

Dynamic (im)balance
alignment measure cheap, fast, effective
INSight*

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*Patent Pending

Background

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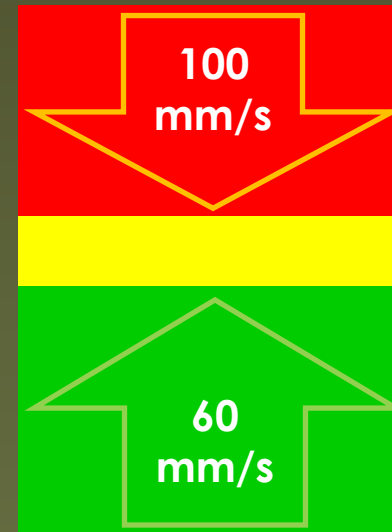
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“The effect of sailing is produced by a judicious arrangement of the sails to the direction of the wind.”

- William Falconer

Vibration

- VDI 3834
 - > Equipment specifications
 - > Methodology
 - > Averaging process



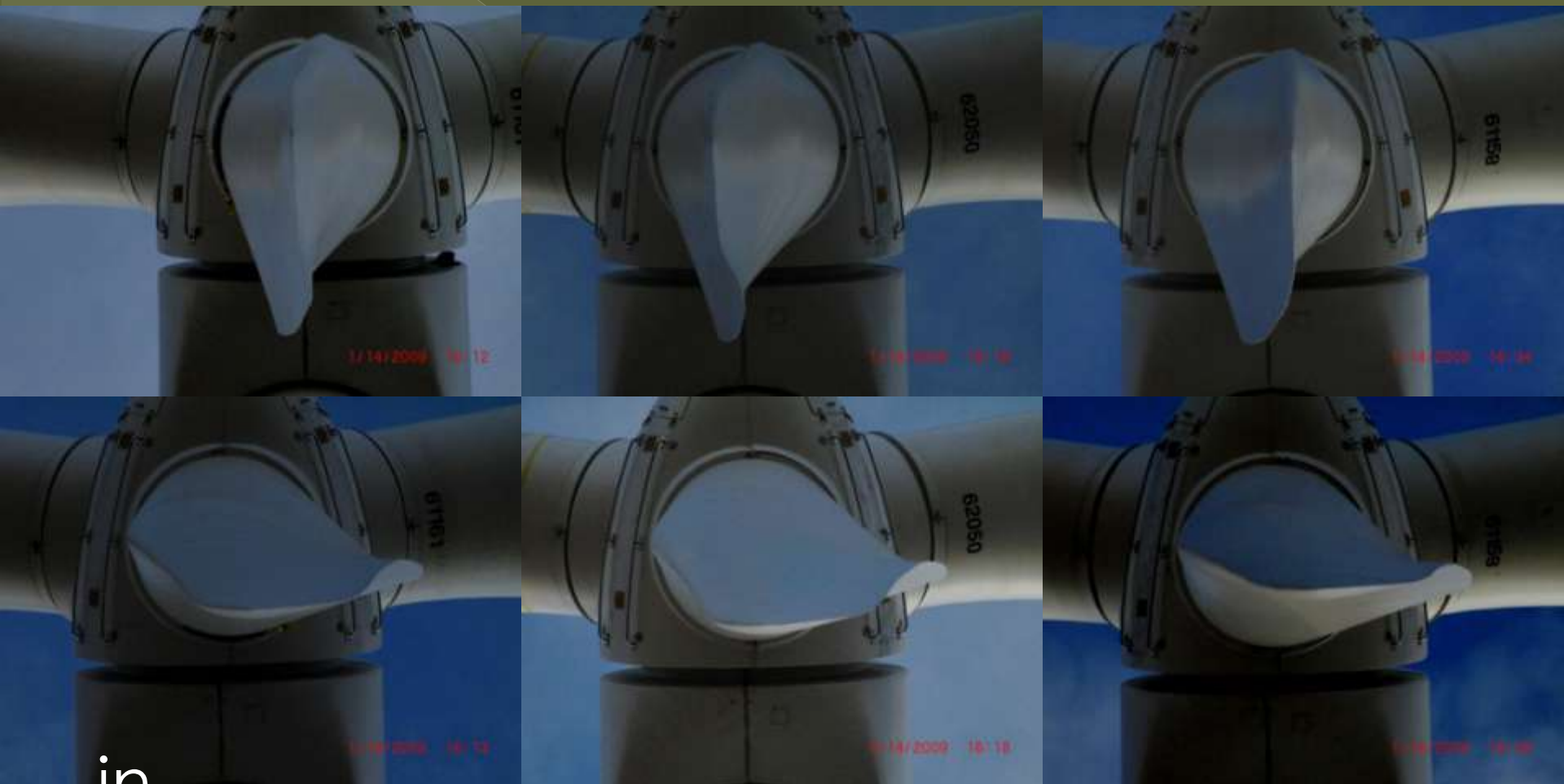
- Anyone that has been in the nacelle where vibration levels are greater than 60mm/s will tell you that the turbine is literally shaking itself apart
- Dynamic balancing weight addition, correction, and verification is effective using horizontal and vertical readings in the 0,1 Hz to 10 Hz range, **if and only if**, axial vibration remains low
- Axial vibration masks weight imbalance determination

