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windEXT

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

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Contents of the Windext project and specification of the digital tools

WP9

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Project consortium

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1 Introduction

Summary of the contents of the WINDEXT project and specifications of the digital tools

Goal of the project is to develop a training course where the different digital tools will be integrated. Once the project had been finished it can be used either as a whole or in different modules.

1.1 Summary

This document takes as background the document prepared by TUD and specifies the main simulators and digital tools to be developed in the WINDTEXT project. It completes also the MAG of the project to clarify some of the tasks and partner's roles related to digitalization, simulation and tests.

1.1.1 General contents

This part of the training material will allow students to gain a basic understanding of how a wind turbine is designed and operated, including a description of the basic components. The students will see an appreciation of how the components function as a system and how wind turbines are connected to the grid in the form of a wind farm including aspects of layout optimization, e.g. minimization of wake losses. Students will be taught about the common faults that are experienced by a wind turbine, their root causes and consequences. Through the use of simulation software, students will be able to see how common problems such as yaw and pitch misalignment give rise to reduction in power output and adverse loads.

1.1.2 Maintenance contents

Complementary to the above issues, the students will be able to learn about the typical WTG fault trees, the main diagnosis activities to identify the faults and the root causes, some maintenance procedures and part of the critical HSE tasks

Learning Outcomes:

- To understand the purpose of function of the major components of a wind turbine
- To understand how a wind turbine generator works as a system including the loads experiences and the power generated
- To understand how a wind turbine is controlled
- To understand how wind turbines are operated together efficiently as a wind farm including the role of other balance of plant, e.g. the network
- To be able to describe the common faults experienced by a wind turbine, including their frequency and severity
- To understand the underlying causes and consequences of common faults
- To experience how common problems such as pitch and yaw misalignment affect power output (and loads)
- To learn the main diagnosis procedures
- To follow the guidelines to repair the identified faults

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- To carry out main preventive activities
- To learn about the different condition monitoring tools and to integrate the data with those supplied by the SCADA
- To check repairs and to follow their reparation
- To recycle dismantled components
- To be familiar with the tasks to avoid accidents and the main HSE tools

Training Materials

- Written material: This implies the elaboration of summarized Word documents for each content. These documents should be mainly based on figures and diagrams instead of developing large books.
- Online lectures, such as videos recorded, although there should not be a lot of online lectures in the course, it can be use in the on-line labs
- Visualización software (videos, photos…)
- Interactive simulation software
- Digital tools
- Online assessment (e.g. multiple-choice questions): This should be advanced tests for the assessment of the modules. For example, including photos and videos in the questions or evaluating a complete maintenance task.

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2 Sub-package 0: Structure of the training course

COURSE STRUCTURES (SEE ANNEX)		
Tool	**Responsible**	**Comments**
Analysis of the proposed modules	8.2 Consulting	It is important to consolidate the different modules
Identification of the additional components to integrate	8.2 Consulting	Digital but also, videos and complementary training handbooks

2.1 Course organization (e.g. Discussion forums, Hangout sessions, Evaluation procedures, etc.) i.e.; how to give the contents of the course

COURSE ORGANISATION			
Tool	**General specfication**	**Responsible**	**Comments**
Discussion Forums		INESTEC	Proposal to implement discussion forums, follow up and updating to different scenarios
Hangout session		UTEC (LATAM) UCY (EU)	Procedures to open the discussion with many participants
Evaluation procedures	automated digital assessment methods (e.g. auto-corrected quizzes)	UTEC (LATAM) UCY (EU)	Contributions of all partners are recommended Multiple-choice Serious Game (SKILLWIND)

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3 SUBPACKAGE 1: Digital tools/text/videos

3.1 Section: Introduction to wind turbine components (see Module 1)

DIGITAL TOOL:			
Tool	**General sepcifications**	**Responsible**	**Comments**
AEROSIMULWIND.BLEND (this is a virtual DE wind turbine already rendered)		TESICNOR	
OTHER GENERAL DIGITAL TOOLS THAT CAN BE FOUND ON THE WEB		TESICNOR	It is important to avoid the dispersion but also, to give a general windturbines/windfarm overview
TEXT FILES, VIDEOS	Photo/video 360º Photo and video 360º also known as immersive videos are recordings where a view in every direction is recorded at the same time, shot using an omnidirectional camera or a collection of cameras. During the playback, the viewer has control of the view direction. It is possible to add a minimum interaction using hotspots.	TESICNOR	interactivity to videos. Adding Questions, branched videos,... Warning! The video could be very disturbing. Look At: https://de.ryerson.ca/games/nursing/mental-health/game.html#/video/4/0/1 Is an exemple of

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	Using smartphones with sensors such as the gyroscope and stereoscope-style enclosures for smartphones (such Explore the use of M5P an Open Source Tool that allows to add as Google Cardboard), the immersive videos can turn into an immersive experience similar to virtual reality.	what you can do with this tool.

