RESkill4NetZero

Renewable Energy Core VET Curriculum

20/04/2026

RESkill
4NetZero
Boosting Green Energy Careers

Project	ReSkill4NetZero
EC-Grant Agreement	101186624
Program	ERASMUS +
Client	European Education and Culture Executive Agency (EACEA)
Start of the Project	01.12.2024
Duration	48 months
Document Title	**ReSkill4NetZero Communications Strategy & Tools**
Work Package	WP3: Core VET Curriculum & EU Qualifications / Certifications
Deliverable	D3.1: Renewable Energy Core VET Curriculum
Lead Beneficiary	EUREC
Project Coordinator	KIC InnoEnergy
Dissemination Level	**PU — Public**
Authors	Nathalie Richet
Reviewers	Reviewer 1 (InnoEnergy) Lucia Grilli (Schuman Associates) Reviewer 3 (Centre de Compétences Génie Technique du Bâtiment)
Description	Public report
Status	**Final**
Delivery Date	28.05.2026
Due Date:	31.05.2026
Approval Date:	25.05.2026

Revision History			
Version	**Date**	**Modified my**	**Comments**
1	**18.02.2026**	**EUREC**	Initial Draft (Nathalie Richet)
2	**24.04.2026**	**EUREC**	Internal Review (Nicolas de la Vega)
3	**28.04.2026**	**Shuman Associates**	External Review (Lucia Grilli)
4	**12.05.2026**	**InnoEnergy & CDC**	Coordinator & Work Package member Review
6	**28.05.2026**	**InnoEnergy**	Final Version & Upload

Co-funded by the European Union

Legal Disclaimer:

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GLOSSARY

AI: Artificial Intelligence

AM: Additive Manufacturing: Manufacturing process that builds three-dimensional objects layer-by-layer from digital models, often referred to as 3D printing. Used in renewable energy component prototyping and production.

CHP: Combined Heat and Power: CHP systems simultaneously produce heat and electricity, improving efficiency.

CAD: Computer-Aided Design: Software used for creating precise drawings or models of systems and components in engineering and manufacturing.

CENELEC / CEN Standards: European standardisation bodies relevant to energy, safety, and industrial processes, referenced for compliance in vocational curricula.

CE: Circular Economy

CRM: Critical Raw Materials

Digital Twin: Virtual replica of a physical system that integrates real-time data and analytics to monitor, predict, and optimise performance.

DEI: Diversity, Equity and Inclusion

EQF: European Qualifications Framework

GIS: Geographic Information System: Software used for spatial data analysis and mapping, applied in energy-planning and permitting.

HVAC: Heating, Ventilation and Air Conditioning

LCA: Life-Cycle Assessment

Module: Major component of the curriculum comprising several learning units; equivalent to a course or subject area.

O&M: Operation and Maintenance

Performance Standard: Benchmark defining how well a learner must demonstrate competence at each learning level (here basic, intermediate, advanced).

PBL: Project-Based Learning

PLC: Programmable Logic Controller: An industrial digital computer used to automate electromechanical processes such as manufacturing lines or energy systems.

RES: Renewable Energy Sources

SCADA: Supervisory Control and Data Acquisition: System architecture for monitoring and controlling industrial processes, including renewable energy operations.

Systems Thinking: Analytical approach that views energy systems holistically, emphasising interconnections between electricity, heat, mobility, and policy.

Executive Summary

The Renewable Energy (RE) Skills Core VET Curriculum is a flagship deliverable of Work Package 3 (Curriculum Design and Development) within the RESkill4NetZero project, funded by the European Union. It directly supports the objectives of the European Green Deal, REPowerEU Plan, and the Net-Zero Industry Act by contributing to the development of a skilled, future-ready renewable energy workforce capable of driving Europe's clean energy transition. Designed as a modular and interoperable European training framework, the curriculum promotes alignment and cooperation among Vocational Education and Training (VET) providers, higher education institutions, and industrial partners. It enables the design of flexible learning pathways, fully aligned with the European Qualifications Framework (EQF) and suitable for micro-credentials and stackable learning units.

Objectives and scope of the core curriculum

Work Package 3 aims to translate the results of the Skills Strategy and Skills Needs Analysis (conducted under WP2) into a structured, evidence-based curriculum framework for renewable energy skills. Its specific objectives are to:

- Develop a common European competence and learning framework for renewable energy occupations.
- Support upskilling and reskilling of professionals across the renewable energy value chain.
- Foster cross-border recognition and transferability of qualifications.
- Provide the foundation for eight pilot training programmes implemented under RESkill4NetZero.

The Curriculum serves as a strategic reference point for educators, training bodies, companies and policymakers, bridging the gap between labour market needs and training provision across Europe.

Methodological foundation: an evidence-based approach

The curriculum design builds on the skills intelligence gathered in an earlier phase of the project through consultations with industry, education providers, and policy stakeholders. This analysis, building on the challenges and needs assessment already identified in Section 1.2.1 of the RESkill4NetZero Grant Agreement and further developed in Deliverable D2.1 Occupational Profiles and Skills Needs Analysis, identified 13 priority occupational profiles across the renewable energy and industrial ecosystem.

These profiles were mapped against three interconnected skill clusters, forming the backbone of competence development:

- **Technical Skills** – electrical and mechanical engineering, system design and

integration, installation and maintenance.

- **Digital Skills** – automation, SCADA and PLC systems, CAD modelling, data analysis, AI, and digital twins.
- **Transversal Skills** – project management, interdisciplinary collaboration, communication, regulatory literacy, and sustainability.

This tri-cluster approach ensures that future professionals combine technical excellence with digital literacy and systemic thinking — essential for success in the twin green and digital transitions.

Curriculum structure and practical use

The RE Skills Core VET Curriculum is organised as a flexible modular framework, comprising 12 main modules subdivided into learning units with defined outcomes and performance standards across three learning levels: Basic, Intermediate, Advanced.

Core Modules:

1. Introduction to Renewable Energy & Systems Thinking
2. Renewable Energy Engineering & System Design
3. Renewable Energy Technologies (solar, wind, bioenergy, geothermal, etc.)
4. Energy Storage & Batteries
5. Electrical Engineering & Grid Integration
6. Installation Practices
7. Operation & Maintenance of RES Plants
8. Health, Safety & Regulatory Compliance
9. Manufacturing & Industrial Processes
10. Circularity, Recycling & Critical Raw Materials
11. Digitalisation, AI & Emerging Skills
12. Project Management & Transversal Skills

Each module integrates competence-based learning outcomes and EQF-aligned performance standards, allowing institutions to tailor course depth and duration. The framework supports the development of modular, stackable training offers and micro-credential pathways, facilitating lifelong learning and professional mobility.

Learner personas and pedagogical innovation

To demonstrate adaptability, the curriculum includes four learner personas that illustrate distinct learning pathways and occupational contexts. These examples reflect the curriculum's versatility across EQF levels 3–8 and its capacity to support lifelong learning, interdisciplinary collaboration, and innovation-oriented training.

Strategic contribution to European skills policy

The RE Skills Core VET Curriculum contributes directly to the implementation of the European Skills Agenda and supports multiple European Union priorities:

- The Large-Scale Partnership on Renewable Energy Skills under the Pact for Skills;
- The Net-Zero Industry Act, promoting re-skilling for clean-tech industries;

- The EU framework for micro-credentials and learning outcome alignment (EQF, ECVET);
- The strengthening of Europe's industrial competitiveness and strategic autonomy in renewable and net-zero technologies.
- The European Climate Law, including the EU objective of reaching climate neutrality by 2050.

By linking industry needs, educational innovation, and policy objectives, the RE Skills curriculum establishes a shared European reference for renewable energy training, fostering coherence, quality, and mutual recognition across borders.

Expected impact

The Curriculum was refined several times according to feedback loops with industry stakeholders, including re-engagement with experts previously consulted in WP2, to validate that the curriculum reflects current and anticipated needs. This iterative and participatory process ensures that the curriculum remains evidence-based, aligned with industry demand, and complementary to EU and national qualification frameworks.

It will underpin the eight pilot training programmes developed within RESkill4NetZero, each showcasing its adaptability across technologies, occupational levels, and learning contexts. These pilots will provide evidence for national and EU-level recognition, as well as for the integration of modular learning into existing qualifications.

In the longer term, the Curriculum is expected to:

- Build a European modular training offer for renewable energy and green skills.
- Enable mutual recognition and mobility of learners and workers.
- Support job creation, inclusiveness, and industrial resilience in Europe's clean energy sectors.

Conclusion

The Renewable Energy Skills Core VET Curriculum is a strategic output of the RESkill4NetZero project and a tangible contribution to the EU's green and digital skills agenda. It demonstrates how European cooperation can deliver evidence-based, scalable, and policy-aligned training frameworks, ensuring that the transition to a climate-neutral economy is also a skills-based and inclusive transformation. By providing a harmonised, modular, and forward-looking framework, the curriculum strengthens Europe's capacity to develop the human capital essential for achieving Net Zero, thereby reinforcing the Union's leadership in renewable energy innovation, sustainability, and workforce development.

PART 1

1. Introduction

This document presents the Renewable Energy (RE) Skills Core VET Curriculum, developed within the framework of the RESkill4NetZero project. It constitutes a key output of Work Package 3 and translates the outcomes of the Skills Strategy and Skills Needs Analysis (WP2) into a structured, modular curriculum for vocational education and training (VET) providers, higher education institutions, and the RE industry.

The curriculum responds to an urgent structural challenge facing Europe's clean energy transition: the growing gap between labour market demand and the availability of qualified professionals across renewable energy value chains. As deployment targets accelerate under the European Green Deal, REPowerEU Plan, the Net-Zero Industry Act, and the European Skills Agenda, Member States face increasing shortages of technicians, engineers, permitting specialists, manufacturing experts, and digitally skilled energy professionals.

Europe's energy transition is not only a technological transformation, but also fundamentally a skills transformation. The rapid expansion of renewable electricity, electrification of heating and mobility, development of hydrogen and storage technologies, industrial decarbonisation, and circular economy integration require a workforce equipped with:

- Strong technical foundations in renewable energy engineering and operations
- Advanced digital competences, including automation, AI, modelling, and data analytics
- Systems thinking capabilities to manage cross-sector integration
- Regulatory literacy and project management skills
- Sustainability and circular economy expertise

Traditional curricula often address these domains separately. However, the transformation of the energy system demands professionals capable of integrating all domains.

The RE Skills Core VET Curriculum therefore adopts an interdisciplinary and modular structure that reflects the convergence of engineering, digitalisation, sustainability, and regulatory environments. It supports the twin green and digital transitions by embedding digital competences and transversal skills across all technical modules.

The Core Curriculum serves four main purposes:

1. Provide a shared European reference framework for renewable energy competences aligned with the European Qualifications Framework (EQF).
2. Support upskilling and reskilling pathways for workers transitioning from adjacent sectors (e.g., construction, fossil energy, manufacturing).
3. Enable modular, stackable, and micro-credential-based learning, facilitating lifelong learning and cross-border recognition.

4. Bridge industry demand and training provision, ensuring that education systems remain responsive to technological innovation and regulatory evolution.

Rather than prescribing a single rigid programme, the curriculum functions as a flexible architecture. Modules and learning units can be combined, adapted, and contextualised according to national qualification systems, sectoral needs, and institutional delivery models. By offering clearly defined learning outcomes across basic, intermediate, and advanced levels, the curriculum supports multiple learner profiles — from entry-level technicians to advanced engineers and regulatory professionals.

Evidence-Based and Participatory Development

The curriculum is grounded in the comprehensive skills intelligence generated under WP2 and further builds on the challenges and needs analysis already identified during the proposal preparation phase (Grant Agreement, Section 1.2.1). WP2 refined and validated these initial assumptions through stakeholder consultations and occupational profile mapping across the renewable energy ecosystem. It reflects direct input from industry associations, companies, academic institutions, and policy experts across multiple renewable energy technologies.

Its development followed an iterative and participatory methodology, including validation loops with stakeholders to ensure:

- Relevance to real-world operational contexts
- Responsiveness to technological innovation (AI, digital twins, advanced manufacturing, hydrogen systems)
- Alignment with regulatory and safety requirements
- Coherence with EU-level frameworks for micro-credentials and lifelong learning

This evidence-based foundation ensures that the curriculum is not only academically robust, but also practically applicable and industry-endorsed.

Structure of the Document

Part 1 of this report outlines the methodological foundations, scope, and architecture of the Core Curriculum, including learner personas illustrating practical learning pathways.

Part 2 presents the detailed module structure, learning units, performance standards, and learning outcomes organised across three progression levels.

Together, these sections establish a coherent, adaptable, and forward-looking framework designed to strengthen Europe's renewable energy workforce and contribute to a competitive, inclusive, and climate-neutral economy. The certifications and qualifications associated with the curriculum are developed in a separate document, D3.2, to be published at the same moment[1].

[1] RESkill4NetZero results are available here: https://reskill4net-zero.eu/results/

2. Summary of the Inputs from Skills Strategy and Skills Needs Analysis

2.1. Occupational profiles

The curriculum development builds directly on evidence gathered through WP2, which identified 13 priority occupational profiles across the renewable energy and industrial ecosystem:

- Energy Engineers
- Industrial Engineers
- Renewable Energy Technicians (wind/solar/geothermal/heat pumps)
- Factory Operatives / Maintenance Technicians
- Industrial Electricians
- Planners
- Renewable Energy Consultants
- Health and Safety Professionals
- HVAC and Refrigeration Technicians
- Renewable Energy Power Plant Operators
- Electricians (Domestic)
- Gas Technicians (biogas/hydrogen)
- Critical Raw Material Recovery Specialists.

2.2. Skill Clusters

These profiles were mapped against three core skill clusters, representing the foundation of competence development across technologies and roles:

Technical Skills

- Electrical and mechanical engineering
- Energy system design and integration
- Fluid dynamics and thermodynamics
- Installation and maintenance protocols

Digital Skills

- Programming (Python, PLCs)
- Data analysis
- SCADA and industrial control systems
- CAD and simulation tools

Transversal Skills

- Project management
- Interdisciplinary teamwork
- Communication and stakeholder engagement
- Regulatory literacy and standards compliance

The selection of these clusters reflects the clear finding that future energy professionals must integrate technical proficiency with digital literacy and cross-sectoral collaboration skills.

