A Case Study of Maximizing the Use of SCADA Data and Nacelle Mounted LiDAR to Optimize Wind Farm Performance

Wind Europe 2016
Session :
Reducing the cost of energy and maximizing the wind farm lifetime
Thursday, 29 September 2016

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1 wind farm, 1 goal → Optimized performance

Co-Author: eurocape New Energy

The wind farm:

10 * 2.5 MW turbines
100m Hub height
100m rotor diameter
Commissionned in 2011
France

Developper and Operator:

Optimizing the wind farm operation and maximizing the use of data high technology measurement solutions

Independent Service Provider:

Supporting Eurocape in finding the way to better use large amount of data available & technical solution for measurement and performance optimization

International Renewable Energy Group

Development	• Partnership with communes and landowners • Wind Park Design • Environmental studies and civil building permit • Grid connection agreement, PPA, CPA, Auctions
Wind & Power	• Wind campaigns, P50, P90 calculation • Turbines benchmarking • Production analysis • Operated wind park optimization
Financing	• Project financing • Specific tax knowledge • Optimization of revenues • Refinancing of running assets
Construction	• Executive Design • Tender Management • Contract Management
Operation	• Technical and commercial management • Production analysis and forecasting • Financial results • SPV Administration
M&A	• Quality Investment Opportunity • Valuation models • Deal execution

DEWI – a Global Brand

Co-Author: eurocape New Energy

Global Wind Energy Services

All-in-One Service Provider

Combining technical expertise with many years of in-depth industry experience, DEWI (UL International GmbH) offers global, one-stop wind energy services to turbine manufacturers, component manufacturers, project developers, utilities and other companies within the sector. UL-DEWI currently operates two wind test sites in Wilhelmshaven, Germany and at the West Texas AM University, USA.

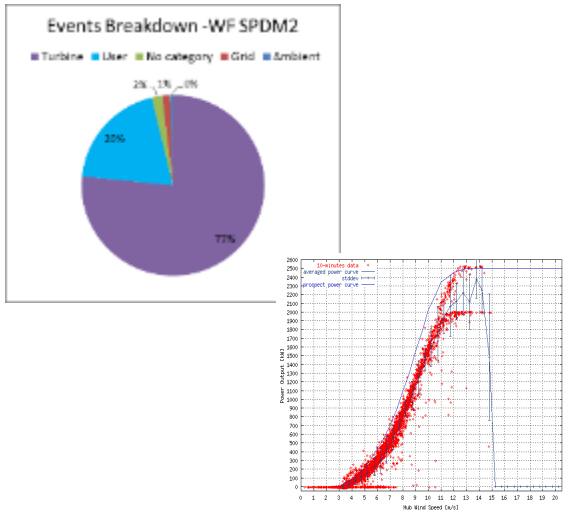
The Approach

Co-Author:

eurocape New Energy

Data Analysis

- ✓ SCADA data
- ✓ Error logs and operation history

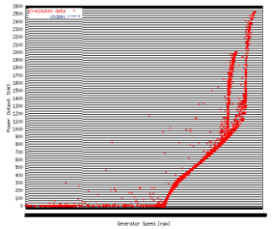


Nacelle Mounted LiDAR

- ✓ Yaw alignment,
- ✓ Nacelle transfer function,
- ✓ Operational Power Curve.

Further analysis & actions

- ✓ Data correction,
- ✓ More acute conclusions,
- ✓ Complementary analysis,
- ✓ Actions.



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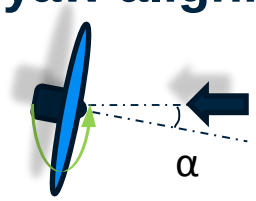

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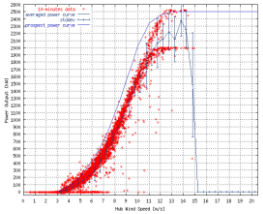

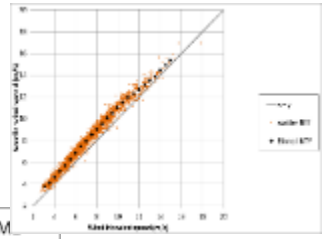

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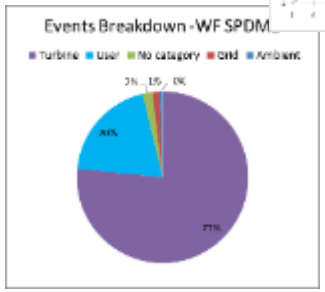

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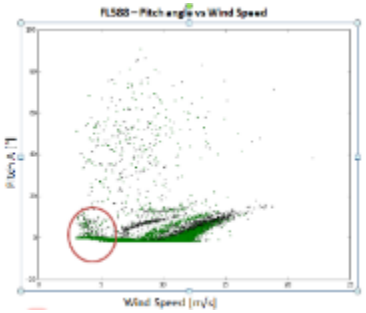

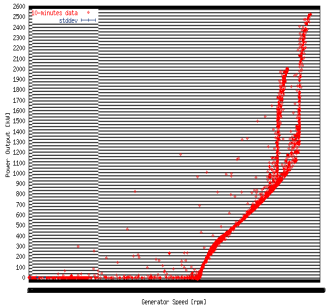

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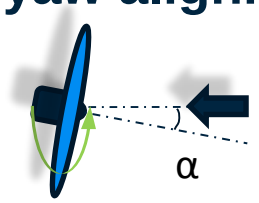

