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Wind Power - Part 2

by Jeffrey C. Bahret, PE

In our Winter 2005 Newsletter, we discussed some of the parameters and physics in calculating the amount of energy available from the wind. The subject of windmills has become one of keen interest and significant controversy in recent years. Undoubtably, this is the reason why we received so many questions and inquires about this subject upon the Newsletter's publication.

As with the earlier article, we will limit our discussion to smaller residential/commercial wind turbine units of 2 to 15 kw (kilo-watt). Part 1 of our discussion dealt with the power available from the wind in the form of "power density". The power density has two main counterparts: velocity and elevation. In this article we will study the next step in the process, that being the "Power Output" of a wind turbine unit. This is the resultant "nuts and bolts" portion of the evaluation. The following will present some simple techniques and supporting examples that will permit approximation of the "Power Output" from a modern wind turbine machine for a given site.

Once you have determined the power density, you can easily estimate the potential power output from a wind machine. All that you need to do is find the total area swept by the turbine's rotor.

As an example, say a windmill sweeping 100m^2 intercepts winds with a power density of 100 w/m^2. The wind machine as a result, intercepts 10,000 watts of power or 10 Kilowatts.

$$P = P/A \times A$$

Since there are 8,760 hours in one year, 87,600 Kilowatt hours of energy (*E*) annually pass through the rotor disc.

$$E = P \times t$$

When the rotor's intercept area is not given or known, it can be easily calculated. On horizontal axis wind turbines use the formula for the area of a circle where *R* is the rotor's radius in meters.

$$A = \pi R^2$$

Use the formula for the area of a rectangle when calculating in intercept area of straight-bladed vertical axis machines

$$A = DH.$$

Now you are able to calculate the power available in the windstream striking any rotor. Take the problem of a 10 meter rotor unit sited in the location where the power density is 110 w/m^2:

Area = $\pi(5)^2$= 80 m^2
Power = *110 w/m*^{2} x 80m^2 = 8,800w
Power/year = 8.8 kw x 8760 hr/yr = 77,000 kwh/yr

Note that this is the power intercepted not the power captured by the wind turbine.

Once the maximum amount of energy available is known, another quick calculation will tell you approximately how much power will be extractable and then be put to use.

Wind generators capture approximately 60 percent of the power available in the wind. In fact, even the best most modern systems can extract little more than 40 percent. Most small wind generators operate at about an overall efficiency of 30 percent. To find the energy captured, simply multiply the energy intercepted by 30 percent. In the previous example, we found that a 10 meter turbine in an area with a calculated 110w/m^2 power density would intercept 77,000 kwh annually. Using our 30 percent overall efficiency figure, we estimate that it would capture roughly 23,100 kwh per year.

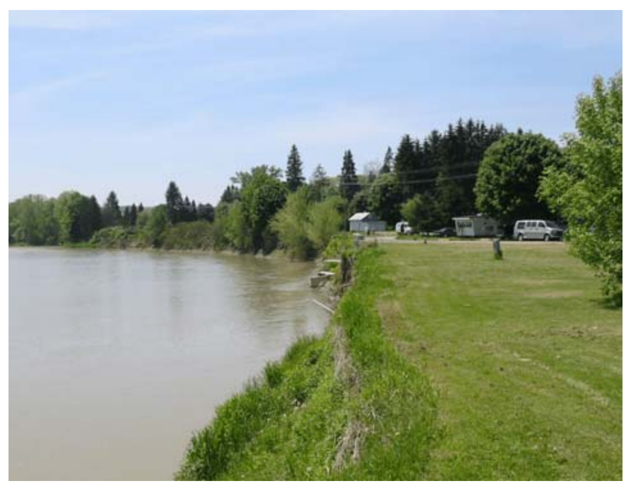
The technique described in this example is best suited for selecting the correct turbine size class to meet a client's energy needs or comparing one size wind machine with another. It tells nothing about the relative efficiency between wind turbines and it assumes an average efficiency over the whole operating range of the unit. A wind machine performance will vary with the wind regime in which it is located. Manufactures tailor their products for specific markets. Consequently, some wind turbines perform better in areas of low average wind speeds than others. The converse is true as well. To determining the performance of a specific wind turbine in a specific wind regime, another approach is needed.

