ERASMUS + PROJECT

IO1. Curriculum for future workers in the field of Micro-Grids

Microgrids project

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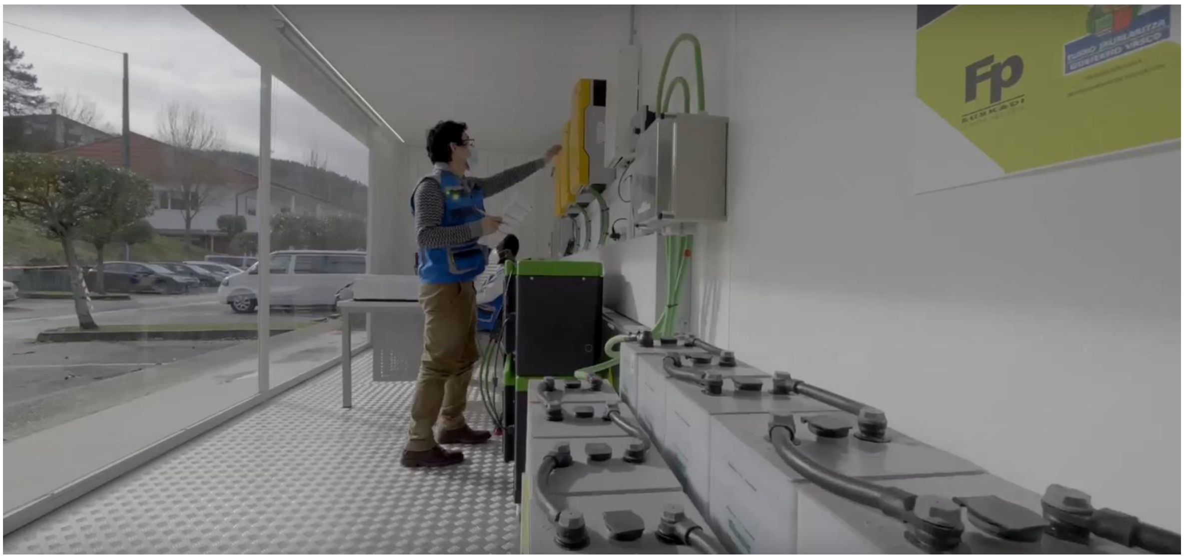
PHOTOVOLTAIC ENERGY

a) Presentation

Professional module:	**Solar Photovoltaic Energy based Micro-grids**
Training cycle:	Renewable Energies
Degree/Level:	VET
Professional Family:	Energy and Water

In this module, the student will learn how to generate electrical energy from the sun, and how to manage it into a renewable based micro-grid: optimise its generation, store it, use it efficiently or interchange it with the main grid.



b) Learning outcomes and assessment criteria

1. Understands the main principles of solar energy.

   Assessment criteria:

   a) The main characteristics of the sun, its position and received radiation on earth have been understood.
   b) Different systems for capturing solar energy have been identified.
   c) Solar energy parameters have been classified, and the student understands the main characteristics of each one.

2. Identifies the elements and main characteristics of solar photovoltaic energy installations.

   Assessment criteria:

a) The types of solar energy installations have been classified.
b) The principle of cell operation has been recognized.
c) The parameters and characteristic curves of the panels have been identified.
d) The operating conditions of the different types of batteries have been described.
e) The characteristics and function of the regulator have been described.
f) The types of converters have been classified.
g) The network connection regulations have been identified.

3. Configures photovoltaic solar installations justifying the choice of the elements.

Assessment criteria:

a) The technical documentation of an installation has been interpreted.
b) The necessary sketches and diagrams have been drawn to configure the solution proposal.
c) The characteristic parameters of the elements and equipment have been understood.
d) The support structure of the panels has been selected.
e) Commercial catalogues and websites have been consulted.
f) The necessary equipment and materials have been selected.
g) The budget has been prepared.
h) The current regulations have been applied.

4. Understands solar photovoltaic based micro-grids and its main elements.

Assessment criteria:

a) Different schemas of solar photovoltaic based micro-grids have been understood.
b) Main systems and components for managing the energy in island-based and grid-connected micro-grids have been taken into account.
c) Storage system types, dimensioning and functioning have been described.
d) Different energy consumption types and strategies have been identified.
e) Micro-grid management systems have been understood.
f) Local and remote monitoring systems and its main parameters are taken into account.
g) Knowledge about context and future of renewable based distributed micro-grids has been acquired.

c) Basic content

1. CHARACTERISTICS OF SOLAR RADIATION	
procedural	- Understands the basis of the solar radiation and characteristics. - Deals with main solar parameters with ease.
conceptual	- The energy of the sun - The solar spectrum - Types of radiation reaching the earth - Sun - Earth position parameters - Solar constant - Radiation levels. Units of measurement - Capture of solar energy: passive thermal capture, active thermal capture, photovoltaic capture - Solar energy parameters: solar irradiance, solar insolation, lightness index, peak sun hours
attitudinal	- Order and cleanliness in the work and activities performed.

