Scaling-up Digitalization Of Critical Components in OFFshore wind turbines (DOCC-OFF)

EMFF-BlueEconomy-2018

With the contribution of the European Maritime and Fisheries Fund of the European Union

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Context

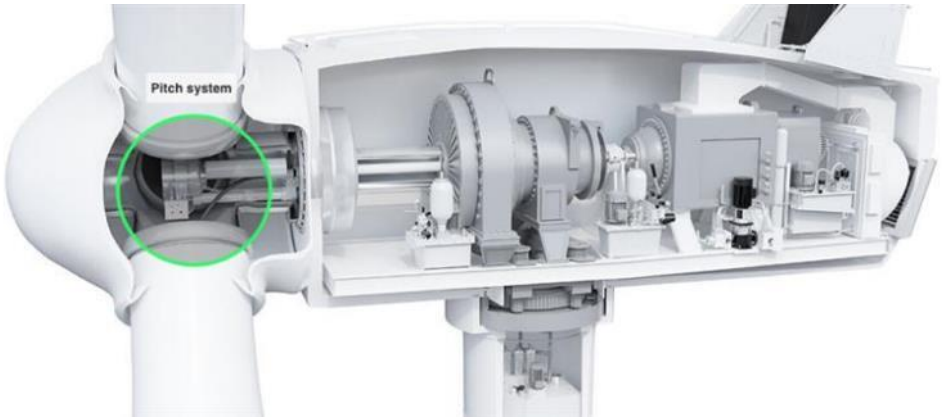
- The EU faces a growing need to improve its energy security and protect its economy from fossil fuel price spikes and uncertainty.
- **European seas hold an important way to produce clean, secure and reliable energy**, as the current technical potential of offshore wind resources is estimated to be sufficient to fulfill Europe's electricity demand by 2030.
- **Europe will see its offshore wind farms grow** from 22,184 MW in 2020 to 65,000 MW by 2030.
- The Offshore wind industry normally incurs costs categorized as CAPEX and OPEX, with each category comprising different elements that correspond with the life cycles of offshore wind farms. OPEX is + 30% of the total cost in bottom-fixed offshore wind farms.
- The expected high growth of investments in Marine Renewable Energies in Europe and globally represent **significant market opportunities which can boost a leading European manufacturing industry**. As a result, European companies can be relevant net-exporters to the global markets and a significant number of high added-value jobs can be created.
- With the crisis generated by the COVID-19 pandemic, **digitalization and renewable energies**, specifically **wind power**, are positioned as technologies to **drive the economic recovery.**

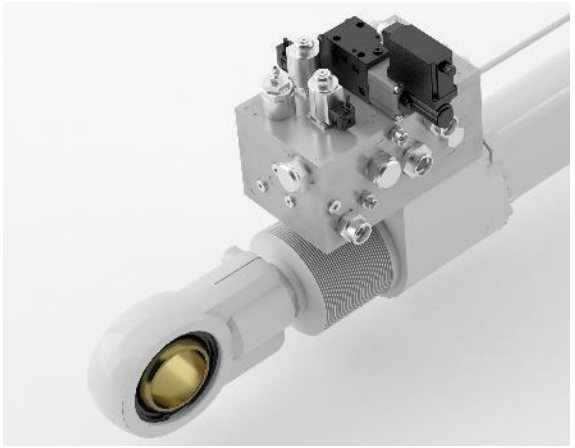
Challenge

- **The cost of wind power generated in offshore wind farms has dropped dramatically**, to a great extent as a result of new auction systems which have forced developers and investors in windfarms to reduce costs both at investment and operational levels.
- **Component suppliers for wind farms are under great pressure of cost reduction** from their customers: wind farm developers and wind turbine OEMs.
- The European wind turbine component suppliers conform a well positioned sector today. But these companies are being challenged by low-cost competitors. For that reason European companies are exploring innovative and added-value strategies for differentiation and niche competitive advantages.
- European companies in the offshore wind value chain are envisaging the **digitalization of wind turbine components and systems as a main source of relevant competitive advantages**: Design optimization, O&M cost reduction, potential new services
- Advances in digitization, communications and data analytics, both in terms of functionality and cost reduction, are making possible to deliver **solutions that allow extracting data from operations and generating business value from them.**

Objective

- The main objective of this project is to **demonstrate the impact of sensing and remote monitoring in the optimization of the design, the increase of the performance and the reduction of maintenance costs of critical components in offshore wind turbines,** such as the **pitch system** used to **adjust the blades** in wind turbines by rotating them so that they use the right fraction of the available wind energy to **get the most power output,** meanwhile **ensuring the turbine does not exceed its maximum rotational speed.**





As a subsystem, the **hydraulic pitch system** is critical for the functionality of the wind turbine generator as it is responsible for:

- Wind power control via blade pitch angles
- Load reduction
- Emergency brake of the wind turbine
- Auxiliary systems such as yaw brake, rotor brake, etc.

