

A wide-angle photograph of a sunset over a vast ocean. The sun is a bright orange orb on the horizon, casting a shimmering path of light across the water. The sky is a mix of soft pinks, oranges, and blues, with wispy clouds. In the far distance, a line of wind turbines is visible on the horizon. The overall mood is serene and expansive.

# BLADE DEFECT FORECASTING

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**WIND POWER LAB**

# KEY MESSAGE

**1** *The green transition push for an increasing need of blade reliability*

**2** *Similar blade defects do not develop with same speed at different locations*

**3** *We need to optimize blade repair planning, taking local environmental impact on blade degradation speed into account*



# Blade Defect Forecasting for the Wind Industry

Grand Solution project



Danmarks  
Tekniske  
Universitet



Danmarks  
Meteorologiske  
Institut

WIND POWER LAB

Innovation Fund Denmark


# INDUSTRY CHALLENGE

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HOME > OFFSHORE WIND > LONDON ARRAY BRACED FOR BLADE FIX

## London Array braced for blade fix

Repairs needed on 140 of 175 Siemens Gamesa turbines at 630MW project.



13/03/2018

### OFFSHORE WIND FIASCO: RENEWABLES INDUSTRY FACES \$BILLIONS IN COMPENSATION FOR EARLY REPAIRS

Date: 23/02/18 | Jyllands-Posten

**Ørsted is in danger of having to repair the blades of more than 600 offshore wind turbines.**



*Ørsted's wind farm at Anholt was completed in 2013. The turbines' blades are so worn down already that they have to be brought to land and repaired. Photo: A2See*

The consortium behind the 630MW London Array in the UK is planning an "emergency" blade repair campaign to 140 of the project's 175 Siemens Gamesa 3.6-120 turbines.

### Siemens sets billions: Ørsted must repair hundreds of turbines

Finans - Kasper Randgaard Andersen - February 23, 2018

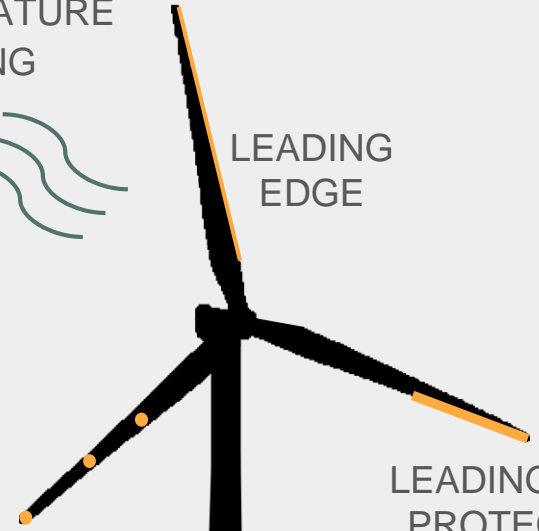
Structural Failure Denmark UK Europe

*Ørsted must repair up to 2,000 wind turbine blades because the leading edge of the blades has worn down after just a few years at sea.*

**We need to know for how long a blade will last in a given location with specific environmental conditions**

## ENVIRONMENTAL PARAMETRES

TEMPERATURE  
LIGHTNING  
RAIN  
WIND  
UV



LEADING  
EDGE

LEADING EDGE  
PROTECTION  
LEP

LIGHTNING  
PROTECTION  
LPS

LOCATION

# SITUATION

Wind turbine blades are designed for +25 years, but erode much faster than expected



EROSION  
PAINT



EROSION  
FILLER



EROSION  
SURFACE MAT



EROSION  
LAMINATE



EROSION  
CORE

SEVERITY

Today blade maintenance plans are based on **assumptions**,  
resulting in insufficient maintenance plans.  
Industry wide rule of thumb is more rain = more erosion

