December 2016

Minutes
of the IEA WIND Task 32 Workshop #4 on

Power Performance: Update to Round Robin for FDIS IEC 61400 12-1 Ed. 2 Calculation of Uncertainty for Lidar Application

Date: 14 December 2016
Workshop Venue: Strathclyde University, Royal College Building, Room 2.15, Glasgow, Scotland
Round Robin and Workshop leader: Luke Simmons, DNV GL
Minutes by Ines Würth, Luke Simmons, David Schlipf

Agenda

9:00	Welcome
9:30	Start of workshop – Introductions to Task 32 and workshop, introduction round
10:00	1st Session: **How was working with the guidelines during the Round Robin?**
	Summary, comparison and plenary discussion of final results (DNV GL – Luke Simmons)
11:00	Coffee Break
11:15	Worked examples from PCWG (Lee Cameron - RES)
11:45	Group discussion on outcome of the round robin
12:30	Lunch
13:30	2nd Session: **What is currently done with respect to uncertainties?**
	Slot 1: NREL and uncertainty (NREL – Andrew Clifton)
14:00	Slot 2: T-piece power curve measurements and uncertainty (Peter Clive – Sgurr)
14:30	Slot 3: The REWS concept: challenges in commercial Power Curve Validation
	(Frank Scheurich – Siemens Wind Power)
15:00	Coffee Break
15:30	Slot 4: Nacelle lidar and uncertainty – UniTTE update (Rozenn Wagner - DTU)
16:00	Slot 5: EDF – Experiences and expectations from a project developer and operator
	(Hugo Herrmann – EDF)
16:30-	3rd Session: **How can we continue to collaborate?**
17:30	Group discussion on result of workshop, follow up items, and IEA Wind power performance roadmap for 2017
19:30	Joint dinner

Minutes

9:30	**Start of workshop – Introductions to Task 32 and workshop, introduction round**

- Welcome from Professor David Infield
- IEA Wind Task 32 Introduction from Operating Agent David Schlipf, University of Stuttgart
- Introduction of all participants

10:00	**1st Session: How was working with the guidelines during the Round Robin? Summary, comparison and plenary discussion of final results (DNV GL – Luke Simmons)**

- Presentation from Luke Simmons, DNV GL about Round Robin
- Synergy with other groups:
  - Measnet workshop carried out a round robin about verification of lidars, but this did not interfere with Task 32 round robin
  - UniTTe: Project led by Rozenn Wagner from DTU is working on the assessment of power curves with nacelle based lidars
  - Power Curve Working Group
  - Klaus Franke, Deutsche Windguard: Publication about REWS uncertainty for Power Curve assessment
- Presentation of results of round robin
  - Big variation of wind speed of rotor equivalent wind speed in the different bins
    - The number of heights for the REWS was not defined in the task for the round robin
  - AEP differs for different wind speeds (WS1 – REWS + Hub height met mast , WS2 – met mast at hub height, WS3- REWS)
  - Power Curves between participants differ most for WS 3
  - Another Wind speed definition of hub height with lidar would have been possible as well
  - Discussion about the definitions of the different wind speeds – different approaches are applied by the round robin participants
  - Cat A: quite homogeneous apart from one outlier
  - Cat B: diverges for higher wind speed bins
  - Agreed next step: open discussion between the participants of the round robin about the different steps that had been applied
  - Average uncertainty of WS 3 –REWS - is around 2% higher
    - It is pointed out that this is a problem if the standard should be applied.
    - Not clear if it is due to the calibration of the lidar. The definitions in the round robin (and the standard) were quite open and there were strong wind speed uncertainty elements that are only applied to the remote sensing device and not the cup (2%). Therefore WS1 and WS2 agree but not WS3 – only here the lidar uncertainty strikes.