2. MAIN COMPONENTS OF A SOLAR PHOTOVOLTAIC SYSTEM	
procedural	- Identification of the main components: photovoltaic panels, batteries, regulators and inverters. - Analysis of the characteristics of each type of component. - Determination of the proper inclination and orientation of the panels. Determination of shadows.
conceptual	- Photoelectric effect: Light absorption Energy transfer. Union of the charges. - Solar cell. Constructive aspects. Operating parameters. - Types of panels: from the cell to the module, constitution of the module. - Characteristics plate of a solar photovoltaic module: module parameters, module losses, hot spot problem. - Shadows. - Orientation and inclination. - Panel grouping and connection systems: series, parallel and mixed. - Types of accumulators: lithium ion, lead acid, nickel-cadmium. - Regulators: types, parameters, operation, protections, location and connections. - Inverters: types, location and connection.
attitudinal	- Collaboration and integration in the work group. - European and regional regulations and normative understanding.

3. SOLAR PHOTOVOLTAIC INSTALLATION CONFIGURATION	
procedural	- Classification of photovoltaic solar energy systems. - Location and fixing of the panels to the structures. - Panel mounting, wiring and connection. - Checking the operation of the panels and batteries.
conceptual	- Types of photovoltaic installations: autonomous and connected to the network. Main schemas. - Low voltage electro-technical regulations for photovoltaic installations. - Solar photovoltaic panel connection types: series, parallel, mixed. - Battery connection types: series, parallel, mixed. - Support systems: mini-wind, mini-hydraulic, etc. - Related European and Regional legislation. Legal procedures to be taken into account.

attitudinal	- Rigor in the calculations that are executed. - Order and method of work. - Participation in the work team.

4. PHOTOVOLTAIC BASED MICRO-GRIDS	
procedural	- Carrying out basic calculations of energy needs and dimensioning. - Preparation of network connection request reports and making the connection to the main grid. - Performance of converter operation tests. - Measurement of disturbances in the network and in the installation. Earth connection measurement. - Measurement of consumption, storing and generation. Understanding of the monitoring system parameters.
conceptual	- Types of facilities: autonomous and connected to the network. - Main schemas for a micro-grid configuration. - Inverter and regulator parameter adjustment. - Consumption main element integration in the micro-grid, i.e. efficient illumination, heat pumps, Electric Vehicle chargers. - Low voltage electro-technical regulations/rules and others. - Grid-connected installations: application and conditions of connection to the network. Connection point. Network connection process. Grid connection converter protections: voltage, frequency and phase checks. Disturbances in the grid and in the installation. - Island installations: main characteristics and functioning. - Protections. Earth. Harmonics and electromagnetic compatibility. - Grid connection converter protections: voltage, frequency and phase checks. - Connection and disconnection sequences. - Consumption and generation meters. - Monitoring systems. - Artificial Intelligence in solar photovoltaic based micro-grid management.
Attitudinal	- Respect for current legislation and safety regulations. - Importance of updating the documentation available for the installation

WIND FARMS

a) Presentation

Professional module:	Wind Farms
Training cycle:	Renewable Energies
Degree/Level:	VET
Professional Family:	Energy and Water

b) Learning outcomes and assessment criteria

1. Characterises wind energy installations, considering their elements and recognising their function.

   Assessment criteria:

   a) Wind energy systems have been identified.
   b) The types of wind energy installations have been classified.
   c) The operation of a wind energy installation has been described.
   d) The main elements that make up a wind energy installation have been recognised.
   e) The characteristics of towers and nacelles have been specified.
   f) The characteristics of blades, rotor and gearboxes have been recognised.
   g) The different types of electrical generators used in wind energy installations have been classified.
   h) Transformers, measuring, control and energy evacuation equipment have been recognised.
   i) Functional diagrams of wind power installations have been interpreted.

2. Plans the assembly of wind energy installations, using projects and manuals.

   Assessment criteria:

   a) The general phases of wind farm assembly development have been specified.
   b) Computer programs have been used as organisational support for the assembly process.
   c) Schemes, sketches and plans of a wind farm have been represented.
   d) Manufacturers' assembly manuals have been interpreted.
   e) Relevant modifications have been made to the assembly drawings.
   f) The civil works phases have been carried out.
   g) The wind turbine assembly phases have been carried out.

3. Characterises the assembly processes used in offshore wind farm projects, recognising the differences with onshore wind farms.

   Assessment criteria:

   a) The special characteristics of offshore wind farms have been defined.
   b) b) The differentiating elements that make up an offshore wind energy installation as a whole have been recognised.
   c) c) The energy evacuation systems have been distinguished.
   d) d) The assembly procedures for this type of installation have been related.
   e) e) The techniques used in the assembly processes of offshore wind energy installations have been differentiated (foundations, anchoring and assembly,

among others).

f) f) The human resources involved in the different phases of the assembly operations of offshore wind energy installations have been related.

g) g) The specific safety measures for this type of installations have been applied.

