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ROTOR GEOMETRY MEASUREMENT

Alpha **Wind** SAS

Toulouse, France

www.alphawind.fr

Official Partner

for France of

windcomp

GmbH

www.windcomp.de

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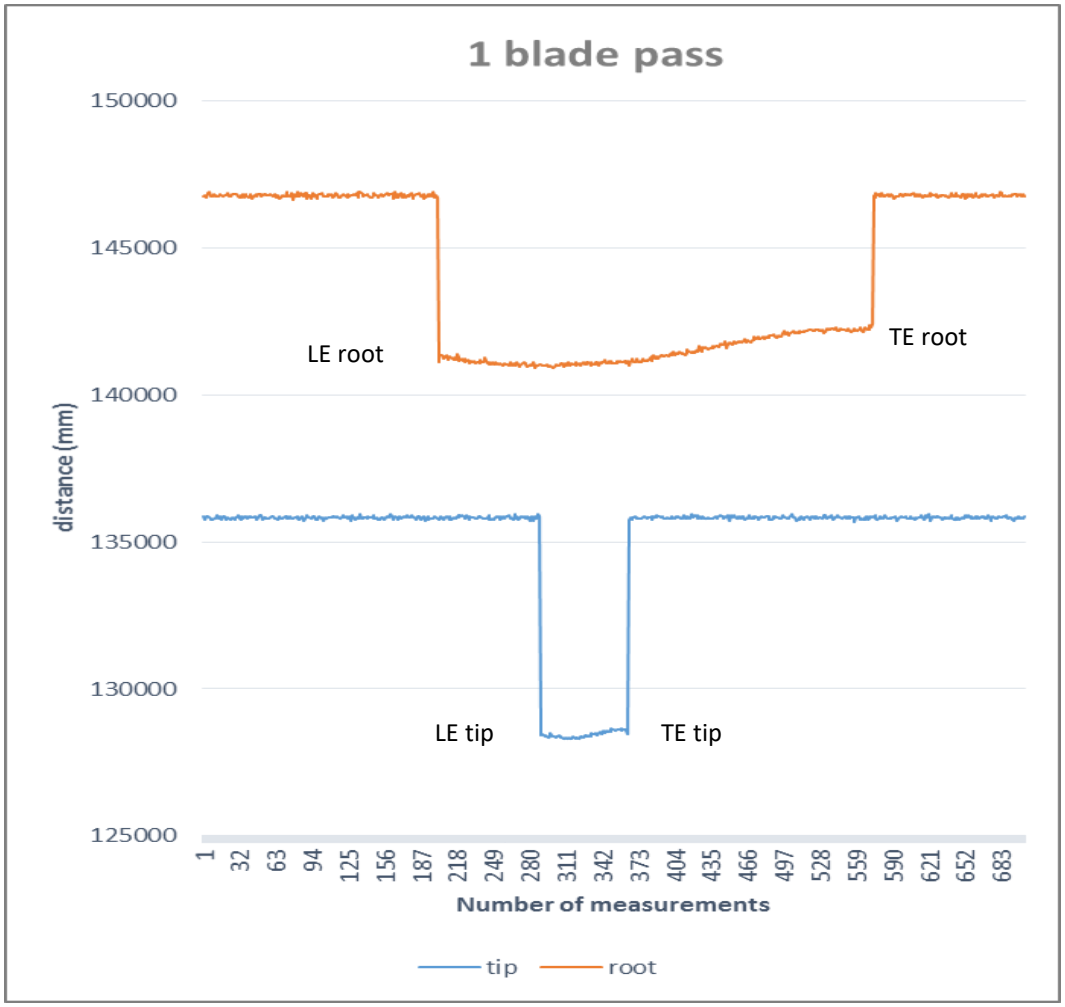
Measurement setup

... A bit of Trigonometry...

