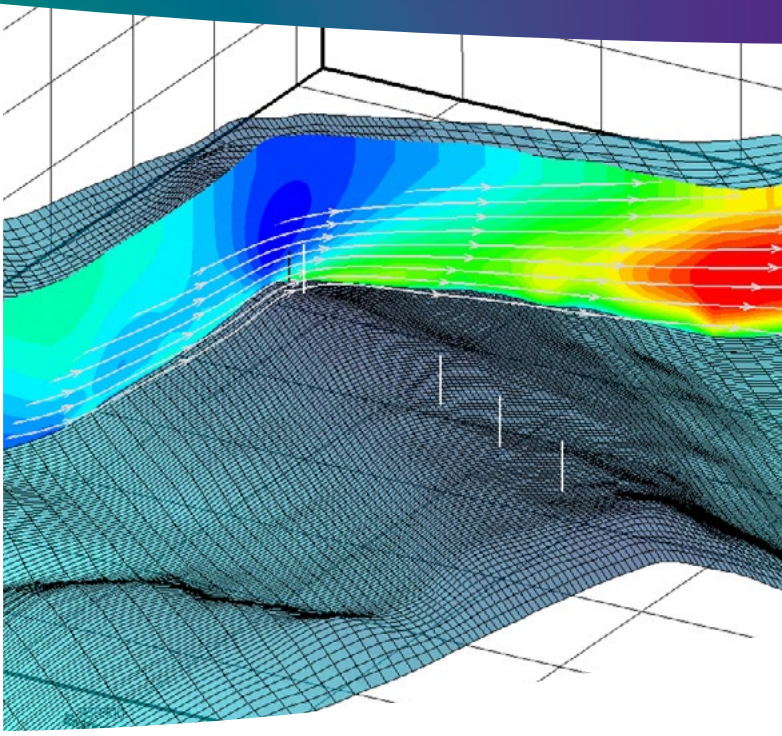
natural power

DYNAMICS

BANKING ON ZEPHIR 300 WIND LIDAR IN COMPLEX FLOW



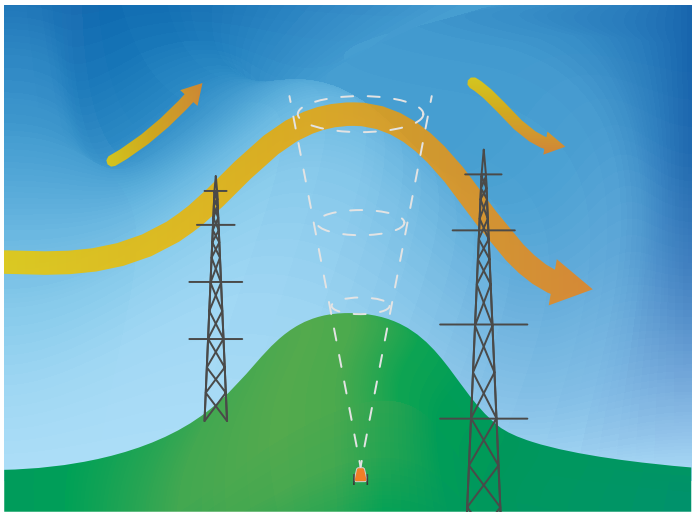
FOR GREATER SURETY IN AREAS OF COMPLEX AIRFLOW

Lidar remote sensing for wind measurements provides significant benefits over traditional meteorological mast anemometry such as practicalities of taking measurements through to project uncertainty reduction. On and offshore, in benign sites, lidar data have an industry-wide acceptance and are handled much the same as meteorological mast data. In areas of complex flow, most commonly due to terrain or forestry, the simple addition of "Dynamics" to ZephIR 300 wind lidar data allows you to do the same.

