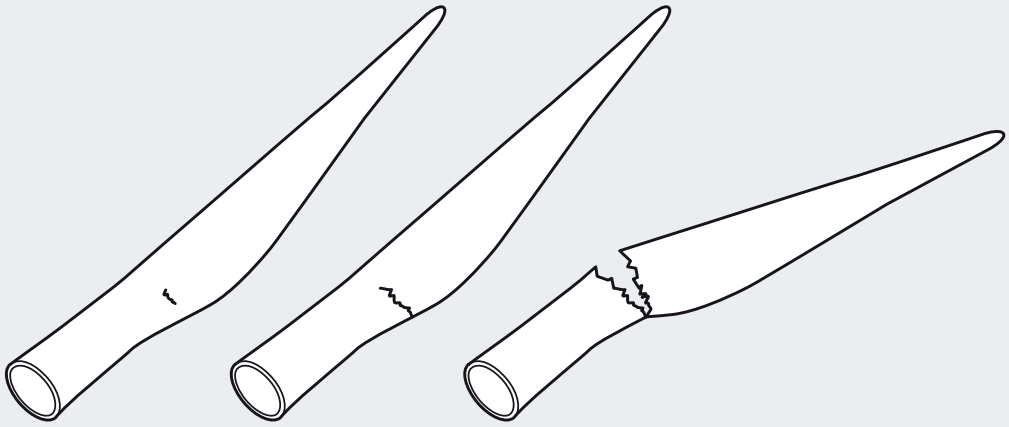
CORTiR II

POSTER COLLECTION

CORTIR II PROJECT
FINAL 2023



UNIVERSITIES

ENERGY UTILITIES

SERVICE COMPANY

INSURANCE

BLADE MANUFACTURES

R&D CONSULTANCIES

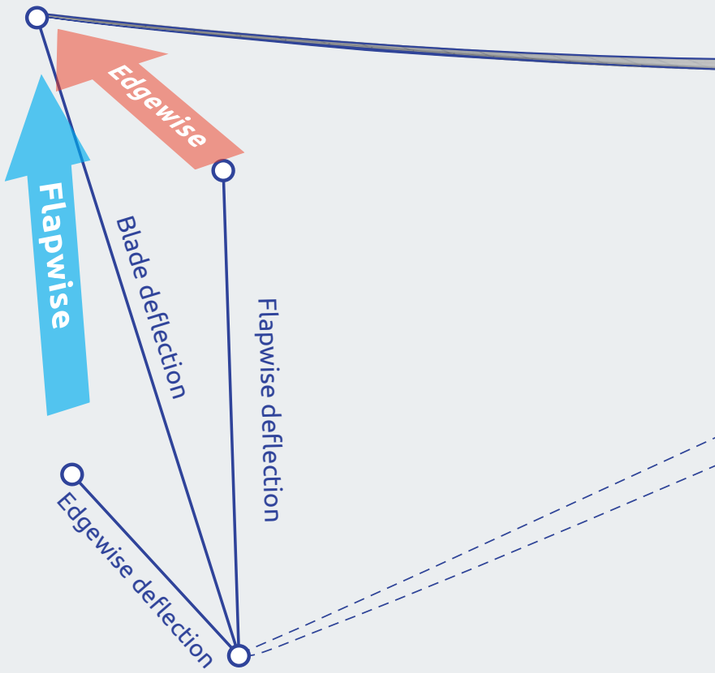
SOLUTION PROVIDER

INDEX

CORTiR II

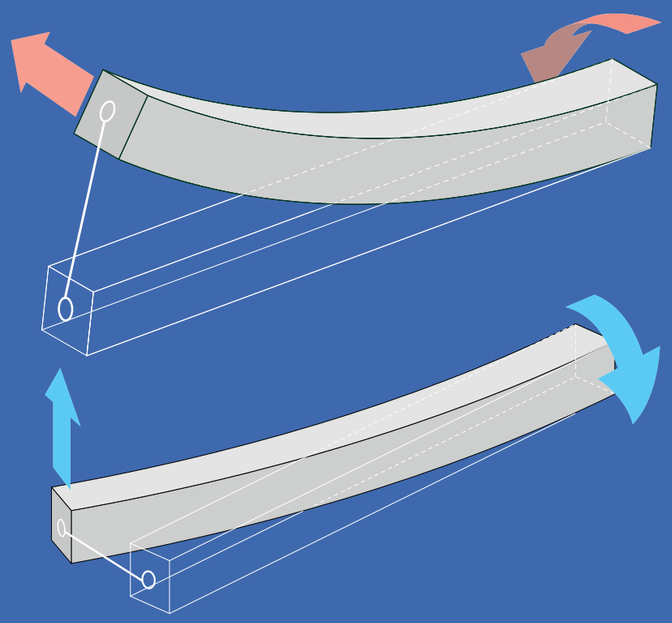
TORSION ON BLADES

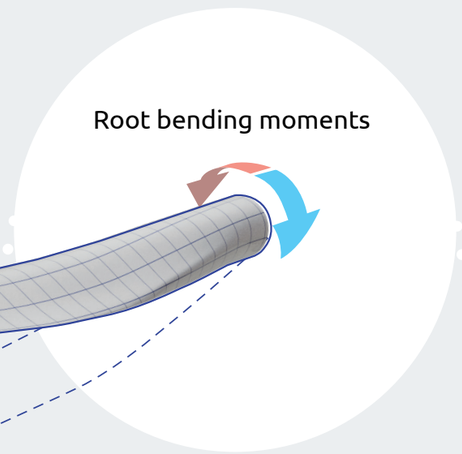
Impact of torsion on blades under operational conditions



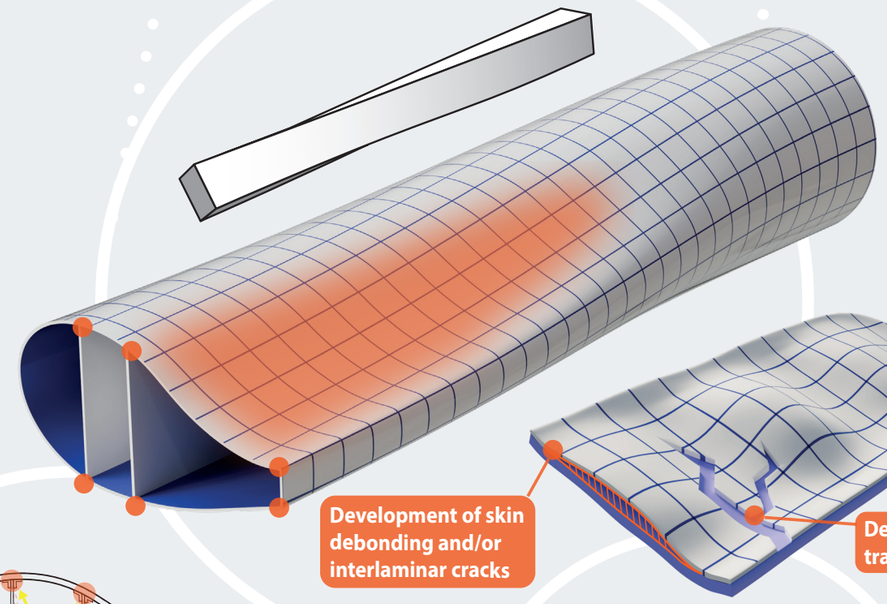
Edgewise aerodynamic tangential forces and gravity are working on the flapwise deflected blade, creating torsion.

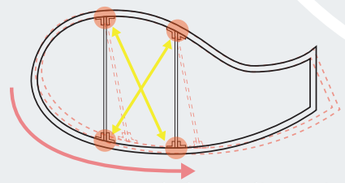
Flapwise aerodynamic tangential forces and gravity are working on the edgewise deflected blade, creating torsion.



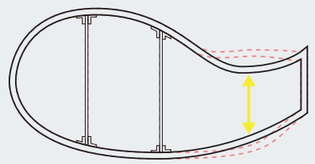


Creation of damage-prone weak points in the transition zone of the blade.

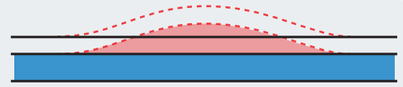




Cross sectional shear distortion



breathing due to torsion



Out-of-plane deformations causes interlaminar stresses, resulting in skin debonding.

