T-shore Education

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Module and Scenario Overview

Module:
Power-to-X
Learning scenario:
Introduction to Power-To-X

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Note This is a fictive generic document intended for training purposes and therefore may vary from the document provided by a company.

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1 Description of module

This course in "Power-to-X as an energy source" gives participants a thorough introduction to the structure and principles of Power-to-X technology. Participants will gain in-depth knowledge of daily service at Power-to-X plants, including an understanding of electrolysis and catalysis processes. The course also covers details of the different substances used in Power-to-X processes, such as carbon monoxide (CO), CO2, hydrogen (H2) and ammonia (NH3), and their associated risks. Furthermore, the course will focus on the safety aspects of using Power-to-X technology, which is essential for safe operation and maintenance.

1.1 Theory

The module consists of a theoretical part where the participant learns about Power-to-X (PtX) plant is designed to convert electrical energy (from renewable sources such as wind or solar) into another form, often fuels or chemicals. There are different technologies that can be applied in a PtX plant, depending on the desired output.

This is divided into e-learning and presentation via slideshow on the computer in traditional classroom teaching. The topics touch; Introduction to Power-to-x in general, supply for electrolysis, forms of electrolysis, cooling of electrolysis – residual heat, the products of electrolysis and safety, laws, regulations and standards.

1.2 Practical

In the practical part, the participant, following the instructor's guidance and documentation, performs practical training doing an electrolysis plant with solar panels and getting the plant to produce hydrogen, as well as burning hydrogen. To understand and illustrate the principles of electrolysis.

1.3 Evaluation

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

2 Instructor pre-qualification

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

Knowledge: specialised education or advanced knowledge in the field of Power-to-X.

Skills: manual skills and experience allowing the presentation of the method of electrolysis plant with solar panels and getting the plant to produce hydrogen.

Ability: educational skills related to the ability to conduct classes as an instructor, a reflective approach to teaching, and an instinct related to safe work practices.

3 Participant pre-qualification

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

Knowledge: Basic knowledge as an electrician or people with similar electrical skills.
Skills: use of manual electrical tools.
Ability: Practical exercises/assignments are carried out in accordance with relevant laws, standards, and work instructions, including safety procedures, in best practices.

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

Name	Q/A	Type	Category	Where to use
PC with projector screen	1	Real-life equipment	Theoretical part equipment	Theoretical part
E-learning on Power-to-x	1	Digital material	Theoretical part material	Theoretical part
Intro to PTX Presentation, PPT (incl. risk assessment)	1	Digital material	Theoretical part material	Theoretical part
Final exam	1	Digital or Printed document	Theoretical part material	Theoretical part
Equipment checklist example	2	Printed document	Practical part material	Preparation for practical exercises part
Learning scenario manual	1	Printed document	Practical part material	Practical part
Small Electrolysis System	1	Real-life equipment	Training infrastructure	Practical part
Safety googles	-	Real-life equipment	Safety equipment	Practical part
Safety cloves	-	Real-life equipment	Safety equipment	Practical part
Safety helmet (if visit to P2X facility)	-	Real-life equipment	Safety equipment	Practical part

Note The list is provided for a group of 6 participants. For smaller or larger groups, the list needs to be adjusted accordingly.

5 Timeframe

Time	Part

4 hours	Theory
2 hours	Practical Exercise: Operation and Analysis of the Pure Hydrogen Separator Cell (see section 11.1)
1 hours	Visit to PTX facility or virtuel tour. (see section 11.2)
0,75 hours	Test, Correction of tests and evaluation
Total: 7,75 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	E-learning on Moodle T-Shore, power-points, lectures, and group work
Practical part	Practical skill training and scenario participation in practical training

Note Learning methods depends on accessibility of infrastructure and equipment.