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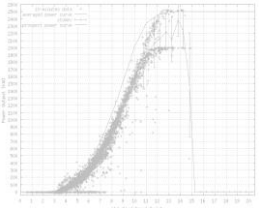

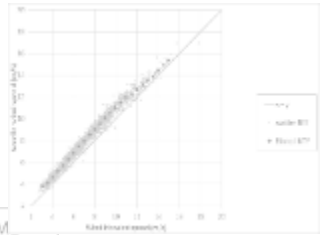

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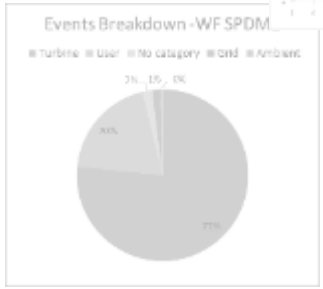

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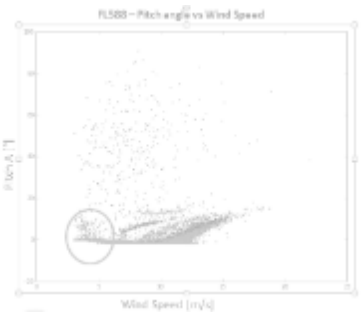
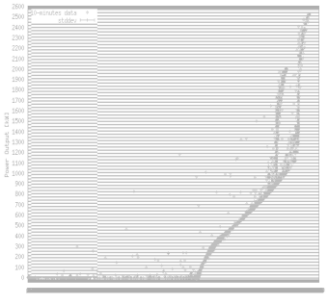
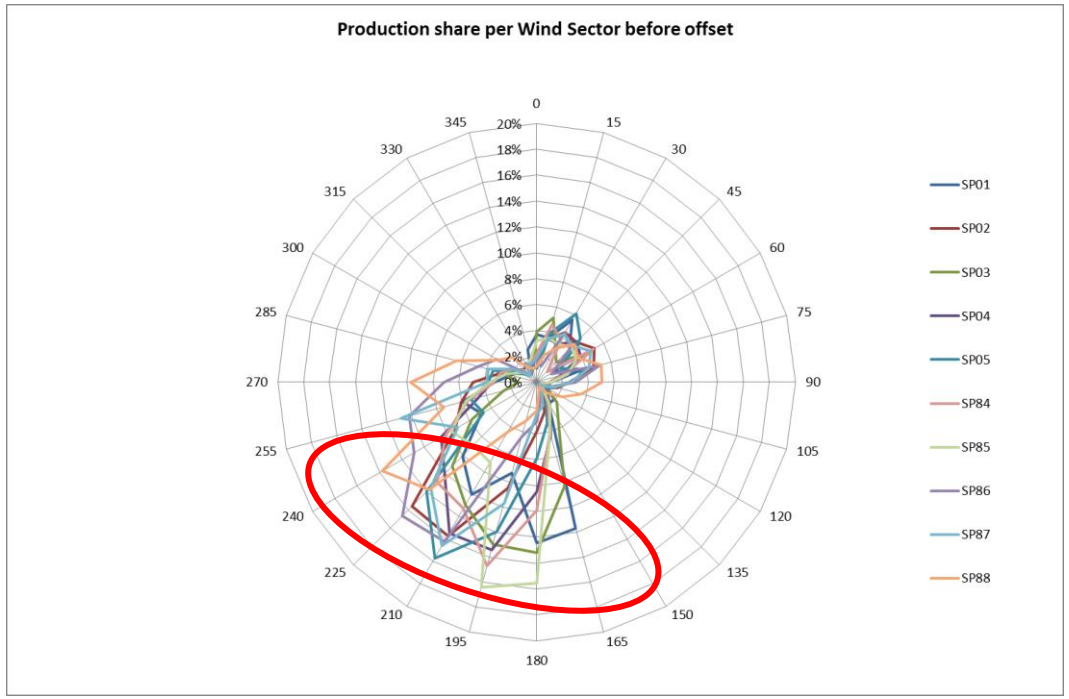




Nacelle orientation and yaw alignment

SCADA data analysis | LiDAR measurement | Post-measurement investigations | Data correction

Co-Author: eurocape New Energy



Analysis of yaw angle time series & production rose

→ track out potential misalignment

Offset identified between the turbines
Suspicion of yaw misalignment

Nacelle orientation and yaw alignment

SCADA data analysis | LiDAR measurement | Post-measurement investigations | Action

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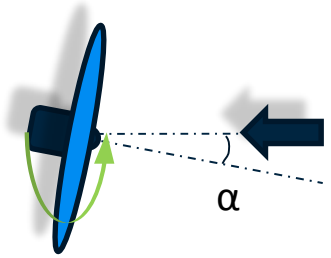