Raw data - Distance values



Mobil laser system for geometry measurement

Advantages:

Measurement of an operating wind turbine

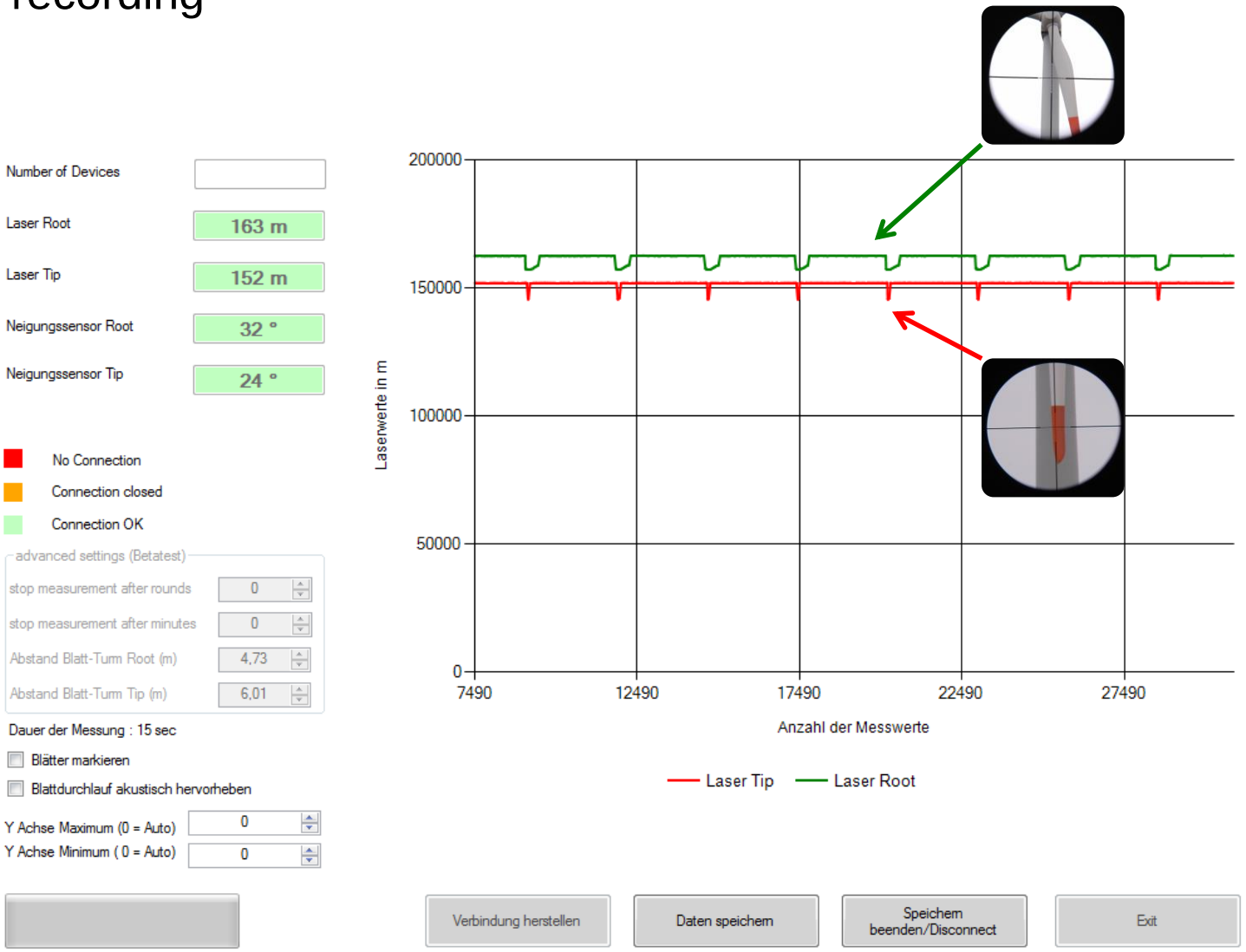
Results available immediately

Easy measurement process, no technician needed

Measurement parameter:

Relative pitch angle	+/- 0.2°
Radial angle	+/- 0.2°
Tower/Blade Clearance	+/- 50mm
Half Twist angle	+/- 1°
Axial tower oscillation	+/- 10mm