7 Main learning outcomes for the module

Main learning outcome	Competency
Knowledge and insight into the structure and operational principles of a Power-to-X plant	Knowledge/skills
Understand basic principles of electrolysis and catalysis related to Power-to-X technologies	Knowledge/skills
Knowledge of characteristics, processes, and risks of substances (CO, CO_2, H_2, NH_3)	Health, Safety, and Environment
Understand key safety considerations when working with Power-to-X systems	Health, Safety, and Environment
Apply health, safety, and environmental procedures during operation and maintenance	Health, Safety, and Environment
Knowledge of ATEX regulations and mitigation of explosion hazards	Health, Safety, and Environment
Communicate technical and safety information effectively	Teamwork & communication

8 Theory part

8.1 Learning theory

The part of the training dedicated to theory - involves classroom-based teaching of theory or the assessment of knowledge for training participants who have completed e-learning before commencing the learning scenario. This can be implemented as a hybrid of both methods.

Note Some modules / practical learning parts may require a back-and-forth between theory and practice.

8.1.1 Instructor must

- Present introduction / opening presentation specific for site
- Inform about and explain feedback questionnaire.
- Present the theory material or verify if participants complete e-learning on their own
- Collect feedback after theory introduction.

8.1.2 Each course participants must

- Learn theory part
- Ask questions related to learning materials and module
- Conduct feedback questionnaire

8.1.3 Learning outcomes

Detailed learning outcome	Main learning outcome
Describe the structure and function of a hydrogen separator cell within a Power-to-X system. Monitor and interpret operational parameters such as current flow, temperature, gas pressure, and hydrogen production rates.	Knowledge and insight into the structure and operational principles of a Power-to-X plant
Explain the fundamental processes of electrolysis and the role of catalysis in hydrogen production. Monitor and interpret operational parameters such as current flow, temperature, gas pressure, and hydrogen production rates.	Understand basic principles of electrolysis and catalysis related to Power-to-X technologies
Identify physical and chemical properties, risks, and safe handling procedures for CO, CO_2, H_2, and NH_3.	Knowledge of characteristics, processes, and risks of substances (CO, CO_2, H_2, NH_3)
Apply ATEX safety principles and operational protocols to prevent ignition risks in explosive atmospheres. Conduct a visual and technical inspection of hydrogen-producing equipment with a focus on safety compliance.	Understand key safety considerations when working with Power-to-X systems

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Implement emergency shutdown procedures and safely manage hydrogen venting operations.	
Conduct a visual and technical inspection of hydrogen-producing equipment with a focus on safety compliance. Implement emergency shutdown procedures and safely manage hydrogen venting operations.	Apply health, safety, and environmental procedures during operation and maintenance
Apply ATEX safety principles and operational protocols to prevent ignition risks in explosive atmospheres.	Knowledge of ATEX regulations and mitigation of explosion hazards
Prepare and communicate written and oral reports covering operational data, safety observations, and improvement suggestions. Collaborate with team members to ensure safe, efficient, and compliant operation of Power-to-X equipment.	Communicate technical and safety information effectively

8.2 Risk Assessment

The part of the training focused on risk assessment and its planning involves the instructor guiding straining participants through an exercise on planning a risk assessment for a specific learning scenario and location. **In this section, important elements are described that help the** training participant **to be able to prepare and make a risk assessment in relation to being part of the work around Power-to-x.**

8.2.1 Instructor must

- *Explain what risk of the different gasses used in Power-to-x* - characteristics, processes, and associated risks of handling substances used in Power-to-X applications, including carbon monoxide (CO), carbon dioxide (CO_2), hydrogen (H_2), and ammonia (NH_3).
- *Explain* key safety considerations when working with Power-to-X systems and the materials involved.
- *Explain different* relevant health, safety, and environmental procedures when operating and maintaining Power-to-X facilities and explain how the work together with different areas of expertise.
- *Show ATEX regulations and guidelines* related to explosive atmospheres, so the training participant can identify and mitigate explosion hazards in Power-to-X environments.
- *Answer questions and give feedback*

8.2.2 Each training participant must

- Ask questions related to learning materials

- **Be able to prepare and make a risk assessment in relation to being part of the work around Power-to-x**

