



An Asset Owners Perspective of Innovation in Support of the Circular Economy

Opportunities for Onshore/Offshore Wind

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CE Strategy For Wind Turbine Assets - The Challenge



Concern about climate change driving growth in clean energy with onshore and offshore wind leading the way

Costs for developing onshore and offshore wind farms are becoming competitive

Global wind energy capacity surpassed 600GW in 2018 and is forecast to grow to 839GW by 2023 with the share of offshore wind increasing

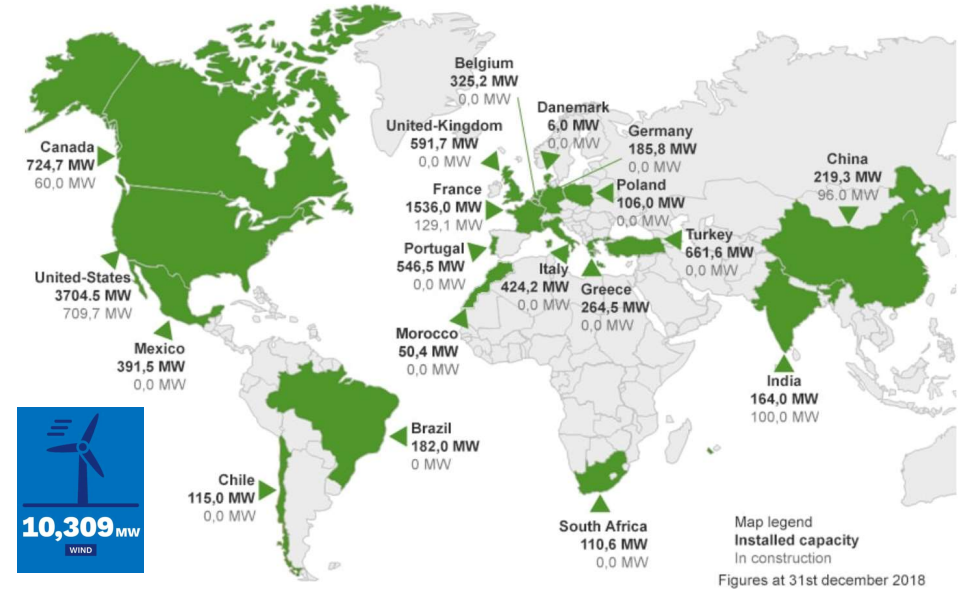


End of life considerations are currently not robustly considered

Repowering and decommissioning are considered an afterthought as industry is focused on construction

CE Strategy For Wind Turbine Assets – EDF Context

- Repair/Refurbish for life extension
 - Blades
 - Gearbox/Drivetrain
 - Pitch Bearings
- Repower
 - Tower/foundation reuse
 - Larger capacity turbines
- Decommission
 - Blades stored on green field / warehouse sites
 - Tower recycled
 - Gearbox/Drivetrain etc sold for spares



Asset Owner CE Strategy – Opportunities for Innovation



➤ **Blades**

- Rapid remotely deployable effective repair solutions – **Life extension**
- Recycling of wind turbine blades as an alternative to “just leaving it in a field” - **Decommissioning**

➤ **Gearbox/Drivetrain**

- AI driven health monitoring for component lifetime prediction - **Life extension**
- Onsite refurbishment of significant damage – **Life extension**
- New uses in other industries - **Decommissioning**

➤ **Offshore Foundations**

- Repurposing to support larger turbines - **Life extension**

Asset Owner CE Strategy – Opportunities for Innovation



➤ Cradle to Grave O&M Approach

- Consumption based O&M dashboard for assessing component life and repairability – **Life extension**
- Development of a recyclability index for components – **Decommissioning**

