Illustrating the Importance of Site Specific PC

Power Curve Working Group Meeting DTU-Risø April 1st 2014
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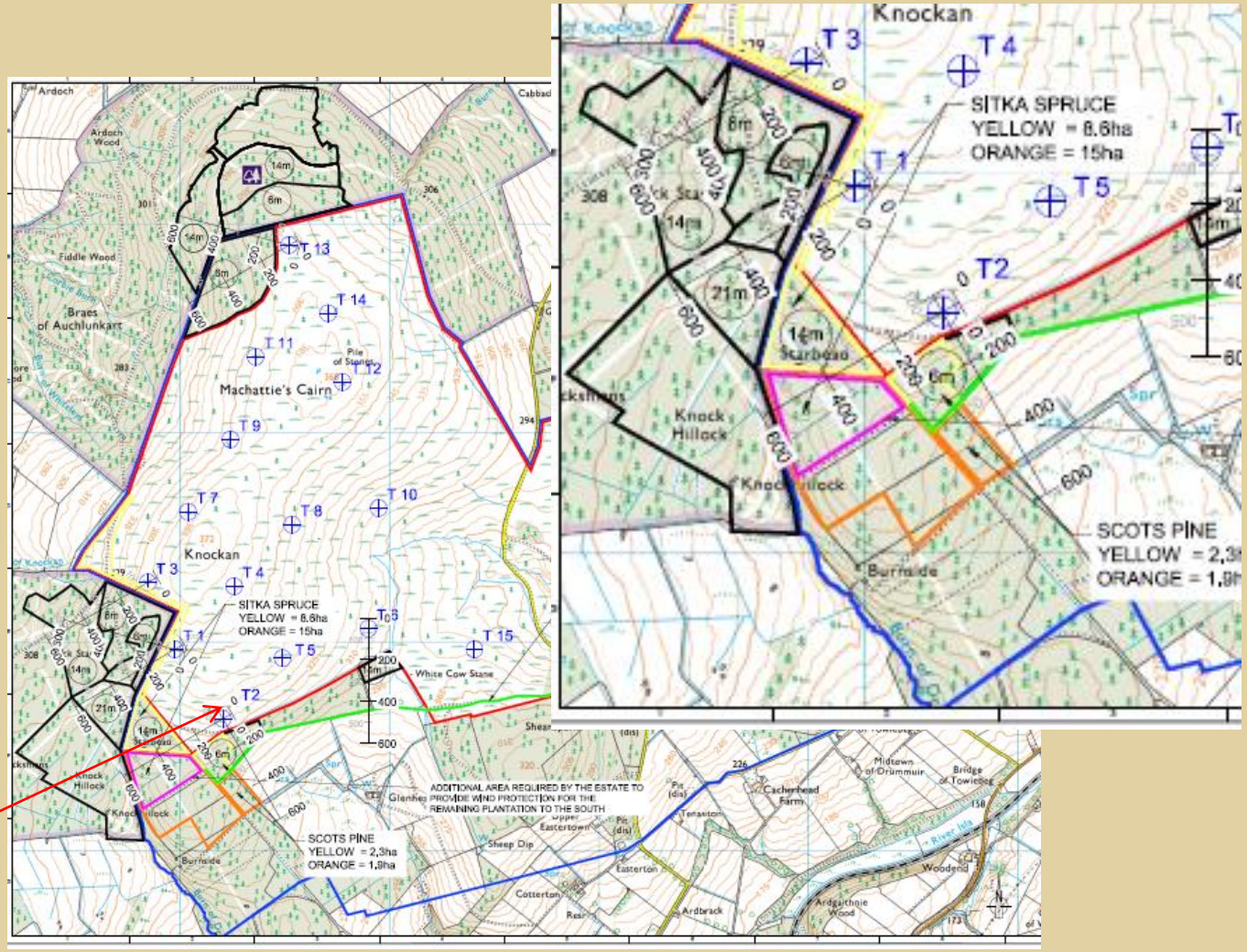
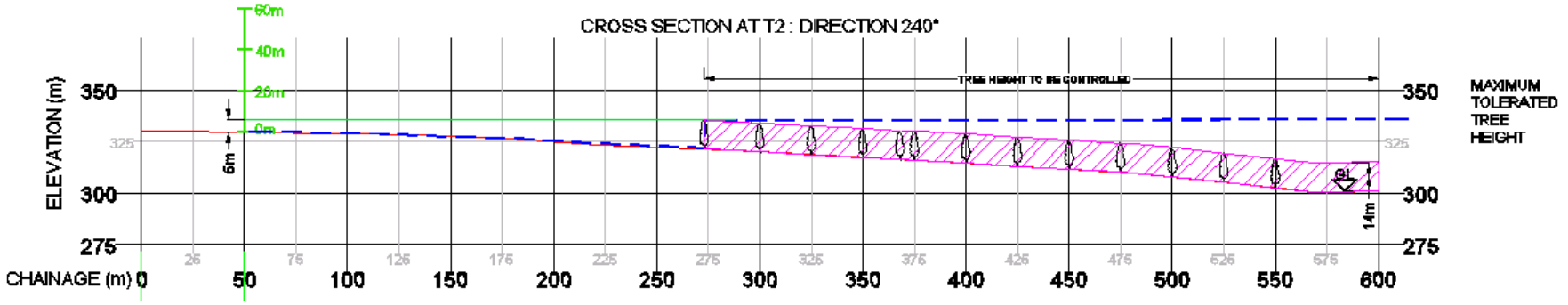
Wind farm on exposed hill surrounded by forest



