of the National Electrical Safety Code.**

Nuisance concerns

Noise

Properly installed and maintained wind machines of the size discussed in this guide generally create sound levels compatible with other land uses including residential development. Noise monitoring at the base of four small wind machines at Rocky Flats test facility in Colorado indicated a sound range of 41 to 68 dBA. The noise levels diminished as the monitoring equipment was moved away from the wind machine. For example the sound recorded at the base of one WECS tower was 52 to 61 dBA but the noise level was only 49 to 52 dBA 72 feet away from the tower. Another example is a wind machine that was monitored by the Minnesota Pollution Control Agency that had a sound level of 50 dBA 40 yards away from the wind machine.

Noise level readings also depend on the height of the WECS tower. An advantage of allowing high wind machine towers is that noise levels will be reduced.

Another factor to consider when evaluating the sound levels of small wind machines is that wind machines will be operating when the wind is blowing and the sound of the wind will mask or partially mask the sound of the WECS. The accompanying chart summarizing the dB noise scale indicates the range of sound generated by small wind machines and the noise of wind in trees. The exact extent to which sounds generated by wind in trees and around buildings will mask the sounds of a wind machine will depend on many factors including location, height, and type of vegetation and buildings as well as on the wind speed. The point is that wind machines don't make any noise when the wind isn't blowing and when the wind is blowing other noises will be created.

A related factor to consider is how sounds from a wind machine will be masked by other noises. For example, sound from a WECS shouldn't be an issue near a heavily used road because the noise of traffic will mask the sounds from a wind machine.

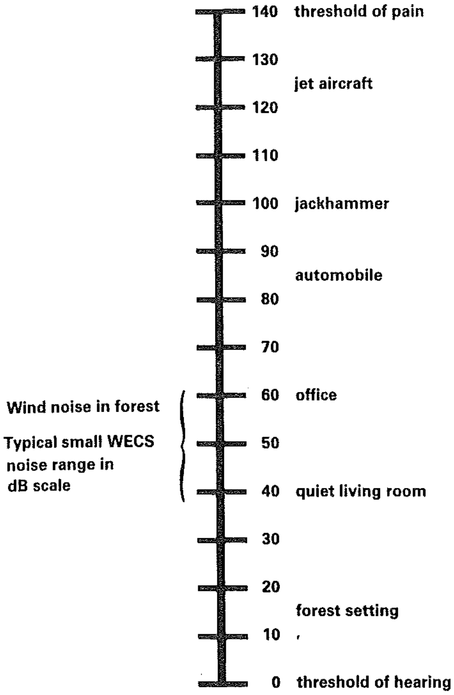
The accompanying dB noise scale also provides a comparison of sound from wind machines with other sounds. Sounds from a wind machine are not a threat to hearing. Sounds from wind machines also don't seem comparable with disruptive sounds like a jackhammer or noisy automobile or other noises that are a nuisance.

The Minnesota Pollution Control Agency noise pollution control standards, NPC 1 and NPC 2, are applicable to sounds from wind machines. These standards could be mentioned in the zoning ordinance to clarify that the state standards will be used to evaluate any possible noise problems. The following language should be sufficient:

> **Noise pollution standards, NPC 1 and NPC 2, established by the Minnesota Pollution Control Agency shall be used to evaluate and regulate noise from WECS. Owners of WECS that are found to be in violation of NPC 1 and NPC 2 shall cooperate in taking reasonable mitigating measures.**

The noise regulations establish three different noise areas. Land uses

dB Noise Scale



in noise area classification-1 (NAC-1) includes residences and other activities that are not very noisy and are sensitive to noise. Noise area classification-2 includes land uses that are less sensitive to noise such as retail stores. Noise area classification-3 includes noisier land uses that are even less sensitive to noise such as industries. Noise standards for day time and night time hours are established for the three noise classification areas. (See accompanying chart.) The figures in the chart are expressed in dBA which is a unit of sound level. The term L_{50} is the sound level which is exceeded 50 percent of the time for one hour, and L_{10} is the sound level which is exceeded 10 percent of the time for one hour.

Minnesota Pollution Control Agency
Noise Control Standards

Noise Area	Day (0700-2200)		Night (2200-0700)	
Classifications	L_{50}	L_{10}	L_{50}	L_{10}
1	60	65	50	55
2	65	70	65	70
3	75	80	75	80

The following example should help explain what all this means. A home would generally be in an area classified as NAC-1, and the day and night standards for NAC-1 would apply. If the noise measured at the home exceeds 60dBA for 50 percent or more of one daytime hour, the noise levels are too high. Whatever is causing the excessive noise is in violation. It is important to note that the measurement is taken at the location of a complaint, not at the suspected source of noise. A wind machine in or near a residential neighborhood, then, would be in violation of the regulations if the noise it produced exceeded the noise standard at a home where the measurement is taken.

