Displacement height

Dense vegetation, such as forests, near the wind turbine can effectively decrease the hub height of the wind turbine by increasing the height needed above ground level to reach a particular wind speed. This is called displacement height and is assumed to be equal to 2/3 to 34/ the height of the surrounding vegetation, depending on the density of the vegetation. Large buildings or other structures can have a similar impact.

from Wind Energy Resource Maps of South Carolina

Prepared by: AWS Truewind, LLC

The displacement height is usually estimated to be about two-thirds to three-fourths the maximum vegetation height. For this project, we assumed that the displacement height was 10 times the surface roughness length, which was in turn defined to be approximately 7.5% of the vegetation height. For deciduous forests with a roughness length of 0.9 m, this resulted in a displacement height of 9 m.

The effect of displacement height is to reduce the wind speed observed near the ground and to increase the apparent wind shear measured with respect to ground level. It can also reduce the wind speed measured in small clearings, since the ground appears to be in a “hole” at a depth below the vegetation canopy. The impact of this hole on wind speed diminishes as the clearing becomes large enough for the flow to reach equilibrium with the new effective ground height. As a rule of thumb, the clearing width should be at least 20 times the displacement height for the effect to be negligible at the center of the clearing, but under some conditions the minimum width should be even larger.

Speed Adjustments for Local Conditions

It must always be kept in mind that the wind conditions at a particular location may differ substantially from the predicted values because of variations in elevation, exposure, surface roughness, or other factors. The following guidelines should be followed when interpreting the information provided by the maps.

Obstacles: The Wind Map assumes that all locations to be considered for wind energy are free of obstacles that could disrupt or impede the wind flow at the height of the wind turbine. "Obstacle" does not apply to trees if they are common to the landscape, since their effects are already accounted for in the predicted speed (however note the discussion of displacement height below). However, a nearby shelterbelt of trees or a large building in an otherwise open landscape could pose an obstacle for a wind turbine. As a rule of thumb, the effect of such obstacles extends to a height of about twice the obstacle height and to a distance downwind of 10-20 times the obstacle height.

Variations in Elevation: Generally speaking, points that lie above the average elevation within a 200x200 m square will be somewhat windier than points that lie below it. A rule of thumb is that every 100 m increase in elevation above the average will result in an increase in the mean wind speed of 0.50 m/s. This rule of thumb is most applicable to small, isolated hills or ridges in otherwise flat terrain. It should be used with caution in mountains where it is difficult to determine what the "average" elevation is, and where wind flows in any event can be very complex.

Variations in Roughness: The roughness of the land surface - which is determined mainly by the height and type of vegetation and buildings - has an important impact on the mean wind speed at heights of interest for wind turbines. The MesoMap system assumes a certain roughness for each type of land cover in its land cover data base. Although the land cover and roughness may vary within a 200x200 m grid cell, the MesoMap system uses the grid cell's predominant land cover to determine the overall roughness for that cell. Consequently, local wind speed variations will result where the local surface roughness differs substantially from the grid cell's predominant roughness (example: a pasture surrounded by forest). Lower roughness sites will in general experience somewhat stronger winds, while higher roughness sites will have lower winds. The magnitude of these speed variations - which will depend on the nature and heights of the roughness elements and on the distances between roughness changes - are not easily predicted.

Displacement Height: An additional factor to consider is that the selected heights chosen on the wind maps may not always be the actual height above ground level. Where the vegetation is dense, the "effective ground level" is not the base of the vegetation because the wind flow is displaced upward. The level of zero wind, called the *displacement height*, is typically about two-thirds the height of the top of the vegetation. In dense forests the height above ground at which the predicted wind speed actually occurs *may be as much as 7-15 m (23-50 ft) higher than indicated on the maps*. For example, in an area covered by forest with an average canopy height of approximately 18 m (60 ft), the Wind Map's wind speed prediction at the 70 m (230 ft) level would actually apply to a height of 82 m (269 ft) above ground [70 + 2/3(18)].

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