Summary of IEA RD&D Wind – 59th Topical Expert Meeting

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Background

An IEA Topical Expert Meeting (TEM) on the Topic “State of the Art of Remote Wind Speed Sensing Techniques using SODAR, LIDAR and Satellites” was organized by and held at Riso National Laboratory in January 2007. This was the first IEA expert meeting on this topic.

There was a common understanding that there was a need for more experience from remote sensing in order to increase the accuracy and the repeatability of measurements, especially comparing the performance of LIDAR and SODAR with anemometers.

On the other hand, interest in and use of remote sensing measurements in wind energy applications have increased considerably, particularly as more data are required at increased heights where tall tower measurements become more difficult and expensive to establish. New and improved remote sensing technology has become available, presenting more opportunities to facilitate this technology. However, there are notable concerns over the reliability and accuracy of remote sensing measurements as compared to conventional measurements such as cup or sonic anemometers mounted on towers. But even the conventional tower measurements are well known to have their issues such as tower flow effects on measurement accuracy.

At the Riso TEM it was decided to develop IEA Recommended Practices for LIDAR and SODAR. Participants pointed out such documents were needed in a near-future time frame. Two ad-hoc groups were formed to put together proposals for the proper operation of a SODAR/LIDAR. Draft documents are in preparation.

After discussions with the leaders of ad-hoc groups, it was decided that the arrangement of a new topical expert meeting in these issues will be very useful and will help to improve the work being done.

Participants / Presentations

A total of 31 persons registered for this meeting. They represented the following countries: Denmark, Finland, Germany, Japan, Korea, Norway, Sweden, Netherlands, Spain, United Kingdom and the United States. A total of 21 presentations were given.

The participants represented a great variety of stakeholders related to the topic. Those were: research organizations, universities, consultants and some manufactures of equipments.

Presentations covered the following topics:

- Overview of existing knowledge and experience on LIDAR and SODAR technical issues, regarding the measurement of mean wind speeds, turbulence quantities, and vertical wind profiles for wind energy applications.
• Calibration of SODAR and LIDAR systems.
• Accuracy and reliability of the different systems and comparisons with other point measurement techniques, e.g. cup anemometers
• Suggestion for a “good measurement practice” using remote sensing equipment.
• Future options for wind energy using SODAR and LIDAR.

A total of 25 presentations were given:

1. Félix Avia, CENER, OA Task 11 IEA Wind (FA)
2. Dennis Elliott, National Renewable Energy Laboratory, USA (DE)
3. Peter Clive, SgurrEnergy Ltd, UK (PC)
4. Xabier Comas, Acciona Energía, Spain (XC)
5. Michael Courtney, Technical University of Denmark-Riso National Lab for Sustainable Energy, Denmark (MC)
6. Yeongmi Ji, POSTECH, Korea (YJ)
7. Neil Kelley, National Renewable Energy Laboratory, USA (NK)
8. Thomas Nostrand, NRG Systems Manufacturer of Lidar Systems, USA (TN)
9. Julie Lundquist, Lawrence Livermore National Laboratory, USA (JL)
10. Rod Frehlich, University of Colorado, USA (RF)
11. Niels LaWhite, Second Wind Inc, USA (NL)
12. Mathew Filippelli, AWS Truewind, USA (MF)
13. Andreas Beeken, Dewi GmbH German Wind Energy Institute, Germany (AB)
14. Regina Deola, SANDIA Sandia National Laboratories, USA (RD)
15. Matthias Wächter, ForWind Center for Wind Energy Research, Germany (MW)
16. Jan Willem Wagenaar, ECN Unit Wind, Netherlands (JW)
17. Daniel Gustafsson, Vattenfall AB, Sweden (DG)
18. Nobuyuki Hayasaki, Itochu Techno-Solutions Corporation, Japan (NH)
20. Daniel Jaynes, Garrad Hassan America Inc., USA (DJ)
21. Kathleen Moore, Integrated Environmental Data, LLC, USA (KM)
22. David Schlipf, SWE am Institut Für Flugzeugbau Universität Stuttgart, Germany (DS)
23. Hyun-Goo Kim, Korea Institute of Energy Research, Korea (HK)
24. Fred Belen, Optical Air Data Systems - Catch The Wind Inc., USA (FB)
25. Kenneth Underwood, Atmospheric Systems Corporation, USA (KU)

