Co-funded by the Erasmus+ Programme of the European Union

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

Newsletter Edition 4, December 2021

Project Overview

Launched in January 2020, WindEXT is an ambitious European funded project. The goal of the project is to develop and standardize specialized training integrating digital tools like Virtual Reality or 360º video tours to complete the classical theoretical methods. Furthermore, the project is an advanced integration of partners of different profiles and experiences to facilitate the exchange of knowledge between Universities, Vocational Training centers and private companies, in a model that it is now followed in different countries to facilitate the employability of students leaving both types of centers.

The goal of this approach is to reduce the LCOE of the windfarms in operation, either existing or new ones, by increase the quality of O&M services while extending the lifetime of the assets and the working HSE conditions of the maintenance personnel. The duration of the project will be three years, so it will end up in December 2022.

After almost two years since the start up un January 2020, the project has allowed the development of a training course based in a MOODLE platform where all the contents are integrated as well as the different digital tools below presented. The intention 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 WindEXT project receives funding under the ERASMUS + programme of the European Union.

The structure of windext is based on four sections and each section has different modules. The sections are:

- Introduction to wind turbine technology

- Maintenance
- Life extension and repowering
- Digital tools

Within the digital tools, WindEXT presents: WExSiM, WExLaB, WExViR and the 'Failure Tree' software.

Through the WExSiM tool, various scenarios can be reproduced in 3D simulation software. WExLaB, shows students the basic concepts and design of a wind turbine. Especially the design of wind turbines is explained with the help of MATLAB Simulink®. WindViR, shows the various maintenance areas (preventive, corrective and predictive) of wind turbines through the H5P tool. Finally, the "Failure Tree" software allows, through a mathematical function, a set of data is taken as input and the probability of failure of different components is obtained as output.

Project situation

After 2 of 3 years of project duration, we have completed the first developments and results. We are thus on schedule for our WindEXT project and will start the pilot tests in spring 2023. When these are successfully completed, the results of our WindEXT project can be presented to the public and can also be actively used by them. Until then we will present our developed training structure and the individual modules on our homepage.

One of the parts that is being developed is the “Failure Tree” software. Currently it has been developed for the Gearbox, but it will also be developed for different parts of the wind turbine.

In addition, the consortium is working on harmonization between Simulwind, the first simulator developed in another Erasmus + call, and WExSiM with the aim that both, the software and hardware of Simulwind, are compatible with WExSiM. At the same time, progress is being made in the last procedure of the WExSiM simulator.

We are confident about the last year of our WindEXT project and optimist that we can bring it to a successful conclusion in line with the expected results.