Visualization by Kirt x Thomsen with Bladena

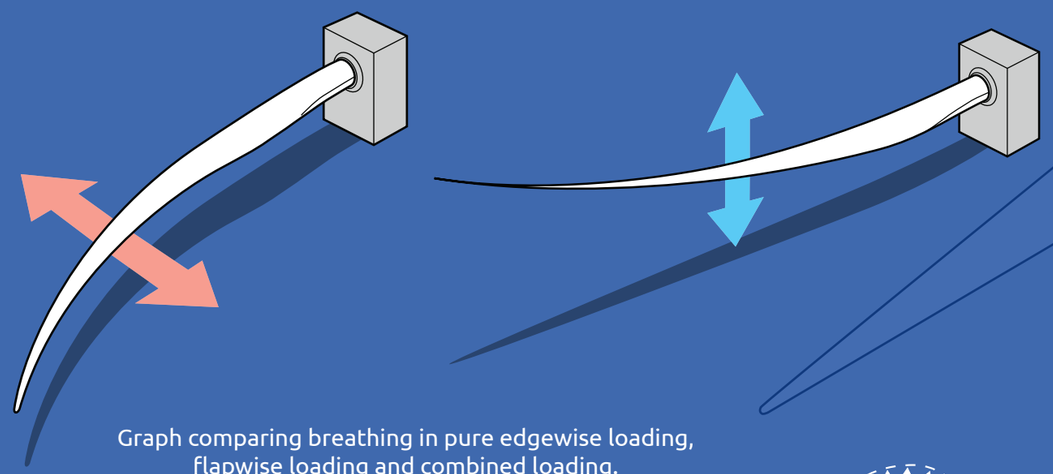
EUDP Bladena BLADE ENABLER KIRTXTHOMSEN

TORSION ON BLADES

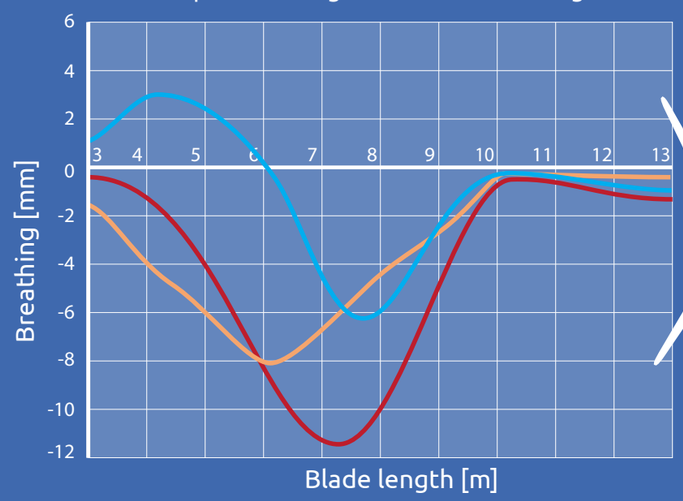
Impact of torsion on blades: Testing vs Blades in operation

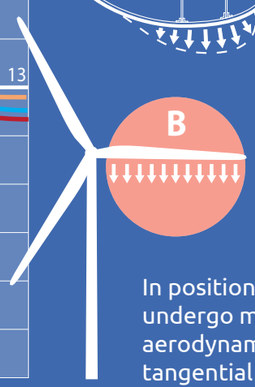
BLADE IN TEST ENVIRONMENT vs BLADE IN OPERATION

The application of edgewise and flapwise load components separately do not represent realistic scenarios, as these load components work on the blade at the same time in the field.



Graph comparing breathing in pure edgewise loading, flapwise loading and combined loading.



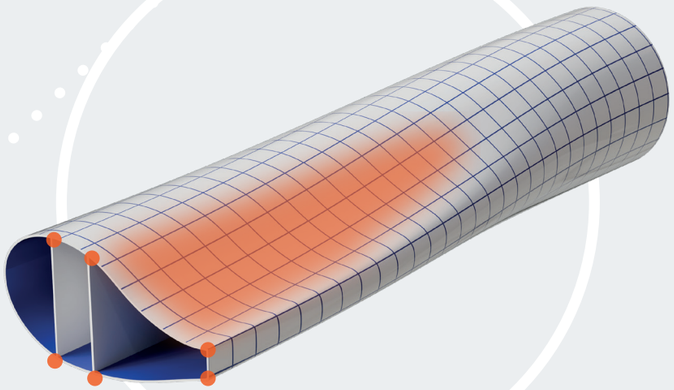


In position B, blades undergo maximum aerodynamic and tangential forces.

