Renewable Energy Research Laboratory, University of Massachusetts at Amherst

Wind Power: Performance & Economics

Wind Power on the Community Scale

Community Wind Power Fact Sheet # 2

RERL—MTC Community Wind Fact Sheet Series

In collaboration with the Massachusetts Technology Collaborative's Renewable Energy Trust Fund, the Renewable Energy Research Lab (RERL) brings you this series of fact sheets about Wind Power on the community scale:

1. Technology
2. Performance
3. Impacts & Issues
4. Siting
5. Resource Assessment
6. Wind Data
7. Permitting

Wind Power Performance, Economics, and Integration

This introduction to wind power technology is meant to help communities in considering or planning wind power. It focuses on commercial and medium-scale wind turbine technology that is available in the United States.

This fact sheet also discusses the integration of wind power into the electrical grid, and the implications of wind power for the regional electrical system.

The focus of this series of fact sheets is medium- and commercial-scale wind.

We also recommend a visit to a modern wind power installation – it will answer many of your initial questions, including size, noise levels, footprint, and local impact. A list of some of the nearest wind power installations is on the last page.

Inside this Edition:

When the wind doesn't blow

A commercial-scale wind turbine delivers varying amount of electricity into the power grid, depending on the wind speed. Even though the power (kW) varies, every kWh it makes is a kWh that is not made by other, dirtier, sources. Experience in the US and around the world has demonstrated that while intermittency has some cost, it is a small percentage of the cost of producing electricity. Refer to supplemental Fact Sheet #2a, and Fact Sheet #1 on Technology, for more detail.

Community-owned wind power at the Spirit Lake, IA, elementary school

Capital Costs and Income

A brief introduction to making money from wind

A well sited and well planned community-scale wind installation in Massachusetts can make modest profits. This is a brief look at the costs and revenues involved in community wind projects.

Income Sources

A community that owns a medium- or commercial-scale wind turbine in New England has, in a sense, three potential income streams:

1. Use and/or sale of electricity (kWh)
2. Sale of Renewable Energy Certificates (REC's)
3. Federal production tax credit (PTC) or Renewable Energy Production Incentive (REPI), when available.

First, the energy (kWh) is sold or used. Energy used on-site is more valuable because it avoids buying energy at the retail price, which includes charges for transmission, distribution, etc. Any power that is not used on-site is sold on the market, typically under a contract referred to as a power purchase agreement, or PPA.

A second contract is needed to sell the Renewable Energy Certificates (REC's) that are "generated" along with the power.

Finally, a federal production incentive may offer either a tax credit or a payment of 1.5-1.8 ¢ / kWh.

Capital Costs

In Massachusetts, installed costs for commercial-scale turbines might be expected to be in the range of $1.2-1.5 Million/MW, i.e. a 1.5 MW machine might cost $2.25 M to purchase and install.

This town-owned wind turbine provides income for the Hull municipal light company

Energy Production Estimates

The amount of energy (MWh) that a wind turbine makes each year depends on many things, but the biggest factors are the wind speed at hub-height, and the size and type of turbine. This table gives a rough estimate of the amount of energy that a commercial-scale wind turbine could make. Use this information to estimate the impact of site choice (i.e. varying wind speeds) and turbine choice (e.g. varying sizes.) See the supplement, Fact Sheet 2a, for more discussion of capacity factor.

A variety of assumptions must be made to estimate capacity factors, so bear in mind that these are approximations and should be used only for comparison.

Annual avg. wind speed at hub height	Estimated Capacity Factor	Estimated MWh/yr per 1.5-1.8 MW turbine
6.0 m/s	22% - 25%	3,320 - 3,500
6.5 m/s	27% - 30%	3,920 - 4,190
7.0 m/s	31% - 34%	4,500 - 4,880
7.5 m/s	35% - 39%	5,150 - 5,540

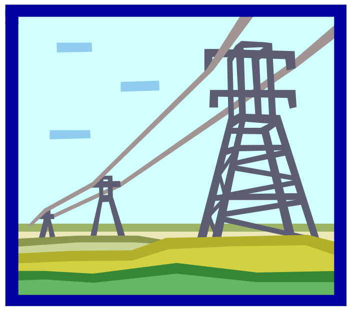
Assumptions used here: Based on manufacturer's data and manufacturer supplied power curves for commercial turbines available in the US in 1.5-1.8 MW size range. Other size turbines area available. Assume Rayleigh distribution, constant sea-level air density, etc. Assume 5% losses to account for unavailability, transformer losses, etc. Binning for estimates is conservative, i.e. based on the lower end of ranges. Note that when considering TrueWind mean speed estimates, they may be given at a hub height of 70 m. Taller and shorter towers are possible. Lower hub heights could result in a lower capacity factor.

Picture credits: 750 kW NEG Micon Turbine in Moorhead Minnesota, source: National Renewable Energy Laboratory, Photographic Information Exchange. Hull Municipal Light Plant, Vestas V47, 660 kW, photo: Doug Welch

Wind Power on the Regional Electric Grid

What is the grid?