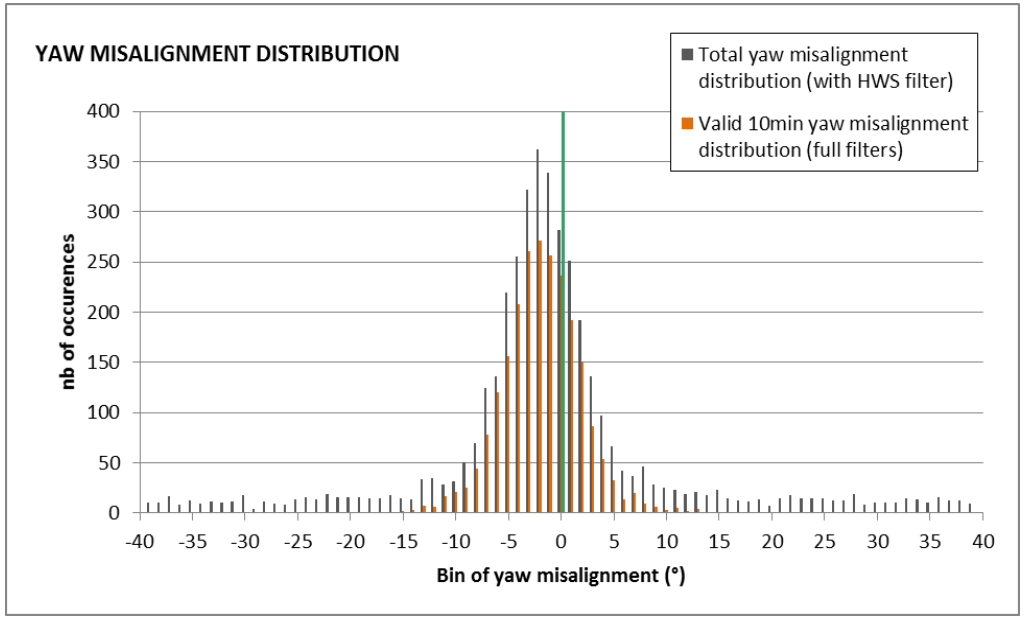

- ✓ Nacelle mounted LiDAR installed at one turbine during 6 weeks
- ✓ 1 week of measurement sufficient to identify yaw misalignment
- ✓ Average misalignment = -1.3°

→ **Measured wind turbine was properly aligned**

Nacelle orientation and yaw alignment

SCADA data analysis | LiDAR measurement | **Post-measurement investigations** | Action

Co-Author: eurocape New Energy

✓ Correction of yaw angle data using LiDAR and met mast

- Correction applied on same free sector:
  - LiDAR measurement: confirmation of proper alignment
  - Comparison of yaw angle with wind direction measured at met mast

  → Data from measured turbine corrected and used as a reference for wind direction.

- Check of all turbines direction against the reference

- Identification of North Offsets for all turbines

Turbine	Direction Offset [°]
WT84	10.00
WT85	23.04
WT86	-10.89
WT87	-3.89
WT88	-28.40
WT01	30.84
WT02	-7.90
WT03	23.60
WT04	2.61
WT05	-1.35

Nacelle orientation and yaw alignment

SCADA data analysis | LiDAR measurement | Post-measurement investigations | Action

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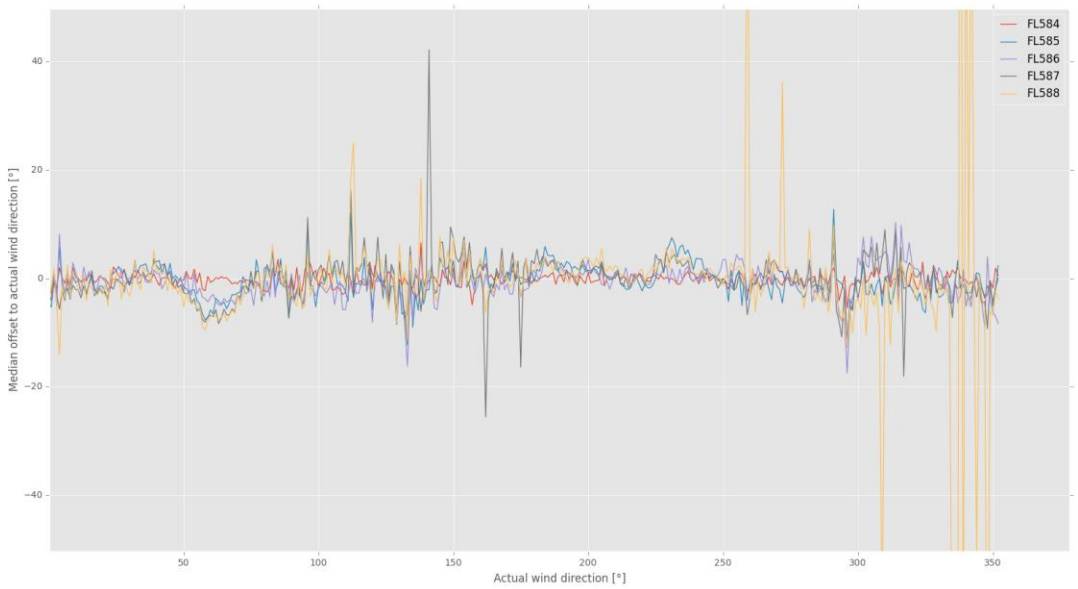
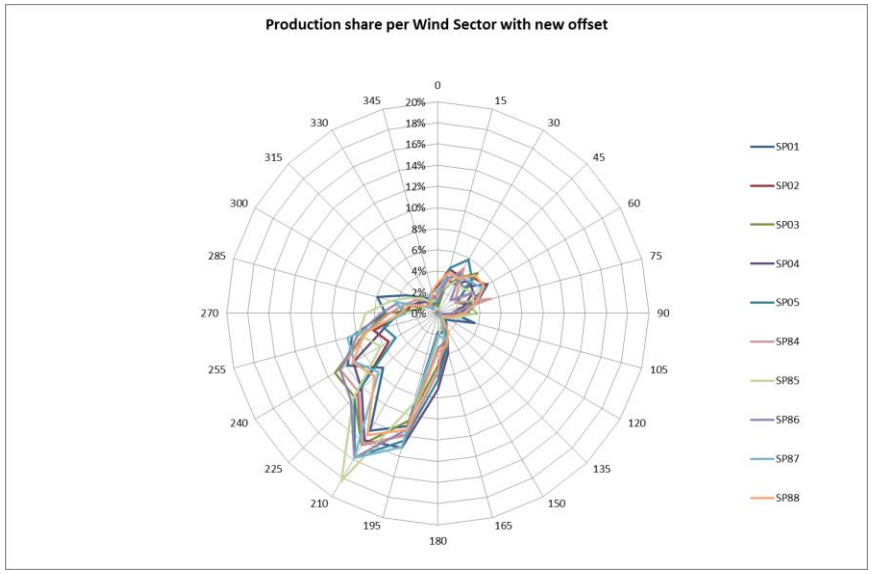
The actions taken to correct the data are the following:

✓ **Correct the turbines directions according to the defined North offsets**

Median offset binned by direction:



Corrected Production Rose:



✓ **Next step: check proper alignment of all turbines on site.**

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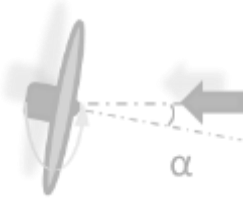

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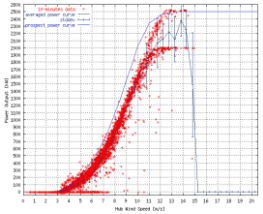

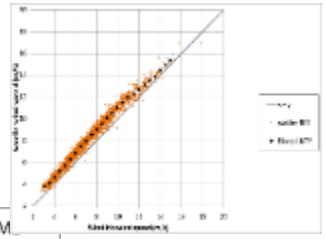

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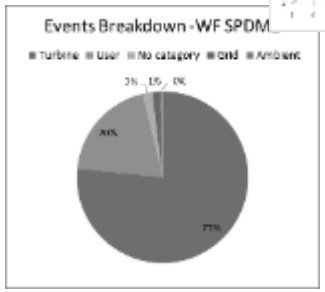

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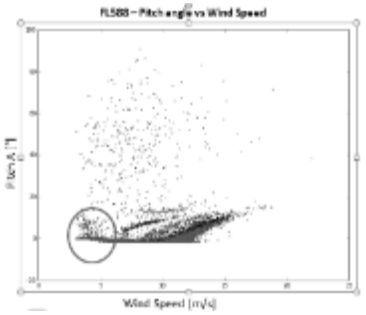

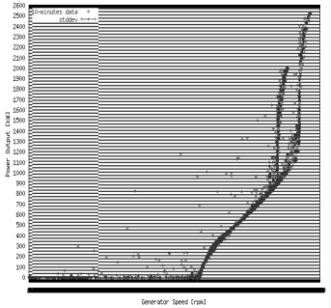

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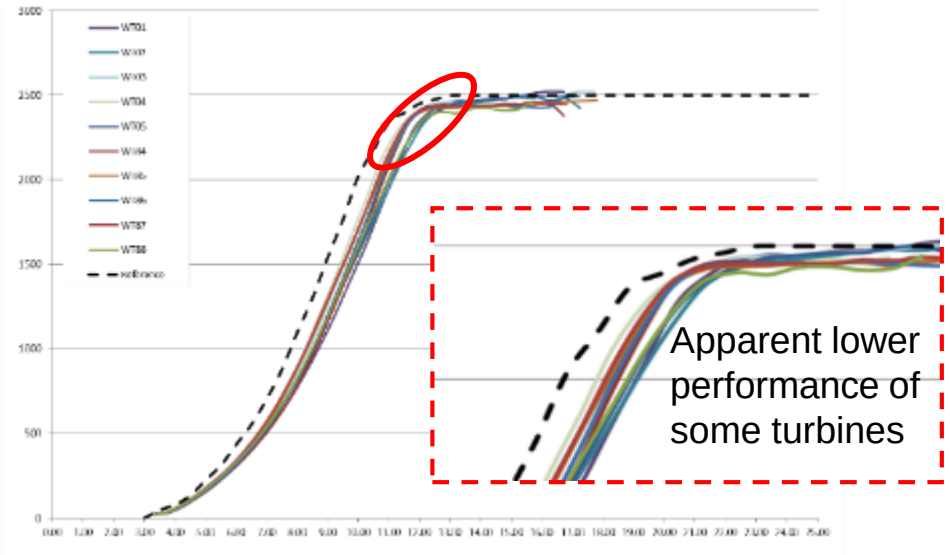
Power curve and nacelle transfer function

SCADA data analysis → LiDAR measurement → Post-measurement investigations → Action

Co-Author: eurocape New Energy

- ✓ 10 min SCADA data analysis
- ✓ Air density correction
- ✓ Data filtering (stops, curtailments, etc.)
- ✓ Monthly power curves analysis
- ✓ Relative comparison
- ✓ Analysis per sector



