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This report describes the main findings resulting from the assessment of the labour market relevant skills for the green transition. The report identifies the six industrial sectors targeted by the GREEN project, identifying a selection of Key occupations for the green transition, and reviewing the skills and competences described for them in ESCO database, considering the Greencomp framework and the ESCO green skills labels. It also includes a revision of the main trainings allowing to develop these occupations at least in two of the most relevant countries for their sector.
It will serve as a basis to develop a set of core green skills for the labour market.

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EXECUTIVE REPORT

The European Green Deal is propelling an ambitious vision of a climate-neutral, resource-efficient, and competitive economy. To attain this vision, the European Union (EU) is embracing a regenerative growth model, driven by circular principles and sustainable practices. Key to this transformation are certain occupations that play a pivotal role in executing sustainable strategies, implementing green technologies, and fostering eco-friendly processes.

This report stems from a rigorous assessment of skills essential for the green transition across six industrial sectors pivotal for steering the green transition: Additive Manufacturing, Automotive, Batteries, Defence, Energy, and Maritime Technologies. Leveraging the GreenComp reference framework for sustainability competences and the ESCO database, our analysis focuses on the industry's critical roles. These roles range from "white-collar" professionals to "blue-collar" workers, all of whom contribute significantly to sustainable practices.

Our methodology involves a **desk analysis of blueprint projects** targeting the six sectors. From this foundation, we ascertain each sector features and select the pivotal occupations for the green transition. A total of 45 occupations have been identified, and for each one of them, the ESCO skills have been reviewed, identifying gaps and aligning them with Green European Competence framework. Furthermore, we explored the most relevant training programs across Europe, analysing their how could they be improved to ensure the preparation of workers and students for the green transition. A **qualitative research component has been integrated**, leveraging online focus groups with experts from the blueprint projects, the labour-market, and the education and training community. In total, 96 experts in the targeted sectors have been informed of this process, and 52 have actively contributed to the discussions, together with the 15 partners elaborating this report. A special care has been taken to ensure an age and gender balance in the focus groups.

These six sectors addressed, categorized by their maturity, encompass **well-established fields like defence and automotive,** necessitating a shift to more sustainable practices. Conversely, **emerging sectors, such as batteries and additive manufacturing**, present opportunities to embed sustainability from their inception, impacting diverse areas like defence, energy, and transportation.
In the green transition journey, the **energy and marine technologies sectors form a hybrid category, amalgamating both traditional and emerging sub-sectors**. This amalgamation demands a skilled workforce capable of orchestrating a seamless transition to sustainable practices. Across all these sectors, a unified effort from policymakers, educators, and employers is imperative to equip the workforce with the requisite skills for the challenges ahead.

Considering a **geographic cross-sectoral approach**, the leadership and contributions of specific countries stand out. Germany consistently emerges as a key player, notably in additive manufacturing and the automotive industry, reflecting its robust commitment to sustainable technologies. Spain and Sweden take the lead in advanced battery technologies, while the United Kingdom, with its expertise in offshore renewable energy, contributes significantly to the green landscape. France, renowned for its prowess in defence and offshore renewable energy, demonstrates a multifaceted approach to

sustainability.
Moreover, Italy, Belgium, and the Netherlands feature prominently in the additive manufacturing and maritime technologies sectors, illustrating a collaborative European effort in the green transition. Eastern European countries, including the Czech Republic, Romania, and Poland, play pivotal roles in defence and automotive, underlining the distributed nature of sustainable practices across the continent.

Identifying **the most relevant occupations for the green transition** involved a comprehensive analysis of blueprint projects and insights from GREEN focus groups across sectors. This process pinpointed **45 key occupations, with engineering and managerial roles dominating**, and only one—naval architect—spanning different sectors. Designers and Engineers emerged as crucial contributors, steering material choices and sustainability solutions. Research and development roles, particularly in emerging sectors, are poised to drive innovation and recycling for circular economy goals.

Digital specialists play a vital role, integrating solutions for data management and cybersecurity in green practices. Operational employees, while perceived to have minimal environmental impact in highly automated sectors, were included in additive manufacturing, defence, and maritime technologies, underlining their role in efficient and eco-conscious production. Notably, training roles were specifically recognized in the automotive sector, suggesting potential importance across sectors.

Among the 45 occupations, the Innovation Manager and Training Manager were highlighted for their cross-sectoral impact on the Green Transition, backed by broad consensus in cross-sectoral focus group. Additional cross-sectoral occupations proposed for consideration include data scientists, AI specialists, sustainability and environmental managers, reliability engineers, designers, and repair and maintenance roles.

Occupations were categorized based on their primary roles in the value chain, with **three groups identified for their cross-sectoral impact on the GREEN transition: Sustainability and Environment Management, Innovation Management, and Research.** This grouping was endorsed by experts in the cross-sectoral focus group, who also emphasized the importance of digital roles, life cycle and waste management, and operational processes.

While specific skill needs for the green transition can be identified and anticipated, it is imperative to **emphasize the necessity for an attitudinal and behavioural shift that complements the already identified skills within different qualification frameworks, as outlined in the GREENCOMP**. **The ESCO labelling framework emerges as a pivotal tool in this landscape, providing a standardized and comprehensive approach to recognizing and assessing individuals' proficiency in these critical fields**. It is noteworthy, however, that not all selected occupations are encompassed within the ESCO database.

Occupational profiles were succinctly summarized, encompassing skills, competencies, and knowledge. In-depth scrutiny was applied to skills labelled as GREEN in ESCO, with the focus group contributing insights that prompted the identification of new green skills for inclusion. Proposals were made to enrich the ESCO green skills list, both by introducing new terms and by infusing a green perspective into existing skills, particularly pertinent in research and development roles. Finally, in the sectoral analyses for additive manufacturing, automotive, batteries and defence, a classification has been suggested, categorizing the remaining skills and knowledge as white and brown.

A total of 228 skills for the Green Transition were identified, with 49 skills and 25 knowledge areas labelled as green by ESCO and an additional list of 13 skills and 4 knowledge areas critical for the green transition, not yet classified as green in ESCO. A comprehensive list of 49 skills and 42 knowledge areas not tagged as green was proposed for embedding sustainability. Batteries, Energy, and Maritime Technologies demonstrated significant overlap in green skills and knowledge.

A select group of six skills emerged as relevant for at least three sectors, such as assessing environmental impact, ensuring compliance with environmental legislation, identifying energy needs, promoting sustainable energy, and knowledge of renewable energy technologies, solar energy, and renewable energy technologies. In the cross-sectoral focus group, experts highlighted the significance of Critical and GREEN thinking, proposing an expansion of transversal skills to include communication, leadership, teamwork, sustainability literacy, and project management.

The skills supply analysis delved into existing training provisions for selected occupations, emphasizing green skills coverage. Specialized providers, particularly blueprint projects and sectoral alliances, played a key role in training for sectors like Additive Manufacturing, Automotive, and Batteries. Noteworthy was the identified **need to enhance sustainability integration across disciplines and augment practical experiences to nurture transversal skills**. The cross-sectoral focus group emphasized two additional areas: **Measuring and assessing environmental impact and adapting to rapid technological changes**.
In promoting collaboration between industry and educational institutions, three methods were endorsed: **collaborative projects, industry expert involvement in curriculum development, and the organization of internships, apprenticeships, or cooperative educational programs**.

A unanimous cross-sectoral agreement was observed in prioritizing the training of Managers and Heads of Education and Training Centres to elevate their skills for an acceleration of the green transition. Recommendations underscored a dual focus on raising awareness and motivation alongside technical training. While sectoral focus groups lacked consensus on optimal training formats, in the cross-sectoral focus group, webinars combined with on-the-job training and MOOCs emerged as the top two preferred options.

Together, we navigate towards a greener horizon.

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1. Introduction

The European Green Deal has set forth an ambitious strategy for achieving a climate-neutral, resource-efficient, and competitive economy. To realize this vision, the EU aims to transition towards a regenerative growth model, reducing resource consumption within planetary boundaries and embracing circular principles to double its material use rate in the next decade.

In this context, certain occupations can play a more significant and strategic role. These key occupations play a pivotal role in driving sustainable practices, implementing green technologies, and fostering eco-friendly processes. While "white-collar" occupations play a crucial role in driving and strategizing the green transition, "blue-collar" workers with less formal education also play a significant and indispensable role in implementing sustainable practices on the ground. These workers are instrumental in translating green strategies into tangible actions, making a direct impact on the sustainability efforts within their sectors. In both cases, it is crucial for key workers to possess the appropriate capacities, skills, and competencies. Equipping these workers with the necessary knowledge and expertise will enable them to contribute significantly to the sustainability efforts within their sectors.

Cedefop defines green skills as “the knowledge, abilities, values and attitudes needed to live in, develop and support a sustainable and resource-efficient society” (Cedefop, 2012). These skills will be indispensable across all sectors and at all levels of the workforce, supporting the development and maintenance of a sustainable and resource-efficient society. By investing in the capacities of key workers through targeted training and skill development initiatives, industries can unlock the full potential of their workforce in driving the green transition.

The capacity building process for the green transition is supported by two pillars: the GreenComp, a standardized framework for green competences, and the ESCO database: a comprehensive database for skill identification:

- **GreenComp Reference Framework:** The GreenComp framework serves as a standardized reference model for sustainability competences at the European level. GreenComp offers a comprehensive set of twelve competences, organized into four distinct areas:
    - **Embracing Sustainability values** (Valuing sustainability, supporting fairness and promoting nature).
    - **Embracing complexity in sustainability** (systems thinking, critical thinking and problem framing).
    - **Envisioning sustainable futures** (future literacy, adaptability and exploratory thinking).
    - **Political agency** (Political agency, collective action, and individual initiative).

- **ESCO Database for Identifying Green Skills:** The ESCO (European Classification of Skills, Competences, Qualifications, and Occupations) database plays a vital role in identifying and cataloguing skills and competences relevant for each occupation. The recent addition of green, brown, and white skill labels further highlights the commitment to sustainability and supports the identification of skills with a positive impact on the environment:

- **brown skills:** those increasing the negative impact of human activity on the environment, as "production of electricity by using coal"
- **white skills**: including knowledge and skills that don't increase nor reduce this negative impact in the environment, as for example: software performance".
- **green skills**: all the skills that help protecting the environment by reducing the negative impact of human activity on the environment, as "cogeneration of heat or cold power from geothermal energy". Meanwhile some examples of green knowledge are: engineering, manufacturing, construction or natural sciences.

This report presents the key findings of the comprehensive assessment conducted to identify the relevant skills for the green transition in the six industrial sectors targeted by the Green project. By bridging the gap between identified green skills and available training programs, this report provides a roadmap for fostering a workforce that is well-equipped to navigate the challenges and opportunities presented by the green economy. It paves the way for a more sustainable and resilient labour market, ensuring a brighter and greener future for the European workforce and beyond.

2. Objectives

This report aims to assess the labour market needs for the green transition within six specific industrial sectors: Additive Manufacturing, Automotive, Energy, Batteries, Defence, and Maritime. The primary goal is to identify key occupations crucial for facilitating the green transition in each sector, understanding the skills and expertise required for sustainability efforts.

The report will utilize the ESCO taxonomy to describe the identified green skills associated with these key occupations, ensuring coherence and alignment with established skill frameworks. In cases where the green transition brings about changes in job roles within the targeted sectors, the report will propose skill revisions or additions to accommodate the evolving demands and complexities of the sustainability drive. This approach aims to enhance the accuracy and relevance of the identified green skills, equipping the workforce with the expertise needed to thrive in a rapidly evolving green economy.

Additionally, the report will map the National Vocational Education and Training (VET) supply concerning green skills coverage to assess the current state of available training and identify potential gaps. By doing so, it will help in developing a set of core green skills tailored to the labour market's needs, aligning with the green transition objectives.

In summary, this comprehensive report aims to provide valuable insights and recommendations for policymakers, industry stakeholders, and education providers to bridge skill gaps and facilitate a smooth and successful green transition across the selected industrial sectors.

3. Methodology

The methodology for this analysis entailed a desk analysis, which involved a comprehensive review of the findings from the blueprint projects Drives, Eddie, Albatts, Assets, Mates, and SAM, all of which have targeted the six sectors addressed.
A comprehensive examination of each sector allowed to ascertain its main features and relevance

across the EU. Through this analysis, a careful selection process has been undertaken to identify 2 to 4 key occupations crucial for driving the Green transition. The chosen occupations have been selected based on their vital role in supporting sustainability initiatives within their respective sectors.

A review of the ESCO skills related to the chosen occupations has been conducted. This assessment focuses on identifying skills labelled as Green within the ESCO taxonomy and discerning any potential skill gaps that might exist. By evaluating the alignment of the identified skills with Green European Competence framework, the report aims to ensure that the workforce possesses the essential competencies needed to drive sustainability efforts effectively.

Furthermore, the analysis extends to the main training programs available for developing the selected occupations. This review encompasses at least two of the most relevant countries for each sector. By examining training opportunities in these countries, the report seeks to shed light on the pathways available for individuals to acquire the necessary skills and expertise demanded by the Green transition.

The combination of these analytical components ensures a comprehensive evaluation of each sector, its vital occupations, the associated green skills, and the training landscape. To further augment the methodology, a qualitative research component has been integrated, leveraging online focus groups with experts from the blueprint projects, the labour-market, and the education and training community. This interactive approach will provide valuable insights into the dynamic labour market needs and skill requirements concerning the green transition. In total, 96 experts in the targeted sectors have been informed of this process, and 52 have actively contributed to the discussions. A special care has been taken to ensure an age and gender balance in the focus groups.

The sectoral analysis and focus groups have been distributed among designated partners to ensure comprehensive coverage of the targeted sectors:

- Additive Manufacturing: Led by EWF in collaboration with CECIMO
- Automotive: Coordinated by VSB-TUO with support from OLIFE
- Batteries: Led by VSB-TUO in conjunction with OLIFE
- Defence: Spearheaded by Mercantec with collaboration from Swantec and EWF
- Maritime Technologies: led by CETMAR in collaboration with CT

Additionally, recognizing the interconnectedness of sectors in their pursuit of sustainability, a cross-sectoral validation group has identified common green skills that transcend industry boundaries. This cross-sectoral focus group has been coordinated by EWF, involving a reduced number of experts from the previous sectoral groups. The results obtained during the sectoral focus groups are presented throughout the document in the chapters dedicated to each of the sectors under study.

By combining desk analysis, ESCO green skills review, and qualitative research through focus groups, this robust methodology endeavours to provide comprehensive and reliable insights into the labour market needs and core green skills required for a successful green transition within the identified industrial sectors.

4. The additive manufacturing sector

This section addresses **Additive manufacturing** (Covered by NACE rev.2 by: C- Manufacturing and Subsectors: C22- Manufacture of rubber and plastic products/ C23 -Manufacture of other non-metallic mineral products /24 Manufacture of basic metals/ C25- Manufacture of fabricated metal products, except machinery and equipment / C28- Manufacture of machinery and equipment n.e.c. /C29 - Manufacture of motor vehicles, trailers and semi-trailers)

Additive manufacturing is a new approach to industrial manufacturing where a physical object is created by overlaying layers of material. According to ISO and ASTM (ISO/ASTM 52900:2015): Additive Manufacturing (AM), noun, the process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing technologies. Many historical terms have circulated and are still being used today: additive fabrication, additive processes, additive techniques, additive layer manufacturing, layer manufacturing, solid freeform fabrication, freeform fabrication and many more. It is important to note that AM does not imply a certain application of the parts being produced like the definitions of the older terms.

The same standard further specifies the names of 7 categories of Additive Manufacturing technologies:
Binder Jetting: AM process in which a liquid bonding agent is selectively deposited to join powder materials.
Directed Energy Deposition: AM process in which focused thermal energy is used to fuse materials by melting as they are being deposited. Note 1 to entry: “Focused thermal energy” means that an energy source (for example: laser, electron beam, or plasma arc) is focused to melt the materials being deposited.
Material Extrusion: AM process in which material is selectively dispensed through a nozzle or orifice.
Material Jetting: AM process in which droplets of feedstock material are selectively deposited. Note 1 to entry: Example feedstock materials for material jetting include photopolymer resin and wax.
Powder Bed Fusion: AM process in which thermal energy selectively fuses regions of a powder bed.
Sheet lamination: AM process in which sheets of material are bonded to form a part.
VAT Photopolymerisation: AM process in which liquid photopolymer in a vat is selectively cured by light-activated polymerization.

One of the aspects **discussed during the focus group** was the classification of AM as a sector. Although it makes sense given the need for qualified workers and specific skills to analyse it as such, at the moment, its scope and transversality to various economic sectors make this analysis difficult.
Concerning the AM relevance for the GREEN transition, as a vector helping other sectors, meaning it is a set of technologies applied to several sectors. The analysis should cover as well as who are the main sectors applying AM (such as ENERGY, DEFENCE, TRANSPORT).

AM as Cross sectoral tool – sustainability in AM is a team effort.

All AM technologies can be classified into one of the categories above.
The Additive Manufacturing value chain, independently of the process, material, or application, can generically be encompassed in the six activities displayed, as represented in the figure below.

Fig 4.1 Additive Manufacturing value chain

Although there are different 3D printing technologies and materials, all are based on the same principle: a digital model is turned into a solid 3D physical object by adding material layer by layer. Therefore, common steps are also required from knowledge to market.

The AM value chain (VC), defined in the framework of projects, such as, FoFaM and AM-motion include the following set of activities:

Modelling & Design
The first step for 3D printing is always the production of a 3D model with the help of computer-aided design software (CAD). Reverse engineering can also be used to generate a digital model via 3D scanning. Then, it is required the conversion of the CAD model into a STL (Standard Triangle Language) file, which uses triangles to describe the surface of an object. Once the STL file has been generated, it is imported into a slicer programme that converts it into a numerical control programming language, making it interpretable by the AM machine and ready to print. The slicer program also allows the designer to customise the build parameters including support, layer height and part orientation.

Due to the specific nature of the layer-by-layer building, the design process is substantially different from conventional production methods. On the one hand, 3D printing lets designers create complex shapes and parts, many of which cannot be produced by traditional manufacturing methods. Moreover, to get the maximum value of the process, topology optimization by means of finite element methods is usually recommended to identify each part of the structure where some material could be removed while maintaining the integrity of the structure. On the other hand, the build strategy should be considered during the design stage.

Materials

A wide range of materials can be used in additive manufacturing, including metals, thermoplastics, ceramics, medical/biochemical materials, glass, etc. This VC segment refers to the production of high-quality raw materials as well as the development of new ones. Materials requirements for AM include the ability to produce the feedstock in a form amenable to the specific AM process, suitable processing of the material by AM, capability to be acceptably post-processed to enhance geometry and properties, and manifestation of necessary performance characteristics in service. On the other hand, it should be considered that the raw materials used in additive manufacturing often have a limited shelf life and require careful handling.

Considering materials to be a crucial segment in the AM value chain, there was a consensus on the **focus group** that **metals and polymers** were the materials on which we should focus our analysis for the green transition, given their wide application in various sectors. It should be noted that the use of other emerging materials such as glass, wood and concrete could become relevant in the future.

AM process

Before the part starts to be created, the orientation of the design and the printer, as well as the process parameters need to be set up. During the production time, process monitoring is important for quality and production throughput.

Correct machine maintenance and calibration are also key factors to ensure process quality. After the additive cycle is done, the part should be removed from the build plate in a safely way. For some additive manufacturing technologies removal of the print is as simple as separating the printed parts from the build platform. However, for other more industrial 3D printing methods the removal of a part is a highly technical process that require highly skilled machine operators.

Post-processing

For technologies that utilize support, it is removed at the post processing stage. Post processing is also essential to compensate for undesired part properties which have been build up during the manufacturing process. In this sense, 3D printing requires different finishing considerations than traditional manufacturing. Procedures for AM postprocessing can be divided in two different groups:

a) thermodynamic post-processing, which comprises heating treatments of the AM manufactured part relieving stresses and influencing its microstructure and porosity;

b) mechanical post-processing, which compensate for surface properties and dimensional tolerances of the product.

Product

As 3D printing opens a new form of manufacturing, certification processes and standards for specific processes and materials are still being developed. Therefore, it is key to perform necessary testing to adequately certify that a part will work as intended, as well as to ensure repeatability for series production applications.

Part quality assessment typically require competences on the testing of geometry, surface finish and material properties. Surface examination can be performed by visual inspection, liquid penetrant testing or magnetic particle inspection. Dimensional validation is possible even for complex parts using laser scanning and micro-CT methods.

Other non-destructive methods such as radiography, ultrasonic inspection, acoustic emission, or leak testing can be used to examine the bulk of the part. On the other hand, in the case of new products, control samples consisting on AM specimens manufactured under the same conditions as the part, as well as selected sections of the part, are tested by destructive methods such as mechanical or corrosion testing methods in order to validate the material quality resulting from the process.

End of life

AM offers different opportunities for improving sustainability, from the product itself (starting from a different design easy to recycle) to repair operations and the reusing of feedstock for parts production.

Additive manufacturing sector is in rapid growth due to the growing adoption of this technique in industrial applications for improving production and shortening the time to market. Concerning to this rapid growth below it's a table[1] showing expected developments and technological trends for the next 10 years (2021-2023) and its impact on skills and occupation. Cost reduction, emerging hybrid materials, workflow simplification, efficient manufacturing are some of the expecting developments related to sustainability measures and concerns.

Analysing the value chain, it is complex to identify which segment is most relevant to the Green transition. Once again, the experts who took part in the **focus group**, showed that the greater or lesser relevance depends on its application, the sector in which it is inserted and the combination of segments, for example in the combination of materials and processes that can be more or less green.
Although both **materials** and **processes** were identified as the main relevant, some of the participants mentioned that the more relevant would be the segment of **modelling & design** because it is what allows, in the project phase to make choices and make decisions more sustainable and therefore with less environmental impact.

[1] Data collected from multiple rounds of forecast (i.e., Delphi method) conducted on June 2021 with AM experts from industry, academic institutions, research, and technological centres, belonging to the IAMIC.

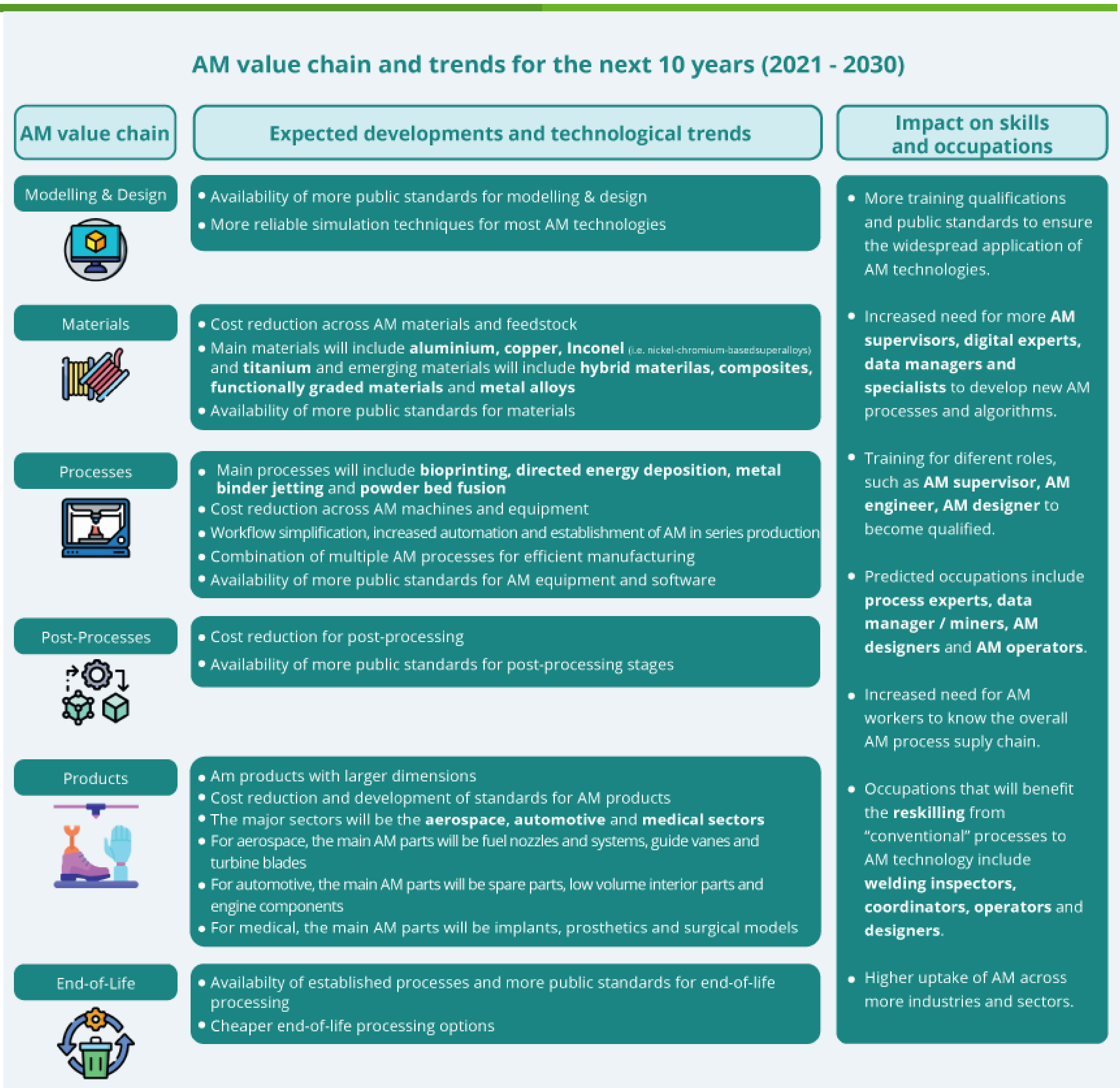


Fig 4.2 AM value chain and trends for the next 10 years

4.1 Sector general overview

AM is anticipated to generate substantial economic revenue by 2025 (Saliba et al., 2020). Furthermore, the Wohlers Report 2019 forecasts $15.8 billion for all AM products and services globally in 2020. The forecast is expected to increase to $23.9 billion in 2022 and $35.6 billion in 2024 (Wohlers, 2020; McCue, 2020). More precisely there was an upsurge in the number of industries that manufacture 3D printers and systems, and the report also noted that many industries, notably aerospace industries (e.g. Airbus and Boeing) increasingly utilise AM to fabricate end-use products and parts. Heidi et al. (2016) reported that manufacturing in the European Union directly contributes to 30 million jobs and twice as many jobs indirectly. Manufacturing also contributes to 80% of total EU exports and 80% of private R&D expenditure. However, when it comes to advanced manufacturing, it only contributes to 1.6 million jobs, and 11% of the total EU production as half of the European manufacturing companies still do not embrace the use of advanced manufacturing technologies. Nonetheless, AM is seen to be an enabler for the EU to secure a strong industrial base.

Within SAM project, 47 national and seven regional initiatives were identified in EU and Non-EU countries[2], with the potential of accelerating the national and regional roll out of AM.
Most of the studies initiatives were identified in Germany, followed by Spain, United Kingdom, Italy and France, since the identified clusters, programmes, networks and platforms can contribute for boosting implementation of training and skills development in AM.

According to the report "Europe Additive Manufacturing Market – Industry Trends and Forecast to 2030"[3], Europe additive manufacturing market is expected to gain significant growth in the forecast period of 2023 to 2030, The major factor driving the growth of the additive manufacturing market is the increasing demand for lightweight components from the automotive and aerospace industries.
Germany dominates the Europe additive manufacturing market due to advanced development in technologies. United Kingdom has been investing in additive manufacturing, particularly in aerospace and healthcare applications. With a national strategy, firstly government-backed to help AM to emerge to be strongly implement by 2025. Spain additive manufacturing sector employs about 700 people and its mainly focus on automotive, aerospace and healthcare. In Denmark was born the Danks AM Hub, a business foundation with a vision to make Denmark a world leader in the use of Additive manufacturing.

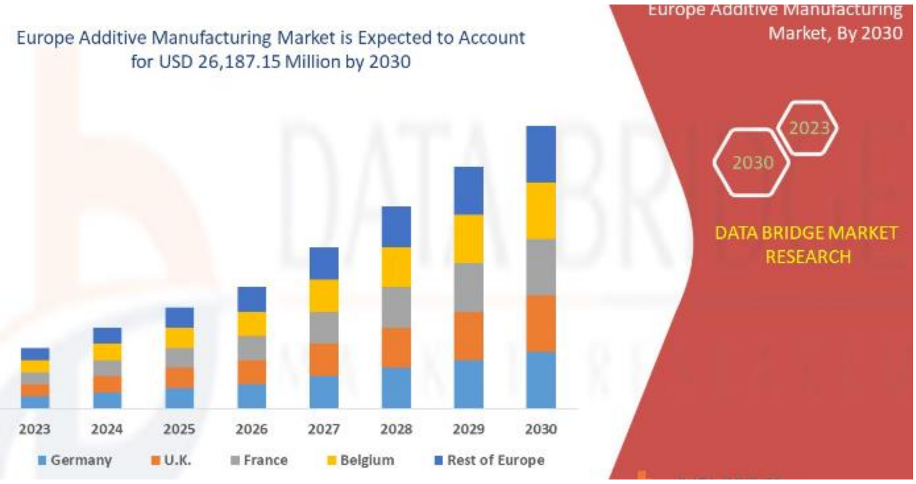


FIG 4.3 Europe Additive Manufacturing Market

In Germany, the Fraunhofer Institute for Laser Technology ILT stands out as a prominent provider of diverse training programs and courses related to laser technology, with a significant focus on AM. These offerings encompass workshops, seminars, and certification programs. Furthermore, the annual Rapid.Tech + FabCon 3.D conference and exhibition, held in Germany, offers a comprehensive platform for AM and 3D printing technologies. It features a wide array of workshops, seminars, and training

2 (D1.3 Long Term Technological Plan - https://skills4am.eu/documents/D1.3_%20Technolgical%20Plan%20VF_reviesed.pdf)
3 Source: Data Bridge Market (2023) - https://www.databridgemarketresearch.com/reports/europe-additive-manufacturing-market

sessions.

In the UK, The Manufacturing Technology Centre (MTC) plays a pivotal role in delivering training and development programs centred on advanced manufacturing technologies, including AM. Their extensive portfolio includes courses and workshops catering to both individuals and companies. Additionally, the University of Warwick offers a range of engineering and manufacturing courses, several of which incorporate AM components into their curriculum.

In Denmark boasts a strong presence in AM education through the Technical University of Denmark (DTU). Within its Department of Mechanical Engineering, DTU offers courses and programs dedicated to AM, seamlessly integrated into their engineering curriculum. The AM-LINE Denmark consortium further enhances the educational landscape by bringing together Danish educational institutions, research organizations, and companies. This collaborative effort results in comprehensive training, educational, and research opportunities.

Lastly, in Spain, AIMEN Technology Centre emerges as a leading provider of training and courses covering various aspects of AM, encompassing both metal and polymer technologies. Their offerings span the spectrum from theoretical knowledge to practical application. Similarly, CEIT - Technological Centre specializes in delivering targeted courses on AM and 3D printing technologies, offering comprehensive programs that cater to both foundational and advanced levels of expertise.

European countries are actively involved in additive manufacturing which is having a significant presence in the industry due to offer new possibilities in terms of design, customization, and production efficiency. The use of AM allows for cost-effective customization and the production of small batches of highly specialized components. This is particularly valuable in industries where customization and rapid prototyping are crucial, can be more sustainable than traditional manufacturing methods because it often generates less waste, uses fewer raw materials, and allows for more energy-efficient production.

Additive manufacturing enables local and distributed manufacturing, reducing the need for long-distance shipping and lowering supply chain costs. This is particularly relevant in Europe, where proximity to markets and customers is essential.

We asked the **Focus Group** participants, whether they agreed with the identification of the European countries for the analysis as the most relevant. Once again it was mentioned that the approach should be made in a sectoral and not geographical manner. The identification of which economic sectors that most apply AM in their manufacturing processes makes more sense and will probably reach the same countries. **Germany** will be the most representative, **Spain, France**, **UK** and **Italy** will follow, but we must also consider **Belgium** to be one of the more representative countries.

4.2 Key occupations for the Green transition

Ever since Additive Manufacturing (AM) appeared on the radar, it has been entitled as a “greener” manufacturing method compared to other conventional processes such as machining. The reason for this is the layer wise “build-up” of material only where needed, rather than the subtraction of excessive material. Looking at the life cycle of an additively manufactured product, there is still a lot of potential throughout the single phases (eg. material, design, and production, in-service and end-of-life) to even increase it. For example, during the design phase of a part, AM benefits from optimised geometries and lightweight designs which should reduce the material consumption and environmental impact during their lifetime. Furthermore, direct repairing methods and “print-on-demand" lead to extended lifetimes and less waste. The carbon footprint of an AM part is mainly influenced by the energy consumption during the manufacturing process (machine utilization) and emissions related to the production of the raw material and transportation in between. [4]

Environmental change is an increasingly important driver of labour demand and skills supply across sectors. The expansion of the green and sustainable economy is being accelerated by concerns related to energy generation, more efficient resource use and environmental management.

Sustainability has become a key topic on the agenda of politicians and corporate executives. The Manufacturing sector has a high responsibility for environmental sustainability, as (1) raw materials pass through production to become products and (2) the capability for re-use, refurbishment, re-manufacturing and recycling are mostly dependent from product design and production. The implementation of Circular Economy will be enabled by consistent sets of policies and regulations, technological advances combined with the integration of people and a global awareness achieved through education efforts, that results in a shift in consumer mindset, behaviour and increase in manufacturing and ecology-oriented skills.

AM processes enable economic component production with the efficient use of materials and vastly increased design freedom, compared to traditional subtractive processes. By using additive techniques, engineers are able to create objects of high complexity based on highly accurate computer-controlled designs, delivering finished components made from both readily available standard and high-performance materials including plastic, metal, composite powders and even human tissue and foodstuffs. Being a digital direct manufacturing technology, Additive Manufacturing also increases the level of digital literacy among workers and contributes to the digitalisation of European Industry. It provides greater liberation for designers and allows them to be much more creative.

International Additive Manufacturing Qualifications Systems (IAMQS) managed by EWF, was created to

[4] https://www.skills4am.eu/documents/D8.1%20SAM%20Environmental%20Sustainability_%20VF_4.11.2021.pdf

ensure that companies and professionals are equipped with the right set of skills to implement AM/ 3D printing at the industrial level. IAMQS is the only AM qualification framework where there is a transparent and clear definition of each professional profile with detailed description of tasks and responsibilities for each role.

For the AM Green transition we have selected 4 key occupations: 3 from IAMQS Professional Profiles (one integrated in ESCO, other who's alignment was already performed but not yet integrated and a 3rd because it is a production process management profile, who has a comprehensive view of both the various processes and the suitability as well as the materials involved enabling green decisions making) the 4th professional profile is from ESCO, 3Dprinting Technician because it's it is a designation that commonly appears in recruitment announcements and which, because of its extent, makes sense for us to address in this study.