# RAIN INTENSITY AND WIND SPEED WIND POWER LAB

Degradation is related to rain intensity and wind speed

If Anholt Wind Farm was located in another **location** with different weather conditions, the blades would have lasted 4-5 times longer

	Anholt	Aalborg
Hours per year with rain > 10 mm/h	2,44	0,38
Hours per year with rain > 20 mm/h	0,53	0,02
Average annual rain in mm	556	723
Average blade life time in years	2,9	13,6

**In this case the same blade\* will last 2,9 years at Anholt, DK compared with 13,6 years in Aalborg, DK**

\*for tip speed 90 m/, wind > 9 m/s and rain intensity > 10 mm/h and 20 mm/h

Why don't we use environmental data for wind turbine blade maintenance planning and operational cost estimates (OPEX)? **Data is not available** to the industry...

Hasager *et al.* 2019

# COMPLICATION

Blade erosion speed varies with local conditions.

Minimal use of site specific data for maintenance plans.



Insufficient data  
planning for  
OPEX budgeting



No availability of  
blade degradation  
forecasting



Increasing  
need of blade  
reliability

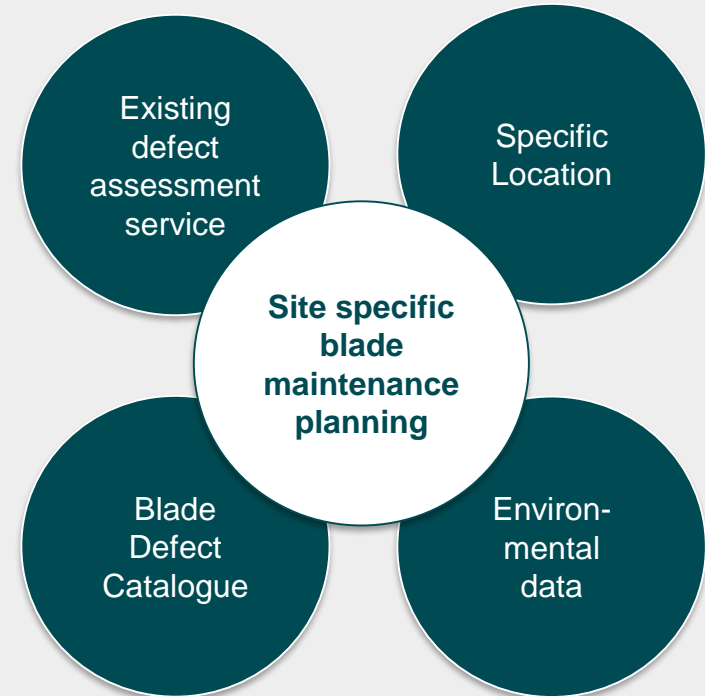
**Impact** from difference in environmental characteristics like UV, rain, etc. are not considered. At Anholt Wind Farm they had to take down all blades from 111 wind turbines as part of end of warranty, due to erosion

# SOLUTION

Enable access to a service combining environmental conditions with site specific maintenance planning

**Combining** wind turbine blade defect catalogue with long-term environmental data using artificial intelligence to establish statistical forecasting tool for operational costs in the next repair season.

**The Solution** will be implemented in blade defect assessment services for the wind industry and will provide the industry with forecasting on when a blade with specific defects will need a repair, in a given environment at a given location.





# DESIRED OUTCOME

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Establish new services for the wind industry to plan for potential blade degradation from local conditions