Background

- Blade misalignment in 20% of the turbines at one site and 50% at another indicate that misalignment of rotor blades are the leading cause of this vibration
- Data supports axial vibration may be the elusive yet quantifiable aerodynamic constituent of rotor balancing equation.
- Once understood the axial vibration component quantifies exact limits to optimization through weight balancing and opens the door to measured correction of aerodynamic imbalance.

Still photography (old way)

Alignment determination from “stills” is discouraged due to inaccuracies arising from wind and rotor lock play



Why “stills” don’t work

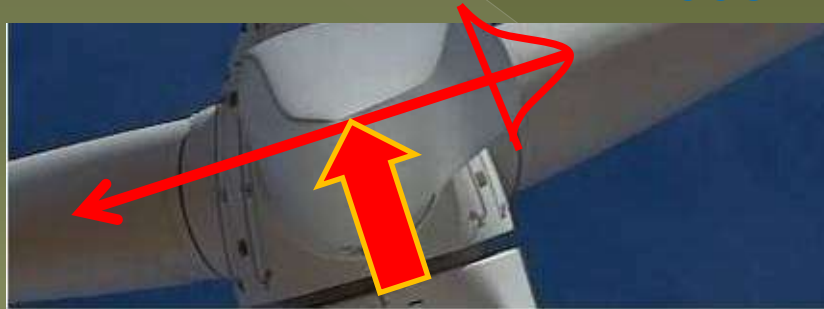
- ◎ Still photography requires:
 - > Still wind conditions
 - > Time consuming and cumbersome rotor advancement and positioning
 - > Minimum of three man crew (3-8 hrs)
 - > Ignoring rotor lock play (often greater than alignment measurement tolerances)
 - > Assuming “stills” capture operating conditions

