



T-shore
Education

Learning Scenario Manual



Co-funded by
the European Union

Erasmus+

Enriching lives, opening minds.

Module:

Sensor Technology

Learning scenario:

Replacing a Sensor



Atlantic Technological University		Scalda	
Energy Innovation		Skilliant	
Fagskolen Rogaland		Skive College	
Hydrogen Valley		TCNN	
Katapult		Wind Energy Ireland	
Noorderpoort		World Class Maintenance	
POM West-Vlaanderen			



THIS DOCUMENT HAS BEEN CREATED AS PART OF THE WIDER T-SHORE PROJECT, CO-FUNDED THROUGH THE EUROPEAN UNION'S ERASMUS+ PROGRAMME.



**Co-funded by
the European Union**

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them.

Document Information

Project Acronym	T-shore
Project Title	Technical Skills for Harmonised Offshore Renewable Energy
Award Number	Project 101055746
Work Package	WP3,4
Deliverable	LSC – Module and scenario overview
Document Title	Sensor Technology Module and Scenario Overview
Primary Author(s)	Gerben Huiszoon, John de Wijze
Co-Author(s)	All partners

Version Control

Version No.	Date	Description	Prepared by	Checked by
01.	09-04-2025	New instruction created	GH	JwD
02	05.2025	Document Updated	DH	

Note This is a fictive generic equipment checklist intended for training purposes and therefore may vary from the equipment checklist provided by a company. It is important that a technician always read and fill checklist carefully prior to any task.

Copyright

This document was developed under the T-shore project, coordinated by Skilliant. © 2024 – Skilliant. All rights reserved. Licensed to the European Education and Culture Executive Agency (EACEA) under conditions



Content

CONTENT	1
1 LIST OF TOOLS	1
2 LESSON OVERVIEW SENSOR TECHNOLOGY	2



1 List of tools

Table 1. List of tools

Tool name	Model / Version	Quantity
Inspection report	Final	1
Gloves	ANSI cut resistant level A1	1
Gloves	Nitrile	2
Safety shoes	-	1
Safety goggles	-	1
Safety helmet	-	1
Overalls/work clothes – long sleeves	-	1
High visibility clothing / vests	-	1
Mechanical tools set (manual torque wrench, screwdriver etc.)	-	1
Electrical tool e.g. Multimeter		1

2 Lesson overview Sensor Technology

The Sensors module consists of 3 lesson blocks, each lasting 4 hours.

Knowledge & Skills related to the Sensors module:

- Has broad and specialized knowledge of hand tools and aids for (dis)assembling and repairing wind turbine components, including sensors.
- Has broad and specialized knowledge of mechanical, electrical, electronic components, including sensors used in wind turbines.
- Has broad and specialized knowledge of measuring tools/equipment for performing measurements on sensors.
- Has broad and specialized knowledge of legal regulations and company procedures and guidelines related to safety, health, and environment in relation to onshore and offshore work, working at heights, and working in confined spaces, and can apply these.
- Can handle hand tools and aids for (dis)assembling and repairing, among other things, sensors correctly.
- Can communicate in technical English and write reports.
- Can repair and replace mechanical, hydraulic, electronic components, including sensors.
- Can apply relevant quality procedures and guidelines applicable in wind farms.



2.1 Structure of the curriculum:

In lesson block 1, the focus is on:

- Acquiring general knowledge regarding the function and operation of sensors in general.
- More specifically, the sensors in a wind turbine.
- Safety and legal regulations regarding working with sensors.

In lesson block 2, the focus is on acquiring skills and learning in practice:

- Identifying the sensors in a wind turbine.
- Learning to work with common measuring instruments (e.g., Multimeter).
- Testing sensors.
- Detecting and analyzing a faulty sensor in a wind turbine.
- Troubleshooting or performing repairs.

In lesson block 3, an integrated assignment is carried out:

- A fault has been detected.
- Carrying out the assignment according to the correct procedure, including; performing safety procedures, diagnosing, reporting, repairing, and delivering the final report.



