PO.035

A more efficient method for static yaw misalignment detection and correction

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Abstract

Wind turbines are designed to face the wind. When the nacelle is not aligned with wind direction, the turbine produces less power than expected. This static yaw misalignment, i.e. the non-zero mean error of yaw alignment, is usually measured by means of a nacelle-LiDAR campaign. This method can only be applied to one turbine at a time. A more efficient method using a ground-based LiDAR (GBL), measuring the absolute wind direction, and nacelle mounted GNSS compass, measuring the absolute nacelle direction was developed, tested and validated on a wind farm located in flat terrain. The yaw error before and after correction was compared to simultaneous nacelle-LiDAR measurements. Results were consistent although a slightly higher uncertainty was observed. However this has a minimal impact on AEP after correction, demonstrating the potential of this new method to bring significant cost reduction and duration of yaw misalignment campaign by correcting several turbines simultaneously.

Objectives

The static yaw misalignment (*Figure 1*) of a turbine is determined by measuring the wind direction upwind of the turbine rotor and by comparing this direction with the nacelle direction. In the case of a nacelle-LiDAR campaign, the LiDAR is aligned with the nacelle and the relative wind direction is measured.

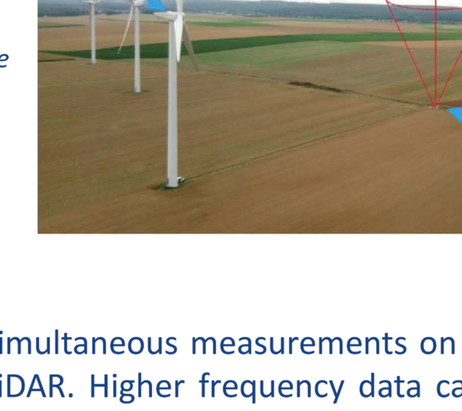

Figure 1: Illustration of static nacelle misalignments with respect to wind direction

Methods

ENGIE Laborelec has developed and tested an efficient method to characterize the static yaw misalignment. The absolute wind direction is measured with a ground-based LiDAR, and the absolute nacelle direction is measured by a Professional Heading and Positioning Global Navigation Satellite System (GNSS) compass mounted on the nacelle (*Figure 2*).

Figure 2: Setup developed by Laborelec to efficiently measure the static yaw misalignment

This methods allows simultaneous measurements on several turbines with a single ground-based LiDAR. Higher frequency data can be used for analysis. The nacelle orientation is measured accurately (irrespective of north offset and SCADA issues).

The simultaneous measurement on several turbines is only possible if the same wind profile is observed for all turbines (i.e. simple terrain configuration)

Results

The GNSS method was tested in one wind farm located in flat terrain (*Figure 3*). A GBL was installed in front of the line of turbines, upwind in the direction of the dominant wind sector.

In order to validate the new method, a parallel yaw misalignment campaign was conducted with nacelle-LiDAR. As shown in the timeline (*Figure 3*), simultaneous measurements by GNSS, GBL and nacelle-LiDAR are available for some turbines.