Average Path Variation

Blade 1



Blade 2



Blade 3



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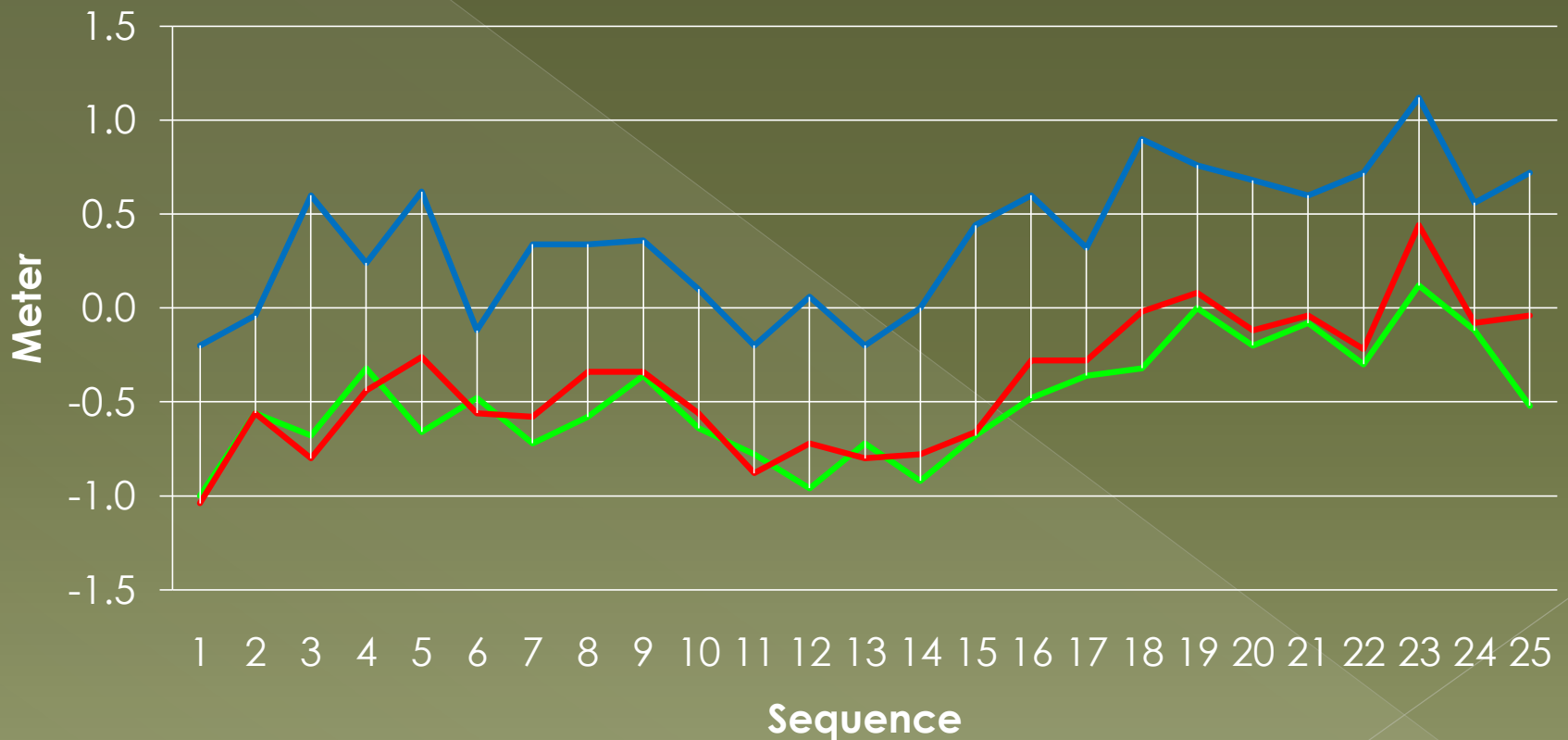
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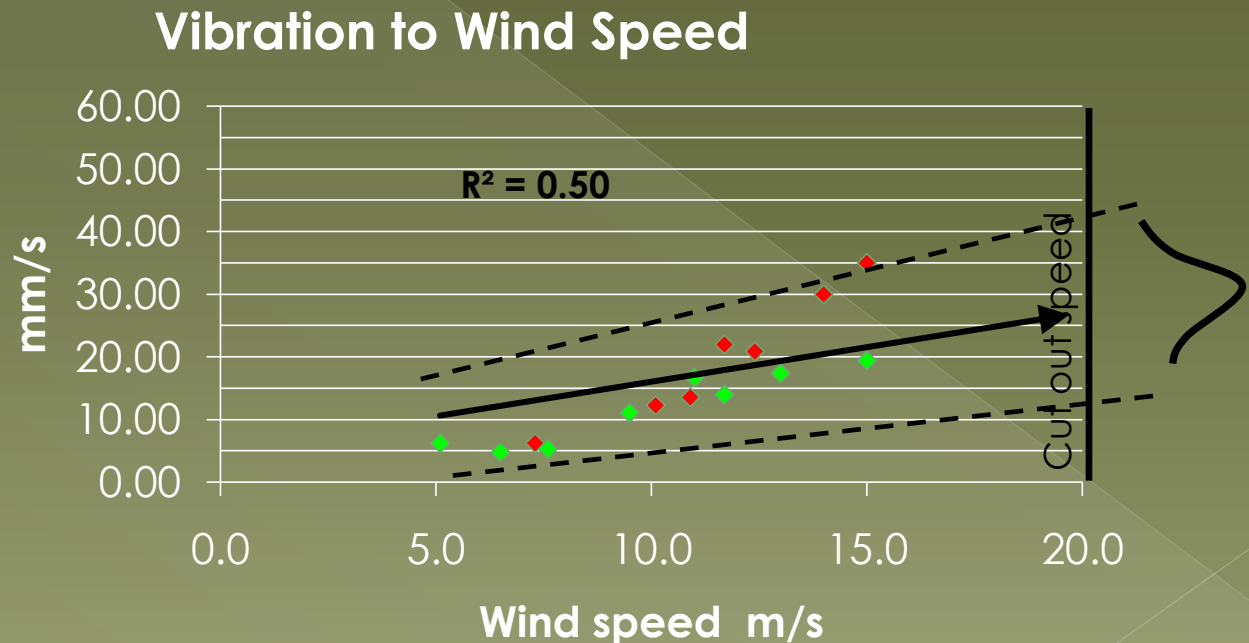
Graphic Comparison