Power curve and nacelle transfer function

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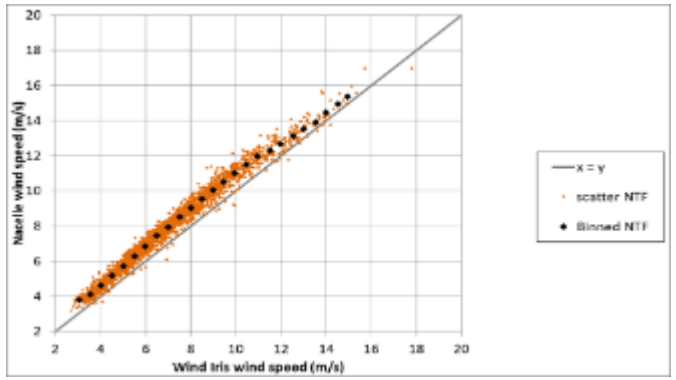
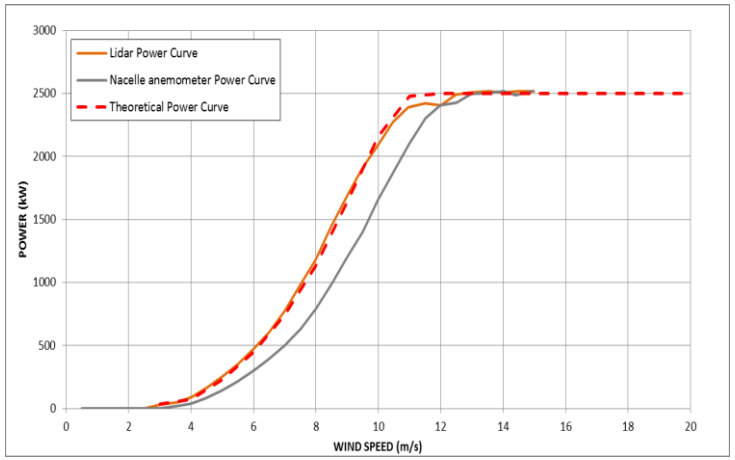
SCADA data analysis → LiDAR measurement → Post-measurement investigations → Action

Nacelle mounted LiDAR installed at one turbine during 6 weeks





<u>Nacelle transfer function:</u>

Strong overestimation of wind speed by nacelle anemometer

→SCADA power curve underestimating power performance

<u>Power curve:</u>

Performance as measured by LiDAR is much better than assessed with nacelle anemometry

	SCADA PC	LiDAR PC
Comparison with theoretical PC	34 % **suspected** under-performance	0.3 % **measured** under-performance

Power curve and nacelle transfer function

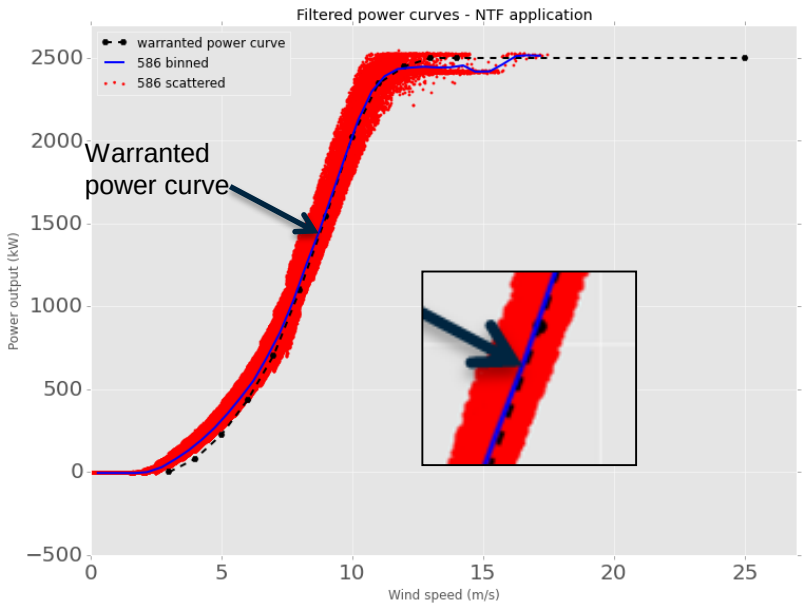
Co-Author: eurocape New Energy

SCADA data analysis → LiDAR measurement → Post-measurement investigations → Action

- Application of Nacelle Transfer Function to wind speed data → better fit to Manufacturer power curve.

Before NTF application

After NTF application



- Fleet nacelle anemometers comparison to understand if the overestimation of wind-speed is general.