4. Prepares procurement plans for the assembly of wind farms, using logistic management techniques and applying quality management methodologies.

Assessment criteria:

a) The supply programme for the assembly of wind farms has been drawn up.
b) b) The logistic control of the assembly of wind farms has been defined.
c) c) Administrative documentation derived from the technical project has been classified in order to draw up the supply programme.
d) d) Procurement and storage needs have been detailed.
e) e) Plans have been drawn up for the coordination between the phases of the procurement, storage and commissioning processes at the appropriate time.
f) f) Quality control criteria for procurement at the different stages of the project have been selected.
g) g) Computer programs have been used as an organisational support for the procurement process.

5. Configures a small wind power installation, calculating and selecting elements and systems.

Assessment criteria:

a) The data necessary to configure the installation have been determined.
b) The different technologies of elements, equipment, components and materials in wind installations have been identified.
c) The necessary calculations have been carried out to size the installations.
d) The characteristics of the elements, equipment, components and materials have been determined.
e) The elements, equipment, components and materials have been selected.
f) The wind power installation has been related to the possible receiving installations.
g) The technical documentation has been drawn up..

6. Performs the assembly operations of a wind turbine of a wind farm, using a real or simulated situation.

Assessment criteria:

a) The initial conditions for the real assembly or its simulation have been considered (documentation and situation, among others).
b) The tower sections have been assembled and aligned.
c) The tower has been hoisted.
d) The nacelle, the rotor and the orientation system have been assembled.
e) The generator has been mechanically coupled.
f) The transformation equipment has been installed.
g) The medium, low voltage and control electrical installation has been assembled.
h) The main electrical components have been installed.
i) The output signal to the grid has been verified.
j) The output parameters have been adjusted..

7. Assesses the risks of offshore wind farms, recognising the specific characteristics of the installation and the environment.

Assessment criteria:

- a) The risks associated with the access and evacuation of offshore wind turbines have been defined.
- b) b) The risks of the different occupational activities carried out in the assembly of a wind turbine to be installed in an offshore wind farm have been assessed.
- c) c) The occupational hazards of the specific activities of commissioning and energising an offshore wind farm have been detailed.
- d) d) The specific maintenance activities in an offshore wind farm have been defined.
- e) e) The hazards of hazardous substances and materials present in offshore wind energy installations have been related.
- f) f) Risk control and prevention measures have been defined in each case.

8. Uses the different safety and personal protection equipment used in the assembly and maintenance of wind farms, defining their use and determining their suitability for each installation or system.

Assessment criteria:

- a) The characteristics of personal protective equipment and specific work clothes used in the assembly and maintenance of wind turbines have been classified and established.
- b) b) The use and characteristics of safety equipment for work in the presence of electrical voltage have been defined.
- c) c) The use and characteristics of safety equipment for the ascent and descent of materials and persons have been defined.
- d) d) The use and characteristics of safety equipment for fall control have been defined.
- e) e) The operation and characteristics of wireless telecommunication equipment have been recognised.
- f) f) The importance of telecommunication equipment as a safety element has been reasoned.
- g) g) Signalling requirements have been identified, as well as the delimitation of protection areas, in wind farm operations.
- h) h) The critical points for inspection and maintenance of personal safety and fall protection equipment have been considered.
- i) i) The use and characteristics of life jackets, flares and other safety equipment used in offshore wind farms have been defined.

c) Basic content

1. CHARACTERISATION OF THE OPERATION OF WIND POWER PLANTS	
procedural	- Classification of types of wind installations. Wind farms, mini wind farms and mini wind turbines (mini wind turbines). - Recognition of the operation and composition of a wind energy installation. - Selection of the main elements that make up a wind energy installation. - Identification of the characteristics of towers and nacelles. - Identification and interpretation of the characteristics of blades, rotor and gearboxes. - Classification and selection of the different types of electrical generators used in wind power installations. - Identification of transformers, measuring, control and energy evacuation equipment. - Interpretation of functional diagrams of wind power installations.
conceptual	- Wind energy systems. Meteorology. - Wind farms. Composition, classification and operation. - Specifications and description of equipment and constituent elements of a wind energy installation. - Specifications and characteristics of towers and nacelles. - Energy evacuation systems - Generators. Types. - Transformers. Types. - Multipliers. Characteristics. - European, national, regional and local regulations.
attitudinal	- - Orderly, methodical and participative attitude in the search for information. - - Interest in complying with current regulations.