Data recording



Acceptable blade angle differences

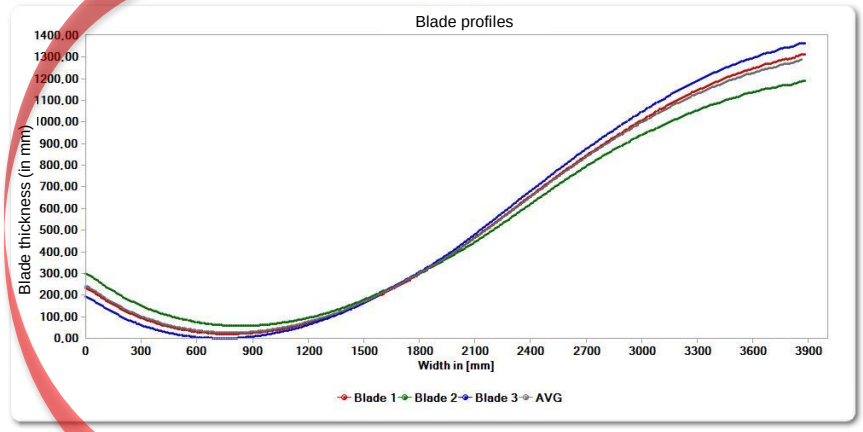
From the guideline for the certification of wind turbines of the Germanischer Lloyd 2010:

> *4 Load Assumptions*
> *. . .*
>
> *4.3.4.1 General influences*
>
> *. . . aerodynamic asymmetries, which can arise through production or assembly tolerances of the rotor blades. A verified tolerance shall be observed. If this is not (or not yet) known, a deviation of the blade angle of attack of ±0.3° (i.e. for a three-bladed rotor: blade 1 at 0°, blade 2 at – 0.3°, blade 3 at +0.3°) shall be assumed.*

A higher asymmetry leads to an increase in the load and thus to a shortening of the service life

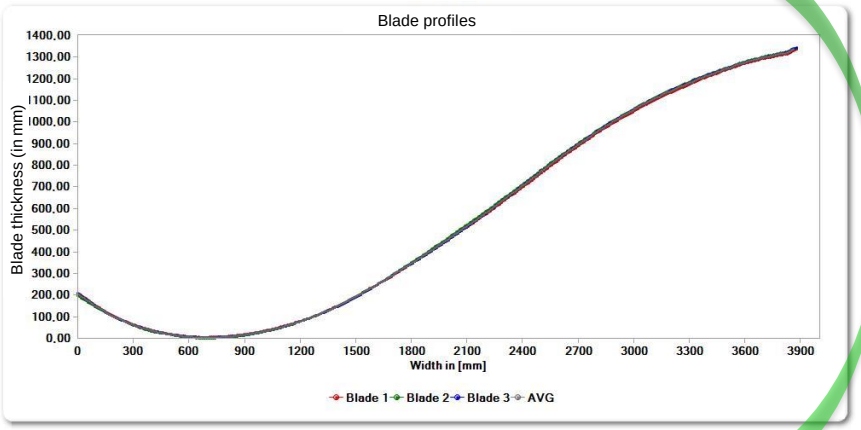
Influence of the blade angle difference on the tower vibrations for 2MW wind turbines (Hub height 80m)