Power curve and nacelle transfer function

Co-Author: eurocape New Energy

- Accurate diagnosis of power performance
- SCADA data post-treatment for future analysis
- Cut-in/cut-out parameters inside turbines to be investigated with manufacturer.
- Anemometry deviation assessment:

→ Wind speed reference analysis between reference turbine (LiDAR NTF applied) and other turbines (in free sectors)

Relative wind speed deviation – Year 2015			
	WT 86	WT 03	WT 04
Reference WT	-7.8%	-6.5%	-4.1%

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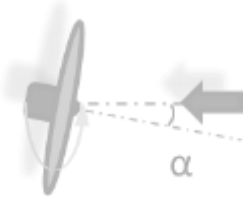

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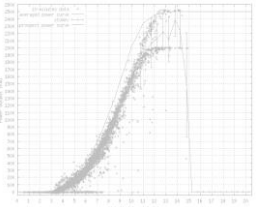

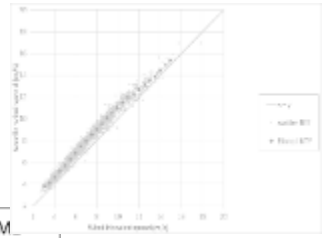

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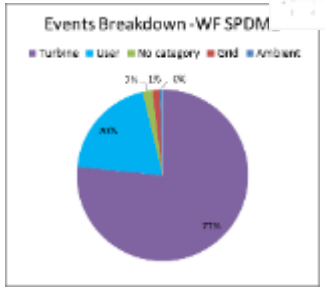

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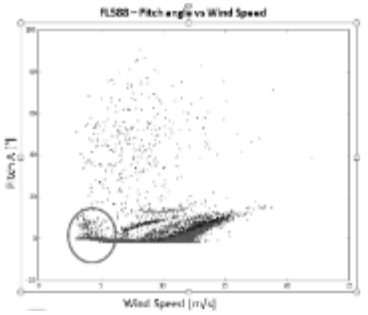

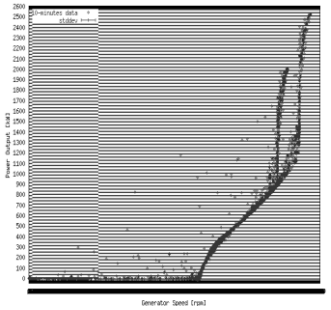

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Error log analysis

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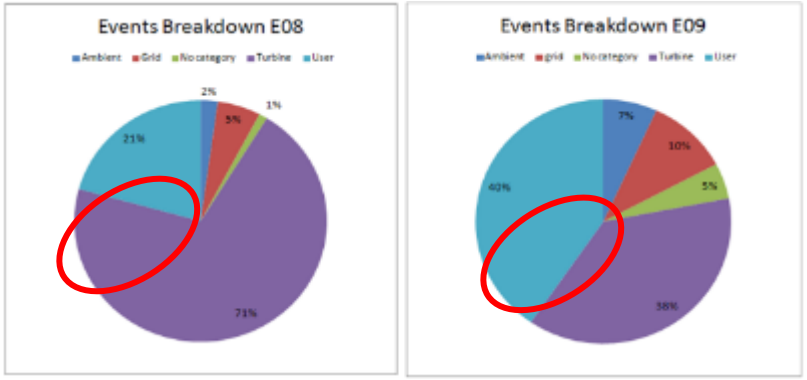
Differentiation per turbine:

- ❑ Identify turbines affected by major down time
- ❑ Identify turbines to focus on
- ❑ Evolution of down time along operational period
- ❑ Periodic or regular events

High variations of downtimes of individual turbine within the wind farm

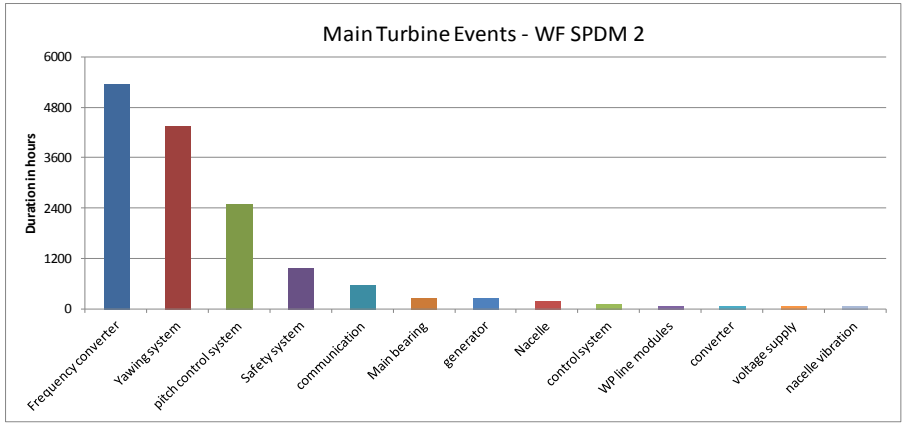


Event types & components:

- ❑ Breakdown events into 4 main categories:
  Turbine / Ambient / User / Grid

- ❑ Detailed breakdown of error logs from category Turbine:

Codes & components leading to most of the down times



Components mainly affected:

- ✓ **Frequency converter**
- ✓ **Yawing system**
- ✓ **Pitch control system**

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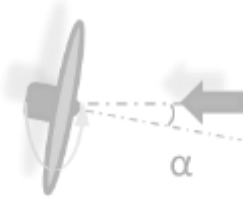

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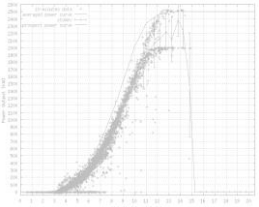

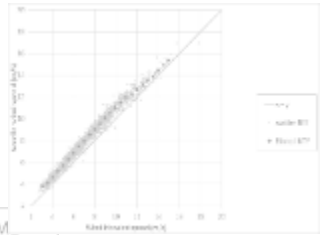

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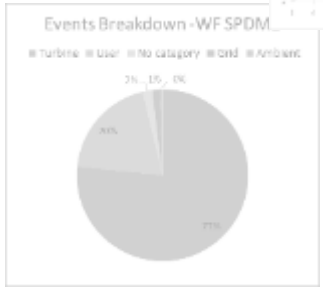