The selected AM Occupations are:

OCCUPATIONS	ESCO	IAMQS
Metal AM Operator	x	x
Metal AM Process Engineer		x
AM Designer*		x
3D Printing Technician	x	

*AM Designer is already aligned with ESCO but not yet integrated

Table 4.1 Selected AM Occupations

METAL AM OPERATOR

Metal additive manufacturing operators operate machines using additive manufacturing processes, such as fitting and setting up, maintenance and repair. They have factual and broad understanding in the field of metal additive manufacturing process. They are able to develop solutions on basic and specific problems related with additive manufacturing machines and processes and self-manage the handling of feedstock (approval, storage, contamination, traceability).

AM DESIGNER

Design Metal AM solutions for AM Processes ensuring and validating that parts can be made cost-effective and efficiently. They also close design projects by verifying requirements for production with engineers as well as process requirements, ensuring liaison with other technical areas to sign of drawings, contributing to projects in a teaming environment cooperation with AM Team. Metal AM Designers have advanced knowledge and critical understanding of the theory, principles and applicability of metal additive manufacturing design for Metal AM processes. They are able to manage complex Metal AM processes design projects, taking responsibility for decision-making in design applications.

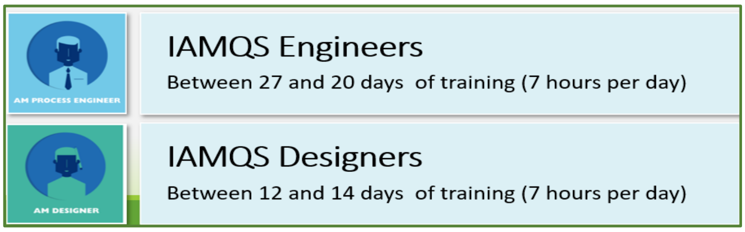
METAL AM PROCESS ENGINEER

Process Engineers are the professionals with the specific knowledge, skills, autonomy and responsibility to implement at least one of the following processes: power bed fusion- laser beam (PBF-LB) PBF-LB; direct energy deposition – laser beam (DED – LB); direct energy deposition – arc (DED-ARC) into the manufacturing chain assuring the efficient production and post-processing of additively manufactured parts. Manage metal additive manufacturing processes activities in a highly complex context. Take responsibility indecision n making and definition of process procedures and applications.

3D PRINTING TECHNICIAN

3D printing technicians assist in the designing and programming of products, ranging from prosthetic products to 3D miniatures. They may also provide 3D printing maintenance, check 3D renders for customers and run 3D printing tests. 3D printing technicians can also repair, maintain and clean 3D printers.

The **engineer and designer** – are the most relevant AM occupation for the green Transition Identified during the **focus group meeting** where were suggested to focus the analysis on these two roles.
The **Designer** chose the process, materials, product shape, and the **engineer** should make that work.



4.3 Skills for the Green transition in the key occupations

Concerning AM occupations, particularly those we chose for being the first ones to be integrated in the green transition, and given that most of these occupations are not integrated in ESCO (only one), we will present below a list of skills specific to each of the occupations, following an identical approach to ESCO, grouping them in the categories of "Essential knowledge", "essential skills and competences", and "Essential skills". From this analysis we will identify which skills by their nature may be indicated as being a green skill. Also, we identify the ones that would be brown skills and white skills, using once again the ESCO labelling.[5]

In the following tables (4.2 to 4.5) it is showed for each skill and knowledge, a classification on white, green or brown. Skills marked with a green X are the ones labelled by ESCO as GREEN the other labelling it is a suggestion concerning their potential to be classified like this, and it will be validated by experts in the scope of focus group. We considered that GREEN transition should be made throughout training in dedicated competence units but mainly should be done transversally within all subjects as an attitude towards materials, processes, and management. As an example, all skills related to predictive maintenance, could be labelled as green, because if an equipment is periodically monitored and calibrated it keeps its efficiency and increase its life cycle.

[5] en_Green-Skills-and-Knowledge-Labelling-ESCO.pdf (edu.ro)

Concerning the above identified AM occupations, during the **focus group** was decided to analyse only skills for these occupations. The most pertinent finding was that, in spite of the skills analysis, the green thinking should be reflected in the contents, methodologies, and learning outcomes of any training program.**. "We need embed green thinking on all skills".** Nevertheless, skills concerning simulation, must be considered for the GREEN transition "**Simulation tools**" and **"Simulation analysis"** from the Designer profile as an example, using simulation is possible to reduce raw materials, waste and be more cost-effective reducing errors.

From AM Process Engineer occupation, other skills were identified **"determine suitable of materials**", "**draft design specifications**" and "**create solutions to problems"** as relevant for the GREEN transition. Critical thinking, creativity are some of the skills that should be embed into the curricula in order to enhanced a carbon footprint-reducing attitude.

Table 4.2: Skills and competences associated to the additive manufacturing operator occupation. The skill/competence highlighted in green is the one labelled as GREEN by ESCO. This occupation has been reviewed during the desk research, but following the experts recommendations it has been eliminated from the analysis.

	ESSENTIAL SKILLS AND COMPETENCES	GREEN SKILLS CLASSIFIER			ESSENTIAL KNOWLEDGE	GREEN SKILLS CLASSIFIER		
		GREEN	BROWN	WHITE		GREEN	BROWN	WHITE
AM OPERATOR	Ensure compliance with environmental legislation	X			Functionalities of machinery			x
	Apply health and safety standards			x	Machines tools		x	
	Follow work schedule			x	Maintenance operations	x		
	Liaise with engineers			x	Quality assurance procedures	x		
	Liaise with managers			x	Waste management	X		
	Manufacture metal additive manufacturing parts		x					
	Maintain additive manufacturing systems	x						
	Operate precision measuring equipment							
	Perform machine maintenance	x						
	Prepare parts for post processing		x					
	Remove processed workpiece		x					
	Set up additive manufacturing systems		x					
	Troubleshoot		x					
	Use personal protection equipment		x					
	Work safely with machines	x						
	Write production reports			x				

Table 4.3: Skills and competences associated to the additive manufacturing designer. This occupation has been retained as relevant to accelerate the green transition, and therefore has been included in the analysis. Two main skills/knowledge were identified as GREEN, Simulations tools and Simulation Analysis.

	ESSENTIAL SKILLS AND COMPETENCES	GREEN SKILLS CLASSIFIER			ESSENTIAL KNOWLEDGE	GREEN SKILLS CLASSIFIER		
		GREEN	BROWN	WHITE		GREEN	BROWN	WHITE
AM DESIGNER	AM materials and properties	x			Design AM parts	x		x
	AM processes	x			Interpret process specific part or assembly requirements	x		
	Think Additively	x			Create new or redesign existing 3D models using CAD tools taking advantage of AM	x		
	Design principles for AM	x			Associate the degrees of freedom of AM machines to the possibilities in terms of design			x
	Simulation tools	x			Relate the capabilities and limitations of AM processes to design considerations	x		
	Post Processing	x			Determine dimensional constraints and geometric tolerances required for AM parts design			x
	Engineering principles	x			Provide solution-based approaches to redefine design problems (Design thinking) within AM processes and parts	x		
	Simulation Analysis	x			Select simulation tools to be used in the Design of AM parts	x		
					Liaise with other technical areas	x		x
					Analyse simulation results			x

Table 4.4: Skills and competences associated to the metal additive manufacturing process engineer. However, this occupation is not from ESCO we used the same labelling to identify skill/competence which could be labelled has green due to its characteristics. This occupation has been retained as relevant to accelerate the green transition, and therefore has been included in the analysis.

	ESSENTIAL SKILLS	GREEN SKILLS CLASSIFIER			ESSENTIAL KNOWLEDGE	GREEN SKILLS CLASSIFIER		
		GREEN	BROWN	WHITE		GREEN	BROWN	WHITE
METAL AM PROCESS ENGINEER	Estimate duration of work			x	types of metal manufacturing processes	x		
	Analyse test data			x	metalworking	x		
	Ensure conformity to specifications	x			supply chain management	x		
	Set quality assurance objectives	x			manufacturing processes	x		
	Manage corrective actions	x			quality assurance procedures	x		
	Determine suitability of materials	x			engineering principles	x		
	Draft design specifications	x			engineering processes	x		
	Create solutions to problems	x			metal joining technologies	x		
	Identify customer's needs	x						

Table 4.5: Skills and competences associated to the 3D printing technician. This occupation has been reviewed during the desk research, but following the experts' recommendations it has been eliminated from the analysis.

	ESSENTIAL SKILLS AND COMPETENCES	GREEN SKILLS CLASSIFIER			ESSENTIAL KNOWLEDGE	GREEN SKILLS CLASSIFIER		
		GREEN	BROWN	WHITE		GREEN	BROWN	WHITE
3D PRINTING TECHNICIAN	Adjust engineering designs	x			3d modelling			x
	Advise client on technical possibilities	x			3d printing process		x	
	Create solution to problems	x		x	Cad software			x
	Draft design specifications			x	Ict software specifications			x
	Identify customer's needs			x	Maintenance of printing machines	x		
	Operate 3D computer graphics software			x	Maintenance operations	x		
	Operate printing machinery		x		Printing materials		x	
	Use CAD software			x	Printing on large scale machines		x	
	Use technical drawing software			x	Printing techniques		x	

As referred to above in this report, GREEN is fed by outcomes and conclusions reached on the SAM project, which is a strategic approach to skills development in AM, where a dynamic forecast methodology focused on skills gaps, shortages and mismatches identification, anticipation, and validation, was developed in order to design and / or revise qualifications and profiles in AM with the engagement of relevant stakeholders within the European and National landscapes.

Forecast methodology addressed within SAM, consisted in a continuous market research to determine skills mismatches and gaps by implementing a set of online surveys with representatives from industry / employers, workers in AM and recruitment agencies.

The applicable surveys cover a range of subjects, including general information and background, AM skills and professional profile needs, relevance of various skills categories, and AM employability data, to name a few. Within SAM, skills have been classified into four different categories:

- Technological skills defined as "Ability to apply knowledge and use know-how to compete tasks and solve problems" [within specific activities]" (Adapted from CEDEFOP 2008)
- Digital skills defined as "range of abilities to use digital devices, communication applications, and networks to access and manage information. They enable people to create and share digital content, communicate and collaborate, and solve problems for effective and creative self-fulfilment in life, learning, work, and social activities at large" (UNESCO, 2022)
- Entrepreneurship or entrepreneurial skills defined as "transversal key competence applicable by individuals and groups, including existing organizations, across all spheres of life" or "when you act upon opportunities and ideas and transform them into value for others." The value that is created can be financial, cultural, or social." (ENTRECOMP, 2016)
- **Green skills defined as "knowledge, abilities, values and attitudes needed to live in, develop and support a sustainable and resource-efficient society (CEDEFOP, 2015)**

To respond to the needs of the **GREEN project**, let us focus only on the analysis done to the so-called **green skills**. After analysing results from the survey conducted with workers ad companies in 2023, we can reach a conclusion that in the case of green domain, workers and companies are in complete agreement. The most voted skills for both are 'reuse/recycling AM materials and products', 'life cycle analysis (LCA)' and 'resource efficiency management'.

It is also interesting to see how these needs have evolved. In a longitudinal study, the same questionnaires were conducted, both to companies and workers in 2020, 2022 and 2023. Overall, some changes can be observed in the skills needs throughout these 3 years. Something to stand out is that from 2022 the needs of both workforce and companies do not seem to show big trend changes, differences are more remarkable in the first period (2020-2022) of this 3-year timeframe.

	TOP 3 SKILLS		
	2020	2022	2023
Green	Circular economy (18,8%)	Reuse/recycling AM materials and products (69,5%)	Reuse/recycling AM materials and products (70,5%)
Green	Life Cycle Analysis (LCA) (15,2%)	Life cycle analysis (LCA) (60,7%)	Life cycle analysis (LCA) (63,4%)
Green	Green awareness (13,4%)	Resource efficiency management (30,4%)	Resource efficiency management (44,3%)

Table 4.6 - Workers

	TOP 3 SKILLS		
	2020	2022	2023
Green	Green awareness (34,8%)	Reuse/recycling AM materials and products (74,5%)	Reuse/recycling AM materials and products (70,6%)
Green	Eco-design (30,4%)	Resource efficiency management (58,2%)	Life cycle analysis (LCA) (56,9%)
Green	Green resources (30,4%)	Life cycle analysis (LCA) (58,2%)	Resource efficiency management (43,1%)

Table 4.7- companies

	TOP 3 SKILLS	
	2020 Future relevance (3Y)	2023 Present relevance
Green	Resource efficiency management (42,9%)	Reuse/recycling AM materials and products (70,5%)
Green	Circular economy (42%)	Life cycle analysis (LCA) (63,4%)
Green	Green awareness (35,7%)	Resource efficiency management (44,3%)

Table 4.8 – TOP 3 Green Skills priorities identified

From these studies and considering the evolution of the AM sector through Europe, we can identify three main green skills that should be part of the qualification framework in AM, "Reuse/recycling AM materials and products", as for the broader scope of this knowledge, should be addressed transversally to all AM occupations. The other two, more related to the specific scope of white collars profiles should be "Life cycle analysis" and "Resource efficiency management".

Although we can find and predict some specific skill needs to the green transition, we also must address the need for an attitude and behaviour change that can be put into action on the already identify skills into the different qualifications' framework within AM as mentioned on the GREENCOMP[6].

In all the occupation profile presented above it is possible to identify some skills that can be trained to have underlying green principles, such as when a designer studies the execution of a particular piece, he can determine the use of green materials whenever this is possible and does not question structural safety issues for example.

[6] https://publications.jrc.ec.europa.eu/repository/handle/JRC128040

4.4 Skills supply for the Green transition

After the validation of the results by the Industry Council, one of the pillars of the European Observatory responsible for providing inputs on skills needed and for being aware for emerging research topics, and based on the above-mentioned findings, SAM stakeholders agreed to develop a training unit (competence unit) on Sustainability for Additive Manufacturing. Within this competence unit, green awareness, circular economy and Life Cycle Assessment will be covered to raise their awareness of all AM Professionals, including AM Operator, Designers, Supervisors and Engineers, for the short Term.

Proposal of a new competence unit – Sustainability in AM
In order to address the topic of sustainability, a competence unit (CU) was developed for a basic level in alignment with the European Qualifications Level (EQF) level 3, aiming at raising awareness on the importance of sustainability applied to AM.

It is expected, that after successfully completing the course, the students gain basic knowledge in:
– Understanding of economic and social contexts of sustainability policies such as "R" Imperatives, Green Deal, Sustainable Goals and etc.
– How to incorporate sustainability along the product´s life cycle
– How AM is currently implementing sustainability and the limitations and possible routes in sustainability (advantages and limitations)

Within this course, the participants are expected to gain the following skills:
– Spot ideas and opportunities for alternative, more sustainable and simple solutions for daily AM activities
– Name advantages and disadvantages of AM sustainability topics
– Identify cases and/or examples for which AM may lead to more sustainable products
– Take the initiative to make suggestions for more sustainable choices along the AM product life cycle.

The course will be ongoing for a recommended time of 7 hours. This corresponds to 14 hours of workload in which participants can dive deeper into the topics via self-study. The knowledge and skills towards sustainability for AM will be evaluated via a short-written assessment (multiple choice) at the end of the course.

Competence Unit - Sustainability for Additive Manufacturing	*RECOMMENDED CONTACT HOURS*
SUBJECT TITLE	
Economic and social context for sustainability policies	1
Sustainability along the product life cycle	1.5
AM within a sustainable production scheme	3.5
Case studies	1
Total	7
WORKLOAD	14

This Competence Unit, piloted within the scope of SAM, was led by IMR, with support from MTC and Lortek.

The positive response to this course supported by the validated findings, lead to the development of two new CUs, the Metal AM Sustainability, Recycling and Circularity and Polymer AM Sustainability, Recycling and Circularity. For the development and validation processes of these two new Competence Units presented below, the contribution of many experts both from the field of additive manufacturing as from educational field, was considered, some were internal to SAM project, but with the majority were external participants that brought important insights for the work that was being developed.

Metal AM Sustainability and Circularity	RECOMENDED CONTACT HOURS
SUBJECT TITLE	
Overview of sustainability	0.5
Concept & Practice of Circularity	0.5
Potential sustainability benefits of AM	0.5
Measuring, predicting and justifying sustainability	0.5
Overview of metal AM process chains and their impact on sustainability	0.5
Impact of AM feed-stock on sustainability	0.5
Impact of part design and material selection	1.0
Impact of AM process selection and build set-up on sustainability	1.0
Impact of Part post processing on sustainability	0.5
Impact of Metal AM facility design and operation	0.5
Repair, reuse & recycling approaches in metal AM	0.5
Recap on all topics covered, assessment and complete post CU survey	0.5
Total	7
WORKLOAD	14

LEARNING OUTCOMES – Metal AM sustainability and circularity	
LEVEL	**Advanced**
KNOWLEDGE	– Advanced knowledge and critical understanding of the theory, principles and applicability of: Sustainability - economic, climate change, critical raw materials, supply chain resilience/reshoring, government policy and standards – Tools for sustainability assessment – Life Cycle Assessment (LCA) – Impact of metal AM process chains on sustainability – Circularity, repair and recycling in metal AM concepts
SKILLS	– Identify the different ways in which sustainability effects our lives – Compare sustainable tools considering their advantages and limitations in Metal AM production Explain the impact of metal AM process chains on sustainability – Evaluate the metal AM process chain to optimize the sustainability process in each segment

Polymer AM sustainability and circularity	RECOMENDED CONTACT HOURS
SUBJECT TITLE	
Overview of polymer AM process chains and their impact on sustainability	0.5
Impact of AM feed-stock on sustainability	1.0
Impact of part design and material selection	1.0
Impact of AM process selection and build set-up on sustainability	1.0
Impact of Part post processing on sustainability	0.5
Impact of Polymer AM facility design and operation	0.5
Repair, reuse & recycling approaches in polymer AM	0.5
Measuring, predicting, and justifying sustainability	1.5
Recap on all topics covered	0.5
Total	7
WORKLOAD	14

LEARNING OUTCOMES – Polymer AM sustainability and circularity	
LEVEL	**Advanced**
KNOWLEDGE	– Advanced knowledge and critical understanding of the theory, principles and applicability of: Sustainability - economic, climate change, critical raw materials, supply chain resilience/reshoring, government policy and standards – Tools for sustainability assessment – Life Cycle Assessment (LCA) – Impact of polymer AM process chains on sustainability – Circularity, repair and recycling in polymer AM concepts
SKILLS	– Identify the different ways in which sustainability effects our lives – Explain the impact of polymer AM process chains on sustainability – Evaluate the polymers AM process chain to optimize the sustainability process in each segment

During the **focus group** were presented new developed competence units in the scope of SAM project "Sustainability for Additive Manufacturing", "Metal AM Sustainability and Circularity" and "Polymer AM sustainability and circularity". The first one aiming at raising awareness on the importance of sustainability applied to AM, with transversal scope has the following skills addressed:

- ✓ Spot ideas and opportunities for alternative, more sustainable and simple solutions for daily AM activities.
- ✓ Name advantages and disadvantages of AM sustainability topics.
- ✓ Identify cases and/or examples for which AM may lead to more sustainable products.
- ✓ Take the initiative to make suggestions for more sustainable choices along the AM product life cycle.

Participants agreed on the importance of include these competence units about sustainability in AM training courses empowering workers with green skills.

When asked how the industry and training providers can joint efforts to ensure the preparation of the workers and students for the GREEN transition from the given actions the priorities given by participants were as follows:

1. **Collaborative research projects** between educational institutions and industry can address real-world challenges.
2. Industry experts can actively participate in the development of educational curricula.
3. Industry can offer **internships, apprenticeships**, or cooperative education programs.
4. Industry professionals can be invited to give guest lectures, workshops, or presentations within educational programs.
5. Establish feedback mechanisms that allow industry partners to provide ongoing input on the relevance and effectiveness of educational programs.

However, it should be noted that this ranking can change in relation to the education system, whether we are talking about students of higher education or VET. **Collaborative research projects are more adequately for HE** and for **VET the most adequately is internships and apprenticeships**.

Integration of sustainability across disciplines was the most valuable area voted by participants as the topic need to be improved in training programs, the second valuable areas was **Measuring and assessing environmental impact** and **Waste management**, in relation to legislation and adaptation to rapid technologies changes that were not pointed as so important. It was consensual point in the discussion that to accelerate the GREEN transition we should start by **improving GREEN skills** of **managers, and heads of education and training centres** as a top-down approach focusing both awareness and motivation and technical trainings for the GREEN transitions. **Blended apprenticeship on-site and in-class, followed by on-the-job training,** was the training format recommended to ensure a timely preparation of the industry.

4.5 Additive manufacture sector results and conclusions

Additive Manufacturing technologies as a new approach to industrial manufacturing. are increasing throughout Europe, mainly in the aerospace, automotive and medical sectors. Since the 1989 when it was first used in Germany, in Europe, technology, materials and applications has evolved and led to new occupation definition and skills until nowadays.

The selection of **AM Process Engineer** and **AM Designer** as the profiles more relevant for the green transition was based on their prominence in the market and the nature of their responsibilities and job characteristics, all which enable them to have a substantial impact on the green transition. Specifically, they can make environmentally conscious choices by selecting greener processes and materials. These two occupations are from the International Additive Manufacturing Qualifications Systems (IAMQS) managed by EWF and was created to ensure that companies and professionals are equipped with the right set of skills to effectively implement AM/ 3D printing at the industrial level.

Upon analysis of the skills identified within the ESCO framework, it becomes evident that only two competencies, namely "Ensure compliance with environmental legislation" and "Waste management," are explicitly categorized as GREEN. These two competencies fall within the AM Operator profile. Conversely, the remaining skills we have classified as GREEN possess characteristics that make them amenable to being addressed from a green perspective.

In the AM Focus Group discussion, it became evident that AM technology serves as a versatile tool with applications across diverse economic sectors, such as defence, energy, and transport, to advance sustainability. The significance of the value chain varies based on several factors, including usage, industry/economic sector, and the design and modelling of AM technology, which encompass material selection and manufacturing process.

For instance, the sustainability of AM can vary based on the interplay of processes and materials, from commonly used metals and polymers for green transition to potential future materials like glass and concrete. Notably, Designers, responsible for material selection, manufacturing processes, and product design, and Engineers, who assess material suitability and devise solutions for environmental sustainability, play pivotal roles in the green transition.

The AM experts reached a consensus on the importance of **integrating environmentally friendly practices, including green thinking, critical thinking**, and **creativity**, when designing training programs. Consequently, new competence units within the SAM project—Metal AM Sustainability and Circularity and Polymer AM Sustainability and Circularity—were introduced to enhance workers' skills for a greener future, and these units should be integrated into AM training courses.

Also, this report presented 3 new competence units that were design in the scope of the blueprint SAM, which need arise from surveys with workers and companies who identify the main green skills that should be addressed.

5. The automotive sector

The Automotive Industry is a broad range of companies and organizations involved in the design, development, manufacturing, marketing, and selling of motor vehicles. It is one largest economic sector in terms of revenue. Software and Hardware engineers in the automotive sector work for automotive manufacturers (OEMs) as well as for the supplier industry of automobile and rail manufacturers, producers in shipbuilding, and the aerospace industry.

The automotive industry is the most substantial mass-market, hence they must achieve special requirements, and extensive sales targets. Suppliers in this industry are often spin-offs to companies that have been on the market for some time.

Which is one of the trends of the past decade?
In other cases, they form independent departments in the corporations of the automotive industry, in shipyards, or at railway manufacturers. There are also networks of automotive companies that benefit from the resulting synergies. The automobile manufacturers offer undoubtedly the largest field of activity for applicants in the automotive industry. It is one of the essential industries in the world as the supply of jobs is stable; the contribution to industrial added value is enormous.

The innovative strength of the industry and its suppliers is equally high. The new challenges of the 21st century include CO2 reduction and alternative drive concepts such as hybrid or electric drives. Changing conditions on the global markets also ensure permanent innovation requirements and impulses. Developments that have been underway for some times are also continuing, for example, electronization in all vehicle areas, lightweight construction, and the integration of vehicles in communication systems. And traffic control, i.e., the principle of “always connected.”

<u>Software development in the automotive sector</u>

In the case of alternative drives, even industry experts have so far not been able to identify the dominant development direction. This forces manufacturers to have offers available in all areas. The expenditure on new research is accordingly high. The technologically sophisticated products – a car consists of 12,000 and more individual parts – are, in turn, manufactured in extremely complex processes. Hardware and software engineers in the automotive industry are required accordingly. With their know-how, they make a decisive contribution to the market position of the suppliers.

The two most important and recent developments in the automotive sector are the increasing integration of software-based functions and about the entire vehicle – in electromobility. The key to the latter is in the automotive industry. Because the electric motors have been around for a long time.

The batteries and the provision of the necessary infrastructure are among the most critical problem areas in which hardware and software engineers in the automotive industry are in demand. In addition to the development of solutions and know-how. They also manage linking research and practice, because the complex research questions arise in the preparation of industrial production. [1]

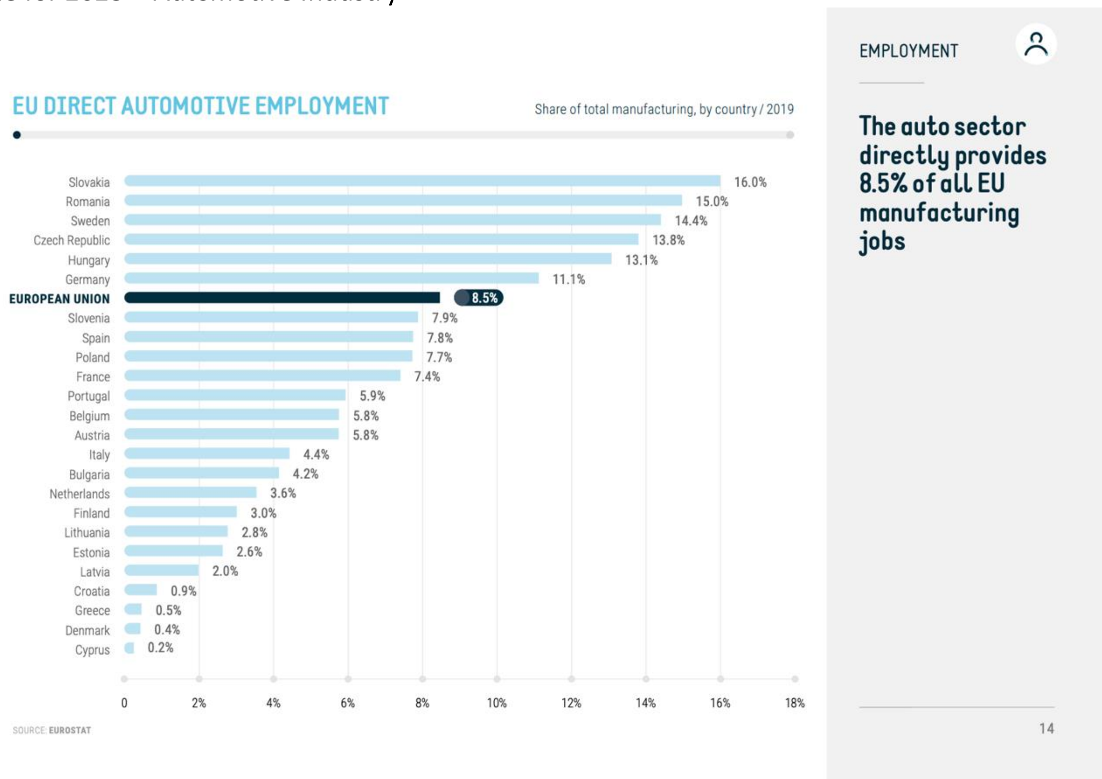
5.1 Sector general overview

The European automotive sector is undergoing a green transition with stricter Euro 6d emission standards. There's a growing emphasis on electric vehicle (EV) development, supported by incentives and subsidies for purchases. The EU is investing in expanding EV charging infrastructure.

Heavy R&D investment focuses on battery technology, lightweight materials, and energy efficiency. Increased collaboration and partnerships aim to drive innovation in EVs and autonomous vehicles. There's a notable emphasis on a circular economy, promoting sustainable manufacturing and recycling.

Some exploration into hydrogen fuel cell technology is happening, particularly for heavy-duty vehicles. Regulatory pressure from the EU is urging compliance with emission standards. This shift has implications for employment, demanding workforce adaptation. The employment rate varies across countries and their dependence on the sector. Below are two graphical analyses to examine the rates and averages for EU countries.

ACEA Pocket Guide for 2023 – Automotive Industry



[1] computertechreviews.com

EMPLOYMENT

EU automotive employment increased by 14% over five years

EMPLOYMENT IN THE EU AUTOMOTIVE SECTOR 2015 – 2019

EU automotive employment	2015	2016	2017	2018	2019	% change 19/18
Direct manufacturing	2,282,219	2,325,011	2,440,720	2,571,359	2,555,502	-0.6
Indirect manufacturing	829,749	823,201	878,774	908,747	919,829	+1.2
Automobile use	3,668,769	3,789,494	3,888,807	3,947,518	4,040,957	+2.4
Transport	3,715,235	4,136,627	4,341,044	4,483,090	4,535,599	+1.2
Construction	610,684	578,368	633,423	665,863	660,240	-0.8
TOTAL	**11,106,656**	**11,652,701**	**12,182,768**	**12,576,577**	**12,712,127**	**+1.1**

Source: ACEA[2]

5.2 Key occupations for the Green transition

Four occupations were selected, due to their relevance for the green transition:

- E-Powertrain Engineers are instrumental in the green transition by designing and optimizing e-powertrains for reduced emissions, improved energy efficiency, and the integration of renewable energy sources. Their work supports the development of sustainable mobility solutions, helps meet regulatory standards, and promotes innovation in the automotive industry. **(project-ecepe.eu)**

- Sustainability Managers provide strategic guidance, drive change within organizations, ensure regulatory compliance, enhance reputation and stakeholder engagement, identify cost-saving opportunities, and foster innovation. Their expertise and leadership are vital in shaping a sustainable future for businesses and the planet.

- Innovation Manager is important for the green transition because they drive sustainable solutions, identify market opportunities, foster collaboration and partnerships, overcome barriers and risks, and promote continuous improvement. Their role is crucial in helping organizations navigate the complexities of the green transition and embrace sustainable practices to achieve environmental and economic success.

- Life Cycle Assessment Manager's expertise and assessment capabilities contribute to the green transition by driving sustainable decision-making, promoting innovation, and supporting the adoption of environmentally friendly practices throughout the entire life cycle of products and systems.

[2] https://www.acea.auto/figure/manufacturing-jobs-in-eu-automotive-sector/

[3]Source DRIVES project

[3] https://www.project-drives.eu/en/driveslearningplatform

5.3 Skills for the Green transition in the key occupations

E-Powertrain Engineer

Engineer with the competence of automotive systems and product lifecycle management, as well as system engineering, propulsion systems, energy storage systems.

E-Powertrain Engineer	Green	Brown	White
Expert level			
• Product Lifecycle Management	x		
• transmission technology			x
• Life Cycle Management	x		
Practitioner level			
• product life-cycle			x
• Function Based Development			x
• Functional Safety			x
• power electronics			x
• Motor Control Unit			x
• hybrid control systems	x		
• Battery Management Systems	x		
Awareness level			
• Homologation			x
• Embedded Automotive Systems			x
• Electric Powertrain	x		
• cyber security			x
• electric motors			x
• Energy Transformation Systems	x		
• Electrical Energy Storage	x		
• Battery Systems	x		
• Fuel Cells	x		

Source[4]

Sustainability Manager

A Sustainability Manager (SUMAN) works on developing and implementing a sustainability strategy for the company.

Sustainability Manager	Green	Brown	White
Practitioner level			

[4] https://skills-framework.eu/job-role- ?id=dkFlQ2dLdDNyb1ZidVhnYzlqTkhOQT09

• Sustainability Management	x		
• strategic planning			x
• Chemistry			x
• Air and Water Pollution	x		
• probability theory			x
• Statistics			x
• Distributions			x
• Integration and Testing			x
• Sustainability in Design Process	x		
• Problem Definition			x
Awareness level			
• Environment and Society	x		
• materials science			x
• energy management	x		
• waste management	x		
• textile materials			x
• leather technology			x
• Calculus			x
• analyse environmental data	x		
• Metal and Aluminium Recycling			x
• Paper Recycling	x		
• Plastic Recycling	x		
• Electronics Recycling	x		
• Textile Recycling	x		
• Leather Recycling	x		
• Life Cycle Management	x		
• assessment processes			x
• arrange audit			x
• Measurements			x
• Sustainable Design	x		
• design process			x

Source[5]

Innovation Manager
ECQA Certified Innovation Agent - Organisation Innovation

Companies nowadays need to be able to quickly adapt to future needs dynamically. This requires

[5] https://skills-framework.eu/job-role- ?id=ZGNDYUdTY3c5RG9jL3pGUEhDQ0dUUT09

innovation at different levels such as to set up a continuously updating and dynamically learning organisation, empowering staff to continuously develop new ideas and products and services, and recently the open innovation concept of using the cloud and networking to build thematic and knowledge driven new partnerships, alliances and value chains.

The innovation agent knows tools and methods to empower employees and managers to implement innovation at these three levels in an organisation and can act as a catalyst for the organisation to adapt to the new market needs and global trends. The Innovation Agent helps to develop new business scenarios for leading European industry in the areas outlined by DRIVES to hep to adapt industry for the main drivers of change in the DRIVES study. This includes innovation and business scenarios for the use of: (1) Connected and automated driving (CAD) and advanced driver assistance systems (ADAS) (2) Alternative power trains (3) Electrification (4) Advanced manufacturing, digitalisation, and robotisation of the manufacturing process (5) Handling of/access to vehicle data (6) 3D printing (7) New communications technologies (8) New/advanced materials Also the Innovation Agent helps to realise strategy initiatives at European level like Gear 2030 and ALBATTS.

The Gear 2030 initiative includes the European Automotive manufacturer association, the European Automotive supplier association, key players in Automotive education to develop the skills needed for future dependent vehicles in a complex eco system and environment. Gear 2030 proposes a very wide scope of qualifications including the whole life cycle of vehicle design and production. Gear 2030 formed a so-called Skills council providing guidance to the European Commission and the European automobile manufacturer association (ACEA). The Gear 2030 skills council report to the European Commission and the ACEA mentions key job roles of the future based on a high-level European commission viewpoint level. ALBATTS is a new EU blueprint project where Northvolt as a strategy to create Europe's battery production chain and research (VW, BMW are co-investing with EU) and developed a set of new innovative drivers and job roles that need to be supported in future.

Innovation Manager	**Green**	**Brown**	**White**
Expert level			
• Dynamic Learning Cycles Design			x
• Core Competence Analysis and First Architecture			x
• Innovation Process Design Including Ideation			x
• teamwork principles	x		
• leadership principles			x
• Leading Innovation Projects and Initiatives			x
Awareness level			
• Innovation Vision 2030	x		
• Drivers of Change Analysis			x
• innovation processes			x

Source[6]

Lifecycle Assessment Manager (Product Manager under ESCO)

[6] https://skills-framework.eu/job-role- ?id=MTZPVlNIWXdaMXVnUzUzWGJJbi9EUT09

The Lifecycle Assessment (LCA) Manager, is responsible for evaluating the environmental impact of a product across its entire lifecycle, focusing on aspects such as raw material extraction, production, distribution, and disposal. Their goal is to minimize the product's carbon footprint and ensure compliance with environmental regulations.

