T-shore Education

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Module and Scenario Overview

Module:
Sensor Technology
Learning scenario:
Replacing a Sensor

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Document Author Partner:Scalda

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Fagskolen Rogaland		Skive College	
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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.

Table of Contents

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1 Description of module – Theory and practical

The module replacing a sensor is part of the minor K1312 Wind turbine Maintenance that is standardized for Dutch VET Education by SBB: https://certificaat-mijn.s-bb.nl/keuzedeel/details/3e3211bf-cb9a-4ace-a291-de2904ebaf12. This minor runs at 6 VETS in the Netherlands and the Dutch Wind industry association NedZero workgroup on human capital coordinates quality and improvements. Gerben Huiszoon of Scalda and Stieneke Boersma of Noorderpoort are part of the human capital workgroup. Students that have completed this minor are guaranteed paid internship by the Dutch Wind industry under the supervision of NedZero. The sensor scenario is one of the exams students can get to complete the minor.

Checking and replacing sensors in a Wind turbine is an entry level task for starting windtechnicians.

1.1 Theory

The module consists of a theoretical part where the participant learns about the sensors in wind turbines and their function. In Scalda, this theory is offered as an E-learning module by author / host Electude through a licence. Scalda and Electude are researching how this E-learning can be translated to English and be offered to T-shore. Next to that, there are several documents available with theory about sensors in wind turbines:

- Scalda theory on sensors
- Lucas-Nülle Unitrain Sensor technology manual
- Festo Nacelle trainer manual of sensors in the turbine trainer.

1.2 Practical

In the practical part, the participant, following the instructor's guidance and documentation, performs practical training doing a visual inspection of sensors in windturbines, inspects the condition of sensors, reports to superiors and replaces and calibrates sensors.

1.3 Evaluation

Throughout the entire module, the participant is evaluated by the instructor. The final evaluation is based on a reports review and discussion with conclusions.

This exam follows the theoretical and practical training that is taken prior to this exam. The student must complete the exam by himself without assistance. During the assignment, all work processes must be completed. The student must show that he/she is able to complete the assignment in the simulated situation. To simulate a realistic working environment, the student will use a practical setup like for example the Festo Nacelle trainer or equivalent. A real working Nacelle is not available for students without qualification. Simulating the performance under challenging (weather) conditions is limited in the simulated environment.

The student is observed by the examiners during the execution of the assignment. The examiners evaluate the performance and record it in the assessment form. The examiners may ask questions to

assess the background knowledge of the student. The result is obtained when all observation criteria have been assessed, and the assignment is completed.

2 Instructor pre-qualification

To conduct the learning module theory and practical training, instructors must meet the minimum requirements below:

Knowledge: equivalent to the basic knowledge of the GWO Basic Technical Training.

Skills: equivalent to the basic knowledge of the GWO Basic Technical Training

Ability: equivalent to the basic knowledge of the GWO Basic Technical Training

3 Participant pre-qualification

To conduct the module (Theory and practical training), participants must meet the minimum requirements below: *Note: Can be something they have done earlier in the WTT education.*

Knowledge: student in a EQF level 4 technical program
Skills: student in a EQF level 4 technical program
Ability: student in a EQF level 4 technical program

4 Overview of theoretical content, scenario documents, training equipment and infrastructure

Name	Q/A	Type	Category	Where to use
PC with projector screen		Digital tools	Theoretical materials equipment	Theoretical part
Scalda theory on sensors		PDF	Manuals	Theoretical part
Lucas-Nülle Unitrain Sensortechnology manual		PDF and E-learning in Labsoft	Manuals	Theoretical part & Practical part
Festo Nacelle trainer manual		PDF and E-learning	Manuals	Theoretical part & Practical part

5 Timeframe

Time	Part
8 hours	Theory
8 hours	Practice in workshop
Total: 16 hours	

***Note**: Timeframe may vary depending on number of participants, level of initial knowledge, skill and ability of participants and need to meet learning objectives.*

6 Learning methods

Part	Learning method
Theory part	PDF or E-learning self-study in Lectude LMS
Practical part	Lucas-Nülle Unitrain sensor technology or Festo Nacelle Trainer

