Preliminary Design Review

MISCE project

Mechatronics for Improving and Standardizing Competences in Engineering

Competence: Wind Energy

Workgroup: Universidad de Castilla-La Mancha

Universitat Politècnica de València

This document is the Preliminary Design Review of the technical competence ‘Wind Energy’. It briefly contains the experimental platform analysed in MISCE project, to be designed and standardised for improving the acquisition level of this competence on engineering degrees.

Version: 1.0

Date: October 5th, 2023

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1 Competence and skills

The conceptual design presented in this document is referred to the technical competence:

C1. Wind Energy

which related skills are (see Table I):

Table I. Skills of Wind Energy

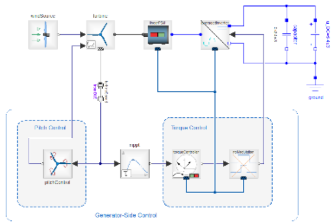
S1.1.	Understanding the different turbine designs
S1.2.	Being able to engineer and design turbine components and systems
S1.3.	Practical skills in setting up onshore turbines
S1.4.	Ongoing maintenance of wind farms
S1.5.	Assessing site suitability of wind farms

The different conceptual designs presented in this document have been analysed to ensure that can improve the acquisition level of the aforementioned competence.

2 Experimental proposals

For this competence, MISCE project proposes the joint use of the devices in Table II, together with their corresponding teaching materials.

Table II. Proposed devices for ‘wind energy’ competence

		
Mini Wind Turbine	OpenModelica + Wind Power System Libraries	Virtual Reality Wind Farm Simulator

In the following sections each device/platform is explained in detail.

2.1 Mini Wind Turbine

This experimental platform consists of a complete mini wind turbine where the nacelle can rotate to be aligned to the wind direction, the angle of attack of the wings can also be configured. It integrates a sensor for measuring the wind speed and direction. Finally, the rotation of the turbine allows to act over a small generator to quantify the energy production (see Figure 1).

Figure 1. Mini Wind Turbine

This proposal requires mechanical, electronics and control devices that allows to control the angular position of the nacelle, the angle of attack of the wings, to measure the speed and direction of the wind excitation and, finally, to measure the energy generation.

The main advantage of this experimental platform is that it is a realistic wind turbine, which allows the student to know about all the subsystem which form a wind turbine and to configure its working mode.

On the contrary, the main drawback is that is a very complex system which requires a lot of effort on its mechatronics design.

2.2 OpenModelica + Wind Power System Libraries

OpenModelica is a free, open-source platform for modelling and simulating complex physical systems using the Modelica language. When combined with wind power system libraries, it enables users to:

- Model complete wind turbines – including aerodynamics, mechanical parts, electrical generators, and power electronics.
- Simulate energy output under varying wind conditions.
- Analyse grid integration and system behaviour in hybrid setups (e.g., with batteries or inverters).
- Optimize wind turbine design through parametric studies.
- Perform virtual site assessment and dynamic performance evaluation.

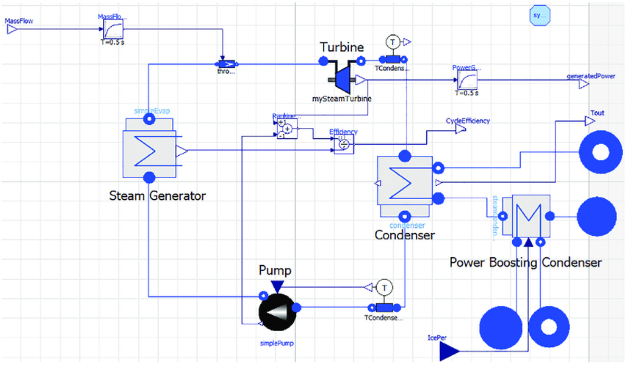


Figure 2. OpenModelica

It offers a powerful and cost-effective tool to teach wind energy system behaviour without the need for expensive hardware. Ideal for technical training and engineering-level understanding.

On the contrary, using OpenModelica effectively requires prior knowledge of system modelling and basic programming in Modelica. This can be a barrier for beginners or vocational-level students without guided instruction.