Local governments can enforce criminal penalties for violation of the Minnesota Pollution Control Agency noise standards. This authority is found in Minnesota Statute 115.071, subdivision 2(C) (1982). This means that the local government unit could ticket or fine wind machines that are in violation of the noise standards. A ticket or fine would be issued after a complaint has been received and measurements indicate that there is a violation. If your community has an existing noise ordinance and has adopted enforcement authority, then any noise from a WECS could be handled under existing local regulations.

It has been suggested that any sounds that may be emitted from wind machines would be of low frequencies that would be disturbing but not in violation of the state noise standards. Low frequency sounds may be felt as vibrations as much as being heard as noise. The reason that disturbing low frequency noises may not be in violation of the noise standards is that the dBA scale that the standards are measured in is geared towards higher frequency sounds. The noise monitoring on WECS done by the Pollution Control Agency indicates that the sounds from the small wind machines are not of particularly low frequency and that the sounds monitored in any frequency range were not disturbing or a violation of the state standard.

Radio frequency or electrical interference

Radio frequency interference is the type of interference of communications signals that can result from operation of an electric generator. Radio frequency interference is often called electrical interference because the source of the problem is an electric generator. This type of interference may create static on radios and horizontal lines across a television screen. The interference is similar to the interference created by operating a mixer or blender close to a television or radio.

Small wind machines typically cause little or no problems with radio frequency interference resulting from operation of the WECS electric generator. Electrical interference is not likely even in large WECS. Electrical generators in wind systems are no more likely to cause interference than any other generator. Electrical generators used in wind systems or in any other type of application are designed to reduce the possibility and magnitude of electrical interference. A generator that causes radio frequency interference to communications reception is regulated by the Federal Communications Commission (FCC).

Electrical interference can usually be reduced or eliminated by filters at either the generator or at the radio, TV, or other device receiving the signal.

The FCC regulations preempt local regulations, and enforcement authority lies with the FCC. The appropriate local government role would be to advise anyone complaining about the interference caused by the generator of a wind system to contact the FCC. The following language should suffice:

> **Efforts should be taken by the proposed WECS owner to purchase, build, or recondition an electrical generator that will not create electrical or radio frequency interference to reception of communication signals. Complaints about electrical or radio frequency interference shall be directed to the Federal Communications Commission.**

Signal interference

A second type of interference that may result from wind machine installation and operation is disruption of TV, radio, microwave, navigational, and other communication signals. This type of interference is not caused by an electrical generator but rather by disruption of the propagation of the signal wave. Some signals travel in a direct line from the transmitter to the receiving antenna. A wind machine and its tower may scatter or reflect these signals. A disrupted TV signal, for example, may result in ghost images on the television screen.

On the local level concern about communication signal interference will likely focus on television signal interference. Problems with television interference have not been reported with small wind machines. A 1978 report to the Wind Systems Branch of the Department of Energy stated that "Smaller WECS are not reported to have a television interference problem." Large wind machines are somewhat more likely to cause television interference. For example, a cable TV system was installed on Block Island off the coast of Rhode Island because of the possibility that interference of conventional TV signals would result from the installation of a large 200 kW machine with 125 foot blades.

Federal Communications Commission (FCC) regulations don't apply to disruption of the prapogation of communication signals. Local regulations, then, can't defer to federal authority.

Because of the small likelihood of television or other communication signal interference resulting from the installation of small wind machines, zoning language on this topic should primarily be informational in nature. It would be appropriate to ask that WECS be sited to avoid significant blocking or reflection of television and other signals. Requiring that the WECS owner take reasonable measures to eliminate signal interference, should interference occur, is also appropriate. The owner of the television or other device that is receiving signal interference should also take reasonable steps to correct the problem, for example, by adjusting antennas.

Each community will need to make its own decision about what to do if television or other signals are disrupted by the installation of a wind machine. One option would be to require that all reasonable efforts to eliminate the interference short of shutting down the wind machine be taken by the WECS owner. Another option would be to allow for the possibility of removing a wind machine if interference occurs that cannot be eliminated by corrective measures. Which option is chosen will depend on an assessment of the importance of television reception compared to the importance of using wind energy. Model language giving the two options are summarized below:

Option 1
Efforts should be made to site WECS to reduce the likelihood of blocking or reflecting television and other communication signals. If signal interference occurs, both the WECS owner and the individual receiving interference shall make reasonable efforts to resolve the problem short of shutting down the wind system.