8.2.3 Learning outcomes

Detailed learning outcome	Main learning outcome
Participants can identify and list specific hazards associated with executing the planned learning scenario.	Has knowledge about hazardous environment, can plan risk assessment and execute work in accordance with risk assessment
Participants can create a corresponding risk assessment addressing the hazards identified in the planned learning scenario.	Has knowledge about hazardous environment, can plan risk assessment and execute work in accordance with risk assessment

9 Practical part - introduction

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 training participants 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 training participants 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 Practical training introduction

Before start of practical exercises:

Participants may be divided into more groups. Max ratio: 6 participants per instructor for practical session.

All participants and instructors shall use appropriate PPE in accordance with local laws and regulations.

The minimum requirement is:

- Overalls/work clothes – long sleeves
- Safety glasses
- Safety cloves

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.

10.1.1 Instructor must

- Present and explain the hazards and risks in practical training zones.
- check if each participant is wearing his/her PPE correctly.

10.1.2 Each training participant must

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

10.1.3 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

Manual handling is a part of the training dedicated to preparing participants for physical tasks such as lifting heavy objects, bending, or assuming unnatural positions during exercises.

10.2.1 Instructor must

- Facilitate warming up exercise, and manual handling exercises with group and discussions on to handle equipment manually according to the equipment characteristics and potential hazards and risks.
- Correct positioning under manual tasks

10.2.2 Each training participant must

- Warm up, and practice correct manual lifting techniques. Focus on correct work positioning.

10.2.3 Learning outcomes

Detailed learning outcome	Main learning outcome
Participants understand the rules for proper manual handling techniques.	Can plan and conduct safe work in accordance with general HSE requirements
Participants can perform practical tasks in compliance with manual handling requirements.	Can plan and conduct safe work in accordance with general HSE requirements

10.3 Equipment check

This part of the training focuses on presenting the verification and inspection process for equipment needed during the practical part, as well as identifying when equipment require quarantine. It also emphasises proper storage conditions and procedures.

10.3.1 Instructor must

- Check that electrolysis equipment is working properly and make
- where the gearbox service accessories, tools, and equipment are stored. Explain how to store it correctly and describe potential consequences of failing to do so.
- Explain the different indicators that must be checked during pre-use and post-use checks
- Explain the reasons for quarantining accessories and equipment.
- Explain how to fill **the equipment checklist for Small Electrolysis System.**

10.3.2 Each training participant must

- Practice the ability to correctly store accessories and tools – executing also during later practical exercises.
- Practice how to conduct pre-use and post-use check of equipment and accessories.
- Practice the ability to identify accessories requiring quarantine.

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- Practice the completion of **the equipment checklist for Small Electrolysis System.**

10.3.3 Learning outcomes

Detailed learning outcome	Main learning outcome
Participants understand the importance of correct equipment storage	Can plan and conduct safe work in accordance with general HSE requirements
Participants can perform equipment inspection	Can plan and conduct safe work in accordance with general HSE requirements
Participants can correctly fill out equipment checklist	Can supply written and verbal report

11 Practical skill training

Practical skill training is a part highly dependent on participants' pre-qualifications. Based on an assessment of participants' skills, the instructor should determine the amount of skill training required to allow participants to engage in exercises from the learning scenario. In cases where participants possess varying skill levels identified through a gap analysis, skill training should be planned according to the lowest skill level identified. This approach ensures learning opportunities for less experienced participants, while for more advanced participants, it serves as a review and practice of their skills.

Examples of skill training exercises related to the **Introduction to Power-To-X** scenario:

- Small Electrolysis System (HydroBullet – Pure Hydrogen Separator Cell)

Implement practical skill training on equipment that can simulate the environment.

11.1 Small Electrolysis System

Operation and Analysis of the Pure Hydrogen Separator Cell.

