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New Task 46: Erosion of Wind Turbine Blades

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New Task 46
Erosion of Wind Turbine Blades

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Sara Pryor (Cornell) and Marijn Veraart (Ørsted) ,
David Maniaci (Sandia),
Jakob Ilsted Bech (DTU) and Maral Rahimi (Hempel),
Fernando Sánchez López (UCHCEU) and Bodil Holst (UiB)

Why blade erosion is relevant?

- Still an unsolved issue: blades today require costly in-situ service
- Net Present Value of costs associated to blade erosion estimated 2-3% (offshore)
- Will get worse: lifetime of offshore projects online by 2030 is 30 years
- Solving the erosion challenge will unlock system-level gains: lower loads, and wind turbine cost

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Why blade erosion is relevant?

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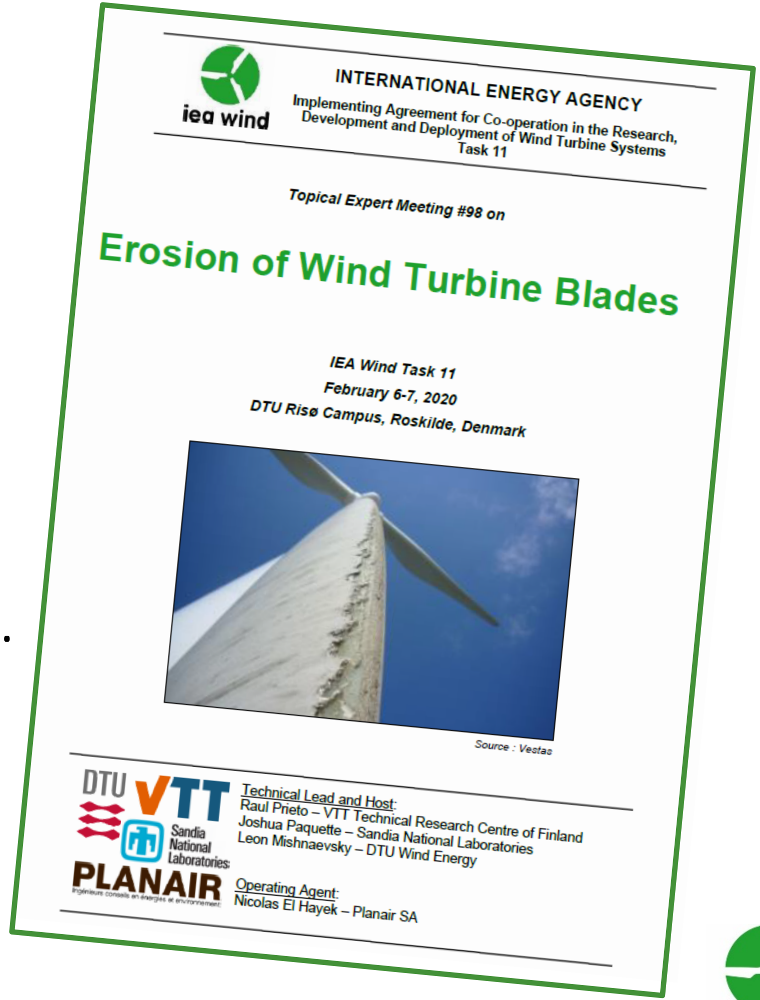
Can IEA TCP Wind help?

- The topic of blade erosion is aligned with two of the **research priorities** established by IEA TCP Wind:
  - **Resource and site characterization**: Improving the practices in resource characterization regarding susceptibility to erosion at wind farm sites.
  - **Advanced technology**: erosion damage models, material properties, characterization of erosion resistance; wind turbine operation with erosion.

Source: Vestas

How can IEA TCP Wind contribute?