11:15	**Worked examples from PCWG (Lee Cameron - RES)**

- Presentation about implementation of the new uncertainty standard – Consensus Analysis Project
  - Description of the required test procedure for PC measurements
  - Collection of spread sheets available that step through the calculation procedure of uncertainties; available now through the PCWG website by asking to gain access to a dropbox; will be open sourced on the website eventually
  - Explanation of the uncertainty terms and the spread sheets
    - Calibration vs. Verification mix up in round robin instruction and standard

11:45	**Group discussion on outcome of the round robin**

3 groups have been formed based on the seating for the discussion led by following moderators:

1. Luke Simmons
2. Ioannis Antoniou
3. Rozenn Wagner

The main two questions have been:

1. What are the barriers in the application of the standard during the Round Robin?
2. What is the primary takeaway massage of the Round Robin?

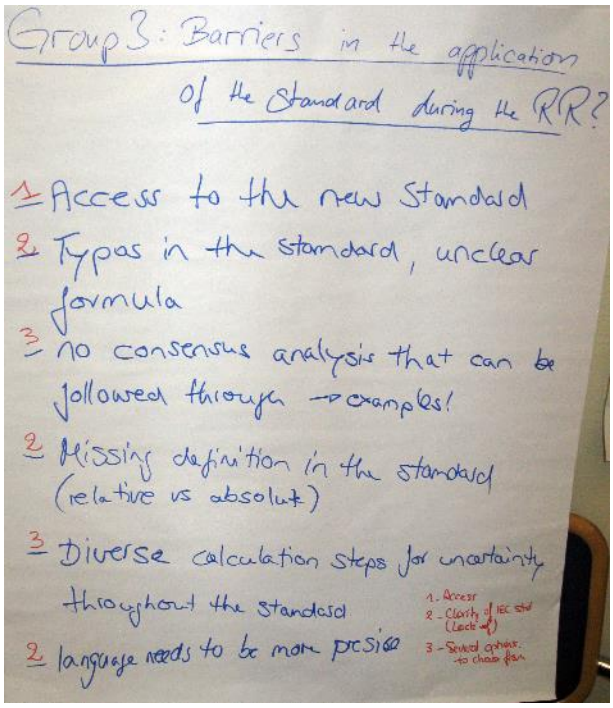

Figure 1: Results of first group discussion: group 3 - barriers.