On the other hand, the Product Manager oversees the overall development, marketing, and performance of a product, working to meet customer needs, maximize revenue, and maintain competitiveness. These roles converge in areas such as sustainability integration, where LCA findings influence product development decisions made by the Product Manager.

Collaboration extends to data collection and analysis, regulatory compliance, and communicating the environmental performance of products. By working together, the LCA Manager and Product Manager contribute to create environmentally friendly and competitive products aligned with market expectations and regulatory standards.

Product Manager in ESCO database was found as a closest in terms of skills and competencies for missing specific data about LCA. To further expand the close relationship between the two occupations here is a list of key skills and competences:

Essential Skills and Competences

- analyse consumer buying trends
- analyse economic trends
- analyse market financial trends
- combine business technology with user experience
- define technology strategy
- design customer experiences
- develop business plans
- develop communications strategies
- develop new products
- develop product design
- develop promotional tools
- draw conclusions from market research results
- execute marketing plan
- identify market niches
- manage product testing
- manage the customer experience
- oversee quality control
- perform market research

- persuade clients with alternatives plan
- product management
- prepare market research reports

5.4 Skills supply for the Green transition

The focus group discussion centred on enhancing the skills supply for the green transition, particularly in the automotive and battery sector.

The discussion on the automotive sector revolved around refining definitions related to motor vehicle manufacturing. Recommendations were made to update old definitions, particularly in line with NACE definitions, to accurately reflect the current industry landscape. It was emphasized that motor vehicles are primarily found on public roads, but specialized equipment and vehicle types require distinct regulations and standards.

The transition towards sustainable practices emerged as a prominent trend, warranting a comprehensive evaluation of the entire ecosystem. The MTA (Mobility Transport and Automotive) ecosystem was highlighted as one of the 14 distinct industrial ecosystems, necessitating precise definitions that go beyond vehicle assembly.

Attention was drawn to NICE100, encompassing electric powertrains and other pertinent definitions. However, there was a notable absence of specifications for plug-in hybrid vehicles, particularly in the context of heavier vehicles, as well as hydrogen-powered vehicles. Clarity was sought in distinguishing between road, off-road, and powertrain vehicles, with an emphasis on utilizing EU definitions as a baseline.

The imperative for advancing recycling and re-use practices within the automotive global value chain was underscored. The concept of a circular economy, as intricately detailed by the European Commission, should also be integrated into discussions.

Crucially, the project should spotlight the most influential job roles and skills crucial to the industry's green transition. A more relevant statistic, such as vehicle production per employer, was suggested to gauge the industry's productivity accurately.

The need for additional skills was identified in several occupations within the automotive sector, including:

- Production Manager: To oversee and optimize manufacturing processes and output.
- Training Manager: To develop and implement training programs to upskill the workforce.
- Quality Manager: To maintain and enhance product quality and standards.
- Design and Development of Battery: Focusing on innovation and improvement in battery technology.
- Logistics and Supply Chain: Managing the flow of materials and components crucial for the

manufacturing process.
- Machine Operator: Operating machinery and equipment in the production process.

Focusing on these skills areas and aligning them with the green transition, the automotive sector can better adapt to the changing landscape of sustainable transportation and environmental responsibility. Furthermore, the related trainings for automotive were discussed in parallel with the transition towards electromobility and therefore main findings in trainings are in section 6.4. below.

In conclusion and furthermore within the research of the skills in accordance to ESCO, were identified the following occupations as relevant :

- SUSTAINABILITY MANAGER
- RECYCLING SPECIALIST
- POWERTRAIN ENGINEER
- LEAN MANAGER

Although the identified job roles seem to differentiate from the selected key occupations the point was to find and highlight green skills from the ESCO database. The electrification of the automotive sector is rapidly expanding, and many key occupations are gradually increasing its value after some period of time. Therefore, it will be upon the database's progress to find and expand its knowledge through a more current analysis of the job market. Based on our validation and research throughout the database we found as a most suitable results to choose the roles above.

As it could be foreseen the skills were carefully adjusted and selected in best relevance with ESCO green skills labelling (although brown skills were not identified at all). Supporting suggested skills expands tables below expressing specific skill/competences and knowledge diversification:

SUSTAINABILITY MANAGER SKILLS	**Green Skill**	**White Skill**
SKILL/COMPETENCE		
advise on corporate social responsibility	X	
advise on sustainability solutions	X	
advise on sustainable management policies	X	
analyse business requirements		X
analyse supply chain strategies		X
assess environmental impact	X	
assess the life cycle of resources	X	
carry out training in environmental matters	X	
conduct qualitative research		X
conduct quantitative research		X
coordinate environmental efforts	X	
ensure compliance with environmental legislation	X	
evaluate company needs		X

forecast organisational risks		X
lead the sustainability reporting process		X
manage environmental management system	X	
manage recycling program budget	X	
measure company's sustainability performance	X	
mitigate waste of resources	X	
monitor social impact		X
perform risk analysis		X
promote environmental awareness	X	
use sustainable materials and components	X	
KNOWLEDGE		
environmental policy	X	
circular economy	X	
climate change impact	X	
corporate social responsibility	X	
emission standards	X	
energy efficiency	X	
environmental legislation	X	
environmental management monitors	X	
global standards for sustainability reporting	X	
green computing	X	
hazardous waste types	X	
risk management		X
sustainable finance	X	
waste management	X	

RECYCLING SPECIALIST	**Green Skill**	**White Skill**
SKILL/COMPETENCE		
ensure compliance with environmental legislation	X	
advise on waste management procedures	X	
analyse environmental data	X	
arrange equipment repairs		X
build business relationships		X
carry out environmental audits	X	
conduct research on food waste prevention	X	
coordinate shipments of recycling materials	X	
design indicators for food waste reduction	X	
develop food waste reduction strategies	X	

develop recycling programs	X	
educate on recycling regulations	X	
ensure compliance with waste legislative regulations		X
ensure equipment availability		X
follow procedures to control substances hazardous to health	X	
follow recycling collection schedules	X	
identify new recycling opportunities	X	
inspect recycling procedures	X	
maintain recycling records	X	
manage contracts		X
manage health and safety standards		X
manage recycling program budget	X	
monitor legislation developments		X
obtain relevant licenses		X
operate recycling processing equipment	X	
oversee quality control		X
promote environmental awareness	X	
recruit employees		X
research recycling grant opportunities	X	
train staff on recycling programs	X	
train staff to reduce food waste	X	
update licenses		X
use different communication channels		X
KNOWLEDGE		
circular economy	X	
environmental legislation	X	
hazardous waste storage	X	
waste management	X	

POWERTRAIN ENGINEER	**Green Skill**	**White Skill**
SKILL/COMPETENCE		
adjust engineering designs		X
anticipate change in car technology		X
apply health and safety standards		X
approve engineering design		X
assess financial viability		X
assess powertrain		X
automotive engineering		X

collaborate with designers		X
compare alternative vehicles	X	
conduct performance tests		X
define technical requirements		X
describe electric drive system	X	
design electromechanical systems		X
design hybrid operating strategies	X	
evaluate vehicle ecological footprint	X	
manage engineering project		X
monitor technology trends		X
perform scientific research		X
use CAD software		X
use CAE software		X
use technical drawing software		X
KNOWLEDGE		
energy saving potential of automated shift systems	X	
battery components		X
biodiesel	X	
electric motors	X	
emission standards	X	
energy efficiency	X	
energy storage systems	X	
engineering principles		X
fuel cell types	X	
hybrid control systems		X
hybrid model		X
hybrid vehicle architecture	X	
mechanical components of vehicles		X
mechanical engineering		X
mechanical systems		X
types of fuels		X
vehicle electrical systems		X

LEAN MANAGER	**Green Skill**	**White Skill**
SKILL/COMPETENCES		
act reliably		X
adjust priorities		X
advise on efficiency improvements		X

analyse business processes		X
analyse internal factors of companies		X
analyse production processes for improvement		X
apply change management		X
assess quality of services		X
consult information sources		X
define organisational standards		X
develop corporate training programmes		X
encourage teams for continuous improvement		X
hire human resources		X
identify improvement actions		X
identify necessary human resources		X
identify process improvements		X
lead process optimisation		X
liaise with managers		X
manage a team		X
manage corrective actions		X
manage medium term objectives		X
manage personal professional development		X
manage production changeovers		X
manage resources		X
motivate employees		X
perform data analysis		X
report on overall management of a business		X
revise quality control systems documentation		X
set quality assurance objectives		X
schedule production		X
use methods of logistical data analysis		X
KNOWLEDGE		
5S methodology		X
accounting		X
Agile project management		X
continuous improvement philosophies		X
hoshin kanri strategic planning		X
leadership principles		X
lean manufacturing	X	
logistics		X
mass customisation		X
production processes		X

project management		X
root cause analysis		X
six sigma methods		X
SMED		X
supply chain management		X
teamwork principles		X

In conclusion, the identification above and integration of green skills within the domains of sustainability management, recycling specialization, powertrain engineering, and lean management is crucial for fostering sustainable practices and contributing to a more environmentally responsible future. The ESCO labelling framework serves as a valuable tool in this context, providing a standardized and comprehensive way to recognize and assess the proficiency of professionals in these fields.

- **Sustainability managers** play a pivotal role in aligning organizational strategies with environmental goals, utilizing their green skills to drive sustainable practices across various sectors. The ESCO labelling enhances the transparency and credibility of their expertise, ensuring that their contributions are recognized and valued within the broader context of sustainable development.

- **Recycling specialists**, equipped with green skills, are essential in managing and optimizing waste streams, promoting the circular economy. The ESCO labelling further validates their proficiency, enabling them to effectively contribute to resource conservation and waste reduction, essential components of sustainable resource management.

- **Powertrain engineers**, with their focus on developing eco-friendly and energy-efficient propulsion systems, are instrumental in advancing sustainable transportation. The ESCO label attests to their green skills, affirming their capacity to innovate and implement environmentally conscious solutions that contribute to reduced carbon footprints and enhanced energy efficiency.

- **Lean managers**, armed with green skills, contribute to resource optimization and waste reduction within organizations. The ESCO labelling system recognizes their ability to implement lean principles that align with sustainability objectives, fostering a culture of continuous improvement and efficiency while minimizing environmental impact.

In sum with findings above, the ESCO labelling framework not only acknowledges the importance of green skills within these critical professions but also provides a standardized means to communicate and assess the impact of these skills on sustainability outcomes. As we move towards a more environmentally conscious global paradigm, especially in the automotive sector with rapid ongoing changes, the integration of green skills, coupled with ESCO labelling, is crucial in ensuring a harmonious balance between economic development and environmental stewardship.

5.5 Automotive sector results and conclusions

The Automotive Industry is a broad range of companies and organizations involved in the design, development, manufacturing, marketing, and selling of motor vehicles. It is one largest economic sector in terms of revenue.

As part of the Mobility industrial ecosystem, the automotive industry is undergoing one of the most transformational social, technological and economic shifts of a generation, shaped by three key disruptive forces:

- electric vehicles and alternative powertrains,
- connected and autonomous vehicles and
- on-demand mobility services.

In this context, a twin transition approach can make a positive impact by 'greening' technology, data assets and infrastructures while accelerating sustainability across the organization.

The following occupational profiles have been initially identified as those capable to promote a greater impact in this twin transition:

Powertrain Engineers
Sustainability Managers
Innovation Manager
Life Cycle Assessment Manager's

By focusing on these skill areas and aligning them with the green transition, the automotive sector can better adapt to the changing landscape of sustainable transportation and environmental responsibility.

In conclusion, the focus on refining definitions, embracing sustainability, and recognizing the pivotal roles and skills in the automotive sector will be instrumental in driving the industry towards a more environmentally conscious and economically viable future.

It was also noted that individuals on manufacturing lines primarily execute established processes without requiring new skills, such as inserting batteries into vehicles. Instead, the emphasis should shift towards combining battery research and development with recycling efforts and cultivating expertise in battery design.

In conclusion to findings in green skills, the identification and integration of green skills across sustainability management, recycling specialization, powertrain engineering, and lean management are steering towards a more environmentally responsible future. The outlined roles of professionals in these domains, including sustainability managers, recycling specialists, powertrain engineers, and lean managers, underscore the significance of their expertise in driving positive environmental change.

The incorporation of the ESCO labelling framework emerges as a pivotal tool in this landscape, offering a standardized and comprehensive approach to recognizing and assessing the proficiency of individuals in these critical fields. For sustainability managers, the ESCO label not only enhances the transparency and credibility of their skills but also ensures that their contributions are duly acknowledged and valued within the broader context of sustainable development. Similarly, recycling specialists, powertrain engineers, and lean managers benefit from the validation provided by the ESCO label, reinforcing their capacity to contribute to resource conservation, waste reduction, and innovative, eco-friendly solutions in their respective domains.

In light of these findings, the ESCO labelling framework not only highlights the importance of green skills but also establishes a standardized means to communicate and evaluate their impact on sustainability outcomes. As the automotive sector undergoes rapid changes towards greater environmental consciousness, the integration of green skills, paired with the ESCO labelling system, stands as a crucial step in ensuring a harmonious balance between economic development and environmental stewardship. This concerted effort is essential as we collectively strive for a sustainable and responsible global paradigm in the face of ongoing transformations within the automotive industry.

6. The batteries sector

This section addresses - C – MANUFACTURING - 27 - Manufacture of electrical equipment - 27.2 - Manufacture of batteries and accumulators (NACE classification).

This class includes the manufacture of non-rechargeable and rechargeable batteries. This class includes: - manufacture of primary cells and primary batteries. Cells containing manganese dioxide, mercuric dioxide, silver oxide etc. - manufacture of electric accumulators, including parts thereof: separators, containers, covers - manufacture of lead acid batteries - manufacture of NiCad batteries - manufacture of NiMH batteries - manufacture of lithium batteries - manufacture of dry cell batteries - manufacture of wet cell batteries.

Batteries are emerging as a critical ingredient in the transition to a more sustainable future because of their role in electrifying transportation and balancing power grids. Battery use is more than an opportunity to eliminate vehicular CO2 and NO2 emissions in a world grappling with climate change; scaling up production of battery-cell manufacturing capacity also offers significant value-creation opportunities for manufacturers, creates new jobs that pay well, and supports national economic growth.[1]

The NACE – CPRS – IAM mapping

From the sustainability perspective there is a mapping from NACE codes of economic activities, into Climate Policy Relevant Sectors (CPRS) and into the variables of the process-based Integrated Assessment Models (IAM) used by the Network for Greening the Financial System (NGFS) to provide its climate scenarios.

Proposed mapping, is to support practitioners, financial supervisors, investors and academics in climate transition risk disclosure and climate transition risk assessment, providing a science-based, transparent and operational tool. [2] [3]

https://pure.iiasa.ac.at/id/eprint/18530/1/SSRN-id4223606.pdf
https://www.finexus.uzh.ch/en/projects/CPRS.html

Classification of the batteries in the EU

It is appropriate to distinguish between different categories of batteries in accordance with their design and use, **independently of their battery chemistry**. The classification into **portable batteries**, on the

[1] https://www.mckinsey.com/industries/electric-power-and-natural-gas/our-insights/capturing-the-battery-value-chain-opportunity
[2] https://pure.iiasa.ac.at/id/eprint/18530/1/SSRN-id4223606.pdf
[3] https://www.finexus.uzh.ch/en/projects/CPRS.html

one hand, and **industrial batteries** and **automotive batteries** on the other hand under Directive 2006/66/EC[4] should be further developed to better reflect new developments in the use of batteries.

Batteries that are used for traction in electric vehicles and which, under Directive 2006/66/EC, fall under the category of industrial batteries, constitute a large and growing part of the market due to the quick growth of electric road transport vehicles. It is therefore appropriate to classify those batteries that are used for traction in road vehicles as a new separate category of electric vehicle batteries.

Batteries used for traction in light means of transport, such as e-bikes and e-scooters, were not classified as a separate category of battery under Directive 2006/66/EC. However, such batteries constitute a significant part of the market due to their growing use in urban sustainable mobility. It is therefore appropriate to classify those batteries as a new separate category of batteries, namely light means of transport batteries (LMT batteries).

Batteries used for traction in other transport vehicles including rail, waterborne and aviation transport or off-road machinery, continue to fall under the category of industrial batteries under this Regulation.[5]

In order to simplify the types of the batteries we can divide them into the following categories based on the target markets.

• Commercial Markets
For lithium-ion batteries, commercial markets include commercial and passenger EVs, stationary storage, and aviation.

• Electric Vehicles Market
For EVs, the leading battery technology is expected to be lithium-based, which offer high energy, high power, and long lifetimes compared to other currently available battery systems. EVs are a critical driver of the demand for lithium-ion batteries and are the primary market focus when outlining the need for domestic lithium-ion battery manufacturing.

• Stationary Storage Market
With greater duration requirements and less stringent density and weight constraints, non-lithium storage technologies may emerge as the most cost-effective long-term solutions for stationary storage.

• Aviation Market
As with EVs, electric aircraft have the potential for emission- free air travel in future.
Lithium-ion batteries have been a significant part of aviation for the past decade. Applications have been used in systems such as avionics backup power supplies, emergency lighting, ELTs, powering auxiliary equipment (crew cabin phones, cabin doors), uninterrupted power systems (UPS), and engine

[4] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32006L0066#d1e488-1-1
[5] https://data.consilium.europa.eu/doc/document/PE-2-2023-INIT/en/pdf

start batteries for fighter jets and drones.

• Defence Markets

The Defence Department requires reliable, secure, and advanced energy storage technologies to support critical missions carried out by joint forces, contingency bases, and at military installations. Faced with increasing kinetic and non-kinetic threats, the Department is shifting toward more distributed, austere, and autonomous operational concepts carried out by platforms and installations with escalating power requirements.

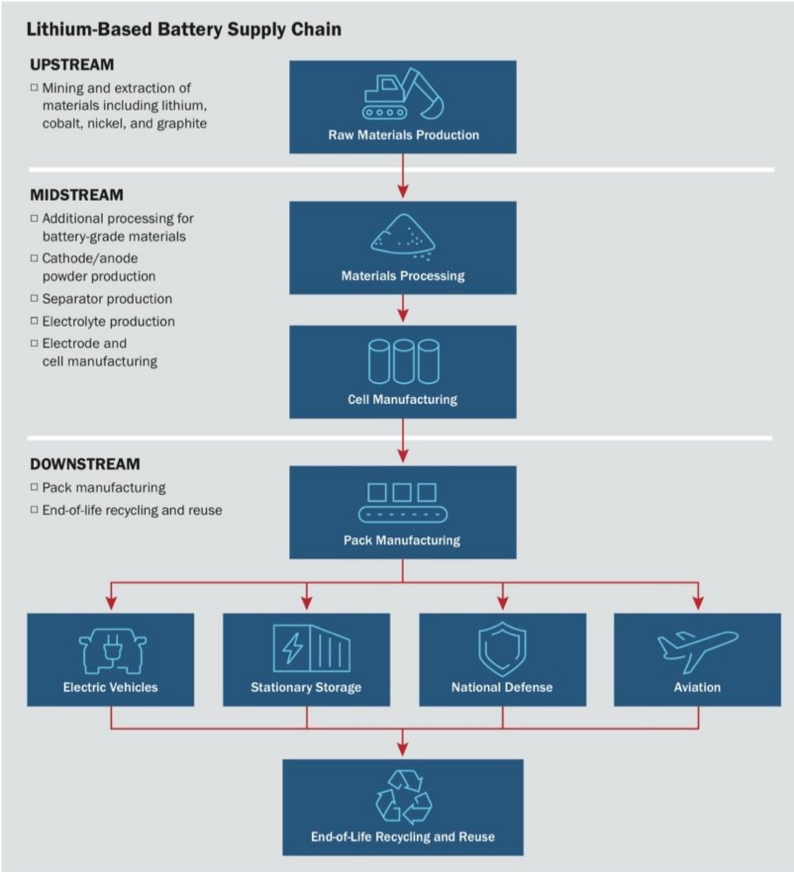
The battery value chain

The battery supply chain is composed of many actors who work to transform raw mineral building blocks into the sophisticated devices we use daily to power our electric vehicles, smartphones, and laptops. The mining industry is responsible for the upstream portion of battery supply chains including identifying and exploring mineral reserves and extracting ores – sediments mixed with valuable minerals – from these resources. These ores are then transported to a facility where they are processed to remove extraneous materials and refined to a quality suitable for batteries. Once refined, one manufacturer uses these materials to make cathodes and anodes – the “positive” and “negative” side of the battery respectively – and sends them to downstream facilities that makes battery cells. Finally, the battery cells are sent to yet another manufacturing facility where they are combined into large packs that can then be used in electric vehicles. At the end of the downstream portion of this supply chain, batteries are hopefully reused or recycled so that their materials can be recovered and used in new batteries.[6]

With the spread of electric vehicles in recent years, the supply chain of Lithium-ion batteries (LIBs) has become a very important issue. The rapid rise in demand for electric vehicles also introduces some supply chain problems in LIBs. In this chapter, the current and future problems in LIB supply chain processes are addressed. It is seen that supply problems may arise with the increase in demand for materials such as cobalt and lithium, which are basically used in battery production. In this context, LIB recycling processes are very important.[7]

[6] https://www.nrdc.org/bio/jordan-brinn/electric-vehicle-battery-supply-chains-basics

[7] https://link.springer.com/referenceworkentry/10.1007/978-3-030-89822-9_114-1



Source[8]

Mining and extraction of materials (Upstream)

The activities of the stakeholders involved in the process of mining and processing of raw materials have an impact on the whole value chain since companies that are using batteries in their products consider this step as a reason for concern due to public scrutiny (environmental impacts, working conditions, political factors, etc.) and potential subsequent (negative) effects on the company's reputation. Not only are stakeholders active in mining, mineral refining, and upstream sector included, but also public organizations and authorities responsible for ecological and economical sustainability, and human rights.

Component production (Midstream):

This includes the manufacture of the anode, cathode, active materials, binder, electrolyte, and separator.

Concerning components and cell manufacturing, mass battery production in Europe is only starting to develop, as big battery players are progressively building and launching their battery production in Europe, the so-called gigafactories. Many of these manufacturers come from Asia, but other players,

[8] https://www.energy.gov/sites/default/files/2021-06/FCAB%20National%20Blueprint%20Lithium%20Batteries%200621_0.pdf

such as Tesla or emerging European companies come into play. Some of them focus on "niche markets" and adapt batteries to sometimes very specific customer needs.

Cell production (Midstream):
This stage involves the production and assembly of single cells. The cell in the battery contains electrodes (anode and cathode), separator and electrolyte. All of these are inserted into a rectangular aluminium case to form a battery cell. It is the basic unit of a battery that exerts energy by charging and discharging.

Module production (Downstream):
The produced cells are then configured into larger modules that involve electronic management. A battery assembly put into a frame by combining a fixed number of cells to protect the cells from external shocks, heat or vibration, forms a battery module.

Pack assembly (Downstream):
The final shape of the battery system installed to an electric vehicle forms the battery pack. It is composed of modules and various control/ protection systems including a battery management system (BMS), a cooling system etc. E.g.: 8 modules (12 cells per module) go into one battery. Pack assembly includes installation of modules together with systems that manage power, charging and temperature.

In the case of the mobile applications/automotive industry, car manufacturers often opt for an in-house module and pack assembly trying to maximize the value they add to the vehicle. Modules and packs are critical to determining an EV's key performance indicator, such as range and charging speed. Control over the use of pack space and the battery optimal working temperature also has strong implications regarding the safety of the battery and the vehicle.

Vehicle integration (Downstream):
This involves the integration of the battery pack into the vehicle structure or other use cases. This will vary from vehicle to vehicle and from use case to another, it is based on the battery-vehicle, or renewable energy device interface determined by the type of connector, plugs, and mounts used. Stakeholders active in battery integration specialize in the production of battery embedded systems like battery management systems, battery thermal management systems, and other components that are associated with battery intelligence. Since this is a crucial part of the whole battery system, many companies that produce energy storage solutions want to manufacture their systems and components. The car manufacturers in Europe are also a good example of this trend. Many global players involved in this value chain come from Europe.

Usage, repair and maintenance
This includes the period in which the battery is used in the vehicle or another application.

Stakeholders in operation, repair, and maintenance of battery electric passenger cars include entities involved in type-approval of vehicles, standardization, vehicle manufacturing, and its supply chain, workers in dealerships, car repair shops, charging infrastructure providers, first responders, or relevant bodies of public institutions.

It also brings about opportunities to introduce brand new business concepts and services. Electrification of vessels creates new challenges to producers, owners, and operators of the vessels, including companies providing servicing and maintenance. Concerning stationary use, energy storage in the grid and off-grid applications have gained interest among various stakeholders from electric utility operators to policymakers. The telecom base stations form a large market that is accentuated by the 5G network deployment. The stakeholders range from telecom technology and base station equipment providers to regulators and beyond.

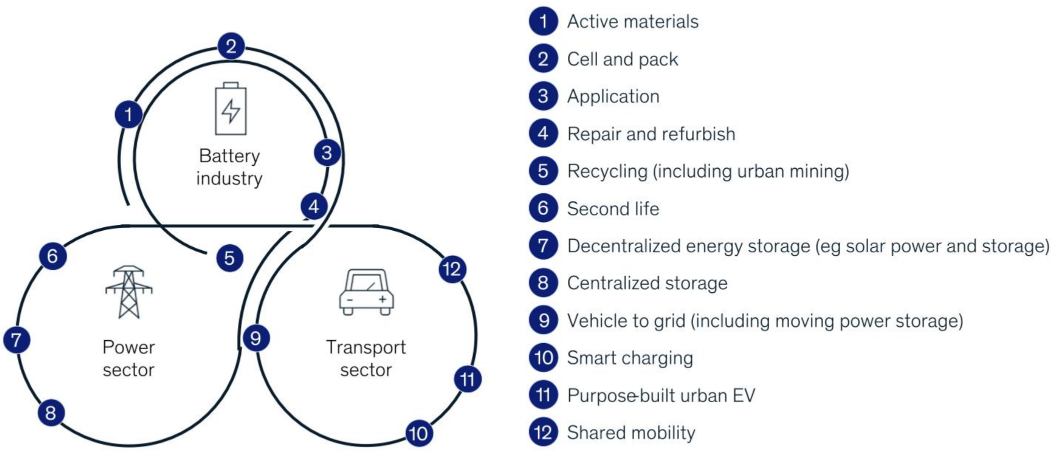
Reuse and Recycle:
Usually, the EV batteries degrade in the first five — six years, due to extreme operating temperature, charging/discharging rates etc. These reduced performance batteries can have a secondary life and be reused as energy-storage devices. Post which the batteries can be sent to the recycling units where they can be processed to extract valuable rare earth materials. It is also important to take into the consideration the design for recycling during the battery product development.

Circular value chain

The linear consumption model, under which products are made, consumed, and then thrown away, is reaching its limits. The excessive pressure this model puts on natural ecosystems, the pollution of air, land, and water bodies resulting from the production and disposal of products, the wide fluctuations in the prices of raw materials and the potential disruptions to their supply are only some of the reasons why it is essential for all of us to make the transition to a circular economy a reality.[9]

[9] https://www.gsb.stanford.edu/faculty-research/publications/road-toward-circular-value-chain

The battery value chain can transform from linear to circular.



Source: McKinsey Battery Insights, 2022

McKinsey & Company

Source[10]

Second life

Entities involved in the second life of batteries range from battery and vehicle manufacturers, through repair and maintenance shops and recycling companies to stationary/storage application operators, such as industrial plant operators, solar panel/wind farm developers, energy production and distribution companies, charging infrastructure operators or real estate owners and households. In the future, refurbished batteries could be also used immobile applications, for example, non-road mobile machinery or micro-mobility vehicles (scooters, e-bikes, etc.). As the second life of batteries is still in its infancy, there are huge opportunities for research and education institutions, standardization bodies, or different public bodies and authorities (providing incentives and altering the legislation). Strategic levers in battery manufacturing

Recycling

The stakeholders in battery recycling involve all steps of the battery value chain since it is important for the efficiency and sustainability of the battery ecosystem, and the circular economy. There is a need for increased battery recycling capacity in Europe and new business models as well. Therefore, apart from battery and vehicle producers, new players completely focused on recycling are coming to the market. They differ in the applied processes and the level of the reclaimed material, but their main goal is to maximize the recovery of critical battery material from Li-ion batteries in a sustainable, economically sound, and safe manner.

[10] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/battery-2030-resilient-sustainable-and-circular

Ecosystem approach and Strategic levers in battery manufacturing

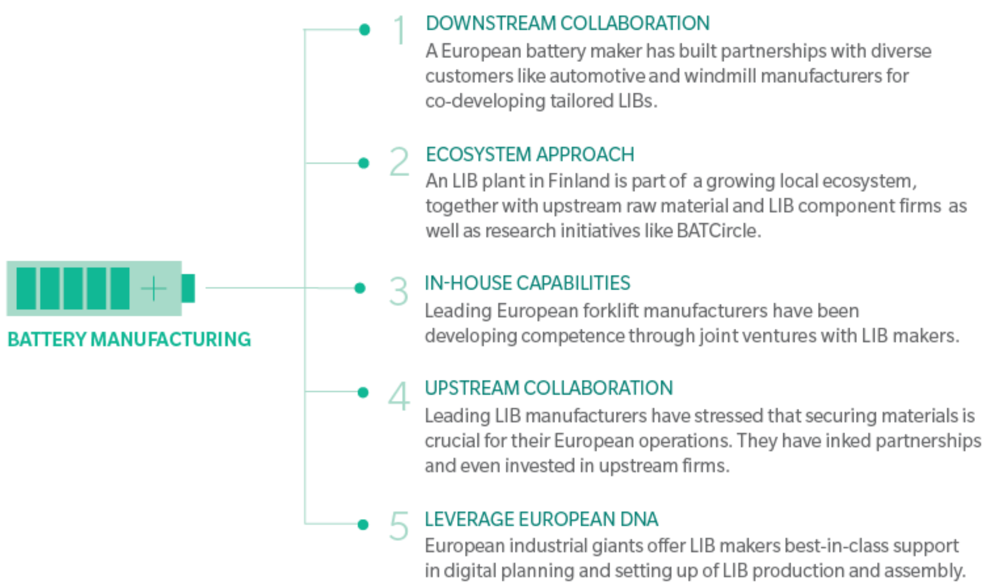
The term "battery ecosystem" refers to the interconnected network of technologies, industries, and processes related to the production, use, and disposal of batteries. This includes various aspects such as battery manufacturing, recycling, end-of-life solutions, and the broader impact on the environment and economy.

Education plays a significant role in the battery industry ecosystem, particularly in the context of developing skills and knowledge to support the growth and sustainability of the industry.

European firms face a challenging industry environment, with significant barriers. The landscape for lithium-ion battery manufacturing is dominated by Asian players.

Advanced LIBs are already under development to address the limitations of this generation. These require significant tacit knowledge in battery design, chemical and thermal properties, interaction processes, cell manufacturing, automation, and assembly. To achieve this, the following strategic levers should be followed.

The industry dynamics and technology development offer European firms the chance to secure future value creation. But in their pursuit, they must keep five important strategic levers in mind.



Source[11]

[11] https://www.oliverwyman.com/our-expertise/insights/2019/nov/perspectives-on-manufacturing-industries-vol-14/new-tech-new-strategies/battery-manufacturing-in-europe.html

In the quest to secure future value creation, European firms must consider five important strategic levers.

1. they should focus on identifying end applications and collaborating with customers to develop and commercialize the most suitable LIB technology while keeping costs low.
2. Secondly, they should proactively build ecosystems across value chains to tailor R&D efforts and stay updated on technology developments.
3. Thirdly, they need to develop in-house capabilities in LIB technologies, investing in talent and equipment for design, development, and production.
4. Fourthly, they should form upstream partnerships to manage investments and costs, ensuring access to necessary resources and mitigating supply-chain risk.
5. Finally, European firms should leverage their roots, brand value, industry relationships, and commitment to sustainability, which offer a potential for cost savings and innovation.

These strategic levers will enable European firms to navigate industry dynamics and technology development effectively.

6.1 Sector general overview

As per McKinsey report[12] global demand for Li-ion batteries is expected to soar over the next decade, with the number of GWh required increasing from about 700 GWh in 2022 to around 4.7 TWh by 2030. Batteries for mobility applications, such as electric vehicles (EVs), will account for the vast bulk of demand in 2030—about 4,300 GWh; an unsurprising trend seeing that mobility is growing rapidly. This is largely driven by three major drivers:

A regulatory shift toward sustainability, which includes new net-zero targets and guidelines, including Europe's "Fit for 55" program, the US Inflation Reduction Act, the 2035 ban of internal combustion engine (ICE) vehicles in the EU, and India's Faster Adoption and Manufacture of Hybrid and Electric Vehicles Scheme.
Greater customer adoption rates and increased consumer demand for greener technologies (up to 90 percent of total passenger car sales will involve EVs in selected countries by 2030).
Announcements by 13 of the top 15 OEMs to ban ICE vehicles and achieve new emission-reduction targets.

