Renewable Energy: Wind Power

Introduction

As fossil fuel prices rise and climate change increases, interest in renewable energy is also increasing. Wind is an abundant resource in much of the United States. Wind energy could reliably supply at least twenty percent of the nation's electricity, and perhaps more. At the end of 2007, wind turbines supplied approximately one percent of all U.S. utility power generation. Wind power development is expanding in the U.S. as technologies develop and improve, and the ability to harness wind in a variety of rural and urban settings is increasing. Wind power technology has diversified in the last decade, with the development of turbines of more sizes and configurations, and of quieter and more efficient design. This range of new turbine types enable wind power to be harnessed in a much wider variety of settings than ever before.

As citizens' interest in sustainability and energy alternatives increases, many local governments that have never processed an application for a wind turbine permit (a Wind Energy Conversion System, or WEC) will be asked to review applications. Most are unprepared, lacking standards that can ensure safe installation in compatible locations. This can result in lengthy, costly public review processes that yield mixed results, while exaggerated fears can lead to adoption of zoning or permitting standards that drive up costs and reduce the efficiency of WECS.

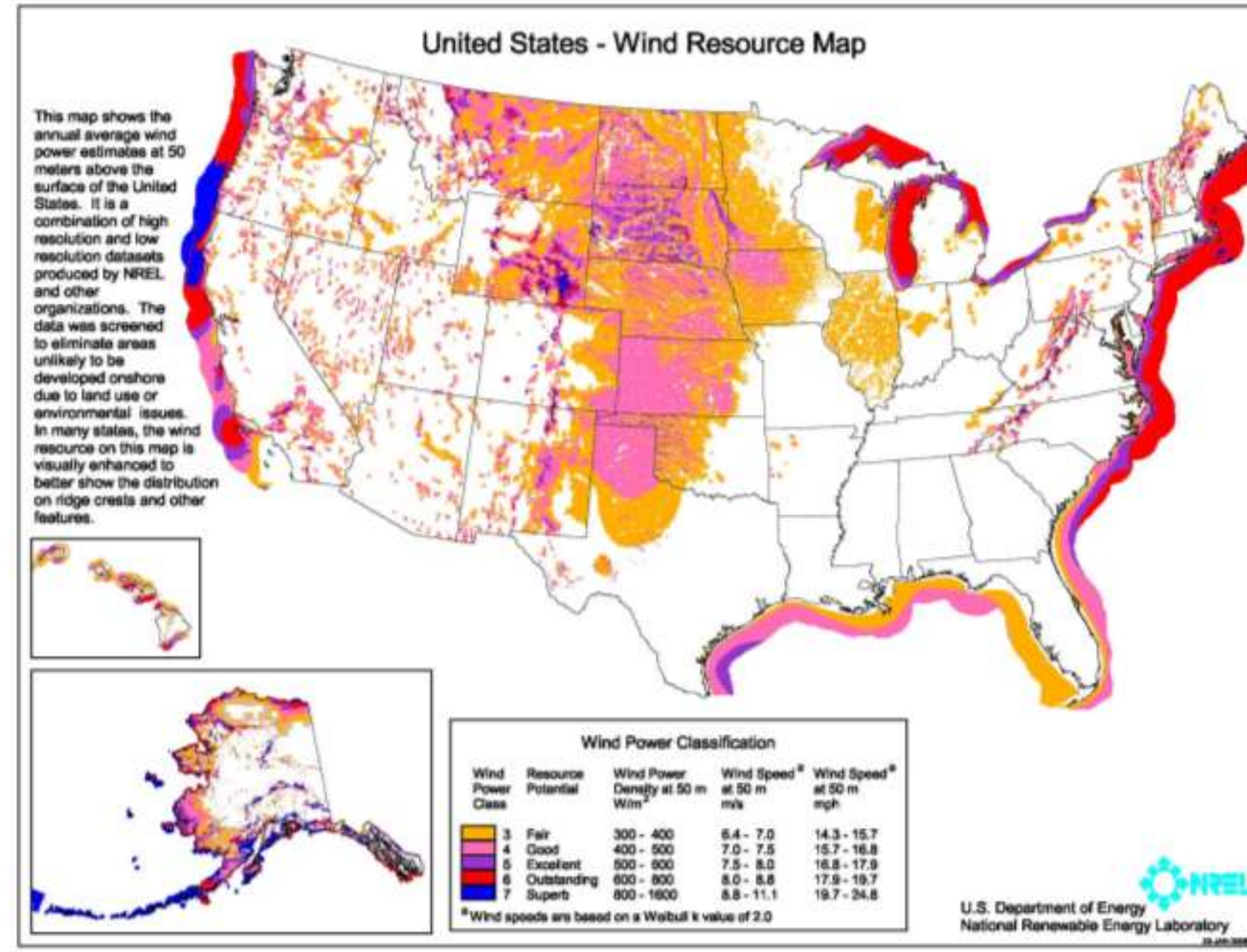
"Large" or "utility-scale" WECS can be 400 feet tall or more, and may be rated to produce as much as 2 MW each. Each MW of utility wind power is enough to power 240-300 homes. "Small wind" refers to wind power generated by WECS rated 100 kW or less, which are generally smaller than 120 feet tall, and are typically used to power farms, homes or businesses.[1] In steady, moderate winds, a single small WEC of 5-7m rotor diameter can power one or more homes.