Project progress

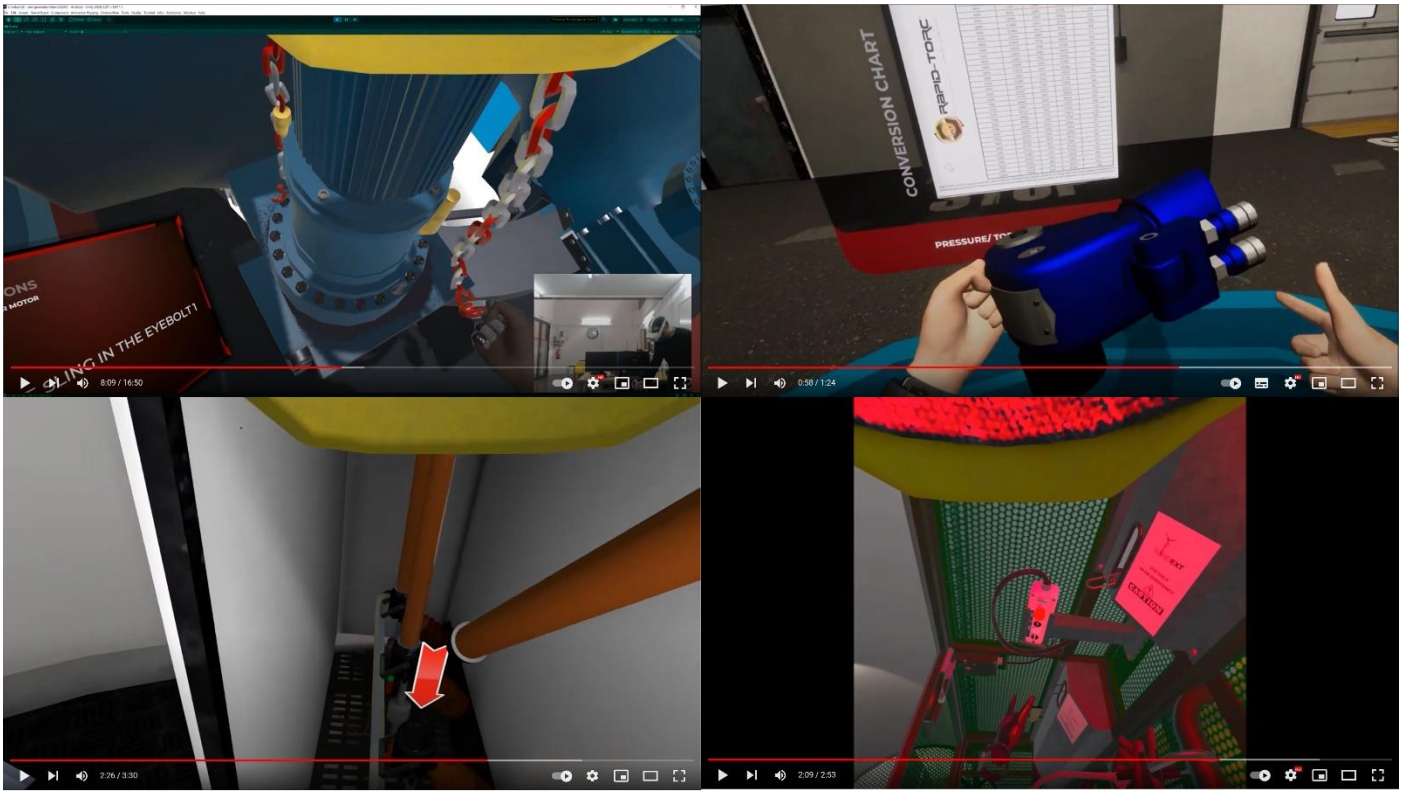
All the content of WindEXT project will be in the MOODLE platform, from the theoretical content to the digital tools, with the exception of WExSiM, which will be accessed externally.

Picture 1: structure of our WindEXT course

WindEXT . Digital tool: WExSiM

The simulation runs on the Oculus Quest 2. We have now completed 5 training scenarios, which can be viewed on our homepage www.windext.com and on our YouTube®-channel WindEXT. The 5 training scenarios are:

- Maintenance and replacement of a yaw drive (top left)
- Quick axle stop and brake pad lubrication
- Evacuation from service lift (bottom right)
- Hydraulic torque wrench operation (top right)
- Replace fuse (bottom left)



Picture 2: Different training scenarios simulation using Oculus Quest

This part of the project has been completed in its development and we are now waiting for the feedback from the pilot tests in order to improve and optimize the individual scenarios accordingly.

Our goal is that the simulation will be available for download from the Oculus Store at the end of the project.