Lesson block 1

Learning Objectives: 1. After the lesson, you will know what sensors are and how they work. 2. After the lesson, you will be able to name examples of sensors.	
General theory	Assignments
Sensors A sensor is a device or component that converts physical quantities such as temperature, pressure, light, speed, distance, and other measurable parameters into a signal that can be detected and processed by a system. It is an artificial version of what is called a sense organ (eye, hearing, balance, touch, taste, smell) in biology. A sensor allows one to perceive information from the environment. It registers changes in the environment, such as temperature, light intensity, or movement. The sensor converts a measured physical quantity into an electrical signal (current), so it can be analyzed by another system.	Assignment A Work in groups of 2 or 3 students a. Name at least 5 sensors that you can find in a house or here at school. b. A mercury thermometer is a good example of a simple form of sensor. Explain the principle of this sensor. What physical processes take place, in other words, how does this system work? Use source information from the internet. Is this an analog or binary sensor? Explain this. c. Your iPhone is lying in the sun. It has become so hot that it shuts down. It can only be turned on again once it has cooled down. Explain how this can happen. d. Make a drawing/sketch of how the principle of a sensor works. How a sensor perceives a physical change and translates it into a signal. Use source information or the internet. Assignment B





At the end of these assignments, the findings will be shared with each other and an explanation will be given on each product.

Examples of sensors include:

- Temperature sensor
- Pressure sensor
- Motion sensor
- Light sensor
- Accelerometer

Sensor technology plays a crucial role in automation, safety, monitoring, and even in the development of smart devices such as smartphones, medical equipment, vehicles, and of course, wind turbines.

Sensors can be divided into two main groups:

- Binary: These can only indicate two values, on or off (0 or 1).
- Analog: These can indicate all values.

Why does the mercury rise in a thermometer?



When the mercury is heated, the mercury molecules move faster, causing them to spread further apart. As a result, the mercury column rises. When cooled, the molecules move slower and come closer together, causing the column to shorten. This is an analog process.

Sensors in a Wind Turbine

The sensors help in monitoring, optimizing efficiency, and ensuring safety.

1. Wind Direction Sensor (Anemometer)

This sensor measures the speed and direction of the wind. This helps the turbine adjust to the wind direction for maximum energy output.

2. Speed Sensor

This sensor measures the speed of the wind, which is important to determine when the turbine should start operating and when it should be shut down to prevent damage from strong winds.

3. Vibration Sensors

These sensors detect vibrations in the turbine. Excessive vibrations can indicate technical problems, such as imbalance in the rotor blades or mechanical failures.

Assignment C

Work in pairs

1. Indicate in this sketch/longitudinal section of the wind turbine where the sensors are located.



These sensors are placed on key components such as the generator, shaft, and bearing. They help monitor the mechanical sensitivity of the turbine and can warn of wear or defects.

4. Temperature Sensors

These sensors measure the temperature of various parts of the turbine, such as the generator, hydraulic systems, electronics, and gearbox.

5. Speed Sensors/Over Speed Sensor

These sensors monitor the rotational speed of the rotor and the generator to ensure the turbine operates efficiently but also stays within safe limits. This prevents the turbine from going into over-speed. Due to centrifugal force, the blades can break. In a wind turbine, a speed sensor measures the wind speed reaching the turbine. This information is essential for optimizing the turbine's operation. This wind speed meter helps regulate the rotor speed and adjust the blade angle to ensure maximum energy output and prevent overloading the turbine at high speeds. In certain situations, the turbine can even stop producing and turn completely out of the wind to prevent 'overspeed'.

2. Analyze a sensor and map the signal path. In other words, draw and sketch the operation of a sensor.

- Analyze a temperature sensor
- Analyze a pressure sensor

Clearly illustrate in the sketch how the physical signal is generated, how it is converted into an electrical signal, and the path this signal subsequently takes to the display of the monitor.

Find this background information in the available source documents or on the internet.

At the end of this assignment, the various findings will be shared with each other.