Option 2
Efforts should be made to site WECS to reduce the likelihood of blocking or reflecting television and other communication signals. If signal interference occurs, both the WECS owner and the individual receiving interference shall make reasonable efforts to resolve the problem. If the problem cannot be eliminated or reduced to a reasonable level, then the WECS can be shut down.

A final note in regard to signal interference concerns the possibility of disruption of airport navigational devices. Review of structures near airports that must comply with Federal Aviation Administration (FAA) notification procedures (see discussion on height and aviation concerns) includes an evaluation of possible obstructions to navigational signals. Compliance with the FAA notification procedures, then, should ensure that a wind machine won't impair navigation communication signals.

Other regulations

Insurance

Requiring that a WECS owner obtain liability insurance either under an existing homeowners policy or as a separate policy has been proposed in some communities. The reasoning behind such a requirement is that any damage caused by a possible accident involving a WECS would be covered by insurance. Presumably most individuals who install a WECS would check on the coverage of a machine under their homeowners policy and either be covered by an existing policy or obtain any necessary additional insurance. Requiring that liability insurance be obtained in some form makes sure that all WECS owners are insured.

Other regulations proposed in this discussion establish siting and design criteria that should reduce the possibility of accidents and the need for liability insurance. Some communities may decide that adopting such "preventive" safety regulations is their proper role and that they don't want to become involved in requiring liability insurance.

If a community is uncertain about requiring liability insurance, this guidebook suggests that the following three factors be evaluated before making a decision. These factors should also be considered in developing appropriate language by communities who have decided to require liability insurance.

First, check on the final Public Utilities Commission (PUC) rules on interconnection between utilities and small electricity producers. The PUC rules on interconnection were being finalized as this guidebook was being printed and it appeared that the rules would allow utilities to require small power producers to obtain liability insurance as a condition of interconnection. The maximum amount of insurance coverage that could be required was $300,000. As staff and budget reductions allow, everyone who receives a copy of this guidebook will receive an update on the final PUC rules. The Public Utilities Commission could also be contacted at: Public Utilities Commission, Room 780 American Center Building, 160 East Kellogg Boulevard, St. Paul, MN 55101 ■ (612)296-7124.

If the final PUC rules on interconnection do allow utilities to require up to $300,000 liability insurance then there would seem to be no need for a local unit of government to get involved in requiring liability insurance. One possible exception would be if a wind machine in the community is not connected to the utility and doesn't need to comply with utility requirements. The following two factors would be most applicable to that possible exception or in the event that the final PUC rules don't allow a liability insurance requirement.

Second, check on the availability and cost of liability insurance that is obtained as a separate policy or under homeowners insurance with local insurance agents. Is such insurance available through local agents? Also check with a wind machine dealer or an individual interested in purchasing a WECS to be sure that the cost of liability insurance isn't an unreasonable burden.

Third, carefully consider requiring any particular amount of liability coverage. What if a certain dollar amount is named in an ordinance and then damage from an accident exceeds that figure? It seems possible that the city or county could get involved in legal disputes involving what constitutes adequate liability insurance coverage for a WECS. The $300,000 maximum liability coverage that a utility may require under proposed PUC rules would be a good guideline to use. Requiring a certain amount of coverage as a minimum amount that could be exceeded at the discretion of the WECS owner may be another way to deal with this concern. Another option would be to require liability insurance without specifying an amount of coverage and let each individual WECS owner and their insurance agent decide what constitutes adequate liability coverage.

A final suggestion is to have the city or county attorney review any language on insurance requirements.

Joint use of electricity

It is possible that one WECS may be jointly owned by two or more people and the electricity produced would be shared. If the proposed WECS complies with the requirements for the district it is in, there should be no problem with joint use of electricity. The following language should suffice:

> **A WECS that supplies energy to two or more structures shall be allowed as long as the proposed WECS complies with all applicable zoning regulations.**

Ornamental wind machines

It may be useful to include language in the zoning ordinance on small ornamental wind machines. The following excerpt from a proposed zoning amendment in North Mankato may be helpful:

> **WECS that are by nature ornamental, rather than functional, shall be exempt from this ordinance if total height is less than 25 feet.**

Wind access

Wind access was discussed in Chapter 2. The conclusion of that discussion was that wind access is important for the safe and efficient operation of WECS but that protecting wind access should remain a private activity. Legislation passed in 1982 and codified in Minnesota Statute 500.30 (1982) clarifies what should be included in a wind easement. It would be appropriate to mention wind access and encourage the use of private agreements to protect access in the zoning ordinance. The following language should be useful:

> **Adequate wind access is essential to the safe and efficient operation of wind machines, and *(insert name of community)* encourages the use of private easements and restrictive covenants to protect wind access.**

Abatement and removal

Many communities include provisions in zoning regulations concerning the abatement of unsafe conditions and removal of a use or structure that is no longer in compliance with the zoning. Provisions of this type have been adopted for wind machines as well. Abatement and removal provisions should provide adequate notice and due process to the WECS owner. Review of such provisions by an attorney is suggested. The following is an example of an abatement and removal regulation:

> **If a WECS is not maintained in operational condition and poses a potential safety hazard or is not maintained and operating in compliance with applicable zoning provisions and state and federal laws, the WECS shall be brought into compliance and to safe operating order within 60 days after notice by *(insert name of community)*. If adequate action to correct problems with the WECS is not taken within 60 days, *(insert name of community)* reserves the right to abate any hazardous situation and to pass the cost of abatement on to the owner or operator of the WECS. Within the 60 day period after notice has been given, the WECS owner or operator has the right to appeal to the governing body of *(insert name of community)* for additional time to correct the situation.**
>
> **If the hazardous condition or violation of regulations is not taken care of by the WECS owner or operator and if the hazardous condition or violation of regulations cannot be corrected by *(insert name of community)* with a reasonable amount of effort, then *(insert name of community)* reserves the right to revoke the WECS permit *(or conditional use permit if the conditional use designation has been chosen)*. After the permit has been revoked, a public hearing will be held on the need to remove the WECS. If the WECS is removed, the cost of doing so shall be passed onto the owner or operator of the WECS. If the WECS has not been operating for twelve successive months after installation, the WECS shall be considered abandoned. A public hearing will be held on the need to remove an abandoned WECS. If removal is deemed necessary, the abandoned machine shall be removed within 30 days of written notice to the owner or operator of the WECS. If the WECS is not removed within 30 days, then *(insert name of community)* shall remove the machine and pass the costs onto the owner or operator of the WECS.**

Partial invalidity

The following provision in the Maple Grove zoning ordinance clarifies that even if part of the ordinance is judged invalid, the rest of it applies. If WECS regulations are added to an existing zoning ordinance, such a provision will probably not be necessary. A partial invalidity provision may be needed if a separate WECS ordinance is adopted.

> **If any section, subsection, sentence, clause, or phrase of this Ordinance is for any reason held to be invalid or unenforceable as to any person or circumstance, the application of such section, subsection, sentence clause, or phrase to persons or circumstances, other than those as to which it shall be held invalid or unenforceable, shall not be affected thereby and all provisions hereof, in all other respects, shall remain valid and enforceable.**

Interpretation

The following provision from zoning language adopted in Maple Grove clarified what regulations will apply if rules or regulations other than those proposed in the zoning ordinance are found to apply to wind machines. Similar language may be useful in your community.

> **It is not the intention of this ordinance to interfere with, abrogate, annul any covenant or other agreement between any parties; provided, however, where this Ordinance imposes a greater restriction upon the use of premises for wind systems than are imposed or required by other Ordinances, rules, regulations, or permits or by covenants or agreements, the provisions of this Ordinance shall govern.**

Vertical axis machines

The zoning language discussed in this chapter was developed with horizontal axis machines in mind because of the greater popularity of this type of machine. The model zoning language in this chapter, however, should be suitable for most vertical axis machines. Some revisions may be necessary with regard to vertical axis wind machines, however, and this should be a topic to consider in periodic reviews of the zoning ordinance.

4 SUBDIVISION AND PLANNED UNIT DEVELOPMENT REGULATIONS

Wind machines in new development

If a new development site were suitable for wind machines, the ability to integrate WECS siting into the development process would enable the most effective and safe use of wind energy resources. If feasible, larger wind machines could be installed to supply electricity needs for groups of homes. Wind machines could be integrated with other energy conservation and renewable energy options, like solar systems, superinsulation and earth sheltered construction techniques, and district heating, to create an energy efficient development.

Amendments

Energy efficient new development and, more specifically, the use of wind machines could be encouraged by amending subdivision and planned unit development (PUD) regulations. Two types of amendments seem appropriate. Other amendments, though, are certainly possible. The purpose section of subdivision and PUD regulations could be amended to provide encouragement for wind machines and other renewable energy techniques and for energy conservation measures. A possible amendment could read:

. . . to promote energy conservation and the use of renewable energy resources through energy-efficient land use patterns and encouragement of wind energy conversion systems, solar energy use, and superinsulation, earth sheltered construction techniques, and other energy efficient techniques.

