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ウィンドファームの風況観測へのリモートセンシング受け入れおよびその目的における LiDAR ZephIRの評価

Commentary on the steps required to adopt remote sensing devices into the measurement of the wind regime at potential wind farm sites and an appraisal of the status of the Natural Power ZephIR Lidar device within this context

Andrew Tindal, Garrad Hassan and Partners Ltd, 7 December 2007

Natural Power have developed the ZephIR Lidar remote wind speed sensing device. GH have been asked to comment on the use of Lidar wind measurements in the context of the development and financing of wind farm projects. This note presents GH's position on the steps which GH consider are required before a new remote sensing system may be considered to be a proven device in the context of wind energy. The current status of the Natural Power ZephIR Lidar system within this process is discussed here. Only measurement of mean wind speed and direction are considered at this stage.

ウィンドファームの
前提としたLiDARに
し、この方法が使え
するために必要と思
ZephIRについて記述
風速と風向のみを対

Cup anemometers are the current industry standard for measuring wind speed at wind farm sites. Measurements from cup anemometers therefore must be considered the norm against which any new measurement device must be judged.

風力発電サイトにお
計で風況を観測する
なっている。したが
法についてはカップ
を基準に対比すべき

GH consider that the process whereby a new remote sensing device may be considered to be a proven device is as follows

次のプロセスがリモートセンシング装置が風況観測に利用可能であることを示すためには必要

テージ
トセンシング製品が存在し、
応じた風速と風向が難なく計
ること。一方、従来の観測で
るデータと対比して検証を得
りるデータがない、もしくは
測のデータ品質より著しく劣
タしか得られないようではだ
のステージでは「量より質」
ートセンシング製品が求めら
業の採算を検討する豊富な
を提供するというより、風の
把握するために使われるもの

Stage 1

During this stage a remote sensing device is commercially available and the device can routinely provide measurements of wind speed and direction with height. However, either limited measurements are available to validate the data produced against conventional measurements or validation data indicates that error bars on remote sensing measurements are substantially higher than those which could be obtained from conventional measurements. During this stage data from a remote sensing device can be useful in providing qualitative but not quantitative data. Remote sensing may assist with understanding the wind flow at a given site but the data may not be used quantitatively in a formal wind speed and energy production analysis used to support the financing of a project.

イルストーン
電テストサイトで実効高度域
測テストが行なわれ、従来方
況観測と比較がなされ時に達
、従来方式の観測と同等の観
が得られていること。その報
術誌に掲載されていること。

Milestone 1

GH consider a milestone is reached when a remote sensing device has been successfully tested at a suitable test location against conventional wind speed measurements over a range of heights relevant to wind energy applications. The tests will have demonstrated that the accuracy achieved through remote sensing is similar to that which would have been achieved with conventional anemometry. The results of the test will have been published in a suitable technical paper.

テージ
サイトにおいて幅広く利用が
いること。観測の実績が増
置方法や頑強性・安定性につ
解が進んでいること。途切れ
した信頼性の高いデータを、
うな観測環境においても提供
能力が実現できていること。
はデータの信頼性が得られな
が認識され、そのデータを分
排除できること。従来方式の
果との検証により、観測デー
業の採算を検討する豊富な
として扱われることが可能と

Stage 2

A device gains increasingly wide use on a range of sites with different meteorological characteristics. A device gains more operational experience and more is learned about the set up, robustness and consistency of the measurement equipment. Confidence is gained that the device provides robust, continuous and accurate data over the full spectrum of operational conditions. Alternatively specific conditions where the device does not provide robust data become well understood and can be excluded from analyses. Data from the remote sensing device may be used quantitatively within a formal wind speed and energy assessment provided, where appropriate, site specific validations against conventional anemometry data are undertaken.

イルストーン
環境や地形のサイトで幅広く
る。データ回収レベルが高
来方式の観測結果との多くの
より裏付けが取れている。

Milestone 2

A device has been used extensively over a range of sites in differing environmental and topographic regions with high data capture levels and numerous validations

テージ
電アセスメントへの使用が事
明できている状況。従来方式
との検証をほとんどもしくは
なくても事業計画を検討する
データを提供できる状況。

which demonstrate close agreement with data derived from conventional measurements.

Stage 3

A device is considered proven for use in the assessment of wind farm sites. The data may be used quantitative within formal wind speed and energy assessments with only limited or no site specific validation against conventional anemometry.

現存のLiDARは第１
クリアしているとは
いまだ第１ステージ

GH consider that the majority of remote sensing devices currently can have not achieved Milestone 1 and therefore may only be considered to be at "Stage 1" as defined above.

ZephIRについては開
証試験の結果の技術
おり、他の情報も加
た。一例として下記
高層タワーの従来方
較テスト結果である
イトの近くには風力
屋がある。また風況
LiDARの設置距離が
一方洋上のテストで
どなく検証データと
ここではこの結果を
る。

Natural Power have supplied a number of technical papers to GH which present the results of a range of validation tests of the ZephIR Lidar device as it has progressed through it's development phases. This has been augmented by experience from GH staff. An example of these [1] present the results of an onshore and an offshore test of the equipment against conventional anemometry installed on tall masts. The onshore test site is complicated by the presence of wind turbines and large power station buildings nearby and the fact that the meteorological mast and Lidar measurements were offset by some 70 m. The offshore measurement represents a test site with few obstructions to the flow. The offshore measurements therefore represents a simple validation data set and it is the results of the offshore test which are considered here.

