Ref. Ares(2026)5351392 - 27/05/2026

JOULIA

Electrification of industrial processes using induction and microwaves technologies

D14.5
Skills Needs Assessment Report

ISQ

27/05/2026

Funded by the European Union

The **JOULIA** project has received funding from the European Union's Horizon Europe Research and Innovation Actions Programme under Grant Agreement No 101192555

Project Information

ACRONYM	**JOULIA**
TITLE	Electrification of industrial processes using induction and microwave technologies
GRANT AGREEMENT No	**101192555**
START DATE OF THE PROJECT	01/12/2024
DURATION OF THE PROJECT	December 2024 – November 2028
TYPE OF ACTION	HORIZON Innovation Actions
TOPIC	HORIZON-CL5-2024-D4-01-03
WEBSITE	www.jouliaproject.eu
COORDINATOR	CIRCE – Technology Centre
PROJECT OVERVIEW	The JOULIA project is focused on **transforming energy-intensive industries by replacing traditional fossil fuel-based heating methods with advanced electric technologies**. These industries rely on **high-heat processes**, which are critical for manufacturing products like **rubber, ceramics, and plastics**. By focusing on specific, high-heat applications, JOULIA seeks to **showcase the potential of electrification to decarbonise operations, enhance efficiency, and drive sustainable industrial transformation.**

Grant Agreement: **101192555** | | 2024 – 2028 | Duration: 48 months
Topic: HORIZON-CL5-2024-D4-01-03 - Alternative heating systems for efficient, flexible and electrified heat generation in industry
Type of Action: Innovation Action

Document Information

Title of deliverable:	D14.5 – Skills Needs Assessment Report
Work Package	WP14 – Dissemination, exploitation and communication
Task	T14.5 – Identification of retraining and upskilling needs
Lead Beneficiary	ISQ
Contributing beneficiaries:	All partners
Due date:	31/05/2026
Dissemination Level	PU – Public

Version Control Sheet

Version	Date	Main modifications	Organisation
0.1	08/05/2026	First draft	ISQ (Cristiano Vieira)
0.2	21/05/2026	Final review	CIRCE (M. Zarzuela)
0.3	25/05/2026	First consolidated version	ISQ (Cristiano Vieira)
0.4	27/05/2026	Final Quality Review	CIRCE (M. Zarzuela)

DISCLAIMER OF WARRANTIES:

This document has been prepared by JOULIA project partners as an account of work carried out within the framework of the EC-GA contract no 101192555.

Neither Project Coordinator, nor any signatory party of JOULIA Project Consortium Agreement, nor any person acting on behalf of any of them:

a. makes any warranty or representation whatsoever, express or implied,

- **i.** with respect to the use of any information, apparatus, method, process, or similar item disclosed in this document, including merchantability and fitness for a particular purpose, or
- **ii.** that such use does not infringe on or interfere with privately owned rights, including any party's intellectual property, or
- **iii.** that this document is suitable to any particular user's circumstance; or

b. assumes responsibility for any damages or other liability whatsoever (including any consequential damages, even if Project Coordinator or any representative of a signatory party of the JOULIA Project Consortium Agreement, has been advised of the possibility of such damages) resulting from your selection or use of this document or any information, apparatus, method, process, or similar item disclosed in this document.

"The methodology of the Report on the Identification of Reskilling and Upskilling Needs for the JOULIA project (Grant Agreement No. 101192555) is based on the extensive experience, tools and models developed in-house by ISQ. It incorporates the European Commission's guidelines and sets out best practices drawn from the relevant literature. This methodology is based on the knowledge and approaches refined through ISQ's involvement in previous projects. These elements have been adapted to meet the specific needs of JOULIA, whilst ensuring compliance with EU recommendations and the conditions set out in the Grant Agreement. This report describes the adapted methodology, as subsequently developed and implemented within the JOULIA project."

Contents

Table of Figures

List of Tables

Table 10: Module 1: Technical and Electrification skills 48
Table 11: Module 2: Digital and technological skills 50
Table 12: Module 3: Sustainability and green management skills 52
Table 13: Module 4: Transversal skills 54
Table 14: Module 5: Gender inclusion 56

Abbreviations

Table 1: Abbreviations

AI	Artificial Intelligence
BESS	Battery Energy Storage Systems
CE	Circular Economy
DSO	Distribution System Operator
EE	Energy Efficiency
EII	Energy-Intensive Industry
EMF	Electromagnetic Fields
EQF	European Qualifications Framework
ESCO	European Skills, Competences, Qualifications and Occupations
EU	European Union
GA	Grant Agreement
GDPR	General Data Protection Regulation
GHG	Greenhouse Gas Emissions
HSE	Health, Safety and Environment
IEA	International Energy Agency
IoT	Internet of Things
IRE	Integration of Renewable Energy
LCA	Life Cycle Analysis
LCC	Life Cycle Costing
LMS	Learning Management System
ML	Machine Learning
MoRRI	Monitoring the Evolution and Benefits of Responsible Research and Innovation
PBL	Problem-Based Learning
PI	Process Industry
PPE	Personal Protective Equipment
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PV	Photovoltaic
R&D	Research & Development

ROI	Return on Investment
RRI	Responsible Research and Innovation
SLR	Systematic Literature Reviews
SME	Small and medium-sized enterprises
TSO	Transmission System Operator
VET	Vocational Education and Training

Executive Summary

This report, corresponding to Deliverable 14.5 (D14.5) of the JOULIA project, presents a comprehensive analysis of the workforce's re-skilling and up-skilling needs in the context of the industrial energy transition. The document focuses specifically on the challenges associated with replacing conventional fossil-fuel-based heating systems with advanced electrical technologies, namely industrial induction and microwave systems, and identifies the skills gaps likely to compromise the efficient, safe, and sustainable adoption of these technological solutions.

This deliverable is part of the twin transition—green and digital—and recognises that the ongoing technological transformation requires not only investment in infrastructure and production processes, but also a profound adaptation of professional profiles and organisational capabilities. In this sense, the report proposes an integrated approach to skills development, aligned with European objectives for decarbonisation, energy efficiency, industrial innovation and social inclusion.

The methodology adopted is based on a human-centred approach and was structured into five complementary stages: (i) documentary review and analysis of the state of the art; (ii) mapping of industrial and institutional stakeholders; (iii) application of an international electronic questionnaire aimed at sector experts and professionals; (iv) data triangulation with strategic weighting of the identified competences; and (v) alignment with the principles of Responsible Research and Innovation (RRI) and with European guidelines on gender equality and inclusion.

The results obtained show that the transition to electrified industrial processes requires a structural reconfiguration of professional competences, going beyond the strictly technical domain of areas such as power electronics, energy integration or thermal control. The study demonstrates the need to develop hybrid professional profiles, capable of combining advanced technical competences with digital, environmental and transversal skills, essential for operating in complex, interconnected and constantly evolving industrial contexts.

To address this challenge, the report proposes the adoption of the Pi-shaped educational model, which combines a solid horizontal base of knowledge in sustainability, digitalisation and energy transition with two complementary vertical dimensions: on the one hand, in-depth technical specialisation (hard skills); on the other, the development of transversal competences (soft skills), including adaptability, critical thinking, problem solving, communication and continuous learning. This approach seeks to ensure not only the future employability of professionals, but also the organisational resilience necessary to sustain long-term industrial innovation processes.

As a result of this methodological process, a training plan structured into 5 modules and 13 submodules was developed, differentiated according to the levels of the European Qualifications Framework. This structure ensures the appropriateness of competences for the different professional profiles involved in the industrial value chain, from production operators and technicians (EQF 4–5) to engineers, specialists and senior managers (EQF 6–7). The plan integrates technical, digital, environmental, organisational and social content, promoting a multidisciplinary approach aligned with the principles of a just transition.

Additionally, the report incorporates assessment mechanisms, microcredential certification and impact monitoring, aligned with European indicators for education, responsible innovation and gender balance. This component ensures not only the validation of acquired learning, but also the sustainability and transferability of the training model to different European industrial contexts.

In summary, D14.5 constitutes a strategic instrument to support the implementation of the JOULIA project's goals, namely the increase in industrial energy efficiency between 25% and 40%, through the empowerment of the workforce to operate electrified technologies efficiently, safely and sustainably. At the same time, the report reinforces the importance of an industrial transition that is technologically advanced, socially inclusive and aligned with the European Union's objectives of climate neutrality and industrial competitiveness.

1. Introduction

The decarbonisation of energy-intensive industries constitutes one of the strategic pillars of European climate policy and a fundamental requirement for achieving the objectives defined in the European Green Deal, the *Fit for 55* legislative package and the goal of climate neutrality by 2050. In this context, the JOULIA project plays a particularly relevant role by promoting the replacement of conventional thermal systems based on fossil fuels with advanced electric heating technologies, namely induction and microwaves, applied to critical industrial processes such as rubber vulcanisation and multi-layer plastic material bonding. The implementation of these solutions aims not only to increase the energy efficiency of industrial processes but also to significantly reduce greenhouse gas emissions, contributing to an estimated energy saving of around 810 MWhEP/year.

However, the realisation of this technological transition does not depend exclusively on the development of innovative technical solutions. The success of industrial electrification also requires a structural transformation of the workforce's competences, capable of ensuring the efficient, safe and sustainable operation of new production systems. Within this framework, D14.5 – "Report on Identification of Re-skilling and Up-skilling Needs" – developed under the leadership of ISQ between months 6 and 18 of the project, serves as a strategic instrument linking technological innovation with the human capacity-building necessary for its effective implementation.

The main objective of this deliverable is to identify, analyse and systematise the re-skilling and up-skilling needs associated with the so-called "Twin Transition", which simultaneously articulates the challenges of the green energy transition and digital transformation. The growing integration of Industry 4.0 and 5.0 technologies implies that industrial professionals no longer operate only in traditional operational environments, but increasingly interact with intelligent, digitalised, interconnected and highly automated systems. Thus, competences related to data analysis, artificial intelligence, predictive maintenance, renewable energy integration, energy efficiency and intelligent system management become as relevant as the technical mastery of the electrothermal equipment itself.

At the same time, the industrial transition process also requires the strengthening of transversal and socio-emotional competences that enable professionals to deal with contexts marked by high technological complexity, rapid organisational evolution and growing economic and environmental uncertainty. Competences such as adaptability, critical thinking, problem solving, interdisciplinary collaboration and continuous learning therefore play a central role in preparing a resilient workforce capable of responding to the future demands of European industry.

In this context, this report presents an integrated analysis of the competences necessary to support the implementation of the technologies developed within the scope of JOULIA. The document details the methodological basis used in identifying training needs, including documentary research, stakeholder mapping, data collection through international questionnaires and the methodological triangulation process that made it possible to validate and prioritise the competences considered critical for the sector. At the same time, the report incorporates the principles of Responsible Research and Innovation (RRI), as well as the European Commission's guidelines on gender equality, inclusion and social sustainability, ensuring that the technological transition proposed by the project is accompanied by an ethical, inclusive and socially robust approach.

The report also presents the structured learning and capacity-building plan developed for the project, organised into training modules differentiated by European Qualifications Framework (EQF) levels, allowing an adequate response to the needs of different professional profiles, from industrial operators and technicians to engineers, specialists and strategic managers. These learning pathways will support the practical demonstration activities at the project's demosites, located in Italy and Poland, contributing to the validation of technical solutions and training methodologies in real industrial environments.

In this way, JOULIA not only promotes technological innovation in European industry, but also proposes an integrated model of industrial transformation, in which decarbonisation, digitalisation, the enhancement of human competences and social inclusion are treated as interdependent and complementary dimensions. This deliverable thus constitutes a strategic contribution to ensuring that the European industrial energy transition is simultaneously efficient, safe, competitive and socially sustainable.

1.1 Current panorama of industrial electrification

The electrification of industrial processes is now recognised as one of the most relevant strategies for accelerating the decarbonisation of the European economy and achieving the climate objectives defined by the European Union for 2030 and 2050. The industrial sector occupies a central position in this challenge, as it accounts for approximately 37% of global energy demand and about half of the world's demand for process heat. Despite growing technological evolution, the industry remains heavily dependent on fossil fuels, which still supply approximately 70% of the thermal energy used in industrial processes. As a consequence, the sector is responsible for a significant share of global energy-related carbon dioxide (CO_2) emissions, exceeding 40% of the world's total.

In the European context, this reality is particularly relevant. Industry represents about 25% of the European Union's total energy consumption; however, only approximately one-third of that energy corresponds to electricity. This persistent dependence on fossil sources for industrial heat generation contributes significantly to the sector's high levels of greenhouse gas (GHG) emissions, which continue to represent one of the main barriers to meeting European climate targets. In this framework, industrial electrification emerges not only as a technological alternative but as a strategic necessity to ensure the competitiveness, sustainability and resilience of the European industrial fabric.

Various recent studies demonstrate that there is high technical potential for the electrification of industrial thermal processes. It is estimated that up to 92% of industrial heat requirements could, in theory, be met through electrical technologies, including electric boilers, industrial heat pumps, induction heating systems and microwave technologies. These solutions offer significant advantages in terms of energy efficiency, thermal control, loss reduction and integration with renewable energy sources. However, despite this potential, the actual adoption rate of industrial electrification remains low, currently standing at around only 4%.

This gap between technical feasibility and practical implementation results from a complex set of structural, economic, organisational and technological barriers that constrain the capacity for industrial transformation.

Firstly, economic and financial obstacles stand out. The relative cost of electricity remains, in many European contexts, higher than that of natural gas and other fossil fuels, reducing the economic attractiveness of electrified solutions in the short term. Added to this is the need for high initial investments in equipment, infrastructure and adaptation of industrial processes, often associated with uncertain or prolonged payback periods. This reality particularly affects small and medium-sized enterprises (SMEs), which have lower investment capacity and greater exposure to technological and operational risk.

Secondly, significant infrastructural limitations persist. The increasing electrification of industry requires more robust, flexible and intelligent electricity grids, capable of responding to increased demand and the integration of intermittent renewable sources. In many cases, the available capacity of industrial electricity grids is insufficient to support new high-power electrified processes. At the same time, the administrative and licensing processes associated with grid connection reinforcements often remain slow and complex, constituting a major delaying factor in the implementation of electrification projects.

Beyond technical and economic barriers, there are also organisational challenges and those related to human competencies. Many traditional industrial sectors still show resistance to change, associated with the perception of operational risk, technological uncertainty and lack of prior experience with advanced electrical systems. At the same time, there is a significant shortage of qualified professionals capable of designing, operating, maintaining and optimising advanced electrothermal technologies and digitalised industrial systems. This skills gap constitutes one of the main critical factors for the success of the industrial energy transition and reinforces the need for structured workforce re-skilling and up-skilling strategies.

The literature review and analyses carried out within the scope of the JOULIA project show that the greatest potential decarbonisation gains are concentrated in medium and high-temperature industrial processes, particularly in the range between 100 °C and 500 °C. Sectors such as rubber vulcanisation, polymer processing, industrial bonding and certain ceramic processes have high potential for direct electrification through advanced electromagnetic technologies. In this context, JOULIA positions itself as a strategic initiative by promoting the application of induction and microwave technologies as sustainable alternatives to conventional combustion-based systems.

These technologies enable localised, precise, contactless heating, eliminating the need for intermediate fluids and significantly reducing energy losses associated with conventional thermal transfer. As a result, estimated energy efficiency gains range from 25% to 40%, accompanied by relevant reductions in carbon emissions, improved process control, reduced operation times and increased production flexibility.

It is important, however, to emphasise that the transition to an electrified industry cannot be understood merely as a technological substitution of energy sources. This is a structural and systemic transformation, implying the reorganisation of production models, the modernisation of energy infrastructures, the integration of intelligent digital solutions and the redefinition of the professional competences necessary for the operation of the industry of the future.

In this sense, industrial electrification simultaneously requires technological investments, coherent and harmonised incentive policies, mechanisms to support innovation and, above all, a workforce prepared to operate in increasingly digitalised, automated and interconnected industrial environments. Human capacity-building thus assumes a central strategic role, constituting an indispensable element to ensure that the European industrial energy transition is not only technologically viable but also economically sustainable, socially inclusive and operationally resilient.

1.2 The "Pi-shaped" (π) Educational Model

The "Pi-shaped" (π) educational model constitutes an advanced approach to skills development designed to respond to the growing demands of contemporary industrial contexts, marked by digitalisation, sustainability and rapid technological evolution. This model represents an evolution of the traditional concept of "T-shaped" professionals. While the "T-shaped" model is based on the combination of deep technical specialisation and a broad set of general knowledge, the "Pi-shaped" model introduces a second dimension of depth, simultaneously integrating specialised technical competences and transversal competences of a cognitive, behavioural and relational nature.

In the context of the JOULIA project, this approach is particularly relevant, since the transition to electrified industrial systems depends not only on the introduction of new technologies but also on the ability of professionals to operate in complex, interdisciplinary and constantly changing environments. The Pi-shaped model thus seeks to develop hybrid professional profiles, capable of combining technical mastery, critical thinking, adaptability and continuous learning.

The structure of the model is organised into three complementary dimensions. The first corresponds to the horizontal bar of the "π" symbol, which represents the breadth of transversal knowledge that all professionals must possess regardless of their specific function. This common foundation is essential to ensure an integrated understanding of the so-called "Twin Transition" — green and digital — and, within the scope of JOULIA, focuses on three fundamental domains: digitalisation, sustainability and human factors. This implies developing competences related to the understanding of data flows, intelligent systems and integrated technologies, as well as promoting environmental awareness, decarbonisation principles and the adoption of sustainable industrial practices. At the same time, the human dimension of technological transformation is valued, including aspects related to human-machine interaction, operational safety and organisational adaptation.

The first vertical leg of the model corresponds to technical specialisation (hard skills), representing the in-depth mastery of specific competences necessary for engineering, operation and industrial maintenance functions. In the case of the JOULIA project, this dimension includes advanced knowledge in induction and microwave heating technologies, power electronics, energy efficiency, renewable energy integration and dynamic energy flow management. The objective is to ensure that professionals possess the technical capacity necessary to design, implement, operate and optimise electrified industrial systems efficiently, safely and sustainably.