Blade position B

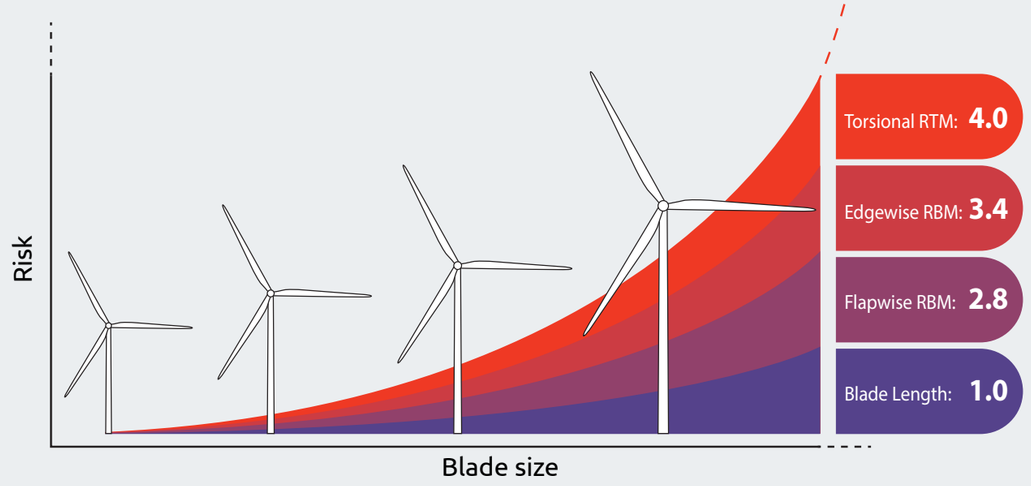
Pure edge (position B)

Pure flap (position B)



Direct impact on the blade's transition zone

In operation, the combination of edgewise and flapwise load components lead to torsional moments. The torsional loads are triggering cross sectional shear distortion and breathing in the transition zone and max chord. The out-of-plane deformations of unsupported panels lead to critical blade damages.



Visualization by Kirt x Thomsen with Bladena

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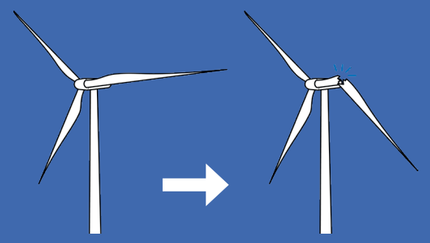
SHEAR WEB DISBOND RTZ SOLUTION™

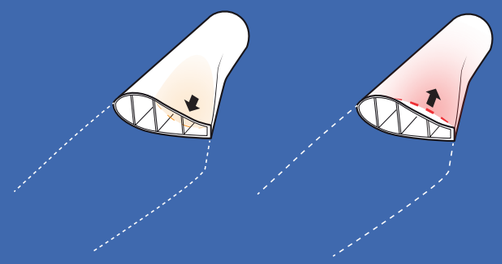
RISK



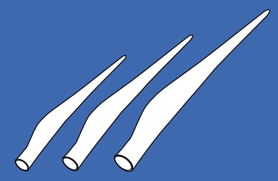
Shear web disbond lead to catastrophic blade failure

AIM

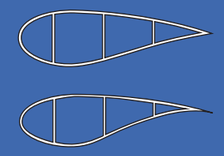
Reduce local deformations and peeling stresses