- TEM #98 convened in Feb-2020 to discuss pressing research needs.
- 29 participants contributed with presentations and fruitful discussion.
- A full day workshop helped establish a backbone for a potential collaborative effort.
- In the wake of TEM, online interactions helped mature the tentative scope of work.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INTERNATIONAL ENERGY AGENCY

Implementing Agreement for Co-operation in the Research, Development and Deployment of Wind Turbine Systems

Task 11

Topical Expert Meeting #98 on

Erosion of Wind Turbine Blades

IEA Wind Task 11

February 6-7, 2020

DTU Risø Campus, Roskilde, Denmark

Source : Vestas

Technical Lead and Host:

Raul Prieto – VTT Technical Research Centre of Finland

Joshua Paquette – Sandia National Laboratories

Leon Mishnaevsky – DTU Wind Energy

Operating Agent:

Nicolas El Hayek – Planair SA

Task 46 is formed by 28 organizations from 11 Countries:

Ireland *SEAI* *NUI Galway, U Limerick, IT Carlow*

Country	IEA Wind Contracting party	Task Participant
Belgium	Belgian Ministry of Economy	Engie
Canada	Natural Resources Canada	WEICan
Denmark	Danish Energy Agency	DTU
		Hempel
		Ørsted A/S
Finland	Business Finland	VTT
Germany	Federal Ministry for Economic Affairs and Energy	Fraunhofer IWES
		Covestro
		Emil Frei
		Nordex Energy
Netherlands	RVO	TU Delft
		Suzlon
		TNO
Norway	NVE	Equinor
		University of Bergen
Spain	CIEMAT	Aerox
		Universidad Cardenal Herrera – CEU
		CENER
		Siemens Gamesa Renewable Energy
		Nordex Energy Spain
United Kingdom	ORE Catapult	ORE Catapult
		University of Bristol
United States	US DoE	Cornell University
		Sandia National Laboratories
		3M

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Scope of work

- Scope structured in four technical work packages plus management
- Work plan to be delivered in 4 years commencing in March 2021
- 10 deliverables with high TRL results including Recommended Practices and validated models.
- 15 deliverables with low TRL results including literature surveys, state-of-the-art reports, roadmaps and reports on available technologies.

WP 1: Management	Raul Prieto (VTT) & Charlotte Hasager (DTU),
WP 2: Climatic conditions	Sara Pryor (Cornell) & Marijn Veraart (Ørsted) ,
WP 3: Wind turbine operation with erosion	David Maniaci (Sandia),
WP 4: Laboratory testing of erosion	Jakob Ilsted Bech (DTU) and Maral Rahimi (Hempel),
WP 5: Erosion mechanics & material properties	Fernando Sánchez López (UCHCEU) & Bodil Holst (UiB)

Task 46 - Erosion of wind turbine blades: WP#2 Climatic conditions

1. Priority areas for mapping LEE potential – focus on hydrometeors

2. Identify (other) crucial parameters (e.g. dust, freezing rain, sea-spray, UV, temperature variation (diurnal & seasonal))

3. Lit rev: Hail, rain & dust in priority areas

4. Lit. rev. Hydrometeor size dist. As f(climate)

5. Data quality/availability update

6. Roadmap for LEE atlas

7. Recommended Practise for measurement of LEE drivers

8. Methods to perform model V&V on LEE drivers

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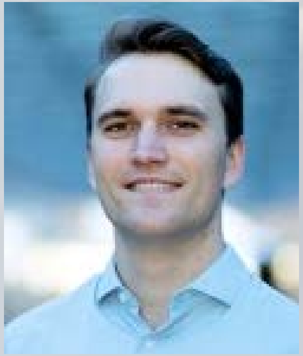

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WP 2: Climatic conditions

- WP2.1 Definition of priority geographic areas for geospatial mapping of erosion potential.
- WP2.2 Identification of additional meteorological parameters for erosion.
- WP2.3 hail, rain & dust climates in target areas
- WP2.4 hydrometeor droplet size distribution as function of climate
- WP2.5 Revisit data availability and quality for key meteorological parameters of relevance to LEE.
- WP2.6 Develop a roadmap for a leading-edge erosion atlas
- WP2.7 Develop Recommended Practice (RP) for measurements of LEE drivers
- WP2.8 Advance methods to conduct model V&V

WP 2: First steps

WP2.1 Definition of priority geographic areas for geospatial mapping of erosion potential.