2. PLANNING THE INSTALLATION OF WIND FARMS	
procedural	- Specification and sequencing of the general development phases Use of computer programs - Representation of diagrams, sketches and drawings of a wind turbine installation. - Interpretation of manufacturers' assembly manuals. - Visualisation and interpretation of digitalised plans. - Carrying out basic operations with graphic files. - Specification and sequencing of civil works phases. - Determination of the wind turbine assembly phases. - Sequencing of tasks related to the legalisation of wind energy installations. - Completion of administrative procedures for the legalisation of wind energy installations.

conceptual	- The configuration of wind farms. - Concept and types of wind farm projects. Specifications and description of equipment and constituent elements of a wind energy installation. - Procedure for the legalisation of wind farm projects. Administrative process for the authorisation of installations. - Technical documentation of a project: report, plans, budget, specifications. Health and safety study. - Project management methods. - Phase diagrams, flowcharts and chronograms. - Energy evacuation systems. - Methods for the assembly of installations. - Formalities before Official Bodies. - Aid and subsidies for installations..
attitudinal	- Assessment of clarity, correctness, cleanliness and order in the preparation of documentation, plans and diagrams in standardised formats. - Attention to the rules of graphic representation. - Commitment to the deadlines established in the execution of tasks. - Orderly and methodical attitude in the performance of tasks.

3. CHARACTERISATION OF ASSEMBLY PROCESSES IN OFFSHORE WIND FARMS	
procedural	- Comparison between onshore and offshore wind energy installation. - Distinction of energy evacuation systems. - Development of assembly procedures for this type of installation. - Identification of systems to optimise the installation, relating the human resources involved in the different phases of the assembly operations of offshore wind energy installations. - Application of specific safety measures for this type of installations.
conceptual	- Offshore wind farms. Characteristics. Location. - Differences with onshore wind farms. - Foundations, anchoring, base platform. - Assembly techniques for offshore wind energy installations (foundations, anchoring and assembly, among others). - Overall operation and configuration of the installation. - Methodological specifications for the assembly of wind turbines and offshore wind farms. - Installation optimisation methods. - Safety systems in the operation of offshore wind farm installations.
attitudinal	- Commitment to the deadlines established in the execution of tasks. - Perseverance in the face of difficulties. - Orderly and methodical attitude in carrying out tasks.

4. DEVELOPMENT OF PROCUREMENT PLANS FOR WIND FARMS	
procedural	- Drawing up the procurement programme for the assembly of wind farms. Classification of administrative documentation. - Coordination of the phases of the procurement, storage and commissioning processes. - Selection of quality control criteria for procurement in the different stages of the project. - Handling of procurement computer programs.
conceptual	- Procurement programme. - Logistics control methods. - Plan for demand, supply, storage and commissioning of wind energy of equipment for wind energy installations. - Procurement management systems. General warehouse. Procurement coordination. - Quality plan in the assembly of wind energy installations. Methods for implementing procurement plans. - Safety plan in the assembly of wind power plants. - Computer software for assisted planning Computerised management of procurement. Basic operations with computer files
attitudinal	- Collaboration and integration in the work group. - Order and cleanliness in the work and activities carried out. - Appreciation of clarity, cleanliness and order in the preparation of documentation, plans and diagrams in standardised formats..

5. CONFIGURATION OF SMALL POWER INSTALLATIONS	
procedural	- Selection of the data necessary to configure the installation. - Selection of elements, equipment, components and materials considering their characteristics. - Carrying out the necessary calculations to size the installations. - Carrying out the interconnection of the wind power installation with possible receiving installations. - Drawing up and filling in the technical documentation. - Drawing up the documentation for the administrative process of legalisation of small wind power installations.
conceptual	- Basic values for the configuration of wind farms. Power requirements. - Wind study. Analysis of the environment. - Technical characteristics of small wind turbines. Types. - Technical characteristics of the converter. Voltage regulator. Auxiliary elements. Electrical energy storage system. Conventional and gel accumulator batteries. - Calculation method for dimensioning installations. - Grid connection systems. Direct connection to the grid. - Technical documentation: catalogues, permits and subsidies, among others.

attitudinal	- Collaboration and integration in the work group. - Interest in the use of manuals, catalogues and technical documentation on configuration and installation of the different elements. - Order and cleanliness in the work and activities carried out. - Rigour in the calculation of parameters and elements. - Interest in carrying out the work correctly and punctually.

6. ASSEMBLY OF WIND TURBINES

procedural	- Determination of the initial conditions for the real assembly or its simulation (documentation and situation, among others). - Execution of the lifting of the tower. - Commissioning of the nacelle. - Assembly of the nacelle, the rotor and the orientation system. - Carrying out the mechanical coupling of the generator. - Installation of the main electrical components. - Verification of the grid output signal. - Checking the presence of generated energy.
conceptual	- Tasks prior to the assembly of a wind farm. - Foundation and anchoring operations. - Lifting work on the tower. - Rotor, hub and blade assembly techniques. - Adjustment of orientation and safety elements. - Transformer installation procedure.
attitudinal	- - Commitment to the deadlines established in the execution of tasks. - - Perseverance in the face of difficulties. - - Interest in carrying out work correctly and punctually.