6. Voltage and Current Sensors These measure the electrical output of the turbine. 7. Position Sensors These sensors measure the position of the rotor blades and the direction of the rotor, allowing the turbine to adjust to the wind flow. 8. Level Sensors These monitor the hydraulic system to check the oil level and ensure there is enough oil/fluid for the system to operate.	
Safety Preparation Lesson block 2 focuses on practice and working with the simulator. In preparation for this, a general safety check and exercise will be conducted.	Assignment D Work in pairs 1. Start by reviewing and practicing all safety regulations applicable to the wind turbine. 2. Identify the safety attributes needed. Develop this into a checklist. 3. What risks might you encounter if safety regulations are not adequately observed? List these.

Lesson block 2

This lesson block is entirely focused on practicing in the various practical rooms.

Learning Objectives: 1. After the lesson, you will know how to identify what is wrong with a sensor. 2. After the lesson, you will be able to troubleshoot and replace a sensor if necessary.	
General theory	Assignments
Short reflection and review of lesson block 1	• Which sensors are present in a wind turbine? • What is the function of the various sensors?
The Chain of Sensors in a Wind Turbine • Sensor 1 In the rotor, there is a sensor to pitch the blades. This system ensures that the blades are optimal for energy production at every wind speed, resulting in less wear and tear. The rotor makes a maximum of 16 revolutions per minute. • Sensor 2 Between the rotor and the main shaft is the speed sensor. If the blades spin too fast, this sensor sends a signal. The disc has openings, and the sensor 'counts' the openings as it rotates. This is a binary sensor.	Assignment A Method Assuming a group size of approximately 12 students, work will be done in subgroups of 3 students per group. Four workstations will be set up: • The Festo simulator • The Nacelle • Lucas Nülle case with sensors • A table with loose sensors from the wind turbine as well as from a house or other machines



• Sensor 3 On the main shaft is a Rotor Lock. This lock blocks the rotor to work on it safely. This lock is manually operated and driven by a hydraulic pump (on or off). It is essentially a safety lock when working on the machine. • Sensor 4 Each blade has its own sensor (pitch cylinders). The blades continuously move because the wind continuously changes. These are hydraulically driven pitch cylinders. The sensor has a controlling function (where the wind comes from) and a steering function (how the blades should continuously adjust to the changing wind flows). The sensor continuously indicates whether more oil pressure is needed from the left or right to adjust the blades. • Sensor 5 In the gearbox, there are two sensors. One sensor measures the temperature of the oil in the gearbox. If it is too low, making the oil too viscous, the gearbox will not work. It must first be warmed up to operating temperature (about 85 degrees Celsius). If it gets too hot in the summer, it needs to be cooled down. A second sensor detects metal particles via a magnet. If too many or too large metal particles are released due to wear/friction of the gear system, accelerated wear occurs. • Sensor 6 Between the gearbox and the generator is the brake sensor. This sensor registers whether the brake is active.	Each group will work on a specific assignment at each workstation for an average of 50 minutes. After rotating and working at all four workstations, the students will return to the classroom to discuss/report their findings and experiences. Assignment for workstation 1. The Festo simulator (approx. 45 min) 1. The instructor briefly explains the assignment (approx. 5 min). 2. The group starts by identifying all the sensors present in the simulator (Festo). 3. Represent this in the attached sketch (longitudinal section of the wind turbine). 4. Describe the name and function of the various sensors. 5. Work out a malfunction. Describe what happens if the temperature sensor in the gearbox is defective and the outside temperature is -4 degrees Celsius. Assignment for workstation 2. The Nacelle 1. The group works under supervision on the Nacelle. 2. The instructor gives brief instructions (5 min). 3. Start by identifying all the sensors on the Nacelle. Indicate this in the attached sketch/drawing of the Nacelle.
---	---