The second vertical leg constitutes the distinctive and innovative element of the Pi-shaped model, as it attributes to transversal competences (soft skills) the same level of strategic importance as technical competences. This dimension includes cognitive, behavioural and relational capabilities essential for responding to the challenges of contemporary industry. Among these competences, the following stand out: critical and analytical thinking, indispensable for evaluating complex technological solutions and supporting decision-making processes; adaptability and resilience, fundamental for dealing with contexts of technological uncertainty and organisational change; problem solving and innovation, oriented towards creating original and sustainable solutions to industrial challenges; and finally, continuous learning, considered the true "backbone" of the model, enabling professionals to maintain their relevance in the face of the rapid evolution of technologies and market demands.

From a strategic perspective, the adoption of the Pi-shaped model in the JOULIA project seeks to overcome traditional approaches to fragmented training that are excessively centred on isolated technical competences. Instead, an integrated vision of professional development is promoted, in which technical capacity-building is accompanied by the strengthening of the human, organisational and social competences necessary to sustain long-term industrial transformation.

In this way, the Pi-shaped model helps to ensure that the technological innovation introduced by JOULIA is accompanied by an effective transformation of human capital, making it possible to create a more flexible, resilient, collaborative workforce prepared to respond to the challenges of industrial electrification and the European energy transition. Consequently, this approach reinforces not only industrial efficiency and competitiveness, but also the social, inclusive and sustainable dimension of technological transition.

2. Objectives

D14.5 of the JOULIA project, entitled “Identification of re-skilling and up-skilling needs”, is led by ISQ and runs from month 6 to month 18, playing a central role in preparing the workforce for the industrial energy transition. Its main objective is to identify skills gaps and qualification needs across the different target groups, ensuring that professionals are adequately prepared to adopt and operate the innovative technologies developed within the project.

In this context, task 14.5 focuses on analysing current and future skills through a comparative exercise between existing professional profiles and those that will be required by electrified industrial processes. This analysis made it possible not only to identify skills gaps but also to anticipate challenges associated with technology adoption, proposing pathways and action plans to overcome barriers related to workforce qualification. The results obtained will also be essential to support the development of specific training modules in subsequent tasks, ensuring a training response aligned with the real needs of the sector.

D14.5 is directly linked to the project’s technological demonstrations, which focus on the rubber and plastics sector, particularly on medium-temperature processes (100–500 °C). Two main applications stand out: the integration of induction heating in the rubber vulcanisation process, demonstrated by ART in Italy, and the use of microwave heating for bonding multilayer pipes, implemented by K-FLEX in Poland. In parallel, the project assesses the potential for replicating these technologies in other relevant industrial sectors, such as food and ceramics, reinforcing their cross-sectoral impact.

Beyond the training dimension, this task is part of a broader framework of industrial decarbonisation, contributing to the replacement of fossil-fuel-based systems with more efficient and sustainable electrification solutions. The project sets ambitious targets, including total estimated energy savings of 810 MWhEP/year and an increase in energy efficiency of between 25% and 40%. These targets are supported by concrete results from the industrial demonstrations, as well as by medium- and long-term impact projections arising from the replication of the technologies.

In summary, D14.5 ensures the link between technological innovation and human capacity building, guaranteeing that the transition to electrified industrial processes is accompanied by a skilled workforce capable of supporting the implementation and scalability of the solutions proposed by the JOULIA project.

3. Methodology

The methodology applied in the preparation of D14.5 was designed to ensure an accurate, evidence-based identification of the workforce's re-skilling and up-skilling needs in the context of the transition to industrial electrification. This process, led by ISQ, adopted a human-centred and technical approach aimed at bridging the skills gap necessary for the effective implementation of the JOULIA project's technological innovations.

The methodological framework was organised into five fundamental stages, enabling a transition from theory to operational practice:

Stage 1 (S1) – Skills desk research: this consisted of an exhaustive analysis of technical and scientific literature, using theoretical frameworks to identify existing transversal and technical skills as well as future market trends.

Stage 2 (S2) – Stakeholder mapping: to avoid overlap within the project, this stage took as its reference Deliverable 4.4 (D4.4) – Report on stakeholder needs, which identified critical actors in the value chain — including process industries, technology suppliers and research partners — to ensure that the training plan responds to the real needs of those who operate and manage the new industrial systems.

Stage 3 (S3) – Preparation and application of an electronic questionnaire: based on the results of the literature review, a digital tool was developed to collect primary data from internal and external project stakeholders. This enabled a self-assessment of workers' current skills and the identification of specific knowledge gaps in electrified heating systems and other soft skills that proved relevant to the project.

Stage 4 (S4) – Data triangulation and prioritisation of training needs: in this phase, an analysis was carried out, cross-referencing the quantitative results obtained from the electronic questionnaire with the strategic requirements previously identified in D4.4.

Stage 5 (S5) – Review and finalisation of the deliverable: this was done by consolidating strategic recommendations, transversally integrating data from the Horizon Europe guidance on gender equality plans and the Responsible Research and Innovation (RRI) practice guide, which includes Gender Equality within the scope of the JOULIA Project (Deliverable 1.5). This stage ensures that the action plan not only addresses technical barriers but also promotes equal opportunities and social inclusion in the energy transition.

3.1 Stage 1 (S1)

The 21 selected documents (Table 2) serve as the indispensable scientific, methodological and strategic foundation for the preparation of D14.5. The combination among these sources enabled the project to move from a technical proposal to an operational human capacity-building plan. The effective contributions of these documents to D14.5 can be divided into four fundamental axes (Technical and Electrification skills; Digital and Technological Skills; Sustainability and Green Management Skills; and Transversal Skills), based on methodological rigour and skills intelligence. The documents provided the necessary protocols to identify skills gaps systematically, as follows:

- Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) and systematic literature reviews (SLR) ensured that the selection of skills for D14.5 was based on replicable scientific evidence.

- Skills Intelligence, through Cedefop methodologies for anticipating skills needs, allowed D14.5 to focus not only on the present but also on future gaps induced by electrification.
- Official Taxonomies, such as the ESCO database, are cited as the central reference for locating and selecting cross-sectoral professional profiles and digital skills, as well as for defining the taxonomies of the skills identified.

Table 2: Studies selected for the literature review

Author(s), year and title	Document type	Thematic Focus
Akyazi, T., del Val, P., Goti, A., & Oyarbide, A. (2022). Identifying Future Skill Requirements of the Job Profiles for a Sustainable European Manufacturing Industry 4.0.	Scientific article	It addresses the "twin transition" (digital and green), exploring how Industry 4.0, digitalisation, and sustainability needs are reshaping the qualification requirements of the workforce.
Bongomin, O., Ocen G.G., Gilbert, Nganyi, E. O., Musinguzi, A., & Omara, T. (2020). Exponential Disruptive Technologies and the Required Skills of Industry 4.0.	Scientific article	It is an academic work of analysis and synthesis that seeks to offer a structured roadmap on the technological impact and educational needs brought about by the fourth industrial revolution.
Bray, R., Mejía Montero, A., & Ford, R. (2022). Skills deployment for a 'just' net-zero energy transition.	Scientific article	Explores the dimensions of the 'Just Transition', which seeks to protect workers' rights, ensure the fair distribution of benefits and burdens, and promote the participation of affected communities during the shift to sustainable economic sectors.
Bukartaite R, Hooper D (2023), Automation, artificial intelligence and future skills needs: an Irish perspective.	Scientific article	It is an academic work of original research that seeks to provide practical and theoretical guidance for companies and governments to deal with the transformations of Industry 4.0 in the labour market.
Cedefop. (2025). Meeting skill needs for the green transition: skills anticipation and VET for a greener future.	Practical guide	It is a technical and guidance publication that offers examples of good practices from Europe and other regions for translating green ambitions into the implementation of skills and training policies.
Chatzichristou, S. (2023, June 19). Skills for the green transition – realising VET's potential [Conference presentation].	Presentation	It is supporting material for a technical and informative lecture aimed at discussing public policies for vocational training geared towards the green economy in Europe.
Deloitte. (2023). A blueprint for green workforce transformation.	Toolkit	It is a strategic and operational guidance manual aimed at workforce transformation in the context of the green economy.
Energy and Utilities Sector Skills Council (2025). Energy and Utilities sector skills framework: Sector overview, job families and pathways.	Technical report	It is a regulatory and informative guide designed to support the development of a competitive workforce that is prepared for the technological and sustainability transformations in the energy sector.
Fareri, S., Apreda, R., Mulas, V., & Alonso, R. (2023). The worker profiler: Assessing the digital skill gaps for enhancing energy efficiency in manufacturing.	Scientific article	It is a research and technological development work that seeks to offer a practical, evidence-based solution for human resource management in the context of Industry 4.0 and the energy transition.
Fondazione MAIRE (2023). CLIMATE GOALS: Winning the challenge of climate goals through the creation of skills and competences worldwide.	Technical report	It is a strategic and analytical document that seeks to map global human capital needs to enable decarbonisation targets and a net-zero emissions economy.

Author(s), year and title	Document type	Thematic Focus
Hofmann Trevisan, A., Acerbi, F., Dukovska-Popovska, I., Terzi, S., & Sassanelli, C. (2024). Skills for the twin transition in manufacturing: A systematic literature review.	Scientific article	It is an academic work of synthesis and strategic analysis that seeks to guide academics, industrial managers and policymakers on the human capital needs for a circular and digitalised industry.
Kyeung Chun, H. (2024). Falling through the cracks? skilling, reskilling and upskilling for job transitions (Ill.).	Book chapter	It is an academic work of economic and social analysis focused on employment policies and human capital development for global sustainability.
L2L (2025). The 2025 manufacturing skills report: are frontlines equipped for success?	Technical report	It is an analytical and strategic market study that uses primary data to guide industrial companies on how to deal with the shortage of skilled labour and the adoption of new technologies.
Lightcast. (2023). Engineering skills needs – now and into the future (Report prepared for EngineeringUK).	Technical report	It is a strategic market intelligence study focused on mapping the future of the engineering and technology sector in the UK.
Pearson (2024). Manufacturing Skills Report.	Technical report	Explore how AI can mitigate the skilled labour shortage by creating additional capacity and reshaping roles, particularly in management and administrative (white-collar) functions.
Pinto, R., Perez, A. L., Gonçalves, G., Lampón, J. F., & Pérez-Moure, H. (2025). A proposed educational framework for professional upskilling in smart manufacturing: On-demand microlearning units.	Scientific article	It is an academic work in engineering and education that seeks to provide practical and theoretical solutions to reduce the skills gap in modern industry.
Pinzone, M., & Taisch, M. (2023). Key competencies for circular manufacturing. In Human Aspects of Advanced Manufacturing (120–125).	Scientific article	It is an academic research work that provides practical guidance for managers to identify skills gaps and develop training programmes aimed at industrial sustainability.
Sajko, T., Koch, V., Treul, S., Pacher, C., & Zunk, B. M. (2025). Identifying competences of engineers in the context of operations management: A literature overview.	Scientific article	It is an analytical and strategic academic work focused on human capital development for modern industry.
SkillsPULSE (2025). Emerging skills and occupations (Deliverable D3.1, Project 101132727).	Technical report	It is a strategic document analysing labour market data, aimed at guiding policymakers and educational institutions on the future skills needed in Europe.
Vitti, M., Trevisan, A. H., Ocampo, H. R., Cuentas, V. K., Sarbazvatan, S., Terzi, S., & Sassanelli, C. (2025). A competency map for circular economy education.	Scientific article	It is an academic research and development work that provides a theoretical and practical foundation for aligning technical and higher education with the demands of the twin transition (digital and green) in Europe.
World Economic Forum (2020). Jobs of tomorrow: Mapping opportunity in the new economy. https://www3.weforum.org/docs/WEF_Jobs_of_Tomorrow_2020.pdf	Technical report	It is a market intelligence and public policy guidance document that seeks to provide a roadmap for governments and businesses to plan workforce reskilling for a more digital and human-centred economy.

For the selection of the documentary corpus, the following keywords were used: skills/competency; manufacturing; sustainability; industry; digitalisation/digital transformation; circular economy; green/transition/skills; artificial intelligence; upskilling/reskilling; energy/efficiency/transition. These keywords were carefully chosen to reflect the "Twin Transition", which serves as the strategic foundation for the development of D14.5. The selected documentary corpus directly contributed to the creation of the skills inventory that was applied in the data collection tool, namely the electronic questionnaire (S3). Thus, the literature review not only identified "what" to teach but also contributed to "how" to teach. In summary, this set of 21 documents provided D14.5 with the theoretical basis (which skills), the methodological basis (how to map them), the social basis (whom to include), and the pedagogical basis (how to train) necessary for the success of the energy transition within the JOULIA consortium.

3.2 Stage 2 (S2)

Deliverable D4.4 constituted a fundamental source of information for the preparation of D14.5, providing a robust empirical and qualitative basis regarding skills gaps and the perceptions of workers and industrial managers.

In methodological terms, D4.4 supported the data triangulation process that guided the analyses carried out in D14.5, enabling the integration of evidence from different sources and ensuring greater consistency and validity in the results. In this context, the following key dimensions were identified:

- Systematic identification of skills gaps, based on the analysis of needs reported by industrial stakeholders.
- Mapping professional profiles and target groups, allowing training needs to be segmented according to roles and qualification levels.
- Definition of priority topics for training, aligned with the identified technological and operational challenges.
- Recommendation of learning methodologies, adapted to industrial contexts and user preferences.
- Identification of psychological and organisational barriers, as well as facilitating factors for the adoption of new skills and practices.

In summary, D4.4 incorporated the "voice of the market" in a structured manner, allowing the training plan developed in D14.5 to be designed with a clear orientation towards stakeholder needs. This approach ensures that the technological transition is accompanied by effective human capital capacity-building strategies, promoting a more sustainable adoption aligned with the sector's demands.

3.3 Stage 3 (S3)

S3 – Preparation and administration of an electronic questionnaire constituted the empirical core of Task 14.5. This phase aimed to convert the theoretical knowledge obtained from the literature review into operational data to support the upskilling plan.

A detailed description of this step is presented below. The third stage of the methodology focuses on the operationalisation of primary data collection through the development and launch of a digital data collection tool (survey). This stage was structured around three fundamental axes:

1. Design and Structuring of the Data Collection Instrument - based on the results of documentary research and the ESCO taxonomy, a structured questionnaire was designed with closed and pre-coded questions to ensure clarity, avoid ambiguities and facilitate subsequent statistical analysis. The instrument is organised into sections that reflect the complexity of the energy transition: Sociodemographic and Professional Profile; Technical and Electrification Skills (Hard Skills); Digital Skills and Industry 4.0/5.0 Technologies; Transversal and Sustainability Skills (Soft Skills).

2. Self-assessment and Gap Identification Functionality – the digital tool functions as a Worker Profiler, allowing workers and managers to carry out a self-assessment of their current skills. Methodologically, the system calculates the "distance" between the self-declared skill level and the ideal profile required to operate the new JOULIA technologies. This process enables the precise identification of individual and organisational skills gaps that the subsequent training modules will need to fill.
3. Implementation and Ethics in Data Collection – the questionnaire is administered to a diverse group of internal and external stakeholders, including consortium partners, equipment operators, maintenance engineers and energy suppliers. To ensure data validity and ethical compliance, the process includes informed consent protocols; data protection (GDPR); and multi-device accessibility.

This stage sought to transform the trends identified in the literature into metric-based evidence, allowing the D14.5 upskilling action plan to be tailored and guided by the real needs of the industry.

3.4 Stage 4 (S4)

The S4 constitutes the analytical convergence phase of the project, in which data triangulation is carried out with the aim of defining, in a structured manner, the strategic priorities of the training plan. This step is based on the integration of two complementary sources of information: on the one hand, the quantitative results of the electronic questionnaire, which include the relevance averages (on a scale of 1 to 10) assigned by respondents – with gender balance – to a set of 18 competency areas; on the other hand, the strategic requirements identified in D4.4, which map technical barriers, organisational needs and safety-related concerns, highlighting critical gaps in areas such as energy efficiency, system control and exposure to electromagnetic fields.

To ensure methodological robustness and to prevent the training plan from being determined solely by isolated perceptions, a weighting mechanism was applied. In this model, competencies previously identified as relevant in D4.4 received a multiplier factor of 1.3, while the remaining competencies retained the original questionnaire values. This approach made it possible to reinforce the priority of competencies that have both strategic validation and empirical relevance, such as energy efficiency and operational safety, which become critical areas for training intervention.

Additionally, triangulation enabled the identification of emerging competencies that, although not initially highlighted in the strategic mapping, revealed a high level of appreciation by stakeholders. In this context, transversal competencies stand out – such as problem-solving, innovation and critical thinking – as well as competencies associated with sustainability, including environmental awareness and the circular economy, which directly align with the project's decarbonisation objectives.

As a result, this step culminates in the definition of a ranked hierarchy of competencies, which supports the design of the training modules. This process ensures that the training plan responds not only to the technical requirements of integrating induction and microwave technologies, but also incorporates essential dimensions such as operational safety, sustainability and the cross-cutting preparation of professionals, contributing to a more balanced and effective industrial transition.

3.5 Stage 5 (S5)

The final methodological stage, S5, which comprised the Review and Finalisation of Deliverable D14.5, represented the moment of consolidation and final validation of all the work carried out within the scope of the skills analysis. This phase translated the results obtained throughout the development of Task 14.5, including: documentary research, stakeholder mapping and the comparative analysis of professional profiles, in order to produce a coherent set of strategic and operational recommendations. The objective was to ensure that the deliverable is not limited to a technical diagnosis, but presents a structured, implementation-oriented action plan that supports the adoption and scalability of industrial electrification technologies, namely induction and microwaves.

From a methodological standpoint, this stage is based on the convergence of three main axes. First, strategic recommendations are consolidated, transforming analytical results into practical guidelines to address skills gaps and support the industrial transition. Second, gender equality is integrated transversally, in alignment with Horizon Europe requirements and Gender Equality Plans (GEPs). This integration includes the analysis of the role of gender in the acquisition of new technical and digital skills, the promotion of inclusive professional profiles and the definition of evidence-based indicators. Notably, data from Deliverable 1.5 (D1.5), which identifies female participation at around 19%, is used to promote greater balance in future training and research activities. Third, alignment with the principles of Responsible Research and Innovation (RRI) is ensured, as set out in D1.5, guaranteeing that the action plan incorporates dimensions such as social justice, transparency, stakeholder engagement and the ability to adapt to changing contexts.

