

## Why MEASNET follows the requirements of IEC61400-12-1:2005 standard in the definition of cup anemometer calibration interval for wind energy applications

Anemometer calibration is one of the MEASNET recognized measurements. Current version of MEASNET “Cup anemometer calibration procedure’ is practically identical to Annex F of the standard IEC61400-12-1:2005 “Wind turbines – Part 12-1: Power performance measurements of electricity producing wind turbines”. The recommendations of this standard are specially aimed to the calibration of anemometers to be used in wind energy applications (wind potential measurements, and measurements of operational characteristics of wind turbines). The range of calibration for cup anemometers to be used in wind energy applications is specifically defined in Annex F, par F.4.

The aim of the restriction in cup anemometer calibration interval is to limit the influence on non-linearity effects. Cup anemometers are in principle non-linear devices, that is the relation between the wind speed and the instrument’s output is not linear. The non linearity effect is directly related to the wind speed range, that is **the greater the range of operation examined, the greater the effect of non-linearity**. In this sense, if a wider range of calibration is selected, then the operational characteristics estimated carry a greater uncertainty element due to the non-linearity. A well engineered cup anemometer can keep non-linearity effects within acceptable levels for a defined wind speed range. If the uncertainty related to anemometer non-linearity is to be kept as low as possible, then the calibration interval must be as narrow as allowed by the specific application of the anemometer.

A modern wind turbine may start its operation at 2 m/sec. At wind speeds below 4m/sec power production is limited, due to the very low power density of the wind flow. Optimum performance (maximum power coefficient) is obtained in the range 8 to 10m/sec. Power out put increases with wind speed up to the nominal wind speed, usually set in the range of 12 -16m/sec. Above nominal and up to cut out wind speed, active power control keeps power output steady independent of wind speed.

Because of the non-linear response of the wind turbine to wind speed, the calculation of energy produced by a wind turbine on a specific site cannot be done using gross average magnitudes like “annual average wind speed” or “wind turbine nominal power”. Instead, energy calculations are made on a bin wise method, where the energy produced in a specific time period from a specific wind speed bin is estimated



Therefore, by increasing the calibration interval above 16 m/sec, the operational characteristics of the anemometer are biased towards the range 16 to 25 m/sec where only 4.5 % of the total energy production is obtained, reducing accuracy (due to increased non-linearity errors) in the range 4 to 16 m/sec where the 95 % of energy is gained. In addition practically all modern wind turbines employ active power control techniques above nominal wind speed, which keep power output steady and independent of wind speed. If the calibration interval is extended, aiming to reduce error in the high wind speed range, this will have no effect in the accuracy of energy estimations in the same range, since power produced is practically independent of the wind speed.

Summing up the above, the definition of the calibration interval for anemometers to be used in wind energy applications in the range 4 to 16 m/sec as specified in the standard IEC61400-12-1:2005 is fully justified, by assuring optimum matching of anemometer operational characteristics with the wind speed range most critical for the specific applications.