	4. There is a mechanical malfunction and an electronic malfunction. 5. Investigate which sensor has which malfunction. 6. Discuss this with the instructor. 7. Repair the malfunction. Assignment for workstation 3. Lucas Nülle case with sensors 1. The instructor briefly explains which equipment with accompanying instructions is present in this case. 2. Analyze the various sensors according to the instructions of the Lucas Nülle software. Assignment for workstation 4. Table with various sensors and peripherals such as a sensor connected to certain parts of a wind turbine or a comparable part of a wind turbine. 1. The instructor briefly explains the various sensors and peripherals. 2. Start by analyzing some sensors. • What material is a sensor made of? • Can I disassemble the sensor or replace parts of it? • How can I measure if this sensor is still working? 3. Work out the circuit diagram of a sensor, showing how it
--	--

	detects the signal (wind/light/pressure/temperature), transmits it, and displays it in a binary or analog value. 4. Find this information on the internet or in a textbook.
Measuring Instrument: The Multimeter This lesson component is entirely focused on acquiring knowledge and skills in the use and application possibilities of the Multimeter. The Multimeter is an important measuring instrument for diagnosing whether the various sensors are still functioning. 	Assignment for workstation 4 Working with the Multimeter Work in groups of 3 people 1. Perform a resistance measurement. 2. Measure the voltage of a battery. 3. What are the capabilities of the Multimeter? Share these experiences with each other. At the end of the four assignments, the (four) groups will exchange their experiences in a plenary session. • What stands out? • What have I learned from this? • What are important points of attention that a wind turbine technician should master well?
Background Information/Tools	Assignment for workstation 1

What measuring equipment do I need? • Digital Multimeter • Technical diagram of the sensor circuit • Safety equipment • Spare temperature sensor (for replacement) • Toolbox Step-by-Step Plan 1. Preparation and safety (turn off the turbine according to the safety procedure). Check if the nacelle is safe to enter. Set the Multimeter to the correct measurement mode. 2. Voltage check on the sensor. Locate the temperature sensor in the nacelle. Check for voltage and proceed to the next step. 3. Check the signal wire. Locate the signal wire that runs from the sensor to the control system. Measure the output signal of the sensor. Note the value and compare it with the expected value according to the data sheet. 4. Resistance measurement. Compare the measured resistances with the factory values. 5. Continuity of wiring. Repair or replace.	Detecting a faulty sensor in a wind turbine/Festo simulator During an inspection, the wind turbine's control system reports that no signal is coming from a temperature sensor in the nacelle. Work in teams and share experiences after analyzing the diagnosis. Given: The display indicates that there is a fault with the temperature sensor. 1. What steps should I follow to make the correct diagnosis? 2. What do I need to investigate this? 3. What safety regulations should I observe? Reflection questions: 1. How can you tell from the measurement that a sensor is defective? 2. What could have been the cause if there was no power supply? 3. Why is it important to always check the wiring?
--	---

6. Assessment. If there is no signal but power is present and the wiring is correct, the sensor is defective. If the wiring is interrupted, fix the cable break. 7. Completion. Install a new sensor if necessary. Restore the installation and test the system again after turning it off. Fill out the work report.	
Practical Assignment Troubleshooting the Wind Speed Sensor of the Wind Turbine  Background information for the assignment: Preparation • Read the fault message from the display/SCADA screen. • Check the documentation and electrical diagrams of the sensor installation. • Determine the type of sensor used (e.g., analog or digital). 1. Diagnosis • Inspect the physical condition of the wind sensor (cable break, contamination, damage). • Measure the signal value with a Multimeter or measuring system.	Assignment for workstation 2. Nacelle Troubleshooting the wind speed sensor of the wind turbine Work in teams Situation sketch A fault message has been received via the SCADA system in a wind turbine; "Incorrect values wind speed sensor data unreliable". The turbine has automatically gone into safe mode. The WP4 instructor gives the assignment to investigate the cause. 1. What steps should I take to determine the cause? 2. What do I need to make the correct diagnosis and possibly carry out a repair? Consider the following; • Preparation • Safety aspects

• Check if the sensor's power supply is present. • Temporarily disconnect the sensor and simulate an input signal to check and test. 2. Repair/Replacement • If defective, disassemble the sensor and replace it with a new one. • Check connections and grounding. • Repair any cable damage if necessary. 3. Check • Restart the system and check if the sensor is giving the correct values again. • Observe if the wind turbine starts up normally. • Report your findings and fill in the fault report. Required Materials: • Multimeter • System documentation • Replacement wind sensor (optional) • Toolset for electronic work • Safety equipment (fall protection, helmet, gloves, etc.) Assessment Criteria: • Safe working according to regulations • Correct use of measuring instruments • Logical and structured troubleshooting • Proper execution of repairs/replacements • Accurate reporting of the work	• Diagnosis • Repair/replacement • Check • Required materials • Assessment criteria
--	---





Lesson block 3

Lesson block 3 consists of an integrated assignment where the theory from lesson block 1 and the practical exercises from lesson block 2 must be applied and tested in the form of a general examination.