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4 SUB-PACKAGE 2: SIMULATION SOFTWARE

4.1 Section Design of a wind turbine generator

SIMULATION SOFTWARE			
Tools	**General Specifications**	**Responsible**	**Comments**
FAST **QBLADE** **SIMULINK** **(Explanation: videos could be done to show how to use these software tools to explain the concepts of the following column. As well, written documents could be used for the same purpose)**	Data gathering Data driven assessment 1- Power curve. Typical and configuration 2- Power coefficient, correlation with landa Loads simulation: 1. Loads on wind turbine blades 2. Loads on mechanical transmission 3. Load analysis (static and dynamic Modal analysis Power optimization, procedures for improving performance WTG design: - types of generators - Converter characteristics - Voltage control	Coordination TUD	Collaboration of: TESICNOR DP2I UCLM INESTEC (generators, converters)

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4.2 Section Operational principles and control of a wind turbine generator

SIMULATION TOOLS			
Tools	**General Specifications**	**Responsible**	**Comments**
FAST **QBLADE** **SIMULINK**	1- Operational principles of a turbine: - Aerodynamic model and control - Mechanical transmission model: 1 and 2 massess - Pitch control, regulation principles - MPPT regulation strategy 2- Wind turbines sensors: - Roles - Typologies - Potential trouble shooting 3.- Logics of control: - Direct speed control - Indirect speed control	Coordination TUD	Collaboration of: TESICNOR UCLM AEE

4.3 Section 5 Wind farm components, layout & design criteria

The following platforms are not free and therefore it would be important to identify the method of using them, through training licenses, presenting only the results, ..

SIMULATION TOOLS			
Tools	**General Specifications**	**Responsible**	**Comments**
WASP **WINDGRAPHER**		UCLM	Collaboration: TUD

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WINDSIM **WindFarmer, Openwind (and others to be considered**	- General lay out and WF components - Communications - Electrical topology - Wakes and wind farm efficiency - Wakes and effects on dynamic loads - Design criteria and tools for cost optimization	TESICNOR

4.4 Section 6 Faults, fault tree analysis

SIMULATION TOOLS			
Tools	**General Specifications**	**Responsible**	**Comments**
SIMULINK	- Fault tree analysis - Common faults in a wind turbine - Typical diagnosis procedures	Coordination DP2I	Collaboration of: TESICNOR TUD 8.2 CONSULTING UCLM INESTEC With the use of tools as H5P it can be created an interactive video with different actions and a subsequent evaluation of the results

The use of simulation tools will be clarified once the fault tree analysis had been initiated

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4.5 Section 7 Maintenance contents and strategy

Besides the contents, extensively mentioned in the MGA and in the proposal the following tools are foreseen

DIGITAL TOOLS			
Tools	**General Specifications**	**Responsible**	**Comments**
SIMULWIND	- To consolidate it as practical tool, split into: • Teacher • Student - Integration of new maintenance procedures (see below) - Complete with a preventive check-list - Integration of new videos and texts	Coordination TESICNOR	All technical partners have to collaborate in the definition of the functional specifications
New Simulator preventive maintenance	- Typical check list - Minor corrective actions	UCLM(for the development of the contents)	
Diagnosis inspections	- Gearbox endoscopies - Blades - Welding towers	UCLM	

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SIMULATOR for corrective actions	- Typical big corrective activities: • Use of cranes • Dismantling the component • Bringing to the ground • Replacing	TESICNOR	
FIRING STINGHING SIMULATOR	- To give more details on the procedure to manipulate the extinguisher - To be completed with a another safety activities	TESICNOR	To be translated into English
EMERGENCY EVACUATION	- Already presented by TESICNOR	TESICNOR	Dp2I To be translated into English
FUSES CHANGES	-		To be translated into English

4.6 Section 8 Virtual lab

VISUALIZATION FO THE VIRTUAL LAB			
Tools	**General Specifications**	**Responsible**	**Comments**
Specific tools	Some visualization features of the virtual lab: - Effect of pitch misalignment on power performance	UCY	Collaboration of all technical partners:

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	- Effect of yaw misalignment on power performance - Working principles of pitch control system - Working principles of yaw control system	
Specific toosls	Some visualization of the specific maintenance activities	UCY

4.7 Section 9 Promotion in Latam

SIMULATION TOOLS			
Tools	**General Specifications**	**Responsible**	**Comments**
	Identification of training centers in LATAM Use of simulators and VR tools have to be identified	UTEC	List of the centers, included Spanish/USA