The final review also includes a quality and compliance validation process, conducted by members of the JOULIA consortium, ensuring that the deliverable meets the standards required by the European Commission, both technically and ethically. In this way, D14.5 is positioned not merely as an analytical report, but as a strategic roadmap oriented towards a just industrial transition, contributing simultaneously to technological innovation, social inclusion and the promotion of more balanced and sustainable working conditions.

4. Results

The results of the methodological stages applied in the preparation of D14.5 were designed to ensure a rigorous, evidence-based identification of the workforce's reskilling and upskilling needs in the context of the transition to industrial electrification. Structured into five fundamental stages – from the literature review (S1), through the collection of data from D4.4 which contained the voice of stakeholders (S2) and the application of an electronic questionnaire to gather primary data (S3), to the comparative analysis of professional profiles (S4) and the review and finalisation of the deliverable (S5) – this approach made it possible to convert theoretical knowledge into an operational plan focused on real skills gaps.

The results obtained reveal that the transition from fossil-fuel-based systems to advanced induction and microwave technologies requires a profound reconfiguration of the workforce's technical profile, with new competences in power electronics, dynamic energy flow management and electromagnetic field monitoring. The analysis, structured according to the Pi-shaped model, demonstrates that training cannot be uniform; it must combine a common horizontal base in sustainability and the energy transition, in-depth technical specialisations, and transversal competences such as adaptability and critical thinking. Additionally, the integration of gender equality and the principles of Responsible Research and Innovation (RRI) contained in D1.5 ensured that the resulting action plan is not limited to a technical diagnosis, but constitutes a strategic roadmap for a just, inclusive industrial transition aligned with the requirements of Horizon Europe.

4.1 Literature review (S1)

The results of the literature review consistently demonstrate that the evolution of contemporary manufacturing is based on the paradigm of the "Twin Transition" — the convergence of the digital transition and the green transition. This theoretical framework provides a solid foundation for defining the identified competences, highlighting that the ongoing industrial transformation is not merely technological but systemic, requiring an integrated reconfiguration of technical, digital and socio-environmental knowledge. Within the scope of D14.5, the literature review identified four skill domains, which were divided into 18 knowledge/competence areas, presented in Table 3.

Table 3: Skills and areas of knowledge identified in the literature review

Domain/Skills	Areas of knowledge/Competencies
Technical and Electrification skills (1)	1.1) Electric Heating Technologies: knowledge in induction and microwave heating systems, including the field of power electronics. 1.2) Electrothermal Engineering: knowledge in electrical engineering, process engineering and the optimisation of the electromagnetic behaviour of materials. 1.3) Energy Efficiency (EE): knowledge and ability to analyse energy consumption, conduct audits, and apply energy efficiency standards and certifications. 1.4) Integration of Renewable Energy (IRE): knowledge of storage technologies, implementation of Smart Grid and assessment of local IRE potential. 1.5) Operational Safety: knowledge of occupational health and safety, identification of hazards and risks, and electrical safety regulations.
Digital and Technological Skills (2)	2.1) Advanced Data Analytics: Big data/advanced analytics domain knowledge, and the ability to use and interpret a wide range of electrical data from decentralised systems. 2.2) 4.0/5.0 Technologies: Knowledge of the application of the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) is crucial for predictive maintenance.

Domain/Skills	Areas of knowledge/Competencies
	2.3) Modelling and Simulation: knowledge to develop and use digital models and simulations to optimise process performance and control flexibility. 2.4) Cybersecurity: knowledge to protect digital infrastructures.
Sustainability and Green Management Skills (3)	3.1) Impact Assessment: knowledge of life cycle analysis (LCA), life cycle costing (LCC) and tools for assessing environmental impact. 3.2) Circular Economy (CE): knowledge about circular economy strategies, resource management, and waste minimisation practices. 3.3) Environmental Awareness: knowledge of the importance of reducing greenhouse gas emissions and environmental sustainability. 3.4) Business Models: knowledge for developing new business models to capitalise on electrification opportunities.
Transversal Skills (4)	4.1) Adaptability and Resilience: the ability to adapt to changes, flexibility and resilience in the face of technological uncertainty. 4.2) Problem Solving and Innovation: Problem-solving skills, creativity and the ability to innovate. 4.3) Critical and Analytical Thinking: the ability to identify strengths and weaknesses of solutions and alternatives, of high value for energy efficiency engineers and consultants. 4.4) Communication and Collaboration: communication skills (including technical details), teamwork and leadership. 4.5) Continuous Learning: skills for a lifelong learning stance and agility in Learning.

In the domain of technical and electrification skills, the literature highlights electrification and energy efficiency as critical factors for industrial decarbonisation. This consensus directly validates the inclusion of skills related to electric heating technologies, such as induction and microwaves, as well as knowledge of electrothermal engineering, which are fundamental for operating and optimising advanced energy systems. Additionally, recent studies underline the need for new safety protocols associated with emerging technologies, justifying the integration of specific operational safety skills.

Regarding digital and technological skills, the analysed studies show that Industry 4.0 and 5.0 imply a growing integration between physical and digital systems, requiring advanced capabilities in data analysis, artificial intelligence, and modelling. The literature based on labour market analysis and technological innovation confirms a growing demand for skills in data analytics, machine learning, and simulation, essential for the management of smart energy systems, predictive maintenance, and optimisation of industrial processes. These results support the inclusion of advanced digital skills as a central element of the emerging professional profile.

With respect to sustainability and green management, the review confirms the transition towards circular economy models as a structural axis of European industrial policies. Life cycle assessment (LCA), ecodesign, and the development of new sustainable business models emerge as key skills to meet regulatory and market demands. These elements fully justify the integration of skills oriented towards environmental impact assessment, circularity, and organisational innovation in the context of the energy transition.

Finally, the literature converges on the importance of transversal skills, highlighting that technical capabilities are only effective when complemented by cognitive and socio-emotional skills. Models such as the Pi-shaped and reports from international organisations reinforce the relevance of skills such as adaptability, critical thinking, complex problem-solving, and continuous learning, which are considered essential in a context of rapid technological transformation. These dimensions are therefore incorporated as structural elements in the proposed skills model, which was subsequently consulted via an electronic questionnaire.

In summary, the literature review supports that the transition promoted by the project is not limited to the adoption of new technologies, but implies a profound transformation of professional profiles. The articulation between technical, digital, and sustainable skills, complemented by transversal capabilities, forms the basis for a workforce prepared for the challenges of the future industry, aligned with the principles of innovation, resilience, and inclusion.

4.2 Analysis of deliverable 4.4 results (S2)

The results of the analyses carried out based on D4.4 – Report on stakeholder needs, made it possible to systematically identify the main actors in the value chain and characterise the critical skills required for the technological transition promoted by the JOULIA project. This methodological exercise aimed to align the training plan with the real needs of the different professional profiles involved, ensuring the practical relevance of the proposed skills, avoiding redundancies and focusing on the gaps effectively identified in the field.

In the case of manufacturing industries — namely in the rubber, plastics, ceramics and food sectors — the results indicate that electrification is perceived as a strategic opportunity for decarbonisation, but is limited by a shortage of specialised internal skills. Priority skills were identified in energy management and efficiency, systems integration and advanced process control, complemented by knowledge in energy storage, sustainability and thermal control. From an organisational perspective, the need for profiles capable of articulating strategic decarbonisation objectives with the technical implementation of industrial solutions stands out, highlighting the importance of hybrid skills.

With regard to equipment operators and maintenance engineers, the mapping revealed a significant gap between existing skills and those required by new induction and microwave technologies. These professionals identified difficulties associated with the greater complexity of the systems, which require an in-depth understanding of energy flows, control mechanisms and real-time monitoring processes. Additionally, concerns related to operational safety have emerged, particularly regarding exposure to electromagnetic fields and radiation, which reinforces the need for specific training and the creation of safety leadership profiles. The importance of practical, hands-on pedagogical approaches, centred on the real operation of systems and the detection of deviations that could compromise product quality, was also highlighted.

Concerning energy suppliers and network operators (DSOs/TSOs), the analysis reveals a transformation of their traditional role, moving from energy suppliers to managers of integrated and intelligent energy systems. This repositioning requires advanced skills in areas such as data science, software engineering and power electronics, as well as capabilities to manage complex industrial load profiles. The use of tools such as real-time telemetry, automated control systems and modelling through digital twins is identified as essential to ensure network stability and efficiency. Additionally, the need for a systemic approach, supported by multidisciplinary teams capable of integrating technical, regulatory and environmental dimensions, stands out.

In summary, D4.4 confirms that the JOULIA training plan must adopt a multilevel and differentiated approach, capable of responding to the specificities of each professional group. The incorporation of this evidence into D14.5 ensures that the action plan is not limited to overcoming technological barriers, but effectively contributes to the development of human capital, an essential condition for an industrial energy transition that is simultaneously sustainable, safe and socially robust.

4.3 Survey (S3)

The characterisation and results of the electronic questionnaire (comprising 22 questions) developed under Task 14.5 of the JOULIA project demonstrate a robust methodological process of skills intelligence, aimed at the rigorous identification of knowledge gaps relevant to re-skilling and up-skilling processes for the industrial workforce. This instrument was designed based on scientific evidence, namely a systematic literature review and European frameworks such as the ESCO taxonomy, ensuring alignment with recognised standards for skills classification. The questionnaire (Annex A) was structured into five sections — respondent characterisation, technical skills, digital skills, sustainability skills, and transversal skills — using closed and pre-coded questions, with clear wording to minimise bias and ensure consistency in data collection.

The application of the instrument yielded 36 valid responses (questions 1–4)[1], originating from a diverse set of stakeholders linked to areas such as sustainable energy, technological innovation, carbon efficiency, and R&D. Noteworthy are a gender balance (50% female and 50% male – Question 2), as well as a high level of engagement, with 81% of participants expressing interest in following up on the project's results (Question 4). Methodologically, the questionnaire uses a 1-to-10 perception scale to assess the relevance of skills in the context of industrial transition, functioning as a worker profiler that allows respondents to self-assess the gap between their current profile and the profile required by new electrification technologies. The results obtained from the survey conducted by means of an electronic questionnaire between 1 and 22 September 2025 are presented below in Table 4 and Figures 1–18.

Table 4: Question 3 – Company sector

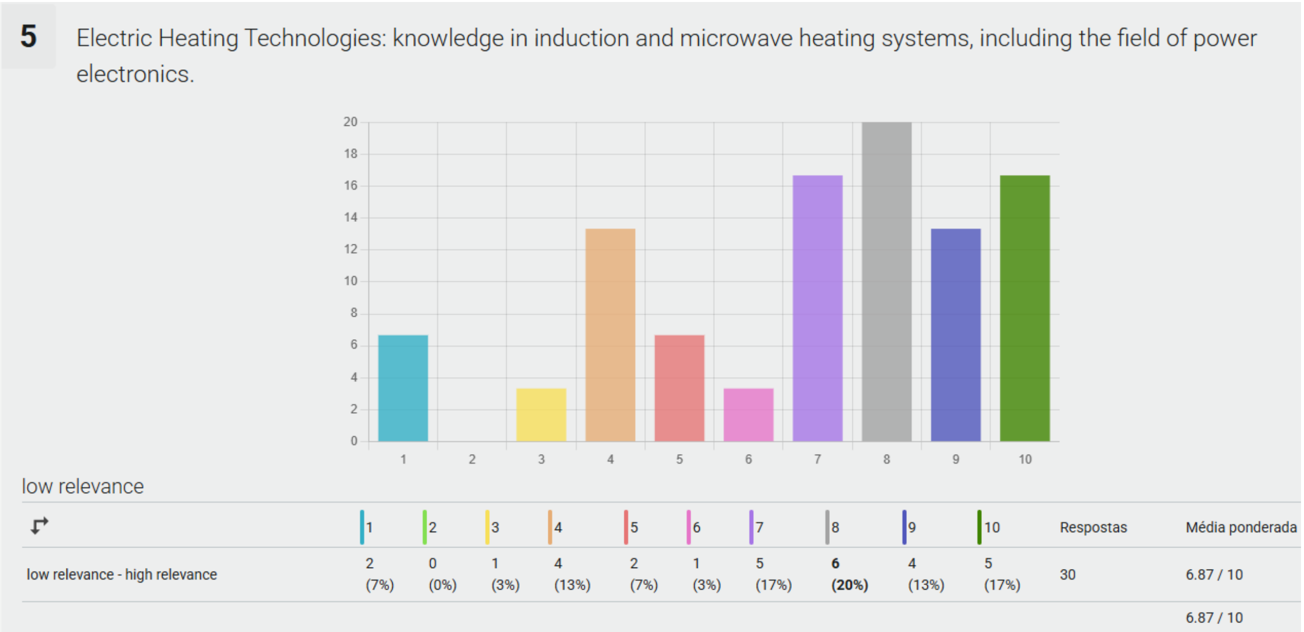
Company sector	% (N=36)
Ceramics	2,78%
Chemistry	2,78%
Construction	2,78%
Education	2,78%
Energy	16,67%
Government	2,78%
Industry	2,78%
Microwave Technology	2,78%
Mining	2,78%
Non-profit organisation	2,78%
Oil and gas	13,89%
R&D	25,00%
Recycling	2,78%
Safety and environment	2,78%
Services	2,78%

[1] The number of respondents varied across the subsequent questionnaire responses - Approximately 22% of participants dropped out.

Company sector	% (N=36)
Technology provider in microwave processing	2,78%
University	8,33%

Results obtained in Section 2, which addressed the following: This section aims to assess the relevance of technical and electrification skills (specific skills relating to the design, installation and operation of new electric heating technologies) for the industrial sector, with a view to developing training courses that prepare professionals to work in line with the objectives of the JOULIA project. Please rate your perception on a scale of 1 to 10, where 1 indicates low relevance of professional skill, and 10 indicates high relevance.

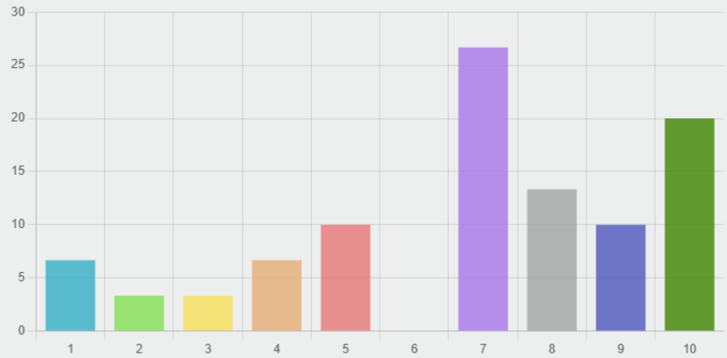
Figure 1: Question 5



Answers: 30.
Weighted average: 6.87/10.

Figure 2: Question 6

6 Electrothermal Engineering: knowledge in electrical engineering, process engineering and the optimisation of the electromagnetic behaviour of materials.



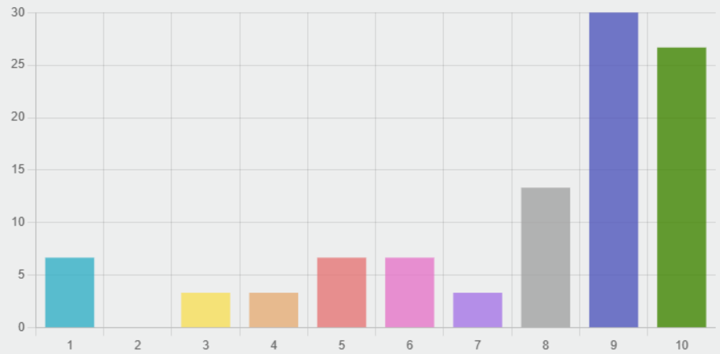
low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	2 (7%)	1 (3%)	1 (3%)	2 (7%)	3 (10%)	0 (0%)	**8 (27%)**	4 (13%)	3 (10%)	6 (20%)	30	6.83 / 10
												6.83 / 10

Answers: 30.
Weighted average: 6.83/10.

Figure 3: Question 7

7 Energy Efficiency (EE): knowledge and ability to analyse energy consumption, conduct audits, and apply energy efficiency standards and certifications.



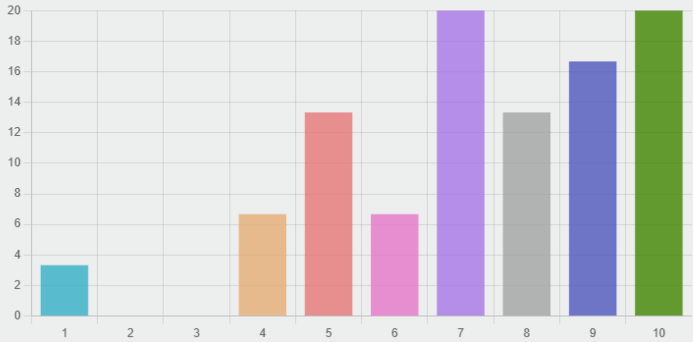
low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	2 (7%)	0 (0%)	1 (3%)	1 (3%)	2 (7%)	2 (7%)	1 (3%)	4 (13%)	**9 (30%)**	8 (27%)	30	7.7 / 10
												7.7 / 10

Answers: 30.
Weighted average: 7.7/10.

Figure 4: Question 8

8 Integration of Renewable Energy (IRE): knowledge of storage technologies, implementation of Smart Grid and assessment of local IRE potential.



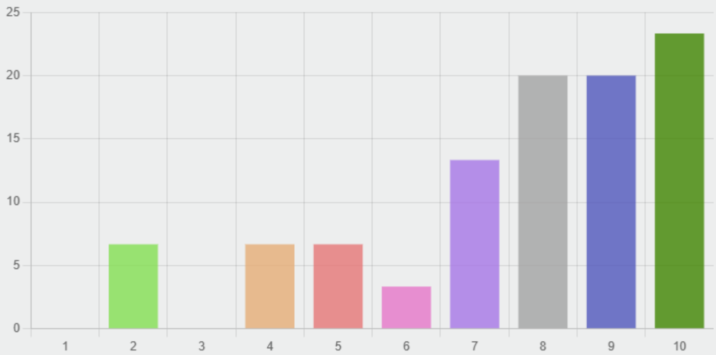
low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	1 (3%)	0 (0%)	0 (0%)	2 (7%)	4 (13%)	2 (7%)	**6 (20%)**	4 (13%)	5 (17%)	6 (20%)	30	7.33 / 10
												7.33 / 10

Answers: 30.
Weighted average: 7.33/10.