A second type of amendment is to provide incentives for the use of wind energy. This type of amendment may be most suited for inclusion into PUD regulations because they typically provide greater development flexibility. The following sample amendment gives an indication of how wind machines and other energy saving measures could be encouraged.

A density bonus of up to 20 percent *(actual percentage may vary)* **may be granted in all residential districts** *(specific residential districts could be indicated)* **that maximize the use of energy efficient development design, renewable energy resources, and conservation measures. Approaches may include wind energy conversion systems, active and passive solar systems, earth sheltered construction, superinsulation techniques, clustered housing units, mixed use developments, and bikeways and other transportation alternatives.**

5 MODEL WIND MACHINE ZONING LANGUAGE

This chapter summarizes the model language presented in Chapter 3. In several instances different options are given and only one option needs to be chosen. Use these samples as guidelines, changing provisions as necessary for your community. The pages in the text where each item is discussed are listed at the end of each sample for your reference. Not all the topics presented here need to be included in an ordinance. For more information on the model language refer to Chapter 3 and the discussions on each of the topics. Checking with the city or county attorney on specific ordinance provisions is recommended.

1.0 Statement of purpose
The city *(or county or township)* **of** *(insert name)* **promotes the effective and efficient use of wind energy conversion system (WECS) with appropriate regulations on the siting, design, and installation of WECS so that the public health, safety, and welfare of neighboring property owners or occupants will not be jeopardized.** p. 17

2.0 Definitions

2.1 Wind energy conversion system (WECS) means any device such as a wind charger, windmill, or wind turbine, which converts wind energy to a form of usable energy. p. 17

2.2 Overspeed controls are mechanisms to limit the speed of blade rotation to below the design limits of the wind energy conversion system (WECS). p. 17

2.3 Total height means the distance between ground level and the tallest vertical extension of the WECS. p. 17

2.4 Lowest extension of WECS blades means the lowest point of the arc created by the rotation of the WECS rotor. p. 17

2.5 Production phase WECS are professionally designed wind machines that are built in significant numbers on a continuing basis after testing. Wind machines made from professionally designed kits will be considered production phase WECS pp. 17-19

2.6 Experimental and home-built WECS are wind machines that are one of a kind, first attempt machines built by a wind power company or individual. pp. 17-19

2.7 Prototype WECS are wind machines built after the experimental design stage in limited numbers for the purpose of testing. pp. 17-19

3.0 Use designation *(6 options—choose 3)*

3.1a Production phase WECS shall be a permitted accessory use in small lot residential districts, _________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(Small lot residential districts means those districts with small lots up to about 15,000 to 20,000 square feet. Fill in the appropriate district title or titles in the blank, for example, R-1 and R-2).* pp. 10-11, 17-19

or

3.1b Production phase WECS shall be a conditional use in small lot residential districts, _________, if the proposed WECS complies with all applicable regulations in the zoning ordinance *(See note in 3.1a, above, on the meaning of small lot residential districts. Fill in the blank with the appropriate district title or tiles.)* pp.10-11,17-19

3.2a Production phase WECS shall be a permitted accessory use in large lot residen-

tial districts and in commercial districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(Large lot residential districts means those residential districts that require minimum lot sizes greater than 15,000 or 20,000 square feet. Some commercial zones like a central business district or a small commercial area in a residential zone may be more appropriately grouped with small lot residential districts. Fill in the blank with the appropriate large lot residential and commercial district titles.)* pp. 10-11, 17-19

or

3.2b Production phase WECS shall be a conditional use in large lot residential districts and in commercial districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance *(See note above in 3.2a on the meaning of large lot residential districts and commercial districts. Fill in the blank with the appropriate district titles.)* pp. 10-11, 17-19

3.3a Production phase WECS shall be a permitted accessory use in industrial and agricultural districts, ________, if the proposed WEC complies with all applicable regulations in the zoning ordinance. *(Fill in the blank with the appropriate district titles. As is noted in the text, wind machines on large plots of land zoned industrial and agricultural may be exempt from regulations.)* pp. 10-11, 17-19

or

3.3b Production phase WECS shall be a conditional use in industrial and agricultural districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(See note in 3.3a. Fill in blank with the appropriate titles.)* pp. 10-11, 17-19

4.0 Homebuilt, experimental, and prototype WECS

4.1 Homebuilt, experimental, and prototype WECS shall not be allowed in small lot residential districts, ________. *(See note in 3.1a on the meaning of small lot residential districts. Fill in the blank with the appropriate titles.)* pp. 18-19