The U.S. Department of Energy (DOE) and National Renewable Energy Laboratory (NREL) have mapped the wind resources in the U.S. (see map on this page) and provide state-level wind resource maps for most states. More than half of the U.S. experiences Class 3 wind or better, which is sufficient to power small WECS at a 50m elevation. Typically, utility wind is developed where winds are Class 4 or better. The electricity production potential of a WEC depends on both the design, and on access to steady, non-turbulent wind. The best wind is found at least 300 feet away from obstructions, such as buildings or trees, and in areas with relatively flat topography, and twice as high.

A U.S. household with average energy demand (10,565 kWh, according to the Department of Energy) that uses the typical mix of U.S. utility energy emits 16,376 pounds of carbon per year. In 2000, the U.S. EPA estimated the annual carbon emissions of an average U.S. passenger car at 11,450 pounds per year. Thus, on average, each home that is powered 100% by wind, which emits no carbon, reduces emissions equivalent to taking 1.4 cars off the road. Wind power has other benefits as well, such as reducing dependence on foreign oil, providing dispersed back-up energy in the event of grid failures, and better air quality.

Zoning and permitting standards are often one of the biggest costs of, and impediments to, WEC installation. Conversely, well-written and reasonable standards can easily encourage installation of WECS.

[1] Watts (W) are units of power. A kilowatt (kW) is 1000 watts, and megawatt (MW) is 1000 kW. WECs are generally rated for their maximum power output capacity under normal wind conditions (as defined by the manufacturer). Energy production and use are commonly expressed in kilowatt hours (kWh), meaning a kilowatt of power used continuously for an hour.



Goals for Wind Power

Goals for wind power elements of a sustainable community development code should be to:

- Provide clear standards to protect neighbors from potential nuisance impacts of WECS (insure that one man's turbine is not another man's migraine)
- Create a predictable environment for those that invest in WECS, in terms of zoning and permitting review time and cost, and access to the wind source over time
- Limit development permitting requirements (such as studies, certifications) to the minimum necessary for rigorous review, and scale them for small versus large WECS
- Avoid overly restrictive, unnecessary provisions (such as low height limitations) that substantially reduce the effectiveness of WECS, which discourages investment in them

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LARGE-SCALE WIND ENERGY CONVERSION SYSTEMS

KEY STATISTICS:

- Approximately one percent of U.S. electrical energy was supplied by WECS as of 2007
- The theoretical wind energy potential of North Dakota is equivalent to twenty-five percent of U.S. energy demand [2]
- Estimates vary, but many studies suggest that WECS could reliably provide twenty to forty percent of nationwide energy needs
- Utility -scale wind power generation is typically developed in areas of Class 4 or 5 winds (in some cases, Class 3 winds are sufficient)
- Typically, each MW of electricity capacity from a wind farm can power 240-300 homes.[3] Thus, a wind farm of 50 1.8 MW wind turbines operating at full capacity could power more than 20,000 homes
- Large scale wind is defined as a WEC that produces 1000 kWh annually; many modern wind farm WECS are 250 to 400 feet tall and are rated at 1.5 to 1.8 megawatts