Figure 5: Question 9

9 Operational Safety: knowledge of occupational health and safety, identification of hazards and risks, and electrical safety regulations.



low relevance

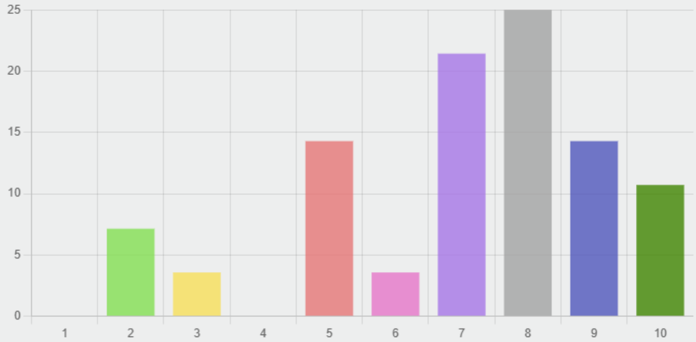
	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	2 (7%)	0 (0%)	2 (7%)	2 (7%)	1 (3%)	4 (13%)	6 (20%)	6 (20%)	**7 (23%)**	30	7.6 / 10
												7.6 / 10

Answers: 30.
Weighted average: 7.6/10.

Results obtained in Section 3, which addressed the following: This section aims to assess the relevance of Digital and Technological Skills (these skills are vital for the flexibility, optimisation and maintenance of electrified systems) for the industrial sector to develop training courses that prepare professionals to work in line with the objectives of the JOULIA project. Please indicate, according to your perception, on a scale of 1 to 10, where 1 means low relevance of professional competence and 10 means high relevance.

Figure 6: Question 10

10 Advanced Data Analytics: Big data/advanced analytics domain knowledge, and the ability to use and interpret a wide range of electrical data from decentralised systems.



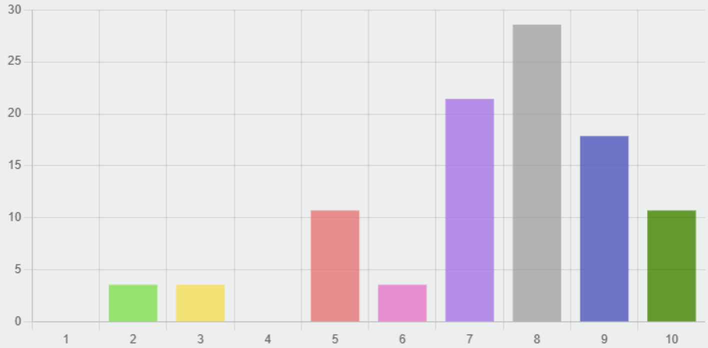
low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	2 (7%)	1 (4%)	0 (0%)	4 (14%)	1 (4%)	6 (21%)	**7 (25%)**	4 (14%)	3 (11%)	28	7.04 / 10
												7.04 / 10

Answers: 28.
Weighted average: 7.04/10.

Figure 7: Question 11

11 4.0/5.0 Technologies: Knowledge of the application of the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) is crucial for predictive maintenance.

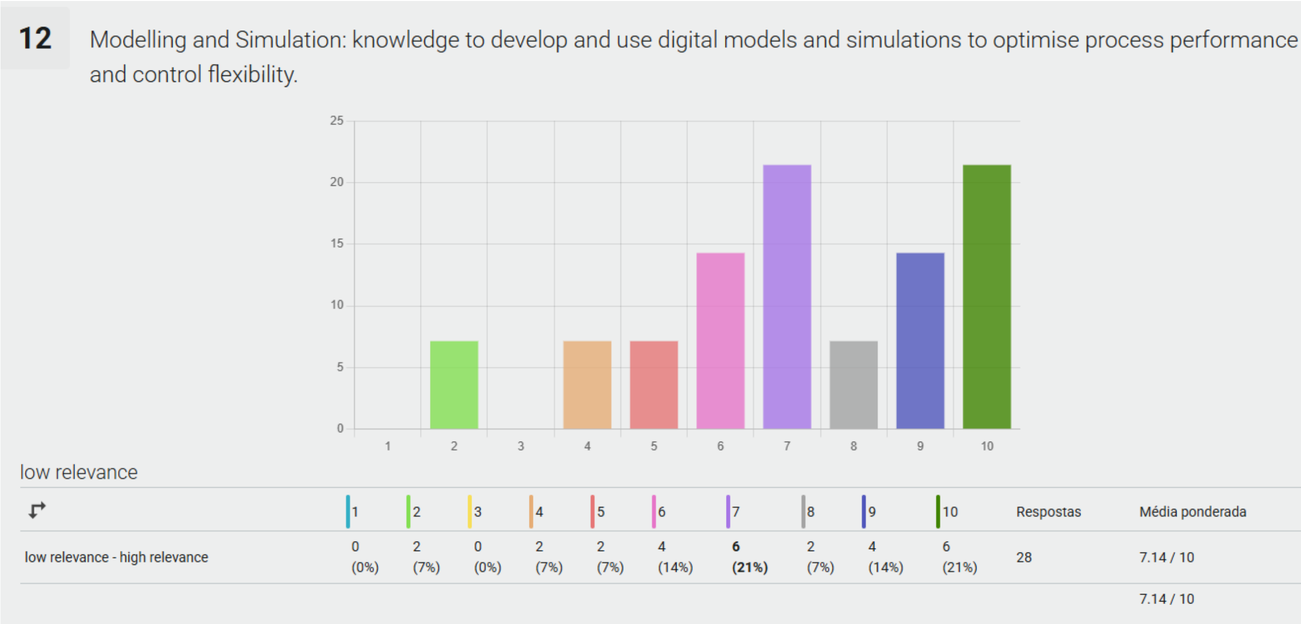


low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	1 (4%)	1 (4%)	0 (0%)	3 (11%)	1 (4%)	6 (21%)	**8 (29%)**	5 (18%)	3 (11%)	28	7.39 / 10
												7.39 / 10

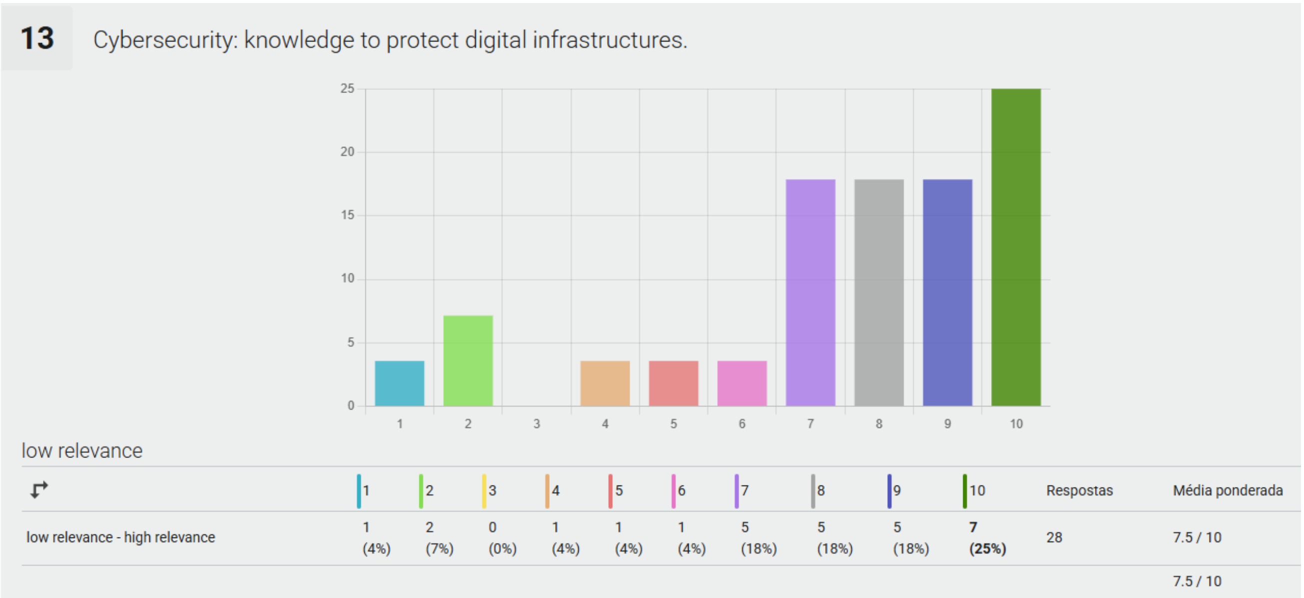
Answers: 28.
Weighted average: 7.39/10.

Figure 8: Question 12



Answers: 28.
Weighted average: 7.14/10.

Figure 9: Question 13

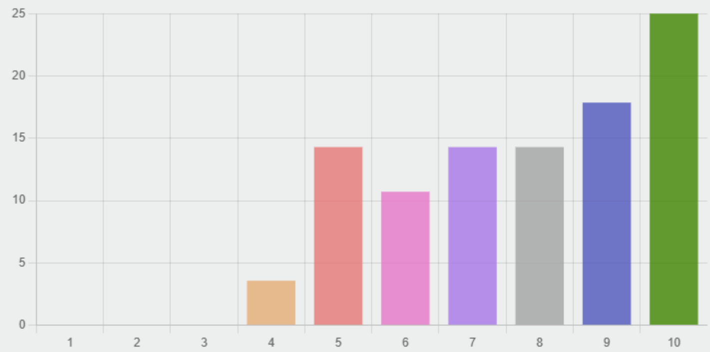


Answers: 28.
Weighted average: 7.5/10.

Results obtained in Section 4, which addressed the following: This section aims to assess the relevance of Sustainability and Green Management Skills (these skills support the goal of decarbonisation and environmental optimisation) for the industrial sector to develop training courses that prepare professionals to act in line with the objectives of the JOULIA project. Please indicate, according to your perception, on a scale of 1 to 10, where 1 means low relevance professional competence, and 10 means high relevance professional competence.

Figure 10: Question 14

14 Impact Assessment: knowledge of life cycle analysis (LCA), life cycle costing (LCC) and tools for assessing environmental impact.



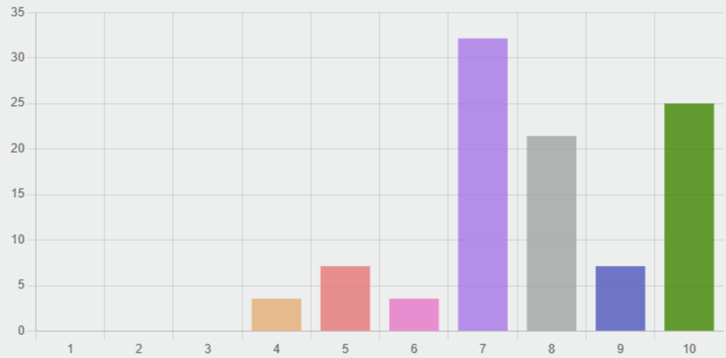
low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	0 (0%)	0 (0%)	1 (4%)	4 (14%)	3 (11%)	4 (14%)	4 (14%)	5 (18%)	**7 (25%)**	28	7.75 / 10
												7.75 / 10

Answers: 28.
Weighted average: 7.75/10.

Figure 11: Question 15

15 Circular Economy (CE): knowledge about circular economy strategies, resource management, and waste minimisation practices.



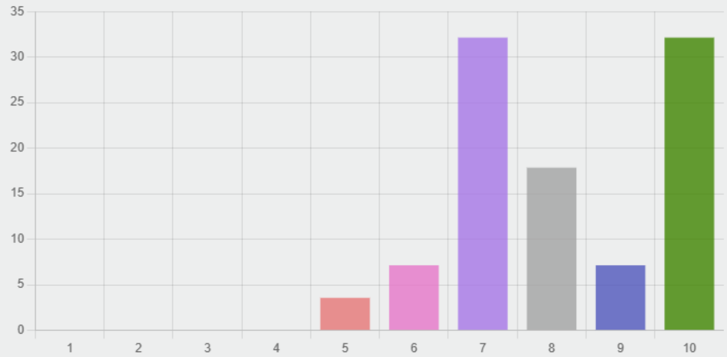
low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	0 (0%)	0 (0%)	1 (4%)	2 (7%)	1 (4%)	**9 (32%)**	6 (21%)	2 (7%)	7 (25%)	28	7.82 / 10
												7.82 / 10

Answers: 28.
Weighted average: 7.82/10.

Figure 12: Question 16

16 Environmental Awareness: knowledge of the importance of reducing greenhouse gas emissions and environmental sustainability.



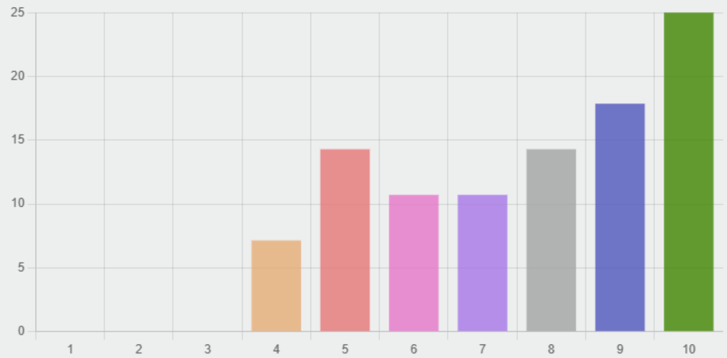
low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	0 (0%)	0 (0%)	0 (0%)	1 (4%)	2 (7%)	**9 (32%)**	5 (18%)	2 (7%)	9 (32%)	28	8.14 / 10
												8.14 / 10

Answers: 28.
Weighted average: 8.14/10.

Figure 13: Question 17

17 Business Models: knowledge for developing new business models to capitalise on electrification opportunities.



low relevance

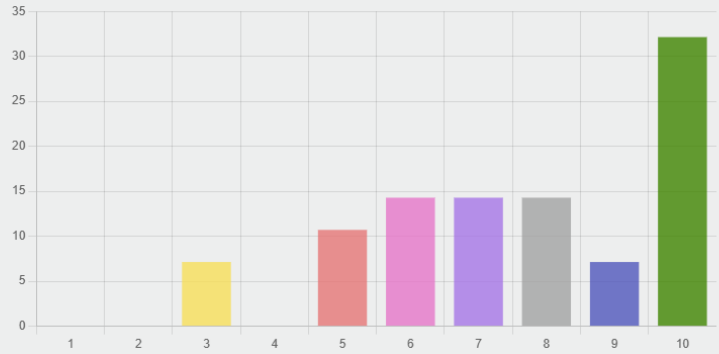
	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	0 (0%)	0 (0%)	2 (7%)	4 (14%)	3 (11%)	3 (11%)	4 (14%)	5 (18%)	**7 (25%)**	28	7.64 / 10
												7.64 / 10

Answers: 28.
Weighted average: 7.64/10.

Results obtained in Section 5, which addressed the following: This section aims to assess the relevance of Transversal Skills (these skills are widely required for the energy transition's success) for the industrial sector to develop training courses that prepare professionals to work in line with the objectives of the JOULIA project. Please indicate, according to your perception, on a scale of 1 to 10, where 1 means low relevance professional competence, and 10 means high relevance professional competence.

Figure 14: Question 18

18 Adaptability and Resilience: ability to adapt to changes, flexibility and resilience in the face of technological uncertainty.



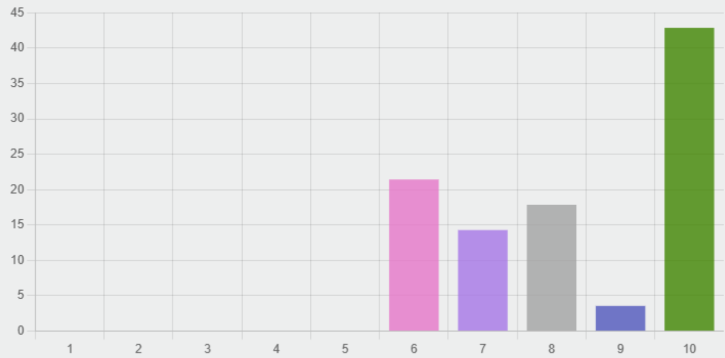
low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	0 (0%)	2 (7%)	0 (0%)	3 (11%)	4 (14%)	4 (14%)	4 (14%)	2 (7%)	**9 (32%)**	28	7.61 / 10
												7.61 / 10

Answers: 28.
Weighted average: 7.61/10.

Figure 15: Question 19

19 Problem Solving and Innovation: Problem-solving skills, creativity and the ability to innovate.



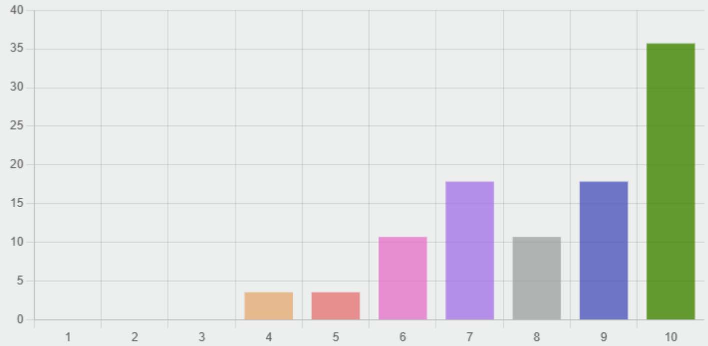
low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	6 (21%)	4 (14%)	5 (18%)	1 (4%)	**12 (43%)**	28	8.32 / 10
												8.32 / 10

Answers: 28.
Weighted average: 8.32/10.

Figure 16: Question 20

20 Critical and Analytical Thinking: the ability to identify strengths and weaknesses of solutions and alternatives, of high value for energy efficiency engineers and consultants.