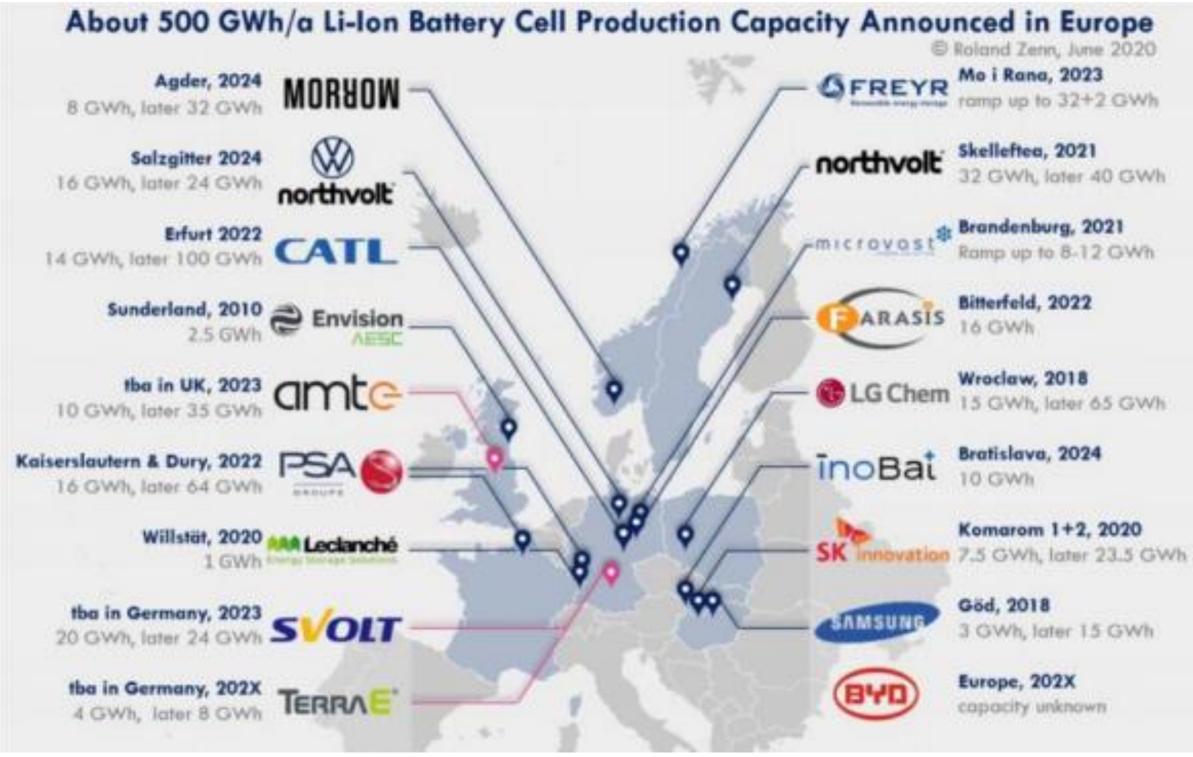
The production volume of Li-ion cells in Europe (EU-27, UK, Norway, and Serbia) accounted for around 35 GWh in 2020, or about 15% of global production capacities. As a result of ambitious development and expansion plans of the battery industry, the share of cells produced in Europe in global production volume is expected to increase to 28 up to 43% by 2030, when it will be around 600 to 870 GWh per

[12] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/battery-2030-resilient-sustainable-and-circular

year.[13]

A global shift away from fossil fuels is leading to a boom in lithium-ion battery applications, ranging from electric vehicles to energy storage systems. The market is projected to have a value of €250 billion in Europe by 2025. (Oliver Wyman report estimates the European market) To secure local value creation and jobs, there is now a concerted push to achieve European sovereignty in LIBs, including the European Battery Alliance to promote manufacturing, and research and innovation initiatives like "Horizon 2020" and "Battery 2030+". The institutions involved have announced multi-million euro grants to foster LIB ventures, secure resources, and build mega-factories.[14]

Major players



Source[15]

There is a global competition for talent and workforce needs to acquire new skills and continuously improve them to boost employability, take new jobs and fuel economic growth.

While the reconfiguration of global supply chains and investment in new technologies offer a great opportunity to re-shore manufacturing and strengthen industry 4.0 in Europe.

[13] https://www.ipcei-batteries.eu/fileadmin/Images/accompanying-research/market-updates/2022-01-BZF_Kurzinfo_Marktanalyse_Q4_ENG.pdf
[14] https://www.oliverwyman.com/our-expertise/insights/2019/nov/perspectives-on-manufacturing-industries-vol-14/new-tech-new-strategies/battery-manufacturing-in-europe.html
[15] https://www.orovel.net/insights/li-on-battery-gigafactories-in-europe-january-2021

However, increasing skills shortages, gaps and mismatches related to the green and digital transition will lead to bottlenecks.

The workforce needs sector specialized skills as well as transversal skills, combining domain-specific knowledge with problem-solving and interpersonal skills such as communication, creativity, readiness to learn or critical thinking, among others.

Enterprises have difficulties in finding employees with these skills and report that this is delaying their investments. Europe needs foresight and skills intelligence to anticipate and manage change, increase investment in training, nurture new types of work and strengthen social cohesion.[16]

6.2 Key occupations for the Green transition

Initial analysis

In 2030, almost every second car sold will be a battery electric vehicle (BEV). This will lead to a significant demand increase of global battery by 35%. Market growth is driven by both increased BEV sales and increasing battery size per BEV. In consequence, the demand for the most relevant active materials, especially lithium, nickel and graphite will grow steadily. We expect an increase from 400,000 up to 6,000,000 tons until 2030.[17]

Even though the lithium battery production is increasing due to CO2 regulations, the production itself it is not without environmental impact.

We have analysed several scientific studies and articles to identify the steps in the Lithium battery production value chain that have the greatest environmental impact. It was found that the employment positions with the greatest environmental impact within the value chain of lithium cell production are in three or 4 areas:

- mining and material extraction
- lithium cell production
- battery pack design
- recycling

Since the production of Lithium batteries is highly automated, the primary environmental impacts are concentrated in research and development roles. The choice of battery chemistry plays a crucial role in the environmental impact, as some chemistries involve the use of rare materials. The design and recycling of battery packs have a significant impact as well. The requirements of the battery chemistry affect the mining and material extraction processes, making their design an important step in mitigating environmental impact.

[16] https://single-market-economy.ec.europa.eu/industry/strategy/skills-industry_en
[17] https://www.strategyand.pwc.com/de/en/industries/energy-utilities/gigafactories-and-raw-materials.html

The process of cell production is energy and water intensive, making the design of the production facility crucial. Even upgrading existing production facilities can greatly improve environmental impact. Given the large quantities in which batteries are produced, the design of the battery pack, the materials used, and the technical parameters that influence battery life are all crucial factors from an environmental perspective. Designing batteries with recycling in mind is particularly important.

Lastly, recycling and finding second life applications for batteries are crucial steps in the value chain from an environmental impact standpoint.

We have analysed the job roles advertised by companies in the four areas of the value chain and matched them with the existing ESCO Drives job role classification. However, we discovered that the ESCO classification lacks sufficient detail, so we had to refer to multiple ESCO job descriptions to accurately describe each real job role.

It is important to note that all the positions we identified are in the research and development field and require a higher education qualification.

Key Selected Job Roles[18]

1. **Mining engineer**
   Collaborates and conducts with others geographical exploration by reviewing maps and drilling logs to determine location, size, accessibility, and estimated volumes of deposits. Works with aggregate production to develop methods to extract material,

2. **Manufacturing engineer - cell assembly**
   Mechanical development engineer creates, develops and scales- up manufacturing processes for battery cell manufacturing line.

3. **Battery System Engineer**
   A battery system engineer is responsible for designing, developing, and testing battery systems for various applications. They work with a team of engineers and scientists to create efficient, safe and cost-effective energy storage solutions for electric vehicles, consumer electronics, grid storage and other applications.

4. **Chemical process engineer**
   Develops and implements chemical process designs of lithium-ion battery recycling processes and primary resource extraction technologies.

[18] https://www.project-albatts.eu/en/skillscards

The occupation names in 6.2 are listed based on the occupation names used in real job advertisement by the real companies. In 6.3. we are mapping corresponding ESCO or Albatts classified jobs that are closest to the advertised occupations. Sometimes there are several corresponding job roles that correspond with the real one, therefore ESCO and Albatts names have been kept under their original names. The structure of the tables in 6.3. - each occupation starts with the real job name and skills followed by ESCO and/or Albatts classified job roles.

6.3 Skills for the Green transition in the key occupations

Occupation 1

Mining engineer - real company job description

This position will be responsible for monitoring aggregate production and planning, including surveying, developing extraction methods, managing capital projects, and assisting in labour/equipment planning.

Occupation 1*	**Mining Engineer**[19]
Value chain step	Mining and material extraction
Closest ESCO job role	**Mine planning engineer**[20]**, Environmental mining engineer**[21]

Mining engineer	**Short term for analysis**	**Green**	**Brown**	**White**
Key Responsibilities (Essential Duties and Functions):				
Working with management in facilitating surveys, plans and development around our aggregate production operations to maintain the Mine Planning Tracking Sheet.	Support the maintenance of the Mine Planning Tracking Sheet			x
Collaborates and conducts with others geographical exploration by reviewing maps and drilling logs to determine location, size, accessibility, and estimated volumes of deposits.	Conducts geographical exploration		x	
Works with aggregate production to develop methods to extract material, evaluating factors such as safety, operational costs, deposit characteristics and overburden depth.	develops methods to extract material		x	

[19]ttps://www.indeed.com/viewjob?jk=b3626a30ef2788d2&from=mobRdr&xpse=SoAY67I3IhaOkxw3sB0LbzkdCdPP&utm_source=%2Fm%2F&utm_medium=redir&utm_campaign=dt
[20] http://data.europa.eu/esco/occupation/7b99007f-c6bf-4703-85d3-f168bc6a9f28
[21] http://data.europa.eu/esco/occupation/32548f7e-8c25-4c49-9f22-78dee3543704

Assists in laying out and directing mine construction operations, such as location and development of ramps and positioning of mining area, access roads etc.	Assists mine construction operations		x	
Assists in drill and blast surveying and report development while working directly with drill and blast vendors to ensure they are operating efficiently.	Assists in drill and blast surveying		x	
Assists in analysing throughput costs, analysing plant flow, and determining cycle time opportunities in the load/haul fleet.	Assists in analysing throughput costs			x
Assists in analysing and determining labour requirements, equipment needs, and operational costs for annual budget preparation and reporting.	Assists in budget preparation and reporting			x
Assists in determining long-range planning designs and data to determine proof of financial justification.	Assists in financial justification			x
Will work with the team to ensure company compliance with mandated safety and environmental policies on all mining/material production practices.	ensure compliance with safety legislation	x		
	ensure compliance with environmental legislation	x		
Will work with company management and State and Federal agencies to ensure compliance with all applicable laws and regulations.	ensure compliance with legislation	x		
Ability to detect safety hazards and respond accordingly.	Prevents safety hazards	x		
Adhere to all state and federal regulations, if applicable, as set forth by the US Department of Transportation (DOT), Occupational Safety and Health Administration (OSHA), Mine Safety and Health Administration (MSHA), or any other regulatory agency.		x		
Additional Responsibilities:				
Display a professional and courteous attitude to co-workers, supervisors, and the general public at all times.	Display a professional and courteous attitude			x
Must be willing to travel and work away from home when required.	Work abroad		x	

Must be willing to work nights and weekends when necessary.	Work in nights and weekends			x
Report to the assigned job site in uniform and ready to begin work at the designated start time.	Report in time			x
Strict adherence to safety requirements and procedures as outlined in the Environmental, Health & Safety Manual.	adheres to safety procedures	x		
Strict adherence to Pike policies and procedures as outlined in the Employee Manual.	adheres to employee procedures			x
Willingness to work in a team environment and assist co-workers or supervisors with other duties as required.	work as a team			x
Qualifications:				
To perform this job successfully, an individual must be able to perform each essential duty satisfactorily.				x
Education/Experience				
Bachelor's and/or associate degree in Mine Engineering; or three to five years related experience or training; or equivalent combination of education and experience.				x
General Requirements				
Must possess a valid driver's license and dependable transportation to and from the job site.			x	
Knowledge/Skill Requirements				
Ability to complete necessary mathematical equations and have knowledge of basic algebra, plain geometry, and trigonometry.	mathematics			x
Must demonstrate the ability to use a computer to communicate effectively. This includes but is not limited to the use of Outlook, MS Office programs, construction software and web-based programs.	Communicate effectively			x
Ability to read and interpret documents such as plans, specifications, procedure, and company manuals.	interpret documents			x

Relevant ESCO classified job description

Mine planning engineer

Mine planning engineers design future mine layouts capable of achieving production and mine development objectives, taking into account the geological characteristics and structure of the mineral resource. They prepare production and development schedules and monitor progress against these.

Mine planning engineer	**Green**	**Brown**	**White**
Essential Skills and Competencies			
address problems critically			x
advise on mine equipment			x
generate reconciliation reports			x
interface with anti-mining lobbyists			x
maintain plans of a mining site			x
monitor mine production			
prepare technical reports			x
schedule mine production			x
supervise staff			x
use a computer			x
use mine planning software			x
Essential Knowledge			
impact of geological factors on mining operations			x
geology	x		
mining engineering			x
Optional Skills and Competences			
ensure compliance with safety legislation			x
evaluate mine development projects			x
assess operating cost			x
mine dump design	x		
monitor mine costs			x
use technical drawing software			x
Optional Knowledge			
mine safety legislation			x
minerals laws			x

Environmental mining engineer

Environmental mining engineers oversee the environmental performance of mining operations. They develop and implement environmental systems and strategies to minimize environmental impacts.

Environmental mining engineer	**Green**	**Brown**	**White**
Essential Skills and Competencies			
address problems critically			x

adjust engineering designs			x
approve engineering design			x
assess environmental impact	x		
communicate on minerals issues			x
communicate on the environmental impact of mining	x		
develop environmental policy	x		
ensure compliance with environmental legislation	x		
ensure compliance with safety legislation			x
maintain records of mining operations			x
manage environmental impact	x		
perform scientific research			x
prepare technical reports			x
supervise staff			x
troubleshoot			x
use a computer			x
use technical drawing software			x
Essential Knowledge			
engineering principles			x
mining, construction and civil engineering machinery products			x
chemistry			x
civil engineering			x
technical drawings			x
engineering processes			x
Optional Skills and Competences			
develop mine rehabilitation plan			x
negotiate with stakeholders			x
present reports			x
Optional Knowledge			
biology	x		
impact of meteorological phenomena on mining operations			x

Occupation 2

Occupation 2*	Manufacturing engineer - cell assembly[22]
Value chain step	Cell assembly
Closest ESCO job role	2141.4.1 - Manufacturing Engineer[23]

Real job description

Manufacturing Engineer, Cell Assembly

Tesla is looking for a highly motivated Mechanical development engineer to create, develop and scale up manufacturing processes for our cutting-edge Tesla battery cell manufacturing line. This role will invent, develop, scale up and optimize battery manufacturing processes within a cross-functional engineering team responsible for the development lifecycle and launch into manufacturing. In this role, you will work closely with many organizations both internal and external to Tesla taking new battery designs from initial concept through into full production.

The battery cell is a critical component in Tesla vehicles and storage systems. This role will have the opportunity to make meaningful contributions to our products. The work environment is demanding, fast-paced and incredibly exciting. The ideal candidate should be ready to push their limits, as they join in highly motivated and capable team to make unbelievable things happen.

Manufacturing Engineer, Cell Assembly	Short term for analysis	Green	Brown	White
Mechanical development engineer to create, develop and scale up manufacturing processes for our cutting-edge Tesla battery cell manufacturing line.	Develop battery cell manufacturing line			x
This role will invent, develop, scale up and optimize battery manufacturing processes within a cross-functional engineering team responsible for the development lifecycle and launch into manufacturing. In this role, you will work closely with many organizations both internal and external to Tesla taking new battery designs from initial concept through into full production.	Develop battery manufacturing processes			x
Responsibilities				
Drive development of new/innovative manufacturing processes from proof of concept through to full scale production that enable improved battery performance and/or cost	Develops Innovations to improve battery performance or cost			x

[22]https://www.indeed.com/m/viewjob?jk=446b3b72dfc4cd70&from=serp&xpse=SoD567I3ID4escAFSb0LbzkdCdPP
[23] http://data.europa.eu/esco/occupation/6818c837-072a-4120-b913-bd360b7b14d0

Be an expert leader in the technical discussion and define process and Equipment development roadmap for Cell assembly processes – Metal forming/ Dispensing battery cell technology.	define cell assembly processes			x
Work with internal and external teams to develop innovative process, product and equipment design solutions to advance battery performance and cell manufacturing.	design solutions to advance battery performance			x
Plan and Execute DoEs to characterize boundary conditions and optimize process for manufacturability and quality.	optimize manufacturing process			x
Develop and manage PFMEA, DFMEA risk assessments to prioritize process improvement projects and ensure adequate metrology and controls are in place.	manage risk assessments			x
Use tools like Minitab/JMP for data analysis and presentation of experimental data	Develops data analysis			x
Establish process controls for SPC and develop process related OCAPs	Establish process controls for SPC			x
	develop process related OCAPs			x
Lead product design for manufacturability (DFM), DFMEA and sustainability, including:	Lead product design for manufacturability			x
Analysis of product design and identification of potential risks to the process	Risk analysis in product design			x
Run CAE/CFD simulations to theoretically understand /De-risk new process/Equipment design changes	Run CAE/CFD simulations			x
Build process documentation to accurately define the process to cross-functional teams (equipment, quality, production, etc.)	Build process documentation			x
Qualifications				
MS or Ph.D. (or relevant exp) in Mechanical Engineering, Manufacturing Engineering, Chemical Engineering, or related field				x
5+ years relevant experience in interdisciplinary/integrated engineering, process development, manufacturing engineering, or 3+ years in Battery R&D and Manufacturing in a commercial lithium-ion environment.				x

In-depth understanding and knowledge of lithium-ion battery technology including material selection, fabrication, and synthesis; new battery cell design, assembly, testing, and failure mode analysis. Hands-on experience with lithium-ion battery cell product development is a strong plus.	lithium-ion battery technology			x
Experience with Metal forming/Stamping/dispensing applications is preferred	Metal working			x
Evidence of Deep understanding of engineering fundamentals and ability to apply them towards manufacturing process development	engineering principles			x
	engineering processes			x
Demonstrated capabilities in manufacturing process development for new products and Ability to transfer technologies from R&D into manufacturing is required.	Transfer R&D into manufacturing processes			x
Proven ability to successfully manage multiple projects and meet deliverable deadlines amidst changing requirements, deadlines, and priorities	project management			x
Manufacturing process specification and evaluation experience	Manufacturing process			x

Relevant ESCO Classified job description

2141.4 Industrial engineer	**Green**	**Brown**	**White**
Essential Skills and Competences			
adjust engineering designs			x
approve engineering design			x
perform scientific research			x
use technical drawing software			x
Essential Knowledge			
engineering principles			x
engineering processes			x
industrial engineering			x
manufacturing processes			x
production processes			x
technical drawings			x

Optional Skills and Competences (selected)			
adjust production			x
advise on safety improvements	x		
analyse test data			x
assess financial viability			x
assess the life cycle of resources	x		
conduct literature research			x
define technical requirements			x
design automation components			x
design electromechanical systems			x
determine production feasibility			x
Optional Knowledge			
3D modelling			x
CAD software			x
CAE software			x
ICT software			x

<u>Occupation 3</u>

Battery system engineer

A **battery system engineer** is responsible for designing, developing, and testing battery systems for various applications. They work with a team of engineers and scientists to create efficient, safe and cost-effective energy storage solutions for electric vehicles, consumer electronics, grid storage and other applications. They are responsible for the overall performance of the battery system, which includes the battery cells, control and management electronics, thermal management and safety systems. They need to have a strong understanding of electrical engineering, materials science, and manufacturing processes, as well as experience with battery management systems, safety protocols and regulations. They also need to be familiar with simulation and modelling tools to predict the performance of the battery systems under different conditions. They need to be able to work closely with other engineers and stakeholders to ensure that the battery system meets the requirements of the application and is compatible with the rest of the system.

The job description comes from the **project Albatts** that was mapping skills and training in the battery sector. The position of Battery systems engineer has been linked in this project to 3 ESCO occupations.

Role 3*	**HV Battery Engineer**[24]
Value chain step	Battery pack assembly
Closest ESCO job role	

ESCO Occupations

ID	NAME	Concept URI
2511.5	embedded system designer	http://data.europa.eu/esco/occupation/10469d70-78a3-4650-9e29-d04de13c62c1
2511.16	ICT system integration consultant	http://data.europa.eu/esco/occupation/bd9d395a-d587-45c6-8d72-ceef226df9e1
2149.9.2	energy systems engineer	http://data.europa.eu/esco/occupation/1ff61522-8947-4c95-b589-cb0e0539a62b

During the analysis of the green skills, the positions of **Embedded System Designer** and **ICT System Integration Consultant**, there were no green skills detected in the ESCO database.

The position of **Energy systems engineer** showed several skills that were classified by ESCO as green. But this position is only partially relevant for Battery system design.

Most relevant and closest is the ESCO classified position of Embedded system designer.

Real job description

We are looking for an HV Electrical Battery Engineer to help us grow the product range and lift the quality of the motorcycle design to new highs.

As a member of the electrical engineering team, the role of HV Electrical Battery Engineer will be to design and develop battery systems across several Norton products. This could include battery topologies, BMS PCB specifications and drawings, reviewing suppliers' specifications and drawings for suitability and creating any relevant requirement documentation. You will be responsible for your design areas from concept to production.

[24] https://www.linkedin.com/jobs/view/3747552694?trk=li_ziprecruiter_Global_careers_jobsgtm_ec6cde9b-1efa-42b8-b4cd-6523386e15d5_job-dist&utm_medium=jobdist&mcid=6810586802156523557&utm_source=ziprecruiter&ePP=CwEAAAGLwCBf1YrxUM9Rzv2O3NY7SN0lDd0TLJ05CCfXavLu7-t4kddA2iMMlyZrXzqmZ574u1tO3t-z9FyK8BXiAZzhPlkQ2pCDyE8KJA&ccuid=49920232553&cid=5a4fa348-183b-4f2d-8a85-7f0cabf959a8

HV Battery Engineer As a senior electrical component engineer, you will be responsible for:	**Short term for analysis**	**Green**	**Brown**	**White**
Understanding the requirements across the product range that must be considered in the development of new battery modules for use on the motorcycle.	Apply battery modules manufacturing requirements			x
Creating, agreeing, and maintaining standard specification documents (environmental/thermal/EMC/electrical etc) that can be used to ensure all selected components are suitable.	maintain standard specification documents	x		
Creating and reviewing electrical hardware specifications (inputs/outputs etc) for the development of new components.	create electrical hardware specifications			x
Creating and assessing thermal/cooling strategies of the battery system	create thermal/cooling strategies of the battery system			x
	assess thermal/cooling strategies of the battery system			
Validating various mechanical and electrical attributes in the design through simulation methods	Validate mechanical and electrical designs			x
Working with other engineers within the wider teams to ensure that all requirements are captured.	collaborate with engineers			x
Working with the testing lead to create test and validation procedures for all new and existing components.	Develop test procedures			x
Validating the fundamental design of electrical components with external suppliers.	Validate electrical design			x
Working with other engineers on the optimal locations/packaging of any items where required based on internal and external requirements.	Design batteries packaging			x
Support the integration engineers through the development of the vehicles to ensure issues are identified and resolved in a timely manner.	Liaise with automotive engineers			x
Working with other departments in the selection of suitable suppliers and components.	Support suppliers identification			x
Working with the wider electrical team to develop functional specifications and requirements for modules.	develop functional specifications for battery modules			x
Personal Specification				

The candidate must have experience in the following:				
Strong Organisational and communications skills	organise information, objects and resources			x
	Apply communication skills			
Passion for New Product and Current Projects (Automotive and Motorcycle interest would be preferred)				x
HV safety and requirements	High voltage safety requirements			x
HV system and component selection	High voltage system and component selection			x
HV Busbar design	High voltage Busbar design			x
Simulation toolsets such as Matlab and Simulink	MATLAB			x
	SIMULINK			x
Cell selection/Supplier liaison				x
Automotive electrical component specification and design	automotive electrical component specification and design			x
Owning and creating specification documents	write specifications			x
ISO/similar standards for component testing/design	Standards for component testing and design			x
Be able to read and understand electrical circuit / PCB schematics as required	Read electrical circuits			x
Component-level testing and fault-finding	Perform product testing			x
CAN/LIN communication and simulation methods	CAN/LIN communication and simulation methods			x
The candidate ideally would have experience in the following, but this is not essential.				
Direct experience of battery and BMS electrical design (e.g., Busbar/PCB design) from a supplier.				x
CREO / Pro-engineer				x
Topology design.				x
The candidate must have an Electrical Engineering degree, or similar combined with relevant industry experience and no less than 5 year's industry experience.				x

Job description Albatts

Note: Albatts - has been a project, in which were defined job roles in the battery manufacturing, the job roles were then linked to required skills and training in the battery manufacturing sector.

Energy systems designer

Battery System Engineer	Green	Brown	White
develop models			x
Process Control			x
analyse test data			x
perform product testing			x
embedded systems			x
Software Development			x
Requirements Engineering			x
risk management			x
project management			x
computer programming			x
inspect quality of products			x
identify process improvements			x
Analysis Methods			x
System Engineering/Specification			x
develop new products			x
safety engineering			x
Functional Safety			x
System Integration			x
apply validation engineering			x
BMS , knowledge			x
Lithium-ion Chemistry			x
Battery Systems			x
Vehicle (Battery) Systems			x
teamwork principles			x
communication			x
Problem Solving			x
communicate with customers			x
English, knowledge			x
use technical documentation			x
health and safety in the workplace			x
Standards/-isation			x
engineering principles			x
mechanical engineering			x

electrical engineering			x
computer science			x

Relevant ESCO classified job description

Embedded system designer
Embedded system designers translate and design requirements and the high-level plan or architecture of an embedded control system according to technical software specifications.

Excludes people performing programming and coding activities.

Embedded system designer	**Green**	**Brown**	**White**
Essential Skills and Competencies			x
analyse software specifications			x
create flowchart diagram			x
create software design			x
define technical requirements			x
develop creative ideas			x
interpret electronic design specifications			x
provide ICT consulting advice			x
tools for software configuration management			x
engineering control theory			x
ICT communications protocols			x
Essential Knowledge			x
signal processing			x
real-time computing			x
task algorithmisation			x
embedded systems			x
systems development life-cycle			x
Optional Skills and Competences			x
hardware architectures			x
C++			x
network management system tools			x
STAF			x
Erlang			x
Visual Studio .NET			x
C#			x
AJAX			x
Lisp			x
ICT security standards			x

ASP.NET			x
Assembly (computer programming)			x
ABAP			x
engineering processes			x
Java (computer programming)			x
OpenEdge Advanced Business Language			x
JavaScript			x
ICT system integration			x
tools for ICT test automation			x
Haskell			x
Salt (tools for software configuration management)			x
Apache Maven			x
SAP R3			x
Smalltalk (computer programming)			x
Microsoft Visual C++			x
VBScript			x
Ansible			x
Python (computer programming)			x
COBOL			x
hardware components			x
SAS language			x
PHP			x
Jenkins (tools for software configuration management)			x
Objective-C			x
TypeScript			x
Swift (computer programming)			x
field-programmable gate arrays			x
Puppet (tools for software configuration management)			x
computer programming			x
software components libraries			x
Scratch (computer programming)			x
CoffeeScript			x
ICT network simulation			x
Perl			x
Scala			x
APL			x
Prolog (computer programming)			x
Groovy			x

Pascal (computer programming)			x
ML (computer programming)			x
MATLAB			x
Ruby (computer programming)			x

Relevant ESCO Job description

Energy systems designer

Energy systems engineers supervise the energy conversion and distribution processes. They analyse energy supply and consumption efficiency developing new ways to improve the existing processes, taking into account both the technical and the financial aspects. They also study the environmental impact of energy usage and combine the production of renewable energy in the current power systems.

Energy systems engineer	**Green**	**Brown**	**White**
Essential Skills and Competencies			
adapt energy distribution schedules	x		
adjust engineering designs			x
advise on heating systems energy efficiency	x		
approve engineering design			x
carry out energy management of facilities	x		
design electric power systems			x
draw blueprints			x
examine engineering principles			x
identify energy needs	x		
inspect building systems			x
manage engineering project			x
perform risk analysis			x
perform scientific research			x
promote innovative infrastructure design	x		
promote sustainable energy	x		
troubleshoot			x
use technical drawing software			x
Essential Knowledge			
energy performance of buildings	x		
energy market			x
electricity consumption	x		
energy			x

technical drawings			x
solar energy	x		
environmental engineering	x		
electrical power safety regulations			x
engineering principles			x
engineering processes			x
renewable energy technologies	x		
Optional Skills and Competences			x
conduct engineering site audits			x
assess financial viability			x
create AutoCAD drawings			x
analyse energy consumption	x		
analyse big data			x
analyse test data			x
define energy profiles			x

<u>Relevant ESCO classified job description</u>
ICT system integration consultants advise on bringing together different systems to interoperate within an organization for enabling data sharing and reducing redundancy.

ICT system integration consultant	**Green**	**Brown**	**White**
Essential Skills and Competencies			x
apply information security policies			x
attend to ICT systems quality			x
consult with business clients			x
define integration strategy			x
define technical requirements			x
ensure proper document management			x
integrate ICT data			x
integrate system components			x
keep up with the latest information systems solutions			x
manage changes in ICT system			x
monitor system performance			x
monitor technology trends			x
optimise choice of ICT solution			x
provide ICT consulting advice			x
use scripting programming			x

verify formal ICT specifications			x
Essential Knowledge			
systems development life-cycle			x
Optional Skills and Competences			
build business relationships			x
educate on data confidentiality			x
write work-related reports			x
manage ICT change request process			x
track key performance indicators			x
create project specifications			x
provide technical documentation			x
use different communication channels			x
perform project management			x

Occupation 4

Recycling and second life

The final section of the battery value chain is dedicated to battery recycling and second life. Key occupations include recycling specialists and engineers, environmental engineers, chemical engineers, machine operators, recycling, R&D, and inventory technicians.

All these job profiles are needed to implement efficient and environmentally friendly processes to recycle and reuse batteries. Knowledge and experience required in this part of the chain extends to battery components and materials, chemical engineering, material science, material recovery, and relevant regulations. Further skills called upon include dismantling batteries, handling of hazardous waste, and battery upcycling – such as repurposing EV batteries for stationary applications.

The battery is composed of many different materials and components e.g. plastics, metals, electrotechnical devices and lithium cells. The reason why we chose chemical engineer is that one of the most difficult tasks in battery recycling is the recycling of the lithium cells itself. All other battery components have been used for very long time in other domains and the recycling processes are established, but the lithium cells are new. That is what represents the real challenge in battery industry today. Therefore, we chose the Chemical engineer job role for our analysis.

Occupation 4*	Chemical Process Engineer[25]
Value chain step	Recycling, cell manufacturing, material extraction
ESCO job role	**Chemical metallurgist**[26]

Real job description

Chemical Process Engineer

As our Chemical Process Engineer, you will develop and implement chemical process designs of our proprietary lithium-ion battery recycling processes and primary resource extraction technologies. This candidate will collaborate with our R&D team, plant operations team, and various internal and external experts to ensure the successful design, construction, and operations of our facilities. The ideal candidate will be familiar with the research & development, design, installation, commissioning, and operations of first-of-kind facilities. They should be passionate about designing, implementing, and maintaining efficient chemical manufacturing processes, ensuring quality control of outputs, specifying equipment, crafting and deploying monitoring protocols, and working in a high-performance and fast-paced environment. The candidate will be a problem-solver and have a keen interest in scaling processes proven at the bench scale up to pilot- or pre-commercial scales. This should include a constant focus on evaluating current processing steps and proposing and developing next-generation solutions to continuously improve system performance and operability. This position will report to our Director of Engineering.

Chemical process engineer	Short term for analysis	Green	Brown	White
Responsibilities				
Design and implement battery recycling & primary resource extraction systems from a laboratory scale basis into pilot and commercial scale systems.	Design battery recycling systems	x		
Iterate technical improvements to novel processing routes for extracting high-purity battery materials consistently from various feedstocks.	Improve processing routes for battery primary resource extraction	x		
Size and select process engineering equipment. Coordinate technical requirements to equipment vendors and review equipment and process submittals.	coordinate engineering teams			x
Complete mass and energy balances for new chemical processing systems.	Complete new chemical batteries processing systems			x

[25] https://jobs.lever.co/batterymetals/4a44ef25-de6d-43b7-aa71-7b7faa6195ee
[26] http://data.europa.eu/esco/occupation/27eb624c-6171-4c71-aa71-bb21e83381d4

Complete process system designs leveraging various solids, liquid, and gas processing technologies.	Complete batteries process system designs			x
Support operations and R&D teams by providing technical feedback and test plans for continuous improvement.	Collaborate with R&D teams			x
Collaborate with program management and construction teams to safely and quickly implement efficient designs.	Collaborate with program management and construction teams			x

Most relevant ESCO job description

Chemical Metallurgist

Chemical metallurgists are involved in the extraction of useable metals from ores and recyclable material. They study the properties of metal, such as corrosion and fatigue.

Chemical Metallurgist	**Green**	**Brown**	**White**
Essential Skills and Competencies			
apply health and safety standards			x
assess suitability of metal types for specific application			x
conduct metallurgical structural analysis			x
develop new installations			x
ensure compliance with environmental legislation	x		
join metals			x
manipulate metal			x
monitor manufacturing quality standards			x
perform sample testing			x
prepare samples for testing			x
prepare technical reports			x
work in metal manufacture teams			x
Essential Knowledge			
chemical technologies in metal manufacture			x
precious metals			x
chemical processes			x
alloys of precious metals			x

precious metal processing			x
ferrous metal processing			x
metal forming technologies			x
non-ferrous metal processing			x
metal and metal ore products			x
types of metal			x
Optional Skills and Competences			
ensure public safety and security			x
process incident reports for prevention			x
test raw minerals			x
extract products from moulds			x
maintain ore processing equipment			x
monitor extraction logging operations			x
separate metals from ores			x
install monitors for process control			x
liaise with quality assurance			x
extract materials from furnace			x

6.4 Skills supply for the Green transition

The energy transition creates significant demand for skilled workers and professionals. Current training resources are not sufficient to meet the demands of the skills shortages in the rapidly growing European battery value chain.

The demand for lithium batteries is expected to increase significantly in the coming years due to the electrification of mobility and the need to reduce climate change. This growing demand creates a need for skilled professionals who can design and develop efficient and safe lithium battery systems.

There are several options how to get the necessary education:

- Training Courses and Certificates: There are several online courses and certificates available that can help individuals gain the necessary skills in lithium battery design. Platforms like Coursera offer courses on battery technologies, algorithms for battery management systems, lithium-based batteries, and more.

- Pact for skills initiatives of government and private entities to support public and private organizations in workforce re-skilling and up-skilling.

- Industry Collaboration: Collaboration between industry and academia is crucial in developing training programs that meet the industry's requirements. By working together, industry experts and educational institutions can ensure that the training provided is relevant and up-to-date with the latest industry advancements

- Classical educational institutions study programs.

Increasing demand for expertise in the battery sector will require to take more agile of education forms and approaches.

Here are few examples:

A - European Battery Academy (EBA) and European Institute of Innovation and Technology (EIT)

Green skills training Example – provider European Battery Academy (EBA) and European Institute of Innovation and Technology (EIT)

The EBA250 Battery Academy, the first training platform in Europe in the field of battery manufacturing for electric vehicles.

In June 2023, The European Battery Academy announced the deployment training for approx. 150,000 workers in Spain over the next five years in the field of batteries through the School of Industrial Organization (EOI) as a result of the agreement signed by the School of Industrial Organization (EOI), part of the Ministry of Industry, Trade and Tourism, and EIT InnoEnergy. This training project by the European Battery Alliance has already held more than 30 training courses since 2018 in collaboration with leading European companies and organizations in the industry, and it offers its services through those local centres specialized in training workers.[27]

In February 2022 the European Institute of Innovation and Technology (EIT) has announced the launch of the European Battery Alliance Academy with a budget of EUR 10 million at the annual ministerial meeting of the European Battery Alliance (EBA).

With the mission to make Europe the global leader in sustainable battery technology, the European Battery Alliance Academy will train, reskill and upskill approximately 800 000 workers by 2025 to meet the demands of the skills shortages in the rapidly growing European battery value chain.

