WAsP and forests

There is not just one answer on how to handle forests in WAsP. How you should model a forest depends on many different factors: type of forest, porosity, density, extent of the forested area and so on. Further, is the met. mast/turbine site close to the edge or is it in the middle of a large homogenous forest? These are important considerations that you will have to take into account for each specific site/forest situation.

Far from the forest…

If the met. mast or turbine site is located far from the edges of the forest, you should simply specify the roughness length value (z_0) of the forest in the map or roughness rose – similar to the way you would specify any other roughness area. Estimating this roughness can be done following the recommendations in Dellwik et al. (2004).

Within the forest…

If the met. mast or turbine site is located well within the forest, the effective height of the anemometer or wind turbine hub is less than the nominal height. This is due to the fact that the entire airflow has been lifted somewhat because of the forest. The height of this new reference level is called the zero plane displacement height (d).

In WAsP, the zero plane displacement height is taken into account by reducing the height above the ground (z) by that amount. So, if the met. mast is surrounded by forest, you subtract the displacement height from the height of the anemometer, i.e the new height is (z-d). Similarly, if the turbine is surrounded by forest, you subtract the displacement height of the forest from the hub height. The roughness length value of the forest is specified in the map or roughness rose – just as described above.

The zero plane displacement height, as well as the roughness length of the forest, depends on the mean height of the roughness elements/canopy (trees), the density of the forest and even slightly on the wind speed. The ratio of zero plane displacement height to height of the forest (canopy) is often given as about 2/3, and typical values of the ratio of forest roughness to height of canopy are in the range from 0.05 to 0.1. However, it should be kept in mind that both zero plane displacement height and the forest roughness depend on the density and other characteristics of the forest, and that these relations still are under scientific scrutiny.

You may read more about estimating zero plane displacement heights and roughness length in the paper “WAsP in the forest” by Ebba Dellwik, Lars Landberg and Niels Otto Jensen (Scientific Proceedings, 2004 European Wind Energy Conference, London).

And in between… (near the edge of the forest)

If the met. mast or turbine site is located closer to the edge(s) of the forest, the modelling becomes increasingly difficult because of the complex flow patterns around the forest edges. Here, there are no simple answers as to how you should estimate and specify the roughness length and zero plane displacement height.

Alternatively

It has been suggested to increase the terrain elevation of the forested areas by an amount corresponding to the zero plane displacement height, while reducing the met. mast/hub height by *d* in the case of the met. mast/turbine being placed within the forest. Furthermore, to 'fill in' the space at the forest edges, where flow separation is expected to occur, by adding a slope in the front and in the back. This should cause the flow to be more physically correct when using a potential flow model like the BZ-model used in WAsP. As a rule of thumb the slope should be 1:4. This approach would then cover the effect of the forest on the overall flow – whether being *far from the forest, in the forest or near the edges*.

This alternative approach has yet to be thoroughly investigated and verified, but some encouraging observations and conclusions have been reported already.

References

Ebba Dellwik, Lars Landberg and Niels Otto Jensen. "WAsP in the forest", Scientific Proceedings, European Wind Energy Conference and Exhibition 2004, London, England, 22-25 November.

BWEA Tree Workshop (2004) URL http://www.bwea.com/planning/trees.html