DNV·GL

ENERGY

Long-term Performance of Wind Farms EWEA Technical Workshop, Malmo, December 2014

Michael Wilkinson 9 December 2014

Does wind turbine performance degrade over time?

- Recent studies from academic institutes in the UK suggest that wind farm production degrades by a significant margin each year
- Resulting in a loss of confidence from wind energy operators and the investment community
- DNV GL draws on extensive experience and high quality, high resolution data to test these claims and perform a root cause analysis



Experience matters: >50 GW of operational analysis; forecasting for >40 GW; Inspections for >700 turbines per year; Largest independent provider of wind farm SCADA





Environmental	Typical energy loss	-0.5% (site specific)
enects	Annual Trend?	Flat



Sub-optimal performance

Drive train degradation





Environmental	Typical energy loss	-0.5% (site specific)
enects	Annual Trend?	Flat

Wind conditions	Typical energy loss	-1% (site specific)
wind conditions	Annual Trend?	Flat

Sub-optimal performance

Drive train degradation



Environmental	Typical energy loss	-0.5% (site specific)
enects	Annual Trend?	Flat

) A (in diagonalities a	Typical energy loss	-1% (site specific)
wind conditions	Annual Trend?	Flat

Sub-ontimal	Typical energy loss	-1% (operator specific)
performance	Annual Trend?	Flat

Drive train degradation





Environmental	Typical energy loss	-0.5% (site specific)
enects	Annual Trend?	Flat

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wind conditions	Annual Trend?	Flat

Sub-ontimal	Typical energy loss	-1% (operator specific)
performance	Annual Trend?	Flat

Drive train	Typical energy loss	???
degradation	Annual Trend?	???



YES

YES

NO

NO







Drive Train Degradation Study - Results





Drive Train Degradation Study - Results



235 turbines



Drive Train Degradation Study - Results

31 wind farms 235 turbines



Environmental	Typical energy loss	-0.5% (site specific)
enects	Annual Trend?	Flat

Wind conditions	Typical energy loss	-1% (site specific)
	Annual Trend?	Flat

Sub-ontimal	Typical energy loss	-1% (operator specific)
performance	Annual Trend?	Flat

Drive train	Typical energy loss	???
degradation	Annual Trend?	???

Environmental effects	Typical energy loss	-0.5% (site specific)
	Annual Trend?	Flat

Typical energy loss	-1% (site specific)
Annual Trend?	Flat

Sub-ontimal	Typical energy loss	-1% (operator specific)
performance	Annual Trend?	Flat

Drive train	Typical energy loss	-0.2% / year for the first 5 years
degradation	Annual Trend?	Downward trend

Factors affecting turbine performance have been reviewed

Long-Term Degradation Study

- Drive train degradation has been investigated
- 35 wind farms with 235 turbines from across Europe included in the study
- Individual sites show differences, but overall a small downward trend is identified
- -0.2% / year for the first 5 years

Further work

- Can we quantify degradation in individual components?
- What happens after year 5/6?

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What could cause production degradation?

 3 possible elements that could cause degradation of wind farm production over time:



Wind resource



DNV GL Wind Index

- Historical wind data from 1996 to 2014
- 50 meteorological stations spread across the mainland of the UK
- Each station has measured consistent wind speed data for 10 years or more



Availability



Definition

Source: Optimising the UK operational fleet in a mature market (Harman et al., Renewable UK 2013)

<u>Database</u>

- Over 300 wind farms across Europe
- Between 1 and 15 years of operation
- >1,500 wind farm years
- All major turbine suppliers to UK represented

System Availability = $\frac{\text{Time ready to operate,}}{\text{Total time}}$