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		Achievement Levels (Note: Higher Achievement Levels Generally Incorporate Lower Levels)				
		Bronze (Good)	**Silver (Better)**	**Gold (Best)**	**References/Commentary**	**Code Examples/Citations**
 A 0.9 MW turbine is erected in the agricultural landscape of Iowa. Credit: NREL	**Remove Obstacles**	▪ Repeal any outright ban on WECS. Instead, regulate to manage impacts ▪ List WECS as an exception to general height limits ▪ Identify areas that are suitable for large-scale WEC facilities in local plans and land use maps ▪ Identify areas that are off-limits to WEC facilities due to scenic, natural, and other values. Avoid the still-borne project syndrome	▪ Allow large-scale WECS as a special use subject to performance standards to speed, and reduce costs, of permitting ▪ Enumerate specific standards vs. case-by-case negotiation ▪ Do not allow rejection of WEC facilities on aesthetic grounds except in specially designated areas	▪ Allow large-scale WECS as a by-right use subject to performance standards to speed, and reduce costs, of permitting ▪ Allow energy produced by a large WEC on one property to be used off-site by property owners who record formal agreements (known as "community wind")	▪ Some states (e.g., CA, NV, WI, NJ, and MI) have passed legislation that restricts local control of WECS to ensure that local regulations are designed to address impacts rather than prohibit WECS ▪ The National Renewable Energy Laboratory (NREL) and U.S. Department of Energy (DoE) provide state wind resource maps that help assess typical wind in a local area Available online. Retrieved January 11, 2011. ▪ A single, large WECS is more cost effective than many small WECS	▪ The American Wind Energy Association offers an excellent siting guide for large-scale wind. Available online. Retrieved January 11, 2011. ▪ Integrating wind power into traditional utility systems has unique challenges. National Renewable Energy Laboratory's provides a range of integration studies and resources. Available online. Retrieved January 11, 2011. ▪ Site-specific assessments are necessary to determine local wind capacity. NREL offers a wind resource assessment handbook. Available online. Retrieved January 11, 2011. ▪ Town of Hull, MA, Installation of two large WECS as part of the municipal utility system. Each is freestanding, and is not part of a wind farm. Available online. Retrieved January 11, 2011.

[2] American Wind Energy Association. *How much energy can wind realistically supply to the U.S.?* Available Online. Viewed 1/6/09.
[3] American Wind Energy Association. *Wind Industry Statistics.* Available Online. Viewed 1/6/09.

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A 44 MW wind farm in West Virginia. Credit: NREL

Beauty in the eye of the beholder: A WECS against a sunset. Credit: NREL

	Bronze (Good)	Silver (Better)	Gold (Best)	References/Commentary	Code Examples/Citations
Create Incentives		▪ Lower or eliminate zoning and permitting fees for utility WECS	▪ Map local areas, identifying wind resources and current uses compatible with utility wind development, and list utility WECS as a by-right use in these areas	▪ The cost of developing wind power is comparable to more traditional utility power. In some places, voters have required utilities to develop sources of renewable energy	
Enact Standards	▪ Adopt standards for utility-scale WECS vs. case-by-case negotiation ▪ Adopt setback standards for wind farms of at least 1000 feet ▪ Exempt utility WECS from district height limitations ▪ Adopt noise standards that regulate the noise level at the property line and protect nearby residents ▪ Do not restrict WECS from prime wind access areas ▪ Adopt standards for minimum ground clearance for the rotor blades. 30 feet is a typical minimum	▪ Allow complementary uses of the land around WECS, such as agricultural uses ▪ Require soils studies to ensure stability adequate for the heavy loads of large WECS ▪ Require shadow and noise modeling to ensure that flickershadow or vibro-accoustical effect will not degrade property values on nearby residences	▪ Zone areas with ideal utility wind power conditions (undeveloped areas with Class 4 or 5 winds near the power grid) for uses that are compatible with wind farm development ▪ Map areas with endangered bird species or major bird migratory corridors and restrict wind farm development in these areas ▪ Require utility companies to restore vegetation disturbed by turbine installation	▪ Setbacks of 1000-1500 feet are generally accepted as adequate to address risk of "ice throw," "flickershadow," or "vibro-accoustical" effects. Studies of sound and shadow effects are appropriate if setbacks are smaller ▪ Without actual nuisance impacts (e.g., noise, flickershadow), studies show no evidence that being within view of a wind farm depresses property values. Available online. Retrieved January 11, 2011. ▪ Avian impacts from turbines are typically very limited outside of major migration corridors. The Audubon Society endorses well-sited wind turbines. Available online. Retrieved January 11, 2011.	▪ Many states offer model WECS ordinance language. Two examples that focus on utility wind facilities are Pennsylvania Available online, and Massachusetts. Available online. Retrieved January 11, 2011. ▪ Many local WEC ordinances in counties and rural areas focus on large, utility WECS. Two examples are Manitowoc County, WI. Available online, and Antis Township, Pa, which requires a minimum WEC size of 2 MW. Available online. Retrieved January 11, 2011.

