Power Curve Working Group Round Robin Exercise 2: Correction for Turbulence Intensity

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IEC61400-12-1 Draft CD, Annex M

- Wind turbine power curves are influenced by Turbulence Intensity.
- A significant aspect of this effect is due to the averaging of the measured power output and the measured wind speed over 10 minute periods.
- When the power curve increases proportionately with wind speed the 10 minute averaging leads to an increase of the power output with increasing TI.
- When the power output increases less than proportionally with the wind speed the 10 minute averaging leads to a decrease of power output with increasing TI.
- The IEC draft gives a method for normalising test power curve data to a reference TI to allow power curves measured at different TI's to be comparable.

Method: Annex M – to correct power curve test data

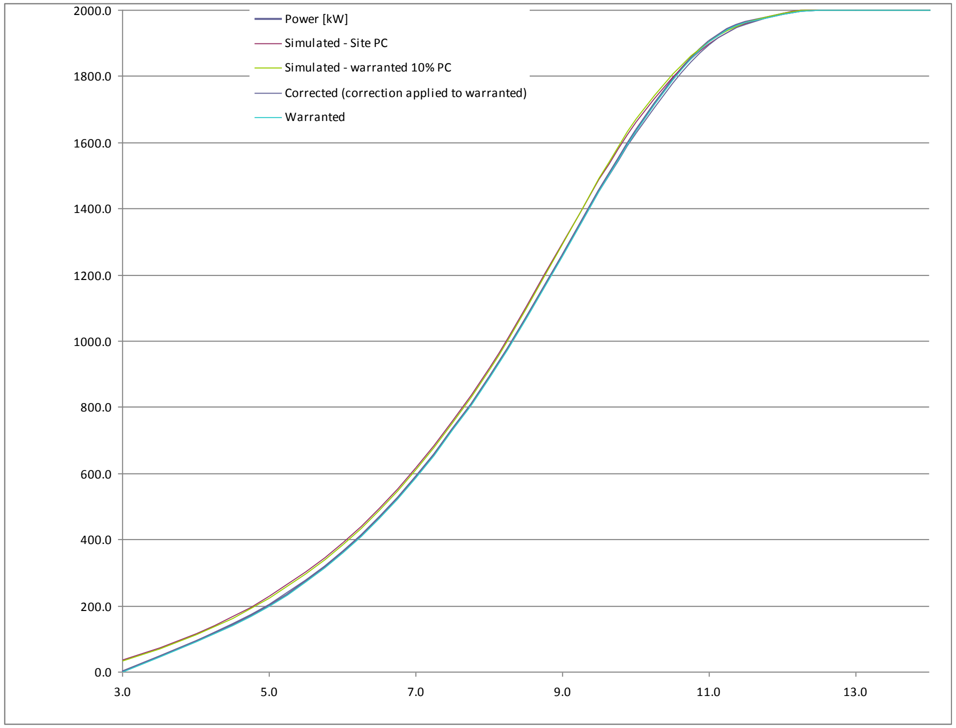
- The key principle of the method:
  - Simulate 10 minute average of power output based on Zero TI power curve and a wind distribution within 10 minute period.
  - The Zero TI curve is derived as follows:
    - Use the measured power curve and find the max Cp. Then reverse this to derive a power curve where Cp is always at this maximum, capped at the rated power.
    - Bin average the measured TI.
    - Carry out iterations applying this measured data TI to match back to the measured power curve by adjusting the rated power, cut in speed and Cpmax to best match the measured curve with the simulated one.
- The Zero TI curve is then used as per the same key principle above as follows:
  - Iterations for 10 minute periods assuming Gaussian distribution with the measured mean and standard deviation – apply to every 10 minutes of PC data to calculate a simulated 'measured' power output;
  - Do this again using the same mean wind speed levels but using the standard deviation corresponding to the desired reference TI (SD = U*TI)
  - Evaluate the difference between the reference and the simulated 'measured' case and apply this to the actual measured power timeseries

Method cont: What RWE did

- Derived the initial Zero TI power curve from the warranted power curve
- Applied the Zero TI curve to each wind speed bin – where each bin consists of a distribution of 0.1m/s intervals spanning +/- 2m/s with a Gaussian distribution.
- Calculated the weighted average result for each 1m/s bin.
- Done for the measured SD and the SD derived from the 10% TI assumption.
- Compared the two resulting simulated curves and applied the difference to the warranted curve.
- NB the adjustments of the Zero Turbulence Power Curve as specified in the last paragraph of p141 of Annex M have not been done.

Results

- Turbine details:
  - Vestas V90, 2MW/VSC_PreMk7
  - Diameter: 90m
  - Air Density: 1.225kg/m3, Assumed: 10% TI



Wind Speed	Correction	Corrected (correction applied to warranted)
0.0		0
1.0		0
2.0		0
3.0	3.153551	3.2
4.0	2.618065	93.6
5.0	4.864199	204.9
6.0	5.942054	367.9
7.0	5.743621	593.7
8.0	5.46285	894.5
9.0	2.832825	1258.8
10.0	-8.2428	1628.8
11.0	-7.89603	1896.1
12.0	-1.25926	1986.7
13.0	0	1999.0
14.0	0	2000.0
15.0	0	2000.0
16.0	0	2000.0
17.0	0	2000.0
18.0	0	2000.0
19.0	0	2000.0
20.0	0	2000.0
21.0	0	2000.0
22.0	0	2000.0
23.0	0	2000.0
24.0	0	2000.0
25.0	0	2000.0

THANK YOU VERY MUCH FOR YOUR ATTENTION

ANY QUESTIONS?

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