The academy was created under the framework of the European Battery Alliance (EBA), which was launched by the European Commission and is managed by EIT InnoEnergy, one of the Knowledge and Innovation Communities of the European Institute of Innovation and Technology. [28]

[27] https://eit.europa.eu/news-events/news/launching-european-battery-academy-reskill-thousands-industry-workers
[28] https://eit.europa.eu/sites/default/files/eba_academy_feb_23.pdf

1.InnoEnergy[29] study courses

The InnoEnergy Skills Institute is one of Europe's leading training skills providers for the sustainable energy workforce, spanning energy storage, photovoltaics, and green hydrogen. Inspired and informed by the dynamic clean energy ecosystem of EIT InnoEnergy.

They are intended for the global workforce, to provide expertise and skills required to create a sustainable economy. The knowledge and know-how are divided into relevant, applicable, and effective modular training courses.

- It offers 35+ courses and programs
- The training is available in 10 languages
- It has more than 40 industry partners
- More than 50 experts from industry and academia

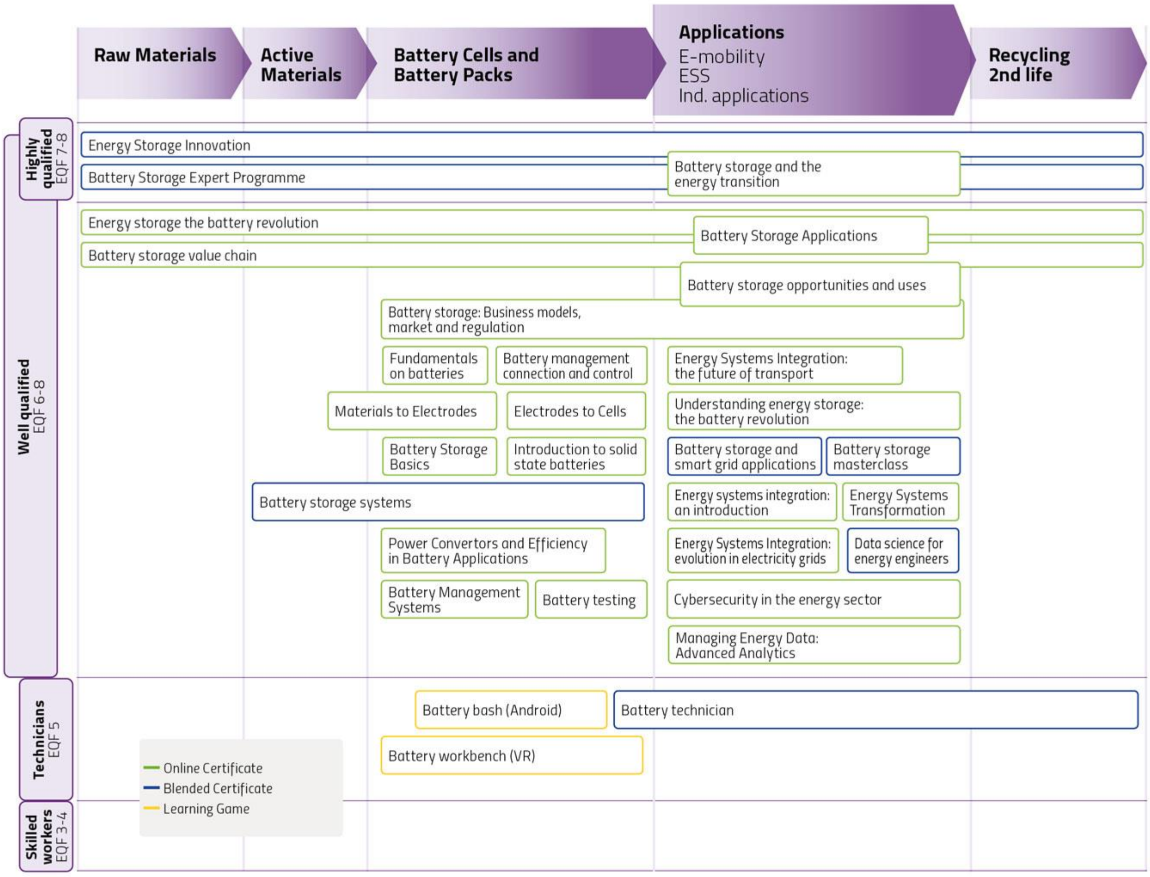
The expertise is backed by a range of sector experts, alliances and partnerships that help them to deliver innovative and highly effective skills training that drives the global transformation of the sustainable energy sector – covering energy storage, photovoltaics, green hydrogen and many other forms of clean technology.

2. Storage – on-demand storage training and certification by InnoEnergy

EIT offers on-demand training **for all levels of technical knowledge**, covering introductory, intermediate, and advanced knowledge of battery technology, applications, and energy systems. Their blended programs with hands-on battery labs help workers to gain the knowledge, skills and confidence they need to fill skill gaps across the battery value chain, from raw materials to **recycling**.

[29] https://www.innoenergy.com/skillsinstitute/skills-solutions/storage/

EIT training portfolio across the battery value chain



Note: The **European Qualifications Framework (EQF)** acts as a translation device to make national qualifications more readable across Europe, promoting workers' and learners' mobility between countries and facilitating their lifelong learning.[30]

The institute offers 5 courses that have recycling in their curriculum. Energy Storage Innovation, Battery Storage Expert Program, Energy Storage the Battery Revolution, Battery Storage Value Chain, Battery Technician.

<u>The battery courses cover all EQF levels.</u>

3. Innoenergy Master's in sustainable energy solutions

Innoenergy offers 2-year study program in cooperation with other European universities in e.g. Sweeden, Spain.

Courses in the first-year focus on topics such as sustainable energy conversion, renewable energy, and ways of ensuring minimal human impact on the environment.[31]

[30] https://europa.eu/europass/en/description-eight-eqf-levels

[31] https://www.innoenergy.com/for-students/master-school/master-s-in-sustainable-energy-systems/

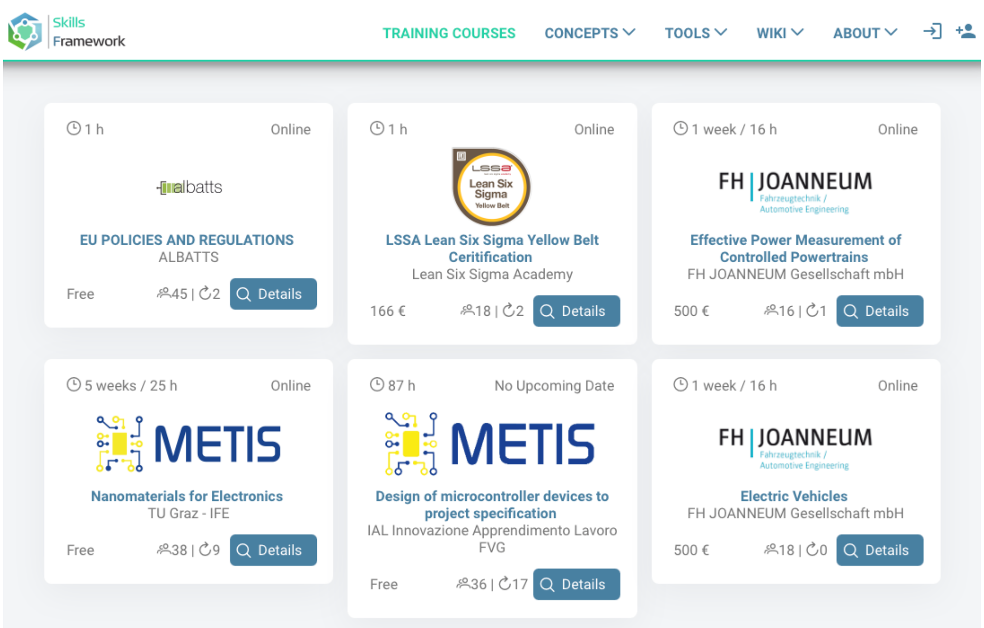
The course deepens understanding of the transformation of primary sources from different forms of Renewable Energy Sources (electrical, thermal, photonic, biomass) into other forms of energy (energy-to-energy), energy storage, energy carriers (such as H2), or synthetic chemicals. A particular emphasis is placed on the management of CO2, a global problem, but at the same time a source of carbon, which is necessary to produce synthetic chemical products.
Requirements: A background in mechanical engineering or chemical engineering is recommended.

B - Automotive Skills Alliance (ASA)[32]

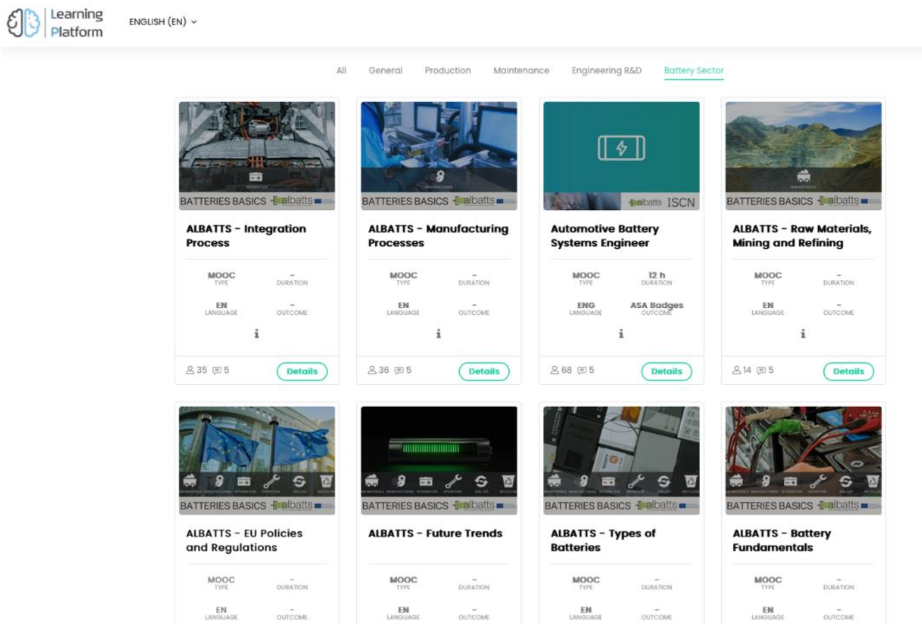
Automotive Skills Alliance has goals to boost the re-skilling and up-skilling within the automotive sector which is facilitated by the wide network of partners.

ASA, headquartered in Brussels, is an organization that operates across Europe and spearheads the skills initiative. They provide comprehensive training programs that focus on the Automotive and Battery Industry. ASA's Knowledge Hub is home to an extensive collection of almost 200 courses.

The Automotive Skills Alliance provides training primarily focused on the technical aspects of battery manufacturing. While some of the courses are offered for free, the majority of them require payment.



32 https://learn.skills-framework.eu



<u>Green skills training Example - Provider ASA / Albatts project</u>

EU Policies and Regulations training

In this unit, structured with 3 modules, you will first learn about the main UN agreements adopted by the EU and an overview of the EU Green Deal and how it is affecting the legal requirements related to batteries, including the Battery Passport, and how it contributes for a sustainable battery industry and its integration into the circular economy.

Germany

Germany is one of the most advanced countries in battery research and development. There are various research centres that create ecosystems with the universities and industry leaders.

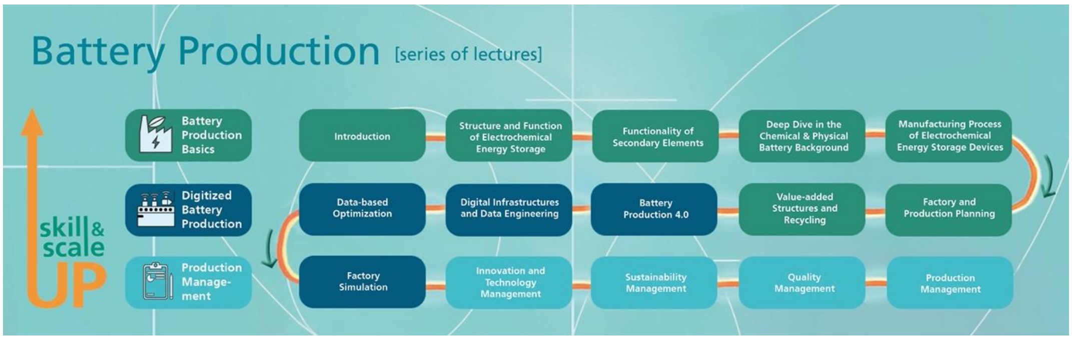
C- Fraunhofer Institute

The Fraunhofer Research Institution for Battery Cell Production FFB and the FH Münster created a joint approach imparting knowledge on battery production. Fraunhofer FFB researchers are teaching students at the FH Münster the basics of battery research in a series of lectures.

1. "Skill and Scale up" program 33

Includes three central research areas of battery cell production.

[33] https://www.ffb.fraunhofer.de/en/events/skill---scale-up.html



In a total of 15 lectures, students are taught detailed knowledge about battery production. Experts from the Fraunhofer FFB each shed light on their area of research, with the following three main topics being covered throughout the semester. These follow the process chain of battery production in terms of content:

basics of battery production:
Based on the current market developments and areas of application of modern batteries, the first section explains, among other things, how electrochemical energy storage devices work and the manufacturing process, cell types and alternative battery technologies, as well as factory and production planning.

digitalized battery cell production:
Digital technologies enable efficient and sustainable cell production. The second focus area of the lecture therefore focuses on battery production 4.0, such as the digital twin, data-based optimization and simulation technology.

production management:
The lecture culminates in the characterization of innovation and technology management, sustainable battery cell production along the entire value chain, and production and quality management in the battery environment. Students from the following disciplines can participate in the lecture: Materials Science, Chemical Engineering, Photonics, Electrical Engineering, Industrial Engineering, Mechanical Engineering, Electrical Engineering, and Energy-Building-Environment.

Green skills are addressed in the program with lectures on Value added structures & recycling, sustainability management.

The program, developed in collaboration with **Münster University of Applied Sciences**, imparts fundamental knowledge in battery research to students during the winter semester of 2023/2024. [34]

1. ELLB - European Battery Cell Learning Laboratory by Fraunhofer FBB

The ELLB course program[35] - is another initiative that offers to its students the most suitable course across all levels of expertise.

[34] https://www.ffb.fraunhofer.de/en/press/New_series_of_lectures_starts.html
[35] https://www.ellb.fraunhofer.de/en/courses.html

ELLB is part of the battery cell research project "FoFeBat" in Münster funded by the Federal Ministry of Education and Research and they are working together with many Fraunhofer institutes, universities and industrial partners on the establishment of the European Learning Lab Battery Cells ELLB - a community with a wide range of innovative upskilling and reskilling offers on the subject of batteries, which is playing its part in shaping and advancing qualification in the battery sector in Europe.

Sweden
In Sweden, the European Battery Alliance works with the InnoEnergy Skills Institute to develop training courses for the battery industry. [36]
EIT InnoEnergy has a presence in academic institutions, such as the Royal Institute of Technology (KTH) in Stockholm, where it plays a role in the Innovation & Entrepreneurship Journey[37]
The InnoEnergy Master School offers programs, with students pursuing studies in renewable energy at institutions like KTH in Stockholm. [38]

InnoEnergy Master School offers two-years dual-degree/dual-location sustainable energy engineering programs to students with an innovative mindset and entrepreneurial ambitions. Our programs are offered in Portugal, Spain, France, Belgium, the Netherlands, Germany, Poland, Sweden and Finland. Students follow academic lectures at one of our 14 partner universities (two years = two different universities) In addition, InnoEnergy organizes the Innovation & Entrepreneurship Journey (minor) during which students follow complimentary training in topics such as business, leadership, entrepreneurship and more. Additionally, students engage in real-life challenges with industry/startups/municipalities and have access to prime internships/employment opportunities through InnoEnergy’s network of over 400 industrial partners. Students with entrepreneurial ambitions can join InnoEnergy’s Sidewalk program designed to support students with the creation of their own start-up through mentorship, development, IP creation, funding and more. For intake 2020, the following programs are offered:

- Master’s in Renewable Energy
- Master’s in Sustainable Energy Systems
- Master’s in Smart Electrical Networks & Systems
- Master’s in Energy Technologies
- European Master’s in Nuclear Energy
- Master’s in Energy Transition
- (NEW) Master’s in Energy Storage

Additionally, RISE[39], a Swedish research institute, offers open and tailor-made courses and introductory trainings for re-skilling and up-skilling in the battery value chain. These courses cover various aspects of the battery industry, including safety, recycling, battery services, and other parts of the battery value

[36] https://ec.europa.eu/european-social-fund-plus/en/news/esf-powers-skills-battery-industry
[37] https://www.innoenergy.com/uploads/2023/01/factsheet-for-student-recruitment-agents.pdf
[38] https://www.innoenergy.com/uploads/2023/01/factsheet-for-student-recruitment-agents.pdf
[39] https://www.ri.se/en/what-we-do/educations/battery-training-and-courses-in-batteries

chain.

It is worth noting that the battery industry in Sweden is experiencing growth and development. Companies like Northvolt have received support from the Swedish Energy Agency, contributing to the promising future of battery technology in Sweden. "When it comes to competence supply, the Swedish Energy Agency supports several initiatives to increase competence in the field, including collaborations with various colleges and universities"[40]

In summary, EIT InnoEnergy is actively engaged in Sweden across various domains, including industry collaboration, skills development, strategic partnerships, academic initiatives, and operational focus, contributing to the advancement of sustainable energy innovations.

Conclusion:

The integration of green skills into comprehensive training programs is more common than focusing exclusively on battery-specific green training. The current scarcity of lithium battery reskilling suggests that the industry is still in its early stages and requires additional educational resources.

Sweden and Germany appear to be the most advanced not only in battery training but also in creating the entire battery ecosystem. Until recently, there was limited information available on training in Spain; however, battery training in Spain has recently reached a new level. The European Battery Academy, in collaboration with InnoEnergy, has announced the deployment of training for approximately 150,000 workers over five years in the field of batteries.

6.5 Batteries sector results and conclusions

Lithium-based batteries power our daily lives from consumer electronics to national defence. They enable electrification of the transportation sector and provide stationary grid storage, critical to developing the clean-energy economy.

The main trends in the green transition

The lithium battery value chain comprises of mining and material extraction, lithium cell production, battery pack production and recycling. Battery production itself is not without environmental impact, the battery production uses rare metals and significant energy and water resources during the manufacturing process.
The main trend in the **Green transition** is to gain maximum use of existing batteries through circular value chain, especially through second life and recycling.

When we discuss the Green energy transition, electric vehicles (EVs) are pinpointed as the principal

[40] https://www.energimyndigheten.se/en/news/2023/the-future-of-battery-technology-in-sweden-looks-promising/

technology in driving sustainability forward. Despite the huge variety of battery technologies on the market, lithium remains the key component in the manufacturing of electric vehicles, but it is also in short supply.
Questions therefore remain about how Europe can develop a sustainable supply chain to support the manufacturing of EVs, while remaining a key competitor in the global market.
One of the ways to achieve this, we all agreed, it would be through circular value chain.
The past Battery Directive was more focused on waste, collection and recycling but not in a joined-up way as we have seen with the new legislation which focuses on the importance of the circular economy.[41]

The main impacts on environment are in **Research** and **Development** occupations that are involved in production facility design, methods of ore extraction and battery chemistry, eventually battery pack design.

Despite the increase in lithium battery production driven by CO2 regulations, it cannot be denied that the production process itself has environmental consequences. Within the value chain of lithium cell production, there are four areas of employment that have the most significant environmental impact:

- mining and material extraction
- lithium cell production
- battery pack design
- recycling

The environmental impact of Lithium battery production is primarily concentrated in research and development positions, as the production processes are highly automated. The impact on the environment by regular factory employees is minimal, given the extensive automation in place.

Key occupations

The following occupations have been selected as those with the highest environmental impact:

Mining engineer
Collaborates and conducts with others geographical exploration by reviewing maps and drilling logs to determine location, size, accessibility, and estimated volumes of deposits. Works with aggregate production to develop methods to extract material,

Mechanical Engineer - cell assembly
Mechanical development engineer creates, develops and scales-up manufacturing processes for battery cell manufacturing line.

[41] https://www.innovationnewsnetwork.com/battery-technologies-and-the-green-energy-transition/12214/

Battery System Engineer

A battery system engineer is responsible for designing, developing, and testing battery systems for various applications. They work with a team of engineers and scientists to create efficient, safe and cost-effective energy storage solutions for electric vehicles, consumer electronics, grid storage and other applications.

Chemical process engineer

is responsible for creating and executing designs for chemical processes in the field of lithium-ion battery recycling and primary resource extraction technologies.

The ESCO job roles in the battery sector are not sufficiently granular and they seem to be quite broad, and they may represent two quite different jobs.

Green Skills Evaluation

Some occupations lack ESCO classified green skills, potentially because key occupations primarily exist within the research and development field, which requires a strong technical background. Environmental specialists, on the other hand, often have only an advisory role.

We suggest that more focus should be placed on environmental issues during training. In the R&D sector, there should be an emphasis on practical environmental topics such as recycling and second life, as it is crucial for R&D engineers to incorporate this knowledge into their designs.

The following overview presents real job descriptions from actual companies for each of the four occupations listed. Any skills identified as green in these job descriptions have been assigned by us during this analysis and can be considered newly identified green skills. This is followed by ESCO classified job descriptions, where any skills marked as green are based solely on the ESCO green skills list.

Occupation 1 - Mining

a) Mining engineer – real job description

The following green skills were marked as green by us.

Will work with the team to ensure company compliance with mandated safety and environmental policies on all mining/material production practices.
Will work with company management and State and Federal agencies to ensure compliance with all applicable laws and regulations.
Ability to detect safety hazards and respond accordingly.
Adhere to any and all state and federal regulations, if applicable, as set forth by the US Department of Transportation (DOT), Occupational Safety and Health Administration (OSHA), Mine Safety and Health Administration (MSHA), or any other regulatory agency.

Strict adherence to safety requirements and procedures as outlined in the Environmental, Health & Safety Manual.

b) Environmental mining engineer – ESCO

The following green skills are classified as green by ESCO

assess environmental impact
communicate on the environmental impact of mining
develop environmental policy
ensure compliance with environmental legislation
manage environmental impact
biology

c) Mine planning engineer - ESCO

The following green skills are classified as green by ESCO

geology
mine dump design

<u>Occupation 2 – Cell manufacturing</u>

a) Manufacturing Engineer, Cell Assembly – real job description

no green skills identified

b) Manufacturing Engineer – ESCO job description

The following green skills are classified as green by ESCO

assess the life cycle of resources

<u>Occupation 3 – battery pack assembly</u>

a) HV Battery Engineer - real job description

The following green skills were marked as green by us.

Creating, agreeing, and maintaining standard specification documents (environmental/thermal/EMC/electrical etc) that can be used to ensure all selected components are suitable.

b) Energy systems designer

This position contains most green skills. Skills with an asterisk are relevant to Li-ion battery manufacturing.

The following green skills are classified as green by ESCO

adapt energy distribution schedules
advise on heating systems energy efficiency
carry out energy management of facilities
identify energy needs*
promote innovative infrastructure design
promote sustainable energy
energy performance of buildings
electricity consumption*
solar energy*
environmental engineering
renewable energy technologies*
analyse energy consumption *

ICT system integration consultant and Embedded system designer had no identified green skills.

Occupation 4 - recycling

a) Chemical process engineer - real job description

The following green skills were marked as green by us.

Design and implement battery recycling & primary resource extraction systems from a laboratory scale basis into pilot and commercial scale systems.
Iterate technical improvements to novel processing routes for extracting high-purity battery materials consistently from various feedstocks.

b) Chemical Metallurgist

The following green skills are classified as green by ESCO

ensure compliance with environmental legislation

Training supply for selected occupations

The energy transition creates significant demand for skilled workers and professionals. Current training resources are not sufficient to meet the demands of the skills shortages in the rapidly growing European battery value chain.

Among the most visible education providers belong:

- **EBA** - provides on-demand training for **all levels of technical knowledge**, covering introductory, intermediate, and advanced knowledge of battery technology, applications, and energy systems **across all battery value chain**. The EBA creates partnerships to provide education in large scale for hundreds of thousands of students.

- **ASA** – provides on-demand training for battery technology for all steps of the value chain except for recycling.

Both platforms provide training on European level and the courses are supplied by various European educational institutions and companies.

On a national level, we have examined the situation in Germany, which is considered one of the leading countries in Europe when it comes to battery research and education. Germany has a number of research institutions that collaborate with universities and companies to provide training opportunities. One particularly noteworthy initiative is the establishment of the Battery University, a partnership between the Fraunhofer Institute and Muenster University. In addition to the Battery University, Fraunhofer also offers the European Learning Lab Battery Cells (ELLB) program, which focuses on battery cell manufacturing courses.

"The green skills are typically integrated into a comprehensive training programs rather than being exclusively focused on battery-specific green training."

The current supply of lithium battery reskilling is insufficient, in capacity and scope, indicating that the industry is still in its early stages and requires additional educational resources. The education process is more focused on skills that are necessary to build the battery. We are slowly seeing the emergence of the courses for green skills.

Focus Group Results

During the focus group sessions, industry professionals engaged in conversations about defining the battery industry and identifying the crucial job positions for a green transition. The experts predominantly took an ecosystem perspective when discussing the definition of the industry, while considering the NACE classification more suitable for statistical purposes.

According to experts, the primary focus **of green job positions will be in the research and development field**. This is because regular workers have limited influence on the environment at a large scale, as the production is mostly automated. **Engineers play a crucial role in designing processes, extraction methods, and assembly lines to accomplish this.**

The importance of the safety manager job position was highlighted.

Sweden and Spain are considered the two primary advanced battery countries by experts, although Germany is widely acknowledged as likely being the top country in this field.

7. The defence sector

The Defence sector covers the design, construction and maintenance of military systems, subsystems and components. Products and services provided by this sector are usually essential to mobilize, deploy and sustain military operations. The special characteristic about this sector is that their products have to comply with military standards. The production of defence materiel represents a great responsibility and is subject to strict regulations. Defence industry covers everything from land, sea and air capabilities to huge electronics and cybersecurity.

Companies operating in the industry vary from large multinational companies to small companies. Usually, Defence industry is led by a small number of companies that have the capacity to design, develop and produce complete systems. These companies exist alongside with small and medium businesses that are specialised in the design and/or production of various subsystems that are incorporated into the supply chain of the driving forces for their subsequent integration.

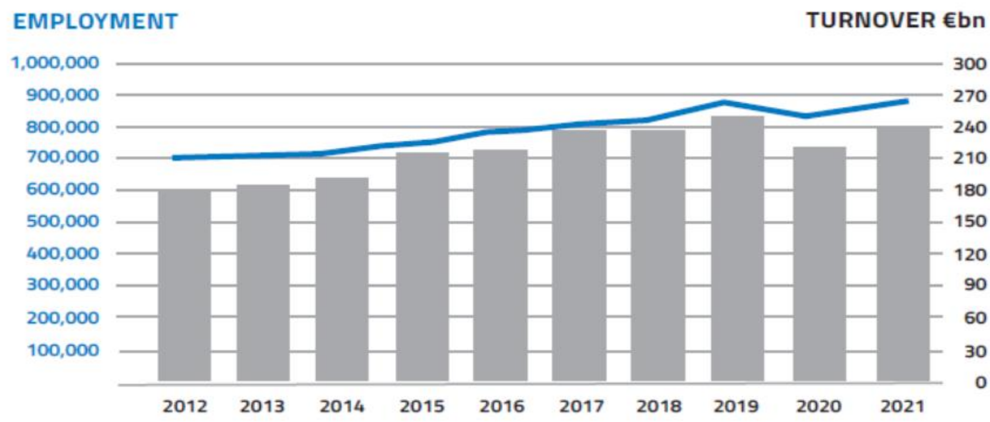
Moreover, companies working for the Defence sector also supply products for the civil sector. This means that employees from this companies work on defence and industrial technologies products, so we can conclude that the knowledge needed to work in the defence sector can be achieved from and used for other industrial sectors.

The “defence systems” (being them ships, aircrafts, land systems, or any subsystem included in any of them) supplied by the industry are generally characterised by their complexity, multi-functionality and high technological level. They are developed over long periods of time and have short production runs and the digital transformation have re-shaping the defence sector during the last decades. This entails a significant mobilisation of human and economic resources and therefore has a strong, and in particular regional, socio-occupational impact. According to the ASD then the defence sector employed 467.000 people in EUROPE, 63% in Land & Naval and 37% in Military Aeronautics. (ASD, 2022)

7.1 Sector general overview

The Defence sector in Europe is a large and complex joint of industries that provide a variety of products and services to the military and other government organizations. The Defence sector in Europe employs thousands of people and generates billions of euros in revenue each year. The functions of the Defence sector and its contractors are:

- Supplying the military equipment needed for the successful execution of military operations.
- Providing the base for the maintenance and development of military potential.
- Playing a crucial role in maintenance/sustainment of the systems: they provide training, technical services, repairs, updates and many other support functions.



[2] The data shown in this report is based on the geographical membership of ASD, encompassing the 18 countries where the national associations are ASD members. ASD geography (for 2021) includes the following EU and NON-EU Member States:

'ASD EU': Countries that are represented among the ASD membership and that at the same are EU Member States: Austria, Belgium, Bulgaria, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Poland, Portugal, Spain, Sweden, and The Netherlands.

'ASD NON-EU': Countries that are represented among the ASD membership and that are not EU Member States: Norway, Turkey, and the United Kingdom.

'NON-ASD EU': Countries that are not represented among the ASD membership but that are EU Member States: Croatia, Cyprus, Estonia, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Malta, Romania, Slovakia, and Slovenia.

Source: ASD Facts & Figures 2022 - https://asd-europe.paddlecms.net/sites/default/files/2022-11/ASD_Facts%20%26%20Figures%202022.pdf (ASD, 2022)

Only companies who have the necessary know-how and expertise are able to develop and support the equipment the armed forces need to cope with the threats they may face. Those companies usually also do business with other sectors, mainly in security, space and aeronautics. All these sectors have a role to play in sustainability since some of these companies contribute to the green transformation for example, by monitoring the greenhouse gases emissions, by contributing to digital transformation, by driving innovation in technologies required for carbon free emissions, etc. The production of defence materiel represents a great responsibility and is subject to strict regulations. Not only have the EU and all Member States developed very tight national (and sometimes regional) regulations, but industry also supports a set of binding international treaties. The Defence industry needs qualified and specialized employees. They need to facilitate this high level of qualification and specialization through training / dissemination of knowledge for all positions.
European Defence industry is scattered over almost the whole EU, though a few countries (Austria, Czech Republic, France, Germany, Italy, Poland, Spain and Sweden) host the majority of the driving force companies and the small and medium companies.
Some of these companies are:

- France: Naval Group, Safran, Dassault, Schneider
- Italy: Fincantieri, Leonardo S.p.a., Beretta, Iveco
- Germany: ThyssenKrupp
- Spain: Navantia, The CT Engineering Group, Santa Bárbara Sistemas, SAES, UROVESA, Indra
- Europe: Airbus, Eurofighter, Thales

7.1.1 Conclusions on the sector general overview and the FG meeting.

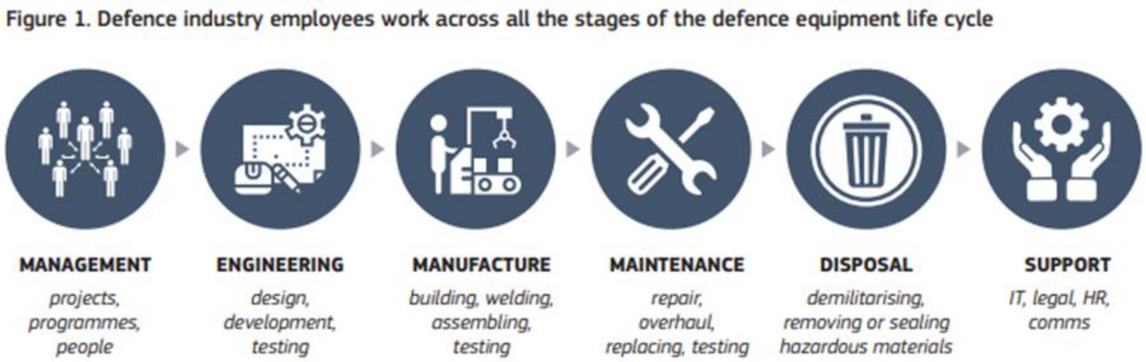
The focus group meeting discussed the sector in general and the countries which host the majority of the driving force companies. The focus group agreed in general with the report, but also pointed out the UK as an important country when it comes to hosting companies which are important for the defence industry.

Another point made was that when it comes to the defence industry then it makes more senses to talk about most relevant companies and not countries. The most relevant companies are often placed in a lot of different countries, which make the country relevant for the defence industry.

Ranging the countries, then Germany and France are considered to be the most relevant countries when talking about the defence industry due to hosting some of the most relevant companies.

7.2 Key occupations for the Green transition

To move towards a more sustainable economy, it is necessary to create a properly skilled workforce. The defence industry covers a lot of different work areas, which all have a crucial impact on our educational systems and the collaboration between HE, VET and industries.



Source: EDSP – European defence skills partnership (https://www.eudsp.eu/event_images/Downloads/Defence%20Careers%20brochure_1.pdf) (EDSP - European defence skills partnership, 2022)

- Naval architects

When a product is being developed, is when a company must address the sustainability of processes and when they should take into consideration the environmental impact of the product by implementing sustainable designs.

If engineers are provided with the necessary green skills / knowledge to innovate when designing ships, then they will be able to improve the sustainability of ships. Naval architects equipped with the right knowledge and skills for sustainable development can improve energy efficiency. For example, creating an efficient design modifying a fossil fuel-based power generation plant, using renewable energy adapted to the military environment or using smart energy management systems. Also, they can improve infrastructures where energy consumption is concerned. All of the above will enable fuel consumption and, therefore, emissions, to be reduced, protecting the environment and reducing greenhouse gas emissions.

