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Advanced maintenance, lifetime extension & repowering of wind farms supported by advanced digital tools

2020-2022

ABOUT THIS REPORT

This document was developed in the framework of the WINDEXT project by Victoria Campos from AEE with the collaboration of the rest of the partners.

Project period

2020-2023

Goal

The goal of the project is to develop and standardize specific contents on specialized training, integrating digital tools like Virtual Reality or 360º video tours, for maintenance wind farms vocational training to complete the classical theoretical methods.

In parallel, it was also fetched the collaboration between Universities, Vocational training centers and private companies in selecting the most appropriate teaching tools.

Intelectual outputs

They are integrated on:
Windext.com
WindEXT Moodle platform & Digital Tools

Conclusions

Innovation
Vocational training
Professional
Growth Knowledge

Project consortium

CONTENTS

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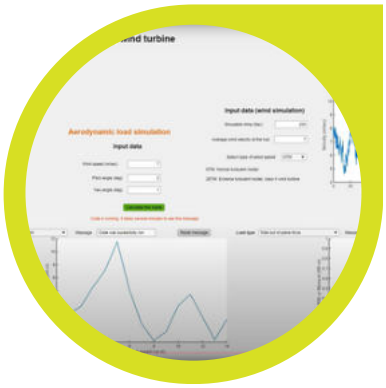
I. PROJECT GOALS

The main goal of the project is to **standardize the training on Wind Farms Maintenance** in a scenario of increasing demand of specialized workers as well as changing of market conditions caused by: the reduction of the generation costs, the life extension of the assets (this the origin of the acronym **WINDEXT, WIND** farms life **EXT**ension) and the complexity of the offshore activities.

This standardization was based on the experience of the partners in developing contents and the use of computer tools like **simulators**, **digital platforms** and **on-line training**, especially important before to access to the turbines. The difficulties of getting dismantled turbines for training, because they compete with the supply of spare components for existing ones still in operation, and the progressive advance of new models, to reinforce the importance of developing new digital tools and simulators.

Therefore, **technicians and students of vocational trainig centers** are the target audience of the project, who will use advanced and innovative materials thanks to the collaboration between private companies, universities and those professional centers. The project wants to foster also the **creation of new business and reinforce those already in the market**.

Additionally to the above points, is also important to keep in mind the growing globalization of the wind sector that it makes necessary to **standardize the training to facilitate the mobilization of workers around the world**. In this sense the use of generic Wind Turbines simulator will facilitate the training to lately adapted to specific technologies once they start to work in real conditions.



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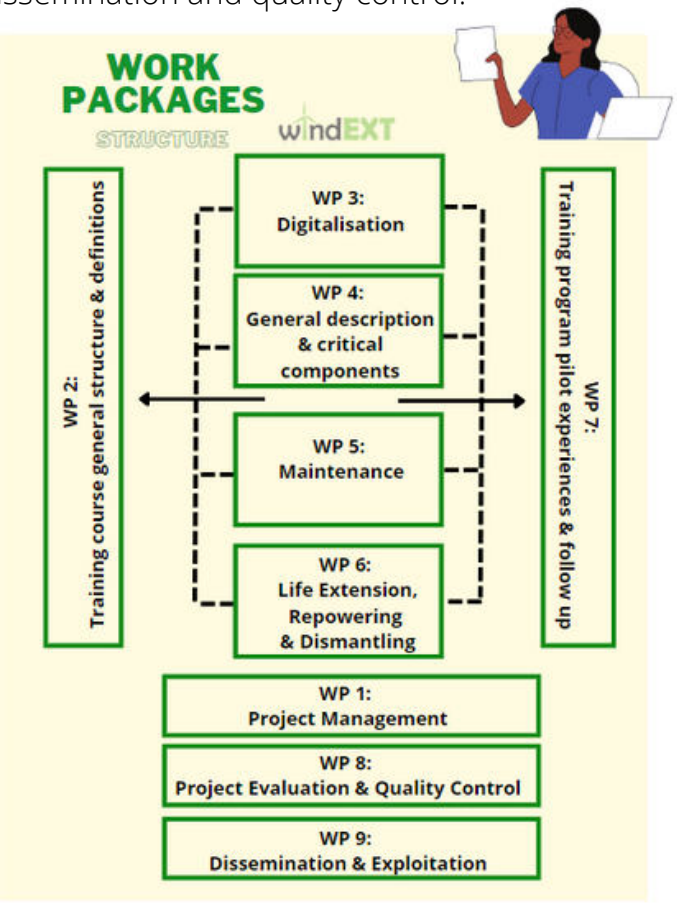
II. THE PROJECT

WINDEXT is organized as a training course with a detailed lay-out where the contents and the different digital tools will be integrated. The initial structure is then based on the experience of the participants and it is addressed not only to pure maintenance but also to contractual, metrics and HSE issues.