T2
Steep slopes
&
Upwind forest

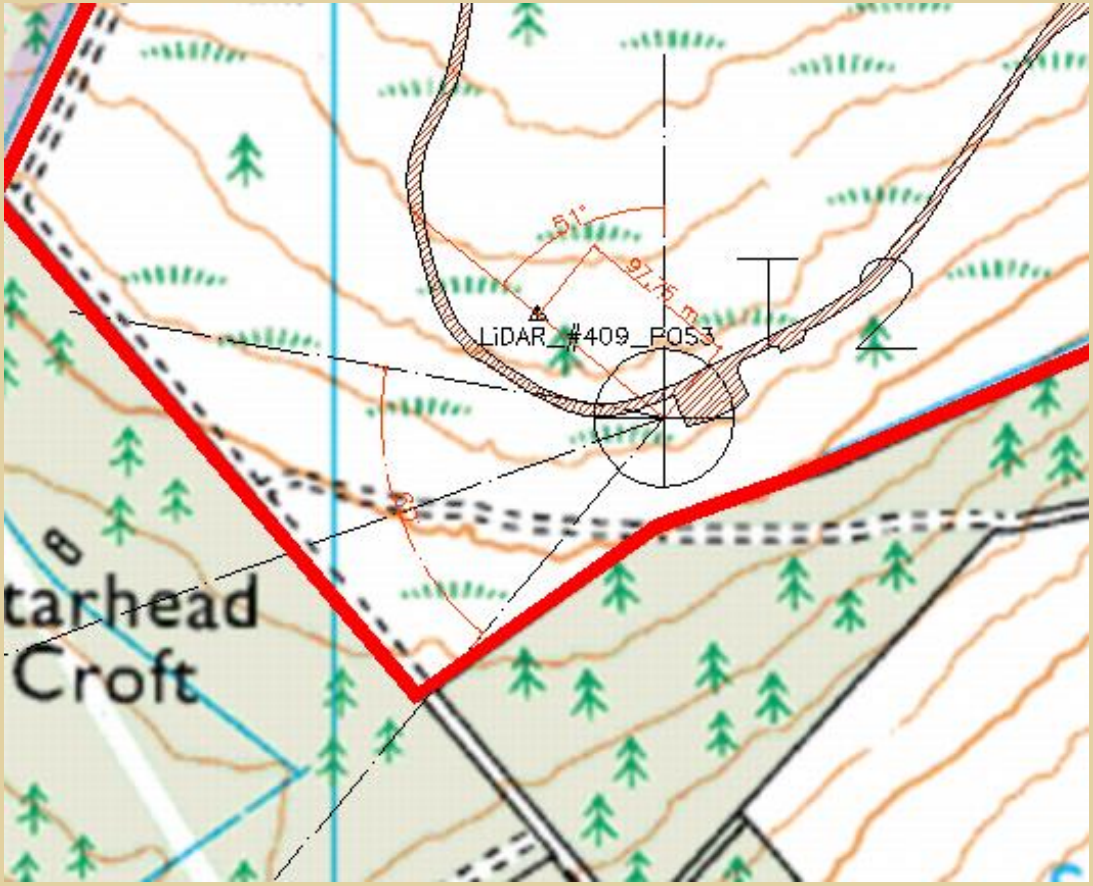
240 Degree Direction Sector Cross Section through T2