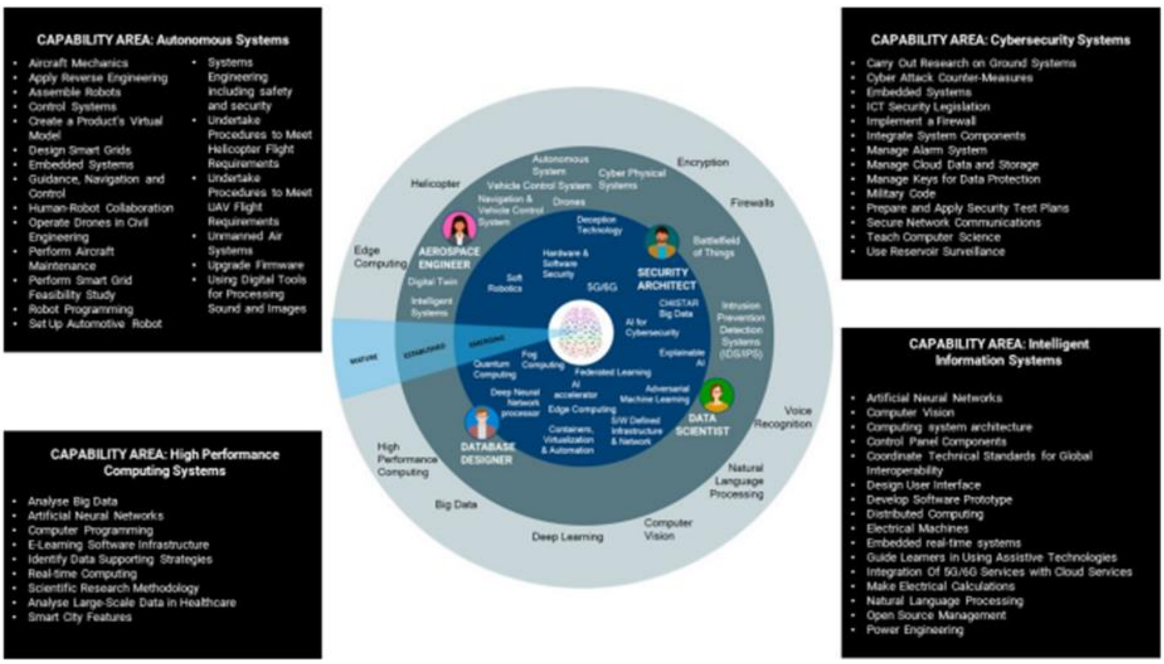
- Mechanical Engineers

With the correct green skills, mechanical engineers can plan and adapt processes to ensure that resources are used in the best way possible according to the energy constraints. They can understand the behaviour of pollutants, design new materials that work in harmony with nature, modify energy systems implementing energy-saving components or using renewable generation. They can implement systems that recycle materials such as metals and glass, whilst minimising the use of materials like plastics.

- Crew members

Products and services within the defence industry also will have to incorporate sustainability principles. Also, they will have to seek new environmental applications for existing products. These changes incorporated in products can imply that it is necessary to train militaries in the use of this new products. For example, the decarbonisation of shipping, alongside digitalization, the increased use of automated ship systems, the use of alternative fuels, etc., will affect people working in the maritime sector.
The transition from using conventional fuels and technologies to alternative fuels and technologies will lead to a need for new and additional training for current and future crew. Also, the implementation of alternative fuel technologies will introduce new technological and operational modes, as well as new safety requirements. In addition, decarbonisation and the uptake of alternative fuel technologies are expected to bring fast-moving technological developments, including increased automation and digitalization.

In the Blueprint project Assets+ they distributed technologies, skills, and job profiles in four capabilities areas.



Source: Assets+ - R4.5 Body of knowledge (https://assets-plus.eu/wp-content/uploads/2023/01/R4.5-Body-of-

Knowledge-thrid-iteration.pdf) (Assets+, December 2022)

The selected defence occupations from the Blueprint project Assets+ are:
Aerospace engineer, database designer, data scientist and security (software) architect

Three of the occupations are relevant for the defence sector in general, only Aerospace engineer is unique for one area of the defence sector. The space sector is a growing sector within the European defence sector and therefore relevant as an occupation for this project.

7.2.1 Conclusion on the key occupations for the green transition and the FG meeting

When discussing the key occupations then the general understanding was that the occupations suggested in the ASSETs+ project were to be considered as key occupations for the green transition in the defence sector. The FG felt that we were missing out on System simulation engineering as this occupation has a great importance towards developing the new technics which is used in the defence sector.
The FG pointed out that we also had to consider **Advanced manufacturing** as a key occupation when we're talking about the defence sector, as this area is of great importance for the sector.

7.3 Skills for the Green transition in the key occupations

Due to the technological development the defence sector is requesting more and more white – collared jobs. According to the Assets+: "*The defence sector needs of managerial skills to ensure flexibility, and a collaborative management to promote the synergic integration across different industries*" (ASSETs+, November 2022)

Assets+ concluded that: "*The high-speed and tangled technological development make multidisciplinary fundamental to manage changes and the unsteady direction of innovation mechanisms, together with the ability to collaborate will be key competences for emerging challenges. Many signals indicate the increasing importance of the coexistence in a single profile of competences related to the domains of Data Science and Project Management, converging towards the figure of the data-driven project manager, who uses data and information of various types and formats to plan and monitor processes, support decision making, elaborate solutions for problems, and manage complex projects. Defence agencies face a growing challenge of effectively processing, exploiting, and disseminating data from multiple, diverse sensors platforms. Workers need analytical skills and cognitive capabilities to manage and process the data collected by the information systems, analysing, and evaluating information for the situational awareness."* (ASSETs+, 2022) This means that especially the STEM competences and the ICT -skills are more in demand from both industries and educational programs.

Analysing the occupations mentioned in the Blueprint project Assets using the ESCO labelling to identify the white, brown and green skills. According to the occupations and the sector then the brown skills are almost non-existent. The brown skills are mostly related to the sectors suppling the defence sector. None of the skills and knowledges have been tagged as green by ESCO, but the following list indicates with an those that are considered as relevant for the green transition and should embed a sustainability approach.

AEROSPACE ENGINEER	Essential skills and competences	Green skills Classifier			Essential knowledge	Green skills classifier		
		Green	Brown	White		Green	Brown	White
	Adjust engineering designs	e		x	Aerospace engineering	e		x
	Approve engineering design	e		x	Aircraft mechanics	e	x	
	Ensure aircraft compliance with regulation	e		x	Engineering principles	e		x
	Execute feasibility study			x	Engineering processes	e		x
	Perform scientific research	e		x	Industrial engineering	e		x
	Troubleshoot			x	Manufacturing processes	e	x	
	Use technical drawing software			x	Production processes	e	x	
	Assess financial viability			x	Quality standards			x
					Technical drawings			x

DATABASE DESIGNER	Essential skills and competences	Green skills Classifier			Essential knowledge	Green skills classifier		
		Green	Brown	White		Green	Brown	White
	Analyse business requirements			x	ICT security legislation			x
	Apply ICT systems theory			x	Business process modelling			x
	Assess ICT knowledge			x	Database			x
	Create data sets	e		x	Database development tools			x
	Create database diagrams			x	Database management systems			x
	Create software design	e		x	Information structure			x
	Define technical requirements			x	Query languages			x
	Design database scheme			x	Resource description framework query language			x
	Develop automated			x	Systems	e		x

	migration methods				development life-cycle			
	Manage database			x	Systems theory			x
	Manage standards for data exchange			x	Web programming	e		x
	Migrate existing data			x				
	Operate relational database management system			x				
	Perform data analysis			x				
	Use markup languages			x				
	Write database documentation			x				

	Essential skills and competences	Green skills Classifier			Essential knowledge	Green skills classifier		
		Green	Brown	White		Green	Brown	White
DATA SCIENTIST	Apply for research funding			x	Data mining			x
	Apply research ethics and scientific integrity principles in research activities	e		x	Data models	e		x
	Build recommender systems	e		x	Information categorisation			x
	Collect ICT data			x	Information extraction			x
	Communicate with a non-scientific audience			x	Online analytical processing			x
	Conduct research across disciplines	e		x	Query languages			x
DATA SCIENTIST	Deliver visual presentation of data	e		x	Resource description framework query language			x
	Demonstrate disciplinary expertise			x	Statistics	e		x
	Design database scheme			x	Visual presentation techniques	e		x
	Develop data processing applications			x				
	Develop professional network with researchers and scientists	e		x				
	Disseminate results to the scientific community			x				
	Draft scientific or academic papers and technical documentation	e		x				
	Establish data processes			x				

	Evaluate research activities			x				
	Execute analytical mathematical calculations			x				
	Handle data samples			x				
	Implement data quality processes	e		x				
	Increase the impact of science on policy and society			x				
	Integrate gender dimension in research			x				
	Interact professionally in research and professional environments			x				
	Interpret current data			x				
	Manage data collection systems			x				
	Manage findable accessible interoperable and reusable data			x				
	Manage intellectual property rights	e		x				
	Manage open publications			x				
	Manage personal professional development			x				
	Manage research data	e		x				
	Mentor individuals	e		x				
DATA SCIENTIST	Normalise data			x				
	Operate open-source software			x				
	Perform data cleansing			x				
	Perform project management			x				
	Perform scientific research	e		x				
	Promote open innovation in research	e		x				
	Promote the participation of citizens in scientific and research activities	e		x				
	Promote the transfer of knowledge			x				
	Publish academic research			x				
	Report analysis results			x				

	Speak different languages			x				
	Synthesise information			x				
	Think abstractly			x				
	Use data processing techniques			x				
	Use databases			x				
	Write scientific publications			x				

	Essential skills and competences	Green skills Classifier			Essential knowledge	Green skills classifier		
		Green	Brown	White		Green	Brown	White
SOFTWARE ARCHITECT	Align software with system architectures			x	Business process modelling			x
	Analyse business requirements			x	Object-oriented modelling	x		x
	Analyse software specifications			x	Systems development life-cycle	x		x
	Build business relationships			x	Tools for software configuration management			x
	Collect customer feedback on applications			x	Unified modelling language			x
	Create flowchart diagram			x				
	Create software design			x				
	Define software architecture			x				
	Define technical requirements			x				
	Design process	e		x				
	Oversee development of software			x				
	Provide cost benefit analysis reports			x				
	Provide technical documentation			x				
	Use an application-specific interface			x				

7.3.1 Conclusion on the skills for the green transition in the key occupations and the FG meeting

The occupations chosen to present for the FG were Aerospace engineer and Data scientist.

In Aerospace engineering they pointed out that they did not think that there was a compliance with regulations as a part of green skills. Rest of the skills and knowledge mentioned they agreed on as being complained with green skills.
As for the Data scientist the FG agreed with the result of this report.

7.4 Skills supply for the Green transition

Review of the main trainings allowing to develop these occupations: at least in two of the most relevant countries for the sector.

The Blueprint project ASSETs+ developed a roadmap that described the evolution of the technological domains in the near future according to the maturity level of the technologies and the deference related skills.

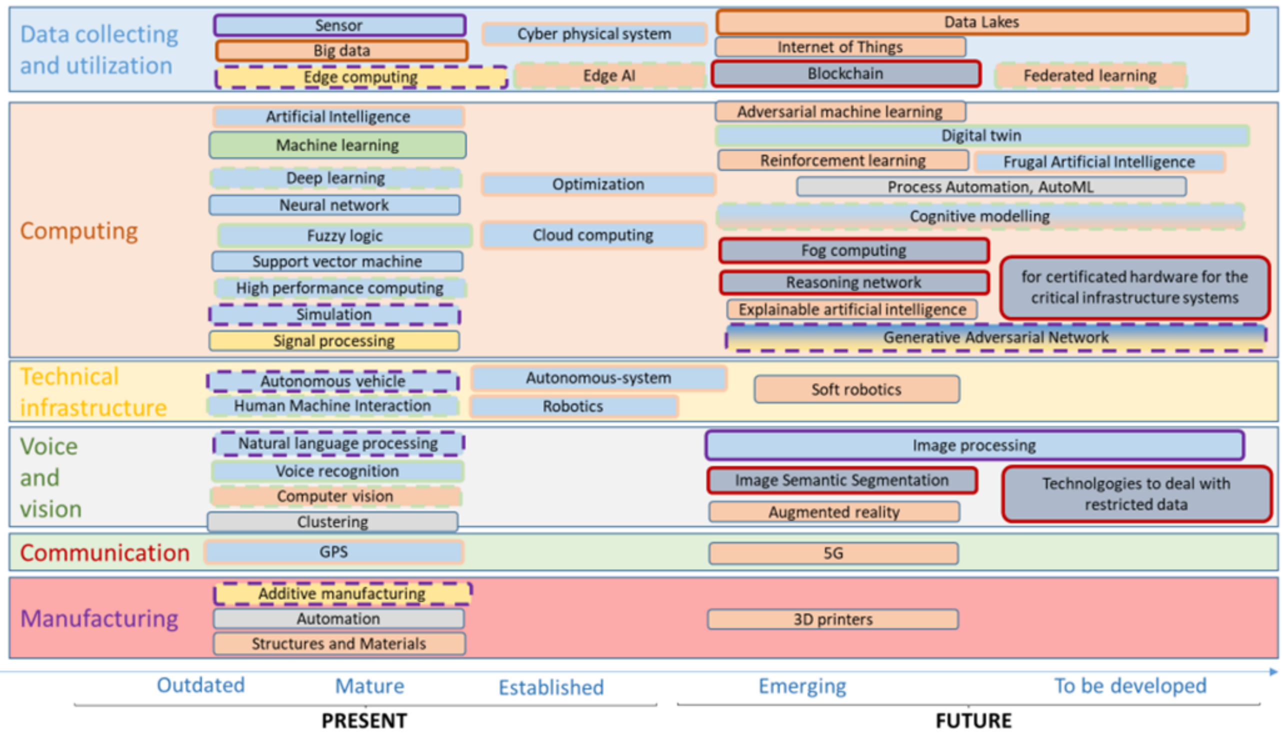


Figure 11 - Artificial Intelligence, Robotics, Autonomous Systems Technology and Applications Roadmap.

Source: (ASSETs+, 2020)

Just as important as the technical skills is the transversal skills. It is important for the employees within the defence sector to work in different work environments, to communicate and collaborate with others. The transversal skills are often mentioned as the “21st century skills” and are e.g., critical thinking, conflict management, problem solving, collaboration, and scientific- and ICT Literacy.
All skills which are needed in order to meet the need for addressing the demand of innovation, sustainability and efficiency.

7.4.1 Conclusion on the Skills supply for the Green transition and the FG

The FG discussed how the industry and the training providers could collaborate in order to ensure the green transition. The general opinion was that the **industry should be more involved** in the process of both identifying the green skills and in the development of the educations.

The FG pointed out that the industry experts should be directly involved in the development for the education, as well as offer internships and cooperative education. This to ensure that the workers are prepared to meet the needs of the industry.
This means that there need to be more **collaboration between education and the industry**, also when it comes to collaborative research projects and involvement of industry professionals in the educations e.g., guest lectures.

The FG discussed which training areas that needed the most improvements. Here the measuring and assessing environmental impact were considered as most important to look into as we need to be aware of the consequences of our industry. That's also why the 2nd most important areas are considered to be integration of sustainability across disciplines and adaptation of rapid technologies changes. This in order to change the development and adapting the green skills and competences to the educations.

To accelerate the green transition, the FG considered the teachers, trainers and intermediated middle-management needed to be educated in the green transition to improve their green skills and competences before meeting the students and workers when educating in green transition.

The FG considered the blended educations as the most relevant when talking about adapting the green skills and competences. They argued that the involvement of the industry needed to be strong in order for the workers to adapt the green skills and competences. That's why the life-long learning is also considered to be important as the workers in the companies need to be up-dated on the development within the green transition.

The FG argued that both technical training for the green transition and the awareness raised and the motivation for the green transition is important when training both students and workers.

7.5 Defence sector results and conclusions

The defence industry covers a lot of different work areas, which all have a crucial impact on our educational systems and the collaboration between HE, VET and industries. The special characteristic of the defence sector is that the companies working for the defence sector also produce for the civil sector. It contains some large multinational companies collaborating with a large range of small companies all over the EU, this makes the defence sector important to a lot of European countries, and it's also influenced by a lot of educational systems. The defence industry is mostly led by a small number of companies that have the capacity to design, develop and produce complete systems.

These companies exist alongside small and medium businesses that are specialized in the design and/or production of various subsystems that are incorporated into the supply chain of the driving forces for their subsequent integration.

The production of defence materiel represents a great responsibility and is subject to strict regulations. This means that the companies' products have to comply with military standards, which means that there is a specialized train in the companies or at the VET or HE sector across Europe which has some similarities. **Defence industry covers everything from land, sea and air capabilities to huge electronics**

and cybersecurity. The Defence sector in Europe is a large and complex joint of industries that provide a variety of products and services to the military and other government organizations. The Defence sector in Europe employs thousands of people and generates billions of euros in revenue each year.

Companies who have the necessary know-how and expertise are able to develop and support the equipment the armed forces need to cope with the threats they may face. Those companies usually also do business with other sectors, mainly in security, space and aeronautics. All these sectors have a role to play in sustainability since some of these companies contribute to the green transformation for example, by monitoring the greenhouse gases emissions, by contributing to digital transformation, by driving innovation in technologies required for carbon free emissions, etc.

Defence industry employees work across all the stages of the defence equipment life cycle, but some of the most relevant stages in relation to the green transition is suggested to be:

- **Naval architects**
- **Mechanical engineers**
- **Crew members**

When engineers are provided with the necessary green skills / knowledge to innovate when designing ships, then they will be able to improve the sustainability of ships. Naval architects equipped with the right knowledge and skills for sustainable development can improve energy efficiency. For example, creating an efficient design modifying a fossil fuel-based power generation plant, using renewable energy adapted to the military environment or using smart energy management systems.

With the correct green skills, mechanical **engineers can plan and adapt processes** to ensure that resources are used in the best way possible according to the energy constraints. These changes incorporated in products can imply that it is necessary to train militaries in the use of this new products.

In the ASSETs+ project the suggestion for the most relevant occupations within the defence sector is:

- Aerospace engineer
- Database designer
- Database scientist
- Software architect

All align with the Naval architect and/or the Mechanical engineer. All the Essential skills and competences as well as Essential Knowledge are mostly to be considered as skills. Some of these are also considered to be transformed to green skills. The most important skills in this transformation are the **transversal skills – "21st century skills**", as these occupations are innovative and **focusing on development of new technologies to the defence sector**.

7.5.1 Conclusion on the FG meeting

The FG meeting was an online meeting with participation from 4 different countries. Both industry and VET were present, in total 5 people participated in the meeting. This is to be considered as too small a FG in order to make the validation of the report result. Afterward we did one interview with a company, this didn't bring any new information to the result of the FG.

This FG result is missing the input from the HE, this is to be considered a weakness according to the result of the FG-meeting.

8. The Energy sector

This section addresses the energy industry, in particular the production of electricity from renewable sources (NACE CODE 35.12), mostly concentrated on solar energy.

Energy is undeniably among the paramount services that profoundly contribute to our overall well-being. Currently, energy production is produced from finite resources such as fossil fuels which release greenhouse gases and have detrimental effects on our planet. There is an evident need for the advancement of new energy supply technologies to facilitate the utilization of high-energy devices by humanity [1].

Renewable energy sources harness energy from inexhaustible materials, ensuring a continuous and sustainable supply. Their usage will significantly reduce carbon dioxide emissions and provide a wider range of energy supply methods. One of the key technologies involves harnessing light energy from the sun in a process known as the photovoltaic (PV) effect. PV systems are made of semiconductor materials and the light energy of the sun to produce electricity. Recent technologies involve rigid materials that can be installed on rooftops and land lands while also flexible materials that can be used as façade materials for windows in houses. Moreover, solar thermal power plants harness the sun's energy through an ingenious process involving the use of mirrors to concentrate sunlight, generating intense heat. This intense heat is then utilized to produce high-pressure steam, which in turn drives turbines to generate clean and renewable electricity.

As per findings released by the International Energy Agency (IEA) [2], it is projected that solar energy production will achieve a significant milestone in the terawatt (TW) scale, notably around 4.8 TW, by the year 2026. The EU strategy for solar energy has set an ambitious plan of achieving over 30 GW of solar PV by 2025 [3]. Solar thermal power production has also seen the installation of approximately 2.3 GW of concentrated solar power capacity since the year 2013 in EU countries. However, in contrast with PV, most of the concentrated solar power projects have moved to countries outside the EU. Nevertheless, the high energy supply of solar power systems underscores its pivotal role as a key driver in the realm of renewable energy supply. The enhancement of the performance and the lifetime of solar energy systems would be crucial in achieving the EU goals. Some key technologies, devices and innovations will include:

Solar system design and installation

As solar systems will be in great demand towards the future and the EU stresses the importance of using the sun's power to produce renewable energy supply, a significant number of systems would require designing and installation to increase the renewable energy supply. Modelling should also be considered to enable the user to estimate and optimize the power supply by the solar systems according to the meteorological conditions mentioned. The estimation of the energy supply and demand of each household would be crucial in determining the size of the solar power plant required for the house.

Autonomous failure detection devices and digitalization of the system

A downside of PV systems is the various faults that can be encountered due to exposure of the systems to different environmental, electrical and structural circumstances. These issues lead to a significant decrease in the PV performance [4]. Using data from electrical and meteorological sensors with different algorithms could help in the detection of faults such as short-circuit, and open-circuit faults occurring and notify the operator as fast as possible. This would decrease the loss in output due to the faults caused to the system. Furthermore, using image processing algorithms could also help identify issues not detected by data-driven processes such as cracks, hotspots, defective bypass diodes and module wiring [5].

Online-based algorithms have already been developed to detect faults in photovoltaic systems, as demonstrated in [6]. This aligns seamlessly with the EU's overarching vision to revolutionize the energy grid into a state-of-the-art digital infrastructure. The digitalization of the system would allow a more automated approach to fault detection where all the electrical, meteorological and imaging data would be collected for analysis. The detection of issues encountered by the systems would be pivotal in sustaining solar energy production over the years.

Use of energy storage devices

The energy supply of PV systems can vary greatly throughout the day, as the PV power output is mainly dependent on solar irradiance and temperature. The use of energy storage devices would prevent grid outages in times of extreme energy supply from the PV systems and allow usage of excess energy in hours when the electricity demand is higher than the electricity supply. The types of energy storage devices include electrochemical systems (e.g., battery and fuel cells), mechanical systems (e.g., flywheel) and thermal systems (e.g., molten salt and heat pumps) [7]. A study of the renewable energy demand and supply of each application would help determine the most suitable energy storage technology.

Research into new materials

Crystallised Silicon (c-Si) solar panels have been dominating the market of solar panels. Some of the key characterisations of silicon that affect panel efficiency include the silicon type, busbar configuration, junction and passivation type (PERC).

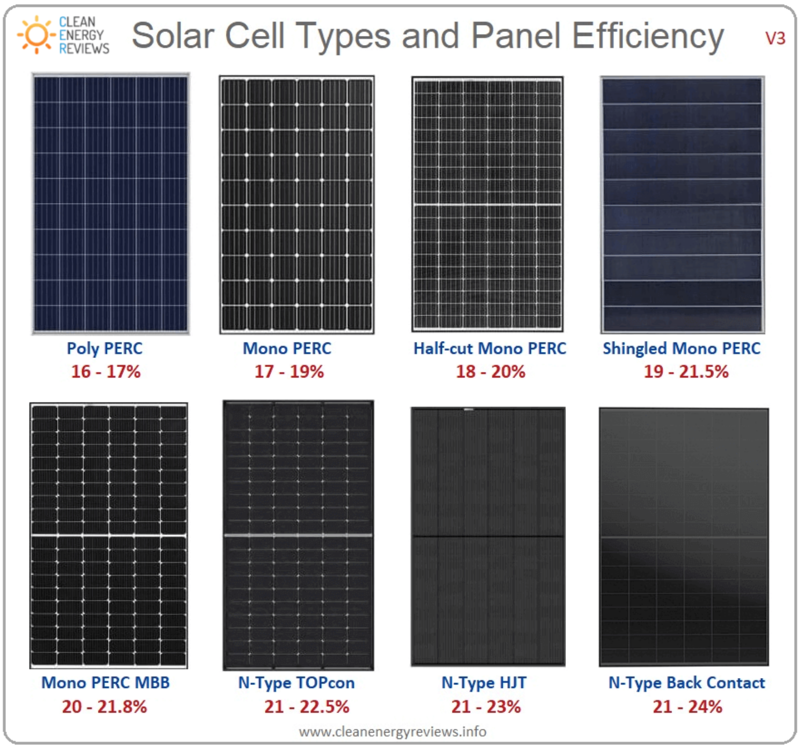


Figure 1: Figure showing all the silicon panel types and their related efficiencies (taken from [8]*)*

For example, panels built using Back-contact (IBC) cells are one of the most efficient silicon cells (23.8 %) because of the exceptional N-type purity and zero no shading issues from busbars. Another type includes the N-type TOPcon (23.8 %) and complex heterojunction cells (22.8 %) that have achieved efficiencies also close to the 23 % [8]. All the types and their related efficiencies of silicon cells are depicted in Figure 1.

However, even the most efficient crystalline Silicon panels (26.7 % [9]) have a relatively low efficiency and has driven researchers to investigate new combinations of materials involving perovskites. The combination of tandem cells where silicon and perovskite are utilized with a current record of around 36 % involves one of the best options for high-efficiency reproducible solar panels [10]. Another material utilized for solar panel production is single-junction Gallium Arsenide (GaAs) which has achieved an efficiency lower than tandem cells but higher than crystalline silicon (30.8 %). The highest efficiency of all materials is achieved using multi-junction cells that reach a value of 50 % [10]. On the other hand, multi-junction materials have a very complex process and are very expensive to produce.

Due to the low efficiency or reproducibility of current solar cells, it becomes imperative to explore novel materials capable of attaining significantly higher efficiencies with reduced manufacturing time. Furthermore, it is crucial to tackling the challenge of recycling these materials, as towards the end of their lifetime, materials would be useless for other applications and thrown into waste.

Smart grid integration

To enable the successful installation of solar systems for energy supply, the configuration of the grid should enable the usage of smart devices to match the energy supply and demand of the area during the day using smart devices. Monitoring the energy demand of each system would be essential in minimizing the extra energy needed from non-renewable sources, especially in times of peak demand.

Developing these technologies through innovation is one of the key tools in achieving the EU goals for sustainable energy production. The growing demand for solar systems and the enhancement of their efficiency presents a significant opportunity to achieve a carbon-neutral society.
Feedback from 4 experts (see Annex 8.1 for participants) in the energy sector was gained through short discussions and a voting in Mentimeter. The results for the description of the energy sector are shown in the Annex 8.2.
234Although all 4 participants agree with the energy sector's description, research into new materials and smart grid technologies are chosen as the most likely to be removed. For technologies to be added to the energy sector, there is a suggestion to include more data on solar thermal systems, since the energy transition will not be accomplished without addressing thermal requirements. Furthermore, more information on smart technologies such as **smart energy management systems** and **smart electrified mobility should be included**. Taking all these inputs into consideration, research into new materials should be excluded from the main technologies, and an attention towards thermal systems including solar thermal systems and heating devices for households and PV systems should be added. Additionally, smart electrified mobility that includes electric cars and buses should not be added since it would be mainly included in the Automotive Focus Sector.

8.1 Sector general overview

Producing energy from renewable sources is one of the key transitions that would enable our transition to a green economy. Energy is needed for fulfilling the basic needs of modern society including transportation, heating and cooling and producing electricity. As we can see from Figure 2, it is evident that more work is essential to meet the EU target of 2030 for renewable energy, as most countries produce more than 50% of their energy from non-renewable sources. Wind and hydro produce the greatest share of renewable energy supply (37.5% for wind and 32.1% for hydro [11]). Furthermore, solar energy systems have been on the rise in the last decade being one of the fastest-growing energy supplies [11]. Solar power's increased productivity and the major decrease in cost (about 82% over 2010-2020) have made solar energy systems one of the most attractive energy supply technologies for the whole EU [3].

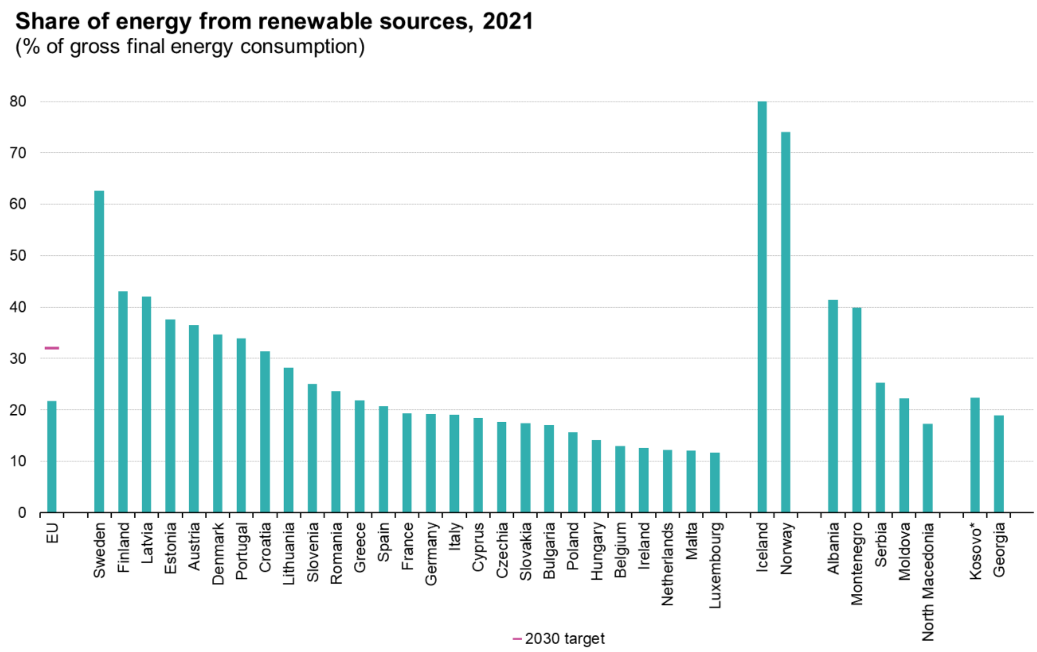


Figure 5: Figure showing the share of energy from renewable sources for each EU country in 2021. Taken from the European Commission website [12].

Figure 3 shows the top EU countries in solar power production in 2022 and their corresponding increase from 2021. As reported by Bethany Meban [13] solar power has shown an incredible 47% growth compared to the 2021 production.

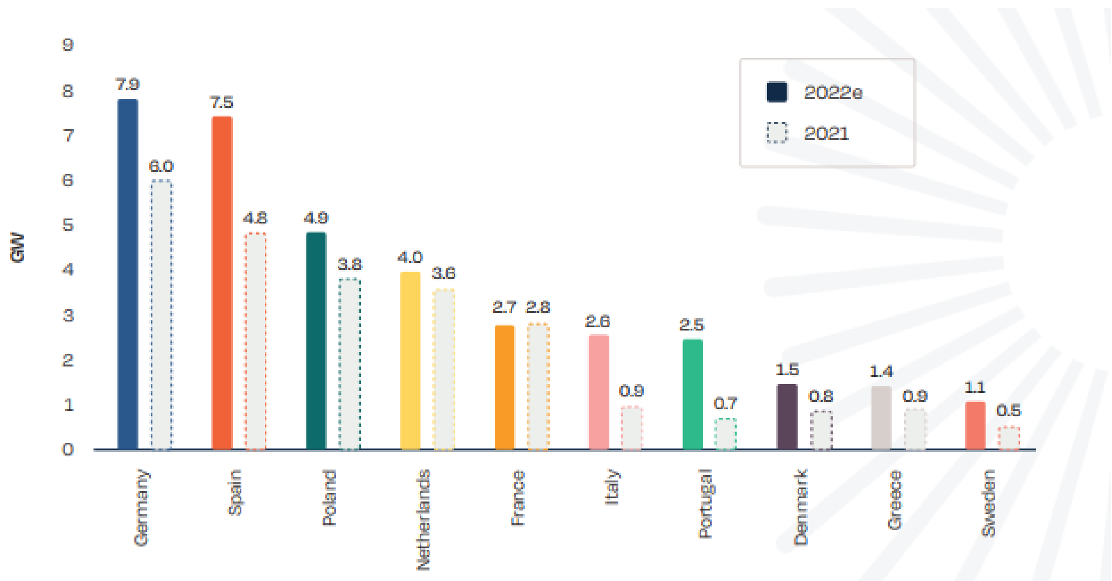


Figure 6: Figure depicting the solar power production in GW of the top countries in the EU. The corresponding values are shown in both 2021 and 2022. Taken from [14].

Germany and Spain are the EU leaders in solar power production, reaching values very close to 8 GW. Due to the high amount of daylight, Spain has taken advantage of solar power and has demonstrated the potential of efficient solar systems. Despite receiving a decreased amount of sunlight per year (relatively), the Netherlands ranks 4th. The Netherlands has introduced floating solar installations on artificial lakes, covering approximately 20% of the country's area with solar panels and generating a high electricity output [15]. Therefore, their innovations and key technologies could position them as significant contributors to meeting the ambitious solar power goals of the EU.

Figure 3 does not consider the population of each country and the solar power production is higher in countries with increased population and land. Therefore, the solar power per capita is depicted in Figure 4 to account for those discrepancies.

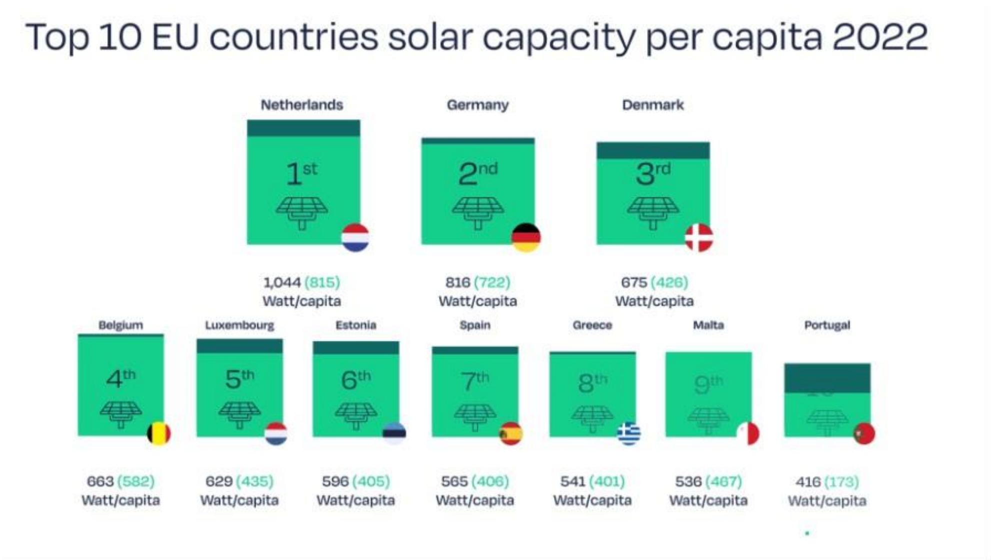


Figure 7: The top 10 countries with the estimated solar capacity per capita for the year 2022. Picture taken from [16].

The Netherlands and Germany have been clear frontrunners in this category. Additionally, Denmark has unleased the potential of solar energy, despite having a low solar energy potential. Denmark produces above average share of its energy from renewable sources, making it a key country in enabling the green transition in the EU over the next years. Despite its relatively low solar power production per capita, Spain is still regarded as a significant player in the field, primarily because of its substantial solar energy production and the significant photovoltaic power potential, particularly in the southern regions (refer to Figure 5). Another country that must be taken into consideration is Cyprus. Cyprus has the highest solar power potential of any country, averaging about 3300 hours of sun per year [17]. As depicted in Figure 5, Cyprus has one of the highest potentials for PV power production and the fulfilment of this potential would decrease significantly the carbon emissions. Furthermore, several EU projects such as PANTERA (CSA, ID: 824389) BERLIN (ENI CBC Med, ID: A_B.4.3_0034), TRUSTPV (IA, ID: 952957), AID4PV (RIF, P2P/SOLAR/1019/0012) and ERIGrid II (RIA, ID: 870620) [18]–[20] for innovation and research undertaken in Cyprus, therefore in the next years, it is expected that solar energy production will rise exponentially with the implementation of the knowledge gathered from this projects.