Parameters driving shear web disbond



Influence on blade size

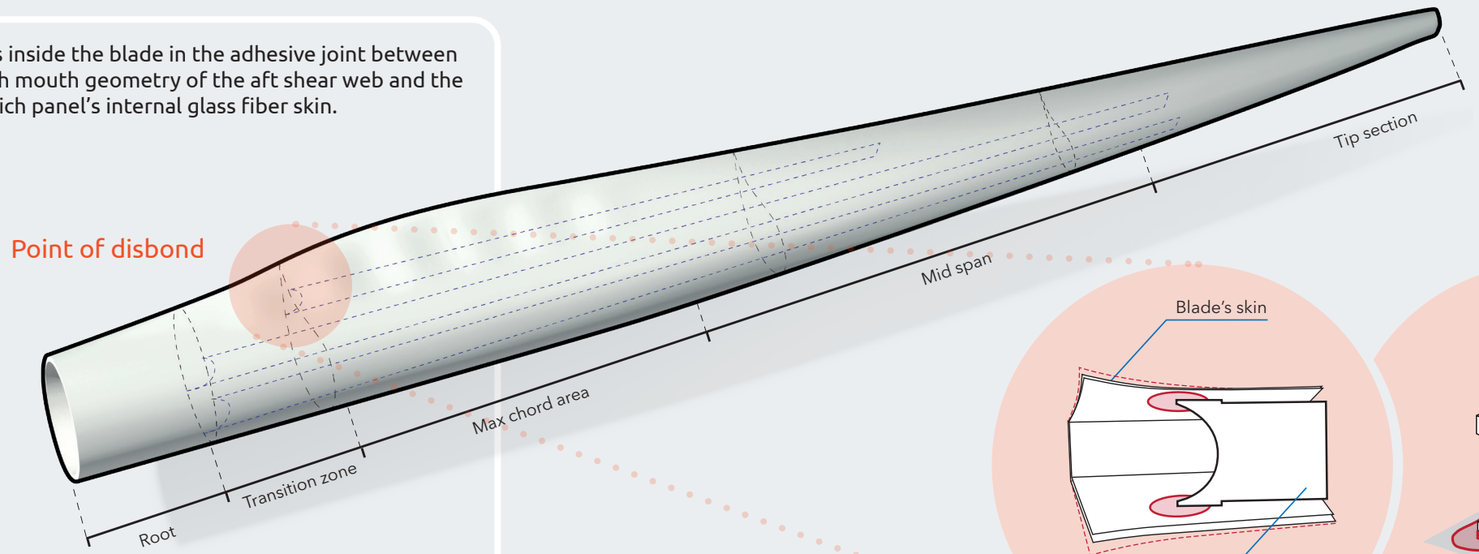


Different pressure side and suction side curvatures

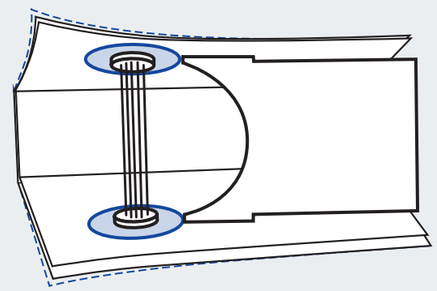
Site conditions

SHEAR WEB DISBOND

Occurs inside the blade in the adhesive joint between the fish mouth geometry of the aft shear web and the sandwich panel's internal glass fiber skin.



RTZ SOLUTION™

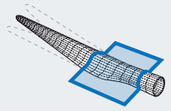


Local deformations in the blade cause peeling stresses, which result in shear web disbonding. The RTZ Solution™ prevents this failure mode.

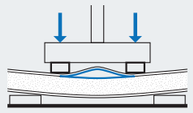
HISTORY

1 **Field observations**
Damage observed in the field

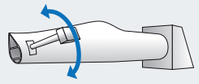
2 **Data collection**
Local deformations observed and measured



3 **Structural simulation**

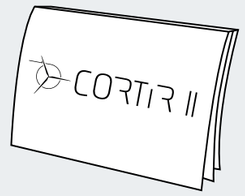


4 **Sub-component test**



5 **Multi-scale testing**
Large-scale test with debonded area

6 **Conclusions**
Conclusions and recommendations



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NIFIS NEW INNOVATIVE FIELD INSPECTION STRATEGIES

CURRENT APPROACH

On-site inspection

Inspection template

NGIR

ISP → WTO

Inspection report

Damage report

Action plan

FUTURE HOLISTIC APPROACH

Inspection methods

Non-destructive testing

Inspection templates

Field data

CAR tool

Blade scaling trends

Database

Damage tolerance approach

NIFIS

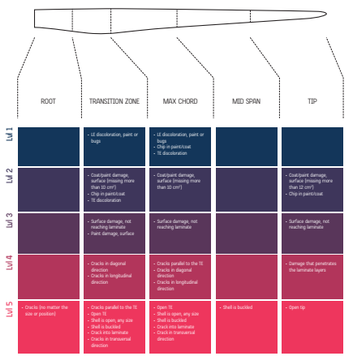
ISP → WTO

Damage report

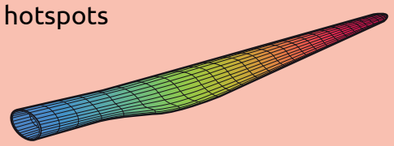
Strategic action plan

Supporting inspections

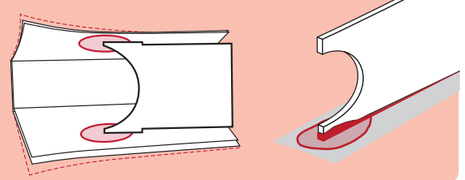
Damage categorization scheme



Blade hotspots



Failure mode illustrations

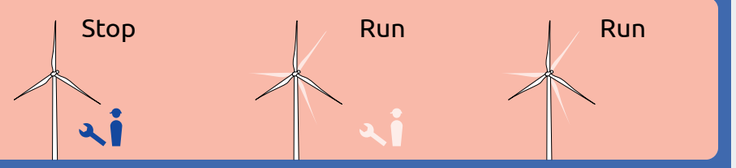


Supporting decision making towards risk-based maintenance strategy

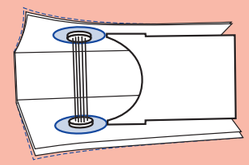
CAR tool

Data and expert knowledge

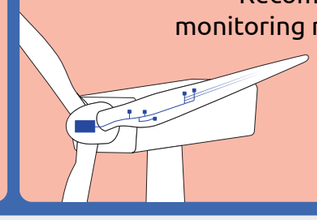
Scaling trends



Repair solutions



Recommended monitoring methods



TIMELINE

2021 (Sep.)

