Wind Energy

To a certain extent, wind energy can be thought of as a derivative of solar energy – winds are created as the sun heats the atmosphere unevenly, creating convection currents. The Earth's rotation and irregularities in its surface also contribute to wind flow. Wind turbines capture the mechanical energy of wind and convert it into electrical energy. Turbines range in technical specifics and size. Individual homes can be powered by turbines in the 2-10kW range, whereas utility-scale wind farm projects often rely on turbines up to 1-2.5 MW in size. (The largest wind turbine in production can generate 7 MW!)

Horizontal vs. Vertical Axis Turbines

The most common wind turbine rotates around a horizontal axis with its main rotor shaft and electrical generator mounted at the top of a tower. Horizontal axis wind turbines must be pointed into the wind to be effective, and the rotor shaft is often programmed to swing around and face the direction of the wind at any given moment. Wind turbines are also sometimes designed around a vertical axis, which doesn't require them to face into the wind (as it can turn the turbine if it hits it from any direction).

Vertical axis wind turbines are more difficult to mount on towers, and are usually installed either at the ground level—at reduced wind speed potentials—or on rooftops.

Intermittency

The main challenge with wind energy is its intermittent nature. In addition to their power capacity (kW or MW), wind energy systems are rated with a **capacity factor,** a percentage that reflects the amount of energy a system actually generates relative to the amount of energy it could generate if it was in operation 24/7 (recall that the amount of energy generated is proportional to the duration over which power is drawn).

Conventional power plants, which can operate constantly and need only be taken offline for routine maintenance, tend to have a capacity factor between 40 and 90 percent. Wind energy systems are more typically rated with a capacity factor between 20 and 40 percent.

For small-scale wind turbines attached to specific facilities, there are two options: remain interconnected with the grid, receiving power from it when the wind is not blowing, or back up the system with batteries or other generating systems to maintain a steady source of energy.

At the grid-level, wind energy is said to be "non-dispatchable," meaning it cannot be turned on and off at will. This generally means that large wind resources must be balanced out with grid storage (such as pumped hydroelectric storage) and complemented by solar energy (which generally peaks when wind energy is at a minimum).

It is believed that if wind power were to constitute more than 20% of a grid's total energy supply, it could lead to destabilization of the grid, although advances in smart grid/demand response technology could help prevent this.

What is the status of wind energy in Massachusetts?

Wind power is currently the primary energy source used to meet RPS requirements in Massachusetts (83% of the total obligation in 2011) and Massachusetts is second to New York in wind RECs produced. The Commonwealth has a goal to install **2,000 MW of wind energy by 2020,** which would amount to about 10% of the state's anticipated power supply.

At the moment, the state has about 565 MW of installed wind capacity and is on pace to meet the 2020 goal. The greatest wind resources in the Commonwealth lie on the coast and on ridges in central and western Massachusetts, but there are also significant regions of wind potential in other inland areas.

Commonwealth Wind

In order to promote development of wind projects within state borders, MassCEC sponsors multiple tiers of Commonwealth Wind funding programs.

"Micro-wind" projects (systems rated 1-99 kW) and community-scale wind initiatives (systems over 100 kW) can be located on residential, commercial, industrial, public, or institutionally owned facilities but must be served by a utility (investor-owned or municipal light plant) that pays into the Systems Benefit Charge (SBC).

MassCEC also runs a funding program for the development stages (feasibility assessments, etc.) of commercial wind energy facilities to minimize early-stage risk associated with such projects, although no solicitations are currently open for proposals.

Projects in the MAPC region include:

- Two installations that equal 6.5 MW in Gloucester
- A 1.5 MW project in Scituate
- A 600 kW project in Chelsea

This is about 8.6 MW of wind power in the MAPC region alone, enough to power 1,800-3,200 homes.

How do I develop wind energy in my community?

Communities wishing to construct a wind farm (as opposed to installing small-scale, distributed turbines) should consider a number of factors, including zoning bylaws, land resources, access to capital, and market access.

Read a sample zoning bylaw put out by the DOER.

The unique terrain of each community will determine how much land is necessary to construct larger projects (the American Wind Energy Association states that some windy ridge areas can yield 1 MW in as little as 2 acres, but this number will range based on each community's land resources).

Before constructing a wind turbine project, some initial capital must be sunk into feasibility assessments. Basic criteria for a viable wind site include:

- **Wind speed:** The DOER requires sites have a minimum wind speed of 6 meters per second, from measurements taken at 70 meters above the ground, in order to be eligible for grant funding. A rough approximation of the wind speed at your site can be determined using the Wind Energy Site Screening tool, although site-specific information may be difficult to glean from these maps.

- **Topography and surface roughness:** Sites near tall cliffs, trees, or buildings may suffer from turbulent wind flow, which can reduce the amount of energy harnessed from wind as well as increase maintenance costs. Sometimes constructing taller turbines can overcome these problems.

- **Proximity to residences:** Turbines should be located a minimum of 1,000 feet away from residences to avoid noise interference.

- **Proximity to airports:** Projects within 3-5 miles of an airport may face turbine size limitations.

- **Access to transportation:** The site must have access to or be viable for the construction of roads that can support the transport of wind turbine construction equipment and components.

- **Distance to transmission lines or load:** The closer turbines are to either transmission lines or facilities that can consume the electricity they produce ("load"), the better the economics of the project will be.

- **Environmental protection issues and permitting:** If the project is located in or near a space designated as a Natural Heritage & Endangered Species Program area, a wetland, open space, MassAudubon Important Bird Area, or a current/former landfill, it may face complications in the permitting process. Although avian fatalities from wind turbines are low in comparison to those from power lines or buildings, an "Avian Risk Assessment" is recommended for early stage planning to determine factors such as the location of nesting areas, availability of prey, or local raptor populations.

For more information on siting considerations, see:

- Center for Energy Efficiency and Renewable Energy: Wind Power: Siting in Communities fact sheet
- AWEA: 10 Steps to Developing a Wind Farm

The cost of constructing wind projects can be high. Residentially sized turbines cost, on average, about $30,000. A larger 100-kW turbine can cost up to $350,000, and utility-scale wind farm turbines are even more expensive. However, they can be designed to be cost-effective. Make sure that the type of turbine and other manufacturing equipment purchased is ideally suited to your sites and community needs.