***Note**: Learning methods depend on accessibility of infrastructure and equipment.*

7 Main learning outcomes for the module

No.	Name		Type	Level
1	Understand the basic working of sensors in windturbines		knowledge	4
2	Diagnose and rectify faults in sensor systems		skills	4
3	Install and maintain sensors in wind turbines		skills	4
5	Apply appropriate safety in working with sensors		skills	4

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8 Theory part

8.1 Learning theory

The Sensors module consists of 3 lesson blocks of 4 lesson hours each. Structure of the lesson program:

In lesson block 1, the focus is on:

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

Lesson block 2

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 defective sensor in a wind turbine.
- (Dis)assembling a sensor.

Lesson block 3

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

- A fault has been detected.
- Execute the task according to the correct procedure, including; perform safety procedures, diagnose, report, repair, deliver final report.

The full theory is described in the Word document “Theory sensor scenario”. For each lesson, there is a PPT available that instructors can use in the classroom to cover the theory in a classical setting with students. The theory is also available as elearning on the Tshore Moodle.

8.2 Risk Assessment

Potential hazards	Who is affected?	Risk	Rating			Control Measures to minimize risk	Residual (new) rating		
			A	x B	= C		A	x B	= C
			Likeli hood	Severity	Risk		Likelihood	Severity	Risk
Obstacles	Participants / Instructor	Slips, trips & falls.	3	2	6	Workshop working areas must be kept clear of obstructions and the floor must be kept free from oil/chemical spills. Any spillages should be cleaned up immediately and cloths disposed of as according to the Hazardous waste policy. Any hazards such as trailing cables, defects to floor coverings and faulty lighting	1	2	2

						etc. should be reported immediately.			
Electrical safety	Participants / Instructor	Electrical shock	3	2	6	Electrical safety measures must be taken to ensure none of the systems are live at the time of inspection or maintenance. Apply proper lock out and tag out procedures and wear PPE.	1	2	2

Note: *as T-shore develops modules according to this template, we will in practice have done a Risk assessment on several things. This can be combined and used as a basis for all new modules*

Likelihood:	1=Highly unlikely; 2=Unlikely; 3=Possible; 4=Likely; 5=Certain
Severity:	1=No injury; 2=Minor injury; 3=Medical treatment; 4=Injury with lost working time; 5=Major injury/ fatality
Risk:	Likelihood x Severity
Low: 1-5=Green	Tolerable low risk
Med: 6-11=Yellow	Monitor, control and maintain strict control measures
High: 12-25=Red	Stop activity! Reassess and apply new control measures to reduce risk to an acceptable level (bellow 11)!

9 Practical part – Introduction

Note: *This part of the document describes how the practical part of the module should be organized. This template is just a guideline which may need local adaptation. Look at it as a helping aid in how to structure the module theory and practical parts.*

9.1 General introduction

This part of the document describes how the practical part of the module should be organised.

This template is a guideline which may need local adaptation. Modules may require that the students undergo practical skill training before they do scenario training. This may include how to operate tools, equipment and how a component function. After the skill training, the students will test their skills and knowledge in a practical learning scenario. Both the practical skill training and the scenario training can be adapted to be a practical examination.

Instructor must provide constructive feedback to participants on relevant practice activities. It includes feedback concerning the correctness of the exercise performed by the training participant, suggestions for improving the execution of the exercise by the training participant, and general remarks about participant safety at a given moment during performing of exercises.

At all the time during training participant can ask questions and expect feedback from the instructor.

9.2 Workshop introduction

Before start of practical exercises, participants may be divided into more groups. Max ratio: 2 participants per practical training setup for practical session. All participants and instructors shall use appropriate PPE in accordance with local laws and regulations. The minimum requirement is:

- Safety shoes with electrical protection requirements

The participants must be instructed about the followings:

- All the equipment to be used and their correct use.

The instructor must be informed immediately if anyone feels ill, in pain, or exhausted about any condition that may affect health and safety. If anybody feels uncomfortable during the training, e.g. uncomfortable working position, dizziness, etc., the instructor must be notified immediately. If anyone gets injured or causes harm to others, the instructor must be notified immediately. Exclusion zones must be set up and maintained around the practical training area.