- Expectation's alignment
- Objective's definition
- NIFIS interface overview
- Damage tolerance initiation (maintenance strategies)

2022 (Jan.)

- Selection of monitoring techniques
- Selection of inspection methods
- Data analysis: BBF and G2D
- Knowledge collection from FEM simulations
- for damage tolerance
- Setting up website/app

2022 (May)

- First Damage Categorization Scheme
- NDT analysis on field conditions
- First guidelines draft for maintenance strategies
- First draft for inspection and repair reports templates

2022 (Sep.)

- Development of ISP blade course
- Holistic CAR Tool integration
- Scaling trends integration
- Damage tolerance integration

2023 (Jan.)

- Gather data from testing
- Holistic inspection and repair reports templates
- Maintenance strategies for Aft Shear Web Disbonding

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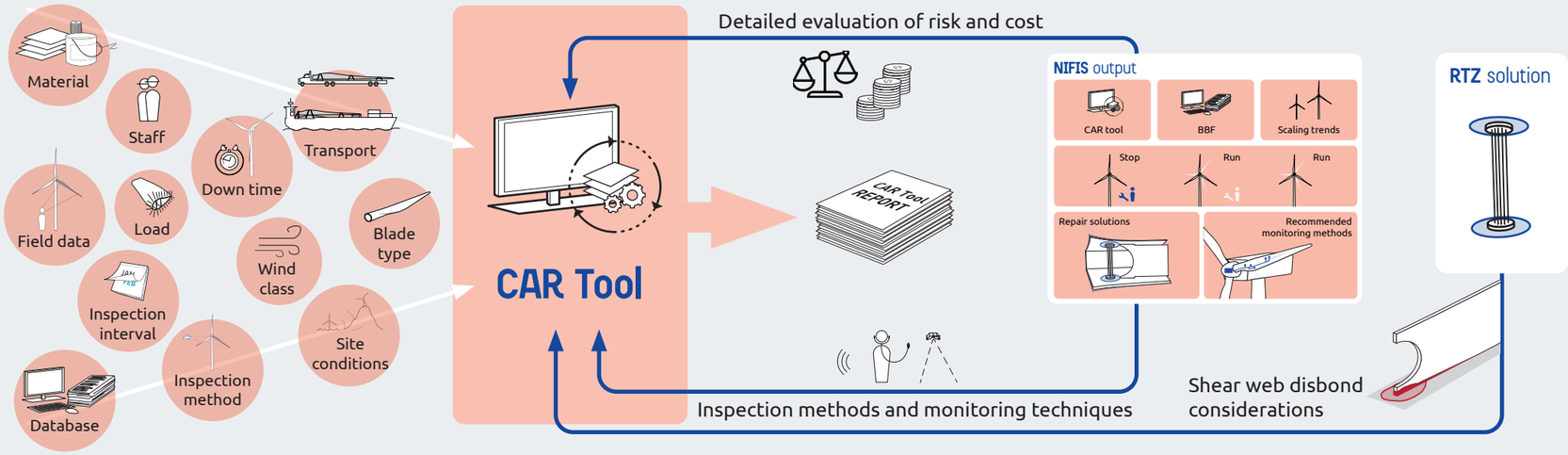
CAR TOOL

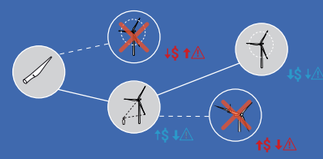
A DECISION SUPPORT TOOL



CAR TOOL VALUES

Operational & Maintenance decisions
Preventive maintenance

Risk considerations
Risk and reliability considered in the decision-making

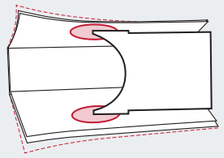


Cost & optimal maintenance strategy
More strategic decisions for WTOs

TRANSFORMATION FROM MINIMAL VIABLE PRODUCT TO HOLISTIC TOOL

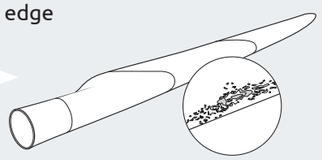
From simple investment calculations	TO	Advanced investment calculations
From no repair type evaluation	TO	Repair analysis
From two inspection methods	TO	Additional inspection methods
From one failure mode	TO	Additional failure modes
From limited to one blade	TO	Wind farm level
From simplified load case	TO	Load improvements
From one blade type	TO	Additional blade types