7. ASSESSMENT OF OFFSHORE WIND FARM RISKS

procedural	- Assessment of specific risks associated with the access and evacuation of offshore wind turbines. - Assessment of specific risks in the assembly of an offshore wind farm. - Assessment of specific risks in the commissioning and energisation of an offshore wind farm. - Assessment of specific risks in the maintenance of an offshore wind farm. - Assessment of specific risks caused by hazardous substances and waste in the marine environment.

conceptual	- Access to installations, safety recommendations. - Risks of professional activities in wind farms. Risks for installation on an offshore wind farm. Risks associated with the location. - Occupational risks of commissioning and energising an offshore wind farm. - Risks and safety actions in the maintenance of an offshore wind farm. - Risks of hazardous substances and materials present in offshore wind energy installations. - Risk control and prevention measures in offshore wind farms and their associated systems. Weather forecasting and information. Safety in navigation. Specific offshore emergencies.
attitudinal	- Commitment to established (planned) deadlines in the execution of a task. - Willingness to plan one's own tasks and self-evaluation of what has been achieved.

8. USE OF SAFETY AND PERSONAL PROTECTIVE EQUIPMENT USED IN THE ASSEMBLY AND MAINTENANCE OF WIND FARMS

procedural	- Choice of collective protection systems and individual protection. - Application of techniques and procedures for the use (selection, use, conservation and provisioning) of personal protective equipment.
conceptual	- Characteristics of personal protective equipment. Specific work clothes. Classification. - Characteristics of safety equipment in the presence of electrical voltage. Use of equipment - Characteristics of safety equipment for ascent and descent. Techniques and use of equipment - Characteristics of fall arrest safety equipment. Types and use - Characteristics of wireless telecommunication equipment. Operation and use. - Telecommunication equipment applied to wind installations. - Signalling. Delimitation of protection zones. Tasks. Safety actions in wind farms. - Inspection and maintenance operations for personal safety equipment. - Characteristics of life jackets. Visual elements in offshore wind farms.
attitudinal	- Appreciation of order and cleanliness of facilities and equipment as a primary risk prevention factor. - Commitment to compliance with environmental protection and quality regulations. - Motivation to create safe environments, respecting regulations and safety protocols in wind power installations. - Recognition of the need for ORP.

MICRO WIND TURBINES

a) Presentation

Professional module:	**Micro turbines**
Training cycle:	Renewables Energies
Degree/Level:	VET
Professional Family:	Energy and Water

b) Learning outcomes and assessment criteria

1. Characterises the wind resource, interpreting measurements and identifying the maximum usable power.

   Assessment criteria:

   a) a) The characteristics of the types of wind regimes have been identified.
   b) b) Rotor topologies have been distinguished according to the maximum usable wind energy.
   c) c) The minimum aerodynamic coefficients necessary for a rotor design have been identified according to the wind classes.
   d) d) The aerodynamic coefficients have been related to the physical parameters of the rotor.
   e) e) The different types of rotors have been classified according to their axis and spatial configuration.

2. Classify electrical generators by recognising their properties and characteristics.

   Assessment criteria:

   a) The components of an electrical generator have been differentiated.
   b) b) The characteristics and types of generators have been categorised.
   c) c) The generator losses have been categorised.
   d) d) The type of generator connections have been identified.
   e) e) The fundamental characteristics and magnitudes of the generated electrical voltage have been identified.
   f) f) The different permanent magnet generators have been classified.

3. Design different mechanical controls of the wind turbine to protect against high winds.

   Assessment criteria:

   a) a) The different systems for positioning the rotor against the wind have been recognised.
   b) b) The different systems that prevent mechanical overloads in the wind turbine have been classified.
   c) c) The advantages of the Furling system in the safety position of the wind turbine have been recognised.
   d) d) The advantages of the Tilt-Back system in the wind turbine have been recognised.
   e) e) Emergency braking systems have been recognised.

4. Distinguishes the characteristics of electrical control systems, specifying their

constitution and values.

Assessment criteria:

a) Electrical control systems have been classified.
b) The constitution of load control systems has been recognised.
c) Classified the different power electronics equipment.
d) The characteristics of the electrical storage system have been recognised.
e) Identified the auxiliary elements that make up the electrical control systems.

5. Characterises the support towers of wind turbines, describing the fastening systems.

Assessment criteria:

a) The constitution of support towers and their types have been recognised.
b) The different behaviours of towers in the event of storms have been recognised.
c) The tower fixing systems have been classified.
d) Tower fixing systems have been selected.

c) Basic content

1. CHARACTERISTICS OF THE WIND RESOURCE	
procedural	- Relation of the elements of the rotor, on drawings and diagrams of a wind turbine. - Identification of the components of a wind rotor. - Classification of the rotor according to the position of the drive shaft.
conceptual	- Betz limit: Number of blades. Torque and speed. 2 or 3 blades. - Aerodynamic coefficients. Lift. Drag. Vector diagram of forces Decomposition of forces in blades. - Blade airfoil design. Radius. Angle of attack. Pitch. Length - chord. Slenderness - Horizontal or vertical shafts. - Vertical axis turbine. - Horizontal axis turbine. - Mechanical fatigue - Enveloping rotor. - Permanent magnet generator
attitudinal	- Order and cleanliness in the work and activities carried out. - Autonomy and responsibility to organise and control one's own work. - Willingness to plan one's own tasks and to self-evaluate what has been achieved.