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5 ANNEX INITIAL MODULES

5.1 MODULE 1:

Title of the Unit	General Content	Detailed content
Introduction to the training course	General presentation of the course	- Objectives of hte course - Contents and structure - Forum of discussión of the participants - Hangout sessions to directly ask for specific questions to the professors - Self-evaluation procedures
Basic concepts-1: WTG (Wind Turbine Generator) components	Presentation of the general concepts related to the wind turbines, detailed description of the different components	- Main WTG components: * Rotor and blades * Drive transmission * Electrical * Power electronics * Tower and foundations
Basic concepts-2: WTG (Wind Turbine Generator) operation modes	Function of the components and typical loads	- Main loads affecting to the wind turbine operation - Procedures to reduce stresses
Basic concepts-3: WF (Wind Farm)	Description of the strucutre and main components of a wind farm	- Wind Farm Layout - Access roads - Cables dips - WTG platforms
Basic concepts-4: WF (Wind Farm)	Electrical components of the WF Balance of Plan (BOP)	- Internal electrical grids - Electrical equipment - Subestation
Fault trees	Examples of WTG fault trees	- Trees to present the fault up to root cause - Different kind of fault treess

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5.2 MODULE 2:

Title of the Unit	General Content	Detailed content
Reviews and reparation of : BLADES	Evaluation of the blades state Main reparation actions	- Analisis of the present blades situation - Proposal of solutions by complexity level
Reviews and reparation of: GEARBOXES	Review of the gearboxex situation Dismnatling of gears and the gearbox as whoel	_ Review of gears - Oil analysis - Bearings
Reviews and reparation of: MECHANICAL TRANSMISSION	Evaluation of the main mechanical components	_ Mian shaft - Low speed shaft - Bearings
Reviews and reparation of: ELECTRIC	Evaluation of the electric components	- Generetor - Transformer - Switchgear
Reviews and reparation of: POWER ELECTRONICS	Analysis of power electronics and mainly the converter	- Converter - Condensators - Crow bars -Plc/control
Reviews and reparation of: FOUNDATIONs	Evaluation of the civil works state	- Review of cracks and defaults - Proposal of solutions
Reviews and reparation of offs-hore wind turbines	Specficities of the off-shore maintenance	- Specific maintenance of critical components - Dismnantling
Off-shore access	Manpower and logistics	- Procedures to access - Use of cranes

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5.3 MODULE 3

Title of the Unit	General Content	Detailed content
Maintennace procedures for life extension	Modes and contractual arrengements to extend the WTGs life	- Introduction of new arrangements in the contracts
Specific actions for life extesion	Specific actions to increase the extended life	_ Actions related to preventive maintenance - Specific actions on main compoenents - Minor corrective actions
Lifetime extension assesment	Introduction to the aerolastic models, data analitics and hybrid models	- Methodology to evaluate the remaining life: generic aerolastic models, measure of failure probability, analytic assesment, necessary data, …
Introduction to condition monitoring	Conditions motioring to evaluate the present WTGS	Presentation of the main characteristics of the condition monitoring
Certificacion procedures	Typical certification procedures	- Phases of the requested certification - Main challenges - Requested means
HSE: fulfilment of safety requeriments of life extension	General presentation of the specificities of HSE in the life extension escenario	- Main risk activities after the certificied life - Prevention Plan - Follow up procedures
Repowering	Main chararacteristics of repowering since the evaluation of the wind farm situation up to the final replacement of the turbines	- Repowering advantages/limitations - Postiion of the different participantes
Social and local impact	Social impacto for the new wind farm layour	- Existing scenario of rents and land uses - New referecne once the wind farm has started its operation - Rents in different markets conditions - Social impact of the transport and replacement of turbines
Impacts of the inssurance and maintenance costs	Comparison between both scenarios	- Costs of insurance - Costs of maintenance - Loss of profits

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Wind farm dismatling	Evaluation of the wind farm state Dismantling procedures	- Diagnosis of the WFGs state: re-use as a whole of by components, or re-cycling. '- Recommended dismantling phases/specific tools for the dismantling and transport - Recommendatins for the conditioning and stock of the different components - Recommnedations for reparation if necessary
Reuse and re-aconditioning of the components	Preparation of the components to be reused	- Preparation of the diffent compoentss - Logisitics for transport and assembling
Replacing of components in the dismantled WTGs	Integration of new components to facilitate the operation of the replaced turbines.	- The blades case - Solutions in case of restrictred access to control software
Land recovery	Use of the wind farm infraestructure	- Pats and roads modifications - Bridges reinforcements - Preparation of assembling land besides the WTG
Recycling of materials	Recovery of composites, metals and electronics	- Separation of different materials - Possible applications - Reuse as fuel - Specific cases - Scrap dealers cases
Health and safety plan	Definiton of the main risks and prevention actions	- Main risky activities - Definition of the safeguard procedures - Follow upo after the new wind farm start up

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