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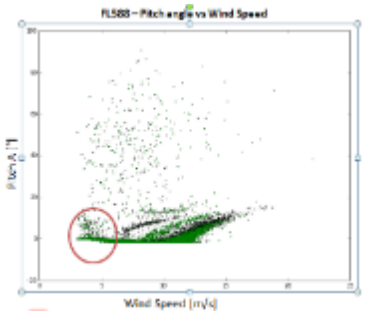

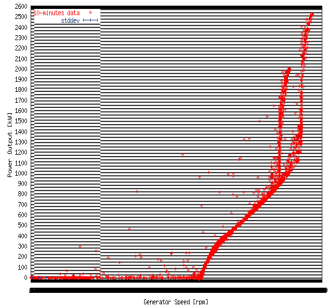

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Further analysis & actions

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eurocape New Energy

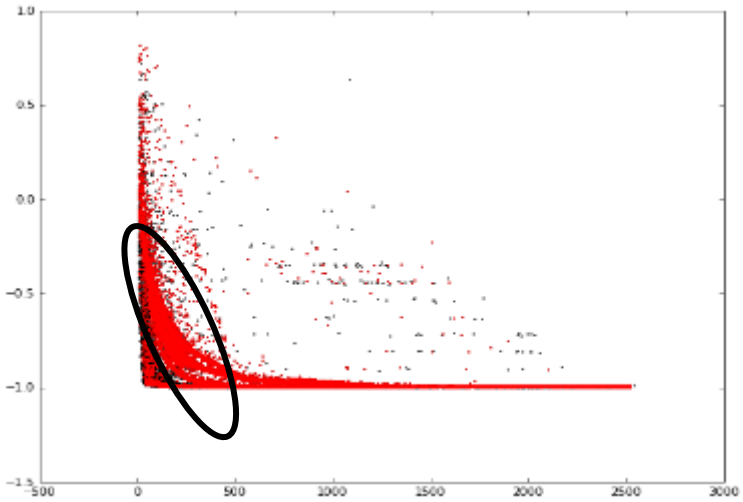
Reactive power production:

One WTG turbine is generating too much reactive power. (0<P<500kW)

→ Regulation at the substation is not efficient. The park master order is not followed.

→ Financial costs: Penalties from grid operator, change of component…

WTG – Scatter plot – Power vs CosPhi

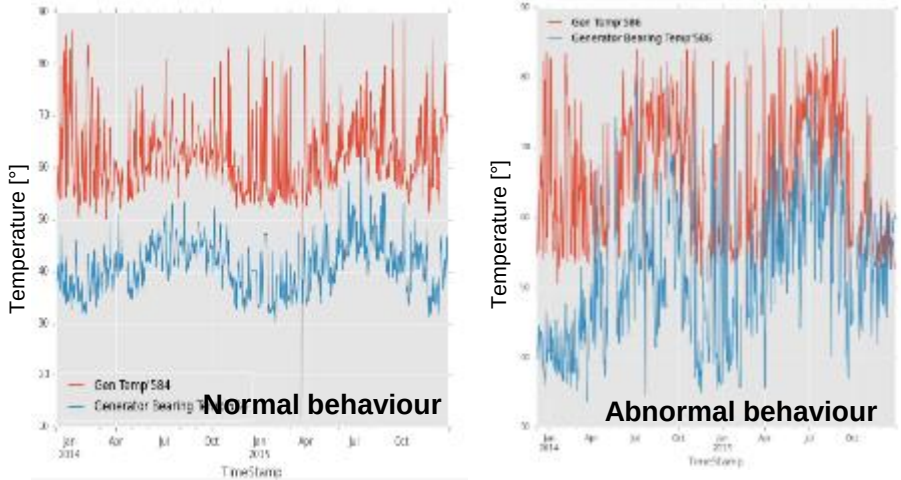


Bearing temperature monitoring

- Identify abnormal temperature level
- Identify high temperature variations
- Changing point identification

→ Components inspections
→Curtailment of turbine before component is breaking

Daily averaged evolution of temperature



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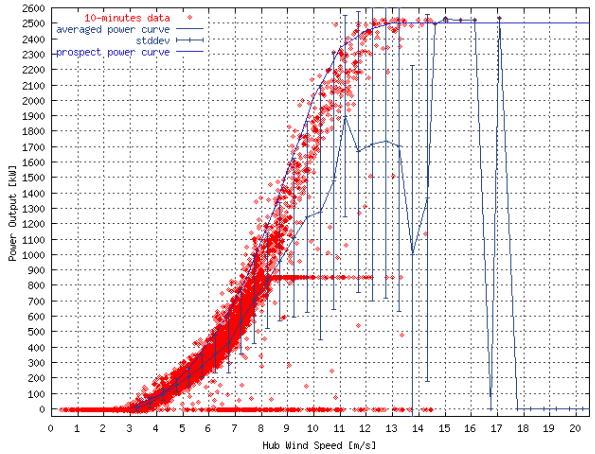
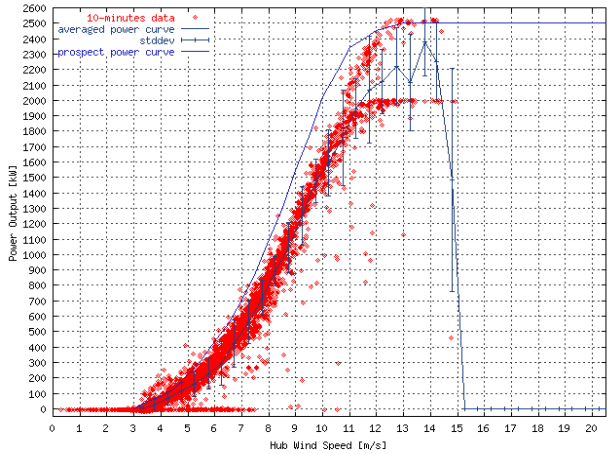
Further analysis & actions