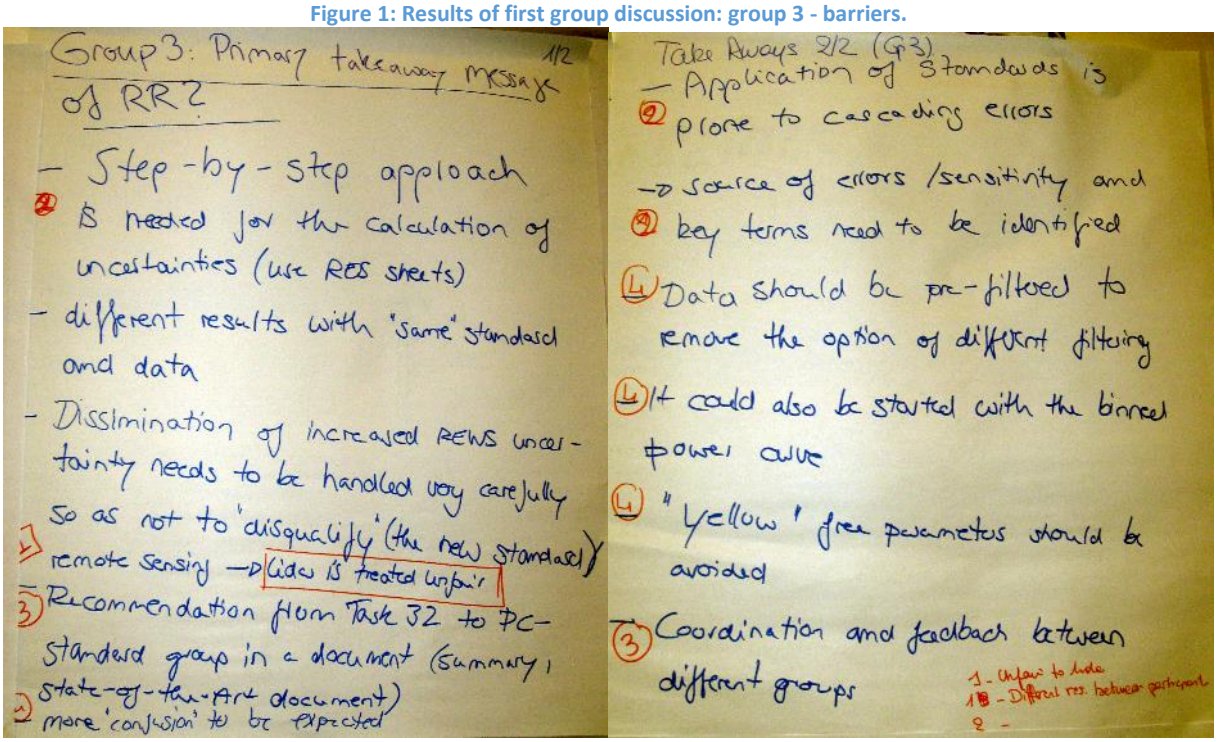

Figure 2: Results of first group discussion: group 3 – takeaway massage.

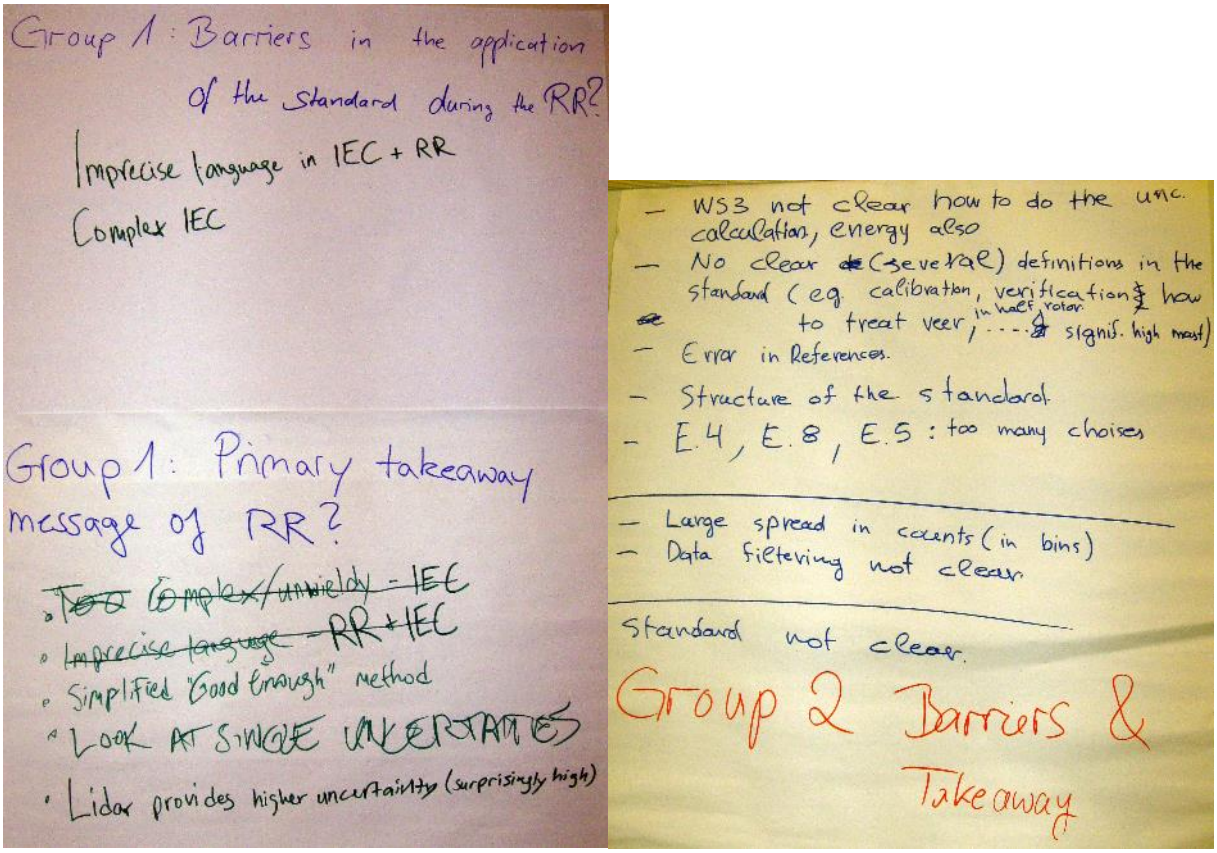

Figure 3: Results of first group discussion: group 1 and 2.