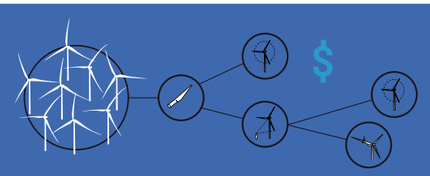
Shear web disbonding



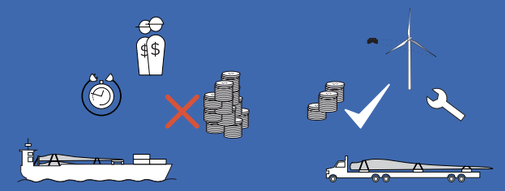
Lightning

Leading edge erosion





Cost & optimal strategy for WTG farms
Best cost-optimal strategy for a specific wind farm



Identification of main sources of cost
Detect where OPEX come from and find an optimal maintenance strategy

2021 (Aug.)
- Initiation of CapEx and LCoE calculations
- Initiation of Lightning and Erosion aspects
- Shear web disconnection

2021 (Dec.)
- Finalized CapEx and LCoE calculations
- First version of Lightning and Erosion considerations
- Starting the Improved Load Environment (ILE)

2022 (Feb.)
- Initiation of Wind farm considerations
- Initiation of Power curve implementations
- First draft of the ILE
- New standardised damage

2022 (Jun.)
- Finalization of Power curve
- First draft of the Wind farm functionality
- Second draft of ILE

2022 (Sep.)
- Finalized Erosion and Lightning additions

2022 (Dec.)
- First draft version of the additional structural defect
- Finalized model of ILE

2022 (Feb.)
- Second draft version of wind farm considerations
- Second version of the additional structural defects

2023 (May)
- Final version of wind farm considerations
- Final version of additional structural defects

2022 (Jun.)
- GUI update
- Documentation
- Trial period

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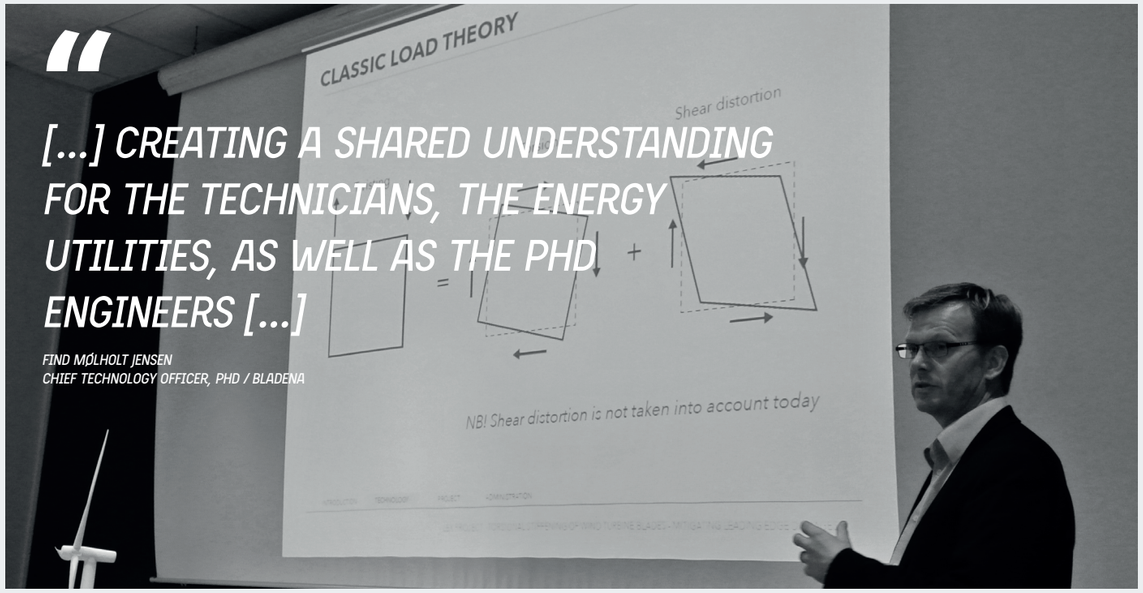
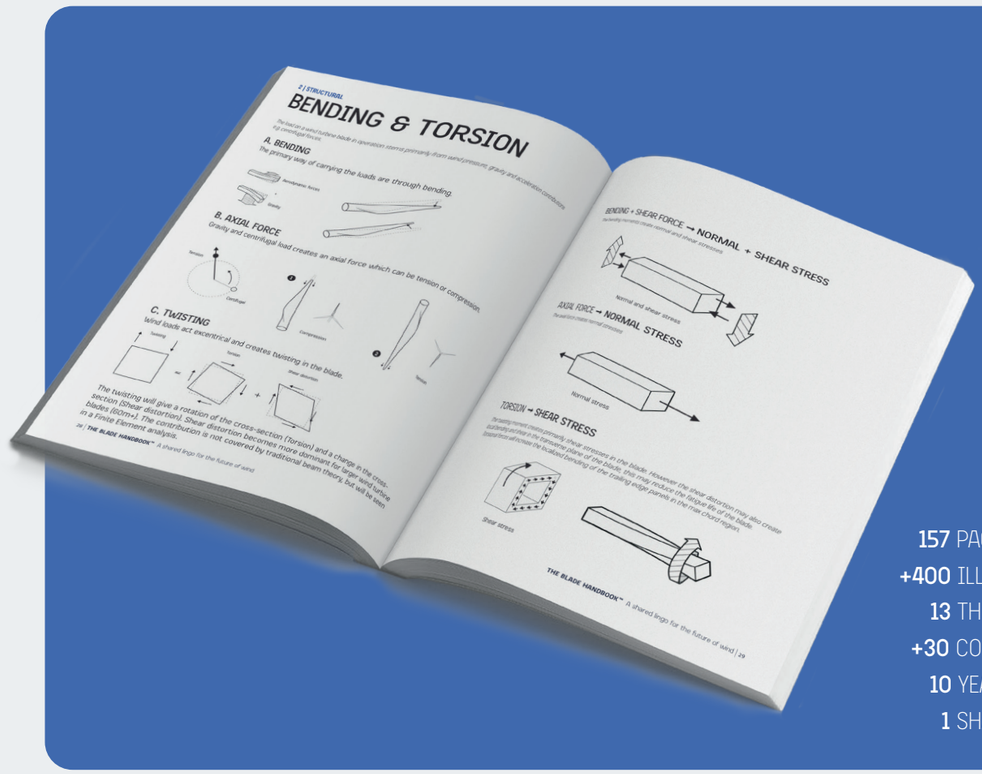
THE BLADE HANDBOOK