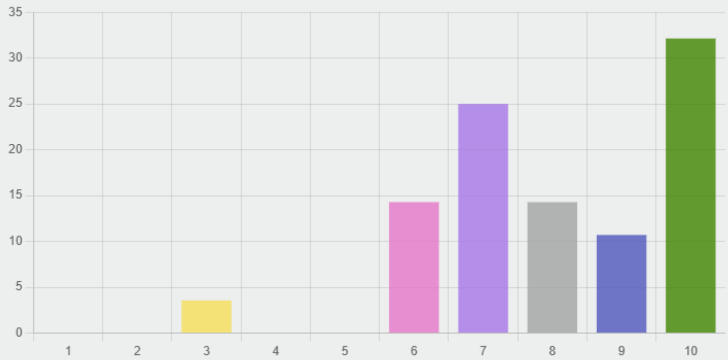
low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	0 (0%)	0 (0%)	1 (4%)	1 (4%)	3 (11%)	5 (18%)	3 (11%)	5 (18%)	**10 (36%)**	28	8.25 / 10
												8.25 / 10

Answers: 28.
Weighted average: 8.25/10.

Figure 17: Question 21

21 Communication and Collaboration: communication skills (including technical details), teamwork and leadership.

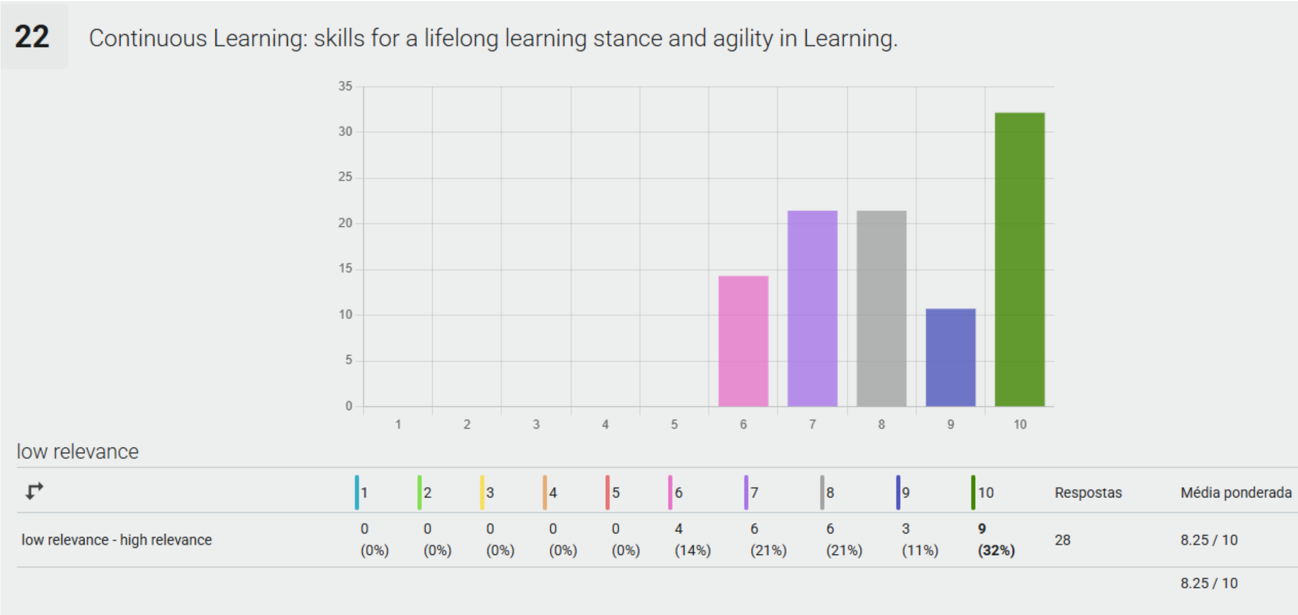


low relevance

	1	2	3	4	5	6	7	8	9	10	Respostas	Média ponderada
low relevance - high relevance	0 (0%)	0 (0%)	1 (4%)	0 (0%)	0 (0%)	4 (14%)	7 (25%)	4 (14%)	3 (11%)	**9 (32%)**	28	8.04 / 10
												8.04 / 10

Answers: 28.
Weighted average: 8.04/10.

Figure 18: Question 22



Answers: 28.
Weighted average: 8.25/10.

The results show a consistent appreciation of all the dimensions analysed, with transversal skills standing out (Table 5), which present the highest scores, particularly in problem-solving and critical thinking, confirming the literature that identifies them as decisive in contexts of high technological complexity. Sustainability skills also stand out, especially environmental awareness, while digital skills — such as data analysis and cybersecurity — reflect the growing importance of industrial digitalisation. In the technical domain, although with slightly lower values, skills associated with electrification, such as electrothermal engineering and electric heating technologies, are also recognised as relevant, highlighting the need to reinforce training in these areas.

Table 5: Skills with higher and lower frequencies

Skills/Knowledge	%
4.2) Problem Solving and Innovation: Problem-solving skills, creativity and the ability to innovate.	83,20%
4.3) Critical and Analytical Thinking: the ability to identify strengths and weaknesses of solutions and alternatives, of high value for energy efficiency engineers and consultants.	82,50%
4.5) Continuous Learning: skills for a lifelong learning stance and agility in Learning.	82,50%
3.3) Environmental Awareness: knowledge of the importance of reducing greenhouse gas emissions and environmental sustainability.	81,40%
4.4) Communication and Collaboration: communication skills (including technical details), teamwork and leadership.	80,40%
3.2) Circular Economy (CE): knowledge about circular economy strategies, resource management, and waste minimisation practices.	78,20%
3.1) Impact Assessment: knowledge of life cycle analysis (LCA), life cycle costing (LCC) and tools for assessing environmental impact.	77,50%
1.3) Energy Efficiency (EE): knowledge and ability to analyse energy consumption, conduct audits, and apply energy efficiency standards and certifications.	77%
3.4) Business Models: knowledge for developing new business models to capitalise on electrification opportunities.	76,40%
4.1) Adaptability and Resilience: the ability to adapt to changes, flexibility and resilience in the face of technological uncertainty.	76,10%
1.5) Operational Safety: knowledge of occupational health and safety, identification of hazards and risks, and electrical safety regulations.	76%

Skills/Knowledge	%
2.4) Cybersecurity: knowledge to protect digital infrastructures.	75%
2.2) 4.0/5.0 Technologies: Knowledge of the application of the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) is crucial for predictive maintenance.	73,90%
1.4) Integration of Renewable Energy (IRE): knowledge of storage technologies, implementation of Smart Grid and assessment of local IRE potential.	73,30%
2.3) Modelling and Simulation: knowledge to develop and use digital models and simulations to optimise process performance and control flexibility.	71,40%
2.1) Advanced Data Analytics: Big data/advanced analytics domain knowledge, and the ability to use and interpret a wide range of electrical data from decentralised systems.	70,40%
1.1) Electric Heating Technologies: knowledge in induction and microwave heating systems, including the field of power electronics.	68,70%
1.2) Electrothermal Engineering: knowledge in electrical engineering, process engineering and the optimisation of the electromagnetic behaviour of materials.	68,30%

Based on this empirical diagnosis and the documents analysed, three broad groups of critical professional profiles for the energy transition promoted by JOULIA have been identified. Firstly, professional engineers, responsible for the design, integration and optimisation of electrified systems, including profiles such as energy engineer, maintenance engineer and electrothermal engineer. Secondly, managers and consultants operate at the strategic and organisational level, ensuring economic viability, the implementation of sustainable solutions and the upskilling of teams. Finally, technicians and operators, who play a central role in the daily operation of systems and in ensuring the safety and efficiency of processes, require significant adaptation to new technological demands. The professional profiles have been addressed according to the design of the training programmes based on the European Qualifications Framework (EQF) level to which they belong, thus avoiding the terms 'white-collar' and 'blue-collar', which imply a professional stratification of greater or lesser importance, entirely inconsistent with the guidelines of inclusion, equality and equity set out in the JOULIA project.

Across all these profiles, the need for a 'Pi-shaped' professional model emerges, combining technical depth with horizontal skills, namely analytical abilities, adaptability, innovation, and continuous learning. This framework reinforces that the energy transition does not merely involve the adoption of new technologies, but a structural transformation of professional profiles. Thus, the results obtained provide a solid foundation for the development of D14.5, which consists of differentiated training roadmaps tailored to specific roles, ensuring an effective response to real industry needs and contributing to a sustainable, safe, and socially balanced transition.

4.4 Data triangulation (S4)

The results of the data triangulation represent the analytical consolidation of the project, systematically integrating the empirical data collected through the electronic questionnaire with the strategic requirements previously defined in D4.4. This triangulation process made it possible to establish a robust hierarchy of priorities for the training plan, ensuring that the training modules respond simultaneously to the technical demands of industrial electrification and the human and organisational dimensions associated with the transition.

The analysis was supported by two complementary sources: on the one hand, the quantitative results of an electronic questionnaire administered to 36 participants, with a gender balance factor (50% female and 50% male), who assessed 18 competency areas based on a relevance scale; on the other hand, the strategic framework of D4.4, which identified critical needs in industrial sectors such as rubber, plastics, ceramics and food. To ensure methodological consistency and strengthen the validity of the results, a weighting mechanism was applied that assigned a multiplier factor of 1.3 to the competencies previously identified as strategic, while the values of the remaining competencies were kept unchanged. This approach made it possible to distinguish between structurally validated needs and emerging stakeholder perceptions, as demonstrated by the data presented in Table 6 below.

Table 6: Data comparison: survey vs. D4.4

Skills/Knowledge	Survey %	D4.4	Final %
4.5) Continuous Learning: skills for a lifelong learning stance and agility in Learning.	82,50%	Yes (x 1.3)	107,25%
1.3) Energy Efficiency (EE): knowledge and ability to analyse energy consumption, conduct audits, and apply energy efficiency standards and certifications.	77%	Yes (x 1.3)	100,10%
4.1) Adaptability and Resilience: the ability to adapt to changes, flexibility and resilience in the face of technological uncertainty.	76,10%	Yes (x 1.3)	98,93%
1.5) Operational Safety: knowledge of occupational health and safety, identification of hazards and risks, and electrical safety regulations.	76%	Yes (x 1.3)	98,80%
2.2) 4.0/5.0 Technologies: Knowledge of the application of the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) is crucial for predictive maintenance.	73,90%	Yes (x 1.3)	96,07%
1.4) Integration of Renewable Energy (IRE): knowledge of storage technologies, implementation of Smart Grid and assessment of local IRE potential.	73,30%	Yes (x 1.3)	95,29%
2.1) Advanced Data Analytics: Big data/advanced analytics domain knowledge, and the ability to use and interpret a wide range of electrical data from decentralised systems.	70,40%	Yes (x 1.3)	91,52%
1.1) Electric Heating Technologies: knowledge in induction and microwave heating systems, including the field of power electronics.	68,70%	Yes (x 1.3)	89,31%
4.2) Problem Solving and Innovation: Problem-solving skills, creativity and the ability to innovate.	83,20%	No (x 1)	83,20%
4.3) Critical and Analytical Thinking: the ability to identify strengths and weaknesses of solutions and alternatives, of high value for energy efficiency engineers and consultants.	82,50%	No (x 1)	82,50%
3.3) Environmental Awareness: knowledge of the importance of reducing greenhouse gas emissions and environmental sustainability.	81,40%	No (x 1)	81,40%
4.4) Communication and Collaboration: communication skills (including technical details), teamwork and leadership.	80,40%	No (x 1)	80,40%
3.2) Circular Economy (CE): knowledge about circular economy strategies, resource management, and waste minimisation practices.	78,20%	No (x 1)	78,20%
3.1) Impact Assessment: knowledge of life cycle analysis (LCA), life cycle costing (LCC) and tools for assessing environmental impact.	77,50%	No (x 1)	77,50%
3.4) Business Models: knowledge for developing new business models to capitalise on electrification opportunities.	76,40%	No (x 1)	76,40%
2.4) Cybersecurity: knowledge to protect digital infrastructures.	75%	No (x 1)	75,00%
2.3) Modelling and Simulation: knowledge to develop and use digital models and simulations to optimise process performance and control flexibility.	71,40%	No (x 1)	71,40%
1.2) Electrothermal Engineering: knowledge in electrical engineering, process engineering and the optimisation of the electromagnetic behaviour of materials.	68,30%	No (x 1)	68,30%

Note 1: Cut-off percentage: ≤ 80%.
Note 2: A weighting factor of 1.3 (+30%) was applied to the skills that showed simultaneous validation in the questionnaire and the D4.4 report, to reinforce strategic relevance and reduce possible biases. This approach made it possible to prioritise skills identified as structural needs of the sector, ensuring greater alignment between empirical evidence, market requirements and project objectives.

The results revealed a set of critical competencies positioned at the top of the hierarchy, combining high empirical relevance with strategic validation. Among these, continuous learning, energy efficiency, adaptability, resilience, and operational safety stand out, reflecting the need for professionals capable of operating in technologically complex and constantly evolving environments. In parallel, competencies associated with Industry 4.0/5.0 technologies and electric heating technologies play a central role in the operationalisation of induction and microwave systems, highlighting the importance of technical specialisation.

Triangulation also made it possible to identify emerging competencies that were highly valued by respondents, particularly in terms of transversal skills and sustainability. Capabilities such as problem-solving, critical thinking, environmental awareness and communication prove to be decisive in ensuring not only technical effectiveness, but also the organisational and social integration of the proposed solutions.

From this analysis, a final hierarchy of competencies was defined based on a cut-off threshold of 80%, which directly guides the selection of priority training modules. Competencies below this threshold are considered complementary and may be integrated in later stages or in specialised modules. This procedure ensures that the JOULIA training plan is simultaneously guided by empirical evidence and aligned with the strategic needs of the sector, promoting a balanced training response that articulates technological innovation, operational safety, sustainability and the transversal development of professionals.

4.5 Aligning training programmes with gender equality (S5)

According to the guidelines of the European Commission (2021, 2025a, 2025b, 2026) under the Horizon Europe programme, the integration of the gender dimension into vocational training programmes must be understood as a continuous, structured process strategically aligned with organisational transformation, rather than as an isolated or one-off action. Within this framework, the inclusion of training and awareness-raising actions in Gender Equality Plans (GEPs) constitutes a mandatory eligibility criterion for access to European funding. These actions should encompass the entire organisation – from top leadership to technical staff, researchers, and administrative personnel – to ensure institutional commitment and systemic impact.

From a methodological perspective, the design of training should be evidence-based, starting from prior diagnoses that identify the organisation's specific needs. A long-term approach is recommended, with continuous training activities that promote critical reflection and the progressive integration of new practices into daily professional life. To ensure accessibility and inclusion, training should adopt flexible formats, including online and asynchronous modules, facilitating the participation of professionals with different responsibilities, particularly those with family obligations. In terms of content, priority areas include tackling unconscious bias, integrating the gender dimension into research and teaching, promoting inclusive leadership, and implementing measures to prevent harassment and discrimination, including practical training on protocols and intervention strategies.

The implementation of this training should be supported by rigorous monitoring and transparency mechanisms, with the definition of clear indicators, such as participation rates by gender and professional group, the number of actions carried out, and participant satisfaction levels. The regular production of reports – preferably public – reinforces institutional accountability and demonstrates alignment with the transparency and good governance principles required by the European Commission.

In this context, the development of a workshop dedicated to unconscious bias in industrial recruitment constitutes a practical application of these guidelines. This type of training should equip decision-makers and human resources professionals to identify and mitigate biases that affect the access and progression of female talent. Among the operational objectives, the deconstruction of merit stereotypes stands out, through the analysis of practical cases that show how the perception of competence can be influenced by gender factors. At the same time, it is essential to develop the ability to critically analyse the language used in job advertisements and evaluations, identifying patterns that associate women with social skills and men with technical or leadership skills.

Additionally, the training should address the revision of evaluation criteria, including the mitigation of the so-called “motherhood penalty”, promoting models that value the quality of the professional trajectory rather than exclusively quantitative metrics. The use of simulations of selection processes – such as CV screening and mock interviews – makes it possible to observe, in a controlled setting, potential asymmetries in the treatment of candidates. Complementary accountability mechanisms should also be introduced, encouraging the formal justification of recruitment decisions and the adoption of corrective measures when there is no diversity in the final shortlists of candidates.

Finally, the training should include components of inclusive leadership, empowering those responsible for decision-making processes to ensure that different perspectives are effectively considered and valued. In this way, compliance with Horizon Europe requirements ceases to be merely a formal obligation and becomes a strategic tool for promoting more equitable, innovative work environments capable of attracting and retaining diverse talent, directly contributing to the success and sustainability of projects such as JOULIA.

4.5.1 Practical integration of the gender dimension

To ensure the effective integration of the gender dimension into the training activities of the JOULIA project, in accordance with the European Commission's guidelines under Horizon Europe, as well as the Responsible Research and Innovation (RRI) framework set out in D1.5 and the outcomes of Task 14.5, the following operational guidelines should be applied in the design, delivery and monitoring of the training programmes.

First of all, the use of terminology that may reinforce professional stereotypes should be avoided, opting instead for classifications aligned with European reference frameworks, such as the European Qualifications Framework (EQF), thereby ensuring neutrality and clarity.

In terms of training content, all training sessions – especially those aimed at managers, engineers and technicians – must include mandatory modules on unconscious gender bias, focusing on its influence on recruitment processes, performance appraisal and career progression. Additionally, the gender dimension must be integrated into technical content, enabling trainees to analyse whether the technological solutions developed consider potential differentiated impacts between women and men, thus promoting inclusive and non-discriminatory industrial design.

From a pedagogical perspective, training should be designed in a flexible and accessible manner, adopting microlearning formats and asynchronous online modalities. This approach facilitates the participation of professionals with varying constraints, particularly those with family responsibilities, thereby contributing to a better work-life balance. It is also essential to ensure representativeness in training materials, including examples, case studies and audiovisual content that depict women in technical and leadership roles, reinforcing their role as role models.

About communication, all training and dissemination materials must use inclusive and non-sexist language, in line with European recommendations. Clear and transparent technical communication should also be ensured on critical aspects such as operational safety, exposure to electromagnetic fields and technology-related risks, to build trust among all stakeholder groups, regardless of gender.

Finally, Table 7 provides a summary of the gender integration actions in the training designed for the JOULIA project.