Blade angle difference of 3.7°



INDUCING

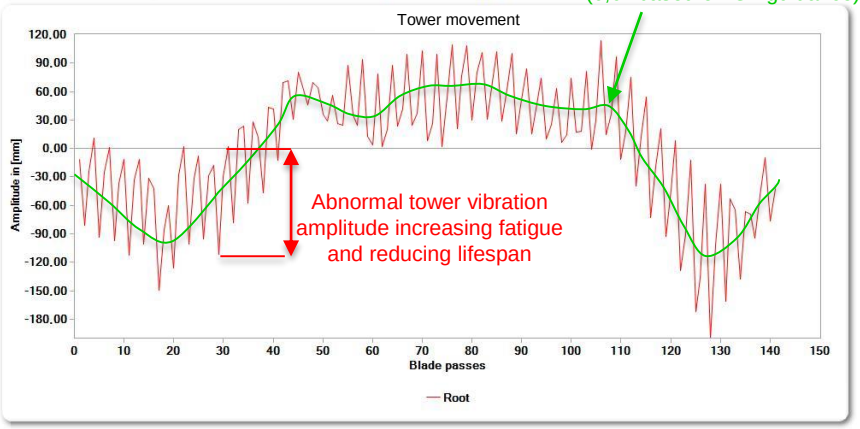
Blade angle difference of 0.1°



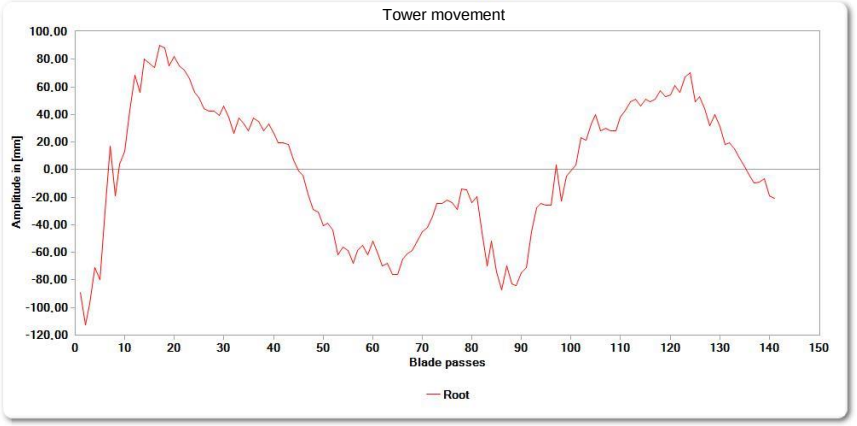
INDUCING

Tower vibration

Expected tower movement with correct blade angle difference (0,6° based on GL guidance)



No tower vibration

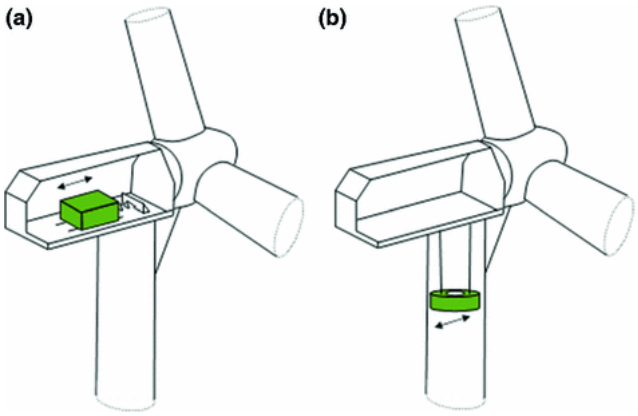


Energy loss estimated at more than 3% AEP

(for a 6m/s average wind speed site)

High tower oscillations at natural frequency

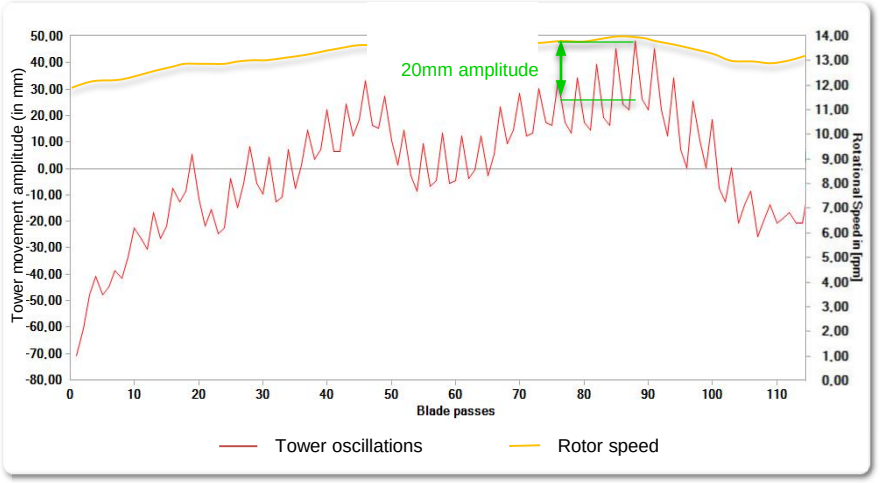
Wind turbine high tower design could includes a tower damping system in or under the nacelle (cf graph below). This system reduces the effect of the tower resonant vibration when the rotor speed reachs the tower natural frequency.



