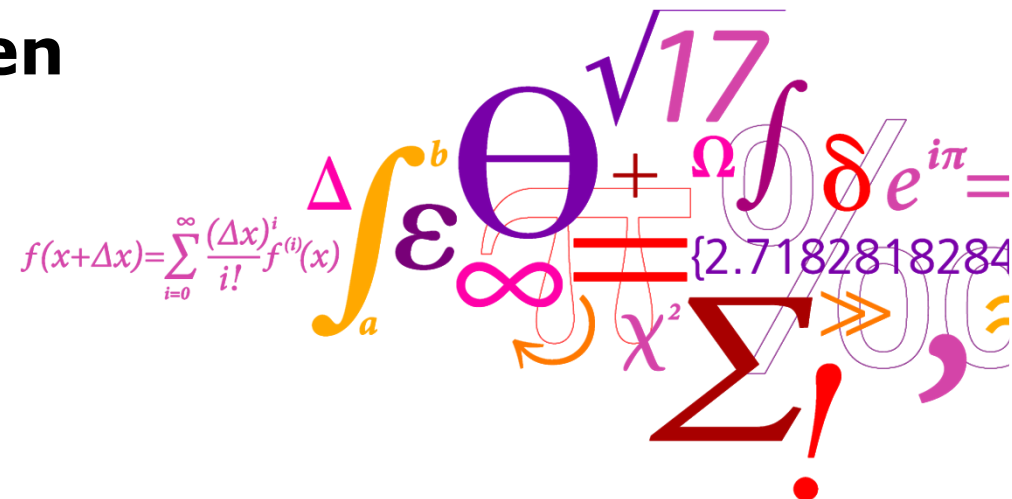


TC88 meeting Feldkirch Austria May 2015

Maintenance team MT12-1

**Wind Turbines – Part 12-1:
Power performance measurements
of electricity producing wind turbines**

**Troels Friis Pedersen
DTU Wind Energy**



Update on documents:

MCR	88_319e_MCR	2008-06
RR	88_421_RR	2011-11
CD	88_422_CD circulated	2011-11
CD2	88_460e_CD circulated	2013-07

Status of MT12-1 May 2015

Meetings

Dates

- Seattle 7-8 January 2009
- Risø 13-15 May 2009
- Boston 6-8 October 2009
- Madrid 9-11 February 2010
- Hamburg 8-10 June 2010
- Glasgow 5-7 October 2010
- Greenville 10-12 May 2011
- Aarhus 16-19 August 2011
- London 24-26 April 2012
- Bremen 18-20 June 2012
- Burlington 9-11 October 2012

Agenda

Organising work
Presentations/subgr
Subgr/presentations
Subgr/improvements
Subgr/proposals/docs
WD1 Subgr/drafting
WD1 Comments
WD2 Comments ->CD
CD National comments
CD National comments
CD Drafting -> CD2

.....continued

Status of MT12-1 May 2015

Continued...

Meetings

Dates

- Paris 14-16 January 2014
- Beijing 6-8 May 2014
- Louisville 7-9 October 2014
- Glasgow 5-7 May 2015
- Frankfurt Spring 2016

Agenda

CD2 SG/Nat. Comments
CD2 Consistency
CD2 Open issues
CDV fine tuning
National CDV comments

Status of MT12-1 May 2015

Main issues at CD2 stage :

- ✓ • National comments (893, 216 technical) considered in subgroups
- ✓ • Definition of rotor equivalent wind speed by energy-equivalent wind speed or by averaged equivalent wind speed
- ✓ • Inclusion of flow inclination angle
- ✓ • Reduction of options in measurement procedures: site calibration and power curve
- ✓ • Re-definition of rotor-equivalent wind speed taking wind veer into account
- ✓ • Verification of procedures in annex L for remote sensing equipment, calibration, classification, verification

Status of MT12-1 May 2015

Main issues at CD2 stage :

- ✓ • Example classification of cup anemometer included
- ✓ • Making annex I and J (classification of cups and sonics) normative
- ✓ • Uncertainty annex E (major revision by subgroup combining all uncertainty issues in annex)
- ✓ • Handling equivalent wind speed in relation to hub height wind speed in a way that the wind energy community will understand and accept the concept

"Fine Tuning" – Glasgow May 2015

- Uncertainty Annex
 - First presentation of the complete Uncertainty Annex
 - Site Calibration > Power Curve Test
 - Propagation of Uncertainties
 - Correlations > "cancellations"
 - Informative > Normative > Informative
- Anemometer Calibration
 - Tunnel precision v Tunnel Accuracy
 - Influence on site calibration v power curve test
- Site Calibration
 - Revert back to REWS to REWS (from height to height)
- Misc - Mast Flow Distortion, Multiple Test Uncert, Upflow
- Acceptance of Non-Perfect Standard
 - A standard can never be state of the art as it defines and is defined by technical maturity