The project is organized in **9 work packages**, 4 are addressed to the contents elaboration and digitalization, 2 to refine the course structure and validate the outcomes and the other 3 to management, dissemination and quality control.

The contents and outcomes of the project are **very practical**. They are related to:

- Faults types and trees to evaluate the root causes
- Maintenance typologies and procedures
- Procedures to extend the life of the assets
- Repowering, recycling & reuse of components and materials
- Health, Safety and Environment
- Principal metrics used in the sector
- Typical contractual arrangements



This structure of the MOODLE Platform is organized in three modules of contents with an additional one for digitalization:

- SECTION A: Introduction to Wind Turbine Technology
- SECTION B: Maintenance
- SECTION C: Repowering & Life Extension. HSE Issues
- SECTION D: Digital tools

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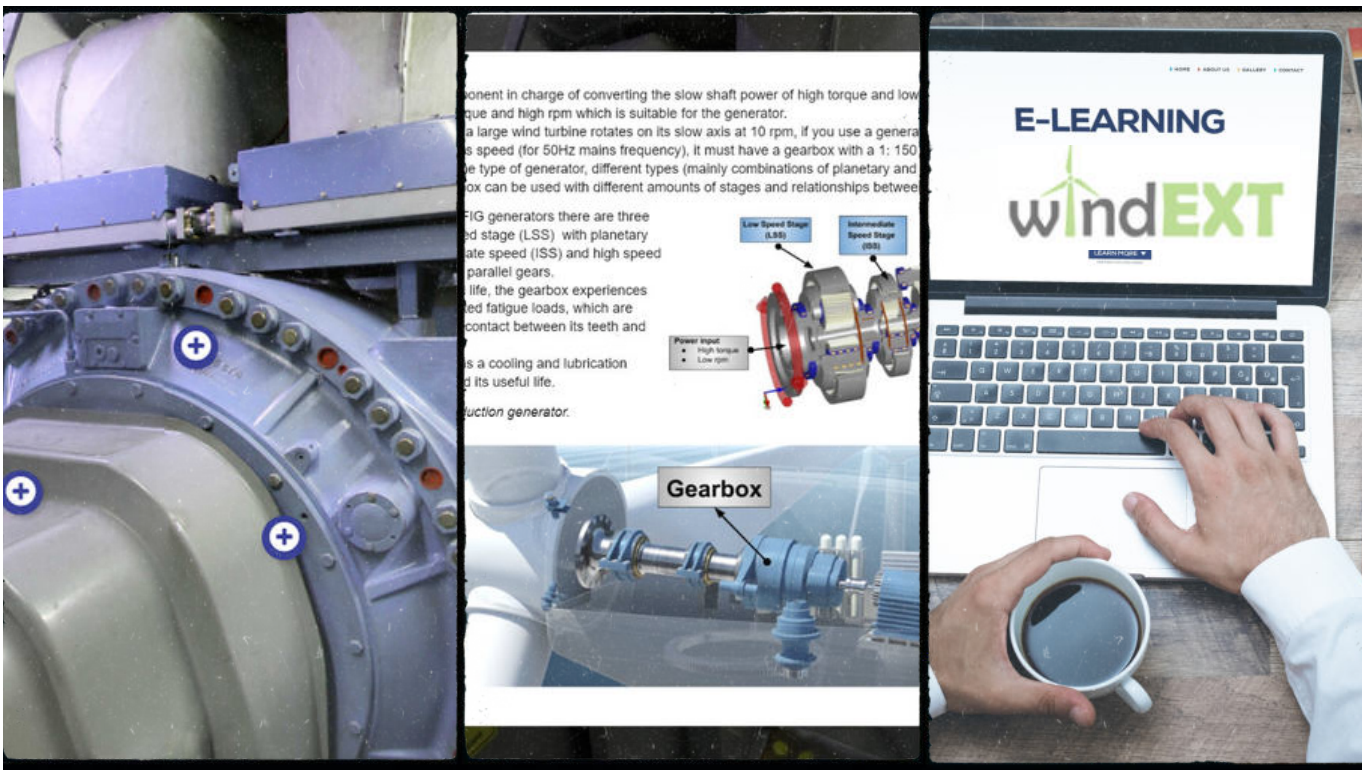
The means of this project are based on the experience not only of the partners but also of the vocational training centers where the pilot tests have been carried out. **The main innovation of the project is related to the development of simulators and digital tools, initially based on Virtual Reality but will be extended to other instruments in this advanced scenario of e-learning**, IOT and augmented reality.