10 Preparation for practical exercises

10.1 HSE brief & PPE dressing

The HSE brief includes information specific to the components and equipment used during the practical portion. It also involves verifying all safety aspects related to the practical exercises and ensuring that participants use PPE correctly.

Instructor must:

- Present and explain the hazards and risks in workshop zones.
- check if each participant has correct PPE and wear it correctly.

Each course participants must:

- Demonstrate the ability during practical exercises to keep themselves out of hazard and risk in workshop zone during scenario exercises.
- Inspect PPE before use and wear correct PPE equipment for training.

Learning outcomes:

Detailed learning outcome	Main learning outcome
Participants can select the appropriate PPE based on the hazard analysis related to planning activities	Can plan and conduct safe work in accordance with general HSE requirements

Participants can wear correctly PPE equipment for planning activities	Can plan and conduct safe work in accordance with general HSE requirements

10.2 Manual handling

There is no special manual handling needed in this training.

10.3 Equipment check

In the practical part, the participant, following the instructor's guidance and documentation, learns how to calibrate sensors using the Lucas-Nulle Unitrain sensor technology

https://www.lucas-nuelle.us/2769/pid/2134/apg/1448/Course-Automation-Technology-7:-Sensors-for-automation.htm

For VETS that are not equipped with this setup, it is advised to use a practical setup with a proximity, magnetic or speed sensor. The student should have a manual to check correct calibration and working of the sensor within accuracy parameters.