4.2a Homebuilt, experimental, and prototype WECS shall be allowed as a conditional use in large lot residential and commercial districts, ________, if the proposed WECS complies with all regulations imposed on WECS allowed as permitted accessory uses. *(Fill in the blank with the appropriate district titles.)* pp.18-19

or

4.2b Homebuilt, experimental, and prototype WECS shall be allowed as a conditional use in large lot residential and commercial districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. In addition, liability insurance must be obtained by the owner of a prototype, homebuilt, or experimental WECS. The amount of liability insurance deemed adequate will be determined by the WECS owner. *(See note in 3.2a on the meaning of large lot residential and commercial districts. Fill in the blank with the appropriate titles.)* pp. 18-19

or

4.2c Homebuilt, experimental, and prototype WECS shall not be allowed in large lot residential and commercial districts, ________. *(See note in 3.2a on the meaning of large lot residential and commercial districts.)* pp. 18-19

4.3a Homebuilt, experimental, and prototype WECS shall be allowed and treated like production phase WECS in industrial and agricultural districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. *(Fill in the blank with the appropriate titles.)* pp. 18-19

or

4.3b Homebuilt, experimental, and prototype WECS shall be allowed and treated like production phase WECS in industrial and agricultural districts, ________, if the proposed WECS complies with all applicable regulations in the zoning ordinance. In addition, liability insurance must be obtained by the owner of a homebuilt, experimental, or prototype WECS. The amount of liability insurance deemed adequate will be determined by the WECS owner. *(Fill in blank with appropriate district titles)* pp. 18-19

5.0 Permit application

5.1a Permitted accessory use No production phase WECS shall be allowed in small lot residential districts, large lot residential and commercial districts, or in industrial and agricultural districts *(assuming that options 3.1a, 3.2a, and 3.3a above have been chosen)* without applying for and obtaining a WECS permit. No homebuilt, experimental, or prototype WECS shall be allowed in industrial and agricultural districts *(assuming that options 3.3a and either 4.3a or 4.3b were chosen)* without applying for and obtaining a WECS permit.

A WECS permit also applies to the operation of a WECS. The permit may be revoked if the WECS operation does not comply with all applicable regulations in the zoning ordinance.

Application for a WECS permit shall be accompanied by a drawing or drawings that show the following:

- **location of the proposed WECS including guy wires and any other auxilliary equipment,**
- **property lines and physical dimensions of the lot,**
- **clearance distances between the farthest extension of the WECS blades to property lines,**

- location, dimensions, and types of existing structures and uses on the lot,
- location of all above ground utility lines within a distance equivalent to the total height of the WECS, and
- location and size of structures, trees, and other objects within 300 feet which are taller than the lowest extent of the blades of the proposed WECS. pp. 19-20

5.1b Conditional use No production phase WECS shall be allowed in small lot residential districts, large lot residential and commercial districts, or in industrial and agricultural districts *(assuming that options 3.1b, 3.2b, and 3.3b above have been chosen)* without applying for and obtaining a conditional use permit. No homebuilt, experimental, or prototype WECS shall be allowed in industrial and agricultural districts *(assuming that option 3.3b and either 4.3a or 4.3b were chosen)* without applying for and obtaining a conditional use permit.

A conditional use permit for a WECS also applies to the operation of a WECS. The permit may be revoked if the WECS operation does not comply with all applicable regulations in the zoning ordinance.

Application for a conditional use permit for a WECS shall be accompanied by a drawing or drawings that show the following:

- location of the proposed WECS including guy wires and any other auxilliary equipment,
- property lines and physical dimensions of the lot,
- clearance distances between the farthest extension of the WECS blades to property lines,
- location, dimensions, and types of existing structures and uses on the lot,
- location of all above ground utility lines within a distance equivalent to the total height of the WECS, and
- location and size of structures, trees, and other objects within 300 feet which are taller than the lowest extent of the blades of the proposed WECS. pp. 19-20

6.0 Size regulations

6.1.1 All WECS in small lot residential districts shall not have rotors that are longer than 28 feet in diameter. p. 20

6.1.2 All WECS in large lot residential districts and commercial districts shall not have rotors that are longer than 35 feet in diameter. p. 20

6.1.3 All WECS in industrial and agricultural districts shall not have rotors that are longer than 50 feet in diameter. p. 20

