PO.037

Operating wind parks:
Nacelle direction monitoring and correction

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Abstract

The direction of turbines towards true North was for long ignored in the wind industry considering that it did not bring significant gain correcting it. This study was driven by two acknowledgments:

- Proper directional data is key to work on WTGs underperformance and to understand the external parameters that it can be result of (lower production in a given direction, increase wake effects,…).
- Directional curtailment and sector management relying on direction given by the controller, thus a directional bias will result in production losses and/or increased mechanical loads.

Two methods are derived to correct the wind turbines for which an offset in direction is suspected. The two methods rely on the sensors available on site:

- Method 1: Only the nacelle sonic sensors (Anemometer/Wind Vane) from the SCADA
- Method 2: A meteorological mast following IEC61400-12-1 conditions and nacelle sonic sensors.

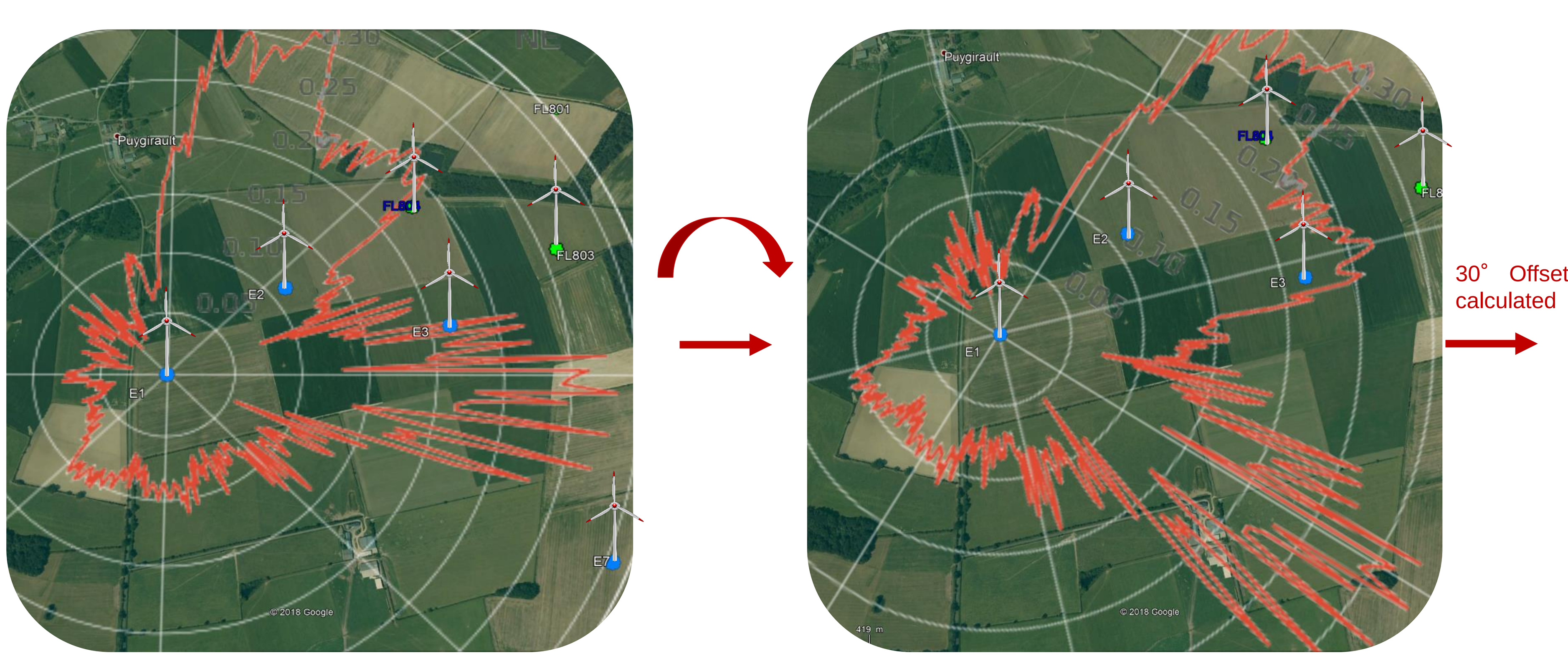
Methodology 1 : "WTG Shading" Correction

Methodology 1 is based on SCADA data and turbine layout.

It considers that the wake of the turbine upwind impacts the turbine downwind and that this phenomenon can be used to determine the actual position of the surrounding turbines. The speed deficit due to the wake is computed under the form of a rose (in red below).

The speed deficit is computed based on the difference between the turbine wind speed and a non-waked reference

Based on the wind farm layout, the wind rose is realigned to match the location of the turbines to the induced wake.