➤ Improving sustainability

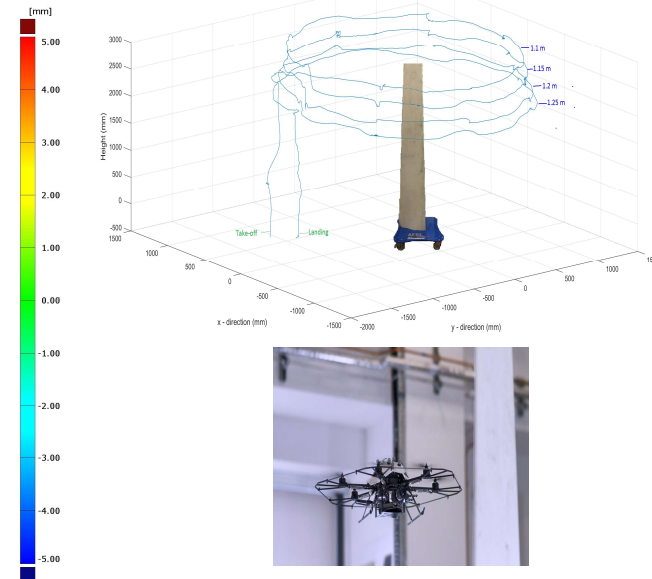
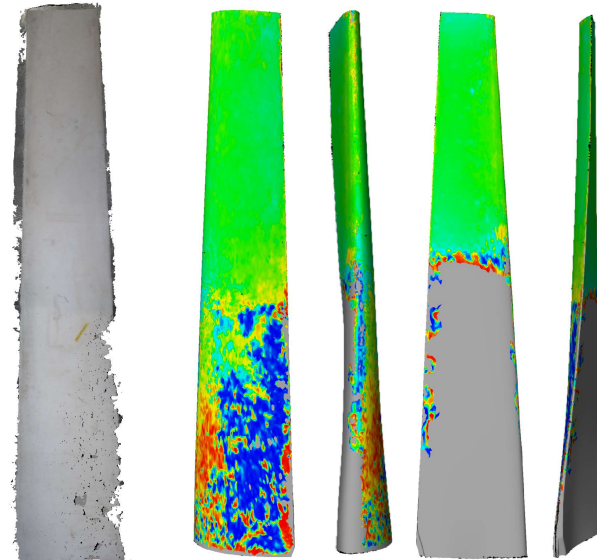
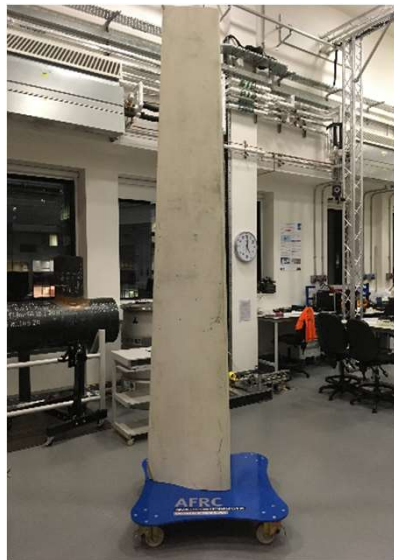
- Assessment tool for evaluating sustainability of wind turbine design on a component level - **Life extension / Decommissioning**
- Supply chain monitoring tool for assessing sustainability of consumables for O&M - **Life extension / Decommissioning**

Asset Owner CE Strategy – Innovation Projects

High Resolution 3D Mapping of Wind Turbine Blade Geometries

Improved damage characterisation for targeted repair strategies

Accurate blade geometries support smarter cutting strategies for blade recycling/repurposing



- Partial blade section scanned using high res camera & reconstructed in 3D
- 3D full 360 ° scan & partial reconstruction of blade using AscTec Firefly with on-board camera
- Sub-mil deviation with 3D Reference Model on some areas
- Identification of damage from 3D reconstruction