Liaisons:

- PCWG investigate the introduction of equivalent wind speed with inclusion of vertical wind speed shear, wind veer and turbulence normalization
- Round robin of power performance measurements
- Reports provided on web site
<http://www.ewea.org/events/workshops/past-workshops/resource-assessment-2013/power-curve-working-group/>
- Meetings arranged in connection with MT12-1 to share experience:
 - Louisville 6-9 October 2014 and
 - Glasgow 5-8 May 2015

Update on documents:

MCR	88_319e_MCR	2008-06
RR	88_421_RR	2011-11
CD	88_422_CD circulated	2011-11
CD2	88_460e_CD circulated	2013-07
CDV	planned	2015-06
FDIS	expected	2016-06
IS	expected	2016-06
Stability date		2017

Status of MT12-1 May 2015

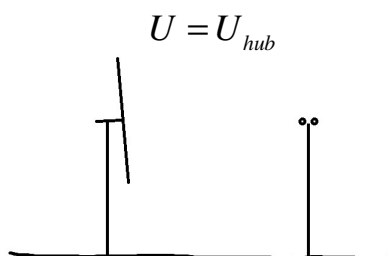
Recommendation for future revisions:

From existing docs split into smaller docs and add new items:

Testing			Model validation	Design
Measurements	Corrections	PC method		
Met mast	Site calibration	Analysis/	Measurements	Basic document
Lidar	NTF	AEP/	versus	Wsp definitions
Nacelle anem.	Induction	Comb. Unc./	Modelling	PC definitions
	Numerical SC	Reporting		All parameter defs.
		Relative PC		PC definitions
				Reporting
				Classes of shear/ veer/turbulence
3 docs	3 (4) docs	2 docs	2 doc	1doc

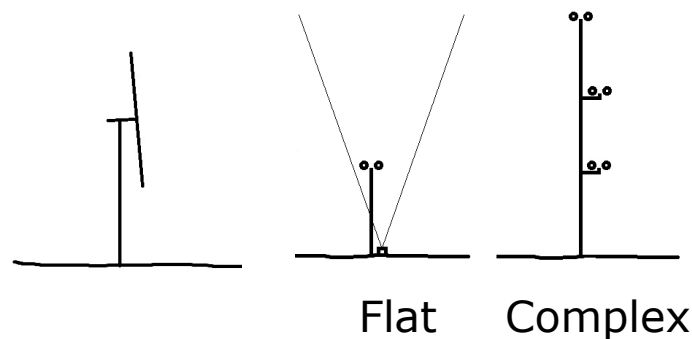
Status of -12 docs

IEC61400-12-1:2005



IEC61400-12-1:2016 rev. 2

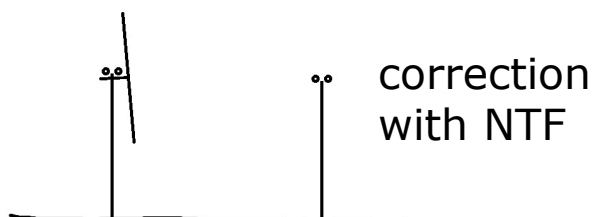
$$U_{eq} = \frac{1}{A} \left(\int_z U_z^3 dA_z \right)^{1/3} \cong \frac{1}{A} \left(\sum_{z,i} U_{z,i}^3 dA_{z,i} \right)^{1/3}$$