Purpose

To provide participants with practical experience in the operation and monitoring of a Pure Hydrogen Separator Cell from Hydrobullet. The exercise focuses on understanding the electrolysis process, safe handling of hydrogen, and analysis of operational data.

Target Group

Training participants and professionals within the electrical, energy, and utilities sectors seeking practical training experience with Power-to-X technologies.

Duration

Approx. 2 hours (including introduction, operation, evaluation)

11.1.1 Instructor must

Materials and Equipment (pre-installed)

- Hydrobullet Pure Hydrogen Separator Cell (e.g., R06 or R11 model)

- Power supply with PWM controller
- Distilled water and appropriate electrolyte (e.g., KOH)
- Gas collection system
- Multimeter and amp meter
- Thermometer and pressure gauge
- Personal protective equipment (PPE):
  a) Safety goggles
  b) Protective gloves
  c) Antistatic clothing
- ATEX-approved ventilation system
- Fire extinguishing equipment and emergency stop controls
- See youtube link for more information (*https://youtu.be/hzwfcIk7KNw*)

11.1.2 Each learning participants must:

1. Introduction and Safety Briefing (15 minutes)

- Overview of the separator cell's function and electrolysis principles.
- Explanation of hydrogen handling according to ATEX regulations.
- Review of emergency procedures and correct use of PPE.

2. Inspection of Pre-Installed Equipment (15 minutes)

- Visual inspection of the prepared setup.
- Verification that all measuring instruments are correctly connected.
- Overview of the gas collection system's function.

3. Operation and Monitoring (60 minutes)

- Start-up of the system under instruction and adjustment of current levels via the PWM controller.
- Continuous monitoring and recording of the following parameters:
- Current consumption (amperes)
- Temperature development within the electrolysis cell

- Gas production (volume, pressure). [By adding dish soap, you can set fire to the bubbles and show the gas production. Be careful in case of minor explosions and do not do it in too close and closed spaces, and do not stand too close to it yourself!]
- Identification of optimal operating conditions and any irregularities.

4. Shutdown and Evaluation (15 minutes)

- Safe shutdown of the system and venting of any residual gases.
- Cleaning and basic maintenance after operation.
- Collection and discussion of data and observations.
- Brief evaluation of potential improvements and industrial applications.

11.1.3 Learning outcomes

Detailed learning outcome	Main learning outcome
- Understand the working principle of a hydrogen separator cell and the fundamentals of electrolysis. - Identify key operational parameters such as current consumption, temperature, gas volume, and pressure. - Recognise signs of operational inefficiencies and take corrective actions.	Operate and monitor a Pure Hydrogen Separator Cell safely and efficiently
- Understand and apply ATEX safety requirements when working in explosive atmospheres. - Properly use personal protective equipment (PPE) and follow emergency procedures. - Handle and vent hydrogen gas safely after production and operation.	Apply relevant health, safety, and environmental procedures, including ATEX regulations, when handling hydrogen
- Identify key operational parameters such as current consumption, temperature, gas volume, and pressure. - Recognise signs of operational inefficiencies and take appropriate corrective actions. - Clearly document operational data and observations following professional standards.	Analyze operational parameters related to electrolysis processes and hydrogen production
- Collaborate effectively with team members during system operation and data collection. - Clearly document operational data and observations. - Report potential safety hazards or system irregularities in a timely and structured manner.	Communicate technical observations and safety considerations effectively in a team setting

12 Learning scenario

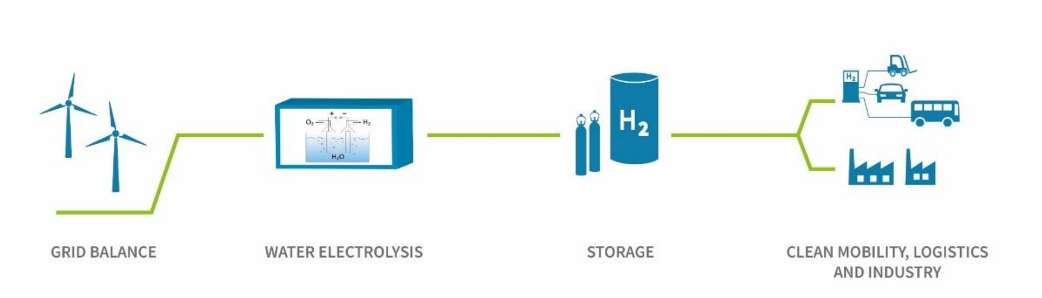
12.1 Scenario - Visit to Power-to-x facility