Other participants were:

26. Jerry Crescenti, Iberdrola Renovables (JC)
Discussion

Following the two days of presentations the floor was opened and a general discussion took place. A number of different topics were handled. However, it was decided to focus the discussion in the issue of “Best practices” for wind resource assessment using Remote Sensing Systems (RSS). There was a general consensus that Best Practices documents should be focused on obtaining bankable data for resource assessment.

In particular, the following topics were discussed, in order to decide whether to include them in the Recommended Practices (RP) document, and which are the priorities:

- Validation of RSS vs tower measurements.
- Simple terrain vs complex terrain issue.
- Field practices
- Uncertainty and turbulence measurements
- Applications of RSS
- Structure of the RP documents
- Future actions

Validation of RSS vs tower measurements.

One of the first priorities to arise is the need to describe the design of measurement programs using best practices of meteorological towers and RSS in simple terrain (DE). There is a consensus among the meeting participants that there is no need to carry out new measurement campaigns. There are already many projects done (some of them presented in this meeting), which show that well designed measurement campaigns present very satisfactory performance of RSS in simple terrain.

Regarding the RSS to tower data comparisons, it was pointed out that a separation between the atmospheric component of the error, and the component associated with the instrument itself, has not been done. Such atmospheric error could be bounded, when necessary, from the tower data, by means of turbulence parameters (RF). The subject of turbulence as seen by RSS is discussed later on.

Simple terrain vs complex terrain issue.

According to the information presented for simple terrain, the confidence in the already existing procedures is very high, and correlation obtained between the measurements performed using remote sensing instruments versus the conditional cup anemometers is excellent.

The situation is different when making measurements in complex terrain; we have seen various results in complex terrain during these meeting, where RSS and towers present different levels of agreement. In some cases, even when the RS instrument is working correctly, the results can be misleading, if the terrain is too complex (DE). In such situations it’s likely that the scatter presented
is dominated by atmospheric characteristics at the measurement site (including the terrain complexity as one of these) rather than by the instrument error (RF).

In relation to this, when comparing measured data using RSS versus data obtained using cup anemometers in complex terrain, it has to be taken into account that also cup anemometers can give not good data (CT). This can be considered under the uncertainty of assessment in complex terrain. It was previously shown in KU’s presentation that even well-designed meteorological towers can show important discrepancies in complex terrain (DE).

It was stated that a classification of the terrain (simple, complex, etc) in terms of remote sensing is not defined, but is necessary (MC).

It was also expressed that more knowledge is required about site characterization; that should be done in coordination with the IEC T88 WG (DE).

The conclusion of this part of the discussion is to focus on simple terrain when elaborating the first versions of the recommended practices. It is agreed that the accuracy of RSS can be verified in simple terrain, but this doesn’t mean RSS should not be used in complex terrain (DE).

Field practices

It was pointed out that there is a need for guidelines on what the recommended field practices are. For instance, recommendations for location of the RSS, because (the usual) installation in the vicinity of a meteorological mast may not be the best location, and that is normally chosen for inter-comparison purposes (FB).

It was also suggested that it should be clear in the RP document what are acceptable uses and deployments of RSS and which are not (DJ). Key issues are to operate and maintain the instruments correctly.

Uncertainty and turbulence measurement

There is a consensus that resource assessment is bankable at the present state of the art using RS instruments; but uncertainty analysis is necessary in order to achieve bankability in wind resource assessment.