13:30	**2nd Session: What is currently done with respect to uncertainties?**

- Slot 1: NREL and uncertainty (NREL – Andrew Clifton
  - Uncertainty influences for lidar measurements → important to understand what and how the measurements are influenced
  - What is the role of the reference?
    - It is still needed to know if the wind field reconstruction is correct – but that does not necessarily have to be a cup but could be the wind scanners.
    - Lidics – short range lidars with very small probe volume is another possibility
    - With nacelle lidars the line-of-sight velocity is directly calibrated.
    - Instead of point measurement metrics, volume metrics such as the rotor effective wind speed should be taken into account
    - Lidar manufactures must release internal values in order to understand everything for the white box approach. It could also be possible to reverse engineer them from the measurements.
- Slot 2: Arc scan wind measurements for power curve tests (Peter Clive – Sgurr)
  - Leakage from reference from lidar verification into power curve measurements. Cat A uncertainties from reference should be able to be eliminated
    - Using of two different references with different Cat A uncertainties
  - It is pointed out that it is supposedly dangerous to standardize only specific types of lidar. This is restricting development of a new technology. However, standards must codify existing experience and this is only apparent for proven technology.

- Slot 3: The REWS concept: challenges in commercial Power Curve Validation (Frank Scheurich – Siemens Wind Power)
  - Shear has a big impact on REWS and therefore AEP. Large seasonal and diurnal variation of the HHWS when compared to REWS
  - REWS makes more sense to assess PC
  - REWS should be taken into account as well for the site assessment.
- Slot 4: Nacelle lidar and uncertainty – UniTTE update (DTU – Rozenn Wagner)
  - Presentation of UniTTe project results concerning nacelle based lidar measurements and loads assessment
  - As the cup is accepted as a reference so far, you have to accept it although it is known, that it is not the one for lidars. The conclusion is that a better approach is needed.
  - The black box calibration vs. white box calibration comparison has not been carried out at DTU. But there is an ECN report on it by J.W. Wagenaar. DNV is starting first tests for nacelle based lidar calibration at their own test site with 30m met masts.
  - DTU still performs horizontal lidar calibrations for 2 beam lidars
  - Reports of the UniTTe project with results of different calibrations are available online
- Slot 5: EDF – Experiences and expectations from a project developer and operator (Hugo Herrmann – EDF)
  - Presentation of project developer's expectations concerning lidar for different applications
  - Uncertainties for floating lidar systems (FLS) are addressed in a new recommended practice document published by the carbon trust
  - To reduce the TI increase of FLS a different approach (converging lidar) could be possible. TI measurements are very important for the design of turbines but the data from FLS is not taken for that application so far. TI increase is due to the movement of the buoy
  - Conclusions from Andy, Rozenn and Hugo are the same concerning the next steps and open research topics (barriers)

16:30-17:30	**3rd Session: How can we continue to collaborate?** **Group discussion on result of workshop, follow up items, and IEA Wind power performance roadmap for 2017**

The group discussions were performed in the some groups as before. The main task was to define a roadmap regarding uncertainty for Power Curve assessment for the next two years.