- 59m hub height, 82m diameter
- 14m trees
- 200 to 550m between turbine and trees in predominant sector
- Trees felled after an initial operation period
- Performance of T2 initially noted to be less than pre-construction estimate.

Lidar Deployment Location

- ZephIR Lidar Deployed
- To side of turbine wrt to 240 degree sector
- 9 measurement heights across rotor disk
- Pre tree felling data set 23/07/2013 to 02/10/2013
- Post felling data set 17/12/2013 to 10/01/2014

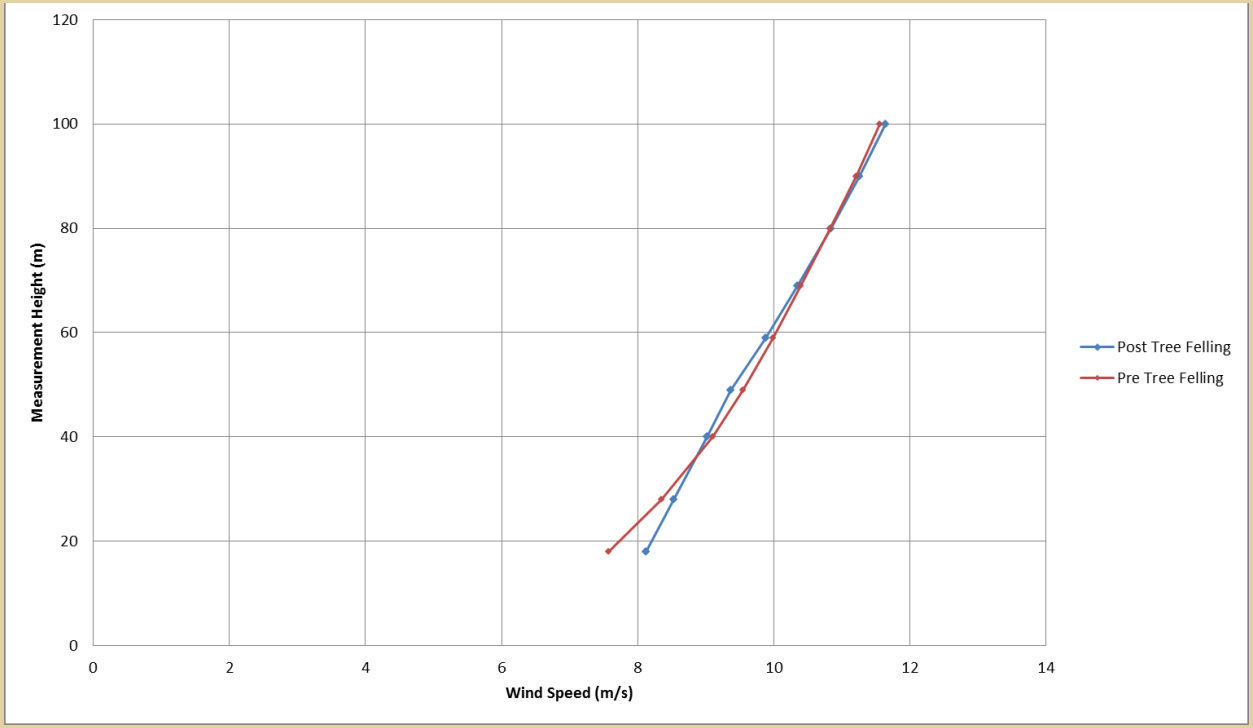


Impact of Trees on Power Performance of T2

Period:	Pre Tree Felling	Post Tree Felling
Direction Sectors Analysed	205 to 288	205 to 288
Hours	552.5	105.5
Last Complete Bin (LCB)	16.0 m/s	17.5 m/s
AEP measured to LCB	91.2 %	95.01 %
Average Shear Across Rotor	0.25	0.19