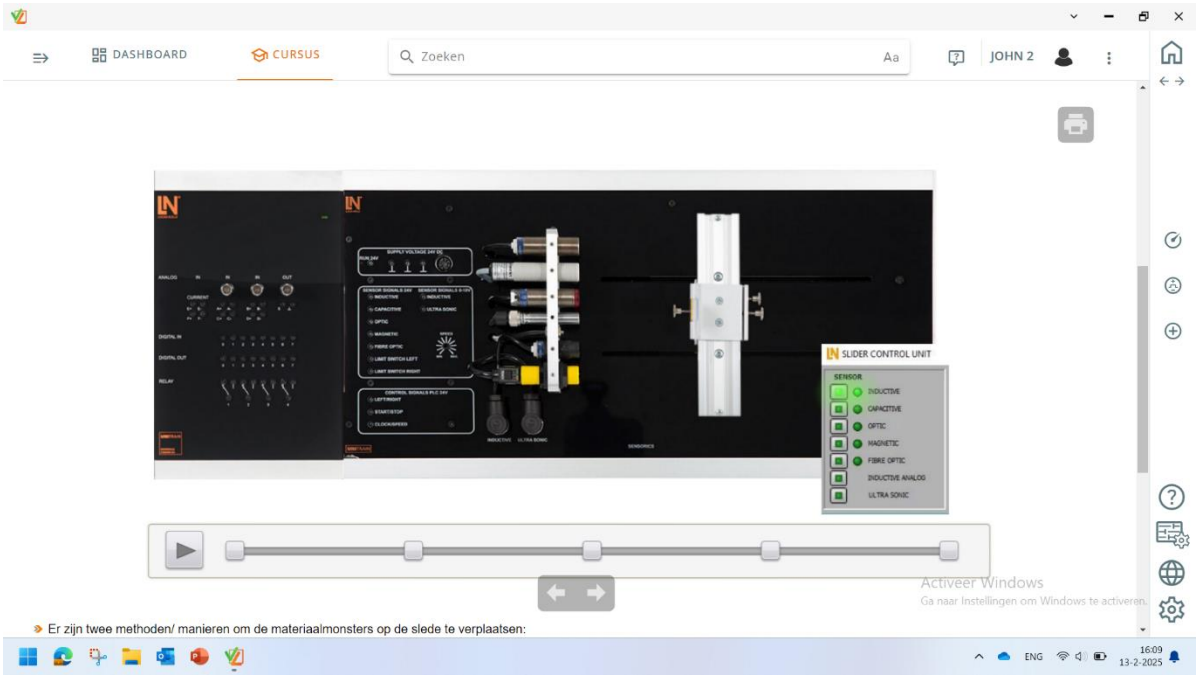


Figure 1:Lucas-Nulle Unitrain sensor technology

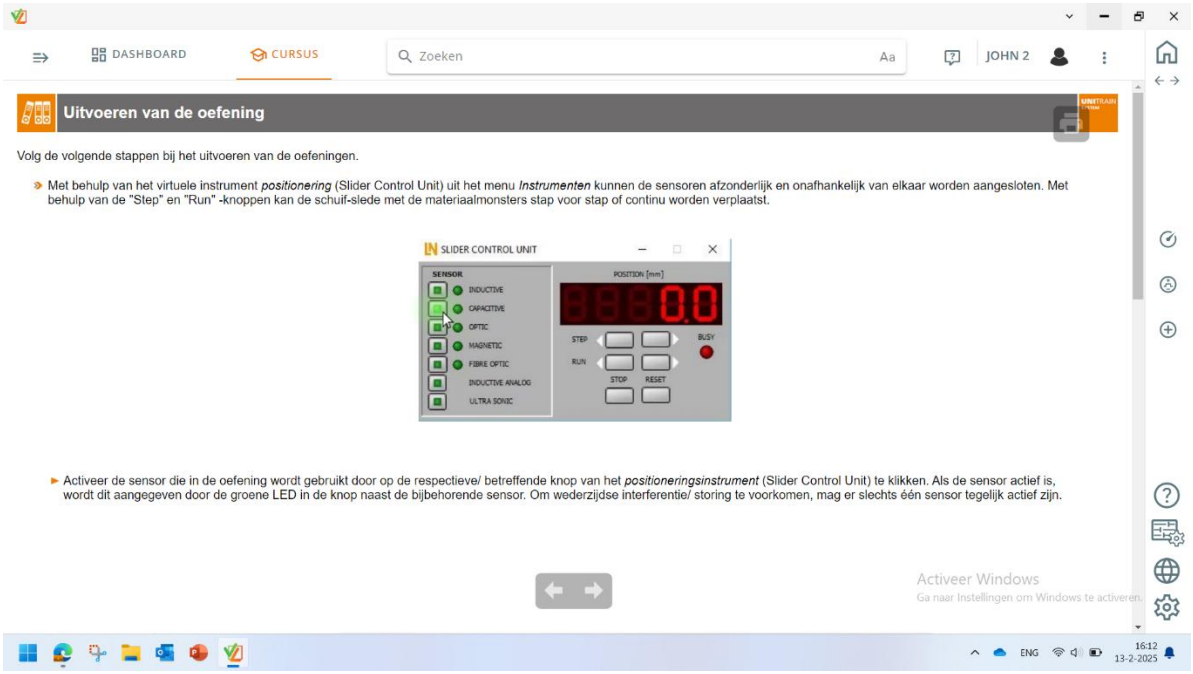


Figure 2: Lucas-Nulle Unitrain sensor technology tutorial

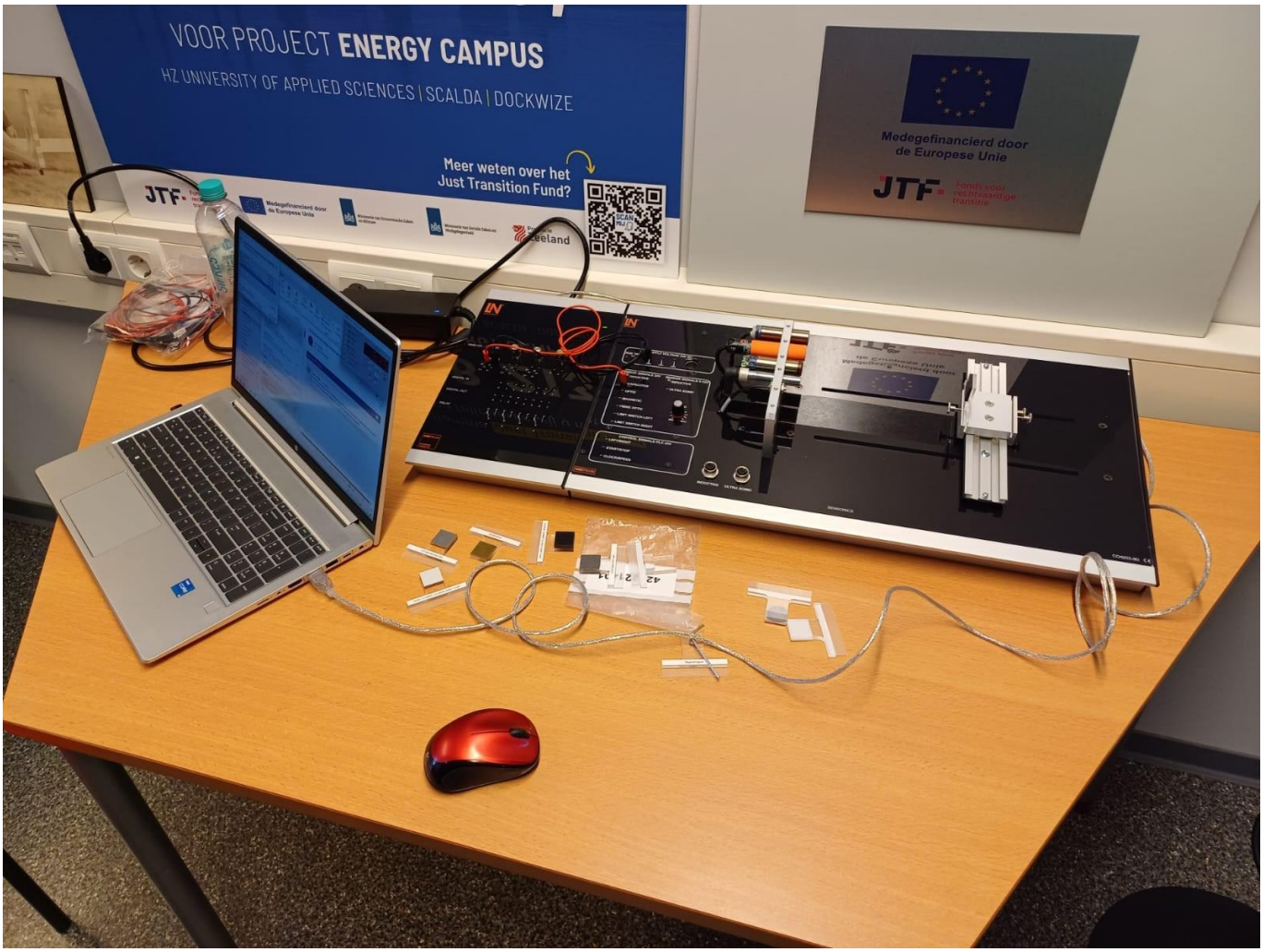


Figure 3: Lucas-Nülle Unitrain Sensor Technology module

https://www.lucas-nuelle.us/2769/pid/2134/apg/1448/Course-Automation-Technology-7:-Sensors-for-automation.htm

For testing and examination, it is recommended that the student can perform the sensor inspection and maintenance independently on a setup like the Festo Nacelle trainer.

https://www.festo.com/us/en/p/nacelle-wind-turbine-learning-system-id_PROD_DID_610873/?page=0

Figure 4: Festo Nacelle - Wind Turbine Learning System 46122-20

11 Practical skill training

11.1 Assignment part 1: checking the error and drafting Unscheduled Service Order (SO) for the inspection

There is a Conditional monitoring system (CMS) report that reports a recurring malfunction of a sensor (Unscheduled maintenance). The student must:

1. Check which errors are reported by the sensor by consulting the display of the Nacelle trainer or equivalent training setup.
2. Check if there is any history of repairing the sensor in existing database.

3. Draft a Service order mentioning the relevant points of attention. The service order should mention the most probable causes of the error and explain if a visual inspection is needed.
4. Draft an Unscheduled Service Order (SO) that a visual inspection is needed. It should include a description of the error, information about tools needed to perform the inspection, how many technicians and hours are needed, what is the priority of work.