2.3. Key insights from Deliverables 2.1and 2.2

Key insights drawn from Deliverable 2.1, *Occupational Profiles and Needs Analysis*[2], further highlight the rationale behind this approach:

"The gap between industry needs and formal training provision is particularly acute in areas where digital and technical domains intersect. Stakeholders repeatedly emphasised the need for engineers and technicians who are not only competent in their traditional domains but are also digitally literate and systems oriented."

"Current training provision often focuses too narrowly on traditional systems, without sufficiently preparing learners for hybrid, digital, and cross-sectoral realities."

These conclusions reinforce the decision to structure the curriculum around three interlinked skill domains, ensuring comprehensive preparation for the green and digital transitions.

The forward-looking analysis conducted in WP2 identified three main drivers of evolving skills demand:

- Technological innovation, notably in AI, digitalisation, additive manufacturing, and hydrogen technologies.
- Regulatory tightening, requiring enhanced expertise in compliance, safety management, and environmental monitoring.
- Economic transformation, driven by localisation, industrial decarbonisation, and circular economy integration.

As a result, new hybrid roles are emerging that combine technical depth with systemic understanding—such as Energy Transition Strategists, Circular Economy Specialists, and Cross-Carrier Energy Planners—complementing traditional engineering and operational positions.

The analysis concludes that:

"Future workers will need to combine technical depth with strategic foresight, digital literacy with system-level thinking, and specialised expertise with interdisciplinary flexibility." Accordingly, targeted enhancements in course content and delivery methodologies are essential to prepare Europe's renewable energy workforce for these evolving requirements.

The Skills Strategy developed under WP2 also highlighted the importance of creating interoperable and modular learning pathways capable of responding rapidly to technological evolution and labour market transformation. Particular emphasis was placed on micro-credentials, lifelong learning approaches, and stronger collaboration between industry, VET providers, and higher education institutions. The

[2] https://reskill4net-zero.eu/results/

strategy further stressed the need to anticipate future hybrid occupations combining engineering, digitalisation, sustainability, and regulatory competences.

3. RE Skills Core VET Curriculum Scope and Methodology

3.1. Scope

The scope of the RE Skills VET Curriculum is to provide an adaptable and interoperable training framework that addresses the skills needs identified through WP2. The curriculum is designed to support multiple user groups—including VET providers, higher education institutions, and industry training centres—allowing each to select, combine, and tailor learning units to meet their specific needs and national or sectoral contexts.

Within the RESkill4NetZero project, the curriculum serves as the foundation for developing eight pilot training programmes, each demonstrating the adaptability of the proposed modules to different occupational levels and technological domains. Methodological steps followed in the curriculum design include:

- Detailed analysis of occupational profiles and skills requirements, as defined in the Skills Strategy (WP2). See table with ESCO skills and associated learning outcomes (annex 1).
- Identification and prioritisation of curricula addressing the needs of the pilot trainings and existing gaps in EU-level VET provision for renewable energy skills.
- Definition of modules, learning outcomes, and associated materials forming the structure of the curriculum.
- Feedback loops with industry stakeholders, including re-engagement with experts previously consulted in WP2, to validate that the curriculum reflects current and anticipated needs.

Unlike traditional technology-specific curricula, the RESkill4NetZero Core VET Curriculum adopts a cross-sector and systems-oriented approach integrating technical, digital, regulatory, and sustainability competences within a single modular architecture. This reflects the increasing convergence between renewable energy technologies, electrification, digitalisation, and circular industrial systems.

3.2. Alignment with industry needs

This iterative and participatory process ensures that the curriculum remains evidence-based, aligned with industry demand, and complementary to EU and national qualification frameworks. The validation phase included a structured consultation process with key stakeholders representing different segments of the renewable energy ecosystem.

Stakeholder Consultation and Representativeness

A total of 14 formal responses were received through the validation questionnaire (see Annex 2 and 3 for the questionnaire template and aggregated responses). The validation consultation was conducted between February and April 2026 through a structured online questionnaire distributed to members of the RESkill4NetZero Advisory Board, industry associations, academic partners, and selected external experts previously engaged during WP2 activities. The consultation aimed to validate the relevance, completeness, modular structure, and learning-level progression of the proposed curriculum framework. Respondents were invited to assess the adequacy of the thematic coverage, the balance between technical, digital, and transversal skills, and the alignment with evolving labour market needs. Contributors included:

- 2 Advisory Board members
- 10 Industry associations representing multiple renewable energy technologies
- 1 External university
- 1 Skills specialist from InnoEnergy

The feedback represents a broad cross-section of the renewable energy value chain, including electricity, heating and cooling, manufacturing, grid integration, and skills development actors. Importantly, no negative feedback was received regarding the overall concept, structure, or relevance of the curriculum. Respondents expressed strong support for:

- The modular and flexible architecture
- The integration of technical, digital, and transversal skills
- The alignment with EU policy objectives
- The inclusion of performance standards across learning levels

This confirms the robustness of the curriculum design and its relevance across technologies and occupational levels. While overall endorsement was high, several constructive recommendations were made to further strengthen the framework: associations representing the heating and cooling sector highlighted the importance of reinforcing: sector coupling approaches (electricity–heat–mobility integration), thermal storage technologies and broader coverage of renewable thermal technologies. These suggestions reinforce the importance of cross-carrier system integration and have informed the strengthening of relevant modules (notably Modules 3, 4, and 6). Other stakeholders noted that certain subsectors are experiencing acute labour shortages and suggested expanding content depth in selected high-demand technology areas and strengthening links between curriculum modules and rapidly scaling industrial segments. This feedback confirms the need for adaptable module depth depending on national and sectoral priorities. Greater emphasis was recommended on building renovation, energy efficiency integration and retrofitting practices. This aligns with EU climate targets and the Renovation Wave strategy, suggesting possible further integration between renewable deployment and energy performance upgrades in buildings. It was also suggested that additional visibility could be given to the upskilling of electricians. In response, attention was given to reinforcing the clarity of learning pathways at EQF levels 3–5, particularly within Modules 5 (Electrical Engineering & Grid Integration) and 6 (Installation Practices).

Stakeholders also provided feedback on the illustrative learner personas: the presence of two technical profiles was initially questioned. After review, both were retained, as they represent distinct technologies and EQF levels. A less purely technical profile was recommended to demonstrate stronger use of transversal and regulatory competences (Module 12). This has been addressed through the inclusion of the Renewable Energy Permitting Officer pathway.

The aggregated responses (see Annex 3) indicate high stakeholder confidence in the curriculum structure, thematic coverage, and competence-based approach. No structural redesign was required. Instead, the feedback led to targeted refinements, including strengthened visibility of thermal and sector-coupling dimensions, clarified electrician and installation pathways, reinforced links to building renovation and energy efficiency and improved articulation of advanced academic pathways.

The first outline of the curriculum as well as the learner persona pathways were also presented during the first open dialogue of the RESkill Alliance, held in Brussels on 19 November 2025. 10 projects sharing similar goals on skills development in the energy sector were invited to share their methodology and insights on curriculum design. Our methodology and first results were positively received.

As next steps, the curriculum will continue to evolve through implementation feedback from the eight pilot training programmes under RESkill4NetZero. These pilots will provide practical validation across technologies, learner profiles, and delivery formats, ensuring continuous improvement and long-term scalability.

4. Core Curriculum Structure and How to Use the Document

4.1. Terminology and Framework Alignment

The curriculum is organised into a modular structure, where each module consists of several learning units corresponding to defined learning outcomes at three levels: Basic, Intermediate, and Advanced. This design enables flexibility in delivery—allowing trainers and institutions to adapt depth, scope, and duration according to learner profiles and programme objectives. To ensure clarity and consistency across different educational contexts, the document distinguishes how terms such as “programme”, “module”, and “unit” are used in various systems:

Modules are composed of different learning units, with different levels of learning outcomes.

Clear mapping of how “course” and “module” are used in different contexts:

1. European / UK Higher Education (Bologna Framework)

Programme → e.g., MSc in Renewable Energy

Modules → these are the main building blocks of the degree. Each module is worth a specific number of

ECTS credits (e.g. Wind Energy Systems, 10 ECTS).

Units / Topics → subdivisions of a module (lectures, labs, seminars).

Here, a programme is composed of modules, not courses.

2. US Higher Education

Degree Programme → e.g., Bachelor of Science in Mechanical Engineering

Courses → the building blocks (e.g., Thermodynamics I).

Lessons / Topics → subdivisions of a course.

Here, a programme is composed of courses, not modules.

3. Online Learning Platforms (Coursera, edX, Udemy, LinkedIn Learning)

Specialisation / Learning Path → e.g., Hydrogen Technologies Specialisation.

Courses → the main unit offered to learners (e.g., Hydrogen Storage).

Modules (or "weeks") → subdivisions of a course (e.g., Safety Aspects, Storage Methods).

Here, a course is composed of modules.

4. Vocational Training / Micro-Credentials

Qualification Framework / Certificate → e.g., Level 5 Diploma in Energy Systems.

Units / Modules → defined components aligned with learning outcomes.

Lessons / Assessments → smaller components.

Often modules or units are the building blocks but sometimes called "courses" if delivered separately.

CONCLUSIONS: based on the Bologna Framework[3], we will use the term 'Module' for the main block and 'learning units' as subdivisions of the modules. The Level Performance Standard and level learning objectives will be developed inside each learning unit. Duration and guidelines for certification will be based on the learning units, which can be mixed and matched to produce tailor-made courses.

4.2 Learning Levels

To ensure clarity, progression, and alignment with European qualification frameworks, the RE Skills Core VET Curriculum is structured across three learning levels: Basic, Intermediate, and Advanced. These levels reflect increasing depth of knowledge, complexity of skills, degree of autonomy, and responsibility in professional contexts.

The levels are designed to be adaptable across EQF levels 3–8 depending on the learner profile, occupational role, and institutional context.

[3] https://education.ec.europa.eu/education-levels/higher-education/inclusive-and-connected-higher-education/bologna-process

Basic Level – Knowledge & Awareness

Focus: Knowledge acquisition, understanding of core concepts, and structured task execution under supervision.

At the basic level, learners are expected to:

- Recall and describe fundamental concepts, terminology, and processes
- Identify components, technologies, and regulatory frameworks
- Explain principles in clear and structured terms
- Perform routine tasks following established procedures
- Operate under guidance or supervision

This level corresponds to introductory or awareness-based learning and is particularly relevant for: entry-level technicians, workers transitioning from adjacent sectors, professionals requiring foundational cross-technology understanding. It reflects structured work situations with limited autonomy but increasing familiarity with sector-specific practices.

Intermediate Level – Application & Analysis

Focus: Practical implementation, problem-solving, system interaction, and independent task execution.

At the Intermediate level, learners are expected to:

- Apply technical knowledge in real or simulated environments
- Analyse system performance and identify causes of malfunction
- Use digital tools and diagnostic instruments
- Compare alternative solutions and justify technical decisions
- Manage small projects or defined work packages
- Work independently within established frameworks

This level represents hands-on competence and operational responsibility. It is particularly relevant for skilled technicians and supervisors, applied engineers, regulatory and permitting professionals, professionals integrating digital tools into technical work. Learners demonstrate increased autonomy, responsibility, and the ability to supervise routine technical operations.

Advanced Level – Evaluation, Optimisation & Creation

Focus: Strategic thinking, innovation, system design, leadership, and decision-making under complexity.

At the Advanced level, learners are expected to:

- Evaluate complex technical, regulatory, and economic scenarios
- Design optimised systems integrating multiple technologies
- Develop innovative solutions using digital tools and AI

- Lead teams or multi-stakeholder projects
- Critically assess policies, sustainability impacts, and long-term trade-offs
- Take responsibility for strategic decisions and continuous improvement

This level reflects expertise that goes beyond technical execution toward system integration, governance, and innovation. It is particularly relevant for senior engineers, project managers, regulatory strategists, advanced manufacturing specialists, researchers and innovation professionals.

This level reflects high autonomy, accountability, and leadership in unpredictable and complex environments.

The three levels are cumulative rather than isolated. The basic level provides foundational understanding, the intermediate one builds operational competence and independent application and the advanced enables system-level integration, innovation, and leadership. Not all learners are expected to reach advanced level in every module. Instead, learning pathways are designed to allow vertical progression (deepening expertise) or horizontal generalisation (expanding across technologies or functions).

This structure ensures flexibility for modular delivery, compatibility with micro-credentials, adaptability across VET, higher education, and professional training contexts and clear mapping to occupational roles and career progression.

5. Learner persona

In order to illustrate how to use the curriculum, we are providing the following learning pathways for 4 potential learner personas.

- Wind turbine technician
- Biogas engineer
- Renewable Energy Permitting Officer
- Renewable Energy Master student

These four examples represent a technical and maintenance pathway, an applied engineering pathway, a transversal role through all RE technologies and finally a research and innovation pathway. They allow understanding of how to combine learning units of different levels according to the individual learning objectives. Indicative durations represent cumulative learner workload across stackable micro-credentials and associated assessments, aligned with the certification framework developed in Deliverable D3.2.

5.1 Wind Turbine Technician (Technical & Maintenance Pathway)

Profile: Vocational learner or upskilled worker employed in wind farm operation and maintenance, aiming to expand skills in digital diagnostics, safety, and sustainability.

Learning Objective: Strengthen technical expertise in wind energy systems with updated digital tools, safety protocols, and cross-technology understanding.