Sustainable Community Development Code Framework

RENEWABLE ENERGY: WIND POWER

SMALL-SCALE WIND ENERGY CONVERSION SYSTEMS (WECS)

KEY STATISTICS:

- Small-scale wind is typically defined as WECS rated to produce electricity at a rate of 100 kW or less
- In moderate (class 3) winds, a small WECS with rotor diameters between 4 and 7 meters generates, on average, enough electricity to power one average U.S. home
- More than half of the U.S. experiences winds of class 3 or better at an elevation of 50 meters
- Every average U.S. home powered by 100 percent wind energy avoids carbon emissions equivalent to removing 1.4 average U.S. passenger cars from the road[4]

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		Achievement Levels (Note: Higher Achievement Levels Generally Incorporate Lower Levels)				
		Bronze (Good)	**Silver (Better)**	**Gold (Best)**	**References/Commentary**	**Code Examples/Citations**
 This home uses both solar and wind technology. Credit: NREL	**Remove Obstacles**	▪ Repeal any outright ban on small WECS. Instead, regulate to manage impacts ▪ Explicitly list small WECS as an exception to general height limits ▪ Exempt rooftop WECS from screening requirements for rooftop electrical and mechanical equipment	▪ List small-scale WECS as a conditional use in non-residential and large-lot residential districts ▪ Scale performance standards and permitting requirements to be appropriate for small WECS, do not treat as large WECS ▪ Preempt home owner association covenants where they contain general prohibitions (such as on accessory structures) that inadvertently prohibit small WECS	▪ Allow small WECS as a by-right use subject to performance standards to speed and reduce costs of permitting ▪ Allow small turbines in a wider range of zone districts including industrial, urban, commercial, large-lot residential, and suburban zone districts ▪ Avoid requiring "camouflage" of WECS in tree colors. The factory color of most turbines, matte grey, is best for blending into a range of sky conditions	▪ Wisconsin state law prohibits municipalities from placing restrictions on WECS except to protect or preserve public health or safety, and where cost does not significantly increase or efficiency decrease. A special exception is provided that WECS may be excluded from a scenic byway of statewide importance. Available online. Retrieved January 11, 2011. ▪ A recent study in Warwick, U.K., (Available online) showed that very few rooftops have fast, clean wind the needed for efficient power generation. Thus, allowing exclusively rooftop WECS has very limited benefit to a property owner, the environment, or the community.	▪ Town of Nevada, IA, zoning regulations allow small WECS by right in the industrial districts and by special use permit in all other districts, subject to performance standards. WECS are exempt from the general height restricts of the zone districts, but height is limited through a use standard. Available online. Retrieved January 11, 2011.

[4] Heller, E. *Wind and Solar Energy Production and the Sustainable Development Code*, RMLUI Symposium. 2007. Available online. Viewed 1/6/09.