Learning outcomes:

- LO1 Demonstrates knowledge and understanding of sensor fault classification. Test scenario done by using Lucas-Nulle CO 4204-8U module
- LO2 Capacity to perform interpretation, analysis and evaluation to formulate strategy to address malfunctions. Demonstrates key knowledge and understanding of components and overall function of system.
- LO3 Ability to conduct and execute work process tasks including documentation and standardized procedures and processes

Notes for teachers

- If the malfunction is a standard scenario that happens often with known procedures for problem solving the task is EQF level 4. If the malfunction is more abstract (and newer) without clear procedures for solving, then it is EQF level 5.
- The students need to be familiar with the error code system and be able to look up the error in a manual.

11.2 Assignment part 2: HSE (Health and safety and environment) and preparing the inspection

The student must:

1. stop the Wind turbine and secure it following the lock-out-tag-out method, including depressurizing the hydraulics.
2. The student is entering the nacelle from the tower. When the student is standing upright in the Nacelle and is looking around to perform a Last-Minute Risk Assessment (LMRA) he/she is confronted with the instruction [by signs or by examiners] that there is **an electromagnetic field, danger of collision, or other risk.** The student may consult a HSE catalogue or similar what appropriate measure to take for this risk and act on it. This may take 10 minutes.

Learning outcomes

- LO4 Stopping and securing a nacelle with the lock-out-tag-out-method
- LO5 Depressurise the hydraulics
- LO6 Understand the regulations and standards related to occupational health and safety
- LO7 Implement safety procedures and protocols for wind energy work environments and adapt them to the different working environments.

11.3 Assignment part 3 performing the inspection and drafting the Unscheduled Service Order (SO) form for the repair

1. The student is to perform the visual inspection based on the service order. This must be a visual inspection and a manual inspection, feeling with hands if any parts are loose or damaged.
2. Draft a **Service report** that contains:

a. A detailed description of the malfunction

b. The inspection results

c. An analysis of the situation

d. The most probable causes of the malfunction.

e. Conclusion

f. Repair advice

3. Draft a Unscheduled Service Order (SO) that repair is needed. It should include Service order description, information about tools needed to perform inspection, how many technicians and hours are needed, what is the priority of work.

The inspection and the drafting of the repair advice must be completed in 30 minutes. The repair advice is given on a English form that is reported back to the client. Next to the most probable cause and repair measure, possible other causes and appropriate measure must be mentioned. The repair advice must be clear, logical and aimed at an adequate solution (effective and efficient).

Notes for teachers:

Here it would be also nice to calculate cost of service and add that information for client. Based on materials needed and number of tech/hours for service

11.4 Assignment part 4 performing the repair and reporting it

Because the Nacelle trainer is expensive (we only do fault search on the nacelle), the repair may be done on a separate setup simulating the environment and assignment.

The student

1. Gets a go from the supervisor to do the repair.
2. performs the repair according to the Service Order and safety procedures that is approved by the client.
3. Follows the repair procedure

4. Replaces the sensor and tests it within the standard time
5. (Optional) Test failure -> verify what went wrong
6. Documents the repair in a service report
   (photos, text, …) according to prescribed template (digital folder)
7. Feedback to the client
8. Recommissioning the installation

During the exam, the student reports the document in a digital project folder. This folder is handed over to the examiners by the end of the exam. Together with the observation forms of the examiners, this is the work that is evaluated and graded. The assessment forms show the criteria for evaluation

Instructor must:

- Discuss with participants each of the exercises and summarize results of them
- Review with participants their filled-out documentation
- Discuss final report outcome
- Or *Facilitate debrief between participants*

Each course participants must:

- Engage in discussion about exercises.
- Finalize all required documentation and verify if all documentation is completed.
- Prepare final report with next step service action proposition.
- And/or:
- Evaluate personal performance
- Identify areas for improvement

Notes for teachers:

possibilities for higher level examination:
malfunction of the new sensor
malfunction of the system
during repair other malfunctioning parts

12 Learning scenario

12.1 Scenario introduction

The replacing a sensor learning scenario is a realistic entry level situation that windtechnicians are asked to do when starting their career. This scenario has been verified with the industry by SBB in the Netherlands and has been converted into a learning scenario and exam on a national level. This exam

is accredited and documented as exam to pass the minor Windturbine Maintenance course K1312 in the Netherlands.