2. CLASSIFICATION AND CHARACTERISTICS OF ELECTRICAL GENERATORS	
procedural	- Selection of electrical generators for different applications. - Recognition of electromagnetic operating elements in micro wind turbines.

conceptual	- Operation of the electric generator. Magnetism. Copper windings. Rotor and stator. Lenz's Law. Maximum magnetic flux. Iron losses. Pulsating electrical torque. Multipole machines. Frequency. Phase. Star and triangle connection. Voltage. Voltage dips Direct current converters Brushes - Electric generator speed variation. - Generator types - Automotive vehicle alternators and dynamos. - Permanent magnet alternators - Electric motors used as electric generators. Permanent magnet alternators. Brushless d.c. Magnetic induction. - Permanent magnet generators. Axial flux, Radial flux. Air gap diameter. Number of poles. Winding shape. - Number of turns. - Wire cross-section.
attitudinal	- Collaboration and integration in the working group. - Rigour in the calculations to be carried out. - Autonomy and responsibility to organise and control one's own work. - Commitment to established (planned) deadlines in the execution of a task.

3. MECHANICAL CONTROL DESIGN IN WIND TURBINES

procedural	- Resolution of vector calculus in the plane. Moment of a force - Carrying out three-dimensional vector calculations on the tail of the wind turbine.
conceptual	- Anti-wind systems. Tail types. (Tail). Yaw system. - Dynamic overloads - Specific tail design for Furling system - Specific tail design for Tilt - Back system. - Controlled shutdown systems. Shut.down. Electric brake
attitudinal	- Rigour in the calculations to be performed. - Autonomy and responsibility to organise and control one's own work. - Commitment to established (planned) deadlines in the execution of a task.

4. ELECTRICAL CONTROL DESIGN FOR WIND TURBINES

procedural	- Perform basic calculations of load control systems. - Carrying out basic harmonic modulation calculations. - Commissioning of the electrical system - Calculation of the storage system
conceptual	- - Load control. Heathers systems. Battery charging systems. - - Phase control - - PWM modulation. - - Stepped charge control. - - Direct AC power supply. - - Connection by transformer. - - Correct battery selection. Prevention of low voltages. Protection relays. Charging voltage. Voltage regulator. - Shunt regulator. - - DC-AC inverters.
attitudinal	- Orderly, methodical and participative attitude in the search for information. - Collaboration and integration in the work group. - Rigour in the calculations to be carried out. - Autonomy and responsibility to organise and control one's own work. - Commitment to the deadlines established (planned) in the execution of a task.

5. CHARACTERISTICS OF WIND TOWERS

procedural	- Carrying out the basic tower height calculation. - Selection of tower fixing elements. - Analysis of the technical characteristics of the fastening elements.
conceptual	- Types of towers. Anchored. Bracing - Atmospheric loads. Storms. - Tower fixing systems, Piping. Fixing elements. Tensioners. Anchors. Rotary guided bases.
attitudinal	- Orderly, methodical and participative attitude in the search for information. - Rigour in the calculations performed. - Autonomy and responsibility in organising and controlling one's own work. - Commitment to established (planned) deadlines in the execution of a task.

ENERGY STORAGE SOLUTIONS

a) Presentation

Professional module:	Energy Storage Systems
Training cycle:	Renewable Energy
Degree/Level:	VET
Professional Family:	Energy and Water

b) Learning outcomes and assessment criteria

1. Recognises different energy storage systems of heat and electricity

Assessment criteria:

a) Identifies the different types of energy storage systems
b) Names the differences between heat and electricity storage systems
c) Distinguishes the principle operation of single heat storage systems

2. Recognises the need of electrical storage systems

Assessment criteria:

a) Names the reasons of storage of electricity in the electrical grid
b) Differentiates the different electricity storage systems
c) Advises the right electrical storage system depending on need

3. Recognises the different types of electrical storage systems

a) Appoints the different classifications
b) Names the most important energy performance
c) Distinguishes the principle of operation of electrical storage systems
d) Names the risks in the field of safety
e) Names the risks in the field of durability

4. Practical experience with pumped hydro systems

a) Indicates the conditions under which this technique can be applied
b) Builds a setup and simulates operation
c) Determines pump and pipe characteristics
d) Determines the efficiency

5. Practical experience with batteries (lead battery)

a) Indicates in what conditions this technique can be applied
b) Shows the chemical reaction equations during loading and discharging
c) Builds a setup and simulates the operation
d) Determines loading and discharging time
e) Determines the efficiency