Tip to tower distance sequentially



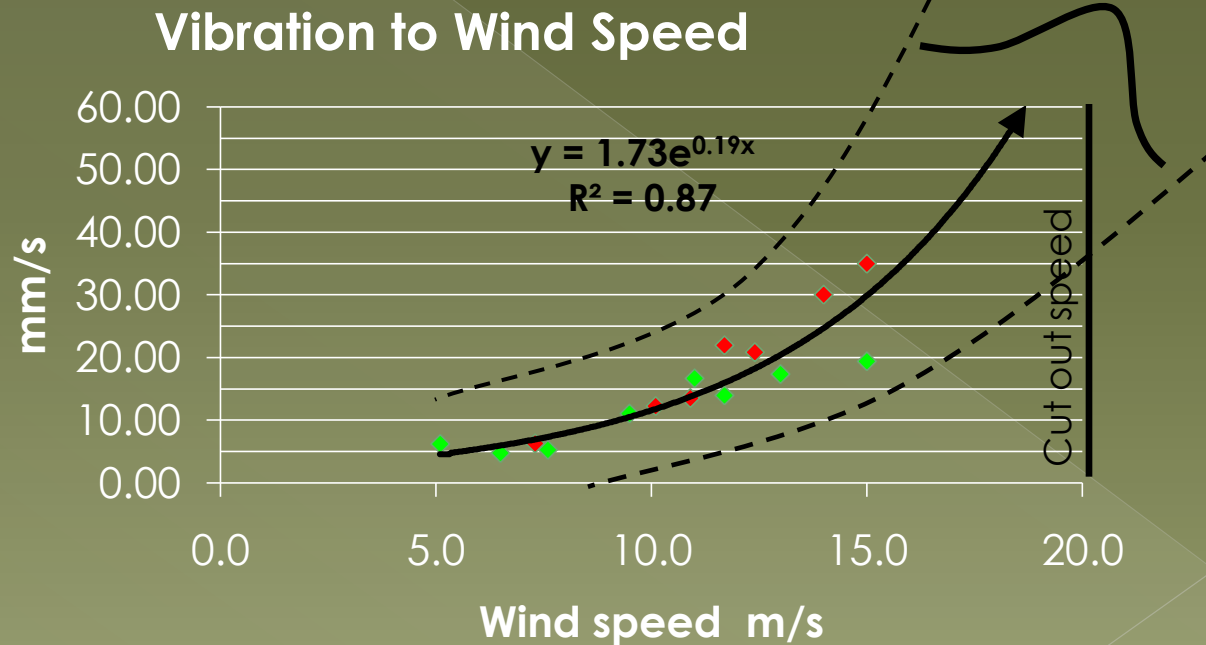
Cost of Misalignment

Trend line with minimal misalignment



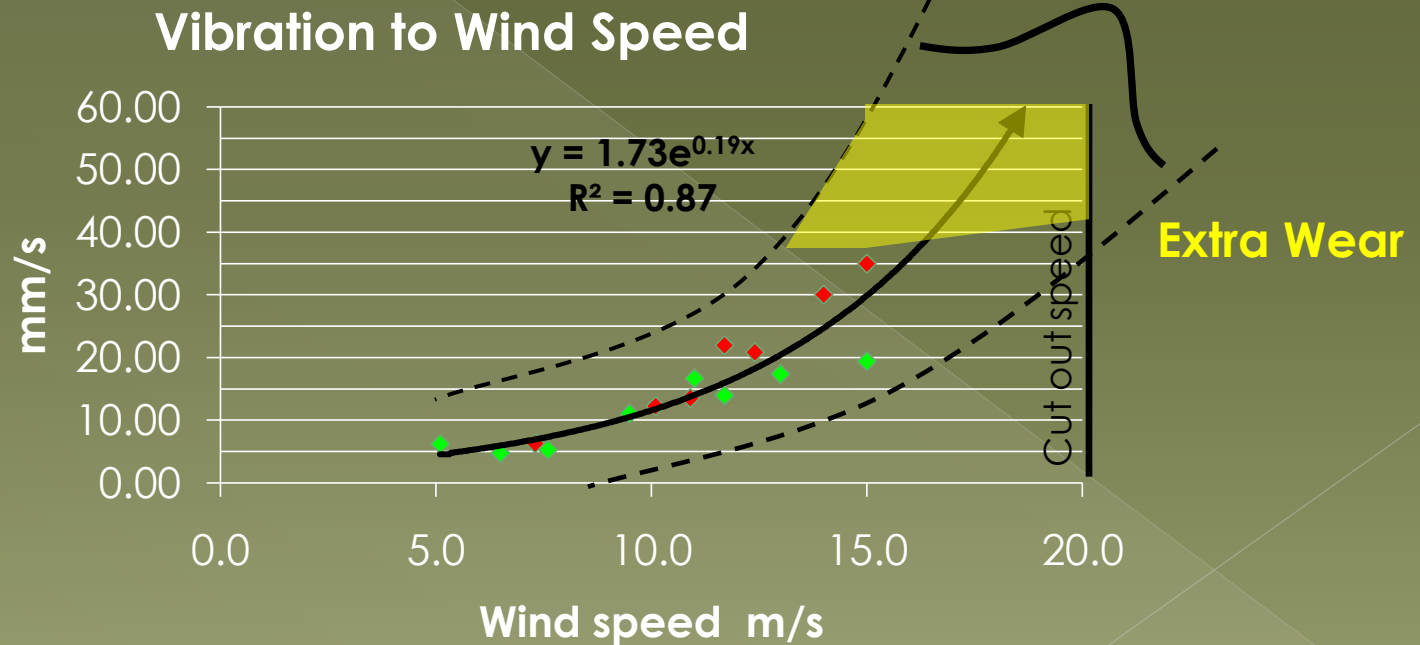
Cost of Misalignment

Trendline with Misalignment



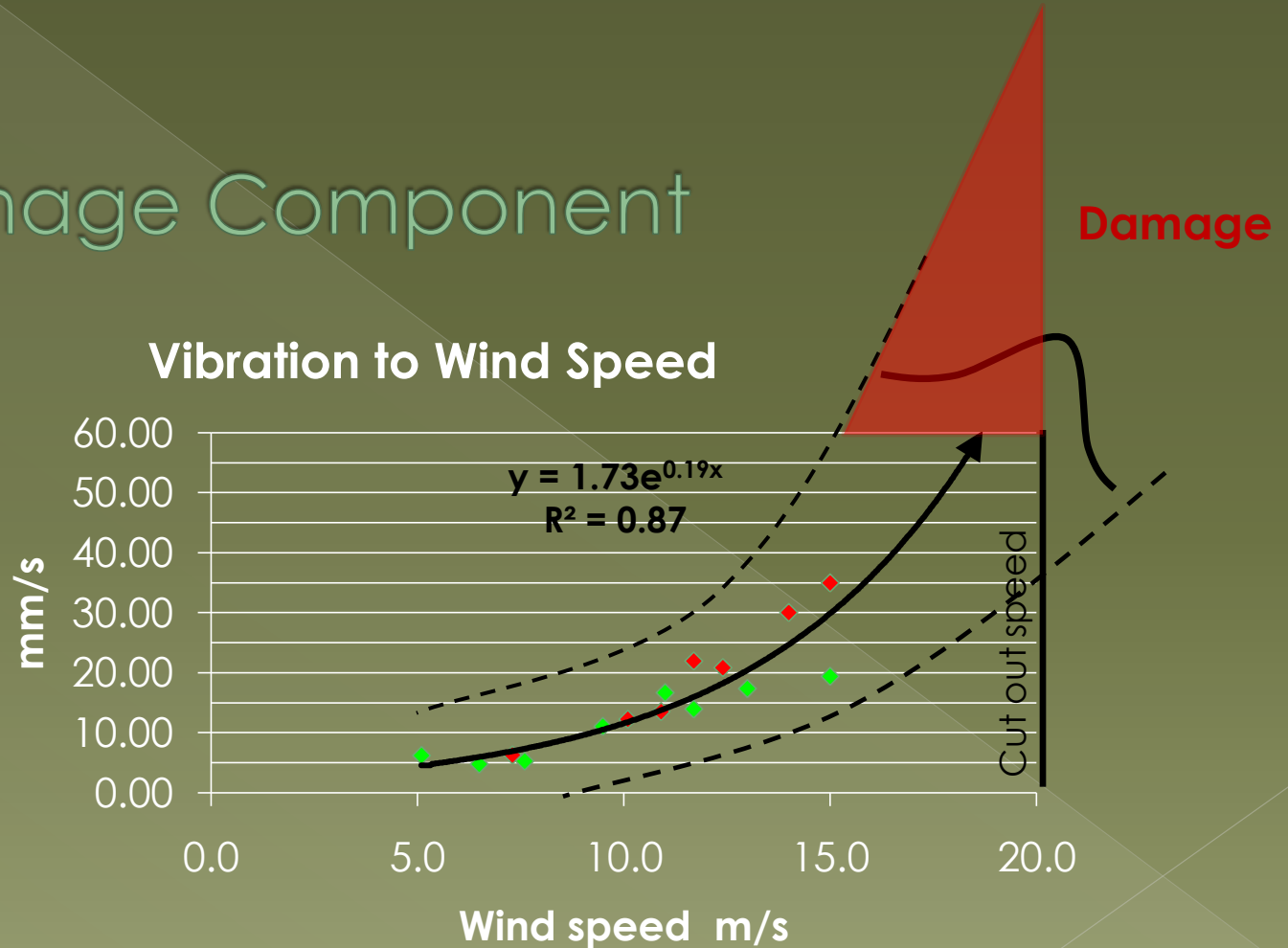
Cost of Misalignment