13 Completion of training practical part

13.1 Safe dismounting and tools storage

This exercise involves safely cleaning up the workshop after completing the practical sessions. It aims to demonstrate the correct sequence for safely dismantling equipment, returning it to the storage space, and preparing it for future use.

Instructor must:

- Inform participants how safely and in what order unmount tools & accessories and return it to the storage.

Each course participants must:

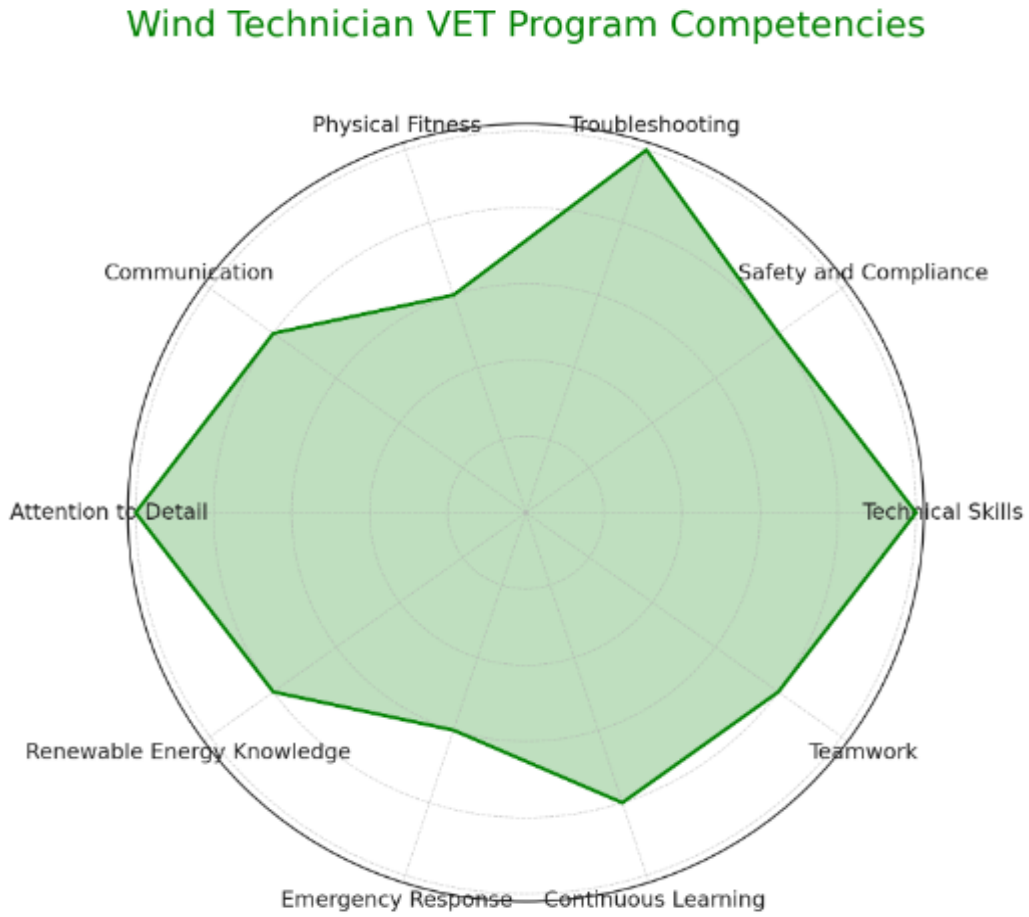
- Safely unmount tools & accessories.
- Correctly return tools and accessories to the storage

14 Learning scenario & module evaluation

This module is evaluated after each edition by the organizing teachers. Improvements are suggested to the author in the COVE and communicated to other T-shore partners in WP3 and during the train-the-trainer sessions where modules are evaluated and calibrated.

15 Spider diagram suggestion:

To explain the complete competency set that the module and scenario should provide after completion.



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