2.3 Virtual Reality Wind Farm Simulator

A Virtual Reality (VR) Wind Farm Simulator provides an immersive, interactive training environment for wind energy operations. It allows students and trainees to:

- Explore and interact with full-scale wind turbines in a 3D virtual environment.
- Practice maintenance tasks, such as blade inspections, gearbox checks, and climbing tower ladders.
- Train in safety procedures, including fall protection, emergency response, and proper use of PPE.
- Understand wind farm layout, access routes, and operational workflows.
- Simulate fault scenarios and troubleshoot equipment in realistic conditions.

VR simulators give learners a realistic, risk-free training environment that mimics real-life turbine maintenance and operation — ideal for building confidence and practical skills without physical danger or high costs.

On the contrary, it requires VR hardware and technical setup: Implementation demands access to VR headsets, compatible computers, and dedicated space, which may pose budgetary or logistical challenges for some educational institutions.

Figure 3. Illustrative concept of VR simulator for wind turbines/farms

3 Competence and skills analyses

Table III summarises the competence and skills analyses of the proposed experimental platform attending to the contribution of acquisition of the technical competence ‘wind energy’ and their corresponding skills in Table I.

As conclusion, in the Framework of MISCE project, we start developing the Mini Wind Turbine device.

Table III. Contribution of each proposed platform to wind energy competence and its corresponding skills

Platform	S1.1	S1.2	S1.3	S1.4	S1.5	**Overall competence contribution**
Mini Wind Turbine	★★★★★ Allows exploration of basic turbine types and blade shapes.	★★★★☆ Hands-on design of small-scale turbine components.	★★★★★ Excellent for assembling and wiring physical systems.	★★★★☆ Basic maintenance tasks can be practiced manually.	★★★☆☆ Limited to controlled lab settings, not real site analysis.	★★★★☆ 4.2
OpenModelica + Wind Power System Libraries	★★★★★ Supports modelling of all turbine types and configurations.	★★★★★ Powerful for simulating and optimizing design parameters.	★★★☆☆ Only simulates installation, no practical setup experience.	★★★☆☆ Useful for understanding maintenance dynamics via simulation.	★★★☆☆ Effective for analysing wind potential and grid integration.	★★★☆☆ 3.8
Virtual Reality Wind Farm Simulator	★★★★☆ Provides immersive exploration of various turbine setups.	★★★☆☆ Not focused on design mechanics, more on operation.	★★★★☆ Strong on simulating realistic installation environments	★★★★☆ Highly effective for safety, inspection, and repair training.	★★★☆☆ Gives spatial understanding of farm layout and access.	★★★★☆ 3.5

References

[1] Bernardes, L., Barros, A. M., & Carvalho, M. D. (2025). Utilization of Wind Turbine Educational Kit as a Tool for Meaningful Learning. *Engineering & Technology Scientific Journal, 13*(2), 35–42.

[2] Junior, A. C., Lazzarin, T. B., & Leon, J. I. (2021). Simulation of Variable Speed Wind Turbines Based on Open-Source Solutions: Application to Bachelor and Master Degrees. *arXiv preprint arXiv:2103.01759*.

[3] Vasar, C., Mihalache, S. F., & Iancu, D. (2018). Wind Energy Conversion System – A Laboratory Setup. *arXiv preprint arXiv:1807.07770*.

[4] Eberhart, M., Chung, S., Haumer, A., & Kral, C. (2015). Open Source Library for the Simulation of Wind Power Plants. In *Proceedings of the 11th International Modelica Conference* (pp. 929–938). Linköping University Press.

Razak, A. (2012). Overview of Wind Turbine Modeling in Modelica Language. *International Journal of Engineering and Technology, 2*(2), 65–70.

Reyna, M. H., Solano, F. M., & Ortega, J. G. (2018). A 3D Playful Framework for Learning the Components of a Wind Turbine Using Kinect. *International Journal of Education and Development using ICT, 14*(3), 133–147.

Schrader, A., Keirstead, J., & Foxon, T. (2020). Worth a Thousand Words: Presenting Wind Turbines in Virtual Reality. *Renewable Energy, 152*, 1107–1115.

[5] Stanica, M., & Sera, D. (2018).Wind Energy Education through Low-Power Wind Turbines and Advanced Software Tools. *Conference on Renewable Energy Education, ICRE 2018*, IEEE Proceedings.