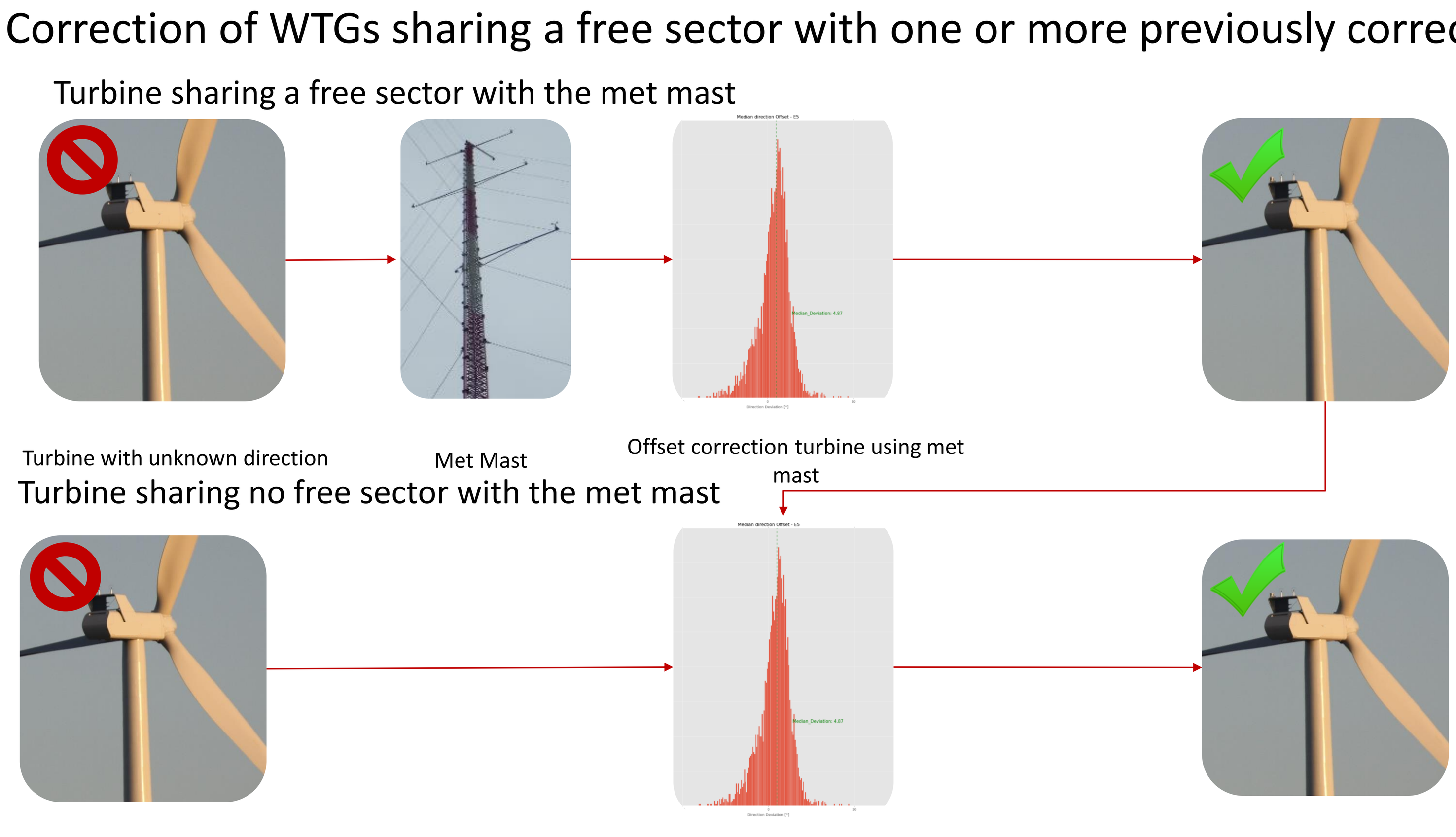


Methodology 2 : Reference Met Mast Correction

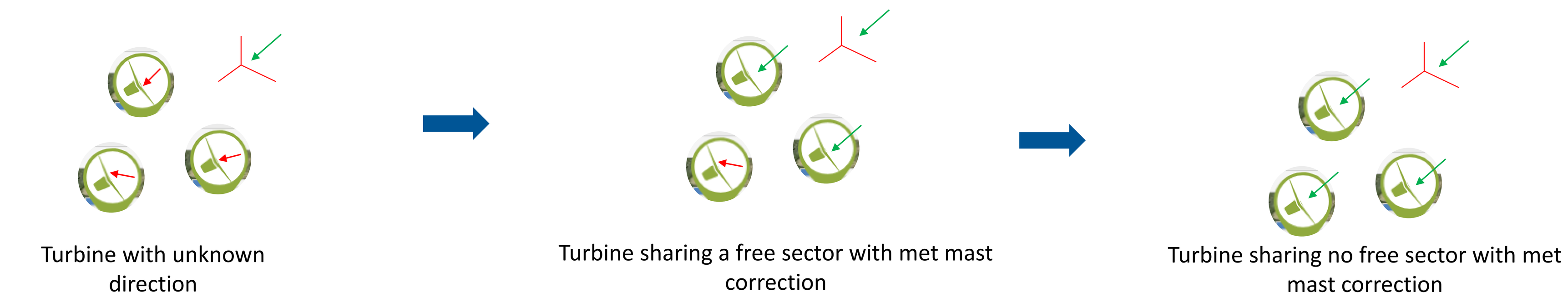
Methodology 2 is based on SCADA data and a reference IEC61400-12-1 meteorological mast.