DOCC-OFF project focuses on **identifying the failure modes** of the pitch system, in order to collect, through the installed **sensors** in the pitch system, the **operating data** to **detect and predict possible failures.** Thus, the project aims to improve the design, the operation and maintenance of the pitch system.

The project partners

- **Basque Energy Cluster (ES, Basque Country) – Coordinator:** is a cluster association formed by more than 160 companies from the energy value chain, including research entities and public administration. Basque Energy Cluster is the lead beneficiary of WP1 Project management and coordination and WP4 Dissemination and exploitation of results.

- **XABET (ES, Basque Country):** is a software company that gathers all available data from the customer and centralizes it for analysis thanks to X-Dwall platform. XABET is the lead beneficiary of WP2 Digital technologies specification and development. Within this Work Package, XABET will develop a digital platform that will capture and manage data from pitch system, exploiting it through specific data analytics tools for the failure modes identified.

- **HINE Renovables (ES, Basque Country):** is a leading supplier of hydraulic systems, hydraulic components and cooling systems for industrial and renewable energy companies. Hine will be able to interpret the data collected in the application developed by XABET and interpret the failure modes of the pitch system. This will enable HINE to improve the design, the operation and maintenance of the pitch system.

- **SIRRIS (BE, Flanders):** is the collective research and technology centre for the Belgian technological industry. This infrastructure and innovation platform has the mission to realize and operate test and measurement infrastructure for the offshore wind energy sector in Flanders and Europe. Sirris is the lead beneficiary of WP3 Digital platform validation and demonstration.

The project

Schedule of the project

	2019		2020												2021									
	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
WP 1. PROJECT MANAGEMENT AND COORDINATION																								
1.1 Management and coordination			☆					☆					☆						☆					★
1.2 Financial and administrative management																								
1.3 Monitoring and reporting of project progress and results																								
1.4 Data management and IPR protection																								
WP 2. DIGITAL TECHNOLOGIES SPECIFICATIONS AND DEVELOPMENT																								
2.1 FMECA analysis																								
2.2 Model development for component/system diagnosis													★											
2.3 Digital architecture specification																								
2.4 Digital platform development																								
WP 3. DIGITAL PLATFORM VALIDATION AND DEMONSTRATION																								
3.1 Validation specifications																								
3.2 System integration																								
3.3 Validation at system level																					★			
3.4 Demonstration at wind turbine level																								
WP 4. DISSEMINATION AND EXPLOITATION OF RESULTS																								
4.1 Communication tools and activities				★																				
4.2 Market uptake and business opportunities analysis																								
4.3 Business case and business models definition																								
4.4 Dissemination and explotation of results																						★		