In this method, the actual or projected output characteristics of the wind turbine at various wind speeds are used. Manufactures always provide this data with their promotional materials. As with the calculations of power density, data on the wind speed frequency distribution is also needed. This is where computers and specialized design software comes into play. The wind turbine manufactures can fine tune this information along with the particular design characteristics of their units to select a "speed class" generator which best suits the area. Where the wind turbine generator "cuts-in" based upon air velocity speed is just as important as its rated or furling speed. Each manufacture will be different due to design configuration variations. For this key reason, it is always necessary to compare the projected yearly power output of different speed-class units from different manufactures.

Town of Hume Completes Streambank Restoration Project

By: Chris Ernst, P.E.

The Town of Hume in Allegany County, NY completed the Genesee River Streambank Restoration Project in the Village of Fillmore during the Fall of 2005 with some remaining landscaping work being finished in the Summer of 2006. The project involved approximately 900 feet of the Genesee River streambank that was steadily being eroded by the river, especially during flood events, and was threatening numerous houses, utilities and a trailer park.



Preconstruction

An Engineering Study was prepared by E&M and submitted to the New York State Emergency Management Office (NYSEMO) and the Federal Emergency Management Office (FEMA) in July of 2004 and the project was approved for final design and construction in November of 2004.

The scope of service for the project included shaping the streambank to a maximum slope of 1.5 feet horizontal to 1 foot vertical (approximately

67% grade) which was an improvement from the vertical banks that were present in the preconstruction condition (see photo). A 5-ft. x 5-ft. toe was excavated in the Genesee River streambed and geotextile fabric and heavy stone filling were installed in this toe and along the reshaped streambank. The purpose of the toe was to prevent the undermining of the stone installed along the streambank, which would in turn cause the rock to slide and allow for further erosion during flood events. The purpose of the geotextile fabric was to provide a barrier between the extra heavy stone filling and the ground underneath the stone. This way no soil will be able to infiltrate its way into the stone, thus causing a void and causing the rock to settle or slide which would again allow for further damage to the streambank.

Postconstruction

The Federal Government through FEMA funded 75% of the project, New York State funded 12.5% of the project through the NYSEMO and 12.5% was funded on the local level by the Town of Hume. The project was bid in April of 2005 and the successful low bidder was Manno Construction Inc. of Ridgway, PA with a bid of approximately $195,000.

Wetlands

By: Allan R. Vanderpoel, P.E.

Wetlands are a fact of life that must be considered in every construction project today. One of the first recommendations we at E&M give to developers is to have a wetland delineation done on a site that is being considered for any type of earth disturbance.

With the importance of wetlands today, it is not surprising that one of the most often asked questions is “What exactly is a wetland?” The definition can be confusing and varies slightly by state.

Pennsylvania defines wetlands as areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas.

New York defines wetlands as those areas of land and water that support a preponderance of characteristic wetland plants that out-compete upland plants because of the presence of wetlands hydrology (such as prolonged flooding) or hydric (wet) soils. Freshwater wetlands commonly include marshes, swamps, bogs, and fens.

Basically, the key factors that define wetlands are certain plants found on hydric soils, or in ponded areas. The plants are sometimes very indicative, such as the cattails which you often see in wet areas, but also include skunk cabbage, sensitive fern, sedges, rushes and a whole host of similar plants. The hydric soils are the abrights, atkins, buchanan, cookport, philo, pope and similar types.

It is no surprise that the hydric soils are most often found along waterways and in low valley areas. An area such as Bradford, Pennsylvania has hydric soils as the predominant soil type throughout the entire valley along the Tunungwant Creek. An indicator of the hydric soils is the rust color, which you associate with peat-types of soil.

Both Pennsylvania and New York classify wetlands by value. Pennsylvania defines certain areas as exceptional value wetlands, which are located along a wild trout stream, waterways listed as high quality, in areas of other protected resources such as habitat for threatened or endangered species, or under the designation of wild or scenic protection. Wetlands in Pennsylvania not classified as exceptional are noted as “other wetlands”. New York has four classes of wetland, ranging from Class I, which provide the most benefits to the environment, to Class IV, which provide the fewest benefits.

Obviously it is more difficult to get permits to work in the exceptional value, or Class I wetlands.

Permitting is required to do work in a wetland under most circumstances. There are exceptions such as agricultural practices. However, in most cases, the developer must attempt to avoid or minimize disturbance of the existing wetlands. In certain cases, mitigation is allowed by constructing replacement wetlands. In all cases, a permit application is required before any work can be started.

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