Wind Energy in Pennsylvania

What is wind energy?

Contemporary wind energy involves the conversion of kinetic energy in the wind into electricity via wind turbines. However, wind energy has been harnessed by humans throughout history via sails to propel ships, windmills used to mill corn or saw wood, and wind pumps for pumping well water for irrigation. Over the last twenty years wind turbine technology has developed to a point where, in some locations, wind generated electricity is cost competitive with conventional generation technologies. Unlike conventional fossil fuel electricity generation processes, wind turbines use no water resources and emit no air pollutants.

How is it used?

Large-scale wind farms comprised of multi-MW wind turbines are connected to the grid to power our homes and businesses, while smaller facilities are used to provide electricity to isolated locations. Wind energy as a power source is attractive as an alternative to fossil fuels because it is plentiful, renewable, widely distributed, clean, and produces no greenhouse gas emissions. While wind energy may be purchased by an end user hundreds of miles away, the electricity actually produced by a wind farm is used within the vicinity of the installation, as electricity flows via the path of least resistance. However, the construction of wind farms is somewhat controversial because of their visual impact and siting complexities that influence their potential impact on the environment.

What resources does it require?

The most critical component to a cost effective wind energy installation is the presence of a strong wind resource. Wind maps are one way to begin the process of investigation of a site's wind power resource, but nothing replaces on-site data collected from an anemometer placed near the hub height of the proposed turbine installation. Most wind installations will be characterized by "capacity factors," (the percent of power generated in a year compared to what the turbine would produce operating at its full generator capacity) on the order of 20-40%. Higher capacity factors are better, but should not be compared with fossil generation capacity factors, nor should they be the deciding factor in selection of a turbine for a site (economics should be the driver).

The next most important element for a wind installation is the proximity to a transmission system and/or an end user, if the installation is off-grid. In a wind farm, individual turbines are interconnected with a power collection system and communications network at a substation. The power produced by the turbines can be fed into the network and sold to the utility company.

While wind turbines do not consume any fuel nor emit any pollutants during their operation, resources are consumed and small quantities of pollutants are generated during the manufacturing of the system components. A lifecycle analysis shows both the energy and the emissions resulting from the various manufacturing processes for each component in the system. For example, one manufacturer found that the average net CO_2 impact of their wind turbine over a year compared to a coal power plant results in a savings of 93,000 tons of CO_2. Additionally, they report that the turbine produces, on average, 31 times more energy than that consumed in the manufacturing process over its twenty year lifetime .

What is its potential for Pennsylvania and the Northeast?

Pennsylvania is one of the East Coast leaders in wind energy in the U.S. due its good wind resource and incentives provided by the state government. Pennsylvania is also close to several potential offshore sites along the Atlantic coast. Gamesa, one of the largest wind turbine manufacturers in the world, located its U.S. headquarters in Philadelphia and has built several wind farms in the state.

Wind energy is also providing many economic advantages in the state, including lessening our dependence on fossil fuels, providing a steady income to land owners, increasing the property tax base for rural counties, reducing emissions and providing tax credits.

What issues are limiting their use?

Most forms of electricity production are dispatchable, meaning the fuel can be converted to electrical energy at a rate controlled by the operator. This allows the electric utility industry to adjust power output to meet demand. Wind power is not dispatchable, meaning wind farms cannot provide a steady supply of power and it is impossible for them to provide power on demand. Energy storage would help allow for a more balanced supply of wind energy, and therefore grid systems which also include hydroelectric generation have generally found a nice balance between wind and hydro. However, without a way to store some portion of the wind generated electricity, the production of wind energy must be monitored in a similar manner as the demand on the grid is monitored, to ensure a match between production electricity and consumption. This balancing act is being handled by electric balancing authorities across the country to manage the 60,000+ MW of existing wind energy capacity, but is thought to have some limiting penetration level, varied by utility, with the current electric transmission and distribution infrastructure.

Although wind power plants have relatively little impact on the environment compared to fossil fuel power plants, concerns have been raised over the sound produced by the rotor blades and aesthetics. Wind turbines produce some sound when they operate, but most of the turbine sound is masked by the sound of the wind itself. The sound at a distance of ½ mile is similar to an airplane passing over in the distance. Shadow flicker may also occur for several minutes per day at certain times of the year, which can irritate nearby residents. Proper sitting decisions can help alleviate these concerns.

There are also concerns about bird and bat deaths, one of the most controversial biological issues related to wind turbines and drawing the attention of fish and wildlife agencies and conservation groups. Proper siting and technology improvements from the early wind farms in the 1980's has reduced bird impacts to well below other anthropogenic sources (i.e. buildings and power lines) . Project developers are required to collect data through monitoring at existing and proposed wind energy sites and make careful sitting decisions. Additionally, research has been conducted in Pennsylvania on bat fatalities which has found a 53-87% decrease in fatalities via an operational change of the turbines at the Casselman wind farm . Because the majority of the bat deaths occur during the fall migration at low wind speeds, the turbine's operational cut-in wind speed was increased in this study during this period.

Other wildlife can also be disrupted because approximately an acre needs to be cleared per turbine. To address these issues, the wind industry, government and non-government agencies have come together in Pennsylvania to form a Wind Farms and Wildlife Collaborative that reviews proposed wind projects and makes recommendations for individual turbine placement to reduce potential environmental impacts.

References

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For More Information

To learn more, visit Penn State Extension's Renewable and Alternative Energy web site (energy.extension.psu.edu) – click on "Energy Use and Efficiency".

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