It was remarked that the key point is to have a procedure to assess the uncertainty of measured data, classified according the site and specific parameters of the measurement campaign, not depending on the instruments (DJ).

It was discussed how typical wind energy metrics, such as the turbulence intensity ($\sigma_u/u$), can be used to classify the measurement uncertainty of the data collected by RS instruments. On the one hand, one could define new sets of turbulence metrics based on RSS (JC). But, on the other hand, as each RSS measures turbulence in a different way, it’d be better to remain with the conventional definition of turbulence (MC). Turbulence seen by RSS can be related to the standard definition of TI, by means of investigating the physics inherent to each RSS device, and establishing the connection between both (RF). Deriving a new turbulence metric, common for all RSS, could be put in the list for future R&D activities, but it is agreed not to be a priority at this point (DE). General opinion is that we are not in the stage of coming up with recommended practices regarding turbulence.

A large number of experts are already studying and analyzing how to assess the uncertainty. And it is not high priority to launch new research project to assess the uncertainty, due to the fact that enough information is already available on it.
Applications of RSS.

Although it was prioritized to focus on the use of RSS for resource assessment, other applications such as power curve measurements, operation and forecasting were discussed.

It was commented that high accuracy requirements are more restrictive for resource assessment purposes than for use in control strategies (DJ). It is important to remark that the availability of data (quantity) should be a priority in addition to the quality (DE).

The RSS measurement is complementary to the cup anemometers measurements and help to have a better picture of the real situation (JC). For instance, in the new IEC Document of Power Curve Standard, the measurement of the vertical profile is going to be included (MC).

It was commented about why not including in the RP also the study on the power performance of Wind Turbines (JW). Introduction of RSS in the measurement of power curve procedure is already being taken care of by the 12-1 revision group (MC).

It was agreed that other applications different from resource assessment should be mentioned in the RP, but main focus should remain in resource assessment.

Structure of the RP documents

A consensus is reached about elaborating a RP document that, basically, would describe under which conditions data from RSS can be bankable, what are the parameters to check that, and how parameters can be measured (DE)

PC’s suggestion that the recommended practices document should be technology specific (lidar or sodar), but not be instrument specific, is agreed by the group. A scheme for the RP is proposed, according to which a general verification protocol could be carried out (common for both lidars and sodars), followed by best practices for lidars and sodar, and finally different documents instrument-specific. This called “Boulder Protocol” document could be integrated with the draft RP documents (PC).

A classification identifying the advantages and disadvantages of some instruments versus other types according the necessities could be done (FB), but as it may lead to discussion of one instrument over the other, it is agreed to focus in the advantages of using RSS complementary with tower masts (JC).

Parameters that should be included in the documents are the bias number and the random error number. Some procedures should be developed, and specified by manufacturers, to evaluate them. Manufacturers should provide reference values of both.

The acceptable (atmospheric) error depends on the application. (RF)
Future actions under the umbrella of IEA Wind

The participants in the meeting were very interested in continuing the efforts in this area, and reiterated the necessity of elaborate the RP on best practices to use remote sensing equipments. Some of the participants will collaborate to the preparation of the RP.

It is suggested by FA that is more convenient to have a small group of people elaborating the draft RP that later on would be passed on to the rest of the members to comment on or complete. In particular, the two ad-hoc groups to deal with sodar and lidar (respectively) are:

- Kathleen Moore & Jerry Crescenti for SODAR RP
- Dan Jaynes and Rod Frehlich for LIDAR RP.

It is also agreed that the next meeting will be held between the operating agent and the components of these two groups, and later on a general, plenary meeting. It is suggested, as tentative, to have drafts of the RP in 6-month time.

The existing documents on sodar RP (also available at www.iedt.com/sodar.html) and PC’s suggestion for protocol will be distributed to the assistants to the meeting. It was also suggested (JC) that a web site is created so that the participants in this meeting