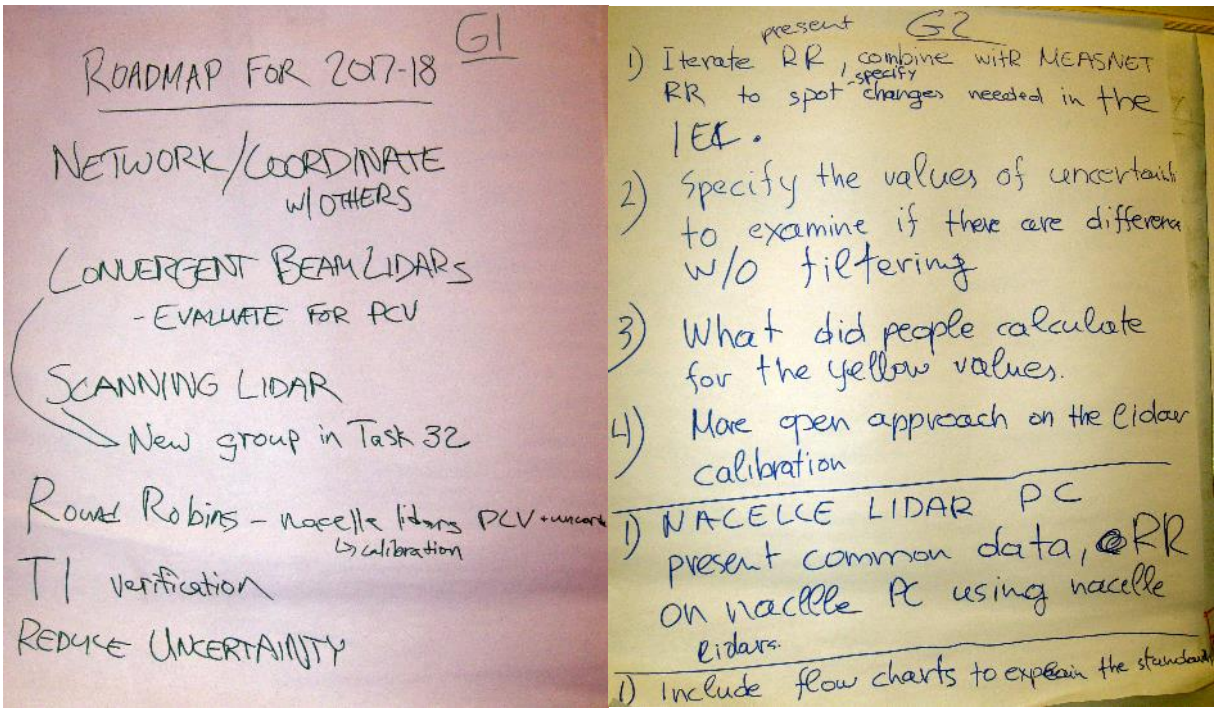

Figure 4: Results of second group discussion: group 1 and 2.