Participants will learn to perform a proactive visual inspection of the different elements of a Power-to-x facility. A visit to a Power-to-x facility could be planned. If not possible, the module could be supplemented by a virtuel tour to a plant: Maade PtX – where the same learning sceanario will be performed (as in real life).

This Power-to-X facility demonstrates how hydrogen can play a role in the future energy system.
By converting surplus wind energy through the electrolysis of water into hydrogen, renewable electricity can be stored when production exceeds demand.
This conversion also helps to balance the electricity grid, contributing to the stability of supply and voltage levels.
The green hydrogen produced can be used both in the transport sector and in industrial processes.

12.1.1 Instructor must

- **Arrange a visit to the Power-to-x facility** with a tour guide and/or operations manager (e.g. in Denmark, near Skive at GreenLab Skive or HyBalance facility, Hobro).
- **Explain the necessity of balance in the electricity grid.** (Wind energy is fluctuating, while the electricity grid requires a stable supply; during periods of overproduction, excess wind power can either be exported, wind turbines can be shut down, or surplus energy can be stored by converting it into hydrogen.)
- **Describe electricity for water electrolysis, storage and consumption.**



- **Explain PEM electrolysis and structure** (PEM (Proton Exchange Membrane) electrolysis is characterised by high efficiency (hydrogen per kWh of electricity) The technology is flexible (short start-up time and no problems with frequent starts/stops) This makes PEM very suitable for balancing fluctuating energy sources)
- Together with the tour guide and/or operations manager, you must together with the training participants **visual inspection of the different elements of Power-to-X.**

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12.1.2 Each training participants must

To achieve the best possible learning outcome from the visit, training participants should (***Compare Document: T-shore exercises check list. Visit to Power-to-x facility _V01_28.04.2025***):

- **Prepare in advance** by reviewing basic principles of renewable energy, electricity grids, and hydrogen production through electrolysis (through e-learning and theory presentation).
- **Actively listen** during explanations regarding grid balance, energy conversion, and PEM electrolysis technology.
- **Take structured notes** on key points explained by the instructor, tour guide, and/or operations manager, especially regarding the flow of electricity, the electrolysis process, and hydrogen storage systems.
- **Observe carefully during the visual inspection** of the facility's different components (e.g., electrolysers, compressors, storage tanks, safety systems) and relate observations to theoretical knowledge.
- **Ask relevant questions** to deepen understanding of the practical operation, challenges, and solutions associated with Power-to-X technologies.
- **Participate actively** in group discussions and visual inspections to enhance comprehension through dialogue and collaborative learning.
- **Reflect after the visit by summarising key takeaways** in a short report or learning journal, focusing on how the observed systems contribute to energy balance and green hydrogen production.

12.1.3 Learning outcomes

Detailed learning outcome	Main learning outcome
Explain the importance of grid stability and how Power-to-X contributes to balancing energy supply and demand.	Understand the role of Power-to-X technologies in balancing fluctuating renewable energy sources
Describe the process of converting electricity to hydrogen via water electrolysis.	Describe the principles and applications of water electrolysis and hydrogen production
Identify operational advantages of PEM electrolysis, including flexibility and efficiency.	Explain the specific characteristics and operational advantages of PEM electrolysis
Visually inspect and recognise the main system components: electrolyzers, compressors, storage tanks, and safety systems.	Identify key elements and processes of a Power-to-X facility through structured visual inspection