Extra Wear Component of Cost



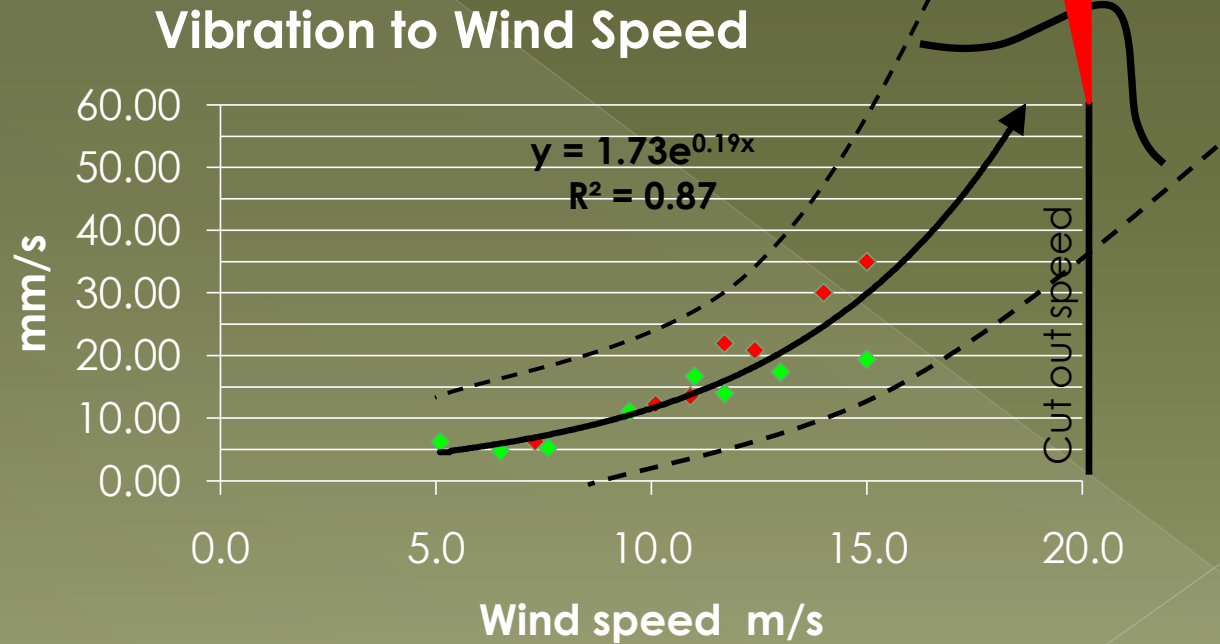
Cost of Misalignment

Damage Component



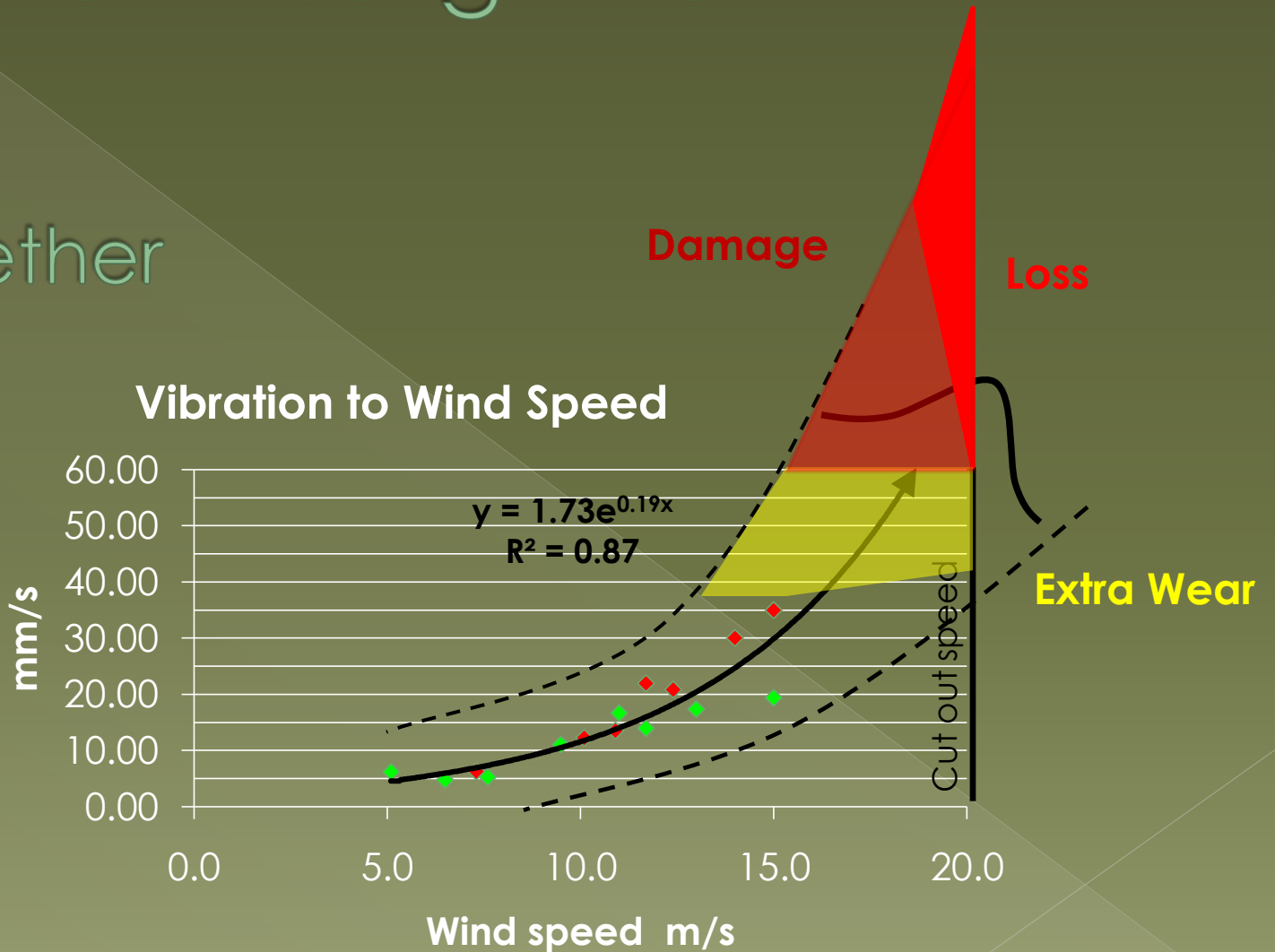
Cost of Misalignment

Loss Component



Cost of Misalignment

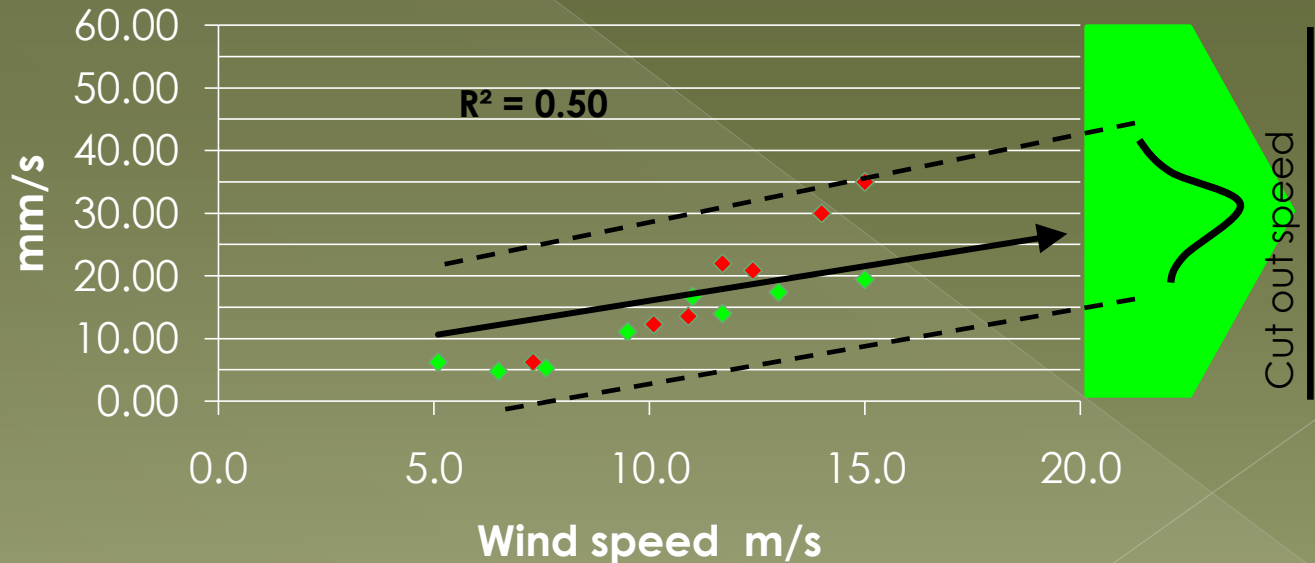
Together



Cost of Misalignment

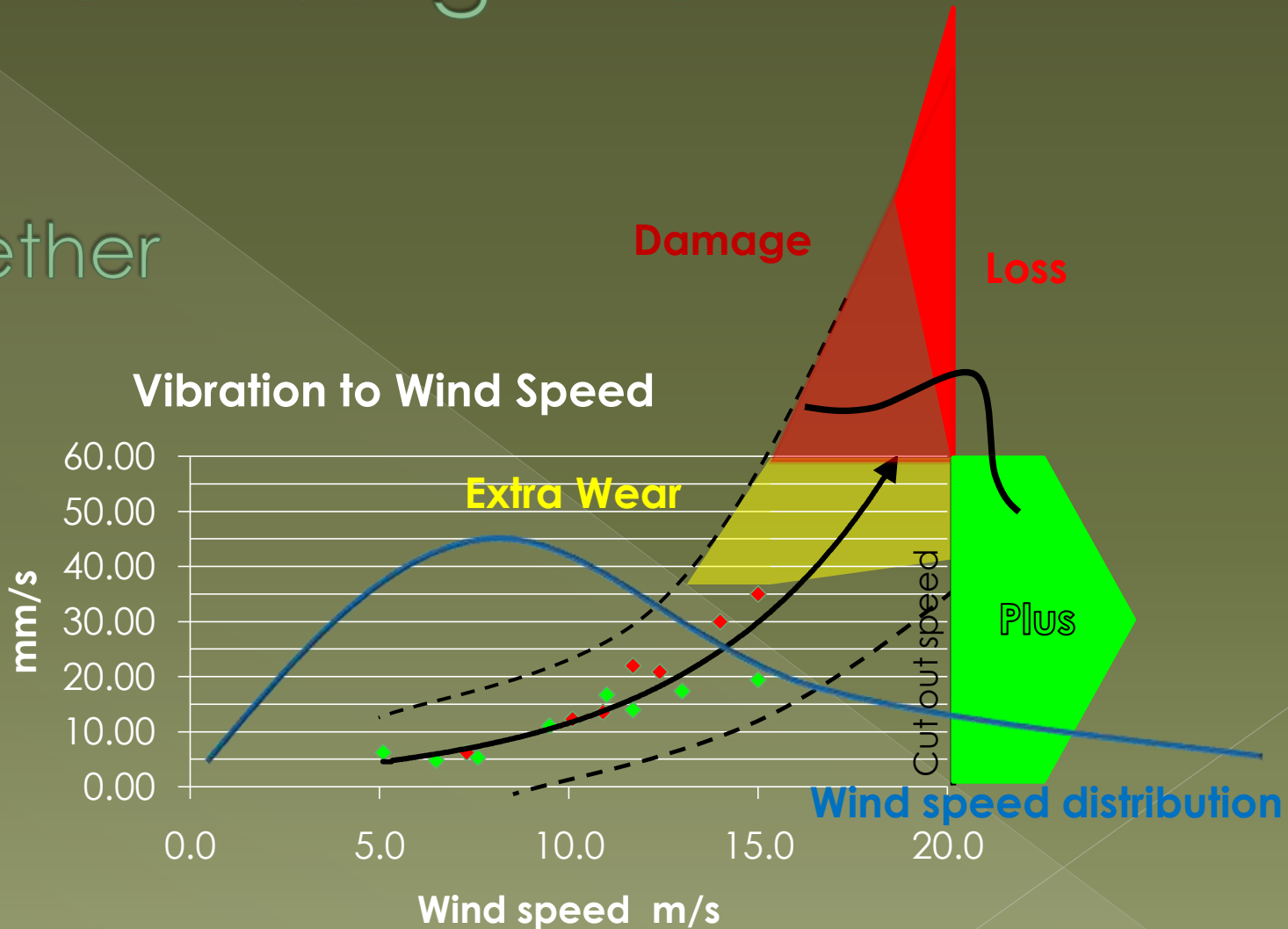
Added Plus to Minimal Misalignment

Vibration to Wind Speed



Cost of Misalignment

Together



Comparison from Site 1

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Turbine	Tip to Tower (deg)	Flutter 1	Flutter 2 >0.2deg	Flutter 2 >0.5deg	Partition (deg)
1	0.90	17.4%	70.8%	36.5%	0.23
2	0.27	6.2%	71.1%	6.1%	0.19
3	0.21	5.0%	44.8%	3.4%	0.31
4	0.45	12.9%	61.3%	24.2%	0.13
5	0.29	8.3%	40.0%	1.5%	0.65
6	0.48	10.0%	76.7%	32.6%	0.26
7	0.27	6.6%	50.0%	1.6%	0.12
8					
9	0.33	17.4%	54.8%	23.8%	0.27
Warning ≤0.20		Warning ≤10%		Warning ≤0.20	

OK

≥CL

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Conclusion

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“The pessimist complains about the wind;
the optimist expects it to change; the
realist adjusts the sails”

- William Arthur Ward

Thank You

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For further information of this technique contact us.