IEC61400-12-2:2013

$$U = U_{hub}$$

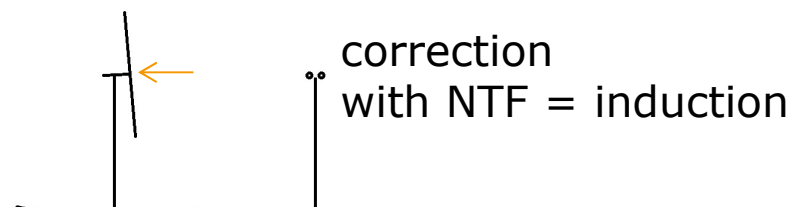
Use of nacelle anemometer



IEC61400-12-2:2013

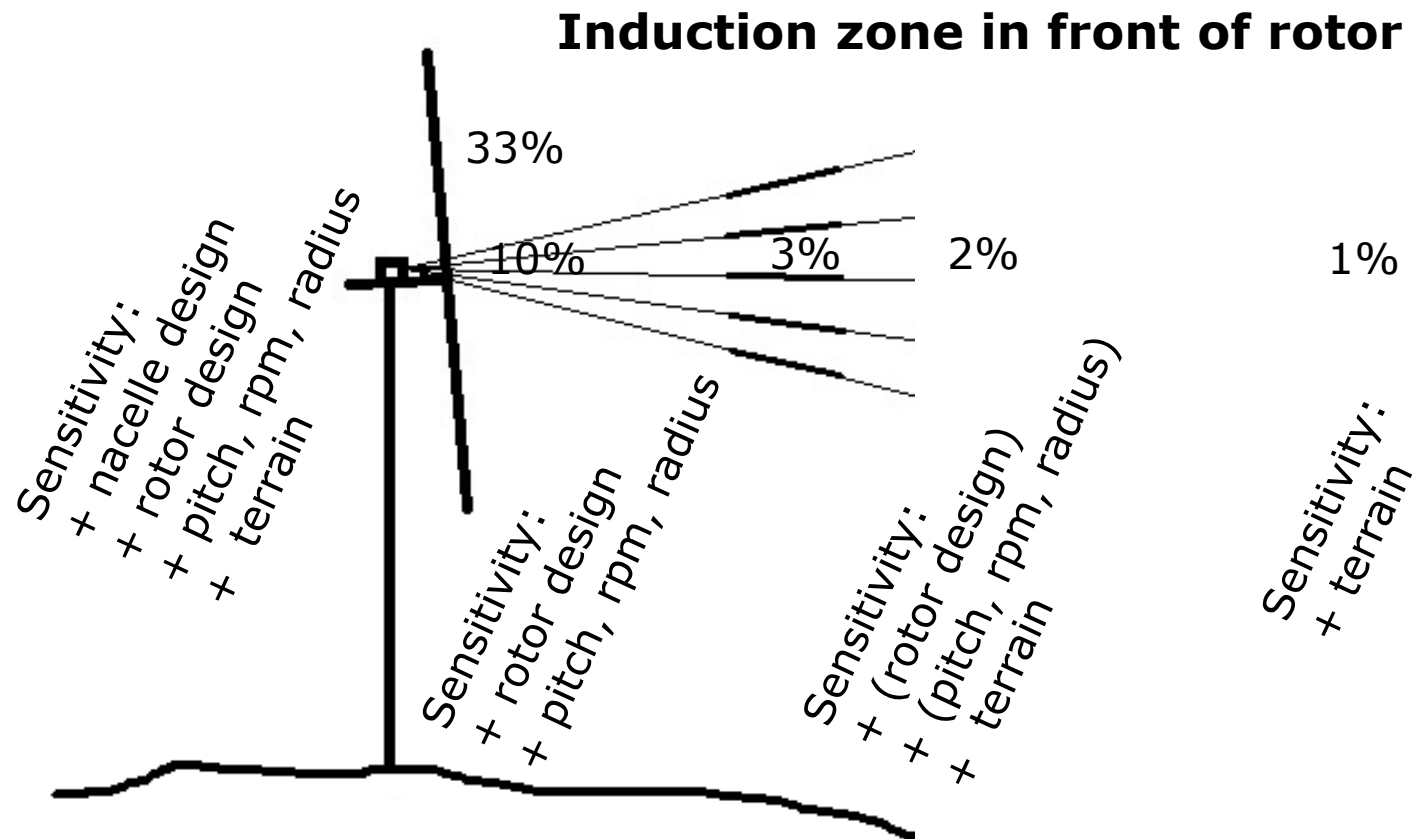
$$U = U_{hub}$$

Use of spinner anemometer



Status of MT12-1 May 2015

Recommendation for future revisions

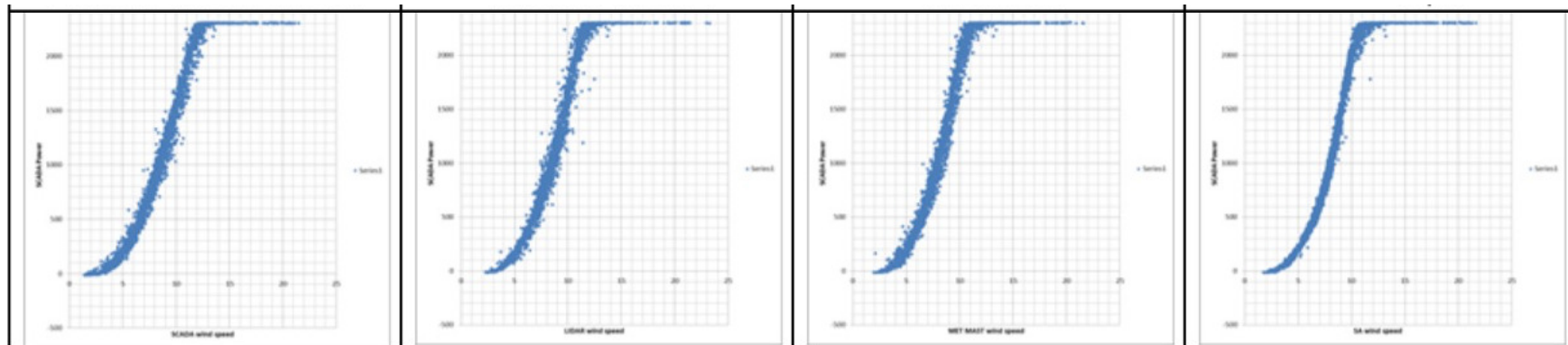


Performance measurements in wind farm free sector (hub height measurements)