Part of the simulators have been developed by the Universities with a double purpose: to adapt the high level software to the vocational training needs and to progress on the root causes of the main components faults.

Complementary to the use of digital tools, **the specific contents and additional information collected and elaborated specifically for the project have also been well received due to the lack of manuals and guides** to be used in vocational training centers.



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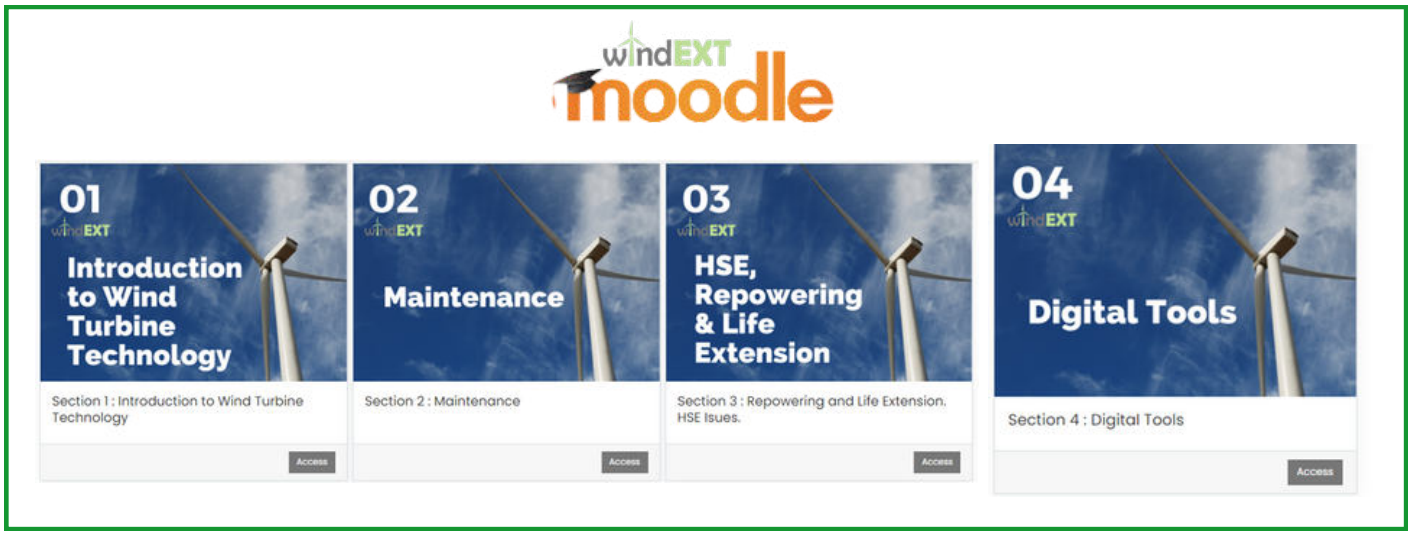
III. INTELLECTUAL OUTPUTS: WINDEXT MOODLE PLATFORM

The project has produced a **standard training course based in a MOODLE platform** where all the contents are integrated as well as the different digital tools below presented. The purpose of the consortium is to promote the use of **either the course as a whole or some independent modules or tools**, serving always as practical basis of the theoretical teaching.

The course provides the training contents of the **wind turbine technology (WTG)** including the descriptions of the different components of a WTG and their function. It also deals with the **maintenance of WTG and Wind Farms (WF)** from both, general and specific point of view, as well as the **main tasks for either extending the life of repowering** the WF installations.

The structure of WINDEXT course is based on **four sections** each one with their different modules:



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I. SECTION 1: INTRODUCTION TO WIND TURBINE TECHNOLOGY

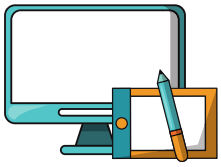
This section provides an **overview of the different components of a wind turbine**, their function and how they fit together as an operational power generation machine.

II. SECTION 2: MAINTENANCE

In this section students can learn about the **different maintenance procedures, the main specifics of offshore maintenance** as well as some general concepts about contractual models and asset management.

III. SECTION 3: REPOWERING AND LIFE EXTENSION. HSE ISUES

In this section are presented the **main challenges and criteria for repowering aging power plants**, as well as **methodologies and procedures for reusing and recycling components**, a critical issue in the application of the circular economy to the wind sector.