A SHARED LINGO FOR THE FUTURE OF WIND



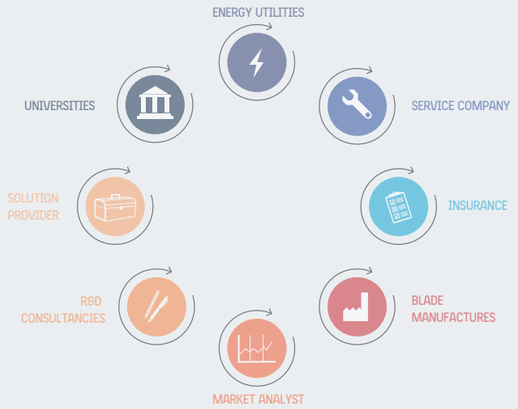
"[...] CREATING A SHARED UNDERSTANDING FOR THE TECHNICIANS, THE ENERGY UTILITIES, AS WELL AS THE PHD ENGINEERS [...]

FIND MØLHOLT JENSEN
CHIEF TECHNOLOGY OFFICER, PHD / BLADENA

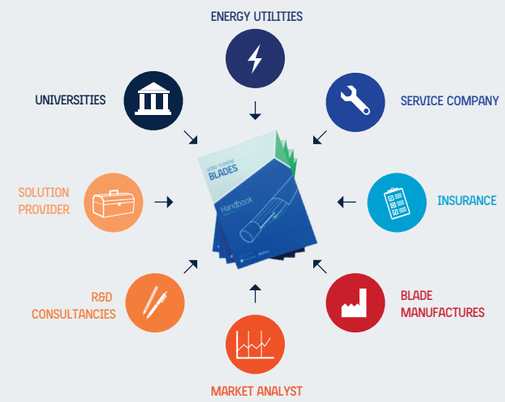


157 PAGES
+400 ILLUSTRATIONS
13 THEMES
+30 CONTENT PARTNERS
10 YEARS CO-CREATION
1 SHARED LINGO

THE WHOLE VALUE CHAIN - FROM ACADEMIA TO HEAVY INDUSTRY



Different terms and definitions



One aligned lingo - better collaboration between stakeholders
- bring down silos
- accelerate the green transition

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CORTIR II

POSTER COLLECTION

CORTIR II Project

The second phase of the CORTIR project builds on top and extends significantly the outcomes of the first phase. Its main deliverables are a new retrofit solution designed for high forces in the Root-Transition Zones (RTZ) of blades, a new innovative state-of the art operation and maintenance strategy and lastly further developments of the Cost and Risk Tool (CAR Tool).

CORTIR Partners

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