Nacelle anemometer 2D nacelle lidar

Met mast

Spinner anemometer



Re ROMOWind

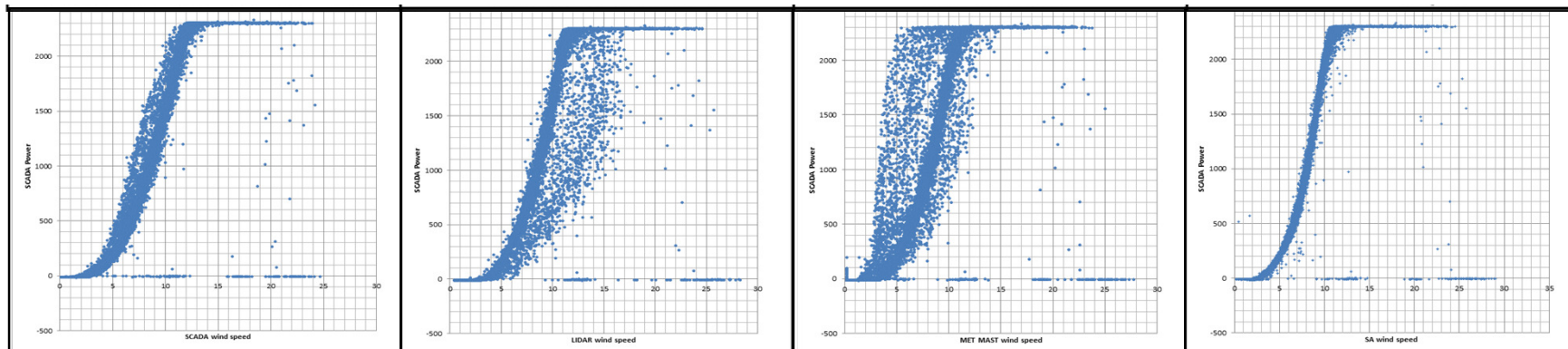
TC88

Performance measurements in wind farm wake situations (hub height measurements)

Nacelle anemometer 2D nacelle lidar

Met mast

Spinner anemometer

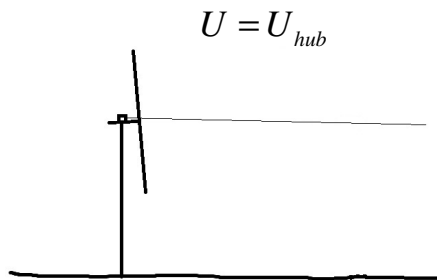


Re ROMOWind

Status of MT12-1 May 2015

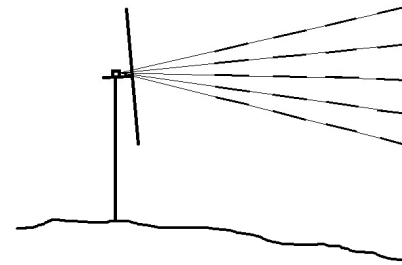
Recommendation for future revisions

Nacelle Lidar 2-beam



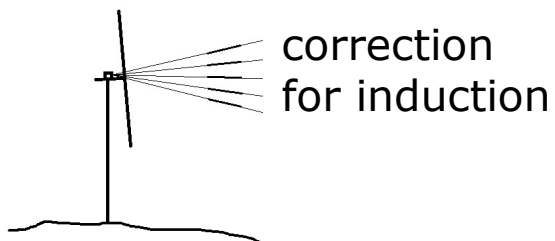
Nacelle Scanning Lidar

$$U_{eq} = \frac{1}{A} \left(\int_A U_{y,z}^3 dA_{y,z} \right)^{1/3}$$



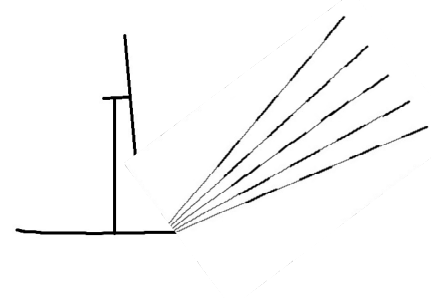
Nacelle Scanning Lidar

$$U_{eq} = \frac{1}{A} \left(\int_A U_{y,z}^3 dA_{y,z} \right)^{1/3}$$



Scanning Lidar

$$U = ?$$



Status of MT12-1 May 2015

Thank you!