洋上テスト（３層観
風速観測結果は従来
以内に納まっていた
式風速計の計測精度
たがいこのテストに
型の観測方式を同等
能力があることを検
これは単に一つのテ
たデータは「Cloud
う手順を通して使わ

The results from the offshore test indicate that, at three separate measurement heights, the wind speed recorded by the Lidar device was within 2 % of that which was derived from the conventional anemometry. The observed agreement between the two sets of results is of approximately the same magnitude as the uncertainty which is typically assigned to data recorded with cup anemometry. The offshore test may therefore be considered as a validation which demonstrates the ability of the ZephIR to reproduce conventional wind speed measurements to an acceptable degree of accuracy. Of course this is only one test and the data have required application of a "cloud correction" algorithm.

上記の結果からZeph
トーンを達成してお
ての第２ステージに
とができる。検証デ
支えられ、単純な地
ば従来型の観測を再
増している。LiDAR
用については更に実
ZephIRの乱流データ
するかという研究が

From the above results GH consider that the ZephIR device may be considered to have achieved Milestone 1 as defined above and that the device may now be considered to be in Stage 2 of it's commercial exploitation. There is a growing body of additional validation data sets which are providing an increasing confidence in the ability of the device to accurately reproduce conventional wind measurements at relatively simple terrain sites. More experience needs to be gained in interpreting Lidar data in complex terrain sites. An additional challenge will be to more fully understand the how turbulence data from ZephIR may be used.

事業上の重要な決断
データにリモートセ
たデータを使う際は
アプローチが必要と

Wind data recorded on a wind farm site is used to make important commercial decisions. Great care is therefore required before data from remote sensing devices is relied upon for use in such analyses. For a device which has completed Milestone 1 as defined above GH consider that the following approach will maximise the weight which can be assigned to the data recorded by a remote sensing device.

基本的にリモートセ
う前後において、装
ションを施す必要が
ZephIRの場合、屋内
トを使い距離120m
レーションを行なう
と参照用のLiDARに
プンスペースにおい
度までのキャリブレ
ている。参照用LiDA
マークRisøのテス
の観測タワーに対し
ションが施されてい

The principle GH consider needs to be adopted in the use of the remote sensing device is to calibrate the device before and after use. Natural Power have provided GH with a summary of the calibration tests which are applied to all new ZephIR devices [2]. Initial factory calibrations are undertaken using moving belts allowing calibration of measurements at distances of up to 102 m from the Lidar to be made. Once these tests are passed a validation against a second reference Lidar in the open atmosphere is undertaken at a range of heights of up to 150 m. The reference Lidar will itself have undergone an independent calibration against a conventional tall meteorological mast, such as the mast at Risø Høsvøre test site, within the last year. As with all measurements it is important that high quality

documentation is maintained regarding the calibration, installation and maintenance of a Lidar based measurement program.

広大なサイトなどで
唯一の風況データの
型の観測タワーを使
ションが望ましい。

Natural Power also offer ZephIR calibration against a conventional tall meteorological mast at an additional fee. Such a calibration is considered to be a "best practice" calibration. For large sites where the Lidar results are the only relevant source of local wind speed measurements it is considered prudent to undertake a calibration against a conventional met mast.

より複雑な地形での
データはまだ十分に
い。複雑地形のサイ
LiDAR上空の観測空
速計のピンポイント
れる風速データに無
が生まれうる。した
サイトではLiDARを
従来型の風況観測と
ましい。事前に現地
キャリブレーション
と従来型カップ式風
を認識し把握してお
い。

It is considered there is not yet a substantial body of data from the operation of Lidar devices at more complex terrain sites. At such sites the larger volume over which Lidar measurements are made compared with the point measurements made by cup anemometers may lead to significant differences between the wind speeds recorded between the two types of device. It is therefore recommended that for sites with complex terrain (or which experience complex wind regimes) that Lidar is currently only used in combination with conventional anemometry. It is recommended that on site calibration is undertaken against the conventional anemometry prior to the measurements(s) of interest to provide an on site calibration measurement over which the differences between the Lidar and cup anemometer data may be identified and quantified.

現在LiDAR観測の精
の、文献に基づく実
が進められている。
LiDARおよびLiDAR
のデータが統計的に
る。

GH will currently use a pragmatic approach, based on results within the literature, to define the uncertainty in Lidar measurements. Natural Power have undertaken to build up a body of Lidar to Lidar and Lidar to conventional met mast data which will allow a more statistical approach to defining the uncertainty in the measurements to be undertaken in the future.

リモートセンシング
増えるほど、先に述
業の必要性は減って

As experience of a remote sensing devices increases the need to undertake all of the above validations reduces. However, it is considered that until Lidar has been used for a considerable period within the wind sector a high level of validation is appropriate.

総括
ZephIRは上記第２ス
３ステーに昇格する
の過程にある。適切
果が肯定的であれば
られたデータは、ウ
おける風速とエネル
トのために量的にも
況となる。

In summary therefore GH consider that the Natural Power ZephIR system may be considered to be within Stage 2 operation as defined within this note and is in the process of building up a body of data to allow it to enter Stage 3 operation. Provided suitable site validation steps as defined above are carried out, and the results of these validations are positive, then GH consider that data recorded using the ZephIR device may be used in a quantitative sense for the formal assessment of the wind speed and energy production of a potential wind farm site.

[1] Detlef, K et al, "An 8 month test campaign of the QinetiQ ZephIR system:, Preliminary results" , http://www.qinetiq.com/home/commercial/energy/ZephIR/case_studies.Par.0006.File.pdf

[2] Scullian, R, "ZephIR Calibration", 27 September 2007, Presentation made by Natural Power at GH Office, Bristol