Learning Path:

Learning Stage	Learning Units	Suggested Learning Mode
Core Foundation	1.2: Renewable Energy Overview 3.2: Wind energy Wind turbine systems (mechanics, control, aerodynamics) 8.1: Workplace Safety	Face-to-face / Practical
Technology Specialisation: Wind	3.2: Wind energy Maintenance diagnostics & predictive systems 7.1 – O&M Protocols	On-site & Simulator
Digital & AI Tools	1.1: Digital Skills Digital twins for wind farms	Blended
Cross-Technology Awareness	4.2: Batteries 4.1: Role of Renewable Energy Storage 5.1: Power Systems (Grid integration basics)	Online / Modular
Green & Career Skills	10.2: Circularity (and end-of-life turbine materials) 12.2: Teamwork & communication	Workshop

Table 1: *Wind turbine technician learning path*

Indicative cumulative workload (pathways are composed of multiple stackable micro-credentials): 120–180 hours depending on prior experience and practical training requirements.

Outcome: RE Core VET Certificate (Intermediate Level) – Modular stack leading to recognition under EQF Level 3–5, aligned with European Technician profiles.

5.2 Biogas Engineer (Applied Engineering Pathway)

Profile: Professional engineer managing biogas plant design and operation, seeking to integrate digital process optimisation, safety, and sustainability concepts.

Learning objective: Deepen system-level understanding, integrate AI and automation, and align with circular economy and decarbonisation objectives.

Learning Path:

Learning Stage	Modules / Units	Suggested Learning Mode
Core Foundation	5.1: Power Systems 1.1: Energy policy, 2.3: Regulation & Permitting 8.1: Workplace Safety	Online / Self-paced
Technology Specialisation:Biogas & Bioenergy	3.3 – Bioenergy & CHP (Anaerobic digestion process design / Biomass feedstock logistics/ Safety and emissions control)	Face-to-face / Lab-based
Digital & Process Optimisation	5.2: Automation & Control (SCADA) 11.1: AI for process control and predictive maintenance 3.3: Digital twins in biogas operations 7.2: Plant Operation	Blended
Sustainability & Circularity	3.3: Resource efficiency and waste valorisation 10.3: Life Cycle Assessment (LCA) 10.4 – Policies and regulations for circularity in the EU	Online
Leadership & Project Management	12.1: Energy project management tools (Stakeholder engagement) 12.3 : Gender & inclusivity in energy projects	Hybrid

***Table 2:** Biogas engineer learning path*

Indicative cumulative workload (pathways are composed of multiple stackable micro-credentials): 180–250 hours including laboratory and applied project work

Outcome: *RE Core VET Certificate (Advanced Practitioner Level)* – Modular route aligned with EQF Level 6 (engineer level), stackable towards continuous professional development credits.

5.3. Renewable Energy Permitting Officer

Profile: Professional working within local, regional, or national permitting authorities, public administrations, or regulatory agencies. Responsible for assessing, approving, and monitoring renewable energy projects (e.g. wind, solar, storage, grid infrastructure), ensuring compliance with environmental, technical, and safety regulations. May come from an engineering, environmental science, planning, or legal background and requires up-to-date technical and system-level understanding of renewable energy technologies.

Learning Objective: Strengthen technical and systems understanding of renewable energy projects to improve permitting efficiency, regulatory decision-making, and alignment with EU climate, energy, and circular economy policies.

Learning Path

Learning Stage	Learning Units	Suggested Learning Mode
Core Foundation: Energy Systems & Policy Context	1.1: Energy Transition & EU Energy Policy 1.2: Renewable Energy Overview 1.3: Systems Thinking	Online / Self-paced
Regulation, Permitting & Compliance	2.3: Regulation & Permitting 8.2: Regulatory Compliance 8.1: Workplace Safety (contextual awareness)	Online / Workshop-based
Technology Awareness (Cross-Technology)	3.1–3.6: Renewable Energy Technologies (overview level) 4.1: Role of Renewable Energy Storage 5.1: Power Systems (grid integration basics)	Modular / Online
Environment & Circularity	10.1: Circular Economy Principles 10.3: Assessment Methodologies & KPIs (LCA basics) 10.4: EU Policies & Regulations for Circularity	Online / Case-based
Digital & Decision-Support Skills	11.1: Digital Skills (data interpretation, dashboards) Digital tools for permitting, spatial planning, and impact assessment	Blended
Project Planning & Stakeholder Engagement	12.1: Project Management & Planning (permitting timelines, coordination) 12.2: Communication & Stakeholder Engagement	Workshop / Simulation

Table 3: *Renewable Energy Permitting Officer Learning Path*

Indicative cumulative workload (pathways are composed of multiple stackable micro-credentials): 80–140 hours depending on regulatory specialisation and case-study activities

Outcome: *RE Core VET Certificate (Intermediate–Advanced Level)* – Modular recognition aligned with EQF Level 5–7, supporting improved regulatory capacity, faster permitting processes, and evidence-based decision-making for renewable energy projects.

5.4. Renewable Energy Master Student (Research & Innovation Pathway)

Profile: Advanced academic learner, conducting applied research on renewable systems integration and AI-based energy optimisation. Interested in complementing research expertise with practical, cross-sector and digital skills relevant to innovation projects.

Learning objective: Bridge academic research with real-world energy transition challenges; strengthen interdisciplinary, digital, and entrepreneurial competencies.

Learning path:

Learning Stage	Learning units	Suggested Learning Mode
Core Foundation (contextual refresh)	1.2: RE Overview (cross-technology) 1.1: EU Energy Transition and Policy 10.2: Recycling and Recovery	Online / Self-paced
Digital & AI for Energy Systems	1.1: Digital Skills 11.1: Apply AI for optimisation Cybersecurity in energy data	Blended (MOOC + workshop)
Innovation & Entrepreneurship	12.2: Professional Skills 12.1: Project skills (Horizon Europe & funding landscape)	Workshop / Case study
Applied Research Integration	Short internship with industry or RTO Collaborative innovation project	Project-based
Green & Ethical Skills	12.2: Ethics of AI & sustainability Gender equality in energy R&I	Online / Discussion-based

Table 4: Renewable Energy Master Student learning path

Indicative cumulative workload (pathways are composed of multiple stackable micro-credentials): 60–120 hours combined with research or internship activities.

Outcome: *RE Core VET Certificate (Advanced Level)* – Recognised micro-credentials that complement PhD-level research training, improving employability in innovation-driven energy roles.

Suggested EQF levels :

Learner Profile	EQF Level	Focus	Learning Mode	Key Outcome
Wind Turbine Technician	3–5	Maintenance, digital tools, safety	Practical & blended	Skilled technician with digital upgrade
Biogas Engineer	6	Process design, digitalisatio n, circularity	Blended / applied	Green engineer with cross-sector digital skills
Renewable Energy Permitting Officer	5-7	Regulation, systems understanding, policy implementation	Online and blended	Technically informed permitting authority enabling faster, higher-quality RES project approvals
Renewable Energy Master Student	7	R&I, AI, innovation	Hybrid acade mic industry	Research-driven RE & AI competence

Table 5: *EQF levels for the learner personas pathways*

6. Core Curriculum table of content

Module 1. Introduction to Renewable Energy & Systems Thinking

- Learning Unit 1.1 – Energy Transition & Policy
- Learning Unit 1.2 – Renewable Energy Overview
- Learning Unit 1.3 – Systems Thinking

Module 2. Renewable Energy Engineering & System Design

- Learning Unit 2.1 – Principles of Renewable Energy Engineering
- Learning Unit 2.2 – Digital Design Tools
- Learning Unit 2.3 – Regulations, Permitting & Financial Frameworks

Module 3. Renewable Energy Technologies

- Learning Unit 3.1 – Solar PV

- Learning Unit 3.2 – Wind Energy
- Learning Unit 3.3 – Bioenergy & CHP
- Learning Unit 3.4 – Geothermal, Hydro & Ocean
- Learning Unit 3.5 – Renewable Heat
- Learning Unit 3.6 - Innovative cutting-edge technologies (PVT, ice storage, PCMs etc.)

Module 4. Renewable Energy Storage & Batteries

- Learning Unit 4.1 – Role of Renewable Energy Storage
- Learning Unit 4.2 – Battery Energy Storage Systems (BESS)
- Learning Unit 4.3 - Battery Systems for Mobility Applications (EV & Integration)
- Learning Unit 4.4 – Thermal, Hydrogen and Hybrid Storage Systems
- Learning Unit 4.5 – Green Hydrogen Systems (Production, Storage & Power-to-X)

Module 5. Electrical Engineering & Grid Integration

- Learning Unit 5.1 – Power Systems
- Learning Unit 5.2 – Automation & Control

Module 6. Installation Practices

- Learning Unit 6.1 – Safe Installation
- Learning Unit 6.2 – Heat Pumps & HVAC

Module 7. Operation & Maintenance (O&M) of RES Plants

- Learning Unit 7.1 – O&M Protocols
- Learning Unit 7.2 – Plant Operation

Module 8. Health, Safety & Regulatory Compliance

- Learning Unit 8.1 – Workplace Safety
- Learning Unit 8.2 – Regulatory Compliance

Module 9. Manufacturing & Industrial Processes

- Learning Unit 9.1 – Manufacturing Basics
- Learning Unit 9.2 – Quality assurance and Quality Control

Module 10. Circularity, Recycling & Critical Raw Materials

- Learning Unit 10.1 – Circular Economy

- Learning Unit 10.2 – Recycling and Recovery
- Learning Unit 10.3 – Assessment methodologies and KPIs
- Learning Unit 10.4 – Policies and regulations for circularity in the EU

Module 11. Digitalisation, AI & Advanced Manufacturing

- Learning Unit 11.1 – Digital Skills
- Learning Unit 11.2 – Digital Manufacturing & Advanced Production

Module 12. Project Management, Planning & Transversal Skills

- Learning Unit 12.1 – Project Skills
- Learning Unit 12.2 – Professional Skills
- Learning Unit 12.3 – Lifelong Learning & Inclusion

PART 2

Module 1. Introduction to Renewable Energy & Systems Thinking

a-Learning Objectives

Learners will be able to explain the European Union's energy transition goals and outline the key pathways to achieving net-zero emissions in line with European Union policies, to identify the main renewable energy technologies and describe how they integrate into modern energy systems and to apply systems-level thinking to analyse cross-sector connections between electricity, heating, and transport from an interdisciplinary perspective.

b-Learning Units and associated Learning Outcomes

Learning Unit 1.1 – Energy Transition & Policy

- Basic: Describe EU climate goals and basic renewable energy targets.
- Intermediate: Explain how EU net-zero pathways affect different sectors (power, heating, transport).
- Advanced: critically apply EU and global policy framework in energy transition projects, from a system perspective.

Basic Level Performance Standard: Can clearly state the EU's climate goals and renewable energy targets when asked and explain why they are important.

Basic Level Learning Objectives:

1. Identify EU climate goals and renewable energy targets to explain their relevance to your role in the energy sector
2. Summarise in plain language how EU net-zero goals influence daily business decisions in your role

Intermediate Level Performance Standard: Can explain how EU net-zero policies affect different sectors

Intermediate Level Learning Objectives:

1. Explain how EU climate goals and renewable energy targets impact major renewable energy industry sectors
2. Explain in detail why EU climate goals and policy are instrumental to success in the sector

Advanced Level Performance Standard: Can critically apply EU and global policy frameworks from a system perspective.

Advanced Level Learning Objectives:

1. Analyse EU and global policy frameworks to identify gaps or contradictions
2. Develop processes and procedures at different levels that align with EU global energy transition goals

Learning Unit 1.2 – Renewable Energy Overview

- Basic: Identify major renewable energy technologies and describe their basic operating principles and applications
- Intermediate: Compare RETs and analyse their advantages, limitations, and system integration challenges
- Advanced: Evaluate optimal technology mixes for an energy system under different regulatory and market scenarios.

Basic Level Performance Standard: Can identify major renewable energy technologies and describe their basic operating principles and applications.

Basic Level Learning Objectives:

1. Identify solar, wind, hydro, bioenergy, and geothermal technologies.
2. Describe their basic operating principles.
3. Recognise typical applications (residential, commercial, utility-scale).

Intermediate Level Performance Standard: Can compare renewable technologies and analyse their advantages, limitations, and system integration challenges.

Intermediate Level Learning Objectives:

1. Compare technical and economic advantages of major RES technologies.
2. Analyse limitations such as intermittency and site constraints.
3. Explain grid integration challenges.

Advanced Level Performance Standard: Can evaluate optimal technology mixes within an energy system under different regulatory and market scenarios.

Advanced Level Learning Objectives:

1. Analyse trade-offs between cost, reliability, and emissions reduction.
2. Evaluate hybrid system configurations.
3. Assess deployment strategies under varying policy scenarios.

Learning Unit 1.3 – Systems Thinking

- Basic: Identify and describe interconnections between electricity, heating, and mobility.
- Intermediate: Apply systems thinking to analyse cross-sector integration cases (e.g., renewable electricity integrated with district heating, thermal storage, electric mobility, and hydrogen systems).
- Advanced: Build quantitative or simulation-based models to analyse sector coupling strategies

(electricity–heat–mobility–hydrogen), assessing impacts on grid stability, energy security, cost-efficiency, and emissions reduction

Basic Level Performance Standard: Can recognise interconnections between electricity, heating, and transport systems.

Basic Level Learning Objectives:

1. Identify sector coupling examples (e.g., EV charging, heat pumps).
2. Describe how energy flows between sectors.
3. Explain the concept of integrated energy systems.

Intermediate Level Performance Standard: Can apply systems thinking to analyse cross-sector integration cases.

Intermediate Level Learning Objectives:

1. Analyse real-life sector coupling case studies.
2. Explain interactions between renewable electricity and thermal storage.
3. Assess benefits and constraints of cross-sector integration

Advanced Level Performance Standard: Can build and evaluate quantitative models of sector coupling strategies.

Advanced Level Learning Objectives:

1. Develop simulation-based models of electricity–heat–mobility integration.
2. Assess impacts on grid stability and emissions.
3. Evaluate cost-efficiency and energy security implications.
4. Evaluate social acceptance, possible resistance and legal implications

Module 2. Renewable Energy Engineering & System Design

a-Learning Objectives

Learners will be able to describe the principles of renewable energy engineering, to use digital tools (CAD, modelling, simulation) to design energy systems, to design hybrid and cross-carrier systems for optimised energy integration and summarise regulatory and permitting requirements for project design.

b-Learning Units and associated Learning Outcomes

Learning Unit 2.1 – Principles of Renewable Energy Engineering

- Basic: Explain core engineering principles
- Intermediate: Analyse small-scale RE systems
- Advanced: Optimise complex hybrid systems

Basic Level Performance Standard: Can explain core engineering principles such as energy balance and efficiency and apply them conceptually to simple systems.