6. Practical experience with the hydrogen fuel cell

a) Indicates the conditions under which this technique can be applied
b) Shows the chemical reaction equations during loading and discharging
c) Builds a setup and simulates operation
d) Determines loading and discharging time
e) Determines the efficiency

c) Basic content

1. CHARACTERISTIC OF PUMPED HYDRO SYSTEMS	
Procedural	- Create a safe working environment - Training in basic electrical work - Fluid dynamics - Power loss
conceptual	- Components of a pumped hydro system - Power of water - Types of pumps and turbines - Resistance pipe and fittings - Efficiency
Attitudinal	- Collaborate in group - Logical thinking - Accuracy - Self-reflection

2. CHARACTERISTIC OF LEAD BATTERY	
Procedural	- Create a safe working environment - MSDS of pure lead, lead oxide and lead sulphate - MSDS of sulfuric acid - Training in basic electrical work - Chemical redox reactions
conceptual	- Lead properties - Sulfuric acid properties - Loading and discharging time - Efficiency
Attitudinal	- Collaborate in group - Logical thinking - Analytical - Self-reflection

3. CHARACTERISTIC OF HYDROGEN FUEL CELL	
Procedural	- Create a safe working environment - MSDS of hydrogen - Chemical redox reactions
conceptual	- Hydrogen properties - Loading and discharging time - Efficiency
Attitudinal	- Collaborate in group - Logical thinking - Analytical - Self-reflection

HYDROGEN STORAGE

a) Presentation

Professional module:	Hydrogen storage in microgrid systems
Training cycle:	Renewable Energies
Degree/Level:	VET
Professional Family:	Energy and Water

A Microgrid is a self-contained electrical generation system that, coupled with energy storage, can provide energy to buildings and services in a local area or in remote locations. Microgrids can connect into the existing national electricity grid or can operate independently in remote locations where connection to the national grid is difficult or too costly. Micrograms also have the ability to provide energy in times of emergencies, like severe weather events and national power outages. A Microgrid allows businesses and communities to be more energy independent and, in some cases, more environmentally friendly by reducing their carbon emissions that contribute to climate change.

In a new Energy Revolution era, the large-scale deployment of Microgrids will require a new approach to how electricity is generated and managed and will include the increased use of batteries and other forms of energy storage, such as hydrogen. Hydrogen is seen as being an important contributor in the future energy transition and to an increasingly decarbonised economy. Hydrogen can be utilised as an energy carrier and therefore hydrogen storage systems can play an important role in the development of microgrid systems. Training in hydrogen systems is essential to produce skilled employees in the supply chain for the rollout of the energy transition across Europe and the rest of the world

On completion of the module, students will be able to understand the basics of hydrogen as an energy carrier and apply the concepts of design, operation and management, safety, and maintenance of a hydrogen storage system as part of an isolated or grid-connected solar and/or wind generation microgrid system.

b) Learning outcomes and assessment criteria

1. Recognises the basic properties of hydrogen, its production and storage, and its function as an energy carrier

   Assessment criteria:

   a) The basic physical and chemical properties of hydrogen have been identified

b) Hydrogen as an energy vector enabling grid-connected and isolated system supply/demand balancing, and contributing to the energy transition and decarbonisation
c) The different methods of producing hydrogen and the most suitable method for microgrid systems has been distinguished
d) The role of hydrogen as an energy vector in an integrated microgrid system have been distinguished

2. Recognises the different types of storage, appropriate materials, key safety issues around hydrogen storage and transport

   Assessment criteria:

   a) The different methods of storing hydrogen have been distinguished

   b) Consideration has been given to appropriate materials for hydrogen storage system
   c) Storage and onward distribution of hydrogen has been considered (storage in a tank, underground storage, connection to gas pipeline) and subsequent transportation
   d) Consideration has been given to awareness of Safety Codes and Regulations with regard to hydrogen storage

3. Recognises the components of a combined hydrogen generation and storage system, and its associated electricity generation system

   Assessment criteria:

   a) The fundamental components of a combined hydrogen generation and storage system and its integration with a microgrid installation have been identified
   b) The hydrogen generation subsystem (electrolyser) has been distinguished
   c) The hydrogen compression subsystem has been distinguished
   d) The hydrogen storage system has been distinguished
   e) The hydrogen conversion subsystem (fuel cell) has been distinguished

4. Characterises hydrogen generation and storage systems

   Assessment criteria:

   a) The appropriate hydrogen generator (electrolyser) has been identified for the installation
   b) The appropriate hydrogen compression and storage systems have been identified for the installation
   c) The appropriate type of fuel cell to convert hydrogen into electrical energy has been identified
   d) The regulatory requirements for the installation have been investigated
   e) The typical configurations of hydrogen systems and their applications have been assessed

5. Design principles have been applied to sizing the appropriate hydrogen generation and storage system for microgrid installations using calculations and applying the relevant regulations