The method is divided in two steps:

1. Correction of the direction of WTGs sharing a free sector with the met mast.
2. Correction of WTGs sharing a free sector with one or more previously corrected WTG.



Below are described the different steps of the correction for the wind farm



Validation

The validation process for both methods was done using WTGs with a trusted North Offsetting. The WTGs being properly aligned, a random offset was applied to turbines direction. Both methodologies were tested on their ability to find accurately the added offset.

Methodology 1 relies on the ability of the operator to properly align the wake to reality. To minimize the impact of the human factor, it was tested on a panel of engineer with knowledge of wake effects. The results of the methodology were averaged

The table below presents the result for the 8 WTGs of the wind farm:

Turbine	WTG-1	WTG-2	WTG-3	WTG-4	WTG-5	WTG-6	WTG-7	WTG-8
Offset Deviation to reference [°] - Method 1 (On average)	5.45	3.22	2.90	3.91	0.97	2.55	3.95	2.90
Offset Deviation to reference [°] - Method 2	2.84	2.45	3.37	8.30	3.43	2.64	0.26	0.25

Both methods provide good accuracy and can be used for correcting wind farms on which directional offset is suspected.

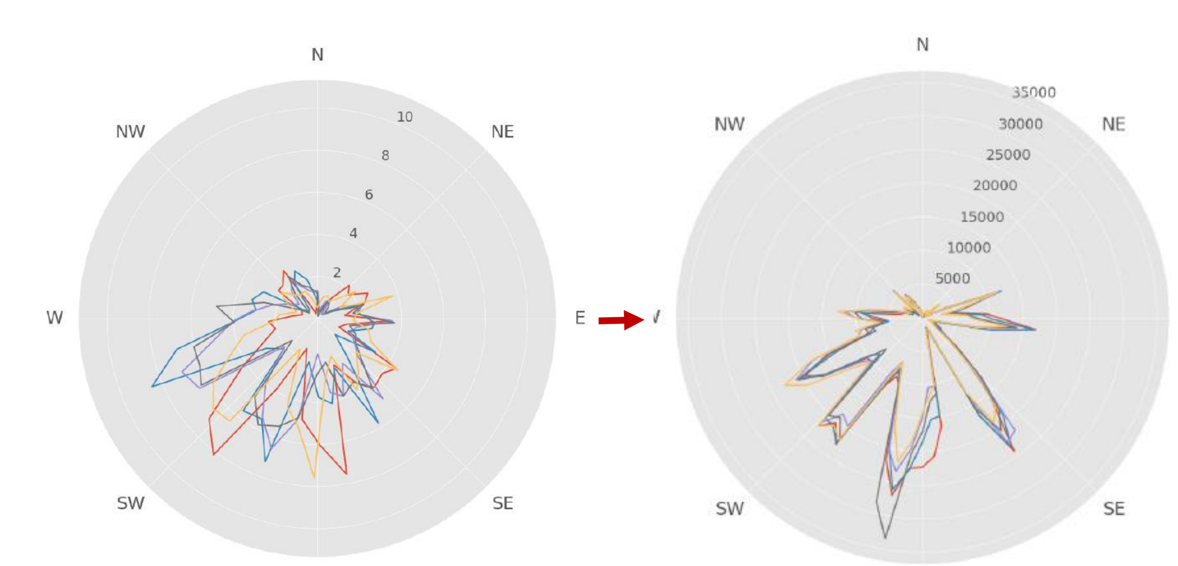
The method 2 is based on the high accuracy measurement that provides a meteorological mast following the IEC61400-12-1 conditions. Therefore, the method 2 is on average more accurate than the method 1.

However, the method 2 propagates the uncertainty of the nacelle sensors and small correction errors can be amplified in the case of a large sample of turbines.

Results

Monitoring:
The correction of the offset allows a proper monitoring of the wind direction and thus to identify odd behavior from a turbine compared to the other in specific direction.

The roses on the right present the effect of the correction of operating wind farm roses.



Directional curtailment: Depending on the direction in which the curtailment occurs, a shift in direction can generate non-negligible production losses. For the wind farm considered in the study, a shift of 30° results in a net loss of 13 000€ and non-compliance with regulation

Sector management:

Sector management is implemented to optimize the production of the turbines while maintaining acceptable loads and fatigue in sectors most impacted by the wake. The benefit of correcting the direction is double here: make sure the turbine runs safely and limit the production losses.

Conclusions

This paper has focused on the importance of the North Offset implemented in the wind turbines and the reason for correcting it. Among other the monitoring of underperformance can be improved, money saved through proper directional curtailment/sector management and increase the life of the turbine

Two methods were defined for North Offset correction and are applicable whatever the instruments available on-site (Nacelle Anemometry – Met Mast Anemometry).

It has shown benefits and limitation for both methods. Those should be chosen depending on the available material on-site and the number of turbines to correct. In the case a met mast is available on site, cross checking the methods is always a good practice.