Tuned mass damper (a) and pendulum damper (b)
Graph from Ningsu Luo, Yolanda Vidal, Leonardo Acho (2014) Wind Turbine Control and Monitoring

CASE A - Tower oscillation with an effecient Damping System

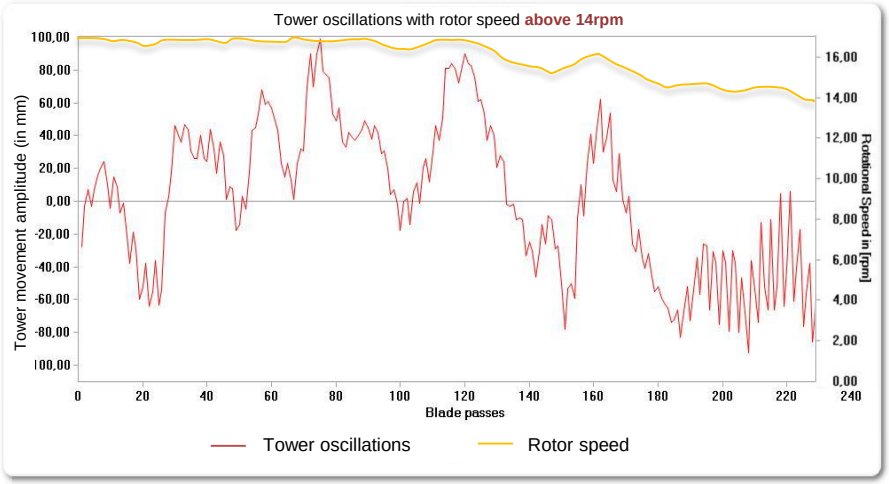
The tower natural frequency being 0,23Hz (=14rpm), the tower maximum deflection appears at 14rpm



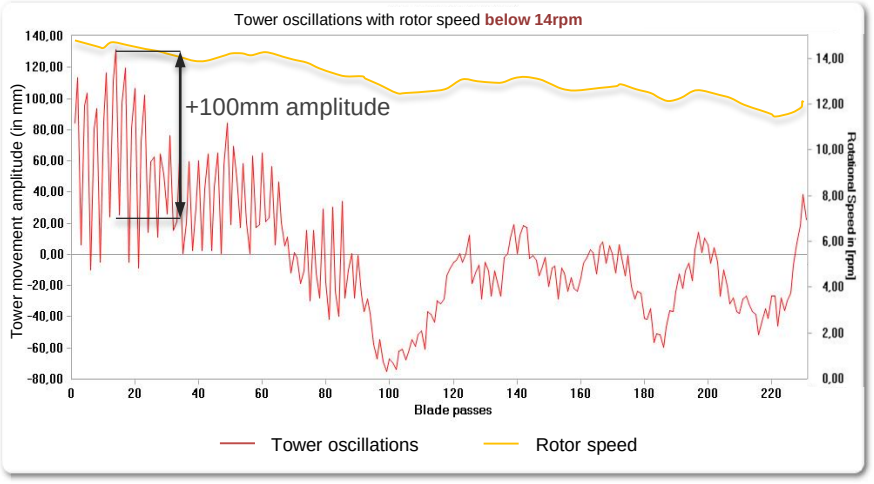
CASE B - Tower oscillation with a defective Damping System or a mass imbalance **(same WTG type and wind conditions as CASE A)**

The tower maximum deflection also appears at 14rpm but is **5x HIGHER, increasing the turbine fatigue and reducing the lifespan**