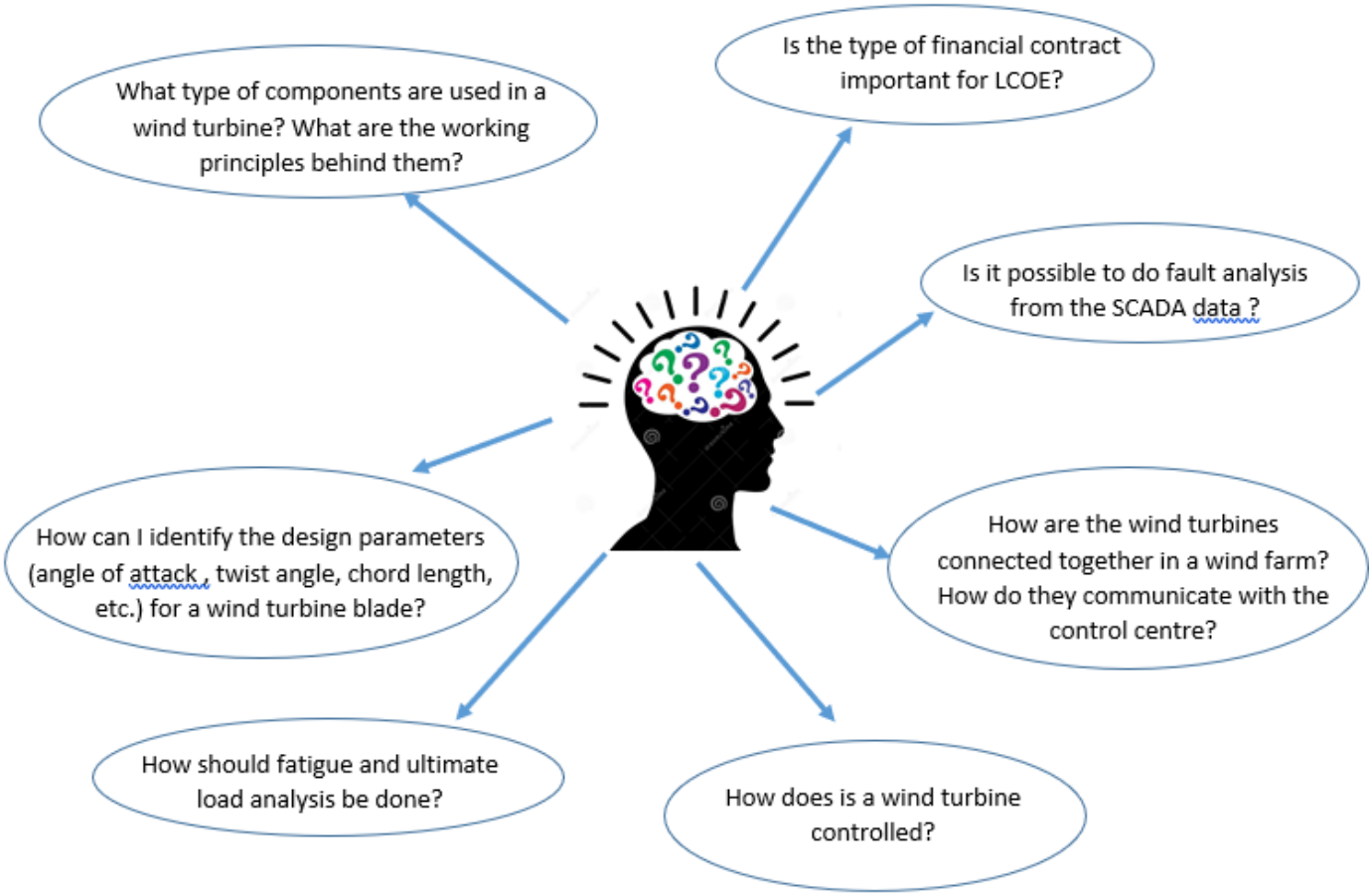
WindEXT. Section 1: Introduction to wind turbine technology. Digital tool: WindLaB

Section one of MOODLE, “Introduction to Wind Turbine Technology” is divided into seven modules:

- Introduction to the Wind Turbine Components
- Design of a Wind Turbine Rotor
- Load Analysis of a Wind Turbine

- Operation and Control of a Wind Turbine
- Wind Farm Component Layout and Design Criteria
- Reliability, Failures, Faults and Fault Tree Analysis
- Contractual Models

The purpose of these sections is to familiarise course participants with different technological aspects and challenges related to the wind turbine. The course aims to answer the main questions that people are going to face when starting out in the wind turbine operations and maintenance field.