Basic Level Learning Objectives: Describe fundamental engineering concepts (energy balance, efficiency).

1. Define energy conservation and describe its role in engineering systems.
2. Recognise and describe what efficiency means in engineering.
3. List common ways to improve energy efficiency in engineering applications.

Intermediate Level Performance Standard: Can analyse and design small-scale renewable systems using fundamental engineering principles.

Intermediate Level Learning Objectives: Apply engineering principles to small-scale renewable systems.

1. Analyse and design small-scale renewable energy systems using fundamental engineering principles such as energy conservation and efficiency.
2. Evaluate the performance and efficiency of small-scale renewable energy systems through the application of engineering concepts and techniques.

Advanced Level Performance Standard: Can optimise hybrid systems using advanced modelling and simulation tools.

Advanced Level Learning Objectives: Optimise complex hybrid systems using simulation and modelling.

1. Develop and implement advanced simulation models to accurately represent the dynamic behavior of complex hybrid systems, incorporating both continuous and discrete event processes.
2. Apply optimisation algorithms to enhance the performance and efficiency of hybrid systems, utilising simulation results to identify optimal configurations and operational strategies.

Learning Unit 2.2 – Digital Design Tools

- Basic: Apply dimensioning, annotations and interpret simple engineering drawings
- Intermediate: Develop and validate system models using simulation softwares
- Advanced: Develop digital twin models and implement AI-driven optimisation.

Basic Level Performance Standard: Can create simple 2D layouts using CAD tools with correct dimensions and annotations.

Basic Level Learning Objectives:

1. Create basic 2D sketches using CAD software.
2. Apply dimensioning and annotations to simple layout designs in CAD tools

Intermediate Level Performance Standard: Can develop and validate system models using simulation software.

Intermediate Level Learning Objectives: Develop system models with simulation software.

1. Demonstrate the ability to create and validate a basic system model using simulation software, including setting up initial conditions, defining parameters, and interpreting results.
2. Apply techniques to optimise system performance through simulation software by adjusting model parameters and analysing the impact of different scenarios on system behavior.

Advanced Level Learning Objectives: Integrate digital twins and AI-driven optimisation of system (design).

1. Develop and implement a comprehensive digital twin model that accurately represents the physical system, incorporating real-time data integration and predictive analytics to enhance system performance and reliability.
2. Design and execute AI-driven optimisation algorithms within the digital twin framework to achieve optimal system design parameters, improving efficiency, reducing costs, and ensuring scalability for future enhancements.

Learning Unit 2.3 – Regulations, Permitting & Financial Frameworks

- Basic: Describe key permitting steps and documentation.
- Intermediate: Summarise regulatory and financial frameworks
- Advanced: Analyse permitting barriers and develop regulatory strategies

Basic Level Performance Standard: Can identify key permitting steps and documentation requirements.

Basic Level Learning Objectives: Identify general permitting requirements at local or national level.

1. Understand the basic steps involved in obtaining a general permit.
2. Recognise the key documents and information required for a general permit application.

Intermediate Level Performance Standard: Can summarise regulatory and financial frameworks influencing project design.

Intermediate Level Learning Objectives: Summarise national/EU regulatory frameworks for project design.

1. Identify and explain the key components of national and EU regulatory frameworks that impact

project design.

2. Compare and contrast the differences between national regulations and EU directives in terms of their application to project design.

3. Analyse permitting and regulatory requirements for building-integrated renewable systems and renovation projects under national and EU frameworks (e.g., EPBD)

4. Explain EU Emissions Trading System (EU ETS) and its impact on renewable energy investment.

5. Compare subsidy structures (feed-in tariffs, Contracts for Differences, investment grants).

6. Analyse financial viability of renewable projects under different regulatory schemes

Advanced Level Learning Objectives: Analyse permitting barriers and propose strategies for streamlining

1. Critically evaluate the impact of regulatory frameworks on permitting processes at different levels and identify key barriers that hinder efficiency.
2. Develop and justify innovative strategies to streamline permitting procedures, incorporating best practices from successful case studies and emerging technologies.
3. Develop financial assessments incorporating carbon pricing, subsidy schemes, and market mechanisms.
4. Evaluate business models and integrate regulatory, financial, and technical constraints into project design decisions

Module 3. Renewable Energy Technologies

a-Learning Objectives

Learners will be able to learn about major RES technologies: solar PV, wind, bioenergy, geothermal, and hydro, to distinguish between rooftop and utility-scale PV and outline basic manufacturing steps. They will be able to analyse onshore and offshore wind systems, including turbine, blade, and tower technologies and explain principles of bioenergy, biogas, and combined heat and power (CHP). They will explore geothermal, heat pump, hydro, and emerging ocean energy applications.

b- Learning Units and associated Learning Outcomes

Learning Unit 3.1 – Solar PV

- Basic: Differentiate rooftop vs utility-scale systems.
- Intermediate: Outline basic PV manufacturing steps and efficiency factors.
- Advanced: Assess integrated PV system performance and optimisation.

Basic Level Performance Standard: Can distinguish between rooftop and utility-scale PV systems and explain their basic components and applications

Basic Level Learning Objectives:

1. Identify key components of a PV system (modules, inverter, mounting, meter).
2. Differentiate rooftop and utility-scale PV systems.
3. Describe basic electricity generation principles in PV cells.
4. Recognise typical installation environments and use cases.

Intermediate Level Performance Standard: Can explain PV manufacturing steps and analyse efficiency factors.

Intermediate Level Learning Objectives:

1. Outline silicon PV manufacturing steps (ingot, wafer, cell, module).
2. Explain factors affecting PV efficiency (temperature, shading, angle).
3. Interpret module datasheets.
4. Compare mono- vs polycrystalline technologies

Advanced Level Performance Standard: Assess integrated PV system performance and optimisation

Advanced Level Learning Objectives:

1. Evaluate the performance of integrated PV systems by analysing real-world operational data, including energy yield, system losses, and efficiency metrics.
2. Diagnose and quantify performance limitations in PV systems (e.g. shading, inverter inefficiencies, thermal losses, and grid interaction issues) using advanced analytical tools and methodologies.
3. Design and justify optimisation strategies for integrated PV systems, incorporating technical, economic, and environmental considerations to improve overall system performance.

Learning Unit 3.2 – Wind Energy

- Basic: Identify components of onshore/offshore turbines.
- Intermediate: Explain mechanical/electrical operation of wind systems.
- Advanced: Model offshore wind farm integration with grid/storage systems.

Basic Level Performance Standard: Can identify main components of onshore and offshore wind turbines.

Basic Level Learning Objectives:

1. Identify turbine components (blade, nacelle, tower, gearbox).
2. Differentiate onshore and offshore installations.
3. Describe how wind energy is converted into electricity

Intermediate Level Performance Standard: Can explain the mechanical and electrical operation of wind systems.

Intermediate Level Learning Objectives:

1. Explain aerodynamic lift principles.
2. Describe gearbox and generator operation.
3. Interpret basic wind resource assessments

Advanced Level Performance Standard: Can model wind farm integration with grid and storage systems

Advanced Level Learning Objectives:

1. Analyse offshore wind farm grid connection requirements.
2. Model integration with battery or hydrogen storage.
3. Evaluate curtailment and grid stability issues.

Learning Unit 3.3 – Bioenergy & CHP

- Basic: Describe principles of biomass conversion.
- Intermediate: Operate biogas/CHP systems under supervision.
- Advanced: Design optimised bioenergy projects with circular economy principles.

Basic Level Performance Standard: Can describe biomass conversion processes.

Basic Level Learning Objectives:

1. Explain combustion, anaerobic digestion, and gasification.
2. Identify feedstock types.
3. Describe CHP concept.

Intermediate Level Performance Standard: Can operate biogas/CHP systems under supervision.

Intermediate Level Learning Objectives:

1. Monitor digester parameters.
2. Explain CHP efficiency metrics.

3. Apply safety protocols.

Advanced Level Performance Standard: Can design optimised bioenergy systems using circular economy principles.

Advanced Level Learning Objectives:

1. Optimise feedstock logistics.
2. Integrate waste heat recovery.
3. Evaluate sustainability impacts.

Learning Unit 3.4 – Geothermal, Hydro & Ocean

• Basic: Recognise geothermal, hydro, and marine energy options.

• Intermediate: Compare efficiency and site suitability of each.

• Advanced: Evaluate feasibility studies for large-scale projects.

Basic Level Performance Standard: Can recognise geothermal, hydro, and marine technologies.

Basic Level Learning Objectives:

1. Identify the main system types.
2. Describe basic working principles.
3. Recognise site suitability conditions.

Intermediate Level Performance Standard: Can compare efficiency and siting considerations.
Intermediate Level Learning Objectives: Compare capacity factors.

1. Analyse geographic constraints.
2. Assess environmental considerations.

Advanced Level Performance Standard: Can evaluate feasibility of large-scale projects.

Advanced Level Learning Objectives:

1. Analyse technical and financial feasibility.
2. Evaluate grid integration.
3. Conduct preliminary risk assessment.

Learning Unit 3.5 – Renewable Heat

- Basic: Identify renewable heat technologies (heat pumps, solar thermal, geothermal heat, biomass boilers, district heating systems).
- Intermediate: Compare renewable heat solutions and thermal storage integration in residential, commercial, and industrial contexts.
- Advanced: Design integrated renewable heat systems combining heat pumps, thermal storage,

smart controls, and sector coupling strategies

Basic Level Performance Standard: Can identify renewable heating technologies.

Basic Level Learning Objectives:

1. Identify heat pumps, solar thermal, and geothermal heat.
2. Describe basic operation principles.
3. Recognise district heating concepts.

Intermediate Level Performance Standard: Can compare renewable heat solutions across sectors.

Intermediate Level Learning Objectives:

1. Analyse system suitability by building type.
2. Compare storage integration strategies.
3. Assess cost efficiency.

Advanced Level Performance Standard: Can design integrated renewable heat systems.

Advanced Level Learning Objectives:

1. Integrate heat pumps with storage and controls.
2. Apply sector coupling strategies.
3. Optimise performance and lifecycle costs.

Learning Unit 3.6 - Innovative cutting-edge technologies (PVT, ice storage, PCMs etc.)

- Basic: Identify emerging renewable and energy storage technologies and describe their purpose.
- Intermediate: Assess integration potential of innovative technologies in renewable energy systems.
- Advanced: Evaluate technical, economic, and environmental performance of innovative technologies in complex energy systems.

Basic Level Performance Standard: Can identify innovative renewable and storage technologies and explain their basic function and application context.

Basic Level Learning Objectives:

1. Define PVT (Photovoltaic-Thermal), ice storage systems, and phase change materials (PCMs).
2. Describe the basic operating principles of hybrid and innovative storage systems.

3. Recognise typical application scenarios (buildings, district systems, industrial use).

Intermediate Level Performance Standard: Can assess the suitability of innovative technologies within specific renewable energy system configurations.

Intermediate Level Learning Objectives

1. Compare innovative technologies with conventional solutions in terms of efficiency and flexibility.
2. Analyse integration requirements (controls, storage coupling, sector coupling).
3. Evaluate technical constraints and site-specific feasibility.

Advanced Level Performance Standard: Can critically evaluate and justify the integration of innovative technologies in complex renewable energy systems.

Advanced Level Learning Objectives:

1. Conduct techno-economic comparisons of emerging versus established technologies.
2. Assess lifecycle impacts and circularity implications.
3. Develop system-level integration concepts including hybridisation and smart control strategies.

Module 4. Renewable Energy Storage & Batteries

a-Learning Objectives

Learners will be able to explain the role of energy storage in renewable energy systems integration, demonstrate knowledge of battery cell and pack design and operation, integrate storage systems with renewable energy installations and the electricity grid, and evaluate emerging storage technologies including thermal energy storage, hydrogen-based systems, and hybrid multi-vector storage solutions.

b-Learning Units and associated Learning Outcomes

Learning Unit 4.1 – Role of Renewable Energy Storage

- Basic: Explain the importance of energy storage
- Intermediate: Select the appropriate storage types to systems
- Advanced: Assess storage-grid synergies

Basic Level Performance Standard: Can explain why energy storage is essential for RES integration

Basic Level Learning Objectives:

1. Define energy storage.

2. Explain variability challenges.
3. Identify main storage categories.

Intermediate Level Performance Standard: Can select appropriate storage types.

Intermediate Level Learning Objectives:

1. Compare battery, thermal, and hydrogen storage.
2. Match storage to application scenarios.
3. Evaluate performance trade-offs.

Advanced Level Performance Standard: Can assess storage-grid synergies.