Table 7: Integration of the gender dimension in JOULIA training

Application Checklist – Integration of the Gender Dimension in JOULIA Trainings
(Aligned with European Commission guidelines under Horizon Europe, D1.5 – RRI and Task 14.5)
1. Language and Framing
Use neutral and inclusive terminology in all training materials
Avoid classifications that reinforce stereotypes (e.g., “blue-collar”, “white-collar”)
Align profiles and competences with European reference frameworks (e.g., EQF)
2. Training Content
Include a mandatory module on unconscious gender bias
Integrate the gender dimension into technical content (e.g., analysis of the differentiated impact of technologies)
Promote principles of inclusive and non-discriminatory industrial design
3. Pedagogical Methodology
Structure training in flexible formats (microlearning, e-learning, asynchronous)
Ensure accessibility for participants with different availability (work-life balance)
Include practical methodologies (e.g., case studies, simulations, real-world scenarios)
4. Representativeness and Materials
Ensure balanced gender representation in examples, case studies and visual content
Include women as technical references and leaders
Validate that materials do not reproduce implicit stereotypes
5. Communication and Safety
Apply inclusive and non-sexist language in all content and communications
Ensure clear communication about operational safety
Adapt communication to different stakeholder profiles, building trust
6. Monitoring and Evaluation
Apply the Gender Balance indicator in all trainings
Monitor participation rates by gender
Assess the impact of training on reducing inequalities
7. Continuous Improvement
Adjust content and methodologies based on the data collected
Identify gaps in female participation and implement corrective measures

Finally, the delivery of the training must be supported by a rigorous, indicator-driven monitoring system. The use of metrics such as the gender balance indicator is mandatory, enabling monitoring of female participation in training activities to improve the ratio currently identified within the consortium. All participation and evaluation data must be collected in a gender-disaggregated manner, ensuring the production of consistent reports aligned with the requirements of Horizon Europe.

The systematic application of these guidelines ensures that the JOULIA training plan not only meets the technical demands of the energy transition but also promotes an inclusive and equitable approach, contributing to a Just Transition and to the development of a more diverse, resilient, and socially responsible industrial sector.

5. Learning Paths

The selection and structuring of the training courses presented below in Table 8 result from a robust methodological process, developed under D14.5, which combined empirical evidence, theoretical framework and alignment with the strategic priorities of the JOULIA project. The central objective was to ensure that the transition to electrified heating technologies – namely induction and microwaves – is accompanied by effective workforce upskilling, systematically reducing the skills gaps identified between current professional profiles and the requirements of the so-called "Twin Transition" (digital and green).

The selection of training modules is based, first of all, on the "Pi-shaped" educational model (Pinto et al., 2025), which guides the construction of professional profiles that balance a cross-cutting foundation of knowledge in sustainability and digitalisation with two complementary dimensions: on the one hand, in-depth technical specialisation (hard skills) and, on the other, the development of soft skills, which are essential for adaptability in complex industrial contexts.

Secondly, a data triangulation methodology (Stage S4) was applied, integrating the strategic requirements identified with stakeholders in D4.4 with the quantitative results of an electronic questionnaire addressed to sector specialists. To reinforce analytical robustness, the skills previously validated in D4.4 were weighted with a multiplier factor of 1.3, allowing structural priorities to be distinguished from circumstantial perceptions. This procedure produced a hierarchical ranking, in which only modules exceeding the 80% final relevance threshold were selected.

Furthermore, the structuring of the training incorporates a differentiation by levels of the European Qualifications Framework (EQF), ensuring appropriateness for different professional profiles. This approach distinguishes between operational levels, associated with system execution and maintenance (EQF 4–5), and advanced levels, geared towards design, analysis and strategic decision-making (EQF 6–7), thereby promoting both professional progression and inclusion.

Finally, the plan explicitly integrates the principles of Responsible Research and Innovation (RRI) and the Horizon Europe gender equality guidelines. The inclusion of a specific module in this area ensures not only compliance with European requirements but also the active promotion of greater equity in the sector, helping to mitigate the currently observed under-representation of women.

In summary, the JOULIA project training plan constitutes a well-founded strategic instrument that goes beyond a technical skills diagnosis, providing an operational roadmap for an electrified industrial transition that is simultaneously efficient, safe and socially inclusive.

Table 8: JOULIA training modules and submodules

Module	Skills	Knowledge	EQF Level
1	Technical and Electrification skills (1)	1.1_Electric Heating Technologies: knowledge in induction and microwave heating systems, including the field of power electronics.	4-5
		1.2_Energy Efficiency (EE): knowledge and ability to analyse energy consumption, conduct audits, and apply energy efficiency standards and certifications.	4-5
		1.3_Integration of Renewable Energy (IRE): knowledge of storage technologies, implementation of Smart Grid and assessment of local IRE potential.	6-7
		1.4_Operational Safety: knowledge of occupational health and safety, identification of hazards and risks, and electrical safety regulations.	4-5

Module	Skills	Knowledge	EQF Level
2	Digital and Technological Skills (2)	2.1_Advanced Data Analytics: Big data/advanced analytics domain knowledge, and the ability to use and interpret a wide range of electrical data from decentralised systems.	6-7
		2.2_4.0/5.0 Technologies: Knowledge of the application of the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) is crucial for predictive maintenance.	4-5
3	Sustainability and Green Management Skills (3)	3.1_Environmental Awareness: knowledge of the importance of reducing greenhouse gas emissions and environmental sustainability.	4-5
4	Transversal Skills (4)	4.1_Adaptability and Resilience: ability to adapt to changes, flexibility and resilience in the face of technological uncertainty.	6-7
		4.2_Problem Solving and Innovation: Problem-solving skills, creativity and the ability to innovate.	6-7
		4.3_Critical and Analytical Thinking: the ability to identify strengths and weaknesses of solutions and alternatives, of high value for energy efficiency engineers and consultants.	6-7
		4.4_Communication and Collaboration: communication skills (including technical details), teamwork and leadership.	4-5
		4.5_Continuous Learning: skills for a lifelong learning stance and agility in Learning.	4-7
5	Gender Inclusion	5.1_Counteracting Unconscious Biases and Managing Diverse Talent	6-7

The assignment of European Qualifications Framework (EQF) levels to the JOULIA project training courses is based on a technical analysis of the complexity of the functions, the degree of autonomy required and the professional profiles for which they are intended, distinguishing mainly between Operators (EQF 4–5) and Engineers/Managers (EQF 6–7). This approach is underpinned by the "Pi-shaped" educational model, which combines a solid transversal knowledge base with technical specialisations and well-developed soft skills.

In the technical and electrification modules, such as Electric Heating Technologies, Energy Efficiency and Operational Safety, the assignment to EQF 4–5 is justified by their focus on practical application, system operation and compliance with standards in an industrial context. These training courses require applied technical understanding and direct work on the factory floor, without involving the design or modelling of complex systems. In contrast, the training course on Integration of Renewable Energy is placed at EQF levels 6–7, as it involves advanced analysis, system integration and modelling-based decision-making – competences typical of engineering profiles.

In the digital domain, the distinction remains: 4.0/5.0 Technologies falls within level 4–5 because it prioritises the operational use of technologies such as IoT and AI to support maintenance and productive efficiency, whereas Advanced Data Analytics is classified as EQF 6–7 because it requires advanced analytical capabilities, interpretation of large volumes of data and a more abstract conceptual command.

Regarding sustainability, Environmental Awareness is assigned to level 4–5 as it constitutes a basic cross-curricular competence oriented towards sustainable operational practices in everyday activities. In the field of soft skills, areas such as resilience, innovation and critical thinking are positioned at EQF levels 6–7, since they imply high autonomy, the ability to deal with uncertainty and the development of original solutions – characteristics associated with engineering and strategic management functions. On the other hand, competences such as communication and collaboration are framed at level 4–5, focusing on operational coordination and effective interaction between teams.

The competence of continuous learning assumes a cross-curricular character, covering EQF levels 4 to 7, reflecting the need for permanent adaptability across all professional profiles. Finally, the training on Counteracting Unconscious Biases and Managing Diverse Talent is assigned to EQF levels 6–7, as it is aimed at decision-makers and managers responsible for organisational changes and policy setting, requiring a high degree of responsibility and strategic vision.

Taken together, this distribution ensures coherence between the learning objectives, functional requirements and European qualification levels, guaranteeing the appropriateness of the competences developed to the different professional profiles involved.

5.1 Guidelines for preparing modules and submodules

The training plan of the JOULIA project, developed under D14.5, is structured around 13 training modules emerging from the applied methodological processes, intending to transform the technical diagnosis and the needs identified by stakeholders into an operational capacity-building roadmap. This plan is based on the "Pi-shaped" educational model, which combines a horizontal foundation of transversal knowledge with in-depth technical specialisations and essential human skills, ensuring a balanced approach between theory, practice and behavioural development.

The adopted teaching methodology favours a flexible, user-centred learning model. The training is organised into on-demand microlearning units, allowing professionals to adapt their learning path to their specific needs and career context. From a pedagogical perspective, approaches such as Problem-Based Learning (PBL) are used, ensuring that participants apply theoretical knowledge in practical situations aligned with real industry challenges.

The training format is blended, combining different teaching modalities to maximise learning effectiveness. It includes digital content such as videos, reading materials and online webinars, complemented by personalised laboratory sessions and face-to-face workshops held at the project's demonstration sites (demosites). This approach is supported by principles of constructivist theory, promoting the active construction of knowledge through experience and practice, while organising content into short, structured units to facilitate assimilation and reduce cognitive load.

Regarding duration, each online microlearning submodule will typically last between one and two hours, allowing efficient integration into the participants' daily work routines. The training will be made available through the ISQ partner's Moodle LMS platform, ensuring intuitive access and compatibility with different devices. The practical, in-person components and technical workshops will take place at the project's demosites, namely at facilities located in Italy, focused on induction vulcanisation, and in Poland, dedicated to microwave bonding processes. Table 9 below details the learning outcomes to be achieved for each submodule:

Table 9: JOULIA training - learning outcomes

Submodule	EQF level	Expected Learning Outcomes
1.1_Electric Heating Technologies: knowledge in induction and microwave heating systems, including the field of power electronics.	4-5	Operate and maintain induction and microwave systems, monitoring energy flows in real time.
1.2_Energy Efficiency (EE): knowledge and ability to analyse energy consumption, conduct audits, and apply energy efficiency standards and certifications.	4-5	Analyse consumption, carry out technical audits and apply standards to achieve the 25–40% efficiency increase target.

Submodule	EQF level	Expected Learning Outcomes
1.3_Integration of Renewable Energy (IRE): knowledge of storage technologies, implementation of Smart Grid and assessment of local IRE potential.	6-7	Design storage systems and integrate renewable sources into industrial Smart Grids.
1.4_Operational Safety: knowledge of occupational health and safety, identification of hazards and risks, and electrical safety regulations.	4-5	Identify electrical hazards and implement protection protocols against electromagnetic fields (EMF).
2.1_Advanced Data Analytics: Big data/advanced analytics domain knowledge, and the ability to use and interpret a wide range of electrical data from decentralised systems.	6-7	Interpret complex electrical data from decentralised systems and manage industrial load profiles.
2.2_ 4.0/5.0 Technologies: Knowledge of the application of the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) is crucial for predictive maintenance.	4-5	Carry out predictive maintenance using IoT and AI to reduce production downtime by 25%.
3.1_Environmental Awareness: knowledge of the importance of reducing greenhouse gas emissions and environmental sustainability.	4-5	Promote operational sustainability and understand the importance of reducing GHG emissions in the sector.
4.1_Adaptability and Resilience: ability to adapt to changes, flexibility and resilience in the face of technological uncertainty.	6-7	Manage technological change with resilience and lead teams in the face of energy transition uncertainty.
4.2_Problem Solving and Innovation: Problem-solving skills, creativity and the ability to innovate.	6-7	Innovate industrial processes and create creative solutions for technical decarbonisation challenges.
4.3_Critical and Analytical Thinking: the ability to identify strengths and weaknesses of solutions and alternatives, of high value for energy efficiency engineers and consultants.	6-7	Critically evaluate the strengths and weaknesses of different energy efficiency solutions.
4.4_Communication and Collaboration: communication skills (including technical details), teamwork and leadership.	4-5	Collaborate in multidisciplinary teams and communicate technical details clearly to diverse stakeholders.
4.5_Continuous Learning: skills for a lifelong learning stance and agility in Learning.	4-7	Demonstrate agility in lifelong learning, maintaining professional relevance in evolving sectors.
5.1_Counteracting Unconscious Biases and Managing Diverse Talent	6-7	Neutralise unconscious biases and implement fair and diverse recruitment and talent management processes.

The evaluation mode and operational details of the training programme are structured to ensure not only the acquisition of knowledge but also the effective validation of competences in an applied context. Firstly, the proficiency assessment sets the goal that, upon completion of the training pathway, at least 80% of participants demonstrate mastery of the defined competences. This assessment is carried out continuously and integrated within each sub-module, combining knowledge tests, practical exercises, simulations of industrial scenarios, and applied tasks. Whenever necessary, reinforcement mechanisms are foreseen, such as content reviews or supplementary activities, ensuring that learners achieve the expected levels of performance.

Concerning certification, learning outcomes are recorded in the form of microcredentials, allowing for formal, transparent and transferable recognition of the competences acquired. These micro-credentials are aligned with European standards, facilitating their validation in the labour market and integration into lifelong learning pathways. In parallel, the monitoring of the programme is ensured through indicators aligned with the MoRRI framework[2], namely indicator EDU1[3], which measures the implementation and

[2] The MoRRI framework (the acronym of which stands for Monitoring the Evolution and Benefits of Responsible Research and Innovation) is a set of tools and indicators developed by the European Commission to monitor and evaluate the implementation of Responsible Research and Innovation (RRI) in research projects.

[3] EDU1 (Training Activities): Records the delivery of technical workshops and knowledge transfer activities.

reach of training activities, and indicator GE1[4], which tracks gender balance. These data are systematically collected and analysed to assess the programme's impact and support decision-making.

Gender inclusion constitutes a cross-cutting and mandatory principle, in accordance with Horizon Europe guidelines. In practice, this translates into the development of inclusive content and methodologies, the active promotion of female participation — currently under-represented — and the elimination of potential biases in technological and pedagogical design. Finally, the programme integrates continuous feedback mechanisms through surveys, participatory evaluation sessions, and analysis of learner performance. This feedback allows for dynamic adjustment of content, methodologies and objectives, ensuring that the training remains aligned with the real needs of industry and with technological evolution.

5.1.1 Module 1: Technical and electrification skills

Module 1 – Technical and Electrification Skills of the JOULIA project has the main objective of equipping the workforce to replace fossil-fuel-based heating systems with advanced electrical technologies, directly contributing to the decarbonisation of energy-intensive industries. This module is structured into sub-modules aligned with EQF levels and the technical requirements of the project, ensuring a coherent progression between theoretical knowledge and practical application.

Sub-module 1.1 – Electric Heating Technologies (EQF 4–5) focuses on the operation and maintenance of induction and microwave systems, ensuring that trainees understand the functioning of components such as induction coils, microwave applicators and power electronics systems. Operationally, they develop skills to monitor energy flows in real time, adjust control parameters, and operate contactless equipment in specific industrial processes such as rubber vulcanisation and multi-layer pipe bonding. They are also prepared to deal with the greater complexity of these systems compared to traditional methods.

Sub-module 1.2 – Energy Efficiency (EE) (EQF 4–5) aims to turn workers into active agents in improving industrial energy performance. To this end, standards, certifications and energy auditing principles are covered, enabling trainees to analyse consumption, identify waste and implement optimisation measures. These actions help to achieve efficiency gains of between 25% and 40%, supported by monitoring systems that validate the reduction of the carbon footprint of processes.

Sub-module 1.3 – Integration of Renewable Energy (IRE) (EQF 6–7) shifts the focus to energy system planning and engineering, intending to maximise the use of renewable sources. Trainees acquire knowledge about storage technologies (such as BESS), smart grids and local energy potential assessment. They also develop skills to analyse the impact of renewable integration in dynamic operational contexts, implement flexibility strategies that adjust consumption to the variability of production and prices, and design digital models that promote energy self-sufficiency and self-consumption.

Sub-module 1.4 – Operational Safety (EQF 4–5) ensures that the technological transition takes place under safe conditions, addressing electrical safety regulations and occupational health standards. Trainees learn to identify risks associated with electromagnetic heating, implement protective measures

[4] GE1 (Gender Balance): Monitors the evolution of female participation in the consortium (currently at 18.8%).

against exposure to electromagnetic fields and radiation, and execute operational procedures that guarantee thermal safety and prevent accidents in high-power industrial environments.

Taken together, Module 1 constitutes the technical foundation of the Pi-shaped model adopted by the JOULIA project, ensuring that technological innovation is accompanied by the development of practical and strategic skills essential for an efficient, safe and sustainable industrial transition.

Table 10: Module 1: Technical and Electrification skills

Module	Submodule	EQF level	Content	Duration	Format
1	1.1_Electric Heating Technologies: knowledge in induction and microwave heating systems, including the field of power electronics.	4-5	Principles of induction and microwave systems; components (coils/antennas); power electronics (inverters); thermal control and real-time operational monitoring.	1-2 hours	b-learning
	1.2_Energy Efficiency (EE): knowledge and ability to analyse energy consumption, conduct audits, and apply energy efficiency standards and certifications.	4-5	Energy auditing methodologies; technical analysis of industrial consumption; efficiency standards and certifications; optimisation and waste reduction strategies.	1-2 hours	b-learning
	1.3_Integration of Renewable Energy (IRE): knowledge of storage technologies, implementation of Smart Grid and assessment of local IRE potential.	6-7	Storage technologies (BESS); Smart Grid architectures; assessment of local potential (solar/wind); flexibility management and grid integration.	1-2 hours	b-learning
	1.4_Operational Safety: knowledge of occupational health and safety, identification of hazards and risks, and electrical safety regulations.	4-5	Electrical safety and HSE protocols; protection against electromagnetic fields (EMF); identification of thermal risks; technical regulations and occupational health standards.	1-2 hours	b-learning

Following the structure presented in Table 10, Module 1 is operationalised through a set of short, targeted learning units that combine technical depth with practical applicability. Each submodule is designed as a microlearning component with a duration of 1–2 hours, delivered in a blended learning (b-learning) format. This approach enables flexibility and accessibility, allowing participants to engage with theoretical content online while complementing it with practical, hands-on experiences where relevant. The modular structure also facilitates progressive skill acquisition, ensuring that learners can build competencies incrementally while aligning with their professional needs.