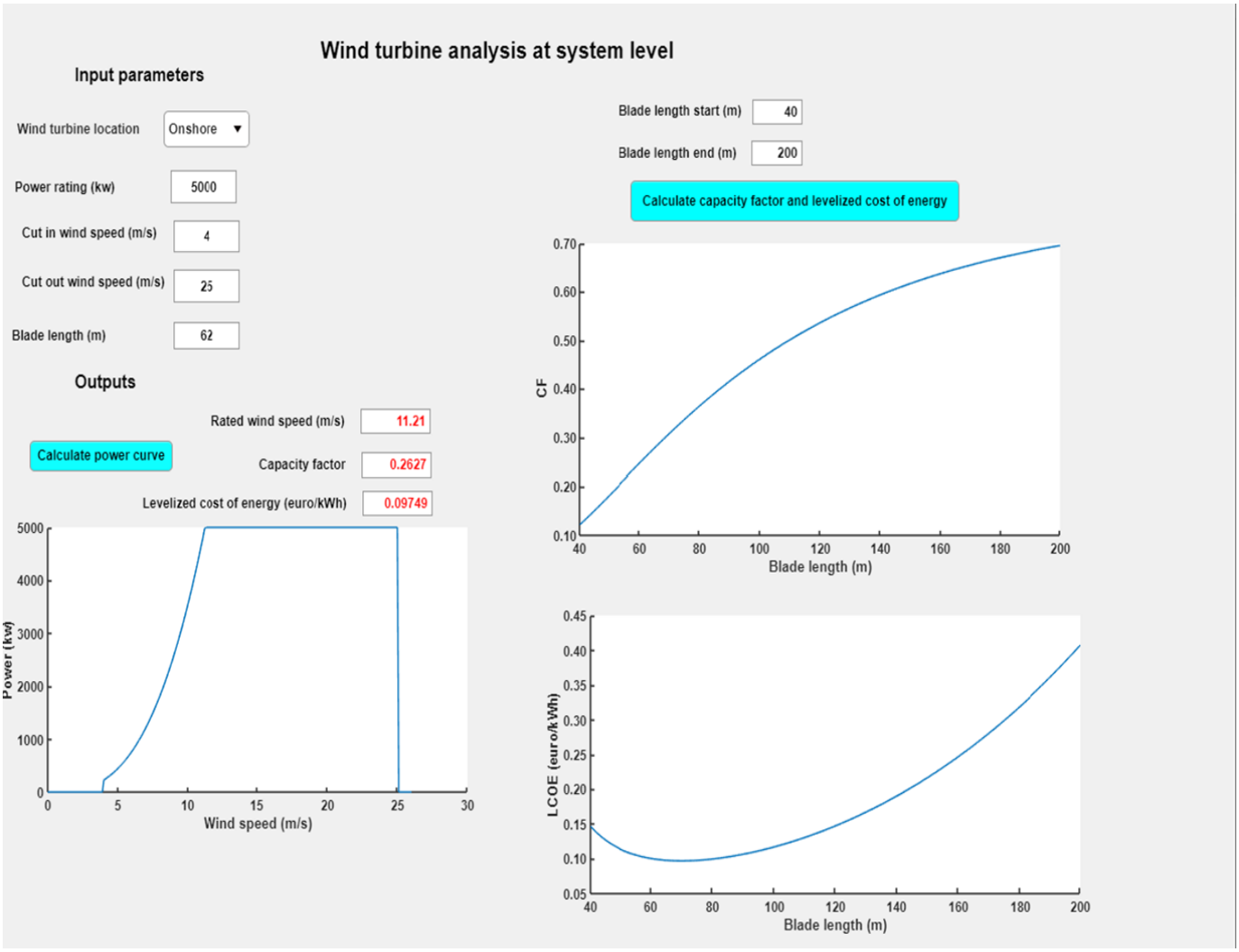
Picture 3: Basic thoughts of WExLaB

The digital tool associated with this section is WExLaB. This software integrates OpenFAST source code with a standalone MATLAB application as a graphical user interface. The software:

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

System level analysis

In the system level analysis, based on the power rating of the wind turbine, the software calculates the power curve, CAPEX, OPEX cost and LCOE for a wind turbine. In addition, the optimum blade length for the lowest LCOE is also calculated. The graphical user interface of the system level analysis software is shown in the following figure.