6.2a The minimum height of the lowest extent of any WECS rotor shall be 30 feet above the highest structure allowed under the district zoning requirements or 30 feet above the expected tree height at maturity, whichever is higher, that is within 300 feet. pp. 20-21

or

6.2b The minimum height of the lowest extent of any WECS rotor shall be 30 feet above the ground. pp. 20-21

6.3 *See the discussion in Chapter 3 on how to calculate maximum height limits appropriate for small and large lot residential districts and commercial districts. Maximum height limits don't seem appropriate in industrial and agricultural districts, but if considered necessary in your community, they can be developed using the same method referred to above.* pp. 21-22

6.4 All proposed WECS shall comply with Federal Aviation Administration notification requirements and any other applicable regulations. All proposed WECS shall be in compliance with any applicable airport zoning. p. 22

6.5 The base of a WECS tower shall be included in calculations of lot coverage. In the case of a guyed tower, the area covered by the guy wire anchor points shall also be included in lot coverage calculations. pp. 22-23

7.0 Installation and Design

7.1a All WECS tower structures shall be designed and constructed to be in compliance with pertinent provisions of the Minnesota State Building Code. Indication of compliance may be obtained from the manufacturer's engineering staff or by a Minnesota professional engineer or by an individual with technical training on WECS. pp. 23-24

or, if the Building Code is not in effect in your area:

7.1b The safety of the design and construction of all WECS towers shall be certified by the manufacturer's engineering staff, by a Minnesota professional engineer, or by an individual with technical training on WECS. The standard for certification shall be good engineering practices. pp. 23-24

7.2 Safety wires shall be installed on the turnbuckles on guy wires of guyed WECS towers. p. 24

7.3 All WECS shall be equipped with manual and automatic overspeed controls. The conformance of rotor and overspeed control design and fabrication with good engineering practices shall be certified by the manufacturer's engineering staff or by a Minnesota professional engineer or by an individual with technical training on WECS. p. 24

7.4 The compatibility of the tower structure with the rotors and other components of the WECS shall be certified by the manufacturer's engineering staff or by a Minnesota professional engineer or by an individual with technical training on WECS. p. 24

7.5 All electrical components of the WECS shall be in compliance with the applicable requirements of the National Electrical Code as currently adopted by the Minnesota State Building Code Division and shall be inspected by a qualified electrical inspec-

tor. The interconnection between the WECS and the electric utility shall be in compliance with the most recent edition of the National Electrical Safety Code. Certification will be supplied in writing that the WECS will automatically disconnect from the utility when there is no power input from the utility. This certification can be supplied by the manufacturer of the WECS. pp. 24-25

7.6 The interconnection of the WECS with the local electrical utility shall comply with all applicable Federal and Minnesota regulations. Applicants for a WECS permit *(or a conditional use permit if the conditional use designation is chosen)* should notify their electrical utility in advance of their installation plans. p. 25

7.7 Battery storage units associated with WECS shall be in compliance with the National Electric Code as currently adopted by the Minnesota State Building Code Division and shall be inspected by a qualified electrical inspector. p. 25

7.8 The safety of structural components of reconditioned WECS and the compatibility of the rotors with the towers of reconditioned WECS shall be certified by a Minnesota engineer or individual with technical training on WECS. The safety of electrical components of reconditioned WECS shall be certified by a Minnesota registered electrical engineer or individual with technical training on WECS. The safety of all modifications to any WECS shall be certified by a Minnesota registered professional engineer or individual with technical training on WECS. Certification of safety is required before the WECS permit *(or conditional use permit if the conditional use designation is chosen)* is granted for modifications made prior to installation. Certification of the safety of modifications made after the WECS is installed and the permit is granted is also required. Failure to have the safety of modifications certified after the permit has been granted shall result in revocation of the permit until certification has been obtained. p. 25

7.9 At least one sign shall be posted at the base of the WECS tower and shall contain the following information:

- notice of no trespassing and
- warning of high voltage.

p. 25

7.10 WECS towers shall either have tower climbing apparatus located not closer than 12 feet to the ground or be unclimbable by design for the first 12 feet. p. 26

7.11a WECS sited on top of buildings shall comply with applicable provisions of the Minnesota State Building Code. Certification of compliance by a Minnesota professional engineer is required. p. 26

or, if the Building Code is not in effect in your area then use the following language:

7.11b WECS sited on top of buildings shall be designed and constructed in conformance with good engineering practices. Certification by a Minnesota professional engineer of compliance with good engineering practices is required. p. 26

8.0 Siting

8.1 No part of a WECS shall be located within or over drainage, utility, or other established easements. No part of a WECS shall be located on or over property lines. The base of a WECS or the guy wire anchors of a guyed WECS tower shall not be on any required minimum front, side, or rear yards. pp. 26-27