From an implementation perspective, the content of each submodule is closely aligned with real industrial use cases, ensuring immediate transferability of knowledge to operational contexts. The focus on induction and microwave technologies, energy efficiency practices, renewable energy integration, and operational safety reflects the critical skill sets required for electrification and decarbonisation pathways in industry. Additionally, the consistent duration and format across submodules support standardisation and scalability of the training programme, making it suitable for replication across different industrial settings and geographical contexts.

Overall, the design of Module 1 ensures coherence between learning objectives, content, and delivery methods, while maintaining alignment with EQF levels. This structured yet flexible approach supports the development of both technical expertise and operational readiness, reinforcing the role of the JOULIA training programme in enabling a skilled workforce capable of driving the transition towards more sustainable and energy-efficient industrial systems.

5.1.2 Module 2: Digital and technological skills

Module 2 – Digital and Technological Skills, integrated into the JOULIA project, has the central objective of promoting the articulation between physical heating systems and advanced digital tools, in order to ensure greater operational flexibility, continuous optimisation and efficient maintenance of electrified processes. This module plays a structural role within the framework of the so-called Twin Transition, which combines the green transition with digitalisation, by ensuring that technologies such as industrial induction and microwaves operate with high levels of efficiency, reliability and adaptive intelligence.

In its development, the module is organised into two distinct submodules, defined according to the qualification levels of the European Qualifications Framework and the specific requirements of the project.

Submodule 2.1 – Advanced Data Analytics (EQF 6-7) is aimed at a more advanced, strategic and engineering-oriented level, seeking to prepare professionals capable of dealing with the growing complexity of contemporary energy systems. In this context, emphasis is placed on mastering knowledge associated with Big Data and advanced data analysis applied to the industrial and electrical sectors. The aim is to equip trainees with the ability to collect, process and interpret electrical data from decentralised systems, enabling more informed and efficient management. At the same time, this submodule supports the transition from traditional roles – often centred on operations – to more analytical and integrative roles related to the management of intelligent, interconnected energy systems, while ensuring grid stability and performance. The use of data science methodologies thus emerges as an essential tool for dealing with complex industrial load profiles, enabling real-time optimisation of energy consumption.

Submodule 2.2 – 4.0/5.0 Technologies (EQF 4-5), in turn, has a more applied character, directed towards the operational context and the industrial production environment. Its focus is on the practical implementation of emerging technologies on the factory floor, with particular attention to operational continuity and worker safety. In this context, solutions based on the Internet of Things, Artificial Intelligence and Machine Learning are addressed, the application of which can significantly transform industrial processes. Among the competences to be developed, the ability to implement and operate predictive maintenance systems stands out, as these monitor critical parameters and anticipate failures in heating systems. Additionally, the development of early warning systems is promoted, capable of triggering alarms whenever operating parameters deviate from safe conditions, contributing to worker protection and accident prevention. This submodule also emphasises the reduction of production downtime and maintenance costs, particularly when compared with traditional combustion-based systems. The use of IoT sensors is also central, enabling continuous monitoring of energy flows and facilitating the integration of renewable energy sources into industrial processes.

In summary, Module 2 establishes a clear differentiation of profiles and competences: on the one hand, engineering professionals (EQF 6-7) are prepared to design, analyse and optimise flexible and intelligent energy systems; on the other hand, operators and technicians (EQF 4-5) are empowered to use digital technologies on the ground, ensuring safe, reliable and economically efficient operation.

Table 11: Module 2: Digital and technological skills

Module	Submodule	EQF level	Content	Duration	Format
2	2.1_Advanced Data Analytics: Big data/advanced analytics domain knowledge, and the ability to use and interpret a wide range of electrical data from decentralised systems.	6-7	Mastery of Big Data and advanced statistical analysis; interpretation of decentralised electrical data flows; Business Intelligence applied to Smart Grids; data modelling for load profile optimisation and strategic efficiency.	1-2 hours	b-learning
	2.2_ 4.0/5.0 Technologies: Knowledge of the application of the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) is crucial for predictive maintenance.	4-5	Fundamentals of IoT and sensor integration; practical application of Artificial Intelligence and Machine Learning for predictive maintenance; operation of early warning systems; technical monitoring for the reduction of failures and production downtime.	1-2 hours	b-learning

Following the structure presented in Table 11, it becomes evident that Module 2 is designed to ensure both vertical coherence (across EQF levels) and horizontal integration (across technological domains), aligning learning outcomes with the operational and strategic demands of industrial electrification. The distribution of content reflects a deliberate balance between analytical depth and practical applicability, allowing different professional profiles to engage with digitalisation processes at an appropriate level of complexity and responsibility.

The relatively short duration assigned to each submodule (1–2 hours), combined with the b-learning format, suggests a modular and flexible training approach, tailored to continuous professional development contexts. This structure enables the rapid acquisition or reinforcement of targeted competencies, facilitating upskilling and reskilling pathways without requiring extensive time commitments. At the same time, it implies that these units are likely to function as part of a broader training ecosystem, where they can be complemented by additional modules or practical sessions depending on organisational needs.

From a pedagogical perspective, the articulation between Submodules 2.1 and 2.2 reinforces the link between decision-making and execution. While the former supports data-driven strategic thinking and system-level optimisation, the latter ensures that such strategies can be effectively implemented and sustained in real industrial environments. This alignment is particularly relevant in the context of increasingly decentralised and data-intensive energy systems, where the ability to translate insights into operational actions becomes a critical success factor.

Moreover, the emphasis on technologies such as IoT, AI and data analytics highlights the shift towards predictive, rather than reactive, industrial practices. By embedding these competences within both engineering and technical roles, Module 2 contributes to the creation of a more resilient and adaptive workforce, capable of responding to variability in energy supply, demand patterns and system performance.

Ultimately, the configuration of this module reflects the broader objectives of the JOULIA project: to support the transition towards cleaner and more efficient industrial processes, while simultaneously equipping professionals with the digital skills required to manage and optimise these systems in an increasingly complex technological landscape.

5.1.3 Module 3: Sustainability and green management skills

Module 3 – Sustainability and Green Management Skills, with a specific focus on the Environmental Awareness submodule, has as its main objective the integration of an ecological perspective into the daily operations of industries, translating the decarbonisation goals of the JOULIA project into concrete, understandable and applicable practices on the ground. Rather than conveying abstract concepts, this submodule seeks to promote an effective change in behaviour, aligning productive routines with environmental sustainability principles.

In the context of EQF Level 4-5, aimed primarily at technicians and operators, the objectives are structured around three fundamental axes. Firstly, understanding climate and industrial impact stands out. In this area, the aim is to equip professionals to recognise the significant weight of greenhouse gas (GHG) emissions associated with the industrial sector, as well as the critical importance of reducing them. At the same time, the submodule seeks to align workers with European sustainability targets, namely those defined in the Fit for 55 [5]package, as well as with the specific objectives of the JOULIA project, which focuses on the electrification of processes as a means of reducing the carbon footprint.

In a second axis, the module promotes environmental and operational sustainability by valuing conscious practices in the use of resources. This implies fostering greater attention to energy efficiency and materials management, encouraging the transition from fossil fuel-based systems to cleaner electrical solutions. At the same time, it aims to develop an environmentally responsible mindset, in which professionals take an active role in meeting their organisations' environmental priorities, contributing to transforming the workplace into a space aligned with global sustainability challenges.

The third axis focuses on the acceptance and appreciation of the technologies promoted by the project. In this context, it is essential to increase knowledge about the direct environmental benefits of induction and microwave technologies, particularly regarding contactless heating and the elimination of potentially hazardous or polluting intermediate fluids. Additionally, the submodule incorporates a social dimension, reinforcing the idea that the energy transition must be fair and inclusive. This translates into the promotion of responsible behaviours that not only reduce environmental impact but also contribute to better safety conditions and quality of life in the industrial environment.

From a methodological perspective, the relevance of this submodule is clearly evidenced by the results of the data triangulation process, in which it obtained a high score (81.40%). This result indicates that, although it was not initially identified as a core requirement in the stakeholder mapping (D4.4), it is widely recognised by workers and experts as a critical element for the success of the industrial transition. Thus, at EQF Level 4-5, the emphasis is on applied, operational awareness, ensuring that technological transformations are not only implemented but also understood, valued and sustained by the professionals who use them daily.

[5] Fit for 55 is a European Union legislative package aimed at implementing the goals of the European Green Deal. Its objective is to reduce net greenhouse gas emissions by at least 55% by 2030 compared to 1990 levels, preparing the bloc for climate neutrality by 2050.

Table 12: Module 3: Sustainability and green management skills

Module	Submodule	EQF level	Content	Duration	Format
3	3.1_Environmental Awareness: knowledge of the importance of reducing greenhouse gas emissions and environmental sustainability.	4-5	Fundamentals of GHG emissions and industrial climate impact; global decarbonisation targets (e.g., Fit for 55); efficient resource and materials use practices; environmental benefits of electrification (induction/microwaves); promotion of sustainability in everyday factory operations.	1-2 hours	b-learning

Following the structure outlined in Table 12, Module 3 is clearly positioned as a transversal component that supports the cultural and behavioural dimension of the industrial transition, complementing the more technical and digital competences developed in other modules. Its design reflects the understanding that technological change alone is insufficient to achieve decarbonisation goals; instead, it must be accompanied by a corresponding shift in awareness, attitudes and day-to-day practices among the workforces.

The concise duration of the submodule (1–2 hours), delivered through a b-learning format, indicates a targeted and accessible training approach, suitable for integration into continuous professional development pathways. This structure allows organisations to efficiently disseminate key sustainability concepts while minimising disruption to operational activities. At the same time, it reinforces the role of this submodule as a catalyst for broader organisational change, encouraging reflection and incremental improvements rather than exhaustive technical instruction.

From a functional perspective, the content prioritises applicability over abstraction. By linking global challenges—such as greenhouse gas reduction and climate targets—to concrete actions within the factory environment, the module helps bridge the gap between policy frameworks, such as Fit for 55, and operational realities. This alignment is particularly relevant in contexts where workers may not be directly involved in strategic decision-making but play a crucial role in implementing sustainable practices on the ground.

Moreover, the emphasis on electrification technologies and resource efficiency reinforces the connection with the broader objectives of the JOULIA project, ensuring that sustainability is not perceived as an external requirement but as an integral component of process innovation and industrial performance. By fostering an informed and proactive workforce, the module contributes to reducing resistance to change and enhancing the adoption of cleaner technologies.

Ultimately, Module 3 functions as an enabling layer within the training architecture: it strengthens environmental literacy, promotes responsible behaviour and supports the long-term consolidation of sustainable practices. In doing so, it helps ensure that the transition towards low-carbon industrial systems is not only technologically viable but also socially embedded and operationally sustained.

5.1.4 Module 4: Transversal skills

Module 4 – Transversal Skills has the central objective of equipping the workforce with the cognitive and socio-emotional competencies needed to deal with the complexity associated with the so-called Twin Transition, which combines the challenges of environmental sustainability with digital transformation. This module serves as the second "vertical pillar" of the Pi-shaped educational model, complementing technical specialisation with essential human capabilities such as adaptability, critical thinking and collaboration, which are particularly relevant in industrial contexts marked by uncertainty, rapid technological change and high competitiveness.

Within the scope of the JOULIA project, the module is organised into several submodules, each aimed at developing specific competences aligned with different qualification levels and professional responsibilities.

Submodule 4.1 – Adaptability and Resilience (EQF 6-7) is aimed at leadership and engineering profiles, to prepare these professionals to manage change processes in scenarios of high technological and organisational uncertainty. In this context, the development of emotional maturity and balance is promoted to deal with setbacks, criticism and resistance associated with the implementation of new technologies. At the same time, the ability to make decisions in situations of risk and ambiguity, particularly relevant in decarbonisation processes, is reinforced, as is the aptitude for ensuring operational continuity in unstable geopolitical and economic contexts.

Submodule 4.2 – Problem Solving and Innovation (EQF 6-7) focuses on creating innovative solutions for complex industrial challenges, having been identified as highly relevant in the data triangulation process. Its objective is to stimulate applied creativity, especially in areas such as electric heating and power electronics, encouraging the identification of new opportunities and strategies aligned with sustainability and energy efficiency goals. This submodule also promotes the development of unconventional thinking, essential for the redesign of processes and the construction of more circular and sustainable business models.

Submodule 4.3 – Critical and Analytical Thinking (EQF 6-7) plays a fundamental role in strengthening analysis and critical evaluation capacity, being particularly relevant for engineers and consultants in the field of energy efficiency. The aim is to equip professionals to identify the strengths and limitations of different technological solutions, as well as to analyse information in a rigorous and well-founded manner. This submodule also encourages the ability to question established practices and promote continuous improvement, using systemic risk analyses to support more informed and strategic decisions.

Submodule 4.4 – Communication and Collaboration (EQF 4-5) focuses on the relational dimension and effective integration among multidisciplinary teams, being particularly relevant for technicians and operators. Its objective is to develop clear and effective communication skills, especially in conveying complex technical content to different audiences. At the same time, the strengthening of collaborative dynamics based on trust, essential for the functioning of interdisciplinary teams, is promoted. This submodule also addresses the management of resistance to change, encouraging understanding of workers' concerns, particularly on sensitive issues such as safety associated with new technologies.

Finally, submodule 4.5 – Continuous Learning (EQF 4-7) constitutes the structuring element of the entire module, often described as the backbone of the Pi-shaped model. Its focus lies in promoting a lifelong learning culture, transversal to all professional profiles. In this sense, it aims to develop the capacity for continuous adaptation, encouraging workers to learn from experience, including mistakes, and to autonomously acquire new skills, particularly in the digital domain. This submodule is essential to ensure that the workforce remains relevant, flexible and capable of generating value in a constantly evolving sector.

In summary, Module 4 ensures that the technological transition promoted by the JOULIA project is not limited to the introduction of new technologies or equipment, but translates into a deeper transformation of professional profiles, making them more resilient, critical, collaborative and oriented towards continuous innovation.

Table 13: Module 4: Transversal skills

Module	Submodule	EQF level	Content	Duration	Format
4	4.1_Adaptability and Resilience: ability to adapt to changes, flexibility and resilience in the face of technological uncertainty.	6-7	Change and technological uncertainty management; resilience in the face of setbacks and criticism; decision-making in ambiguous scenarios; operational flexibility in turbulent and volatile environments.	1-2 hours	b-learning
	4.2_Problem Solving and Innovation: Problem-solving skills, creativity and the ability to innovate.	6-7	Creativity methodologies and industrial innovation; application of Design Thinking in electrified processes; identification of strategic "green" opportunities; complex technical problem solving.	1-2 hours	b-learning
	4.3_Critical and Analytical Thinking: the ability to identify strengths and weaknesses of solutions and alternatives, of high value for energy efficiency engineers and consultants.	6-7	Systemic analysis of risks and opportunities; critical evaluation of strengths and weaknesses of technological alternatives; structured logical reasoning; critical interpretation of arguments and assumptions.	1-2 hours	b-learning
	4.4_Communication and Collaboration: communication skills (including technical details), teamwork and leadership.	4-5	Clear technical communication to diverse stakeholders; storytelling and persuasion techniques; collaboration in multidisciplinary teams; tactical leadership and building trust networks.	1-2 hours	b-learning
	4.5_Continuous Learning: skills for a lifelong learning stance and agility in Learning.	4-7	Learning agility strategies; culture of "learning to learn" and learning from mistakes; autonomous updating of digital and sustainable skills; agility in acquiring new knowledge.	1-2 hours	b-learning

Following the structure presented in Table 13, Module 4 reveals a coherent and integrated approach to the development of transversal competences, ensuring alignment between higher-level cognitive skills (EQF 6-7) and more operational, interaction-oriented capabilities (EQF 4-5). This distribution reflects a deliberate effort to embed soft skills across all layers of the workforce, recognising that the success of the JOULIA project depends not only on technical proficiency but also on the ability of individuals and teams to adapt, collaborate and innovate in dynamic environments.

The modular design, with short-duration units (1–2 hours) delivered in a b-learning format, supports flexibility and scalability in training implementation. It allows organisations to integrate these competences into ongoing professional development strategies without significant disruption to operations, while also enabling tailored learning pathways depending on role, experience and organisational context. This is particularly relevant in industrial settings undergoing rapid transformation, where continuous upskilling must be both efficient and immediately applicable.

From a systemic perspective, the progression across submodules reinforces a logical competency flow: from individual adaptability (4.1), through creative and solution-oriented thinking (4.2), to structured critical analysis (4.3), and finally to interpersonal effectiveness (4.4) and long-term learning capacity (4.5). This sequencing mirrors the evolving demands placed on professionals operating within the Twin

Transition, where technical challenges are increasingly intertwined with organisational, behavioural and strategic dimensions.

Moreover, the explicit inclusion of Continuous Learning as a cross-level submodule (EQF 4-7) highlights its role as an enabling competence that underpins all others. By fostering learning agility and self-directed skill acquisition, the module ensures that the workforce is not only prepared for current technological shifts but also capable of responding to future disruptions. This forward-looking orientation is critical in sectors characterised by accelerated innovation cycles and evolving regulatory frameworks.

In practical terms, Module 4 functions as a bridge between knowledge and action. It translates technical and sustainability-driven objectives into human performance, ensuring that professionals can effectively interpret, communicate and implement change. By strengthening resilience, enhancing problem-solving capacity and promoting collaborative behaviours, the module contributes to building a workforce that is not only technically qualified but also organisationally responsive and strategically aligned.

Ultimately, the configuration of this module reinforces the idea that the industrial transition is not merely a technological process, but a human one. By integrating transversal skills into the core of the training, the JOULIA project ensures that innovation is accompanied by a consistent cultural transformation, capable of sustaining long-term results.

5.1.5 Module 5: Gender inclusion

Module 5 – Gender Inclusion, with a specific focus on submodule 5.1 Counteracting Unconscious Biases and Managing Diverse Talent (EQF level 6-7), has the main objective of integrating the dimensions of social justice and equal opportunities into the energy transition process promoted by the JOULIA project. This module is aimed primarily at strategic and management profiles, seeking to translate the principles of Responsible Research and Innovation (RRI) and the guidelines of Horizon Europe into practical skills applicable to decision-making in industrial contexts.