Advanced Level Learning Objectives:

1. Analyse grid flexibility services.
2. Model storage dispatch strategies.
3. Evaluate economic optimisation.

Learning Unit 4.2 – Battery Energy Storage Systems (BESS)

- Basic: Identify and recall BESS components, applications, and safety risks
- Intermediate: Assemble and test stationary battery modules
- Advanced: Analyse battery chemistries and evaluate suitability for stationary storage

Basic Level Performance Standard: Can identify BESS applications and safety risks

Basic Level Learning Objectives:

1. Identify types of stationary battery systems (utility-scale, C&I, residential)
2. Recognise faulty or unsafe components (thermal runaway risks, wiring issues, BMS faults)
3. Describe key components (cells, modules, packs, inverters, BMS)

Intermediate Level Performance Standard: Can assemble and test battery modules

Intermediate Level Learning Objectives:

1. Assemble battery modules safely
2. Conduct performance testing (capacity, efficiency, degradation indicators)
3. Interpret battery diagnostics and monitoring data

Advanced Level Performance Standard: Can evaluate battery technologies for stationary applications

Advanced Level Learning Objectives:

1. Compare Li-ion, LFP, and emerging chemistries
2. Assess lifecycle performance and degradation behaviour
3. Evaluate suitability for grid services (frequency regulation, peak shaving, backup)

Learning Unit 4.3 – Battery Systems for Mobility Applications (EV & Integration)

- Basic: Identify EV battery systems, applications, and safety considerations
- Intermediate: Analyse EV battery integration and charging systems
- Advanced: Evaluate advanced battery technologies and mobility integration strategies

Basic Level Performance Standard: Can identify EV battery applications and safety risks

Basic Level Learning Objectives:

1. Identify EV battery system architecture (modules, packs, thermal management)
2. Recognise safety risks (high voltage, thermal runaway, crash damage)
3. Describe basics of EV charging and wallbox integration

Intermediate Level Performance Standard: Can analyse EV battery integration and operation

Intermediate Level Learning Objectives:

1. Analyse EV charging systems (AC/DC, smart charging, fast charging)
2. Evaluate vehicle-to-grid (V2G) and vehicle-to-home (V2H) concepts
3. Interpret EV battery performance data and diagnostics

Advanced Level Performance Standard: Can evaluate battery technologies for mobility applications

Advanced Level Learning Objectives:

1. Compare Li-ion, LFP, solid-state technologies in mobility contexts
2. Assess lifecycle, performance, and safety trade-offs for EV use
3. Evaluate integration of EVs into energy systems (grid services, flexibility markets)

Learning Unit 4.4 – Thermal and Hybrid Storage Systems

- Basic: Identify thermal storage technologies
- Intermediate: Compare use cases for batteries and thermal storage in sector-coupled systems.
- Advanced: Design and optimise hybrid storage systems

Basic Level Performance Standard: Can describe principles and applications of thermal and hybrid storage systems.

Basic Level Learning Objectives:

1. Define thermal energy storage systems (e.g., hot water tanks, phase change materials, underground thermal storage).
2. Identify key components of hybrid storage systems combining electrical and thermal storage.
3. Explain typical use cases in buildings, district heating, and industry.

Intermediate Level Performance Standard:
Can analyse thermal and hybrid storage options for specific applications.

Intermediate Level Learning Objectives:

1. Compare thermal storage technologies based on efficiency, cost, and scalability.
2. Analyse integration requirements within heating and electricity systems.
3. Evaluate system performance using basic modelling or calculation tools.

Advanced Level Performance Standard: Can design and optimise integrated thermal and hybrid storage systems.

Advanced Level Learning Objectives:

1. Design hybrid storage systems combining electrical and thermal components.
2. Evaluate techno-economic performance under different load/generation scenarios.
3. Optimise dispatch strategies for sector-coupled energy systems.
4. Assess lifecycle and sustainability impacts.

Learning Unit 4.5 – Green Hydrogen Systems (Production, Storage & Power-to-X)

- Basic: Identify hydrogen technologies and applications
- Intermediate: Analyse hydrogen system integration
- Advanced: Evaluate and design hydrogen-based energy systems

Basic Level Performance Standard: Can describe basic principles and applications of green hydrogen systems.

Basic Level Learning Objectives:

1. Define green hydrogen and distinguish it from grey and blue hydrogen.
2. Describe hydrogen production via electrolysis (basic principle).
3. Identify hydrogen storage methods (compressed gas, liquid hydrogen, carriers).
4. Recognise main safety considerations in hydrogen systems.
5. Identify key applications (industry, transport, energy storage).

Intermediate Level Performance Standard: Can analyse hydrogen systems and their role in energy integration.

Intermediate Level Learning Objectives:

1. Compare electrolysis technologies (PEM, alkaline, SOEC) at a conceptual level.
2. Analyse hydrogen value chain (production, storage, transport, use).
3. Evaluate Power-to-X pathways (hydrogen to ammonia, methanol, synthetic fuels).
4. Assess integration of hydrogen into energy systems (sector coupling).
5. Interpret basic efficiency and energy conversion trade-offs.

Advanced Level Performance Standard: Can evaluate and design green hydrogen systems within integrated energy infrastructures.

Advanced Level Learning Objectives:

1. Design hydrogen-based energy systems for grid balancing and industrial use.
2. Evaluate techno-economic performance of hydrogen vs alternative storage options.
3. Optimise hydrogen deployment in sector-coupled energy systems.
4. Assess lifecycle emissions and sustainability of hydrogen pathways.
5. Analyse hydrogen infrastructure requirements (pipelines, storage hubs, refueling networks).

Module 5. Electrical Engineering & Grid Integration

a-Learning Objectives

Learners will be able to differentiate between low- and high-voltage systems in RES, outline the skill sets required for industrial versus domestic electricians, and apply SCADA, PLC, and automation tools for system monitoring and control. They will also be able to assess grid integration aspects, including the use of digital twins and smart grid technologies. The module supports both industrial engineering profiles and electrician upskilling pathways.

b-Learning Units and associated Learning Outcomes

Learning Unit 5.1 – Power Systems

- Basic: Differentiate Low Voltage and High Voltage systems in RES and apply safe installation and connection procedures relevant to domestic and industrial electricians.
- Intermediate: Apply power system principles to renewable energy grid connection and protection design.
- Advanced: Evaluate grid stability challenges related to renewable energy integration.

Basic Level Performance Standard: Can differentiate LV and HV systems and apply safe installation and connection procedures.

Basic Level Learning Objectives:

1. Distinguish between LV and HV systems used in renewable energy installations.
2. Apply basic electrical safety rules during installation and maintenance.
3. Recognise the basic principles of grid connection for renewable energy systems.

Intermediate Level Performance Standard: Can apply power systems knowledge in RES context.

Intermediate Level Learning Objectives:

1. Analyse RES grid interconnection requirements.
2. Evaluate transformers and inverters roles in grid-connected RES.
3. Assess protection systems used in RES.

Advanced Level Performance Standard: Can evaluate grid stability challenges.

Advanced Level Learning Objectives:

1. Analyse frequency and voltage stability issues in power systems with high renewable penetration.
2. Model grid disturbances related to renewable energy variability.
3. Propose mitigation strategies to improve grid stability and resilience.

Learning Unit 5.2 – Automation & Control

- Basic: Simple use of SCADA/PLC tools to control energy systems
- Intermediate: Operate automation tools
- Advanced: Integrate digital twins and smart grid technologies into automation systems

Basic Level Performance Standard: Can operate basic automation and control systems used in renewable energy installations.

Basic Level Learning Objectives:

1. Identify key components of automation systems (sensors, PLCs, SCADA).
2. Describe the role of monitoring and control in renewable energy systems.
3. Interpret simple operational data from monitoring dashboards.
4. Follow basic control procedures under supervision.

Intermediate Level Performance Standard: Can configure and apply automation and control systems in renewable energy contexts.

Intermediate Level Learning Objectives:

1. Program basic PLC logic for renewable energy applications.
2. Monitor system performance using SCADA systems.
3. Analyse operational data to detect faults or inefficiencies.
4. Adjust control parameters to improve system performance.

Advanced Level Performance Standard: Can design and optimise advanced automation architectures for renewable energy systems.

Advanced Level Learning Objectives:

1. Develop integrated control strategies for hybrid and distributed energy systems.
2. Implement predictive maintenance approaches using operational data analytics.
3. Design automation solutions integrating IoT and digital twin technologies.
4. Evaluate cybersecurity risks in energy automation systems.

Module 6. Installation Practices

a-Learning Objectives

Learners will be able to apply safe and efficient installation practices for RES systems, to carry out electrical, HVAC, and refrigeration installations. They will be able to install and retrofit heat pumps to industry standards and to commission and troubleshoot renewable energy systems.

b-Learning Units and associated Learning Outcomes

Learning Unit 6.1 – Safe Installation

• Basic: Apply basic safety regulations

• Intermediate: Perform supervised installations that comply with safety regulations. Perform electrical connections for PV, heat pumps, and storage systems in compliance with national wiring standards and grid codes

• Advanced: Lead installation teams for large projects complying with safety regulations,

Basic Level Performance Standard: Can perform renewable energy installations in compliance with safety regulations

Basic Level Learning Objectives

1. Identify safety requirements for electrical and mechanical installations.
2. Use installation tools and equipment correctly.
3. Apply grounding and basic electrical protection measures.
4. Follow standard installation procedures for PV, wind, or battery systems.

Intermediate Level Performance Standard: Can independently carry out installation tasks and ensure compliance with technical standards.

Intermediate Level Learning Objectives

1. Install renewable energy components according to manufacturer specifications.
2. Conduct electrical testing and commissioning procedures.
3. Interpret technical drawings and wiring diagrams.
4. Ensure installations comply with grid and building codes.

Advanced Level Performance Standard: Can supervise installation projects and ensure technical and regulatory compliance.

Advanced Level Learning Objectives

1. Plan installation workflows and allocate resources.
2. Coordinate multidisciplinary installation teams.
3. Conduct final inspection and certification procedures.
4. Resolve complex installation challenges and technical deviations.

Learning Unit 6.2 – Heat Pumps & HVAC

- Basic: Identify components of heat pumps & HVAC systems
- Intermediate: Retrofit heat pump and HVAC systems in existing buildings, integrating energy efficiency upgrades and ensuring compliance with national building renovation standards
- Advanced: Design and operate combined systems to optimise cost, reliability and efficiency. Design integrated building renovation solutions combining renewable heating, energy efficiency measures, smart controls, and on-site renewable generation

Basic Level Performance Standard: Can describe the operation and components of heat pump and HVAC systems.

Basic Level Learning Objectives:

1. Explain the basic thermodynamic principles of heat pumps.
2. Identify key HVAC system components (compressor, evaporator, condenser).
3. Describe different heat pump types (air-source, ground-source, water-source).
4. Recognise safety considerations for refrigerants.

Intermediate Level Performance Standard: Can install, commission, and maintain heat pump and HVAC systems.

Intermediate Level Learning Objectives:

1. Install heat pump systems according to technical specifications.
2. Perform system commissioning and efficiency testing.
3. Diagnose common operational faults.
4. Integrate heat pumps with renewable electricity and thermal storage systems

Advanced Level Performance Standard: Can design and optimise integrated HVAC and renewable heating systems.

Advanced Level Learning Objectives:

1. Design heat pump systems for residential and commercial applications.
2. Optimise system sizing and performance using modelling tools.
3. Evaluate seasonal performance factors (SPF) and lifecycle costs.
4. Integrate HVAC systems into sector-coupled energy strategies.

Module 7. Operation & Maintenance (O&M) of RES Plants

a-Learning Objectives

Learners will be able to explain observation and measurement standards and protocols, to use diagnostic tools for predictive and preventive maintenance, to operate and monitor biogas, wind, and PV plants. They will be able to manage energy performance using monitoring systems.

b-Learning Units and associated Learning Outcomes

Learning Unit 7.1 – O&M Protocols

- Basic: Explain observation and measurement standards for various RES power plants
- Intermediate: Apply predictive and preventive (maintenance) tools for various RES power plants
- Advanced: Design and implement O&M strategies for various RES power plants

Basic Level Performance Standard: Can clearly describe observation and measurement standards applied to renewable energy power plants (wind, PV, biogas) and explain why consistent monitoring is essential for performance and reliability.

Basic Level Learning Objectives:

1. Identify key observation and measurement standards relevant to the operation of renewable energy installations.
2. Explain in plain language how accurate data collection and monitoring contribute to operational efficiency and safety.
3. Recognise the importance of standardised observation and measurement procedures for ensuring compliance and quality assurance in O&M activities.

Intermediate Level Performance Standard: Can apply predictive and preventive maintenance tools effectively across various RES technologies, using operational data to anticipate and mitigate potential failures.

Intermediate Level Learning Objectives:

1. Apply predictive maintenance methodologies (e.g., vibration analysis, thermography, SCADA data analysis) for early fault detection in renewable energy assets.
2. Implement preventive maintenance schedules aligned with manufacturer and industry standards for different types of RES plants.

Advanced Level Performance Standard: Can design and implement integrated O&M strategies for RES plants that optimise performance, minimise downtime, and align with sustainability and safety standards.

Advanced Level Learning Objectives:

1. Develop comprehensive O&M strategies tailored to specific RES technologies and operational contexts.
2. Integrate digital tools (e.g., AI-based monitoring) into O&M planning and execution.
3. Assess and optimise resource allocation, workforce planning, and logistics to enhance long-term plant performance.
4. Design procedures and policies that ensure continuous improvement in O&M performance,

safety, and sustainability compliance

Learning Unit 7.2 – Plant Operation

- Basic: Monitor RES systems using O&M protocols
- Intermediate: Troubleshoot arising issues
- Advanced: Optimise performance at scale

Basic Level Performance Standard: Can effectively monitor biogas, wind, and PV plants using established O&M protocols, interpret operational parameters correctly, and identify deviations or anomalies that may affect system performance or safety.

Basic Level Learning Objectives:

1. Identify and follow O&M protocols specific to biogas, wind, and PV plants during daily monitoring activities.
2. Understand key operational indicators such as energy yield, conversion efficiency, temperature, pressure, and fault alarms for each plant type.
3. Use digital monitoring systems (e.g., SCADA, plant dashboards) to record, interpret, and report data accurately.
4. Recognise early warning signs or deviations from normal operation and escalate issues according to established procedures.

Intermediate Level Performance Standard: Can diagnose and troubleshoot operational issues in biogas, wind, and PV plants by analysing O&M data, identifying root causes, and applying appropriate corrective measures.

Intermediate Level Learning Objectives:

1. Apply troubleshooting techniques specific to biogas systems (e.g., digester temperature or feedstock issues), wind turbines (e.g., gearbox or inverter faults), and PV plants (e.g., string failures or inverter errors).
2. Use performance data and fault histories to pinpoint and correct mechanical, electrical, or control system problems.
3. Collaborate with maintenance teams to document interventions and update preventive maintenance plans accordingly.
4. Ensure troubleshooting aligns with safety, environmental, and compliance standards for each RES technology.

Advanced Level Performance Standard: Can optimise plant performance at scale across biogas, wind, and PV assets by designing data-driven strategies and implementing continuous improvement processes.