- Compile comprehensive meta-data regarding available hydrometeor data (e.g. rain, hail characteristics and co-availability of wind speeds) for assessing LEE with a particular focus on regions with major wind energy penetration. The deliverables will be a report & spreadsheet summarizing the meta-data. In the report we will document where there are sufficient & sufficient quality data available for parameters of crucial importance to characterizing LEE.

WP2.2 Identification of additional meteorological parameters for erosion.

- Compile comprehensive meta-data regarding available data for additional parameters of importance to LEE – specific foci; wind blown dust, UV, occurrence of freezing rain, corrosive agents such as sea spray. The deliverables will be a report & spreadsheet summarizing the meta-data. In the report we will document where there are sufficient & sufficient quality data available for parameters of crucial importance to characterizing LEE.
- Conduct comprehensive literature reviews and synthesize knowledge gained from projects in order to better characterize

WP 3 : Wind turbine operation with erosion

This work package has three key overarching objectives:

1. Promote collaborative research to mitigate erosion by means of wind turbine control, assessing the viability of erosion safe mode.
2. Improve the understanding of droplet impingement in the context of erosion.
3. Improve the understanding of wind turbine performance in the context of erosion, specially the effect of LEE surface roughness on aerodynamics.

Activity	WP code
Model to predict annual energy production loss on blade erosion class	WP3.1
Report on standardization of damage reports based on erosion observations	WP3.2
Droplet impingement model for use in fatigue analysis	WP3.3
Potential for erosion safe-mode operation	WP3.4
Accuracy of LEE performance loss model based on field observations (validation)	WP3.5

Please reach out if interested in collaborating!

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WP 3 : Wind turbine operation with erosion

- WP3.1 Model to predict annual energy production loss based on blade erosion class.
- WP3.2 Report on standardization of damage reports based on erosion observations.
- WP3.3 Droplet impingement model for use in fatigue analysis.
- WP3.4 Potential for erosion safe-mode operation.
- WP3.5 Accuracy of LEE performance loss model based on field observations (validation).

WP 3 : First steps

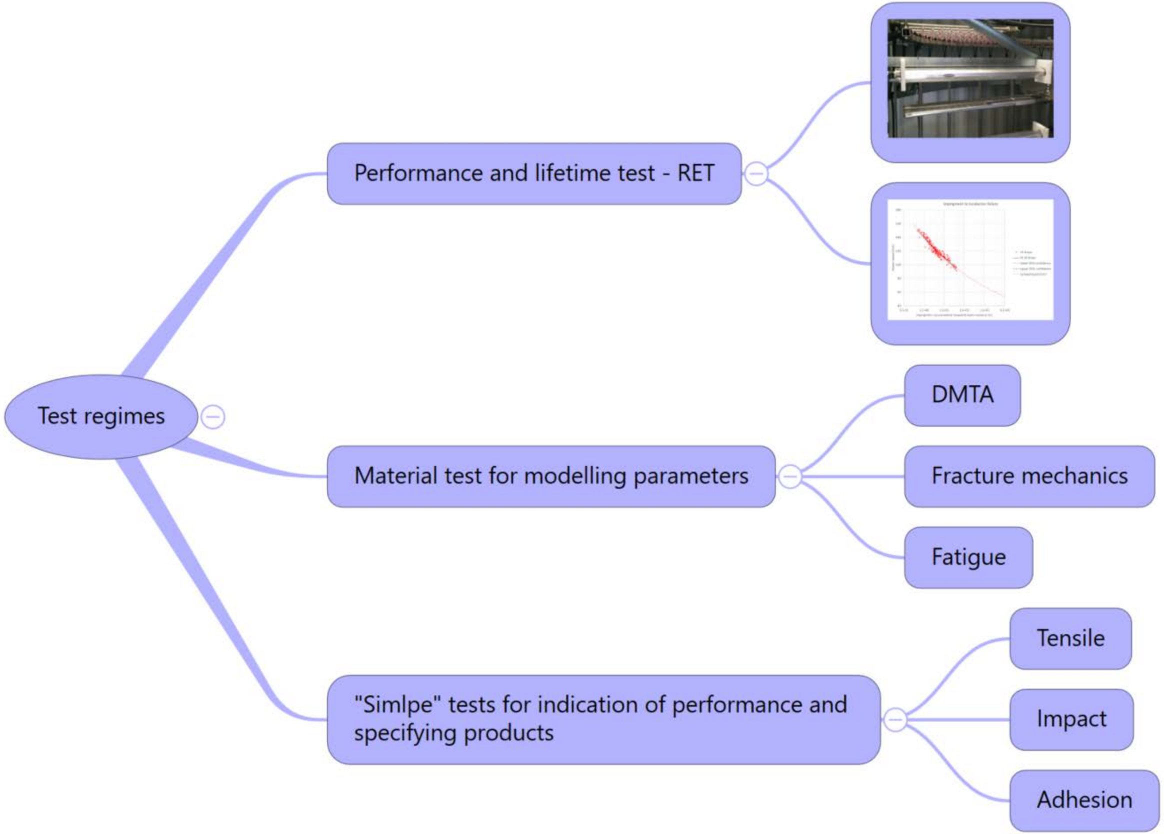
WP3.1 Model to predict annual energy production loss based on blade erosion class.