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 A rooftop WECS was integrated into this new San Francisco home. Credit: R. Wood.  In Saco, Maine, this small WECS supplies power for the transit station. Credit: City of Saco, ME.	**Create Incentives**	▪ Give credit for on-site WECS in any green-building or performance-based development review points system ▪ Reduce or eliminate zoning permitting fees for small WECS	▪ Rather than limit power generation to on-site use only, as is often done in defining small utility/power generation facilities, allow some excess production, as long as on-site use is the primary purpose and the production is non-commercial	▪ Use district-wide building height limits to protect wind access and increase predictability for those that invest in WECS ▪ Encourage net metering caps of not less than 5MW, if at all, to encourage development of distributed energy generation ▪ Map areas with the best wind potential and restrict new uses to those that are locally acceptable in conjunction with small turbines	▪ Some communities restrict power generation to "on-site use," eliminating the potential community benefit of excess clean energy to help balance community impacts. A better approach is a limit overall system size for distributed generation, net metering, and/or grid interconnection, such as to 5MW ▪ The LEED Neighborhood Certification includes credit for on-site energy generation. Available online. Retrieved January 11, 2011.	▪ Eagle County, CO (Available online) and Marin County, CA (Available online) are examples of communities with performance-based permitting systems that award points for producing wind energy. ▪ Some states and utilities offer incentives. The state of Oregon offers a residential tax credit for wind turbines of $2 per kWh produced during the first year, up to $6,000. Available online. Retrieved January 11, 2011.
		Bronze (Good)	**Silver (Better)**	**Gold (Best)**	**References/Commentary**	**Code Examples/Citations**
 A 100 kW WECS in an industrial area of Dorchester, Massachusetts. Credit: NREL.  A 2 kW WECS fits into a residential neighborhood in Winter Harbor, Maine. Credit: NREL	**Enact Standards**	▪ Adopt standards that are scaled for small versus large WECS ▪ Adopt setback standards for WECS of 1.1 - 1.5 times the total turbine height (support structure height + rotor radius) ▪ Exempt WECS from district height limitations, similar to flagpoles or cell towers. Allow WECS to be placed at least 25-35 feet higher than structures or tree line within 300 feet of turbine ▪ Define small WECS according to the industry standard of 100 kW or less ▪ Require one "Danger High Voltage" sign. Only require fencing or anti-climbing features as for similar attractive nuisances (e.g,	▪ Adopt standards that allow for alternative compliance, such as: ○ setback standards that may be decreased if a building inspector certifies correct installation or if neighbors record waivers ○ climb-ability standards that do not require fencing if there are no climbable features below 12 feet above ground level ▪ Adopt height standards for buildings in all urban districts, to provide predictability about obstructions and wind turbulence for property owners that are considering installing a WEC ▪ Adopt standards for minimum ground clearance for the rotor blades (thirty feet is a typical minimum) ▪ Require proof of approval of a grid connection from the local utility to	▪ Require that new developments of high energy consuming uses generate on-site energy using renewable resources such as geothermal, solar, or wind ▪ Optimize wind access with height standards that allow WECS to be twice as tall as surrounding structures and mature trees ▪ Allow energy produced by a small WEC on one property to be used off-site by neighbors who record formal agreements	▪ Small turbines do not have "ice throw," "flickershadow," or "vibro-accoustical impacts; Siting or environmental impact studies need not be required for small WEC permitting. Available online. Retrieved January 11, 2011. ▪ Bird kill from small WECS is extremely limited: less than the kill rate of a house cat or sliding glass door. Available online. Retrieved January 11, 2011. ▪ Restrictive height limits expose small WECS to much greater wind turbulence, which dramatically deteriorates performance and longevity, undermining cost effectiveness. The DoE's Wind powering America program offers a web presentation on the importance of tower height. Available online. Retrieved January 11, 2011.	▪ Many states offer ordinances for municipalities. The draft Wisconsin (Available online) and Michigan models (Available online) are examples that include standards specifically for small WECS. ▪ City of Centennial, CO, zoning ordinance allows small WECS by right in any zoning district with just a building plan check, and includes simple, clearly written standards to address potential impacts. Available online. Retrieved January 11, 2011. ▪ City of Chicago, IL allows rooftop WECS as a permitted accessory use, subject to setbacks and noise limitations. Available online. Retrieved January 11, 2011. ▪ City of Duluth, MN allows a WEC, up to 130 feet tall, as a permitted accessory use on lots in suburban, commercial, and industrial districts. Available online. Retrieved January 11, 2011.

 After one neighbor installed a small WECS, several neighbors followed suit in the upscale community of Oak Hills, California. Credit: NREL		swimming pools, cell towers) ▪ Adopt noise standards that regulate the noise level at the property line ▪ Require underground placement of transmission lines from the WECS to the user or power grid to the maximum extent feasible ▪ Instead of a minimum lot size, allow WECS on any lot where it meets setback, sound, and all other standards ▪ Do not require screening of WECS, which reduces their efficiency and cost-effectiveness	enable net metering ▪ Restrict small WECS in limited historic, scenic, or other special character areas where their visual impact is unacceptable to community members ▪ Do not require WECS to be lower than mature trees, which reduces their efficiency and cost-effectiveness			▪ City of Henderson, NY allows rooftop WECS as a permitted accessory use in all districts, small WECS as a special use in business districts and some residential districts, and wind farms as a special use in some districts. Available online. Retrieved January 11, 2011. ▪ Camden County, NC wind ordinance setbacks are based on the height of the WECS. Smaller setbacks are allowed with a wind easement from an adjacent property owner. Permits for large WECS require an acoustical study, but not for small WECS. Available online. Retrieved January 11, 2011.