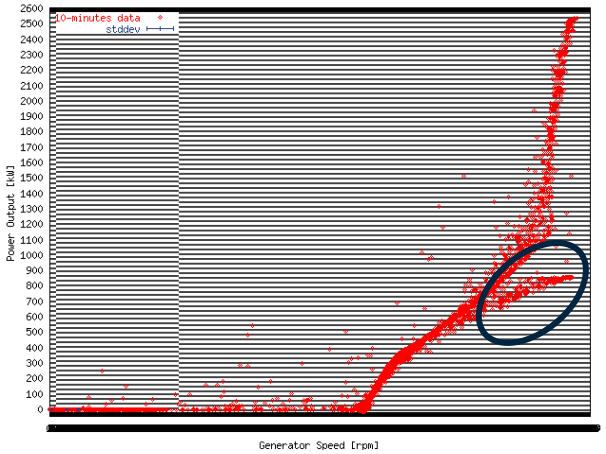
Co-Author: eurocape New Energy

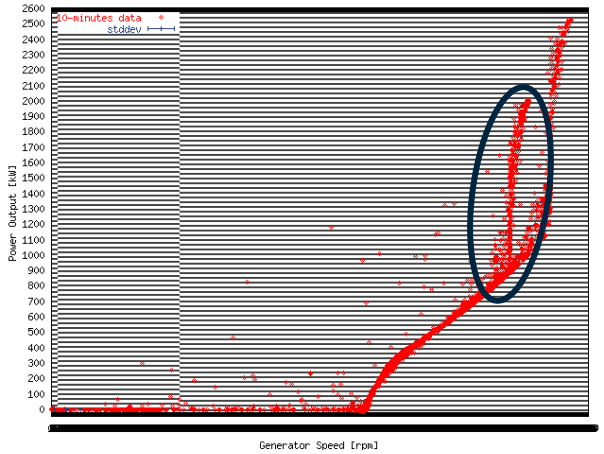
Power curve





Power vs generator speed





Power curtailment with **reduction of the torque**

→Corresponding to curtailment after change of the transformer.

Curtailment applied: full speed range is used and pitch control limits the power

Operation with **increased torque**

Curtailment applied limiting the speed range.

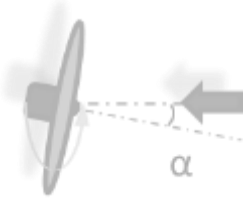
Investigation with Maintenance company in order to better adapt curtailment strategies

Contents

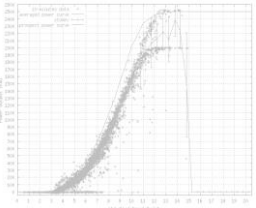
Co-Author:

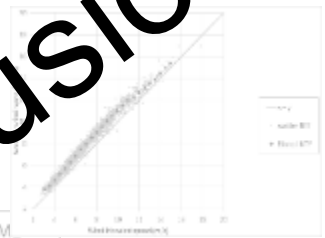
eurocape New Energy

1. Nacelle orientation and yaw alignment

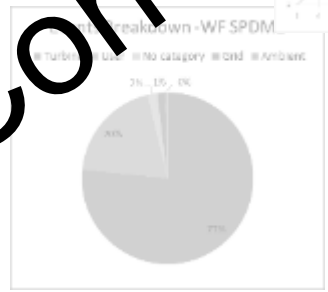


2. Power curve and Nacelle transfer function



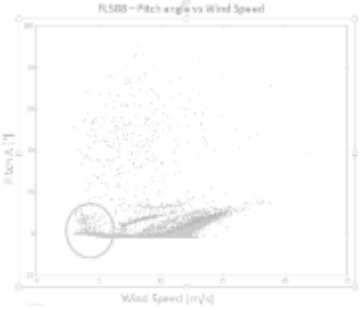


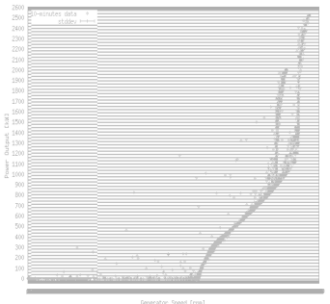
3. Error log analysis



Conclusion

4. SCADA data: complementary analysis





Conclusion

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How to better monitor wind farm performance ?

- ✓ Maximize use of operational data as first step of performance analysis
- ✓ Use of more accurate measurement to gather complementary more accurate data

➡ Correction of the data to get better analysis & conclusions

➡ Decide on correction to be applied on turbine settings to improve performance and reduce loads

➡ Set up data monitoring to improve performance, optimize maintenance and reduce downtimes

Thank you.

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