Tower oscillations with rotor speed **above 14rpm**

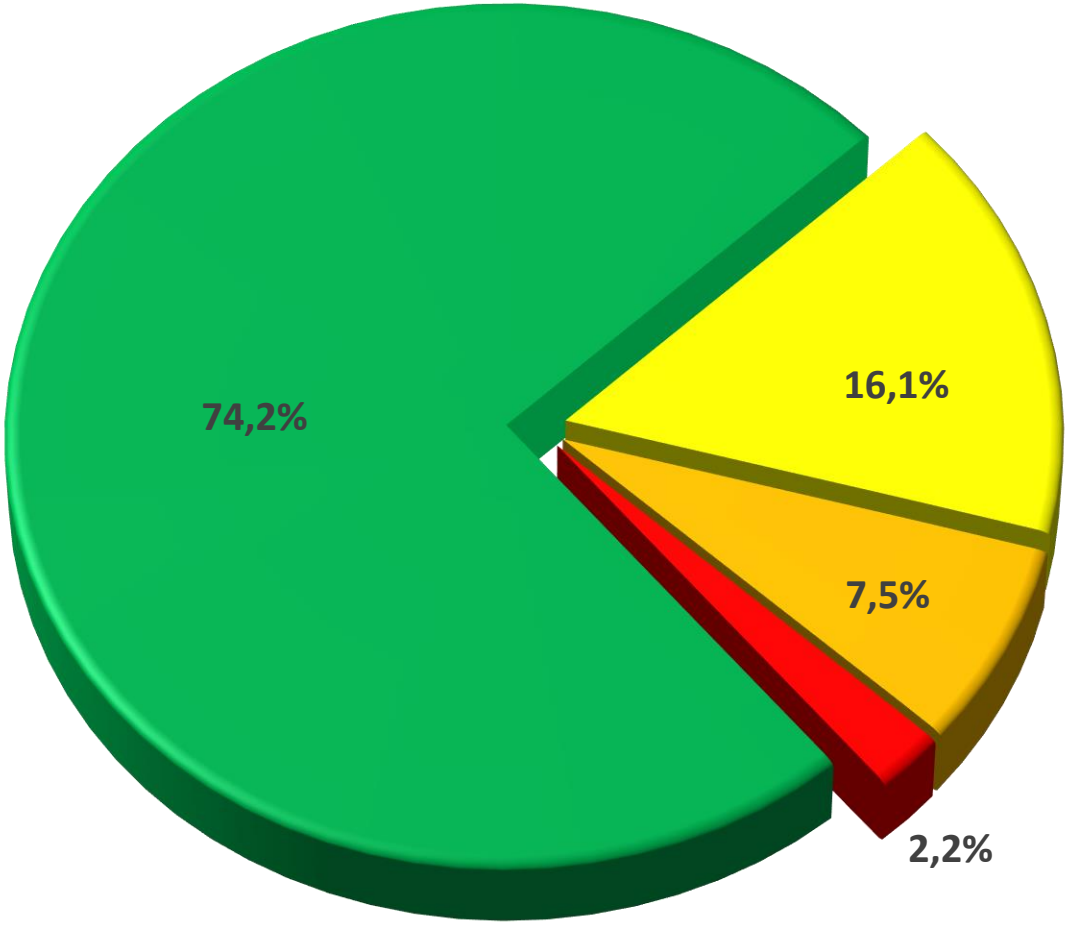


Tower oscillations with rotor speed **below 14rpm**



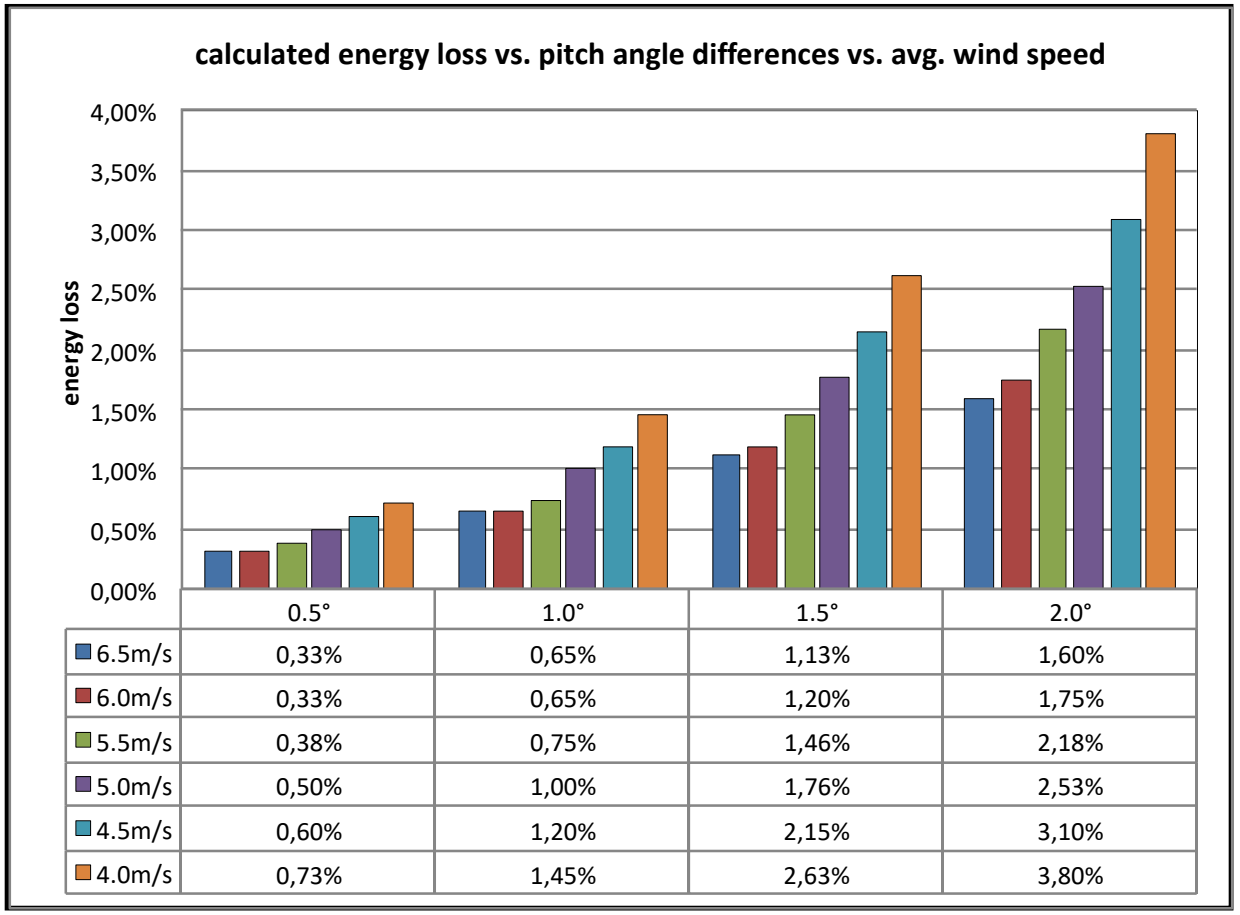
Control your tower damping system and your rotor mass imbalance to avoid lifespan reduction

Percentage of defective Wind Turbines observed on the first 2177 inspected in Europe



NB: 0,6° blade angle difference is the design hypothesis taken from the GL 2010 guideline for the certification of wind turbines.

Energy loss due to blade angle difference



	0.5°	1.0°	1.5°	2.0°
6.5m/s	0,33%	0,65%	1,13%	1,60%
6.0m/s	0,33%	0,65%	1,20%	1,75%
5.5m/s	0,38%	0,75%	1,46%	2,18%
5.0m/s	0,50%	1,00%	1,76%	2,53%
4.5m/s	0,60%	1,20%	2,15%	3,10%
4.0m/s	0,73%	1,45%	2,63%	3,80%