Site specific blade design requirement

Blade requirements for specific site conditions

**NEW – On demand analysis service**



New wind farm site investigations

Site specific OPEX blade repair planning input for site selection

**NEW - On demand analysis service**



Wind farms in operation

Future repair campaign forecasting for blades in operations

**Add-on** to blade defect assessment service in the market today

# VALUE CREATION

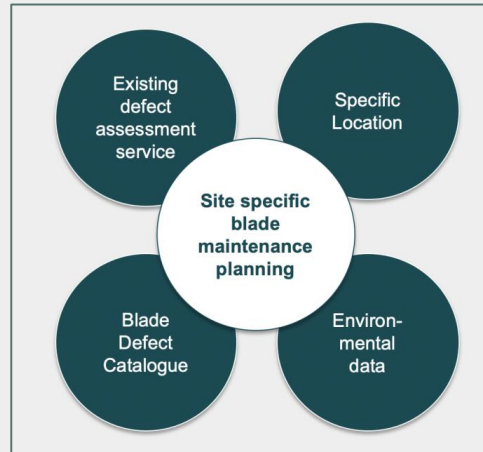
## Society

*value creation*

- Supporting overall green transition to no subsidies wind power, lowering cost
- Reliable electricity production for ever growing electricity consumption
- Job creation for Wind Power LAB and repair companies, with a global market potential



**Secure blade reliability**  
**Know local degradation speed**  
**Optimize blade repair planning**



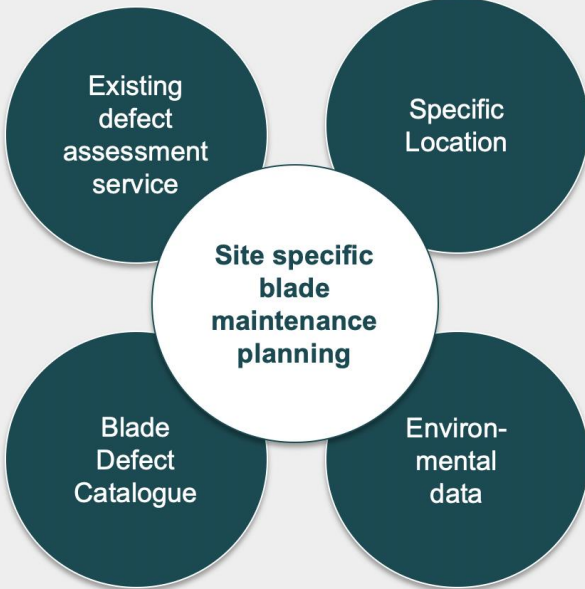
## Wind industry

*value creation*

- Avoided catastrophic failures, safeguarding production
- Enabling blade defect risk mitigation and blade repair forecasting
- Enabling site specific blade maintenance cost planning (OPEX) as part of wind farm project development

# SUM UP

2



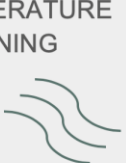
4

**Does a blade last for 2,9 years or 13,6 years in a given location?**

- Secure blade reliability
- Know local degradation speed
- Optimize blade repair planning

### ENVIRONMENTAL PARAMETRES

- TEMPERATURE
- LIGHTNING
- RAIN
- WIND
- UV



LEADING EDGE



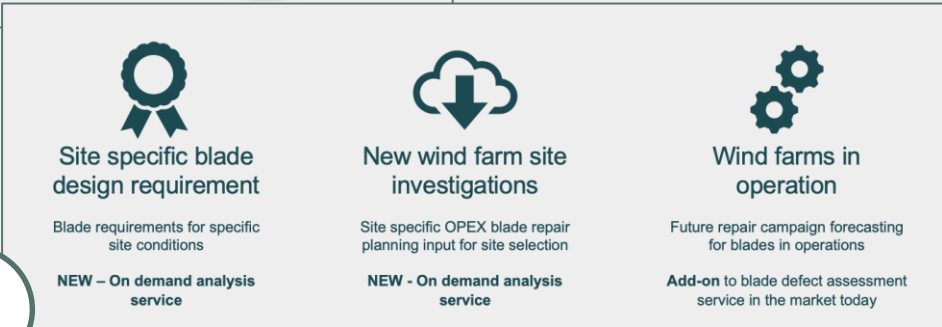
LIGHTNING PROTECTION LPS

LEADING EDGE PROTECTION LEP

LOCATION

1

3





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