8.2 Effort should be made when siting a WECS and any related equipment to avoid locations that may be vulnerable to vehicular accidents. It is recommended that WECS towers and guy wire anchors be 10 feet away from any roadway. If the lot configuration does not allow an installation with a 10 foot clearance, then the portion of the WECS within 10 feet of a roadway shall be shielded by posts or a fence. p. 27

8.3 *Aesthetic regulations may be developed if considered necessary. See discussion in Chapter 3.* p. 28

8.4 Clearance between WECS and electrical lines shall be in compliance with the requirements outlined in the most recent edition of the National Electrical Safety Code. p. 28

9.0 Nuisance concerns

9.1 Noise pollution standards, NPC 1 and NPC 2, established by the Minnesota Pollution Control Agency shall be used to evaluate and regulate noise from WECS. Owners of WECS that are found to be in violation of NPC 1 and NPC 2 shall cooperate in taking reasonable mitigating measures. pp. 28-29

9.2 Efforts should be taken by the proposed WECS owner to purchase, build, or recondition an electrical generator that will not create electrical or radio frequency interference to reception of communication signals. Complaints about electrical or radio frequency interference shall be directed to the Federal Communications Commission. p. 29

9.3a Efforts should be made to site WECS to reduce the likelihood of blocking or reflecting television and other communication signals. If signal interference occurs, both the WECS owner and the individual receiving interference shall make reasonable efforts to resolve the problem short of shutting down the wind system. pp. 29-30

or

9.3b Efforts should be made to site WECS to reduce the likelihood of blocking or reflecting television or other communication signals. If signal interference occurs, both the WECS owner and the individual receiving interference shall make reasonable efforts to resolve the problem. If the problem cannot be eliminated or reduced to a reasonable level then the WECS can be shut down. pp. 29-30

10.0 Other regulations

10.1 *See discussion in Chapter 3 on liability insurance requirements.* pp. 30-31

10.2 A WECS that supplies energy to two or more structures shall be allowed as long as the proposed WECS complies with all applicable zoning regulations. p. 31

10.3 WECS that are by nature ornamental, rather than functional, shall be exempt from this ordinance if total height is less than 25 feet. p. 31

10.4 Adequate wind access is essential to the safe and efficient operation of wind machines, and *(insert name of community)* encourages the use of private easements and restrictive covenants to protect wind access. p. 31

10.5 If a WECS is not maintained in operational condition and poses a potential safety hazard or is not maintained and operating in compliance with applicable zoning provisions and state and federal laws, the WECS shall be brought into compliance and to safe operating order within 60 days after notice by *(insert name of community).* If adequate action to correct problems with the WECS is not taken within 60 days, *(fill in name of community)* reserves the right to abate any hazardous situation and to pass the cost of abatement on to the owner or operator of the WECS. Within the 60 day period after notice has been given, the WECS owner or operator has the right to appeal to the governing body of *(insert name of community)* for additional time to correct the situation. If the hazardous condition or violation of regulations is not taken care of by the WECS owner or operator and if the hazardous condition or violation of regulations cannot be corrected by *(insert name of community),* then *(insert name of community)* reserves the right to revoke the WECS permit *(or conditional use permit if the conditional use designation is chosen).* After the permit has been revoked, a public hearing will be held on the need to remove the WECS. If the WECS is removed, the cost of doing so shall be passed on to the owner or operator of the WECS. If the WECS has not been operating for twelve successive months after installation the WECS shall be considered abandoned. A public hearing will be held on the need to remove an abandoned WECS. If removal is deemed necessary the abandoned machine shall be removed within 30 days of written notice to the owner or operator of the WECS. If the WECS is not removed within 30 days, then *(insert name of community)* shall remove the machine and pass the costs on to the owner or operator of the WECS. p. 31

10.6 If any section, subsection, sentence, clause, or phrase of this Ordinance is for any reason held to be invalid or unenforceable as to any person or circumstance, the application of such section, subsection, clause, or phrase to persons or circumstances other than those as to which it shall be held invalid or unenforceable, shall not be affected thereby, and all provisions hereof, in all other respects, shall remain valid and enforceable. pp. 31-32

10.7 It is not the intention of this ordinance to interfere with, abrogate, annul any covenant or other agreement between any parties; provided, however, where this Ordinance imposes a greater restriction upon the use of premises for wind systems than are imposed or required by other Ordinances, rules, regulations or permits, or by convenants or agreements, the provisions of this Ordinance shall govern. p. 32