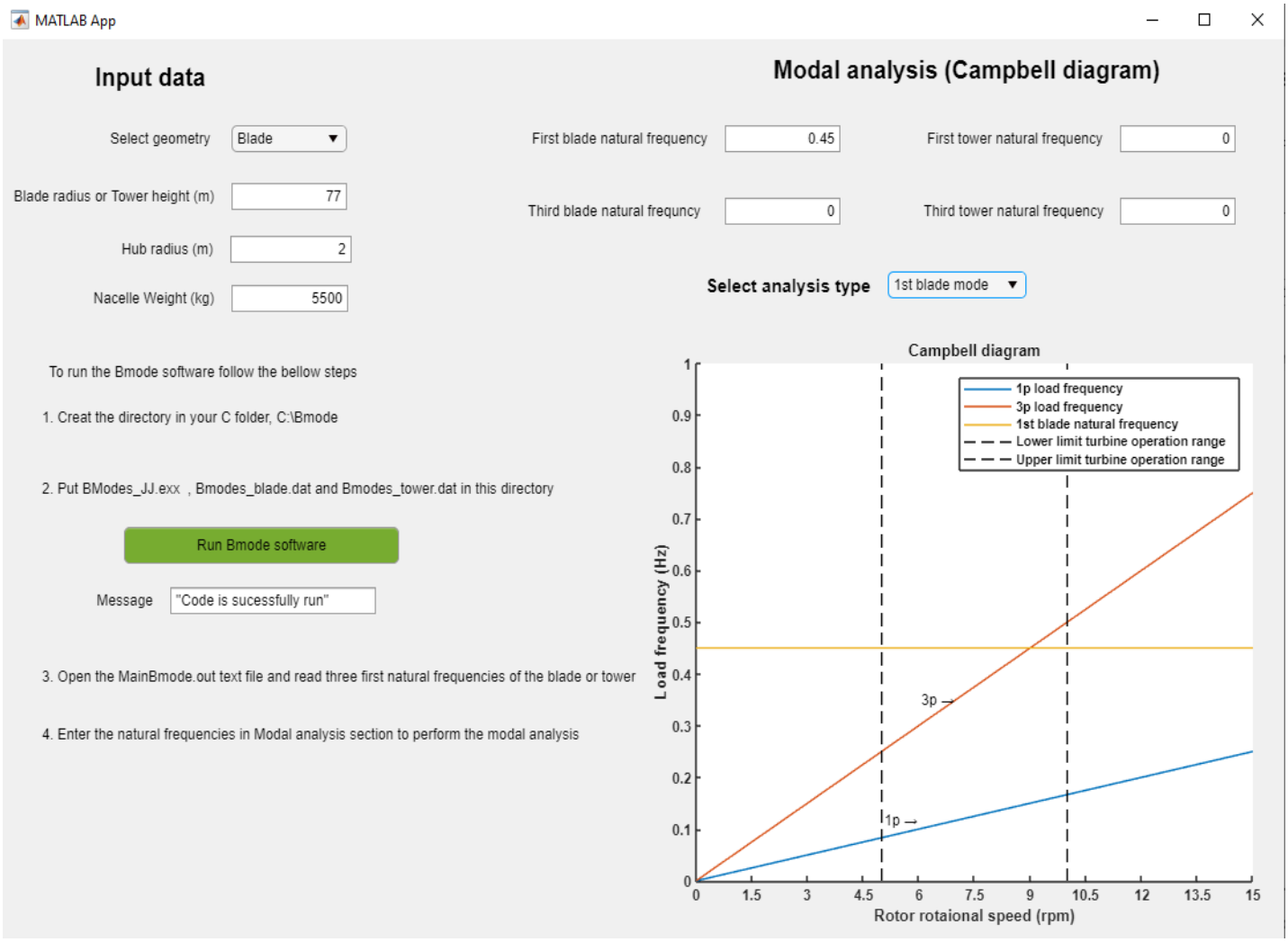


Picture 4: system level analysis software

Modal analysis

One of the challenging aspects of a wind turbine compared with many other structures is that due to the rotation of the blade causing the wind turbine to experience cyclic loads in addition to the static and stochastic loads imposed by the turbulent wind. If these cyclic loadings have the same frequency as the natural frequencies of the blade or tower it may lead to the failure of the wind turbine structure. So modal analysis as a tool to investigate this issue is an important part of the wind turbine design. This is critical in the fatigue loads of the turbine which will be used to determine the DEL (Damage Equivalent Load) of the different componentes/materials and it will affect to failure tree evaluated in other training course sections.