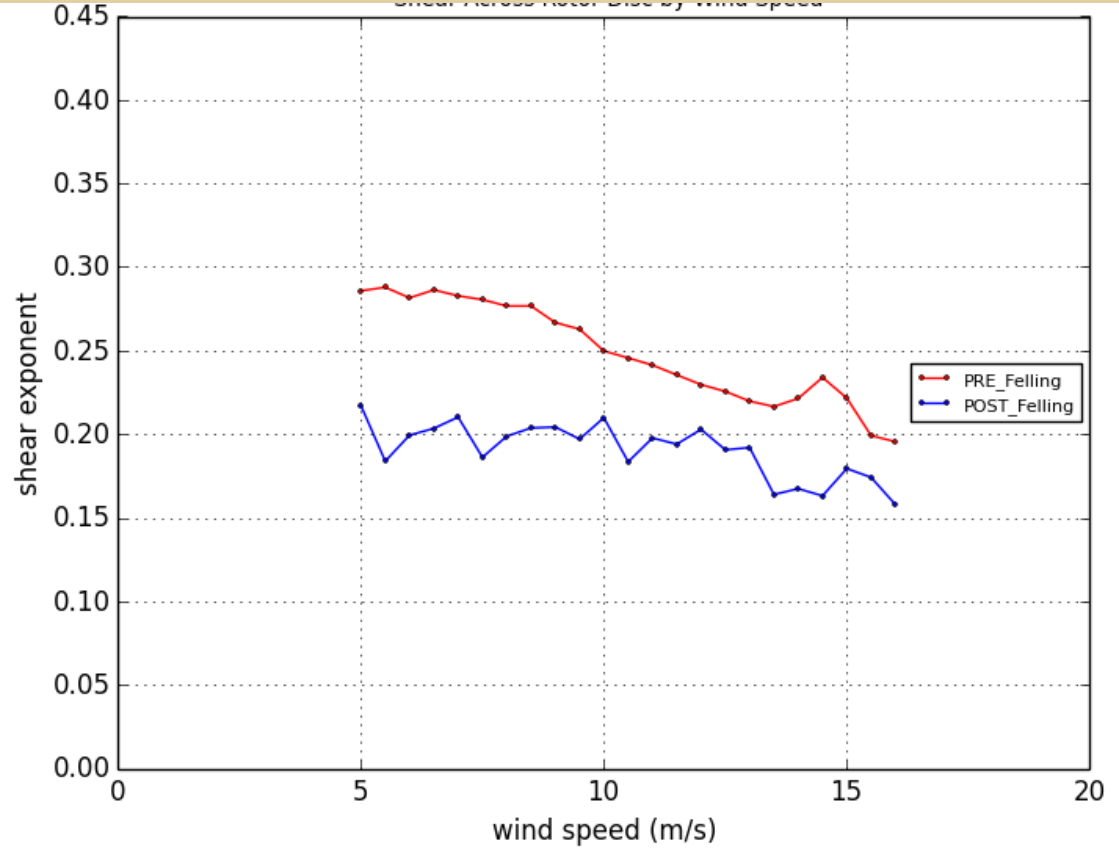
- T2 Power curve measurements not site calibration corrected
- Relative pre and post felling comparison is instructive however
- Significant improvement in performance
- Significant reduction in across rotor shear exponent
- Change in performance not fully explained by REWS => largely a Type B effect => “Outer-Range” Situation