Advanced Level Learning Objectives:

1. Develop optimisation frameworks integrating predictive analytics and digital twins for biogas, wind, and PV plant operations.
2. Evaluate KPIs such as capacity factor, availability rate, and maintenance response time to identify performance improvement opportunities.
3. Implement strategies for cross-plant performance benchmarking and best-practice sharing.
4. Design scalable operational models that enhance output efficiency, reduce downtime, and support sustainability and profitability objectives across all RES assets.

Module 8. Health, Safety & Regulatory Compliance

a-Learning Objectives

Learners will be able to implement OSH (Occupational Safety and Health) practices in renewable energy workplaces and apply safety measures for hydrogen, refrigerants, and high-voltage systems. They will be able to conduct environmental impact assessments and risk analyses and navigate permitting and compliance processes.

b-Learning Units and associated Learning Outcomes

Learning Unit 8.1 – Workplace Safety

- Basic: Apply basic Occupational Safety and Health (OSH) practices in renewable energy workplaces, including hydrogen, refrigerant, and high-voltage safety measures.
- Intermediate: Implement OSH protocols in RES context
- Advanced: Conduct risk & impact analyses

Basic Level Performance Standard: Can apply fundamental Occupational Safety and Health (OSH) procedures in renewable energy workplaces under supervision.

Basic Level Learning Objectives: Identify common workplace hazards in renewable energy installations (electrical, mechanical, chemical, hydrogen-related).

1. Apply basic safety procedures for working with high-voltage systems, refrigerants, and hydrogen.
2. Use personal protective equipment (PPE) correctly.
3. Follow emergency procedures and reporting protocols.

Intermediate Level Performance Standard: Can implement and monitor OSH protocols in renewable energy environments and ensure compliance with safety standards.

Intermediate Level Learning Objectives:

1. Conduct workplace risk assessments for renewable energy installations and maintenance activities.
2. Implement safety procedures for confined spaces, elevated work (e.g., wind turbines), and battery systems.
3. Apply lock-out/tag-out (LOTO) procedures for electrical systems.
4. Ensure compliance with national and EU safety regulations in operational contexts.

Advanced Level Performance Standard: Can design, evaluate, and improve safety management systems in renewable energy operations.

Advanced Level Learning Objectives:

- Develop comprehensive risk management strategies for renewable energy projects.
- Conduct environmental and safety impact analyses for hydrogen, battery, and high-voltage systems.
- Evaluate accident reports and implement corrective and preventive measures.
- Lead safety audits and continuous improvement processes.

Learning Unit 8.2 – Regulatory Compliance

- Basic: Recognise regulatory processes
- Intermediate: Navigate permitting processes
- Advanced: Lead compliance audits in the RES context

Basic Level Performance Standard: Can identify basic regulatory processes and documentation requirements in renewable energy projects.

Basic Level Learning Objectives:

1. Recognise key authorities involved in renewable energy permitting.
2. Identify basic permitting steps and required documentation.
3. Describe environmental impact assessment (EIA) procedures at a general level.
4. Explain why compliance is essential for project approval.

Intermediate Level Performance Standard: Can navigate permitting and compliance processes for renewable energy projects.

Intermediate Level Learning Objectives:

1. Interpret relevant national and EU regulatory requirements for project approval.

2. Prepare and review documentation for renewable energy permitting applications.
3. Coordinate with regulatory authorities and stakeholders during compliance procedures.
4. Ensure projects align with environmental, grid, and construction regulations.

Advanced Level Performance Standard: Can lead compliance audits and manage regulatory strategy for renewable energy projects.

Advanced Level Learning Objectives:

1. Conduct compliance audits for renewable energy installations.
2. Develop regulatory strategies to reduce permitting delays.
3. Integrate evolving EU directives (e.g., RED, EPBD) into project planning.
4. Advise organisations on regulatory risk management and mitigation strategies.

Module 9. Manufacturing & Industrial Processes

a-Learning Objectives

Learners will be able to describe manufacturing processes for PV, batteries, and hydrogen components and apply Industry 4.0, automation, and robotics in clean tech production. They will be able to conduct quality assurance and quality control and recognise the roles of operatives, technicians, and industrial engineers in RES manufacturing.

b-Learning Units and associated Learning Outcomes

Learning Unit 9.1 – Manufacturing Basics

- Basic: Describe PV/battery processes
- Intermediate: Operate automated PV, battery, or hydrogen component production lines under supervision in an industry 4.0 environment.
- Advanced: Optimise Industry 4.0 workflows in the context of RES related items such as PV, battery, etc.

Basic Level Performance Standard: Can describe manufacturing processes for renewable energy components and identify key production stages.

Basic Level Learning Objectives:

1. Describe basic manufacturing steps for PV modules, batteries, and hydrogen components.
2. Identify key materials used in renewable energy manufacturing.
3. Explain the role of automation in modern clean-tech production.
4. Recognise workplace safety and quality requirements in manufacturing environments.

5. Identify the main professional roles involved in RE manufacturing including factory operatives, maintenance technicians, and industrial engineers, and describe their respective responsibilities within the production process.

Intermediate Level Performance Standard: Can operate automated renewable energy production lines under supervision within an Industry 4.0 environment.

Intermediate Level Learning Objectives:

1. Operate automated production equipment for PV, battery, or hydrogen components.
2. Monitor digital production systems and interpret performance indicators.
3. Apply basic troubleshooting procedures in automated manufacturing lines.
4. Ensure adherence to quality and safety standards during production.

Advanced Level Performance Standard: Can optimise Industry 4.0 production workflows in renewable energy manufacturing.

Advanced Level Learning Objectives:

1. Analyse production data to improve efficiency and reduce waste.
2. Integrate robotics, automation, and digital monitoring systems into manufacturing processes.
3. Develop workflow optimisation strategies using digital twins or predictive analytics.
4. Implement continuous improvement strategies to enhance productivity and sustainability.
5. Integrate circular economy principles into manufacturing process design, including strategies for waste reduction, to minimise the environmental footprint of renewable energy component production.

Learning Unit 9.2 – Quality assurance and Quality Control

- Basic: Recognise QA roles
- Intermediate: Apply quality checks
- Advanced: Lead certification processes

Basic Level Performance Standard: Can follow quality control procedures in renewable energy manufacturing environments.

Basic Level Learning Objectives:

1. Identify quality standards applicable to renewable energy components.
2. Perform basic inspection and testing procedures.
3. Record and report production deviations.

4. Apply safety and compliance checks during production.

Intermediate Level Performance Standard: Can implement quality assurance procedures and monitor compliance with industry standards.

Intermediate Level Learning Objectives:

1. Conduct systematic quality inspections and testing protocols.
2. Analyse production data to identify defects or inconsistencies.
3. Apply ISO and industry-specific quality standards.
4. Recommend corrective actions to address quality issues.

Advanced Level Performance Standard: Can design and manage comprehensive quality management systems in renewable energy manufacturing.

Advanced Level Learning Objectives:

1. Develop quality assurance frameworks aligned with international standards.
2. Lead internal and external quality audits.
3. Implement continuous improvement strategies using performance metrics.
4. Integrate sustainability and circularity criteria into quality management systems.

Module 10. Circularity, Recycling & Critical Raw Materials

a-Learning Objectives

Learners will be able to apply circular economy principles to RES, manage end-of-life processes for RES components, and recover and recycle critical raw materials (CRM). They will be able to implement environmental monitoring and compliance in recycling.

b-Learning Units and associated Learning Outcomes

Learning Unit 10.1 – Circular Economy

- Basic: Identify and understand the principles of circular economy
- Intermediate: Apply supply chain analysis to a RET context
- Advanced: Analyse and critically assess how a supply chain, production system, or company business model supports or hinders the implementation of robust circularity principles.

Basic Level Performance Standard: Understand the principles of circular economy in the context of supply chains and production and identify how they appear in sustainability reporting

Basic Level Learning Objectives:

1. Describe key principles and goals of the circular economy and their relevance for renewable energy systems.
2. Understand and map the basic structure of renewable energy supply chains and identify main points of material inflow, outflow, and loss. Understand the different scopes definition for balancing parameters and relate them to the supply chain structure.
3. Understand existing frameworks for sustainability reporting and their relation to principles of circular economy

Intermediate Level Performance Standard: Can apply supply chain analysis and sustainability reporting to a RET supply chain context

Intermediate Level Learning Objectives:

1. Identify key stages of a renewable energy supply chain and recognise opportunities for circular practices (e.g., reuse, remanufacture, recycling).
2. Explain how circular economy aspects are reflected in sustainability reporting frameworks and link supply chain transparency and traceability with circular economy performance.
3. Link circularity indicators (e.g. recycling rate, product lifetime, recovery factor) to sustainability reporting categories and explain their relevance.

Advanced Level Performance Standard: Can critically appraise the weaknesses and strengths of a supply chain / productive structure or company business for supporting a robust circularity.

Advanced Level Learning Objectives:

1. Critically appraise a company or supply chain for its ability to support circular economy goals.
2. Design strategies for improving circularity and resource efficiency.
3. Integrate circular business models and assessment outcomes into broader sustainability reporting and ESG frameworks and evaluate their feasibility and impact.

Learning Unit 10.2 – Reuse, Recycling and Recovery

- Basic: Describe recycling processes
- Intermediate: Identify and design suitable recycling pathways to meet specified recycling targets for various materials.
- Advanced: Design and critically assess and compare the suitability and implementation of different recycling processes for different components

Basic Level Performance Standard: Can describe recycling/reuse processes and their implementation status

Basic Level Learning Objectives:

1. Describe main recycling, reuse, and recovery processes for renewable energy technologies (PV, wind, batteries).
2. Identify the current implementation status of these processes in the EU and typical technical or logistical bottlenecks.
3. Explain the main environmental and economic drivers that influence recycling and recovery practices.

Intermediate Level Performance Standard: Can identify and sketch suitable recycling processes for target recycling rates of different materials

Intermediate Level Learning Objectives:

1. Select and outline suitable recycling/recovery processes for specific materials.
2. Compare recycling options based on performance and sustainability.
3. Evaluate challenges and opportunities for scaling recycling processes.

Advanced Level Performance Standard: Design and critically assess and compare the suitability and implementation of different recycling processes for different components.

Advanced Level Learning Objectives:

1. Assess recycling pathways for complex multi-material components.
2. Critically evaluate trade-offs between efficiency, complexity, cost, and environmental impact.
3. Formulate recommendations for improving the circular performance of a company or technology

Learning Unit 10.3 – Assessment methodologies and KPIs

- Basic: Describe methodologies of life-cycle assessments
- Intermediate: Perform and interpret simplified sustainability and circularity assessments
- Advanced: Perform integrated sustainability assessments

Basic Level Performance Standard: Can describe the methodologies of LCA and data foundations for sustainability and circularity assessment

Basic Level Learning Objectives:

1. Describe the purpose and basic structure of Life Cycle Assessment (LCA), Material Flow Analysis (MFA) and Criticality Assessment.

2. Identify key data sources and databases used in sustainability and material assessments.

3. Recognise typical indicators (KPIs) for sustainability and circularity and understand that multiple criteria must be balanced in decision-making. Introduction to the method of Multi-Criteria Decision Analysis, MCDA.

Intermediate Level Performance Standard: Is able to perform and interpret simplified sustainability and circularity assessments, understanding their methodological limitations.

Intermediate Level Learning Objectives:

1. Apply the basic steps of an LCA or criticality assessment to a simplified renewable energy technology case

2. Explain how results depend on data choices, system boundaries, and assumptions and interpret in terms of environmental and resource sustainability.

3. Use multi-criteria decision analysis (MCDA) principles to to integrate environmental, technical, and economic indicators in decision-making

Advanced Level Performance Standard: Can perform integrated sustainability assessments (LCA, criticality assessment) and critically interpret their results in the context of circularity and decision making.

Advanced Level Learning Objectives:

1. Conduct an LCA and/or criticality assessment following international standards using appropriate datasets

2. Integrate results from multiple indicators (environmental, resource, and circularity KPIs) into a consistent MCDA evaluation framework.

3. Critically evaluate the implications of the assessment results and formulate well-argued recommendations for design or policy improvement.

Learning Unit 10.4 – Policies and regulations for circularity in the EU

- Basic: Understand the structure and scope of EU circular economy policies relevant to renewable energy systems

- Intermediate: Evaluate the consistency and effectiveness of EU circular economy regulations and identify implementation challenges

- Advanced: Evaluate and design targeted improvements for EU circular economy policy relevant to RETs.

Basic Level Performance Standard: Understand the structure and scope of EU circular economy policies and regulation frameworks relevant to renewable energy systems

Basic Level Learning Objectives:

1. Describe EU policies and frameworks related to the circular economy (Green Deal, CRM Act, WEEE, Ecodesign, EU-DPP).
2. Explain their objectives and identify specific instruments and targets relevant to renewable energy technologies
3. Explain the institutional landscape of circularity governance in the EU (European Commission, JRC, EEA, national authorities).

Intermediate Level Performance Standard: Can evaluate the consistency and effectiveness of EU circular economy regulations and identify implementation challenges.

Intermediate Level Learning Objectives:

1. Analyse the benefits and limitations ("black spots") of EU policy frameworks in promoting circularity in renewable energy systems.
2. Compare different policy domains and discuss their coherence or potential conflicts from a circularity perspective.
3. Assess how policy instruments interact with data infrastructures and reporting obligations

Advanced Level Performance Standard: Can critically evaluate and design targeted improvements for EU circular economy policy relevant to renewable energy technologies.

Advanced Level Learning Objectives:

1. Propose evidence-based measures to address identified policy gaps or inconsistencies in EU circular economy frameworks.
2. Appraise the likely environmental, economic, and social impacts of proposed measures on renewable energy systems.
3. Integrate policy, technological, and business perspectives to formulate strategic recommendations that strengthen circularity governance in Europe.