The modal analysis software firstly calculated the natural frequencies of the blade and tower and then a Campbell diagram is plotted to assess whether the cyclic loading frequencies coincide with the natural frequencies of the blade or tower within the operational range of the wind turbine. The graphical user interface of the modal analysis software is shown in the following figure.



Picture 5: modal analysis software

Load analysis

To calculate the load on each blade and to understand the different parameters of the wind turbine that can alter the load on the blade or tower is the main purpose of this part of simulation of software. In this part of the software, in addition to the load on each blade, the blade performance or Cp-λ can be calculated. This part of the software is still under construction.

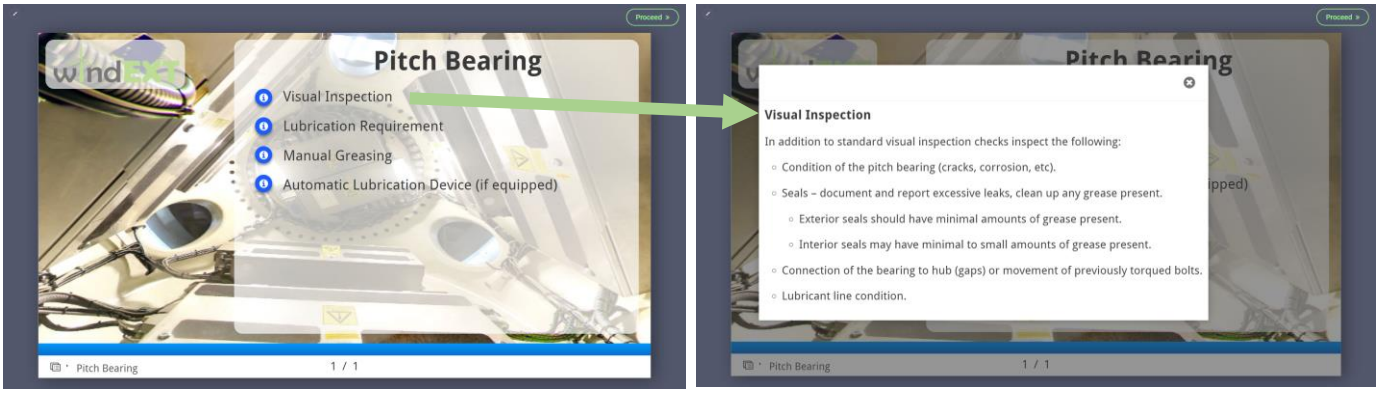
Operation and control of the wind turbine

This part of the software suite shows how the wind turbine is controlled across its operational range of wind speed. The blade torque and the blade pitch angle can be calculated during the operation of the wind turbine. This part of software is still under construction.

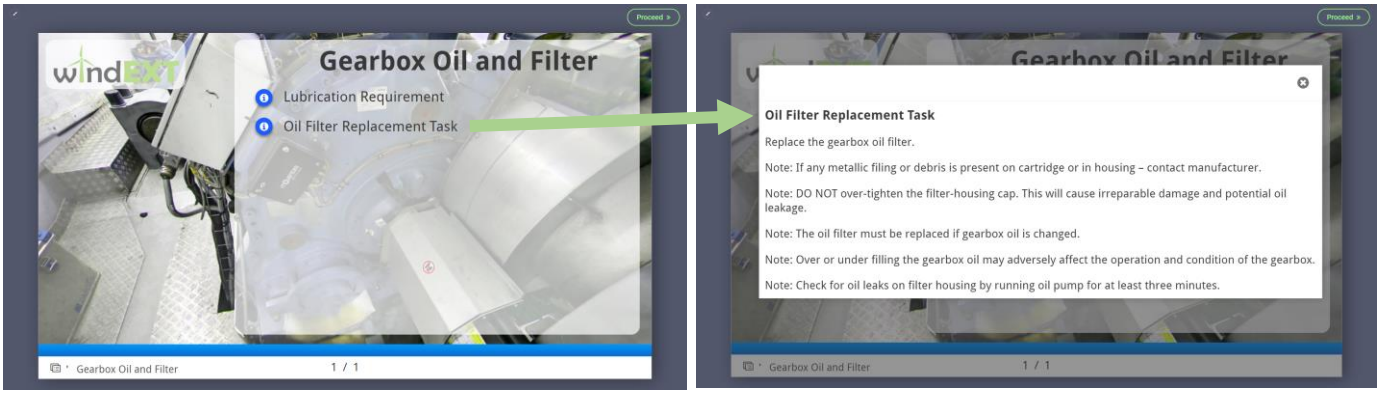
WindEXT. Section 2: Maintenance: Digital tool: Virtual Reality WindViR

In the second section of the course, students are taught the different approaches to maintenance strategies. This includes preventive, corrective and predictive maintenance. The theoretical teaching material for each section will be available on the Moodle platform.