Asset Owner CE Strategy – Innovation Projects

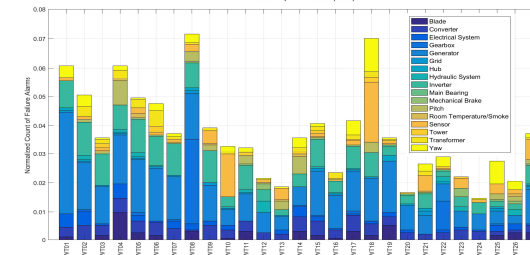
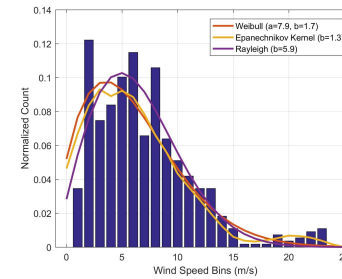
Leveraging the value of O&M data

Improved reliability and component lifetime estimations which can feed into a index for repair or recycling

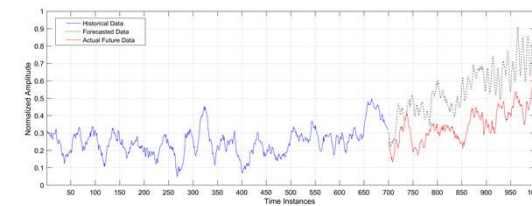
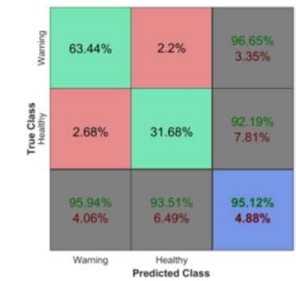
Optimising maintenance and supply chain strategies for extended life



Reliability Statistics



Machine Learning



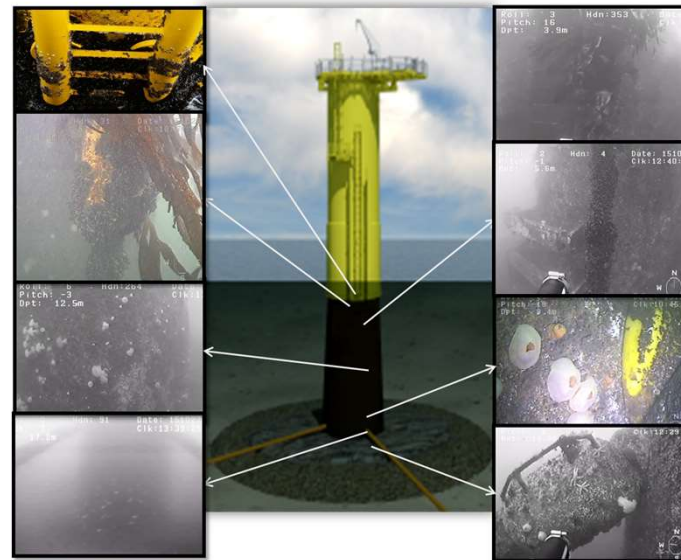
- Detailed O&M database of Teesside Offshore Wind farm developed consisting of 2 years of data
- Reliability profiles for major components developed for Siemens 2.3 MW turbines
- In-house and commercial Machine Learning algorithms validated for predicting component lifetime
- Risk based inspection strategies developed for optimising maintenance to support asset life extension

Asset Owner CE Strategy – Innovation Projects

Monitoring marine ecosystem around offshore wind foundations

Improved understanding of marine species around offshore wind submerged structures which help to guide impact of decommissioning on marine environment

Helps to guide the case for converting offshore wind submerged structures into artificial reefs or for supporting aquaculture initiatives



Purple Laver
(*Porphyra umbilicalis*)



Green Filamentous algae (*Ulothrix*)



Red Filamentous algae (*Audouinella*)



Green Sea Lettuce
(*Ulva lactuca*)



Acorn Barnacle
(*Balanus crenatus*)



Darwin Barnacle
(*Eliminius modestus*)



Blue Mussel
(*Mytilus edulis*)



Common Limpet
(*Patella vulgata*)



Marine Splash Midge
(*Telmatogeton japonicus*)

- Compiled database of extent and type of marine species growing on splash and submerged zone of the foundations at Teesside Offshore Wind Farm
- Assessed the threat of hard marine fouling aggregation to long term foundation integrity and determined cleaning regimes to reduce impact of hard marine fouling



Website

edfenergy.com/about/research-development



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