Learning Objectives: 1. After the lesson, you will know if you can successfully complete the exam component on sensors. 2. After this lesson, you will be able to troubleshoot a sensor by following all required steps from A to Z.	
Description of the Case	Assignment
In block 1, we were introduced to the principle and operation of sensors in general and specifically to the sensors of the wind turbine. Additionally, we extensively covered the safety aspect in the context of maintenance work on a wind turbine. Block 2 focused on acquiring practical skills, including learning to work with common measuring equipment, diagnosing faults, and repairing/replacing sensors. Block 3 is entirely dedicated to an integrated exercise where, in teams (3 technicians), a detected fault is diagnosed and repaired. This assignment also serves as a test case to determine if you, as an aspiring wind turbine technician, are deemed competent as a beginner professional.	



Given: • Each team consists of 3 people (aspiring wind turbine technicians). • Each technician has specific talents and areas of interest but often also has a different background in terms of knowledge and skills. Consider the following; • Specific electronics knowledge • Mechanical technical knowledge • ICT • Construction/Infrastructure technology	
Case: 1. The team (3 people) receives a message from the central plant (PD4) that there is a malfunction in wind turbine A7. 2. The SCADA system displays an error message. There was a severe storm last night, and wind turbine A7 has shut down and does not automatically restart.	Assignment Method Each team consists of 3 people. Each team conducts a separate investigation. This could be a malfunction in the wind sensor, temperature sensor, vibration sensor, or speed sensor. Since there is only one Nacelle and one Festo simulator available, a rotating system will be used. Each group will have a maximum of 40 minutes to analyze the malfunction in the Nacelle or the Festo. This means that the preparatory work must be well-coordinated among the team members. More specifically:

	a. The entire group is first clearly informed about the problem (a malfunction in a sensor in the Festo and a malfunction in the Nacelle) (approx. 10 min). b. The team is divided into groups of 3 people with different expertise (mechanical, electronic, ICT, general). c. Each team starts by developing a step-by-step plan on how to approach the problem (approx. 20 min). d. Then, two teams go to the Nacelle and two teams go to the Festo. e. Each team has 40 minutes to diagnose, analyze, report, and repair the malfunction in practice. f. Each team has 20 minutes to describe what they have done and complete the corresponding checklist. Guidelines for the student: 1. Investigate what the cause might be. 2. What equipment do I need? 3. Describe all the steps in sequence. 4. Perform the required actions. 5. Divide the tasks within the team so that all talents are maximized. Apply the principle of Master-Apprentice-Journeyman, where everyone uses their specific expertise in their area and helps colleagues in the learning process to acquire that expertise. 6. Observe all safety conditions. 7. Report where the malfunction is to the PD4/Central plant. 8. Repair the malfunction if necessary.
--	--

	9. Describe all actions in a checklist: ○ Safety ○ Malfunction ○ Diagnosis ○ Analysis ○ Reporting to PD4 ○ Repair At the end of this exercise, the different teams will present to each other how the process went, what they learned from each other, and what aspects are still unclear (approx. 1 hour).
--	---



Co-funded by the European Union

The T-shore project is funded through the the
Erasmus+ Centres of Vocational Excellence
(CoVEs) call 2021

Acknowledgements

We would like to extend our sincere thanks to all the project partners for their invaluable contributions to this report and their dedicated work on the T-shore project.

Our deepest appreciation also goes to all T-shore stakeholders, particularly the members of the regional Centres of Vocational Excellence (CoVEs), whose ongoing efforts are instrumental in driving the success of this initiative.

t-shore.eu
tshore.eu@gmail.com