Impact on Shear



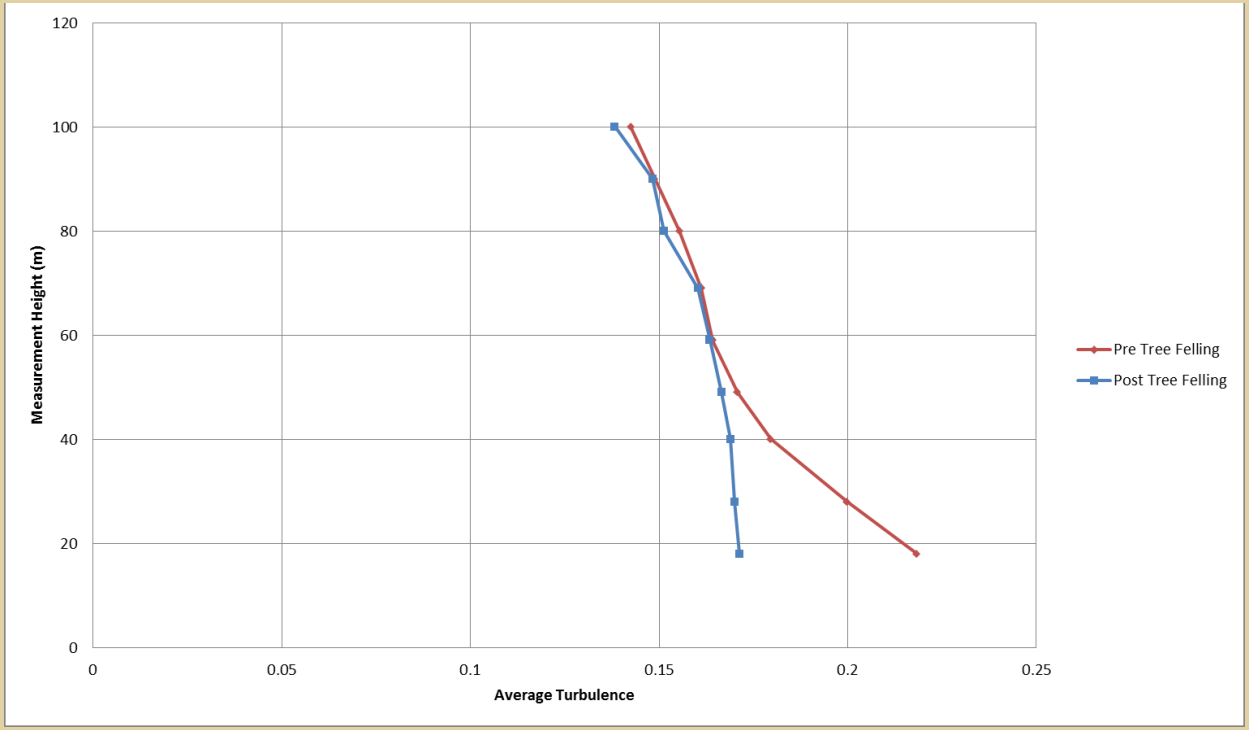
- Significant impact on lower half-rotor shear
- Insignificant impact on upper half-rotor shear

Shear impact of trees wind speed dependent



- Possible increased mixing of boundary layer with wind speed due to tree excitation is reducing shear
- Modelling performance impact of forestry is even more complex

Impact on Turbulence



- Dramatic reduction in turbulence in lower half-rotor
- Upper half-rotor turbulence profile more or less unaffected
- Turbulence normalisation by REWS segment may be informative

Conclusions

- Low hub heights, large rotors and tall trees are bad news!
- Hub height met mast measurements probably inadequate to describe the situation.
- Full rotor height remote sensing measurements provide valuable insight.
- Interaction of shear (and turbulence) layer is wind speed dependent in the presence of trees > more complex corrections required.
- Removing trees may return the inflow to “Inner-Range” conditions => power curve impact may be predictable
- Where trees are present (and hub height low/rotor large) power curve corrections (REWS, turbulence normalisation) may not be successful as we experience “Outer-Range” phenomena.


power for good