Apply fundamental safety principles during the site visit, understanding risks related to hydrogen and electricity.	Apply basic knowledge of health, safety, and environmental procedures relevant to Power-to-X systems
Take structured notes and actively participate during the tour, focusing on technical observations. Formulate and ask relevant questions to deepen understanding of Power-to-X operations. Summarise the visit experience in a structured report, highlighting key technical and safety insights.	Communicate technical observations and reflect critically on the learning experience

12.2 Final Exam

The final exercise, Final Exam, focuses on clear and accurate communication of content, as well as reflections on the previously performed exercises. In this part, the instructor evaluates how well the participants understood the tasks they carried out and whether they drew correct conclusions and reflections. In the final part of the module, a test and evaluation are performed, where participants will complete a multiple-choice test. The test can be used in both a physical and digital context.

12.2.1 Instructor must

Preparation and Framing:

- Ensure that the test is ready with 15 multiple-choice questions, each offering 3–4 answer options.
- Inform participants about the format, duration, and rules of the test.
- Review practical aspects before starting, including the use of permitted materials (only personal notes and course materials).
- Distribute or make the test materials available, either physically or digitally.
- Monitor the test to ensure it is completed individually and without unauthorised aids.
- See document for supplement information and suggestions for exam and evaluation: **T-shore_SkiveCollege_Introduction to Power-to-x_final exam and evaluation form_V01_29.04.2025**

Time Management:

- Allocate a total of 40 minutes for the test: 20 minutes for the test itself and 20 minutes for introduction, wrap-up, and any administrative matters.

Evaluation and Grading:

- Assess participants' answer sheets.
- Evaluate participants’ understanding based on the number of correct answers.

- Provide results according to the passing requirement: minimum of 12 correct answers out of 15.

Final Feedback:

- Offer individual or group feedback, possibly in connection with the module wrap-up session.

12.2.2 Each training participant must

Preparation:

- Review personal notes and course materials before the test.
- Ensure understanding of previous exercises and module reflections.

Test Completion:

- Take the test individually, without using unauthorised materials.
- Answer all 15 multiple-choice questions within the allotted 20 minutes.
- Ensure clear and unambiguous marking of answers.

After the Test:

- Submit the test as instructed by the instructor.
- Receive and reflect on the assessment and any feedback given.

12.2.3 Learning outcomes

Detailed learning outcome	Main learning outcome
1. Explain PTX concept and role 2. Describe PTX processes 3. Recognise PTX system elements 4. Identify benefits/challenges 5. Apply sector-specific knowledge 6. Evaluate climate impact 7. Demonstrate terminology understanding	Participants demonstrate a fundamental understanding of Power-to-X technologies, their processes, applications, and relevance within the energy transition.

13 Completion of training practical part

For this module, there is not needed any safe dismounting and tools storage, nor cleaning up after practical training needed, after completing the practical sessions.

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14 Learning module & scenario evaluation

This gives an overview of the practical and theoretical documents needed to complete this learning scenario and the evaluation of these accordingly.

Module part	Exercise name	Evaluation method
Theory	learning theory	Classroom based training and LMS system Moodle verification that participant completed e-learning. **Feedback from participants.**
Theory	Risk assessment	Instructor evaluation based on the **dialogue with** the participants.
Preparation for practical exercises	HSE brief & PPE dressing	Instructor evaluation based on the participant's correct preparation procedure.
Preparation for practical exercises	Manual handling	Instructor evaluation based on the participant's demonstration of proper manual handling techniques.
Preparation for practical exercises	Equipment check	Instructor evaluation based on the **equipment check** report completed by the participant.
Practical skill training	Small Electrolysis System	Instructor evaluation based on the practical skills demonstrated by the participant.
Learning scenario	Visit to Power-to-x facility	Instructor evaluation based on the participant's practical skills demonstrated and the completed section of the **exercises checklist report**.
Learning scenario	Final Exam	Instructor evaluation based on the participant's practical skills demonstrated and the completed section of the **final exam and evaluation form report**.

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