- Develop a common model of aerodynamic performance loss due to leading edge roughness and erosion standardized classes. Quantification of performance degradation (loss of AEP) as a function of roughness and 'erosion climate'.

WP3.2 Report on standardization of damage reports based on erosion observations.

- Standardization of damage reports for validation of any erosion potential assessment and to allow effective integration of data from operators with laboratory derived estimates.

WP 4: Laboratory testing of erosion



WP 4: Laboratory testing of erosion

- WP4.1 Available technologies for lab test (report).
- WP4.2 Erosion failure modes in LE systems (literature review).
- WP4.3 Normalization of test substrates (recommended practice).
- WP4.4 Pre-evaluation of test specimens (recommended practice).
- WP4.5 Test data analysis, damage accumulation and VN curves (recommended practice).
- WP4.6 Simple mechanical test for screening of key parameters (report).
- WP4.7 Correlation between RET data and expected field service life (report and model).
- WP4.8 Aging – unloaded and during testing.

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WP 4: First steps

WP4.1 Available technologies for lab test (report).

- Production of a report on technologies available for the laboratory evaluation of erosion. The review aims at covering as much as possible of laboratory testing relevant for wt blade erosion, ranging from formulation and micro-structure over basic physical, chemical and mechanical properties to rain erosion resistance.Topics include:
  – Rain erosion tests, – Impact tests, – Viscoelastic properties, – Fracture mechanics, – Fatigue
  – Microstructure Characterization, – Aging, etc.

WP4.2 Erosion failure modes in LE systems (literature review).

- Literature review and partner experience document on failure modes associated to the erosion process. The task is divided in WP4.2a "Failure modes in laboratory testing", running in parallel with WP4.1 and WP 4.2b "Failure modes on turbines in the field". The work will be performed in alignment with WP3.2 and WP5.2.

WP 5: Erosion mechanics & material properties

- WP5.1 Damage models based on fundamental material properties.
- WP5.2 Multilayer systems.
- WP5.3 Microstructure and macroscopic material properties.

WP 5: First steps

WP5.1 Damage models based on fundamental material properties.

- Identify appropriate damage models for accumulative droplet impact erosion attending specific failure modes based on fundamental material properties. Define appropriate testing methodologies for the material properties defined as input parameters in the modelling. Work will be performed in alignment with WP2.8 and 3.3 (modelling including droplet impingement aerodynamics and key atmospheric issues) and WP4.7 (modelling from RET Data).

- Report 1 based on Literature Review: Identify lacks and drawbacks on state-of-the-art erosion damage modelling techniques and corresponding material characterization including partner's experiences.
- Report 2 based on alternative/complementary erosion damage model studies including partner's experiences.

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Operating agents

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