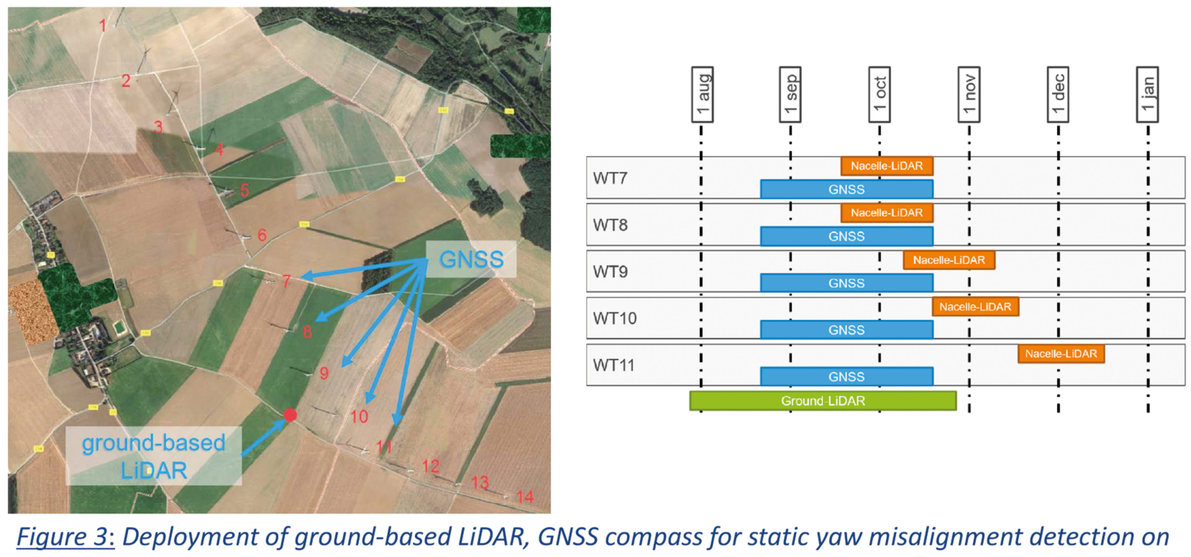

Figure 3: Deployment of ground-based LiDAR, GNSS compass for static yaw misalignment detection on five wind turbines. Parallel deployment of nacelle-LiDAR to validate the method.

As an example, the static yaw misalignment detected by the two methods (GBL + GNSS and nacelle-LiDAR) on wind turbine 7 is given in *Figure 4.* The measure was done before and after correction.

The results presented in *Table 1* shows the yaw misalignment detected on the five turbines with a verification after correction on turbine 7 and 8. The absolute error between the two methods is low with small impact on AEP.

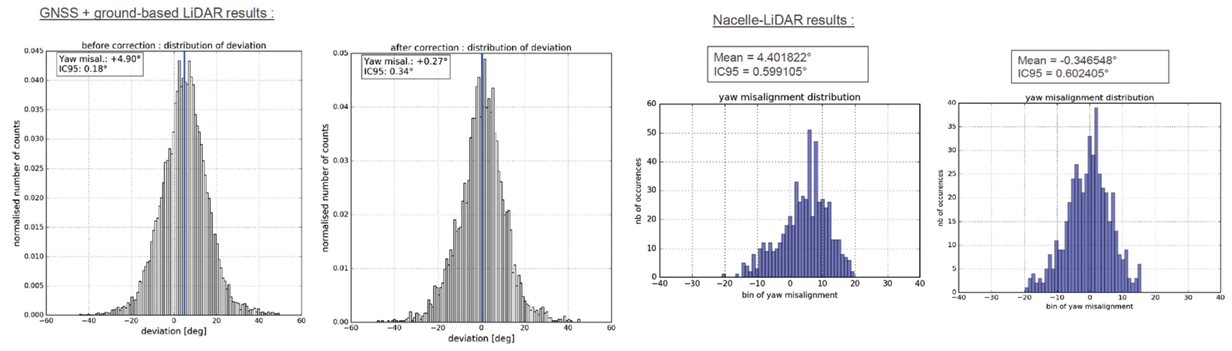

Figure 4: Measurement of static yaw misalignment with GBL + GNSS and nacelle-LiDAR before and after correction on wind turbine 7.

Table 1: Yaw misalignment detected on the five investigated turbines and compared with traditional nacelle-LiDAR measurements

turbine	time period	Yaw Misalignment		Absolute error [deg]	Error on AEP [%]
		Nacelle-LiDAR [deg]	GNSS [deg]		
7	before correction	4.40	4.90	0.5	0.011
	after correction	-0.35	0.27	0.62	0.018
8	before correction	-9.50	-6.54	2.96	0.400
	after correction	0.50	-0.20	0.7	0.022
9	before correction	-9.26	-11.13	1.87	0.160
10	before correction	-5.74	-5.89	0.15	0.001
11	before correction	-10.10	-9.04	1.06	0.051

Conclusions

A new method to measure static yaw misalignment of wind turbines has been developed by Laborelec. This technique uses a ground-based LiDAR and several nacelle-mounted GNSS compasses. It is a cost-efficient alternative to nacelle-LiDAR campaigns. The completed test campaign on five turbines showed that resulting yaw misalignments are close to those obtained with the simultaneously executed nacelle-LiDAR campaign, which validates the method.

Contacts

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