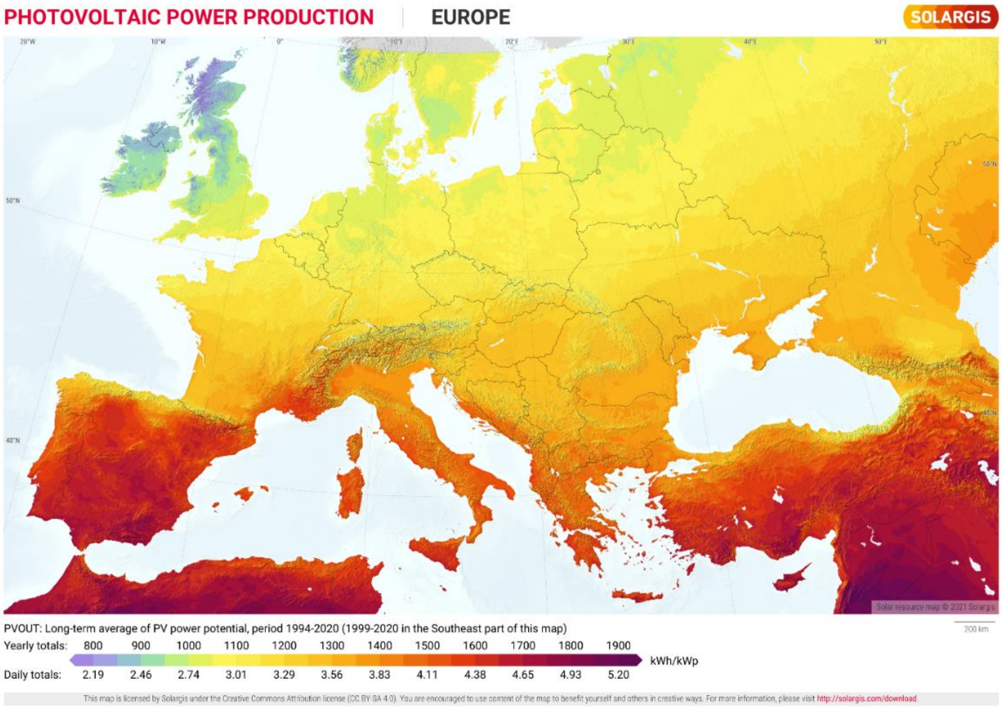


Figure 8: PV solar power potential of the EU countries. Picture taken from [21].

The key countries for the energy transition were selected due to 2 parameters which were:

- Highest solar power production, and
- Hours of sunlight per calendar Year.

Therefore, taking the parameters and the data found into consideration the top 5 countries that should be selected for the energy transition are:

- Germany,
- Spain,
- Denmark,
- Netherlands,
- Cyprus.

The innovation of solar power in all EU countries and their contribution to renewable energy production will be crucial in achieving carbon neutrality by 2050.
91011The feedback of the energy experts concerning the country selection is depicted in Figures 8.2.4-8.2.6 (see Annex 8.2). There is one disagreement with the selection of countries, however, all experts agree that the selected countries are important. The addition of countries for the green transition in the energy sector include the **Mediterranean countries** (Greece and Italy) which like **Cyprus**, have a high potential for producing solar energy. Additionally, **France** that is included in the top 10 countries for solar power production in years 2021 and 2022 (see Figure 3) should also be considered according to experts. **Latvia** was surprisingly included in the selection of key countries since it did not appear in the top 10 Eu countries of both solar power production and solar power per capita. Although the

country has fallen behind in solar energy production compared to EU countries, a renewable energy company (Green Genius) is set to invest a lot of money to build a 100 MW in Latvia [22] , significantly increasing the energy production. Therefore, the selection of countries should expand to include more than 5 countries and especially Mediterranean countries and Latvia that will have huge investments in the following years should be included in the key countries.

8.2 Key occupations for the Green Transition

To facilitate the green transition, several occupations will experience a surge in demand, and numerous job opportunities will emerge in connection with sustainability initiatives. As mentioned previously, the digital transformation of energy would be an important tool in achieving a sustainable and efficient system. Resources should be allocated towards energy efficiency, data processing, maintenance of equipment, distribution and transmission systems to enable digitalization of the grid. The EDDIE project [23] outlines the importance of the blending of digital and green skills to enable an efficient transition to a green future. Given the ambitious EU goals set for solar power and the exponential rise of solar power production over the last year, the following occupations were considered the most important for the Green Transition:

Energy systems engineer

The role of an energy systems engineer would be to perform an analysis of the building needs and enable smart grid integration of renewable energy sources. The knowledge of the energy systems engineer would prove crucial in modelling the solar panels while also having adequate theoretical knowledge to identify potential faults. Additionally, as mentioned previously, energy storage systems and grid integration would be paramount in the matching of energy demand and supply at different times of the day. For grid-connected PV systems, energy systems engineers should design systems that can safely and seamlessly interact with the utility grid. This involves synchronizing the system's AC output with the grid's voltage and frequency and implementing protection mechanisms during grid outages. They could also be involved in designing heating and cooling systems, performing scientific research to consult users and designing passive energy measures according to the Electrical Power Safety Regulations. In the future, energy systems engineers should be able to work with data to enable efficient use of the grid to maximize its performance.

Solar Energy Technician

Solar Power Installations have never been higher in history. According to SolarPower Europe [24], it is anticipated a global installation of solar power ranging from 341 GW to 402 GW in 2023. The trend of increased adoption of rooftop solar systems is also projected to persist, with an additional 159 GW expected to be set up during the same year. This means that experts in installing and maintaining photovoltaic systems would be in great demand for the operation of all these systems. Solar Energy. As the number of systems increases, the faults increase, therefore more technicians would be needed to fix the faults encountered as soon as possible to ensure maximum performance. Technicians would be more involved with the hands-on tasks of ensuring the safety, performance and integration of solar systems in the grid. Their input and expertise would be important in designing solar energy systems with reduced probabilities of faults occurring. An additional skill should be the technician's skill to acknowledge errors from the digital data acquired and be able to have specialised expertise in solar systems.

Research Engineer
As photovoltaic solar cell efficiency remains at a relatively low value (the efficiency for tandem cells in research has reached values greater than 29 % [25]), innovation and research into new materials that with higher efficiency while being also recyclable would allow reduced waste materials and increased energy production. Additionally, improving existing solar systems, analysing processes and conducting experiments could prove beneficial in maximizing the potential of solar energy. Additionally, work on new energy storage systems such as hydrogen could be essential in storing energy at low cost and enabling its usage at a later stage when the energy supply would be less than the energy demand. As machine learning and digitization will be key issues of the future, research engineers should be able to have programming skills and perform data analytic procedures with great accuracy and speed.

ICT Security Engineers
Cybersecurity plays a pivotal role in establishing a sustainable distribution system. With the growing volume of data processed and accessed digitally by multiple users, it becomes increasingly crucial to bolster security measures. These safeguards are essential to foster trust between producers and consumers as we progress into the future. Skills such as an ICT security technician and ICT networking hardware would be essential in building a secure network from potential hacking attacks. ICT security engineers act as the guardians of information within a company or product, holding the responsibility for safeguarding the associated systems. Their role entails overseeing the security aspects of networks and systems, as well as devising, strategizing, and implementing security architecture, which encompasses reference models, and solution architectures, as well as security policies and protocols.

Although all 4 experts agreed on the key occupations, the research engineer should be removed from the key occupations that would enable the green transition. 3 of the experts prefer to add the **Project engineer** occupation instead of the Research Engineer, which will be the 4th main occupation for the green transition.

1213148.3 Skills for the Green transition in the key occupations

After identifying the key occupations that would drive the Green Transition in the Energy sector, it is important to consider which skills would be important for each occupation. A list of skills and knowledge is split into the essential and optional. The green skills as identified by the ESCO database are given a Green colour for distinction. The main layers of the skills required for the green transition include **communication, creativity, information and working with computers skills**. Additionally, hands-on occupations such as technicians in the field should also work with machinery and specialized equipment, either connected to the software or the hardware part. Using the ESCO database, the following skills and knowledge categories were identified for each occupation:

Table 1: Essential and optional skills and knowledges of the key occupations for the green transition

Occupation	Essential Skills and Knowledge	Optional Skills and Knowledge

Energy Systems Engineer	• Promote sustainable energy, • Environmental engineering, • Renewable energy technologies, • Energy performance of buildings, • Solar energy, • Smart grid systems, • Perform energy simulations, • Determine appropriate heating and cooling system, • Adapt energy distribution schedules, • Carry out energy management of facilities, • Identify energy needs, • Promote innovative infrastructure, • Design electric power systems, • Adjust engineering designs, • Approve engineering design, • Inspect building systems, • Manage engineering project, • Troubleshoot, • Use technical drawing software, • Electrical power safety regulations, • Perform risk analysis, • Perform scientific research.	• Design passive energy measures, • Use data processing techniques, • Analyse big data, • Work with computers.
Solar Energy Technician	• Install concentrated solar power systems, • Install electrical and electronic equipment, • Install photovoltaic systems, • Mount photovoltaic	• Determine the suitability of materials, • Install automation components, • Maintain solar energy systems, • Analyse big data, • Work with computers.

	panels work ergonomically, • Solar energy, • Types of photovoltaic panels, • Provide information on solar panels, • Follow health and safety procedures in construction, • Use measurement instruments, • Check compatibility of materials, • Comply with legal regulations, • Follow safety procedures when working at heights, • Inspect construction supplies, • Inspect electrical supplies, • Install circuit breakers, • Interpret 2D plans, • Interpret 3D plans, • Test procedures in electricity transmission.	
Research Engineer	• Execute feasibility study, • Collect samples for analysis, • Gather experimental data, • Use technical drawing software, • Engineering processes, • Define technical requirements, • Interpret technical requirements, • Manage engineering project, • Scientific research methodology, • Perform scientific research.	• Use data processing techniques, • Use non-destructive testing equipment, • Analyse big data, • Run laboratory simulations, • Assist scientific research, • Apply safety procedures in the laboratory, • Materials science, • Physics.
ICT Security Engineer	• Ensure information security,	• Optimise choice of ICT solution, • Implement anti-virus software,

	• Manage IT security compliances, • Monitor system performance, • Perform data analysis, • Perform risk analysis, • Report test findings, • Troubleshoot, • Verify formal ICT specifications, • ICT security legislation, • ICT security standards, • Attack vectors, • Business analysis, • Cyber-attack countermeasures, • Information architecture, • Information security strategy, • Unstructured data, • Manage digital identity, • Keep up with the latest information systems solutions, • Keep task records, • Analyse ICT system, • Define data quality criteria, • Define technical requirements, • Define security policies, • Operating systems, • Organisational resilience, • Risk management, • Develop information security strategy, • Educate on data confidentiality, • Identify ICT security risks, • Identify ICT system weaknesses, • Implement ICT risk management, • Manage disaster recovery plans, • Execute ICT audits, • Execute software tests,	• Implement a firewall, • Implement a virtual private network, • Implement spam protection, • Safeguard online privacy and identity, • Internet of Things, • Cloud Technologies, • Cloud monitoring and reporting, • ICT encryption, • Web application security threats.

	• Provide ICT consulting advice, • Cyber security, • Emergent technologies.	

For the Energy systems engineer, a lot of suggestions for additional skills to be added were made. This included **power electronics, big data analysis, energy market analysis, energy storage, automotive** and **hydrogen technologies**. This is in line with the suggestions for the energy sector's description where most attention should be paid toward electrifying transportation and include power electronics to enable a better integration of smart technologies into the grid. For the solar energy technician, the experts seem to agree with the skills and knowledges proposed, but would include **market analysis, legal, data quality** and **analysis skills** in the list. This would enable the solar energy technicians to be in line with the current market demands and regulations, installing solar systems up to current EU standards. For the other 2 occupations, energy experts agreed and did not propose any new skill or knowledge to be added.

15161718192021228.4 Skills supply for the Green transition

Training should update and cover the most important skills discussed in the previous section. As previously identified, working with data, specialized equipment knowledge as well and strong communication would be crucial in ensuring the green transition. The staff were divided into 3 categories:

- managers/administration
- engineers/researchers
- technicians/specialists

Further information about the occupations that fall into each category can be found into Annex 1 of the EDDIE project [23]. Regarding a general overview of the engineers, researchers and technicians' roles it was found that there is a strong demand for "Accessing, analysis and visualization of data" skills, agreeing with the aforementioned significant skills for the energy transition. For technicians, it is highly demanded that they have the "Administration of hardware infrastructure" skill, enabling the safe operation of hardware devices and allowing a safer transition to the digitalized energy grid. Cybersecurity has depicted a strong demand by companies, as data protection would be essential in a digitalized system. Regarding **transversal skills** which include **problem-solving, communication, planning and organization**, it was found that managers and engineers should have higher skills compared to technicians. Skills such as "Leadership" and "Customer Handling are the most important for managers, whereas for engineers "Ease of Learning" and "Innovation and Creativity" are some of the most crucial abilities to have. For all categories, "Team Working" is considered essential and should be included in all learning institutions. The results of the demand and supply of the skills for each job category are summarized in Figures 6-8.

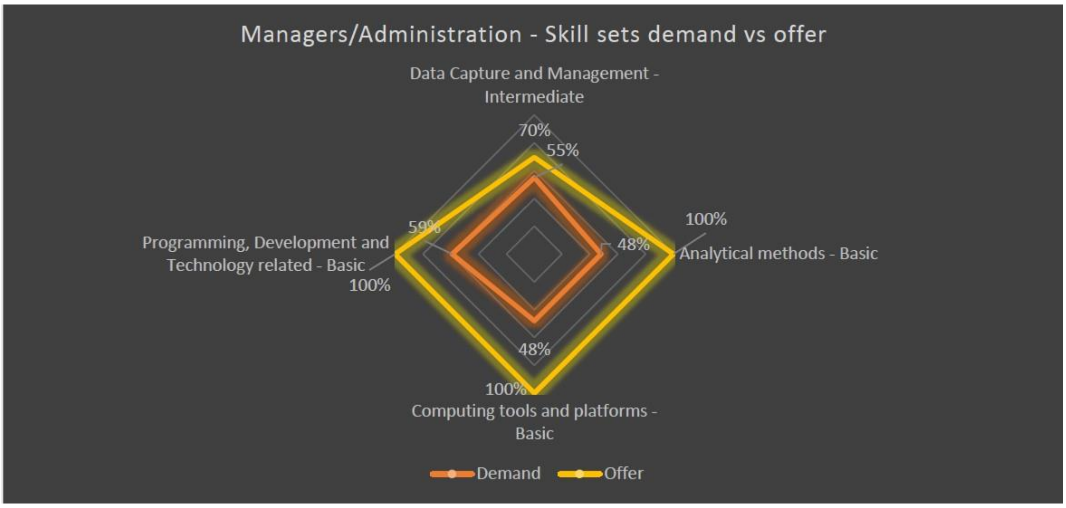


Figure 23: The skill demand and supply (offer) of different skill set categories for Managers/Administration [23].

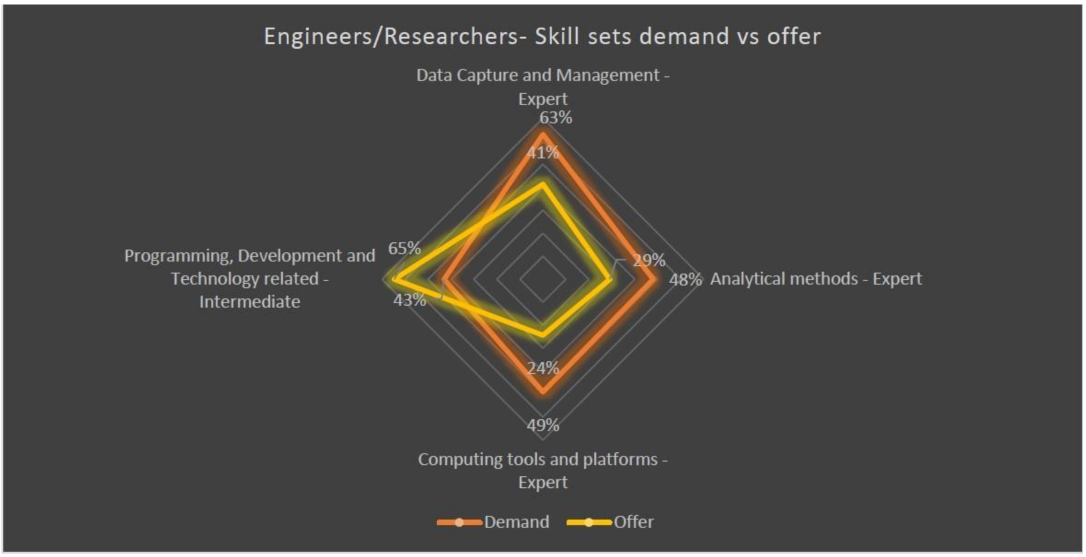


Figure 24: The skill demand and supply (offer) of different skill set categories for Engineers/Researchers [23].

Figure 25: The skill demand and supply (offer) of different skill set categories for Technicians/Specialists [23].

An important conclusion of the interviews conducted as part of the EDDIE Project is the high value given to resilience and adaptability in the curricula of both education and training providers. In addition, educational programs should be repurposed to energy-related master's programs, where the global energy challenges will be discussed. The change of master's programs towards problem-based or challenge-based learning that works on economic, business and social issues should be one of the key strategies of the future. There is also a recommendation to create more specialist programs (80/20 when compared to generic) to enable the program to be more tailored towards the employers' needs. Some of the main topics that should be discussed in the program should be energy efficiency, smart grid and renewable energy systems. Furthermore, energy economics should also play a pivotal role in enabling students to identify market needs and understand the regulatory costs. Postdoctoral programs should be mainly focused on generating new knowledge and providing innovative solutions to the unsustainable society we are currently living in. They should mainly focus on renewables while also including long-term implementations in the Smart Grids section.

The findings of the EDDIE project [23] show a great review of the training programs available in 2 of the key countries discussed before (Germany and Spain). Regarding Germany, it has conveyed the lowest expertise demands. The highest demand in Germany is in the "Data capture and Management" sector which includes skills to evaluate and manage data, information and digital content. It was also considered as one of the highest skill demands in all 5 countries examined by the project. Germany has shown a great assessment of its learning sector, having a high ranking between Level 6 and Level 8 in the European Qualifications Framework (EQF) (ranges from 1 to 8 with 8 being the highest level). Many programs exist already in both Bachelor and Master levels that cover a wide range of topics such as energy engineering, the Internet of Things (IoT), renewable energy, and smart energy. All courses have laboratories and projects that would be important in the understanding of the material from the student. A focus on digitalization includes courses on machine learning, data analytics, intelligent energy systems and cybersecurity. DUAL vocational education and training systems are noticed in German education systems, where students choose a practical or vocational path and adapt the curricula to the individual's objectives. The VET programs focus on manufacturing mechanical parts, assembling connections and distribution boards, and carrying out maintenance.

Spain, on the other hand, has depicted the greatest demand for skills compared to the countries studied in EDDIE. One of the highest demands was regarding the programming and technology skills of the individual. At the Bachelor level, specialized courses in energy engineering with less focus on automation are seen in Spain, providing students with mathematical and methodological knowledge with corresponding programming laboratories. On the master level, some courses focus on smart grids, thermal energy, and renewable energy. It should be noted that the prestige of the program plays a big role in hiring a candidate for companies which is mainly dependent on the quality and ranking of the university. A great coverage of digitalization techniques, like Germany, is noticed in Spanish universities. In Spain, DUAL programs are also noticed which focus on getting the theoretical knowledge first and applying the knowledge to company programs in the following years. Moreover, attending daily classes both in person and online helps professionals gain the knowledge required for learners. Skills that are seen in Spanish programs include assembling and maintaining telecommunication hardware in buildings, electrical installations, and automated systems, following standards and regulations, and ensuring the operation of electrical systems while having respect for the environment.

The concept of nano degrees is explored by some departments. Nanodegrees compose a specialization towards technologies such as machine learning, data science and blockchain in about 6 months. Online courses have also been a point of interest for educational institutions after the COVID-19 pandemic. 15 courses tackled the issues of smart grids, smart energy systems and cybersecurity. They are mostly highly focused and oriented towards individuals with higher level education, except 2 which had a level of 4 on the EQF scale. Some skills that should be more covered by institutions include “Changing business landscapes”, “Regulation and policy landscape” and “Enabling sustainability through Digitalization”. Additionally, security and administration issues should be covered more in the curricula of the different universities and organizations due to the path towards digitalization of the grid that would be followed in the next years. Skill gaps were also identified in the skill “Evaluate Data, Information and Digital Content” and in relatively all the analytical methods (e.g., “Perform big data analysis”, “Application of statistical methods”). Furthermore, the competencies related to "Utilization of high-performance computing resources and highly available systems," "Data access, analysis, and visualization," and "Data access, analysis, and visualization on cloud infrastructures" exhibit limited inclusion and represent skill deficiencies among candidates. The skillset “Data Capture and Management” is one of the most fulfilled skillsets in all countries except Germany. The least offered methods are summarized in the following table which is taken from the EDDIE report. In addition, you can see in Figure 9 the discrepancy between the demand and supply for each corresponding technology sector. The most significant gaps are expressed in the areas of “Digital Platforms”, “Cybersecurity” and “Cloud Services”.

Table 2: Table showing the least offered skills from Educational Providers. The table is taken from the EDDIE project report [23].

Category	Skill
Analytical Methods	Application of data mining approaches
	Perform big data analysis
Computing tools and platforms	Accessing, analysis and visualization of data
	Managing security and privacy issues on digital platforms
	Administration of hardware infrastructure (web servers, workstations, etc.)
Programming development and technology-related	Development of web applications
	Query data from the database
	System Design competence
	Blockchain skills
	Understanding of cybersecurity

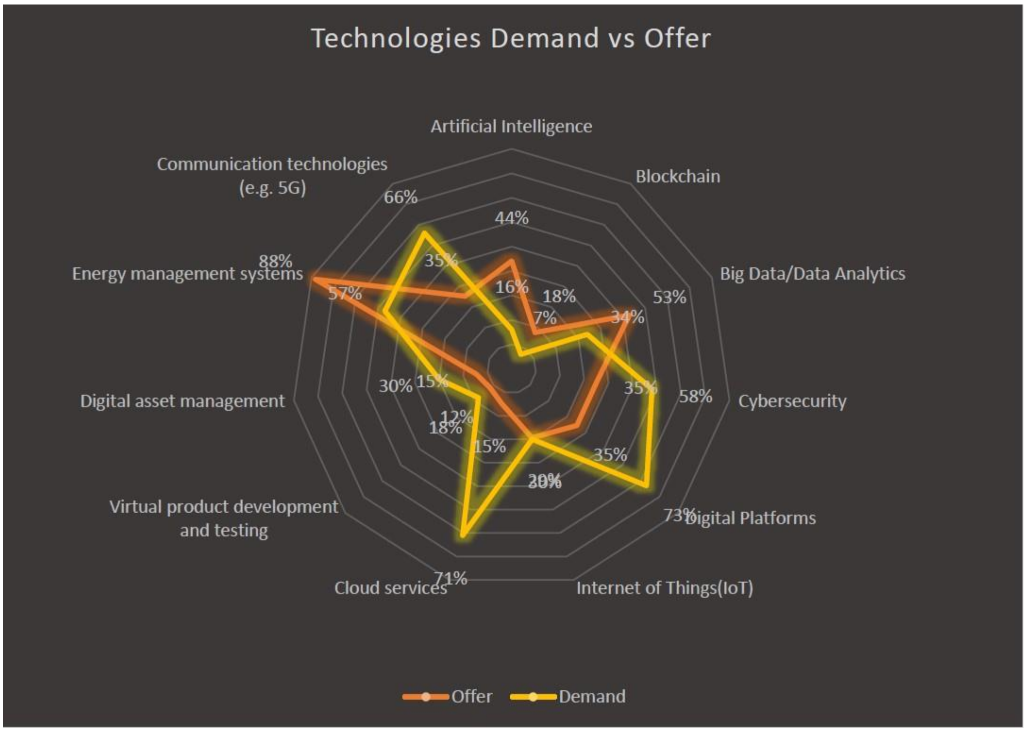


Figure 26: Figure showing the difference between technology demand and what the institutions offer. The graph is taken from the EDDIE project report [23].

Concerning the skills supply, energy experts provided valuable input into the teaching methods and the lack of skills of the labour market including students. . Areas that need more improvement included the awareness of current environmental issues, communication skills and integration of sustainability across disciplines. Therefore, more work should be added towards making individuals aware of the current environmental issues and integrating the green technologies into the industry while also working towards better communication within and outside of organizations. Adaptation of rapid technological changes and promotion of innovation is also another topic that experts wanted training institutions to give more attention.

2728The topics that should be discussed more according to energy experts include **renewable energy systems, energy storage systems** and **AI technologies**. AI systems seem to be covered in most curricula, according to the results of the EDDIE project, however, **renewable energy systems** and **energy storage systems** were topics that needed further discussion in training programs. These results also agree with the results of the previous question (Figure 8.2.18). As for the aspects that students lack, experts saw a lack of transversal skills and practical skills. More attention should be paid to providing students with more practical experience and communication skills that would enable better teamwork and results. For the **better collaboration of industry** and **academia, internships**, and **active participation of companies in the educational curricula** are effective methods to enable a better preparation of workers and students for the green transition. Additionally, experts depicted that **collaborative research projects** between academia and industry could be one of the most effective methods to increase collaboration between academia and industry. Visits and guest lectures were also voted but were less effective collaboration methods according to the voting results. The training format that was most voted for by energy sector participants included **lifelong learning and on the job training** to allow a faster incorporation of students into the workplace. Blended apprenticeships were also selected as a potential method of fostering students' involvement in a working environment.

2930318.5 Energy sector results and conclusions

Energy would be one of the fundamental sectors in ensuring the green transition and reducing humanity's carbon footprint. EU has a key objective of obtaining carbon neutrality by 2050. Therefore, **transition to renewable energy technologies** such as wind, water and solar are the main tools for this green transition. Almost all countries of the EU produce more than half of their energy from non-renewable sources, therefore innovation and awareness are important to reduce the detrimental effects of greenhouse gases.
While wind and hydro are regarded as the most fruitful energy sources, solar has gained attention in the following years showing an exponential rise in its usage over the last decade. Solar energy's reduction in cost, flexibility and clean production would prove crucial in the following years. After consultation with energy experts, heating and cooling should play a significant part in the energy sector, helping produce better solar thermal systems and increase their productivity. Solar energy produces electricity through light energy (photovoltaic effect) and thermal energy (concentrated thermal energy). Considering the amount of sunlight each country experiences and the amount of solar energy it produces annually, the key EU countries for solar energy were considered:

- Germany,
- Spain,
- Netherlands,
- Denmark,
- Cyprus.

Energy experts pointed out that more countries should be considered including **Mediterranean countries** (Italy, Greece) and **Latvia** where major investments are expected in the near future. Each EU country should play their role in this sustainable transition to green energy. Europe has set a goal of digitalizing the energy grid to enable a more sustainable and efficient energy network. The installation and maintenance of solar systems are expected to increase in the following years. Furthermore, security procedures should be followed to enable the protection of data processed by the grid. The key occupations for the solar energy sector were:

- **Energy systems engineer** to consult and aid individuals in the solar energy systems according to the standards and regulations of the EU,
- **Solar energy technician** for maintaining, installing, and allowing safe operation of solar energy systems,
- **Research engineer** to increase innovation and the understanding of renewable energy sources and smart grid technologies,
- **ICT security engineer** to enable better security of the grid and administration of hardware devices.

After review from the energy experts, research engineer was considered as a secondary occupation and a more managerial role like the one of a **project engineer** should be included in the key occupations. Using the ESCO database, the skills for each occupation were extracted and categorized into green skills. Future skills for the occupations to be ready for the digitalization of the system were also included. Concerning the skills for each occupation, the **managerial skills, marketing, power electronics** and **energy storage systems** should be included in the Energy systems engineer, whereas for the solar energy technician it is very important to know **data quality** and **processing skills**. After identifying the skills and occupations necessary for the green transition in the Energy sector, an overlook of the skills supplied by different educational institutions in academia and VET was conducted for Germany and Spain. Germany was found to have the least skill deficiencies, while Spain had the largest skill deficiencies. Both educational and VET programs provide a good theoretical background of both green and digital skills required for a carbon-neutral future. This is done through both in-person and online courses while also a variety of practical exercises is provided to the learner through assignments and projects. However, skills that should be more covered by institutions include "Changing business landscapes", "Regulation and policy landscape" and "Enabling sustainability through Digitalization". Additionally, security and administration issues should also be addressed more in the curricula of the different universities and organizations due to the path towards digitalization of the grid that would be followed in the next years. The summary of skill gaps and a schematic of the supply and demand of each skill and different technology sectors can be found in Figures 6-9 and Table 2. Energy experts have identified **transversal** and **practical skills as the main skill gaps** of current graduates. To facilitate this, **better cooperation between academia and industry is needed** that can happen more effectively through collaborative research projects, internships as part of the curriculum, active participation of industries in educational material and joint meetings between the 2 types of institutions. The topics of renewable energy systems, energy storage systems and AI should be discussed further, while also better awareness of the current environmental issues and integration of sustainability across disciplines should be included in educational curricula. Finally, energy experts support **life-long learning** and **on-job training** as methods of better incorporation of students into industry. Addressing the skill gaps will be crucial for a sustainable and digital transition in the coming years, aimed at mitigating the adverse human impacts on the planet.

9. The maritime technologies sector

This section addresses maritime industry, in particular **shipbuilding (NACE CODE 30.11)** and **offshore renewable energy (NACE CODE 35.11)**, which are strongly linked and require of new capacities built to succeed in an increasingly digital, green and knowledge driven economy.

Currently around the 90% of the world's trade is transported by international maritime transport. Although ships are pollutant, they represent the most efficient transport in terms of carbon emissions per transported ton. Despite of this fact, the size of the ship themselves and of global fleets as a whole, make vessels and maritime transport one of the sectors upon which we have to act in order to achieve a greener future. A major part of the solution will be increasing ship efficiency through the new maritime technologies. These maritime technologies include:

- The use of alternative fuels

The use of alternative marine fuels such as liquefied natural gas (LNG), biofuels, hydrogen, and ammonia are an important strategy to reduce the carbon footprint of vessels and the sector's reliance on fossil fuels.

- On shore power supply

While in port, ships keep their auxiliary engines running to have the power needed to operate their systems. Auxiliary engines usually consume diesel or heavy oil, and generates both, exhaust gases and noise. Shore power is a key factor in green shipping. Connecting the ships to on-shore power supply at berth reduces significantly the emissions of air pollutants from auxiliary engines.

- Ship Design and ship building

Improved design and operation can help to reduce greenhouse emissions from ships. Technological solutions that improve energy efficiency, both in machinery (such as propulsion systems) and on board vessels (including lighting and other appliances), are being explored.
The International Maritime Organization IMO introduced two mandatory energy efficiency standards for ships: an energy efficiency design index EEDI for new ships (technical measure) [1] and a ship energy efficiency management plan (SEEMP) for all ships (operational measure) [1]. The index gives a ship's estimated emissions of CO2 per unit of traffic work.
In addition, since January 2023, the IMO has introduced the Energy Efficiency Existing Ship Index (EEXI) measurement, which will be mandatory for each ship, as part of the yearly assessment of their carbon intensity indicator (CII) [2]. Both aim at promoting more sustainable and energy-efficient practices.
Also, the development of hull coatings can all help to reduce fuel consumption and pollutant emissions.

- SCR system for ships

SCR catalysts help to reduce the concentration of nitrogen oxide in the exhaust gases of diesel engines below the limits set by IMO Tier III. SCR is an available technology which has been successfully applied to a great range of engine and vessel types, using different fuels and in different ranges of engine conditions.

- Scrubbers for ships

Scrubbers remove SOx and reduce the harmful emissions generated by burning fuel. As regulations become more restrictive regarding SOx emissions, the demand of scrubbers is expected to increase.

- Autonomous ships

Using sensors, cameras, and advanced algorithms, vessels can operate and navigate without human intervention. Through these technologies is possible not only to improve safety but also reduce fuel consumption.

Offshore Renewable Energy (ORE) constitutes a clean and inexhaustible source of energy, capable of reducing greenhouse gas emissions and creating less damage to the environment, in comparison to traditional fossil-based energy. Offshore wind energy is increasingly gaining ground as one of the best sources of renewable energy in Europe and the European Union. The EU strategy for Offshore Renewable Energy sets the objective of increasing offshore wind energy production capacity from 12 GW to at least 60 GW by 2030 and 200 GW by 2050. This development would be complemented by 40 GW of Ocean Energy and other emerging technologies by 2050.

The demand for offshore structures, equipment, and zero-emission specialised vessels represents a great opportunity for the industrial value chains, clusters and ecosystems. As seen, the maritime technologies sector has become an innovation driven and advanced sector which requires skilled technical people.

9.1 Sector general overview

9.1.1 Shipbuilding

The shipbuilding sector is defined as a synthetic industry, producing a unique product, rarely in series, with a high unit value (usually exceeding the financial capacity of the shipbuilding companies), long production periods, very sensitive to economic cycles, with almost permanent world over-capacity, and strongly exposed to international competition.

The European maritime technology sector consists not only of shipyards or marine equipment manufacturers, but also maritime consultancy and engineering companies. The continuous fragmentation (e.g. through outsourcing) and internationalisation of the supply chain results in varying distribution of production values between the different steps of the value chain. The distribution of the workload in the supply chain can be roughly assigned as: +/- 30% to the shipyards, +/- 40% to the material suppliers (including components and systems) and +/- 30% to subcontractors [3].

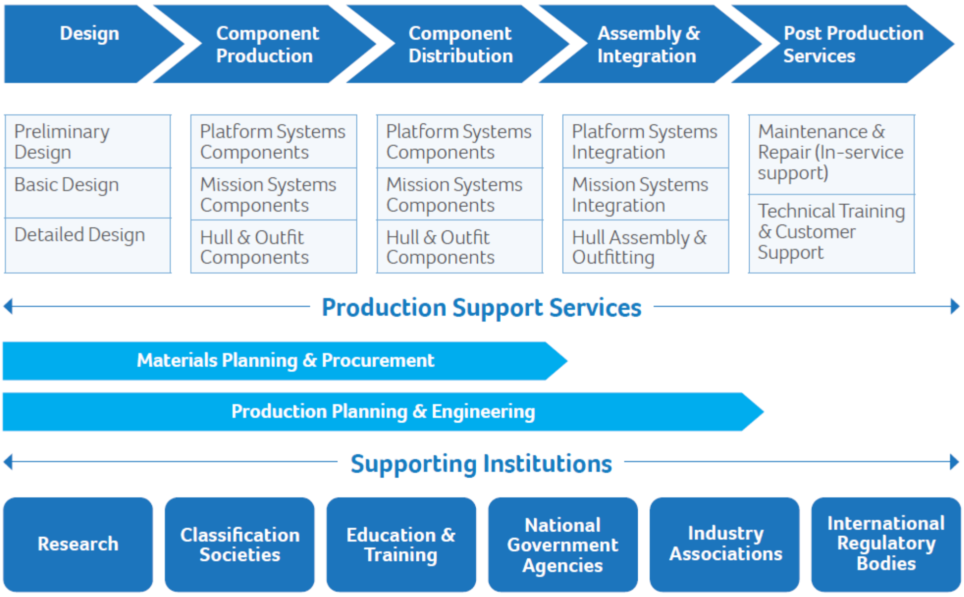


Figure 9.1: The shipbuilding value chain – key phases and processes [4].