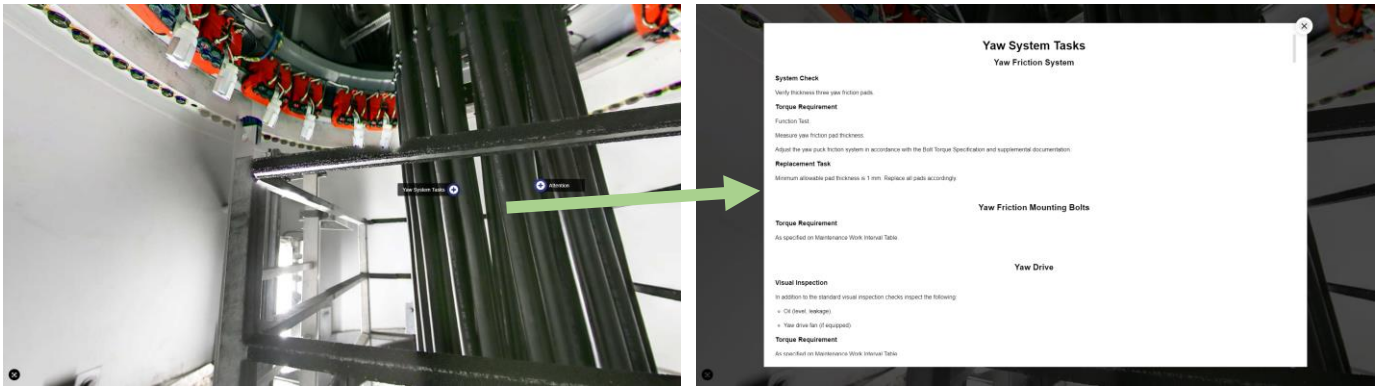
Through the WindViR digital tool, the theoretical concepts of this section can be better assimilated with virtual tours through a wind turbine with 360 ° images using the H5P tool.



Picture 6: example of preventive maintenance task on Pitch Bearing.



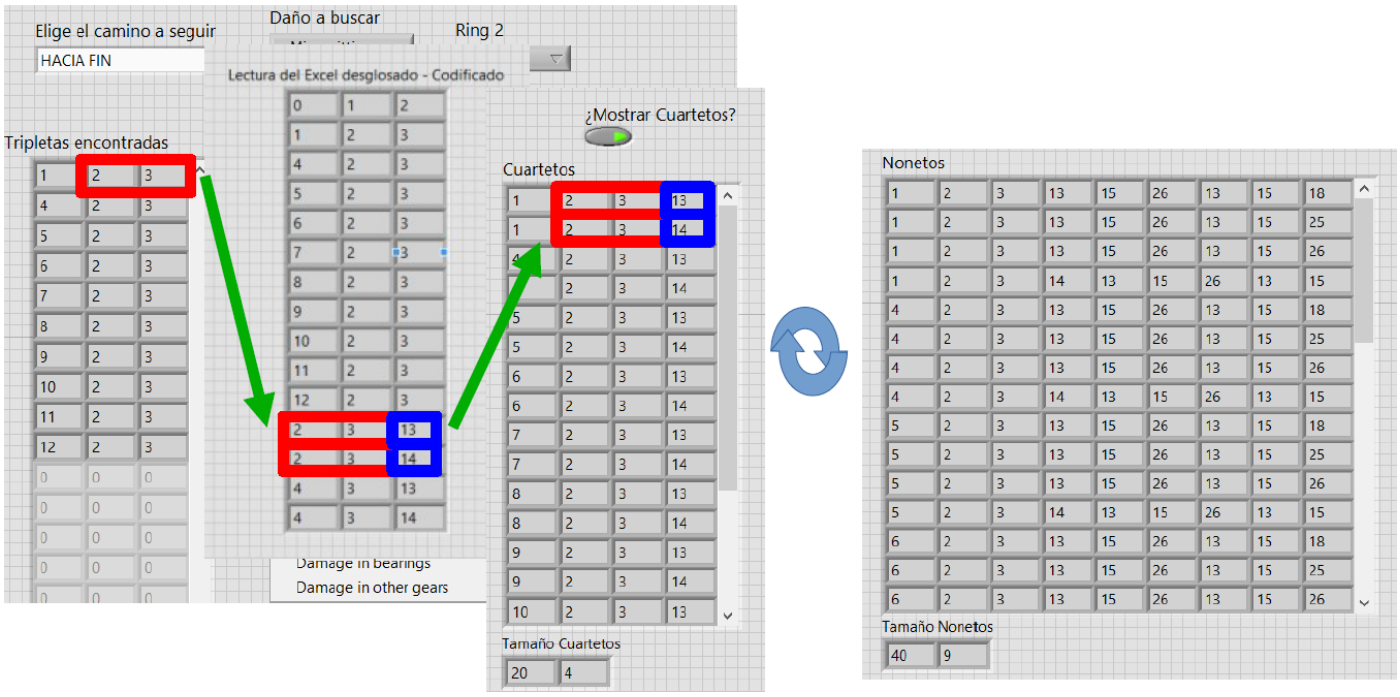
Picture 7: example of preventive maintenance task on Gearbox.