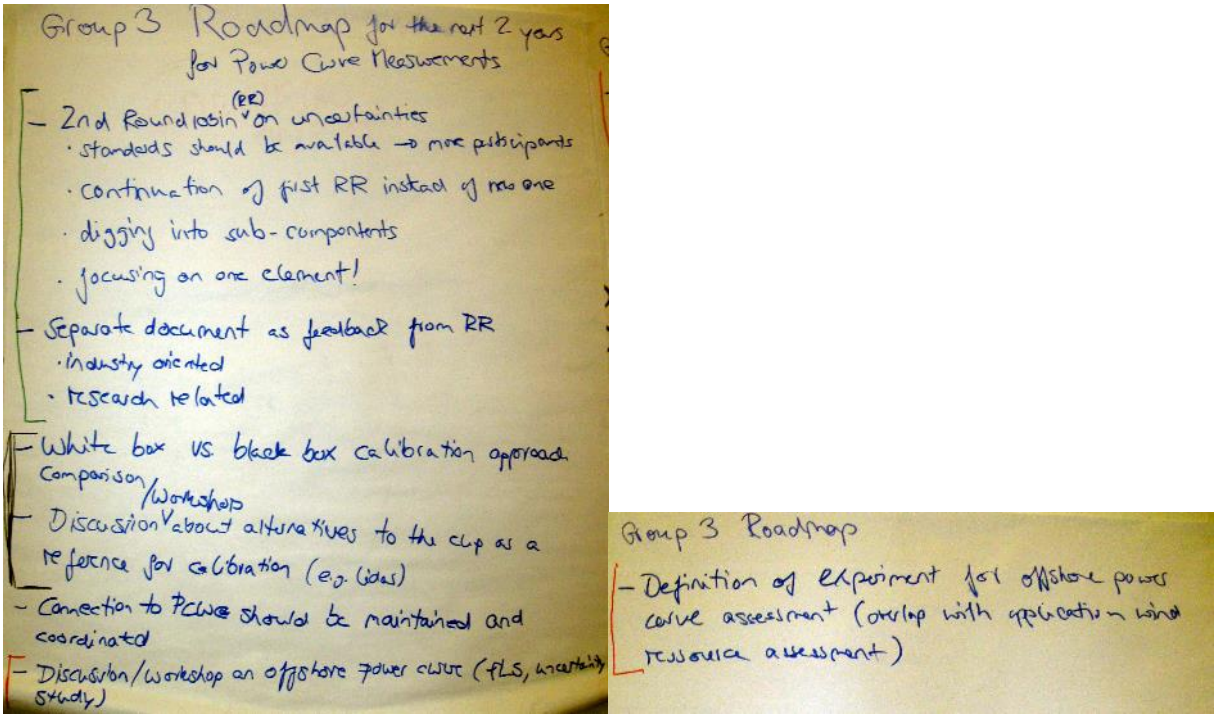

Figure 5: Results of second group discussion: group 3.

Participation List

Name	Country	Institution
Adrian How	UK	SSE
Andrew Clifton	USA	NREL
Asger Anker Sorensen	Denmark	DONG Energy
Benny Svardal	Norway	Christian Michelsen Research AS
Bert Gollnick	Germany	Senvion
Bruno Declercq	Belgium	Engie Lab
Cédric Arbez	Canada	TechnoCentre Éolien
Christos Tsouknidas	Denmark	Siemens
David McCracken	UK	SSE
David Schlipf	Germany	SWE University Stuttgart
Dennis Wouters	Netherlands	ECN
Detlef Stein	Germany	DNV GL
Ellie Weyer	USA	AWS Truepower
Fabrice Guillemin	France	IFP Energie Nouvelles
Fotis Kokkalidis	Greece	CRES
Frank Scheurich	Denmark	Siemens
Gibson Kersting	USA	E.ON
Gordon Barr	UK	SSE
Hong Yue	UK	University of Strathclyde
Hu Wei	China	Goldwind
Hugo Herrmann	UK	EDF Energy
Ines Würth	Germany	SWE University Stuttgart
Inhaeng Kim	South Korea	Jeju Energy Corporation
Ioannis Antoniou	Denmark	Siemens
Javier Saez Gallego	Denmark	Siemens
Jochem Vermeir	Belgium	Tractebel Engie
Jochen Rainer Cleve	Denmark	DONG Energy
Julia Gottschall	Germany	Fraunhofer IWES
Klaus Franke	Germany	Deutsche Windguard
Kyungnam Ko	South Korea	Jeju University
Lee Cameron	UK	RES
Luke Simmons	USA	DNV GL
Michael Harris	UK	ZephIR Lidar
Minsang Kang	South Korea	Jeju Energy Corporation
Nils Schlüter	Germany	Wind-consult
Paul Kühn	Germany	Fraunhofer IWES
Paul Mazoyer	France	Leosphere
Paula Gomez Arranz	Denmark	DTU
Peter Clive	UK	SgurrEnergy Ltd
Ross Tyler	USA	Business Network for Offshore Wind
Rozenn Wagner	Denmark	DTU
Sarah Allardyce	UK	Mott MacDonald
Seán Hayes	Ireland	Mainstream Renewable Power
Shane Holden	Ireland	Bord na Móna
Stathis Koutoulakos	Netherlands	Vattenfall
Stefan Goossens	Netherlands	Vattenfall
Theodore Holtom	UK	Wind Farm Analytics
Wang Haibin	China	Goldwind