Module 11. Digitalisation, AI & Advanced Manufacturing

a-Learning Objectives

Learners will develop digital skills in data analysis, coding (Python), CAD/AR, and automation. They will be able to apply cybersecurity and digital infrastructure best practices, use AI, modelling, and simulation for system optimisation. They will explore additive manufacturing and advanced production techniques. Digital competences in this module are structured to serve all occupational levels, from technicians and installers to system designers and policy experts.

b-Learning Units and associated Learning Outcomes

Learning Unit 11.1 – Digital Skills

- Basic: Use data tools such as Excel, Power BI and Tableau
- Intermediate: Build models and simulations in Python programming language
- Advanced: Apply AI for optimisation

Basic Level Performance Standard: Can use basic data tools (Excel, Power BI, Tableau) to clean, organise, and visualise datasets clearly and accurately. Apply digital tools in practical renewable energy contexts.

Basic Level Learning Objectives:

1. Identify and apply basic functions and formulas in Excel for data manipulation and analysis.
2. Create clear, informative visualisations in Power BI or Tableau to communicate simple insights.
3. Demonstrate the ability to import, filter, and summarise data from different sources.
4. Interpret data visualisations to support simple decision-making in your work context.
5. Apply digital tools in practical renewable energy contexts. (use digital measurement tools like thermal cameras, smart meters; perform basic heat load calculations using digital tools (e.g., LiDAR-assisted scans).

Intermediate Level Performance Standard: Can build and run models or simulations in Python that analyse or predict business-relevant data trends.

Intermediate Level Learning Objectives:

1. Write Python scripts to process and analyse datasets using libraries such as Pandas, NumPy, and Matplotlib.
2. Develop basic simulations or models (e.g., forecasting, regression, or clustering) relevant to your domain.
3. Interpret model outputs and translate them into actionable business insights.
4. Apply programming best practices to ensure reproducibility and data integrity.
5. Use application-specific tools (e.g., heat pump sizing software, PV design tools).
6. Apply data interpretation to improve installation accuracy and system performance

Advanced Level Performance Standard: Can apply AI techniques to optimise processes, enhance decision-making, or automate complex tasks.

Advanced Level Learning Objectives:

1. Design and implement AI-driven solutions (e.g., predictive analytics, natural language

processing, optimisation algorithms).

2. Evaluate the ethical, organisational, and technical implications of AI deployment.
3. Integrate AI tools into existing workflows to improve performance or efficiency.
4. Critically assess AI outputs and ensure transparency and accountability in AI-assisted decision-making.

Learning Unit 11.2 – Digital Manufacturing & Advanced Production

- Basic: Describe additive manufacturing
- Intermediate: Prototype simple parts
- Advanced: Integrate into production lines

Basic Level Performance Standard: Can clearly describe the principles, technologies, and advantages of additive manufacturing in comparison to traditional production methods.

Basic level Learning Objectives:

1. Define additive manufacturing (AM) and explain its core processes (e.g. FDM, SLA, SLS, metal printing).
2. Identify the main materials used in additive manufacturing and their typical applications.
3. Compare additive and subtractive manufacturing in terms of cost, flexibility, and sustainability.
4. Describe how additive manufacturing contributes to innovation, customisation, and waste reduction in modern production systems.

Intermediate Level Performance Standard: Can design and prototype simple parts using additive manufacturing technologies.

Intermediate Level Learning Objectives:

1. Use CAD software to design 3D models of simple mechanical or functional parts.
2. Prepare files for 3D printing (e.g. slicing, parameter settings, support structures).
3. Operate a 3D printer safely and interpret common printing errors and material issues.
4. Evaluate printed prototypes in terms of dimensional accuracy, functionality, and usability for iterative design.
5. Document and communicate the prototyping process to support product development teams.

Advanced Level Performance Standard: Can integrate additive manufacturing into production lines to enhance efficiency, flexibility, and product innovation.

Advanced Level Learning Objectives:

1. Analyse production workflows to identify opportunities for additive manufacturing integration.
2. Develop strategies for hybrid production systems combining traditional and additive processes.
3. Evaluate cost-benefit and sustainability impacts of AM adoption at scale.
4. Design process improvements to enable digital manufacturing ecosystems (e.g. Industry 4.0, digital twins, smart factories).
5. Propose policy, quality assurance, and maintenance guidelines for AM implementation in industrial environments.

Module 12. Project Management, Planning & Transversal Skills

a-Learning Objectives

Learners will be able to manage RES projects and engage stakeholders effectively and support planners and consultants in urban planning, permitting, and strategy. They will demonstrate leadership, teamwork, and professional communication. They will be able to apply financial literacy, risk management, and entrepreneurial thinking and commit to lifelong learning, diversity, and inclusion in renewable energy careers.

b-Learning Units and associated Learning Outcomes

Learning Unit 12.1 – Project Skills

- Basic: Describe project stages
- Intermediate: Manage small projects
- Advanced: Develop and lead multi-stakeholder projects. Navigate permitting, public consultation, and multi-level governance processes in renewable energy projects

Basic Level Performance Standard: Can articulate the standard phases of a Net-Zero project lifecycle (initiation, planning, execution, closure) and identify the key documents and stakeholders associated with each phase.

Basic level Learning Objectives:

1. Identify the five primary phases of a project lifecycle in the project context and the Net-Zero goal.
2. Define key project management terms (e.g., scope, milestone, deliverable, stakeholder).

3. List the typical roles and responsibilities within a project team (e.g., project manager, engineer, technician).

4. Identify all stakeholders, their roles, and responsibilities within the project.

Intermediate Level Performance Standard: Can independently develop a comprehensive project plan (scope, schedule, budget, risk register) for a small-scale applied project (e.g., rooftop PV) and monitor progress against milestones using standard project management software.

Intermediate Level Learning Objectives:

1. Apply project management methodologies (e.g., Agile, Waterfall) to define the scope and deliverables of a project for a given case study. - Use digital tools (e.g., MS Project, Trello) to create a detailed Work Breakdown Structure (WBS) and a Gantt chart.

2. Develop a preliminary budget and a resource allocation plan for a small-scale project.

3. Identify and document key project risks (technical, financial, social and environmental) and propose mitigation strategies, applying systems thinking.

Advanced Level Performance Standard: Can design and manage the governance structure for a complex, multi-stakeholder project (e.g., a community-owned wind farm), effectively balancing competing interests and navigating complex regulatory and financial contexts to ensure project success.

Advanced Level Learning Objectives:

1. Evaluate and select the appropriate project management framework (e.g., PRINCE2, PMBOK) for large-scale, high-risk energy projects.

2. Develop a comprehensive business case, including financial modeling (ROI, NPV) and a lifecycle assessment (LCA) to integrate environmental and social costs.

3. Formulate strategies to navigate complex regulatory frameworks, manage administrative procedures, secure project financing, identifying and mitigating associated risks.

4. Design and implement a multi-stakeholder communication and engagement plan, ensuring the fairness and inclusion of local communities and minority voices.

5. Lead project review meetings, manage scope changes, and resolve high-level conflicts among stakeholders.

Learning Unit 12.2 – Professional Skills

- Basic: Communicate effectively with various stakeholder groups
- Intermediate: Collaborate in multidisciplinary teams
- Advanced: Demonstrate leadership & entrepreneurship

Basic Level Performance Standard: Can draft clear, concise, and professional emails and short reports for different audiences (e.g., a status update for a manager vs. an informational note for a client) using predefined templates.

Basic level Learning Objectives:

1. Identify the different stakeholder groups and their primary interests, recognising the importance of values such as fairness and intergenerational justice.
2. Practice active listening techniques in role-playing scenarios.
3. Structure a basic presentation using a clear introduction, body, and conclusion.

Intermediate Level Performance Standard: Is able to actively contribute to a multidisciplinary team, fulfilling assigned roles, sharing information effectively, and participating constructively in problem-solving discussions to achieve a common goal.

Intermediate Level Learning Objectives:

1. Apply collaborative digital tools (e.g., Slack, Microsoft Teams, shared documents) to coordinate tasks and share information within a team.
2. Facilitate a brief team meeting, ensuring a clear agenda and actionable outcomes.
3. Adapt communication style (e.g., technical vs. non-technical language) for different team members and external stakeholders, demonstrating critical thinking when presenting complex data in an accessible way.

Advanced Level Performance Standard: Can take the initiative to lead a team, motivate members, mediate conflicts, and make decisive judgments under pressure. Can identify and articulate a new service or process improvement opportunity based on experience.

Advanced Level Learning Objectives:

1. Apply situational leadership models to guide and support a team through challenges.
2. Develop and deliver a persuasive presentation that articulates a vision for a sustainable future, convincing stakeholders of the long-term value (economic, social, environmental) of an initiative.
3. Conduct a root cause analysis of a team conflict and facilitate a resolution process.
4. Draft a business proposal for an innovative idea that actively promotes sustainability, outlining the value proposition and necessary resources.

Learning Unit 12.3 – Lifelong Learning & Inclusion

- Basic: Recognise DEI (Diversity, equity, and inclusion) principles
- Intermediate: Apply inclusive practices

- Advanced: Champion workforce diversity

Basic Level Performance Standard: Can define key DEI terms and provide examples of their importance in a work context, such as in team composition and communication.

Basic level Learning Objectives:

1. Define Diversity, Equity, and Inclusion and explain the difference between them.
2. Identify the benefits of a diverse workforce in the renewable energy sector.
3. Recognise examples of unconscious bias in provided scenarios.
4. Explain how the principles of fairness and justice are a foundation for sustainability

Intermediate Level Performance Standard: Can consistently demonstrate inclusive behaviors in team settings, such as actively soliciting opinions from all members, using inclusive language, and contributing to a psychologically safe environment.

Intermediate Level Learning Objectives:

1. Develop a personal learning plan to address an identified skills gap, including specific goals, resources, and timelines.
2. Practice techniques for giving and receiving constructive feedback respectfully.
3. Apply inclusive communication strategies in group discussions to facilitate collective action and ensure all perspectives are considered.

Advanced Level Performance Standard: Can proactively identify and address non-inclusive practices within a team or a project and can develop and advocate for initiatives that promote diversity, equity, and continuous learning.

Advanced Level Learning Objectives:

1. Analyse organisational culture case studies and propose strategies to improve inclusivity and foster a learning environment.
2. Develop a mentoring plan to support the professional development of colleagues.
3. Design and present a proposal for a DEI initiative that contributes to creating a more sustainable and inclusive future vision for the organisation.

ANNEXES

ANNEX 1: Mapping of D2.1 ESCO Skills to Learning Outcomes and EQF Levels

This annex presents the mapping between the ESCO-based occupational skills identified in Deliverable D2.1 and the learning outcomes developed within the RE Skills Core VET Curriculum.

The table illustrates how identified sectoral skills needs have been translated into curriculum modules, learning units, and EQF-aligned competence levels. It demonstrates the methodological continuity between the skills intelligence phase (WP2) and the curriculum design phase (WP3), ensuring traceability between labour market needs and training provision.

The mapping also supports transparency, interoperability, and future recognition of modular learning pathways and micro-credentials across European education and training systems.

ESCO Skills	Main Learning Outcomes	Possible Course	EQF Level	Cluster	Recommended Occupational Profiles
Install and maintain electrical systems	Perform compliant installations; Troubleshoot faults	Electrical Installation for RE Systems	3–4	Technical	Industrial Electricians; Electricians (Domestic); Renewable Energy Technicians
Operate machinery, inspect equipment	Operate safely; Conduct inspections; Maintain equipment	Factory Operatives / Maintenance	3–4	Technical	Factory Operatives / Maintenance Technicians; Renewable Energy Power Plant Operators
Install photovoltaic systems, install wind turbines, maintain heating	Commission RE systems; Perform diagnostics; Read schematics	Renewable Energy Technician	4–5	Technical	Renewable Energy Technicians (wind/solar/geothermal/heat pumps); HVAC and Refrigeration Technicians

systems					
Operate gas pipelines, monitor biogas plants	Apply safety protocols; Conduct repairs; Monitor systems	Gas Technician	4–5	Technical	Gas Technicians (biogas/hydrogen); Renewable Energy Power Plant Operators
Install HVAC systems, perform energy audits	Install HVAC units; Assess efficiency; Follow compliance	HVAC & Refrigeration Technician	4–5	Technical	HVAC and Refrigeration Technicians; Energy Engineers
Operate SCADA systems, troubleshoot systems	Use SCADA; Optimise operations; Respond to faults	RE Power Plant Operations	4–5	Technical	Renewable Energy Power Plant Operators; Industrial Engineers
Troubleshoot with software	Use diagnostic tools; Recommend actions	Problem Solving with Digital Tools	4–5	Transversal & Soft Skills	Renewable Energy Technicians; Industrial Electricians; Factory Operatives / Maintenance Technicians
Program PLCs, monitor SCADA	Program logic systems; Monitor performance	SCADA & PLC Programming (Supervisory Control and Data Acquisition (SCADA) and Programmable Logic Controller (PLC) systems used in energy automation)	5–6	Engineering	Industrial Engineers; Industrial Electricians; Renewable Energy Power Plant Operators
Manage projects, lead teams	Plan and execute RE projects; Manage stakeholders	Project Management for RE Deployment	5–6	Planning & Leadership	Energy Engineers; Renewable Energy Consultants; Planners
Conduct audits, ensure QA	Conduct audits; Implement standards	Quality Assurance & Certification	5–6	Planning & Leadership	Industrial Engineers; Health and Safety Professionals; Factory Operatives / Maintenance

					Technicians
Facilitate meetings, communicate	Facilitate engagement; Present information	Stakeholder Engagement & Communication	5–6	Transversal & Soft Skills	Renewable Energy Consultants; Planners
Create business plans	Develop business ideas; Assess opportunities	Entrepreneurship in Renewable Energy	5–6	Transversal & Soft Skills	Renewable Energy Consultants; Energy Engineers
Interpret regulations, apply law	Apply EU/National laws; Ensure compliance	Energy Law & Regulation	6	Planning & Leadership	Planners; Renewable Energy Consultants; Health and Safety Professionals
Conduct LCAs, design for sustainability	Evaluate sustainability; Recommend alternatives	Sustainability, LCA, circularity of RETs	6–7	Planning & Leadership	Critical Raw Material Recovery Specialists; Renewable Energy Consultants; Energy Engineers
Apply systems thinking, model energy systems, plan strategies	Analyse and integrate multi-domain issues	Interdisciplinary Systems Thinking / Multi-Energy System Planning	6–8	Transversal & Soft Skills	Energy Engineers; Industrial Engineers; Planners
Manage teams, mentor staff	Lead teams; Implement change strategies	Leadership in Energy Transition	6–8	Transversal & Soft Skills	Energy Engineers; Renewable Energy Consultants; Industrial Engineers; Renewable Energy Power Plant Operators

ANNEX 2: Feedback questionnaire

Annex 2 contains the stakeholder validation questionnaire used during the curriculum consultation process conducted between February and April 2026

Feedback Survey – Renewable Energy Skills Core VET Curriculum (WP3)

This survey aims to collect feedback from board members and industry associations on the Renewable Energy Skills Core VET Curriculum developed under the RESkill4NetZero project. Your insights will help refine the curriculum to better align with sector needs, policy priorities, and workforce development objectives.