☆ Kick-off meeting: Olaberria 21/01/2020

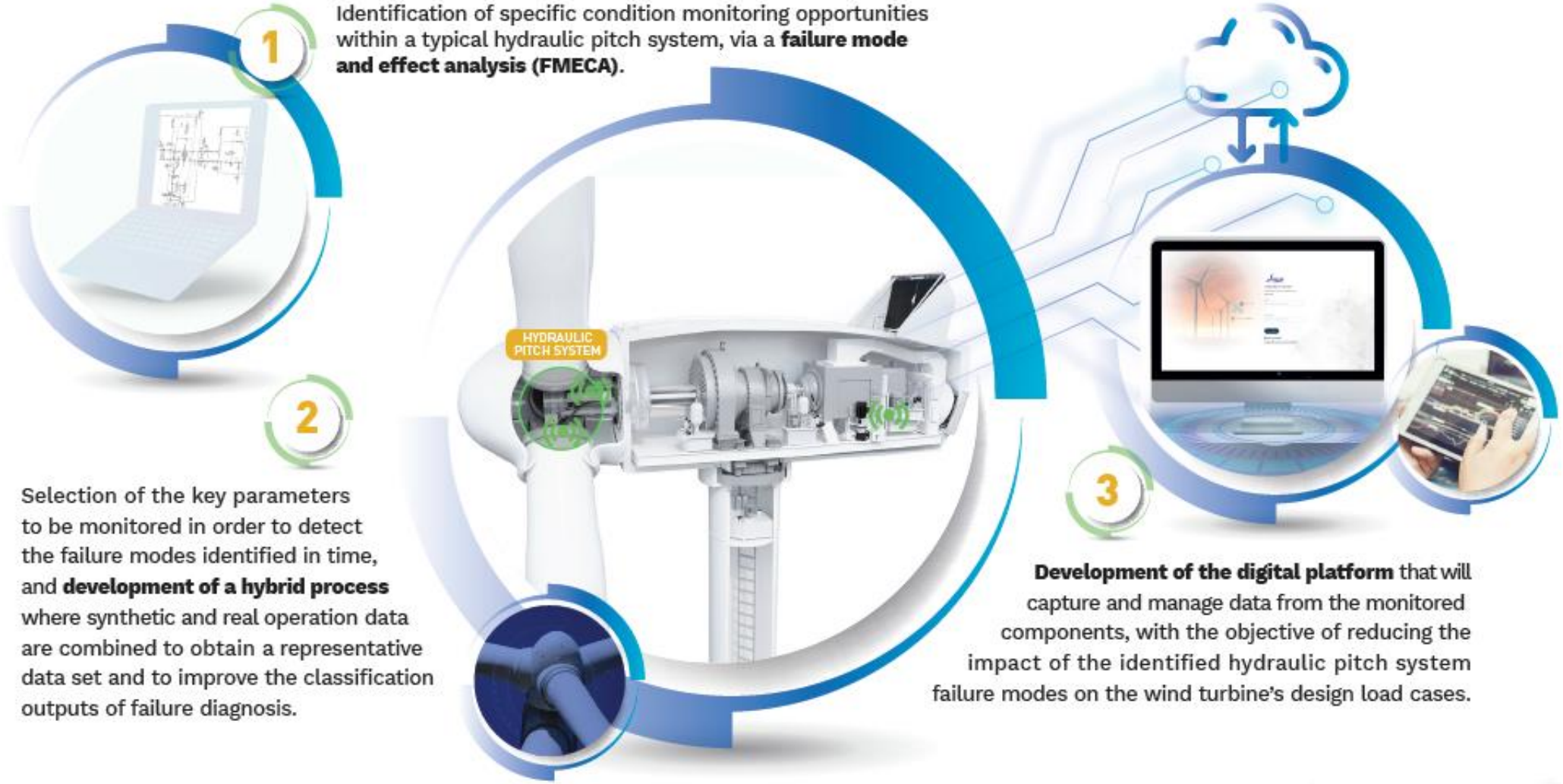
☆ Steering committee meeting:
- Online 09/06/2020
- Donosti 03/11/2020
- Leuven 31/05/2021

★ Final steering committee meeting: Bilbao 29/10/2021

★ Milestones:
- Website publication: 29/02/2020
- Hybrid model prototype: 30/11/2020
- Lab testing & validation execution: 31/07/2021
- Workshop with industrial stakeholders: 31/08/2021