   Assessment criteria:

   a) System user needs have been identified
   b) The hydrogen generation and storage requirements have been quantified based on surplus power availability from curtailed wind/solar
   c) The electrolyser, hydrogen storage and fuel cell systems and associated equipment have been selected based on surplus power calculations
   d) The required safety calculations and mechanisms have been applied according to regulations
   e) The appropriate design configurations of hydrogen systems within isolated and grid connected installations have been applied
   f) The required system component specifications have been applied based on end user energy consumption and load data, and surplus power availability calculations
   g) The management and maintenance of the system have been considered

c) Basic curriculum content

1. BASIC PROPERTIES OF HYDROGEN, ITS PRODUCTION, STORAGE, AND FUNCTION AS AN ENERGY CARRIER	
Procedural	- Identification of the physical and chemical properties of hydrogen - Identification of the different methods of hydrogen production - Identification of the different forms of hydrogen storage - Relationship between hydrogen as an energy carrier and its role in balancing energy supply/demand - Identification of the role of hydrogen in energy transition and decarbonisation
Conceptual	- The physical and chemical properties of hydrogen - Methods of hydrogen production - Types of hydrogen storage systems - Hydrogen as an energy carrier and its role in an integrated microgrid generation installation
Attitudinal	- Good attitude to learning and work activities - Develop autonomy and responsibility to organise and manage one's own work within a planned timeline - Willingness to develop one's own learning tasks and self-evaluate what has been achieved - Independent study and self-motivation to enhance learning and skills

2. TYPES OF STORAGE, MATERIALS USED, KEY SAFETY ISSUES AROUND

HYDROGEN STORAGE AND TRANSPORT	
Procedural	- Identification of the different types of hydrogen storage systems - Identification of appropriate materials for hydrogen storage systems - Appropriate storage, distribution and transportation methods have been considered - Identification of relevant safety codes and regulations on hydrogen storage and transport
Conceptual	- Different types of hydrogen storage systems - Materials used to construct hydrogen storage systems - Hydrogen storage, distribution and transportation methods (cylinders, tanks, connections to pipelines and transport vehicles) - Safety Codes and Regulations on hydrogen storage
Attitudinal	- Good attitude to learning and work activities - Develop autonomy and responsibility to organise and manage one's own work within a planned timeline - Willingness to develop one's own learning tasks and self-evaluate what has been achieved - Independent study and self-motivation to enhance learning and skills - Attention to the relevant safety codes and regulations

3. COMPONENTS OF HYDROGEN GENERATION, STORAGE, AND ELECTRICAL GENERATION SYSTEMS WITHIN MICROGRID INSTALLATIONS	
Procedural	- Recognition of the components of the hydrogen generation and storage system and their integration with the solar/wind installation - The hydrogen generator (electrolyser) has been distinguished - The hydrogen storage system (compression or cooling) has been distinguished - The electrical generator (fuel cell) has been distinguished
Conceptual	- The hydrogen generation installation: the electrolysis (electrochemical) process of producing hydrogen from water by applying an electrical current - Electrolysers (PEM, Alkaline, etc,.). Operating parameters of an electrolyser: function of electrodes (cathode and anode) and electrolytes (ionic conductors). Low temperature electrolysis. Electrolyte cells and stacks - Types of hydrogen compression and cooling systems to enable storage. Pressurised gas cylinders/cryogenic liquid tankers - Types of fuel cells (PEMFC, etc,.). Fuel cell conversion of hydrogen to electrical energy. Isolated systems. Grid connected systems
Attitudinal	- Collaboration and cooperation in work group and good attitude to

	learning and work activities - Develop autonomy and responsibility to organise and manage one's own work within a planned timeline - Commitment to one's own learning tasks and self-evaluation of what has been achieved - Independent study and self-motivation to enhance learning and skills

4. HYDROGEN MICROGRID DESIGN AND CRITICAL SAFETY REQUIREMENTS FOR ITS OPERATION AND MAINTENANCE	
Procedural	- Carrying out basic calculations of energy surplus (from curtailment) based on wind/solar location - Carrying out electrolyser size requirements based on surplus energy calculations - Consideration to the location and design of the hydrogen system in relation to its integration with wind and solar installations and ease of management, operation and maintenance - Analysis of risks associated with hydrogen generation and storage - Recognising specific safety requirements for hydrogen integration within microgrid systems - Considerations for hydrogen detection and monitoring
Conceptual	- Surplus wind/solar energy calculations and electrolyser system size calculations including conversion losses - Site location of integrated hydrogen microgrid system - Case Studies of accidents in microgrid scale hydrogen systems - Hydrogen sensor types and applications - Hydrogen detection strategies for microgrids - Maintenance of hydrogen detection systems for microgrids
Attitudinal	- Develop autonomy and responsibility to organise and manage one's own work - Commitment to one's own learning tasks and self-evaluation of what has been achieved - Attention to the relevant regulations and legislation