In this framework, the first axis of intervention focuses on neutralising unconscious biases in the sector. The aim is to equip managers and leaders to identify and understand how implicit prejudices can influence, often involuntarily, processes such as recruitment, performance evaluation and career progression, particularly in technical areas such as electrothermal engineering. At the same time, the module seeks to combat the gender stratification still present in these sectors, challenging the perception that certain technical roles are predominantly male and contributing to correcting low levels of female representation.

The second axis focuses on talent management and inclusive recruitment. In this domain, the objective is to develop skills to review and improve selection procedures, ensuring the application of fairer and more balanced criteria capable of mitigating biases such as those penalising motherhood. Additionally, the use of neutral and inclusive language is promoted in the definition and communication of new professional profiles, particularly relevant in a context of industrial transformation driven by electrification.

The third axis addresses the integration of the gender dimension into technological development and implementation. Here, the aim is to raise awareness and train technical leaders to critically assess whether technological solutions — particularly those associated with induction and microwave heating — incorporate principles of equity in their design and use. The goal is to ensure that technological innovation does not introduce, directly or indirectly, barriers to access or use. Concurrently, the identification and definition of new professional profiles that promote greater female participation in the electrified industrial environment are encouraged.

Finally, the fourth axis focuses on cultural change and strategic compliance. This domain includes the promotion of work-life balance policies, which are fundamental for retaining diverse talent and creating more inclusive work environments. At the same time, alignment with the eligibility requirements and good practices defined within Horizon Europe is ensured, encouraging the implementation of structured, evidence-based continuous training plans.

Overall, at EQF level 6-7, this module privileges a transformational leadership approach. More than promoting awareness, it seeks to empower decision-makers and senior engineers to redesign organisational processes and management practices, ensuring that the industrial energy transition is not only technologically advanced but also socially just, inclusive and sustainable in the long term.

Table 14: Module 5: Gender inclusion

Module	Submodule	EQF level	Content	Duration	Format
5	5.1_Counteracting Unconscious Biases and Managing Diverse Talent	6-7	Identification of implicit biases in the sector; inclusive recruitment strategies and diverse talent management; work-life balance policies and organisational culture change; integration of the gender dimension into technological design; strategic leadership for compliance with RRI and Horizon Europe guidelines.	1-2 hours	b-learning

Following the structure presented in Table 14, Module 5 demonstrates a targeted and strategic approach to embedding gender inclusion within industrial transformation processes, ensuring that equality principles are not treated as peripheral considerations but as integral components of innovation and organisational performance. The configuration of the module reflects a clear alignment with the broader objectives of the JOULIA project, reinforcing the idea that the success of the energy transition depends not only on technological advancement but also on inclusive and equitable workforce practices.

The concise duration of the submodule (1–2 hours), delivered in a b-learning format, suggests a focused and high-impact training intervention designed for decision-makers with limited availability. This format enables the rapid acquisition of critical awareness and practical tools, while also allowing for flexible integration into executive training programmes and organisational development strategies. At the same time, it implies that the module functions as a catalyst for deeper structural changes, which must be sustained through internal policies, monitoring mechanisms and continued learning initiatives.

From an operational perspective, the content outlined in the table supports the translation of abstract principles—such as those promoted by Horizon Europe and the RRI framework—into concrete managerial practices. This includes the redesign of recruitment processes, the adoption of inclusive communication standards, and the incorporation of gender-sensitive criteria in both human resource management and technological development. Such alignment is particularly relevant in industrial contexts undergoing rapid transformation, where new roles and competencies are being defined and where there is a critical opportunity to embed inclusivity from the outset.

Moreover, the emphasis on leadership at EQF level 6-7 highlights the role of senior professionals as agents of change within their organisations. By equipping them with the ability to recognise systemic biases, implement inclusive strategies and foster organisational cultures based on equity, the module contributes to reducing structural barriers and improving talent retention and diversity outcomes. This leadership dimension is essential to ensure that inclusion is not confined to policy statements but is effectively operationalised across organisational processes.

Ultimately, Module 5 functions as a governance and cultural alignment mechanism within the training architecture. It bridges the gap between regulatory expectations, organisational strategy and day-to-day practices, ensuring that gender inclusion is embedded in both decision-making and implementation. In doing so, it supports a more balanced, fair and sustainable industrial transition, where technological innovation is matched by social responsibility and inclusive growth.

6. Final considerations

In terms of a final synthesis, the training plan developed within the scope of the JOULIA project presents itself as a structured, coherent and methodologically robust proposal, capable of responding in an integrated manner to the technical, digital, environmental and social challenges associated with contemporary industrial transition. Its consistency results from the articulation between empirical evidence, theoretical framework and alignment with European strategic priorities, ensuring that the proposed training solutions are not arbitrary, but well-founded and oriented towards real impact.

One of the main merits of this plan lies in the adoption of the Pi-shaped educational model, which ensures a balance between technical specialisation, transversal skills and a common knowledge base in sustainability and digitalisation. This approach makes it possible to overcome traditional, often fragmented, training models, promoting more complete, adaptable professional profiles prepared for complex and rapidly transforming industrial contexts. The complementarity between hard skills and soft skills does not appear here as an accessory element, but as a necessary condition for the effectiveness of the energy transition.

The use of a data triangulation methodology, combining stakeholder input with quantitative validation, reinforces the credibility of the choices made. The establishment of a relevance threshold (80%) and the differentiated weighting of strategic competences demonstrate analytical rigour and avoid the inclusion of irrelevant content. This process ensures that the selected modules effectively correspond to the needs of the sector, reducing the risk of misalignment between training and industrial practice.

Differentiation by European Qualifications Framework levels is also a critical element of quality, as it ensures the appropriateness of content for different professional profiles. By clearly distinguishing between operational roles (EQF 4–5) and engineering and management roles (EQF 6–7), the plan promotes not only training effectiveness but also professional progression and inclusion, allowing different profiles to access qualification pathways tailored to their responsibilities and development potential.

Another particularly relevant aspect is the explicit integration of Responsible Research and Innovation principles and Horizon Europe guidelines, particularly in the area of gender equality. The inclusion of a specific module dedicated to this theme demonstrates a broad vision of industrial transition, recognising that technological innovation must be accompanied by social and organisational transformation. This option reinforces compliance with European requirements but, more importantly, contributes to building a more equitable and sustainable sector.

From a pedagogical perspective, the use of microlearning, the blended learning model and approaches such as Problem-Based Learning ensure flexibility, applicability and effectiveness in skills acquisition. The short, modular structure facilitates the integration of training into the professional context, promoting continuous learning without compromising productive activity. At the same time, the connection to real contexts — namely through the demosites — guarantees effective knowledge transfer to practice.

Finally, the assessment system, microcredential certification and monitoring through indicators aligned with the MoRRI framework ensure not only the validation of learning but also the measurement of the programme's impact. The incorporation of continuous feedback mechanisms reinforces the adaptive capacity of the plan, allowing its dynamic adjustment in response to technological evolution and industry needs.

In summary, this training plan is not limited to addressing identified skills gaps; it constitutes a strategic instrument for industrial transformation. By articulating technology, people and organisation, it ensures that the transition to electrified energy systems is not only efficient and safe, but also inclusive, sustainable and long-lasting.

References

Akyazi, T., del Val, P., Goti, A., & Oyarbide, A. (2022). Identifying Future Skill Requirements of the Job Profiles for a Sustainable European Manufacturing Industry 4.0. *Recycling*, *7*(3), 32. https://doi.org/10.3390/recycling7030032

Bongomin, O., Ocen G.G., Gilbert, Nganyi, E. O., Musinguzi, A., & Omara, T. (2020). Exponential Disruptive Technologies and the Required Skills of Industry 4.0. *Journal of Engineering*, 4280156. https://doi.org/10.1155/2020/4280156

Bray, R., Mejía Montero, A., & Ford, R. (2022). Skills deployment for a 'just' net-zero energy transition. *Environmental Innovation and Societal Transitions*, 42, 395–410. https://doi.org/10.1016/j.eist.2022.02.002

Bukartaite R, Hooper D (2023), Automation, artificial intelligence and future skills needs: an Irish perspective. *European Journal of Training and Development*, 47(10), 163–185. https://doi.org/10.1108/EJTD-03-2023-0045

Cedefop. (2025). *Meeting skill needs for the green transition: skills anticipation and VET for a greener future*. Publications Office of the European Union. https://data.europa.eu/doi/10.2801/6833866

Chatzichristou, S. (2023, June 19). *Skills for the green transition – realising VET's potential* [Conference presentation]. 14th Cedefop Brussels Seminar, Brussels, Belgium. https://www.cedefop.europa.eu/files/cedefop_skills_green_transition.pdf

Deloitte. (2023). *A blueprint for green workforce transformation*. https://www.deloitte.com/content/dam/assets-zone2/uk/en/docs/about/2023/deloitte-uk-a-blueprint-for-green-workforce-transformation.pdf

Energy and Utilities Sector Skills Council (2025). *Energy and Utilities sector skills framework: Sector overview, job families and pathways*. Ministry of Human Resources and Social Development. https://www.hrsd.gov.sa/sites/default/files/2025-02/Energy%20and%20Utilities%20Sector%20Skills%20Intro%20Report_EN.pdf

European Commission: Directorate-General for Research and Innovation. (2021). *Horizon Europe guidance on gender equality plans*. Publications Office of the European Union. https://data.europa.eu/doi/10.2777/876509

European Commission: Directorate-General for Research and Innovation. (2025a). *Fostering gender equality: key figures from Horizon Europe: R&I monitoring flash*. Publications Office of the European Union. https://data.europa.eu/doi/10.2777/2941871

European Commission: Directorate-General for Research and Innovation. (2025b). Horizon Europe guidance on gender equality plans (GEPs). https://data.europa.eu/doi/10.2777/8336488

European Commission: Directorate-General for Research and Innovation. (2026). Gender equality plans (GEPs): how to be ready for ex-post checks. https://data.europa.eu/doi/10.2777/9460977

Fareri, S., Apreda, R., Mulas, V., & Alonso, R. (2023). The worker profiler: Assessing the digital skill gaps for enhancing energy efficiency in manufacturing. *Technological Forecasting and Social Change*,*196*, 122844. https://doi.org/10.1016/j.techfore.2023.122844

Fondazione MAIRE (2023). *CLIMATE GOALS: Winning the challenge of climate goals through the creation of skills and competences worldwide*. https://fondazione.groupmaire.com/media/filer_public/9d/b3/9db38f3c-4c11-4826-ba78-5c4cee183c4e/231205_fm_climategoals_web.pdf

Hofmann Trevisan, A., Acerbi, F., Dukovska-Popovska, I., Terzi, S., & Sassanelli, C. (2024). Skills for the twin transition in manufacturing: A systematic literature review. *Journal of Cleaner Production, 474*, 143603. https://doi.org/10.1016/j.jclepro.2024.143603

JOULIA Consortium. (2025, 30 de September). *D4.4 – Report on stakeholder needs (Deliverable D4.4)*. White Research SRL. https://www.jouliaproject.eu

JOULIA Consortium. (2025, December 1). *D1.5 – RRI First report and Progress Report (Deliverable D1.5)*. CIRCE. https://jouliaproject.eu/

Kyeung Chun, H. (2024). Falling through the cracks? skilling, reskilling and upskilling for job transitions (Ill.). In *Rethinking economic transformation for sustainable and inclusive development: turning a corner?* (pp. 205–234). Edward Elgar Publishing. https://doi.org/10.4337/9781035348466.00013

L2L (2025). *The 2025 manufacturing skills report: are frontlines equipped for success?* https://www.l2l.com/hubfs/The%202025%20Manufacturing%20Skills%20Report.pdf

Lightcast. (2023). *Engineering skills needs – now and into the future* (Report prepared for EngineeringUK). https://www.engineeringuk.com/media/ge1bxifs/engineering-skills-needs-report-lightcast-engineeringuk-may-23.pdf

Pearson (2024). *Manufacturing Skills Report*. Workforce Skills Division. https://faethm.ai/hubfs/WFS%20Project%20folders/Skills%20Transformation%20Reports%20Campaign%20(STR)/Manufacturing%20STR/2024%20Manufacturing%20Skills%20Report.pdf

Pinto, R., Perez, A. L., Gonçalves, G., Lampón, J. F., & Pérez-Moure, H. (2025). *A proposed educational framework for professional upskilling in smart manufacturing: On-demand microlearning units*. *Procedia Computer Science, 253*, 2039–2048. https://doi.org/10.1016/j.procs.2025.01.265

Pinzone, M., & Taisch, M. (2023). Key competencies for circular manufacturing. In *Human Aspects of Advanced Manufacturing* (120–125). AHFE International. https://doi.org/10.54941/ahfe1003514

Sajko, T., Koch, V., Treul, S., Pacher, C., & Zunk, B. M. (2025). Identifying competences of engineers in the context of operations management: A literature overview. *Procedia Computer Science, 253*, 1760–1769. https://doi.org/10.1016/j.procs.2025.01.238

SkillsPULSE (2025). *Emerging skills and occupations* (Deliverable D3.1, Project 101132727). https://www.skillspulse.eu/wp-content/uploads/2025/07/D3.1_Emerging_skills.pdf

Vitti, M., Trevisan, A. H., Ocampo, H. R., Cuentas, V. K., Sarbazvatan, S., Terzi, S., & Sassanelli, C. (2025). A competency map for circular economy education. *Procedia Computer Science, 253*, 336–345. https://doi.org/10.1016/j.procs.2025.01.096

World Economic Forum (2020). *Jobs of tomorrow: Mapping opportunity in the new economy*. https://www3.weforum.org/docs/WEF_Jobs_of_Tomorrow_2020.pdf

Annex

ANNEX A - Survey

Survey of training needs and professional skills for the industrial sector within the scope of the JOULIA project

Dear participant, this questionnaire consists of 22 questions and should take between 5 and 7 minutes to complete. Your participation is crucial to help us analyse training and professional skills needs that meet the current labour market. The main objective of the JOULIA Project is to electrify industrial processes using induction and microwave technologies. There are no right or wrong answers. The important thing is that we have as much detailed information as possible. We thank you in advance for your cooperation.

Informed, free and clear consent. Your participation is voluntary, and you have the right not to participate. If you decide to participate in this research, it is important to know that you can withdraw at any time without any consequences.
Your answers will be kept confidential and anonymous. The data collected will only be used within the scope of the JOULIA project.

Section 1 - This section seeks to characterise each respondent and inquire about their desire for greater contact with the JOULIA project.

1) Contact details:
2) Gender
Female
Masculine
Others
I prefer not to say
3) Please, Indicate your company's sector of activity:
4) Are you interested in being part of the project's mailing list to be informed about results, events, and training related to the development of the JOULIA project?

Section 2 - This section aims to assess the relevance of Technical and Electrification skills (these skills are specific to the design, installation, and operation of new electric heating technologies) for the industrial sector in order to develop training courses that prepare professionals to work in line with the objectives of the JOULIA project. Please indicate your perception on a scale of 1 to 10, where 1 means low relevance of the professional skill and 10 means high relevance.

5) Electric Heating Technologies: knowledge in induction and microwave heating systems, including the field of power electronics.

6) Electrothermal Engineering: knowledge in electrical engineering, process engineering and the optimisation of the electromagnetic behaviour of materials.
7) Energy Efficiency (EE): knowledge and ability to analyse energy consumption, conduct audits, and apply energy efficiency standards and certifications.
8) Integration of Renewable Energy (IRE): knowledge of storage technologies, implementation of Smart Grid and assessment of local IRE potential.
9) Operational Safety: knowledge of occupational health and safety, identification of hazards and risks, and electrical safety regulations.

Section 3 - This section aims to assess the relevance of Digital and Technological Skills (these skills are vital for the flexibility, optimisation and maintenance of electrified systems) for the industrial sector to develop training courses that prepare professionals to work in line with the objectives of the JOULIA project. Please indicate, according to your perception, on a scale of 1 to 10, where 1 means low relevance of professional competence and 10 means high relevance.

10) Advanced Data Analytics: Big data/advanced analytics domain knowledge, and the ability to use and interpret a wide range of electrical data from decentralised systems.
11) 4.0/5.0 Technologies: Knowledge of the application of the Internet of Things (IoT), artificial intelligence (AI), and machine learning (ML) is crucial for predictive maintenance.
12) Modelling and Simulation: knowledge to develop and use digital models and simulations to optimise process performance and control flexibility.
13) Cybersecurity: knowledge to protect digital infrastructures.

Section 4 - This section aims to assess the relevance of Sustainability and Green Management Skills (these skills support the goal of decarbonisation and environmental optimisation) for the industrial sector to develop training courses that prepare professionals to act in line with the objectives of the JOULIA project. Please indicate, according to your perception, on a scale of 1 to 10, where 1 means low relevance professional competence and 10 means high relevance professional competence.

14) Impact Assessment: knowledge of life cycle analysis (LCA), life cycle costing (LCC) and tools for assessing environmental impact.
15) Circular Economy (CE): knowledge about circular economy strategies, resource management, and waste minimisation practices.
16) Environmental Awareness: knowledge of the importance of reducing greenhouse gas emissions and environmental sustainability.
17) Business Models: knowledge for developing new business models to capitalise on electrification opportunities.

Section 5 - This section aims to assess the relevance of Transversal Skills (these skills are widely required for the energy transition's success) for the industrial sector to develop training courses that prepare professionals to work in line with the objectives of the JOULIA project. Please

indicate, according to your perception, on a scale of 1 to 10, where 1 means low relevance professional competence and 10 means high relevance professional competence.

18) Adaptability and Resilience: ability to adapt to changes, flexibility and resilience in the face of technological uncertainty.

19) Problem Solving and Innovation: Problem-solving skills, creativity and the ability to innovate.

20) Critical and Analytical Thinking: the ability to identify strengths and weaknesses of solutions and alternatives of high value for energy efficiency engineers and consultants.

21) Communication and Collaboration: communication skills (including technical details), teamwork and leadership.

22) Continuous Learning: skills for a lifelong learning stance and agility in Learning.

Thank you for completing this survey.