Wind lidars for wind speed profiling and measurement make the assumption of a homogeneous flow across the area they scan. In areas of complex flow this assumption does not necessarily hold true. In these situations, wind measured in a cone as shown in the figure above may differ when compared to a single point measurement, in the same way as two masts located a small distance apart in complex flow would also differ. However, using wind flow modeling it is easy to compute conversion factors that convert data from lidar measurements to mast-equivalent values, allowing users to benefit from the mobility, reduced uncertainty and generally more practical wind measurement solution available with wind lidar. Natural Power uses an automated process called Dynamics that makes use of the VENTOS®

Computational Fluid Dynamics (CFD) flow model for ZephIR 300 data. VENTOS® - a scientifically-validated CFD code - is specifically designed to improve certainty of wind flow modeling and is up to 40% more accurate when compared to standard industry models. These outputs lead to improved certainty on energy yield predictions. It is this core CFD code which has enabled the development, and ensures the accuracy, of the Dynamics process.

Natural Power therefore considers ZephIR 300 wind speed data, when converted with Dynamics, to be at DNV GL Stage 3 in complex terrain - ZephIR 300 can be used with little or no additional on-site met data.



Complex airflow over a hill where any measurement taken will differ from location to location - either an averaged volume measurement, or two independent single point measurements

ZephIR Lidar

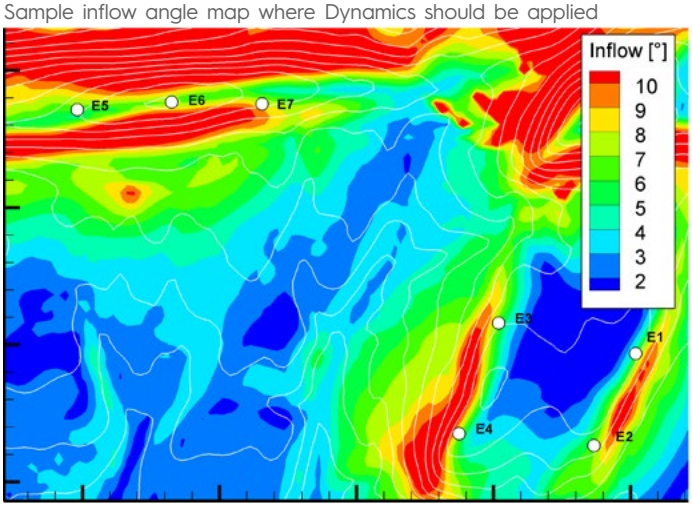
> ZephIR 300 is the industry leading wind lidar for providing remote wind speed measurements as part of wind energy assessments, permanent mast replacements and for trouble-shooting on operational sites.

VALIDATION

Dynamics validation was achieved by comparing the measured wind speed values from cup anemometers and co-located lidars, before and after conversion factors are applied. In order to reduce cup anemometry uncertainties, only data from paired cups where the measured difference was very low was used.

Complex and non-complex sites are used in the validations, as have sites from various regions. Model uncertainty associated with model sensitivity ranges from 0.6% to 0.9%, i.e. half of what is expected on properly installed top class cup anemometers.

Sample inflow angle map where Dynamics should be applied



ACCEPTANCE AND RECOMMENDATIONS

Average values of wind speed measured with lidars benefit from Dynamics in most cases where discrepancies >1% were found between the mast and lidar data. On a site basis where there are discrepancies in the range of -1% to +1%, it is recommended that the original ZephIR 300 data with no correction is used.

If comparing lidar results to a conventional on-site met mast, measurements should be located no more than 35m apart. The optimal distance is, in practice, dependent on terrain complexity as well as purely practical aspects. In complex terrain, differences in wind speed can quickly reach values of the order of cup anemometer and dynamics uncertainty.

It is imperative that measurement equipment be adequately deployed and mounted. Significant tower shadow, tilted cup anemometers, and malfunctioning instruments are all factors that potentially make a comparison impossible due to the high uncertainty in the mast measured values.

In conclusion, lidars in general can add significant benefit within a wind measurement campaign. With the application of Dynamics, ZephIR 300 can now be used confidently without the use of additional anemometry through this clear and auditable data conversion process provided by Natural Power.

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