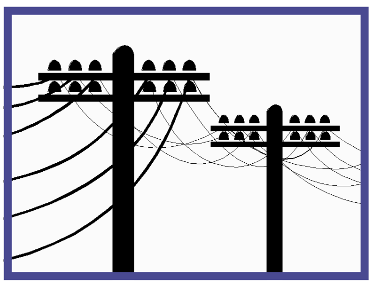
The grid is our regional electric system. The complex system consists of all the generators in a region, all the electric loads (such as lights, refrigerators, motors, etc.) and all the transmission and distribution power lines that connect them. The New England grid is managed by ISO New England (New England Power Pool) headquartered in Holyoke, MA.



Transmission

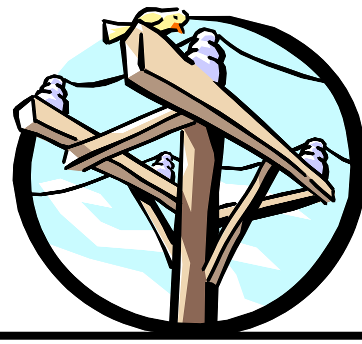
Power is transmitted long distances at high voltages then dropped down to medium voltages for local distribution.

Some typical transmission voltages are 115 kV (kilovolts) and 138 kV.



Distribution

Electricity is distributed locally at medium voltages. Some typical distribution voltages are: 13.8 kV, 34.5 kV, and 69 kV.



Grid Interconnection

The New England regional electric grid is a complex balance of millions of loads and thousands of generators. The electric loads fluctuate constantly, and at any given moment, the generators must deliver exactly the amount of power that the loads use.

Any commercial-scale wind turbine in New England will be connected to the grid. If only one or two turbines are installed at a site, their transformers may be connected into most points in the distribution network. A project with more than a few turbines will require the construction of a new substation. In either case, an interconnection study must be submitted to ISO-NE and the owners of the transmission or distribution lines at point of interconnection. A Facility Study then determines what, if any, additional electrical components are required

Impact of Wind Power on the Grid

How are utilities reacting to windpower? How does it affect their operations?

A number of US utilities formed a consortium, the Utility Wind Interest Group (UWIG), to study the implications of increasing amounts of wind energy on the grid, including the impact of intermittency on day-to-day utility planning and load-following capability. A recent summary of their work concluded, "Work conducted to date has shown that wind power's impacts on system operating costs are small at low wind penetrations (about 5% or less). In most cases, these incremental costs would detract from the value of wind energy on current wholesale markets by 10% or less. At higher wind penetrations, the impact will be higher, although current results suggest the impact remains moderate with penetrations approaching 20%. While wind power does have some costs associated with grid operations, it also has some advantages from the utility's point of view, including short construction lead times, modularity, no emissions, and higher customer approval.

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Community Wind: US Examples

Many towns are benefiting from community-owned or sponsored wind projects. Massachusetts does not have the broad expanses of land that some Western and Midwestern states do, so land-based wind power here is more likely to follow these examples of community-scale wind:

- Hull, MA: Municipal electric company owns Vestas V47, 660 kW: hullwind.org
- Mackinaw City, MI, leases town land to owner of two 900 kW turbines www.mackinawcity.org/
- Moorhead, MN: municipal utility owns 2, 750 kW turbines www.mpsutility.com/capture.htm
- Traverse City, MI: 660 kW, sol.crest.org/efficiency/ghgcasestudies/utilities/traverse.html
- Worthington, MN, 4, 900 kW turbines www.riverwinds.biz/watch_us_grow1.htm
- Spirit Lake, IA school owns two turbines. www.spirit-lake.k12.ia.us/dist/bg/wind.htm and www.greenpowergovs.org/wind/Spirit Lake case study.html
- Lac qui Parle, MN: the school district bought a 225 kW turbine in 1997 .
- Waverly Light & Power, IA operates 3 turbines wlp.waverlyia.com/search_wind.asp
- Kotzebue, AK: Kotzebue Electric Assoc. owns Atlantic Orient & NPS Northwind turbines.
- Forest City, IA, school owns 600kW Nordex
- Blackfeet Nation, MT owns a Vestas V-17
- Rosebud Sioux, SD, 750 kW NEG Micon
- Pipestone School , MN, 750 kW NEG Micon
- Algona, IA municipal utility, 3 x750 kW

Community-owned wind turbine in Spirit Lake, IA

For More Information

A thorough and accessible introduction to wind power technology, from the Danish Wind Industry Association: www.windpower.org/en/core.htm

Wind Energy Explained: Theory, Design and Application, Manwell, McGowan, & Rogers, Wiley, 2002

The Utility Wind Interest Group's Operating Impacts Studies analyze the costs and impacts of integrating wind power into the grid: www.uwig.org/operatingimpacts.html

For the on-line version of this fact sheet with live links, and the rest of the fact sheet series, see RERL's website: www.ceere.org/rerl/about_wind/

For links to more sources, see www.ceere.org/rerl/rerl_links.html

"Wind Power Can Fund Schools" campaign, Utah state energy office