Technological approach

Digital technologies specification and development



Technological approach

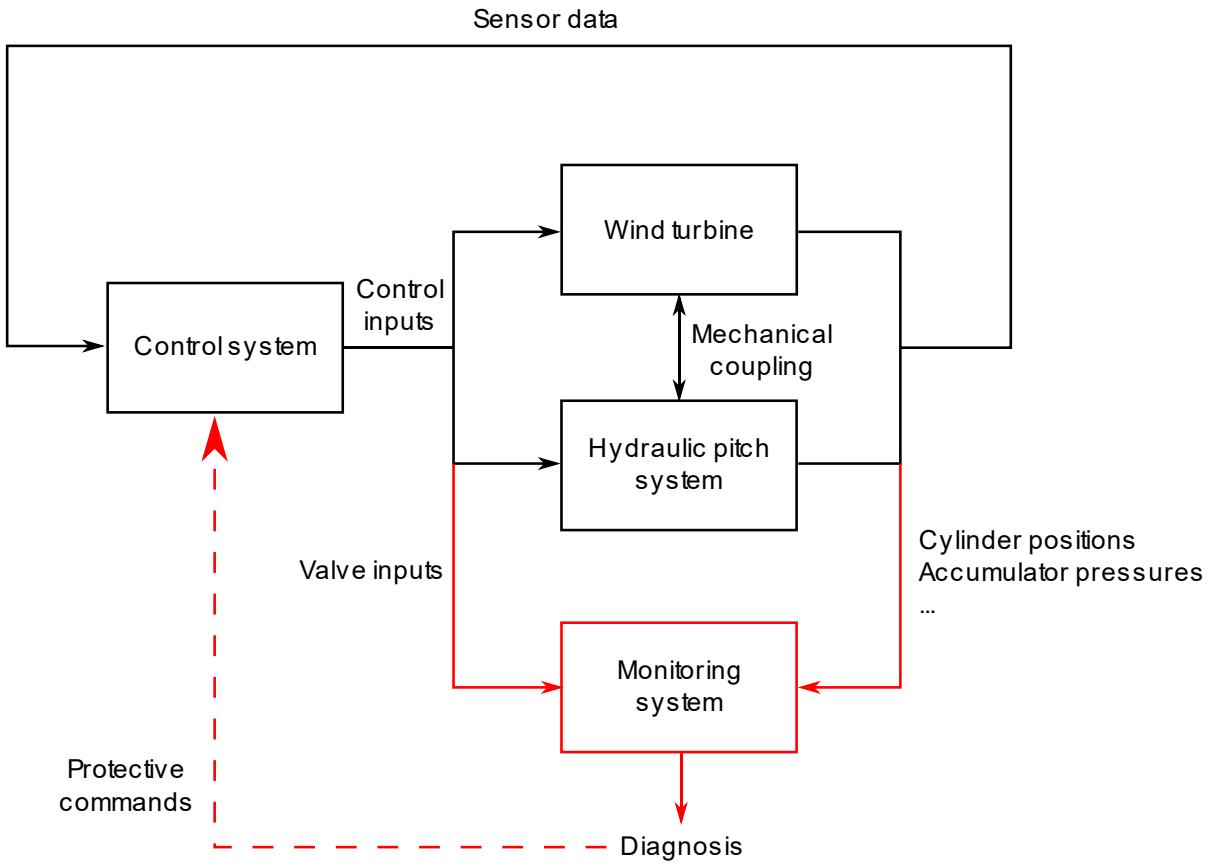
FMECA Analysis

Undetectable		Likelihood		
		Credible	Rare	Usual
Severity	Unwanted pitching	Occupational hazard		
	Degraded emergency pitch manoeuvre		Extreme loads	
	Degraded pitch reference following		Cumulative	Fatigue loads
	Tolerable		Cumulative	
Detectable		Likelihood		
		Credible	Rare	Usual
Severity	Unwanted pitching			Occupational hazard
	Degraded emergency pitch manoeuvre			
	Degraded pitch reference following			
	Tolerable			

Criticality level	Failure mode	Proposed mitigation
Occupational hazard	-	-
Extreme loads	Cylinder piston-side pipe or hose leak	Statistical analysis of proportional valve command signals, cylinder position and accumulator pressure
	EV4 closed	Emergency pitch manoeuvre tests on start-up
	EV6 closed	
	Emergency accumulator pre-charge too low	Hybrid method to estimate accumulator pre-charge
Fatigue loads	Cylinder piston seal leak	Statistical analysis of proportional valve command signals, cylinder position and accumulator pressure
	Cylinder friction excessive	
	Cylinder rod-side pipe or hose leak	
	Service accumulator pre-charge too low	Hybrid method to estimate accumulator pre-charge
	Pump flow rate reduced	Hybrid method to estimate accumulator pre-charge, detect pressure-line leaks and pump degradation
	Distribution pressure line leak	
	S1 offset	Sensor redundancy

Technological approach

Hydraulic pitch system monitoring



DOCC-OFF proposes the use of pitch system variables set and measured by the turbine control system, such as

- the cylinder positions,
- the accumulator pressures and
- the hydraulic valve inputs

to automatically diagnose hydraulic pitch system failures. This can then be used to both send protective commands to the turbine control systems, e.g. to limit power output, and plan maintenance sorties more efficiently.

Technological approach

Digital platform

DOCC-OFF will develop a digital platform that will gather the operation data captured by the sensors installed in the pitch systems.

The monitoring of these data, will allow to have a control on the operating data of the pitch system, thus performing a predictive maintenance over the possible failure modes identified.

Technological approach

Digital platform validation and demonstration

- The goal of WP3 is to validate the systems developed in WP2 in a testing site and analyse the opportunities to demonstrate the full integrated solution.

WP3 Digital platform validation and demonstration

Validation specifications

- Definition of requirements of the testing sites and different test-benches.
- Definition of the validation methodologies and tests to be carried out as well as the results and performance indicators.

System integration

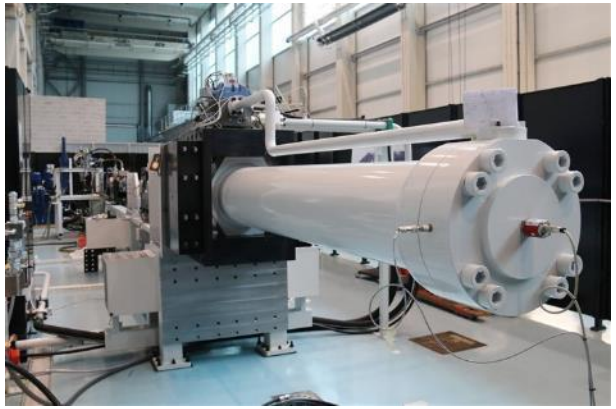
- Integration of the different building blocks developed in WP2 (models, sensors, efficient communications, HPC architectures, secure data transfer protocols, data analytics, etc.)

Validation at system level

- Validation of the solution on existing singular testing infrastructures.

Analysis at wind turbine level

- Technical and economic study of the integration of the pitch components and the digital solution into an operating wind turbine in real offshore environment conditions.



Thank you

Contact Person

Telephone

Email

Web

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