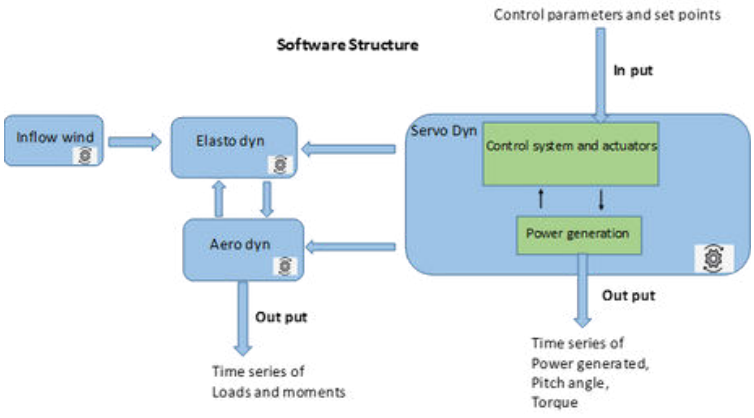
IV. SECTION 4: DIGITAL TOOLS

1

WExLaB

This software integrates *OpenFAST* source code with a standalone *MATLAB* application as a graphical user interface. There are four parts of software:

- System level analysis
- Modal analysis
- Load analysis
- Operation and control of the wind turbine



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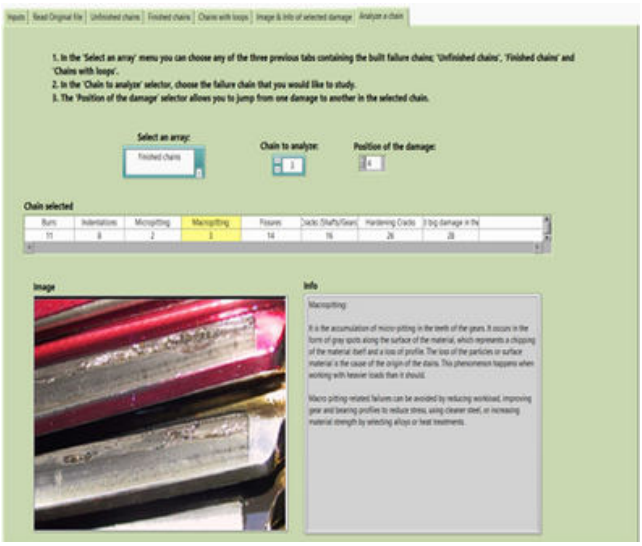
2

CaDWEx



CaDWEx (Cascade Damage Explorer) is a software that allows to explore the chains of damage of a specified component in the area of failure cascade analysis. With the assessment of experts, the possible faults (failure modes) were analysed and listed for the gearbox. The subsequent faults were defined for each individual fault as it can be observed in the tables below, so that a complete failure cascade was created. Using this failure cascade generated, the students can now learn about the faults, and how individual faults develop in the gearbox of a wind turbine along time.

3

Through **WExViR**, the theoretical concepts of the sections can be better assimilated using interactive contents that allows a friendlier approach than traditional written materials. **WExViR** uses the H5P software as an interactive guided tool. Virtual tours have also been developed through a wind turbine with 360° images.

WExViR

360° Move around tool

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4

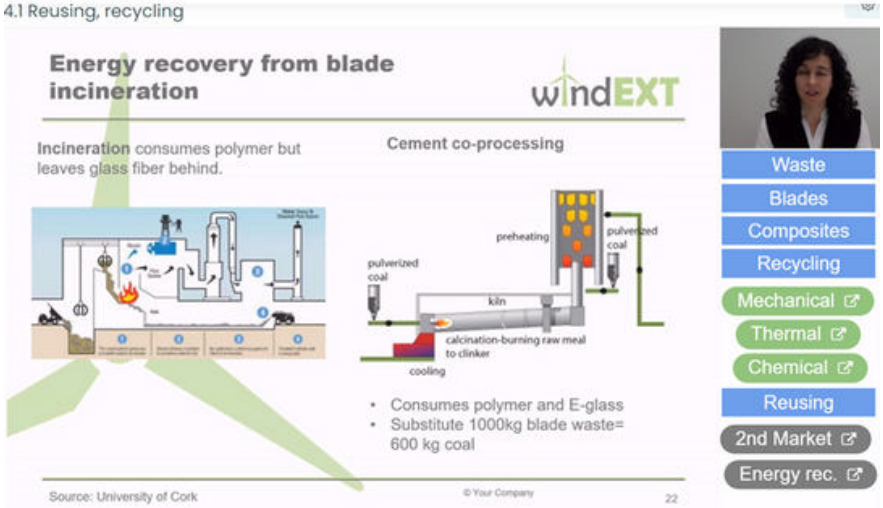
WExSiM

The simulation runs on the Oculus Quest 2. There are 5 training procedures, which can be viewed on our web page www.windext.com and on our YouTube®-channel WindEXT. The 5 training scenarios are:

- Maintenance and replacement of a yaw drive
- Blocking High speed shaft and pad lubrication
- Evacuation from service lift
- Hydraulic torque wrench operation
- High voltage cabinet fuse replacement

5

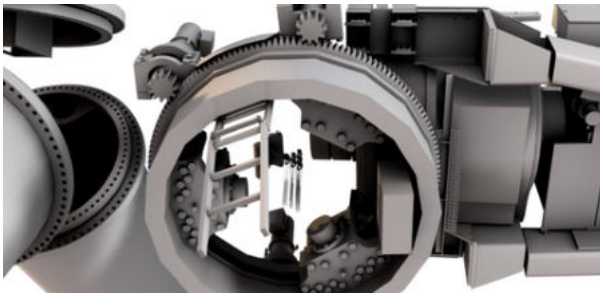
In section 3 the contents are presented through different training videos with the special function of interactivity. The development has been done with the collaboration of different educators and teachers.



6

SIMULWIND

WindEXT has developed a new version of the SimulWind that allows the software to be used in up to four VR Googles, Vive PRO, Vive Pro 2, Oculus Rift and Oculus Quest 2. That makes possible 13 vocational training centers in Spain are using now SimulWind as training tool.



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V. PROJECT CONSORTIUM

A consortium of European key players in the Wind Industry (entrepreneurial associations and maintenance companies), Universities and vocational training centres come together, to create the reference training course WindEXT.

The presence of UTEC/CEFOMER from Uruguay is considered fundamental to adapt the contents to another sociological/legal scenario as the LATAM countries.

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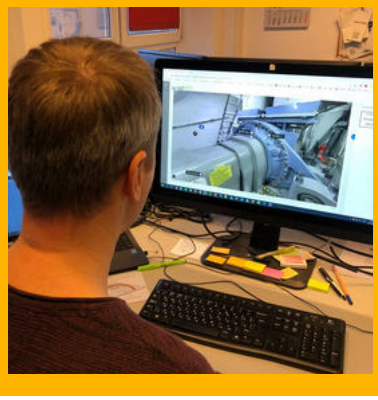
VI. PILOT TESTS

SPAIN
TESICNOR - AEE

HOLLAND
TUDELFT - AEE



PORTUGAL
INESTEC - AEE

GERMANY
RSC - AEE

+ 8 EXTRA

MORE THAN 100 PEOPLE: STUDENTS, TEACHERS, PUBLIC & PRIVAT COMPANIES...

UCLM WINDTALENT WINDEUROPE LEÓN SEVILLA LLEIDA VALENCIA MADRID

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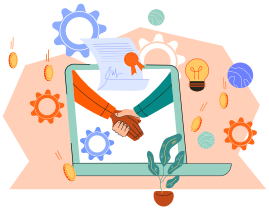
VII. PROJECT CONCLUSIONS



The experience in the development of the Project has allowed to draw several conclusions:

- The importance and interest of creating links between university and vocational centres, not always simple. The firsts have difficulties in lowering the contents level and the for the second ones, it is not easy to understand the theoretical background to explain the failures and root causes.
- The difficulties of coordinating teams with different professional approach and different ways to approach the foreseen tasks of the project.
- However, working with such diverse entities has been truly motivating and has allowed mutual learning among the participants. In fact, the COVID pandemic has had a positive influence because it has allowed to have a more continuous contact through the telematics meetings.
- The importance of digital tools to approach the wind maintenance network, complex due to the multitude of technologies involved and the need to do it in so demanding physical conditions: work at heights and narrowed space.
- The pilot experiences and the first simulations have been welcomed by vocational training centers and they encourage to follow for this path in the future.

In this sense and in the line pointed out above, the possibility of giving continuity to the work carried out is being considered, with the partners' own means as well as with some possible public support. In this sense, the strategic approach for the future is based on the following points:

- Follow up of the impact of using the **WindEXT** tools in the vocational centers at world wide level.
- Possible extension with new maintenance procedures.
- Evaluation of the possible updating of the tools to follow the hard and software advances on VR.
- Integration of new areas, taking into consideration the experience of other national and ERASMUS projects, as for instance off shore wind and PV maintenance.

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