Picture 8: example of preventive maintenance task through the move-around tool.

WindEXT. Digital tool: Failure Tree

In the area of fault tree analysis, the main focus is on the gearbox. All possible faults were analyzed and listed. The subsequent faults were defined for each individual fault with subsequent numbers as it can be observed in the tables below, so that a complete fault tree was created. Using this fault tree, the students can now learn how individual faults develop in the gearbox of a wind turbine. The learning material should also show when and how to react correctly to the respective faults.



Picture 9: fault tree analysis

Pilot tests

Before the release of the fith newsletter, some Pilot Tests will be organised to present the main project achievements and to get feed backs from the participants on the usefulness and potential improvements of the different outcomes.

The first Pilot Test will be organised by TESICNOR in Pamplona and besides the presentation of the different project contents, specially those related to preventive and corrective maintenance, the different tools will be checked with the use of specific hardware. This first pilot will be used as a reference for the other three to be organised before the end of the project.

Project meetings

Third meeting, October 7 and 8, 2021, Cyprus

After revoking the travel restrictions due to the corona pandemic, we were finally able to carry out our third TPM in attendance again. Therefore we met on October 7th and 8th in Cyprus at the University of Cyprus in Nicosia. However, since not all project partners were able to travel to Cyprus, these partners were put online.

The meeting highlighted the progress of the project. Our developed Moodle platform, which is supposed to combine all developed training content, has already been completed. The first 3D videos of wind turbines from our WP3 have been completed and the simulation has also been further developed. The first training scenarios have also been completed and were tested in Cyprus by the partners. A first MATLAB simulation from WP4 has been completed, with the help of which a wind turbine can be designed. The program can be run as an independent

program. Extensive documents on the topics of preventive, predictive and corrective maintenance were created in WP5. In addition, the first questionnaires have been created on the Moodle platform, which can be answered after studying the documents. Extensive fault trees have been created in WP6, which represent every possible development of damage in wind turbine gearboxes. The next step here is to create corresponding learning programs.

Furthermore, all administrative matters were discussed and asked for constant cooperation, even on these not-so-exciting topics.

Overall, we, as the project consortium, can be satisfied with the progress. This has also been confirmed to us in the mid-term report.

Dissimination and Exploitation of project results

On the project website www.windext.com, all results will be published. There will be also published 6 newsletters during the project. If you are interested in this newsletters, you can register in our database at info@windext.com to get newsletters automatically.
Finally, the project has its own Twitter channel. Follow @Wind_EXT and you will be informed about the current project status.

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.

Project Leader:
Association Empresarial Eolica (AEE)

Projectpartner