Data source: DEWI Magazin Nr. 11,

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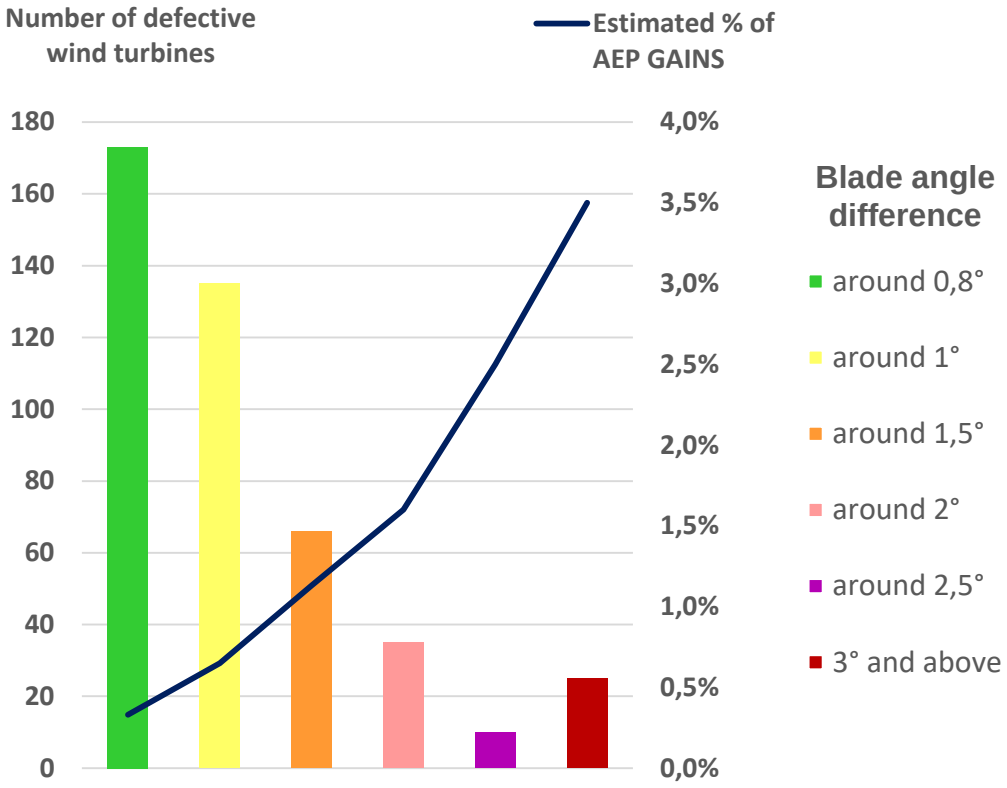
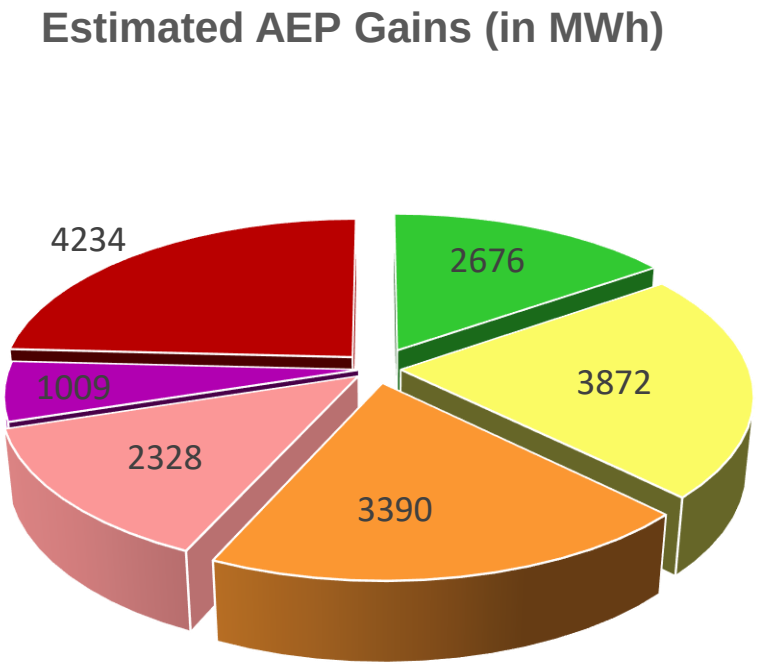
Estimated Annual Energy Production Gains after correction of the blade angle defect of the 2030 inspected Wind Turbines





444 wind turbines with blade angle difference above 0,7°

Site Hypothesis: 6,5m/s average wind speed and 2300hr capacity factor

35 686MWh of estimated production gain since march 2017 equivalent to **2 854 899€** (at 80€/MWh)

Average Payback Period of ALPHA WIND Control Investment in 7,9 months

They have put their trust in us

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