1. Strategic Relevance and Alignment

1.1. How well does the curriculum align with current and emerging workforce needs in your sector? Comments:

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1.2. To what extent does the framework reflect the priorities of EU initiatives such as the Green Deal, REPowerEU Plan, and Net-Zero Industry Act? Comments:

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1.3. Which modules or learning units are most relevant for your organisation or sector? Comments:

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1.4. How could this framework support your sector's workforce or training strategies? Comments:

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2. Technical and Occupational Relevance

2.1. Do the 13 occupational profiles identified reflect your organisation's key roles? Comments:

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2.2. Are there any missing or emerging roles that should be added? Comments:

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2.3. How relevant are the three skill clusters (technical, digital, transversal) to your workforce? (ranking 1 to 5 + comments):

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2.4. Which qualification levels (EQF 3–8) are most relevant for your company? Comments:

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3. Curriculum Design and Implementation

3.1. Is the modular structure practical for your training environment? Comments:

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3.2. Could your organisation use micro-credentials or stackable units in training? Comments:

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3.3. Would additional guidance be useful for implementation? Can you think of concrete examples? Comments:

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4. Innovation, Digitalisation and Emerging Skills

4.1. How relevant are digital skills (AI, data, automation) to your sector's needs? Comments:

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4.2 Are there new areas (e.g. hydrogen, AI, recycling etc.) that should be given greater focus in our curriculum? Comments:

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5. Additional comments

5.1. Should additional topics be included? Comments:

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5.2. Please write here other comments you would like to provide:

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ANNEX 3: Consolidated results of the feedback questionnaire

Annex 3 presents the consolidated and anonymised results of the stakeholder consultation used to validate and refine the curriculum framework.

Overall assessment

Stakeholders consider the Executive Summary and overall framework clear, well-structured, and broadly aligned with current and emerging renewable energy workforce needs. The 13-module structure is viewed as balanced, modular, and suitable for adaptation across sectors. Module 12 received a specific positive mention for its depth and clarity.

1. Strategic Alignment & EU Policy Coherence

Respondents agree the curriculum reflects major EU priorities (Green Deal, REPowerEU, Net-Zero Industry Act). It is seen as supportive of:

- Clean tech industrial acceleration
- Energy system integration
- Digitalisation of energy
- Workforce upskilling across EQF 4–7 primarily, with relevance extending to EQF 3–8

2. Skills Architecture (Technical, Digital, Transversal)

The three-cluster model (technical, digital, transversal) is considered highly relevant across sectors.

However, two structural observations emerged:

- The current personas (e.g., wind and biogas profiles) strongly reflect technical pathways but do not clearly illustrate the transversal cluster. Clarification may be needed on whether transversal skills are embedded within the "student persona" or distributed across profiles.
- There is concern about grouping Master's and PhD levels together. Stakeholders highlight important differences between applied/system-oriented Master-level competencies and research-frontier, innovation-driven PhD-level competencies. A clearer differentiation in learning outcomes and research orientation was recommended.

These observations were discussed with the consortium, and it was decided to keep the Master student only (not PhD) and to create another persona (permitting officer) which would allow an example with several transversal skills.

3. Integration vs. Installation: A Key Competence Gap

A strong recurring theme concerns integration skills. Several stakeholders stress that the sector is moving beyond "installation" towards energy system integration. In particular:

- Electricians are increasingly described as integrators, not only installers.
- Professionals must ensure interoperability between technologies (PV, storage, EV charging, heat pumps, automation systems).
- Intelligent operation (e.g., self-consumption optimisation) is becoming essential.

There is a call to:

- Elevate integration skills explicitly in the framework.
- Reposition automation and building energy management systems so that they are not framed solely under engineering, but also accessible at technician/installer level.
- Recognise that integration skills are in high demand (supported by external survey data referenced by stakeholders

Some learning units and level objectives were reviewed in this sense.

4. Technology Scope – Areas for Reinforcement

While the curriculum is considered comprehensive, stakeholders propose strengthening or clarifying coverage of:

- Thermal Energy Storage (including molten salts and high-temperature storage)
- Solar thermal technologies
- Hydrogen
- Low-temperature district heating and heat pumps
- Hybrid renewable systems
- Bidirectional EV charging systems
- Building Automation and Control Systems (BACS)
- Cybersecurity for energy systems
- ESG compliance and sustainability governance
- Digitalisation (AI, data analytics, digital twins) is viewed as increasingly important, though relevance varies slightly by sector.

5. Modular Structure & Micro-Credentials

The modular structure and stackable micro-credentials are broadly welcomed. Benefits identified:

- Flexible upskilling
- Recognition of prior learning
- Industry-aligned short courses
- Cross-sector mobility

However, one important caution was raised: training portability across countries must account for national variations in building codes, standards, and regulatory frameworks. Stakeholders recommend guidance on adapting modules to national contexts.

6. Qualification Levels & Occupational Profiles

The 13 occupational profiles are generally seen as relevant. Some additional or emerging roles were suggested:

- Thermal energy storage management
- Thermal Energy Storage integration engineers
- High-temperature heat specialists
- Sector-specific innovation roles

EQF 4–6 appear most critical for workforce deployment, with EQF 7–8 relevant for advanced engineering and research functions.

Conclusion

Feedback confirms the curriculum is robust, strategically aligned, and relevant across renewable energy sectors. Refinements should focus on system integration, technology specificity, qualification differentiation, and implementation guidance to maximise impact, transferability, and long-term sector relevance. All comments were addressed and reflected in this final version of the curriculum.

ANNEX 4: One module with detailed examples of learning outcomes

Module 2. Renewable Energy Engineering & System Design

a-Learning Objectives

Learners will be able to describe the principles of renewable energy engineering, to use digital tools (CAD, modelling, simulation) to design energy systems, to design hybrid and cross-carrier systems for optimised energy integration and summarise regulatory and permitting requirements for project design.

b-Learning Units and associated Learning Outcomes

Learning Unit 2.1 – Principles of Renewable Energy Engineering

Basic Level Learning Objective: Describe fundamental engineering concepts (energy balance, efficiency).

2. Define energy conservation and describe its role in engineering systems.
3. Recognise and describe what efficiency means in engineering.
4. List common ways to improve energy efficiency in engineering applications.

Intermediate Level Learning Objectives: Apply engineering principles to small-scale renewable systems.

2. Analyse and design small-scale renewable energy systems using fundamental engineering principles such as energy conservation and efficiency.
3. Evaluate the performance and efficiency of small-scale renewable energy systems through the application of engineering concepts and techniques.

Advanced Level Learning Objectives: Optimise complex hybrid systems using simulation and modelling.

1. Develop and implement advanced simulation models to accurately represent the dynamic behavior of complex hybrid systems, incorporating both continuous and discrete event processes.
2. Apply optimisation algorithms to enhance the performance and efficiency of hybrid systems, utilising simulation results to identify optimal configurations and operational strategies.

Examples at Basic Level

Learning Outcome 1: Define energy conservation and describe its role in engineering systems.

- A student explains energy conservation using a simple solar lamp example:
- They describe that energy cannot be created or destroyed, only converted (sunlight

→ electrical energy → light).

- They explain that the solar panel converts solar energy into electricity, which is stored in a battery.
- They identify that the total energy output cannot exceed the energy input from the sun.

Learning Outcome 2: Recognise and describe what efficiency means in engineering.

A student examines a simple electric heater:

- They explain that efficiency compares useful output energy to input energy.
- They calculate efficiency using a simple formula (Efficiency = Useful Output / Input × 100%).
- They identify that energy losses may occur as heat dissipated to the surroundings.

Learning Outcome 3: List common ways to improve energy efficiency in engineering applications.

A student evaluates a small household solar system:

- They suggest reducing cable losses by using proper wire sizing.
- They recommend using energy-efficient appliances (e.g., LED lighting instead of incandescent bulbs).
- They propose improving insulation to reduce heating demand.

Example for Intermediate Learning objectives:

Learning Outcome 1: Analyse and design small-scale renewable energy systems using fundamental engineering principles such as energy conservation and efficiency.

A student designs a solar-powered water pumping system for a rural community:

- They calculate the energy required to pump water daily.
- Using solar irradiance data, they size the solar panel array and battery storage.
- They apply energy conservation principles to ensure the system meets demand without excess loss.
- Efficiency is considered in selecting the pump and inverter to minimise energy waste.

Learning Outcome 2: Evaluate the performance and efficiency of small-scale renewable energy systems through the application of engineering concepts and techniques.

A student evaluates a wind-solar hybrid system installed at a company:

- They collect data on energy output from both sources over time.
- Using tools like MATLAB/Simulink or HOMER, they simulate system behavior under different weather conditions.
- They calculate system efficiency and identify performance bottlenecks (e.g., inverter losses, battery degradation).
- Recommendations are made to improve system reliability and energy yield.

Example for advanced level

Learning Outcome 1: Develop and implement advanced simulation models to accurately represent the dynamic behavior of complex hybrid systems, incorporating both continuous and discrete event processes.

A student builds a simulation of a hybrid renewable energy system combining solar panels, wind turbines, and battery storage.

- They use e.g. MATLAB/Simulink to model continuous energy flows and discrete control events (e.g., switching between energy sources).
- The simulation includes real-world variables like weather data, load demand, and system constraints.
- The student validates the model by comparing simulated outputs with actual performance data.

Learning Outcome 2: Apply optimisation algorithms to enhance the performance and efficiency of hybrid systems, utilising simulation results to identify optimal configurations and operational strategies.

A student uses genetic algorithms or linear programming to optimise the operation of a hybrid microgrid.

- They simulate different configurations (e.g., battery size, inverter settings, energy dispatch schedules).
- The goal is to minimise cost and maximise energy efficiency while maintaining system reliability.
- Based on simulation results, they recommend the best setup for a rural electrification project.

Learning Unit 2.2 – Digital Design Tools

Basic Level Learning Objective: Use CAD tools for simple layouts.

1. create basic 2D sketches using CAD software.
2. apply dimensioning and annotations to simple layout designs in CAD tools

Intermediate Level Learning Objectives: Develop system models with simulation software.

1. Demonstrate the ability to create and validate a basic system model using simulation software, including setting up initial conditions, defining parameters, and interpreting results.
2. Apply techniques to optimise system performance through simulation software by adjusting model parameters and analysing the impact of different scenarios on system behavior.

Advanced Level Learning Objectives: Integrate digital twins and AI-driven optimisation of system (design).

1. Develop and implement a comprehensive digital twin model that

accurately represents the physical system, incorporating real-time data integration and predictive analytics to enhance system performance and reliability.

2. Design and execute AI-driven optimisation algorithms within the digital twin framework to achieve optimal system design parameters, improving efficiency, reducing costs, and ensuring scalability for future enhancements.

Examples on basic level:

Learning Outcome 1: Create basic 2D sketches using CAD software.

A student designs a simple layout for a rooftop solar installation:

- They draw the building roof outline in 2D using CAD software (e.g., AutoCAD).
- They insert rectangular shapes representing solar panels.
- They arrange panels to fit within roof boundaries while avoiding shaded areas.

Learning Outcome 2: Apply dimensioning and annotations to simple layout designs in CAD tools.

A student completes the solar layout drawing:

- They add dimensions to indicate roof length and width.
- They label panel spacing and orientation angle.
- They include basic annotations such as "South-facing array" and "Inverter location.

Examples on intermediate level:

Learning Outcome 1: Demonstrate the ability to create and validate a basic system model using simulation software, including setting up initial conditions, defining parameters, and interpreting results.

A student uses Simulink to model a simple heating system:

- They define system components like a heater, thermostat, and room environment.
- Initial conditions (e.g., room temperature) and parameters (e.g., heater power) are set.
- The student runs the simulation and compares the temperature response to expected behavior, validating the model.

Learning Outcome 2: Apply intermediate-level techniques to optimise system performance through simulation software by adjusting model parameters and analysing the impact of different scenarios on system behavior.

A student models a battery charging system in MATLAB/Simulink:

- They simulate different charging profiles (e.g., constant current vs. pulse charging).
- Parameters like voltage limits and charge rates are adjusted.
- The student analyses simulation results to determine which profile minimises charging time while preserving battery health.

Examples on advanced level:

Learning Outcome 1: Develop and implement a comprehensive digital twin model that accurately represents the physical system, incorporating real-time data integration and predictive analytics to enhance system performance and reliability.

A student creates a digital twin of a smart HVAC system in a commercial building:

- They use sensor data (temperature, humidity, occupancy) to mirror the real-time state of the system.
- The digital twin is built using platforms like Azure Digital Twins or Siemens NX, integrating IoT data streams.
- Predictive analytics are applied to forecast energy consumption and detect anomalies, improving system reliability and reducing downtime.

Learning Outcome 2: Design and execute AI-driven optimisation algorithms within the digital twin framework to achieve optimal system design parameters, improving efficiency, reducing costs, and ensuring scalability for future enhancements.

A student integrates AI algorithms into a digital twin of a renewable energy microgrid:

- They use machine learning models to optimise battery charging schedules and energy dispatch based on weather forecasts and load predictions.
- The AI continuously adjusts system parameters to minimise energy waste and operational costs.
- The solution is scalable, allowing future integration of additional energy sources or storage units.