Nowadays European market consist of high technology products and services where value is obtained through knowledge, innovation and technology. That is the only way to compete in the global market. Generally, each vessel built is a unique prototype. For each new project, each company designs a unique product adapted to the needs of the customer.

One of the consequences of developing high technology and unique products is that the sector requires high skilled technical people. Companies must adapt the know-how of their workers to the new technological advances in order to compete successfully.

Also, EU is investing in sustainable new technologies, adopting digital solutions and automation processes to reduce pollution and remain competitive.

Based on the 2019 order book data expressed in Compensated Gross Tonnage (CGT) for each country, together with the number of employees in that industry and the value added at factor cost, a scale has been established to rank the most representative countries in the Shipbuilding and repair industry. As shown in Figure 2, the most important group of countries are Italy (17%), Germany (16%) France (14%) and UK (13%), followed by Spain (6%) and the Netherlands (5%).

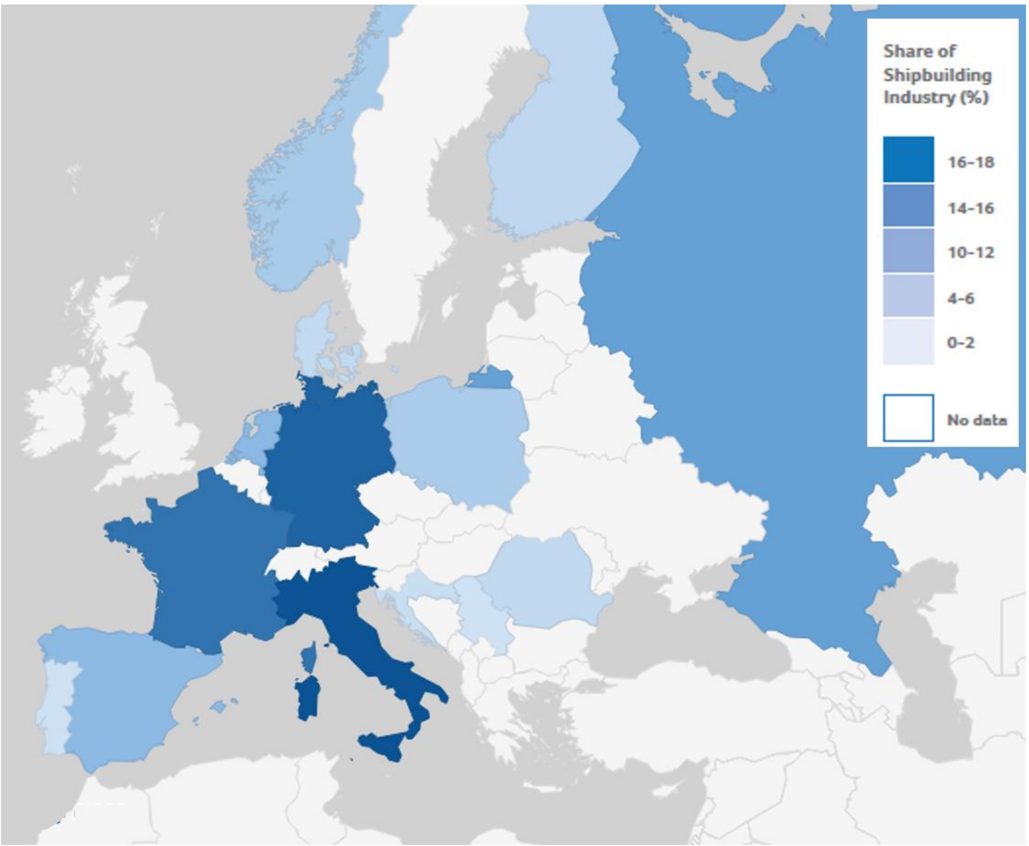


Figure 9.2: Importance of Shipbuilding sector in the EU and UK, considering the added value generated, the employment and prospects for future contracts. Based on the gross value added at factor cost (GVA[54]) and employment from 2018, and the order book 2020 [4].

Results of GREEN Focus group:

A discussion was held on the shipbuilding sector main features across EU. The aim of this discussion was to validate the sectoral boundaries and to confirm the criteria for selecting countries relevant for the analysis. The following questions were addressed in this section:

- Do you agree with the selected descriptors for the shipbuilding sector?
- Do you think the shipbuilding sector should be considered as critical for achieving a greener and more sustainable future?
- Do you agree on the selection of most relevant countries for the analysis of the Green Transition in this sector?

All experts agreed with the selected descriptors for the shipbuilding sector and considered it should be considered as critical for achieving a greener and more sustainable future.

Most of the experts indicated that **UK, Spain** and the **Netherlands** should be included in the selection of most relevant countries for the shipbuilding sector. It was also highlighted that in terms of capacity, specially related to ship sections construction and merchant ships building, Romania is one of the

[54] GVA: Gross income from operating activities after adjusting to operating subsidies and indirect taxes, obtained from the European Commission, Directorate General for Maritime Affairs and Fisheries(2020 & 2021)

largest ship constructors even though the type of ships they are building are not green ships. Also, Finland in terms of innovation should be taken into consideration.

9.1.2 Offshore Renewable energy

The main forms of offshore renewable energy systems are categorized into two main groups, according to the maturity of the technology employed[55]: Fixed Offshore Wind is the most mature sub-sector, whilst Floating Offshore Wind and Ocean energy have different degrees of readiness: Wave, Floating Offshore Wind and Tidal are progressing fast, of which the latter is closer to commercial exploitation, and Offshore Solar is under development.

Most of the offshore wind industry in Europe is dominated by a small number of key players [5]. All new wind farms have been led by **four wind farm manufacturers:** Siemens Gamesa Renewable Energy (SGRE), MHI Vestas Offshore Wind, GE Renewable Energy and Senvion. **With regard to the situation of the wind turbine component manufacturing in Europe, a small number of companies likewise have the majority of the market share**. The Sif Group dominates the mono-pile foundations, followed by Bladt and EEW. Lamprer and the Navantia-Windar Consortium specialize in jacket manufacturing. **The export and array cable market in Europe has more variety than that of wind turbines** and foundations. Finally, **the service providers and specialist suppliers in the 3rd tier of the value chain include a significant number of smaller suppliers** who can adapt very quickly to the market and offer solutions for the industry [6].

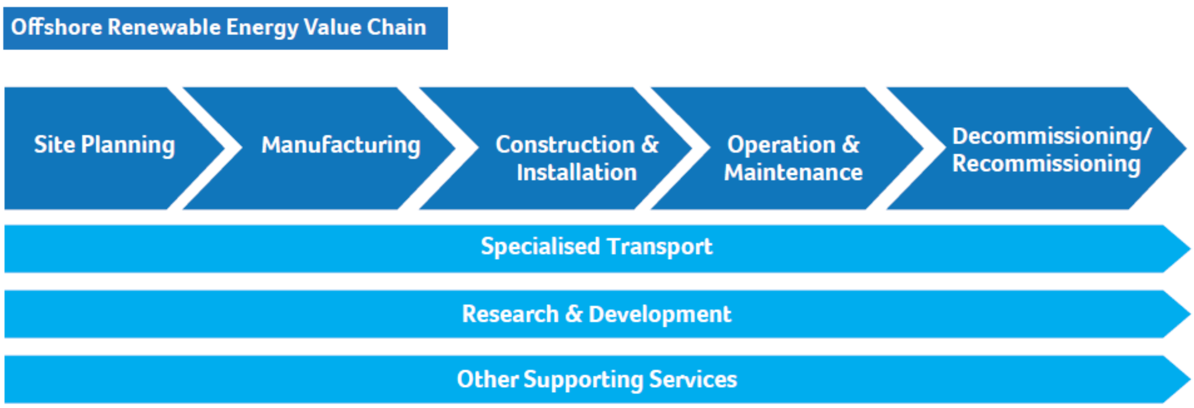


Figure 9.4: The ORE value chain – key phases and processes [4].

Regarding the geographic spread of the Offshore Renewable Energy sector in Europe (see Figure 4), there are two different landscapes depending on the type of energy technology:

In the more mature sector of fixed offshore wind energy, the UK is the European country with the largest installed capacity (45%) followed by Germany (34%), Denmark (8%), Belgium (7%) and the Netherlands (5.5%). A nascent industry is present in Finland, Sweden, France, Spain, Ireland and

[55] This categorisation and terms used to describe the technologies employed to extract energy from the oceans follow the lexis employed by the European Commission, Directorate-General for Maritime Affairs and Fisheries in *the EU Blue Economy Report 2023.*

Portugal.
Considering ocean energy technologies and floating offshore wind projects, France leads the ranking (51%), followed by the UK (20%), leading the promising tidal and wave energy sector, then Norway (14%), Spain (10%), and Portugal (4%). The Netherlands represents less than 1%.

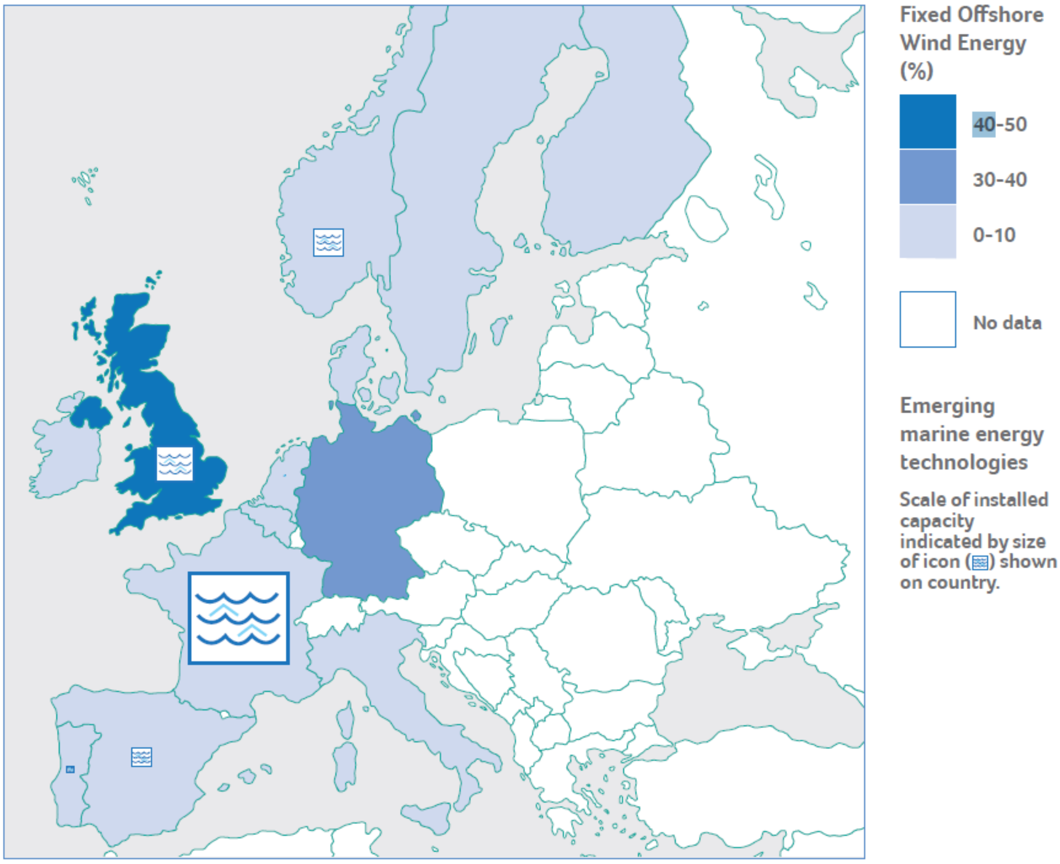


Figure 9.5: Importance of offshore wind energy sector in the European countries[56], based on the fixed offshore wind installed capacity. The icons show the installed capacity share of the emerging marine energies in the European countries (floating wind energy projects + ocean energy (i.e. wave & tide) [4].

Results of GREEN Focus group:

A discussion was held on the sector main features across EU. The aim of this discussion was to validate the sectoral boundaries and to confirm the criteria for selecting countries relevant for the analysis. The following questions were addressed in this section:

- Do you agree with the selected descriptors for the ORE sector?
- Do you think the ORE sector should be considered as critical for achieving a greener and more sustainable future?

[56] EU Member States, UK and Norway data are included in these figures

- Do you agree on the selection of most relevant countries for the analysis on the sector of ORE?

All experts agreed with the selected descriptors for the ORE sector. Even though almost all experts agreed ORE sector is important for the Green transition, it was stated that there are more *traditional* sectors that should be studied, for example maritime transport, ports or any other sector important for energy transition. To open an overall vision on the sectors, some experts consider that the efforts should be joint.

All the experts agreed with the selection of the most relevant countries for the ORE in Europe, but almost the half indicated that **more countries should be considered**.

Some of the countries considered relevant by the experts were:

- Denmark
  Denmark is a pioneer of the development of offshore wind power. The world's first offshore wind farm was established in 1991 in Denmark. The installed capacity is not as big compared to Germany and France because it is a small country, but it is necessary to consider that Denmark had by far the highest share of wind power in its gross final electricity consumption.

- Portugal
  Portugal is a key player. They were the first ones installing floating wind and everything has been done between Spain and Portugal. The country **has set ambitious energy transition targets** and aims for **80% of the country's generation to be renewable by 2026. The favourable wind conditions made offshore wind energy technology play a key role.**

A special comment was made regarding regulation laws. Offshore wind projects can be slower to get going than their onshore equivalents. And depending on the country it could be easier or faster to build offshore wind farms. For example, wind farms must be located in the territorial waters (14 nautical miles) or exclusive economic zones (200 nautical miles) of their host country. They must go through a complicated approval process, including environmental impact assessments that consider their effect on marine habitats, migrating birds, etc.

9.2 Key occupations for the Green transition

The MATES blueprint project [7] identified 105 occupations involved in the maritime technologies, including primary and supporting occupations. Those occupations are either related to the shipbuilding value chain, the ORE value chain, or to both, as shown in table 1:

Table 9.1: Quantitative summary of occupational profiles in the maritime technologies, distinguishing the primary occupations from the secondary ones.

	Shipbuilding	ORE	Shipbuilding + ORE	TOTAL
Primary	28	21	7	**56**
Supporting	1	22	26	**49**
TOTAL	**29**	**43**	**33**	**105**

The complete list of occupations per sector is available in annex 9.1

9.2.1 Shipbuilding

Taking MATES foresight [8] as our guidance document for this analysis, we can see that the occupations deemed to be the most affected by future green trends are grouped around the two technologies which are supposed to have more impact in the next years in the maritime industry for shipbuilding. Those two technologies are:

- Exploitation of alternative fuels and renewable energy sources
- Green retrofitting

As previously explained, exploitation of alternative fuels implies moving from fossil to non-fossil fuels, being these fuels produced with renewable or zero carbon energy resources. Green retrofitting consists of installing on-board ships innovative elements or systems to meet the new regulatory emission standards. The occupations considered to be most affected by these trends as proposed by MATES are presented in table 9.2.

Table 9.2: List of the most relevant trends for the green transition in the shipbuilding sector, and occupations considered to be most affected by them. (Source: ATES foresight [8])

Green trend	Occupation
Exploitation of alternative fuels	Marine Engineer Naval architect Marine Engineer drafter Marine Engineering Technician Vessel engine assembler Alternative fuels engineer

Green retrofitting	Marine Engineer Naval architect Marine Engineering Technician

From all these occupations, only those with higher demand in the marketplace are going to be studied further. This analysis was also developed in MATES [9]. 160 job advertisements posted over a two-month period (May – June 2019) were analysed in various major employment websites addressing 6 European countries (i.e. Germany, France, Italy, Spain, Netherlands and UK). After the analysis, it was concluded:

- Engineers was the occupational group that most advertisements addressed (i.e. 37% of total). Naval architects, marine engineers, design engineers and project engineers proved to be in the highest demand.
- Technicians were the second occupational group most addressed (i.e. 26% of total). Pipe-fitters, welders and shipwrights were the main occupational profiles in demand.
- Managers also received the same attention (i.e. 26% of total), and especially managers & directors of facilities and departments, project managers, consultants and other occupational profiles dealing with the planning and management of operations, facilities and personnel.
- Drafters, who work closely with engineers in design departments, were addressed by 8% of the collected advertisements.
- Engineering technicians and especially those with electro-mechanical background were also targeted by 3% of the collected advertisements.

Taking into account the occupations deemed to be most affected by the green transition, together with the demand at the job market, we selected tree occupations from the shipbuilding value chain for the present analysis: two occupations from the engineering group – the one in highest demand, representing the so called “white collars” – and one from the mechanics group of occupations, representing the “blue collars” occupations that may require more new capacities for the green transition.

- Naval Architect:

In accordance with ESCO description, Naval Architects design, build, maintain and repair all types of boats from pleasure crafts to naval vessels, including submarines. They analyse floating structures and take various features into account for their designs such as the form, structure, stability, resistance, access and propulsion of hulls. World maritime innovation is expected to minimise the impact of shipping on the environment. Ship designs are expected to comply against demanding environmental standards, requirements for new equipment and for sustainability within the context of lifecycle.
The ship’s engine room is the greatest contributor of environmental pollution on a ship. The diesel engines and other machinery present in the engine room consume fuel to work and generates carbon dioxide and other poisonous gases in return. The key to reduce this poisonous emission is to improve the design of these machines and also of the ship. The ships should be designed in such a way that it

poses least threat to the environment. Thus, better the design, greener is the ship.
Hull design is important for the overall efficiency of the ship. Optimization of hull lines of the ship increases the speed of the ship, saves fuel and improves the economic efficiency.
Also, the machinery fitted in the ship can improve its environmental impact. The less energy it consumes, the less it pollutes and the more efficient it is, the better.
Therefore, the better way to ensure a ship is green is from the beginning of its conception, and that is the Naval Architect´s job. So, providing them with the appropriate green skills will improve the impact of shipping in the environment.

- Alternative fuel engineer:

According to ESCO description, alternative fuel engineers design and develop systems, components, motors, and equipment which replace the use of conventional fossil fuels as main power source for propulsion and power generation with the feature of using renewable energies and non-fossil fuels. They strive to optimise energy production from renewable sources and reduce production expenses and environmental strain. The alternative fuels employed mainly include Liquefied Natural Gas (LNG), Liquefied Petroleum Gas (LPG), biodiesel, bio-alcohol as well as electricity (i.e., batteries and fuel cells), hydrogen and fuels produced from biomass.
Reducing emissions to air and introducing new propulsion technologies are key challenges for the worldwide shipping sector. The high technology, the complex products, the need of most advanced vessels and technologies) and the innovative manufacturing processes will require for more and more highly skilled technical people and d fewer less qualified people. This occupation is born of the necessity to fill the skills gap in alternative fuels.

- Vessel engine assembler:

As per ESCO description, a vessel engine assemblers build and install prefabricated parts to form engines used for all types of vessels such as electric motors, nuclear reactors, gas turbine engines, outboard motors, two-stroke or four-stroke diesel engines and, in some cases, marine steam engines. They review specifications and technical drawings to determine materials and assembly instructions. They inspect and test the engines and reject malfunctioning components.
Due to the changes the sector is undergoing: decarbonisation of shipping, automated ships, alternative fuels…, vessel engine assemblers will have to update their skills in order to cope with the new necessities of the sector. All these changes suppose the introduction of new and innovative equipment that fulfils the new characteristics of the sector.

Results of GREEN Focus group:

A discussion was held on the sector main occupations. The aim of this discussion was to validate which are the most affected and/or most demanded sectoral occupations and also to confirm the criteria for selecting them for the analysis. The following questions were addressed in this section:

- Do you consider this selection of occupations is adequate (naval architect, vessel engine assembler, alternative fuel engineer)?
- Would you eliminate or add any further occupation?
- If your answer is yes, which one would you include?
- And would you eliminate any of the 3 proposed occupations?

As result of the discussion held about the selected key occupations for the green transition and the main reasons for their relevance in this process, experts proposed to modify the proposed list. For some experts, **Marine Engineer** was considered a much better profile than a Naval Architect as the overall ship design should be more efficient and would comply with the current or upcoming regulations. But in the opposite, other experts considered that both occupational profiles are really linked, either in terms of the use of space (equipment arrangement in the vessel) as in terms of the use of new fuels, batteries, etc. Besides, the relative importance of the Marine engineer versus the Naval architect may vary depending on the type of vessel. It was also proposed to add **Marine Engineer Technician** as we should focus not only on profiles with high level of education and also add up another vocational training which is aligned with the Marine Engineer, but this proposal was less seconded by the group.

Most of them mentioned that they would add some other occupations.

And, regarding adding some occupations, the occupation considered to be more relevant to be included is marine engineer, since they will be the ones to operate the new types of engines with their new characteristics, and marine engineering technicians, since they will be the ones to maintain those new engines.

On the other hand, regarding if any of the mentioned occupations should be eliminated, vessel engine assembler was proposed to be eliminated since, despite some new engines could appear, as far as they are internal combustion engines, their building would be similar to the existing ones (not their operation and maintenance). Anyway, most experts considered the three proposed occupations should be included.

As a result, we conclude that the Marine Engineer will be added to the list of selected occupations for this analysis.

9.2.2 Offshore Renewable Energy (ORE)

Offshore renewable energy is increasingly gaining ground in Europe and the European Union. In consequence, not only the occupations of this value chain are being more demanded, but also new occupational profiles are being created. In particular, the following ones were identified in MATES and updated in ESCO database:

ORE engineer
ORE technician
ORE Plant Operator
Drone Pilot

Marine renewable energy systems require energy storage capabilities, and these technologies are evolving to reduce their environmental impact. The MATES foresight [8], identified the occupations considered to be the most affected by the evolution of the energy storage technology.

Energy storage	Power distribution engineer Electric power generation engineer Maintenance and repair engineer	Solar power plant operator Power production plant operator

As in the Shipbuilding sector, the occupations being studied are those with high demand in the marketplace. The analysis of the current job vacancies is included in the report Baseline Report on present skills needs in shipbuilding and offshore renewables value chains from MATES [9]. 99 job advertisements posted over a four-month period35 (March – June 2019) in various major employment websites addressing three European countries (i.e. the UK, France and the Netherlands) were collected and reviewed.
Managers and engineers proved to be in greater demand i.e. were requested in 52% and 27% of all identified advertisements respectively. Smaller was the demand for technicians, analysts, consultants and designers. At this point, it should be stressed that, compared to the advertisements for the shipbuilding sector, in those for ORE no specific occupational profile was requested, but the aforementioned broader groups were addressed instead, with different specializations being in demand. The ORE industry is currently in greater need of (a) managers specializing in the overall planning and development of ORE projects as well as in specific processes such as construction and installation and operation and maintenance, (b) wind turbine technicians, and (c) engineers specializing in electrical engineering, structural and geotechnical engineering, and design processes. [9]

The following managing occupations have been identified as supporting occupations for the ORE value chain (in bold are marked those that also are relevant for the shipbuilding value chain).

Managers	Policy manager **Project manager** **Operation manager**	Industrial maintenance supervisor **Construction safety manager**

Considering all this information, we selected one occupation from the ORE value chain for the present analysis:

- ORE engineer

As per ESCO description, offshore renewable energy engineers design and supervise the installation of offshore energy farms and equipment. They research and test locations to find the most productive location, ensure the successful execution of the design plan and make any necessary modifications or provide targeted advice. Offshore renewable energy engineers test equipment such as wind-turbine blades, tidal stream and wave generators. They develop strategies for more efficient energy production, and environmental sustainability.

Results of GREEN Focus group:

A discussion was held on the sector most affected occupation. The aim of this discussion was to validate which are the most affected and/or most demanded sectoral occupations and to confirm the criteria for selecting them for the analysis. The following questions were addressed in this section:

- Do you consider this selection of the most affected occupations is adequate (ORE engineer)?

All the experts considered the selected occupation to be adequate, so no further debate seemed to be needed.

9.3 Skills for the Green transition in the key occupations

For each occupational profile identified, the associated skills and competences, as listed in ESCO [10] are summarized in Table 9.3. It has been highlighted in blue all those skills and competences and knowledge which are considered green skills according to ESCO. Additionally, some of the skills and competences that are not yet labelled as green by the ESCO team, but that could be considered as such, have been highlighted.

		ESSENTIAL SKILLS AND COMPETENCES	ESSENTIAL KNOWLEDGE	OPTIONAL SKILLS AND COMPETENCES	OPTIONAL KNOWLEDGE
SHIPBUILDING	Naval architect	assess financial viability	engineering principles	adjust engineering designs	CAE software
		ensure vessel compliance with regulations	engineering processes	analyse big data	automation technology
		execute analytical mathematical calculations	maritime law	analyse energy consumption	battery chemistry
		execute feasibility study	mathematics	analyse production processes for improvement	battery components
		use maritime English	mechanical engineering	analyse stress resistance of products	battery fluids
			mechanics of vessels	analyse test data	business intelligence
				assemble mechatronic units	chemical products
				assemble sensors	cloud technologies
				assess environmental impact	composite materials
				conduct energy audit	control engineering
				conduct performance tests	data analytics
				control production	data mining
				create technical plans	data storage
				design automation components	defence system
				design prototypes	design principles
				develop energy saving concepts	energy efficiency
				develop waste management processes	environmental legislation
				draft design specifications	fluid mechanics
				ensure compliance with environmental legislation	fuel gas
				identify energy needs	guidance, navigation and control
				install automation components	information extraction
				install mechatronic equipment	information structure
				integrate new products in manufacturing	manufacturing processes
				maintain robotic equipment	material mechanics
				operate battery test equipment	mechatronics
				perform data mining	physics
				perform scientific research	quality standards
				perform test run	renewable energy technologies
				promote innovative infrastructure design	robotic components
				promote sustainable energy	robotics
				record test data	sensors
				simulate mechatronic design concepts	solar energy

			test mechatronic units test sensors use CAD software use CAM software use specific data analysis software utilise machine learning	statistical analysis system software stealth technology **synthetic natural environment** types of maritime vessels unstructured data vessel fuels visual presentation techniques
Vessel Engine Assembler	align components apply health and safety standards apply preliminary treatment to workpieces bolt engine parts ensure equipment availability **ensure vessel compliance with regulations** fasten components read engineering drawings read standard blueprints troubleshoot use power tools use technical documentation wear appropriate protective gear	engine components mechanics mechanics of vessels operation of different engines quality standards	**analyse energy consumption** calibrate electronic instruments clean components during assembly **conduct energy audit** conduct performance tests develop energy saving concepts diagnose defective engines disassemble engines inspect quality of products keep records of work progress liaise with engineers operate battery test equipment operate handheld riveting equipment operate lifting equipment operate soldering equipment operate welding equipment position engine on test stand re-assemble engines recognise signs of corrosion record test data	battery chemistry battery components battery fluids chemical products electromechanics electronics **energy efficiency** engineering principles engineering processes fuel gas **renewable energy technologies** rivet types **solar energy** vessel fuels

			repair engines	
			send faulty equipment back to assembly line	
			set up automotive robot	
			tend riveting machine	
			use CAM software	
			use testing equipment	
			write records for repairs	
Alternative fuels engineer	adjust engineering designs	CAD software	analyse production processes for improvement	aerospace engineering
	analyse energy consumption	chemical products	analyse stress resistance of materials	aviation English
	approve engineering design	circular economy	assess financial viability	aviation standards and recommended practices
	assess hydrogen production technologies	electrochemistry	conduct performance tests	battery chemistry
	conduct energy audit	electronics	control compliance of railway vehicles regulations	battery components
	design electric power systems	energy efficiency	control production	battery fluids
	design electrical systems	energy storage systems	create technical plans	marine technology
	develop energy saving concepts	engineering principles	design prototypes	mechanics of vessels
	dispose of hazardous waste	environmental legislation	disassemble engines	rail construction engineering
	ensure compliance with environmental legislation	fuel cell types	draft design specifications	rail design engineering
	ensure compliance with safety legislation	fuel gas	ensure aircraft compliance with regulation	rail infrastructure
	execute feasibility study on hydrogen	health, safety and hygiene legislation	ensure vessel compliance with regulations	vessel fuels
	identify energy needs	market pricing	execute feasibility study	
	perform scientific research	mechanics	inspect engine rooms	
	plan maintenance activities	offshore constructions and facilities	operate battery test equipment	
	promote innovative infrastructure design	offshore renewable energy technologies	prevent sea pollution	

		promote sustainable energy **provide information on hydrogen** **use sustainable materials and components** use technical drawing software use testing equipment use thermal management	power electronics **renewable energy technologies** **smart grids systems** statistics systems development life-cycle technical drawings thermodynamics	record test data train employees use maritime English	
SHIPBUILDING: addition suggested by the Focus Group	Marine Engineer	adjust engineering designs approve engineering design ensure vessel compliance with regulations execute analytical mathematical calculations perform scientific research use maritime English use technical drawing software	engineering principles engineering processes maritime law mathematics mechanics mechanics of vessels technical drawings	analyse big data **analyse energy consumption** analyse production processes for improve analyse stress resistance of products analyse test data apply medical first aid on board ship assemble mechatronic units assemble sensors **assess environmental impact** assess financial viability communicate using the global maritime c **conduct energy audit** conduct performance tests control production coordinate fire fighting create technical plans design automation components design prototypes **develop energy saving concepts** **develop waste management processes** disassemble engines draft	CAE software Global Maritime Distress and Safety System **International Convention for the Prevention of Pollution from Ships** assessment of risks and threats automation technology battery chemistry battery components battery fluids business intelligence chemical products cloud technologies composite materials control engineering data analytics data mining data storage design principles electrical engineering electromechanics electronics

			design specifications **ensure compliance with environmental legislation** execute feasibility study extinguish fires **identify energy needs** inspect engine rooms install automation components install mechatronic equipment install transport equipment engines integrate new products in manufacturing lead a team in fishery services lubricate engines maintain electrical equipment maintain electronic equipment maintain robotic equipment maintain safe engineering watches maintain shipboard machinery manage engine-room resources manage ship emergency plans manage the operation of propulsion plan operate battery test equipment operate control systems operate life-saving appliances operate marine machinery systems operate pumping systems operate ship propulsion system operate ship rescue machinery	**energy efficiency** **environmental legislation** fire-fighting systems fisheries legislation fisheries management fishing vessels fluid mechanics fuel gas guidance, navigation and control information extraction information structure international regulations for preventing collision material mechanics mechanical engineering mechatronics pollution prevention precision mechanics quality of fish products **renewable energy technologies** risks associated with undertaking fishing operati robotic components robotics sensors **ship related legislative requirements** **solar energy** statistical analysis system software stealth technology synthetic natural environment unstructured data vessel fuels

				perform data mining	visual presentation techniques
				perform small vessel safety measures	
				perform small vessel safety procedures	
				perform test run prevent fires on board	
				prevent sea pollution	
				promote innovative infrastructure design	
				promote sustainable energy	
				re-assemble engines	
				record test data	
				repair engines	
				simulate mechatronic design concepts	
				survive at sea in the event of ship abandc	
				swim test mechatronic units	
				test sensors	
				train employees	
				use CAD software	
				use CAM software	
				use specific data analysis software	
				use tools for construction and repair	
				utilise machine learning work in a fishery	
				work in outdoor conditions	
ORE	Offshore Renewable Energy Engineer	address problems critically	automation technology	**advise on offshore renewable energies subjects**	electricity market
		adjust engineering designs	data storage	analyse big data	**maritime law**
		adjust voltage	electrical engineering	assess financial viability	mechatronics
		approve engineering design	electrical power safety regulations	conduct underwater surveys	unstructured data
		conduct engineering site audits	energy	**coordinate electricity generation**	

		coordinate communication within a team	energy market	develop strategies for electricity contingencies	
		design automation components	engineering principles	draw blueprints	
		design offshore energy systems	engineering processes	follow safety procedures when working at heights	
		develop test procedures	information extraction	operate meteorological instruments	
		ensure compliance with environmental legislation in food production	innovation processes	oversee pre-assembly operations	
		ensure compliance with safety legislation	marine engineering	perform hydrodynamics calculations	
		inspect offshore constructions	**marine technology**	**promote sustainable energy**	
		manage engineering project	**oceanography**	respond to electrical power contingencies	
		perform data analysis	**offshore constructions and facilities**	review meteorological forecast data	
		perform project management	**offshore renewable energy technologies**	run simulations	
		perform scientific research	**renewable energy technologies**	survive at sea in the event of ship abandonment	
		prevent marine pollution	sensors	test procedures in electricity transmission	
		read engineering drawings	statistical analysis system software	test sensors	
		report test findings	technical drawings	utilise machine learning	
		research locations for offshore farms	**types of photovoltaic panels**	work in inclement conditions	
		research ocean energy projects	**types of tidal stream generators**		
		use remote control equipment	**types of wave energy converters**		
		use technical drawing software	**types of wind turbines**		

Table 9.3: Skills and competences associated to the maritime occupations selected due to their relevance in the Green Transition, as listed in ESCO [10]. Skills and competences highlighted in blue are those labelled as GREEN by ESCO. Those highlighted in orange are not yet classified as GREEN, but would be further analysed to propose their green labelling to the ESCO team.

Results of GREEN Focus group:

A discussion was held on each occupational profile identified and their associated skills and competences, as listed in ESCO, highlighting the ones considered as *green*. The aim of this discussion was to validate the listed ones for some of the occupations analysed in previous sections and suggest some that might be missing for each occupation, according to the experts. The following questions were addressed in this section:

- Do you consider the green skills and knowledge presented are relevant for this occupation (naval architect)?
    - Do you find a skill or knowledge missing? Which one?
- Do you consider the green skills and knowledge presented are relevant for this occupation (vessel engine assembler)?
    - Do you find a skill or knowledge missing? Which one?
- Do you consider the green skills and knowledge presented are relevant for this occupation (alternative fuels engineer)?
    - Do you find a skill or knowledge missing? Which one?
- Do you consider the green skills and knowledge presented are relevant for this occupation (ORE engineer)?
    - Do you find a skill or knowledge missing? Which one?

No skill or knowledge were considered to be missing for naval architect's case. In fact, most of the experts considered that the green skills presented are relevant for this occupation.

Plants integration and fuel consumption knowledge were suggested as relevant knowledge for vessel engineer assembler. This case is quite more heterogeneous from the point of view of the experts.
Plants integration could be relevant because the transition in shipbuilding from "traditional" fuels to new propulsion solutions could imply hybrid systems, greener fuels or a combination of different sources that can be coexisting at the same time on a vessel, and they can be of different natures, some being green and some other being brown. There is where the importance of plant integration in the green transition may lie.

Knowledge on energy storage/batteries was considered to be missing for alternative fuels engineer. All the experts, as expected, considered green skills are relevant for this occupation.
Knowledge on energy storage, new materials and offshore maintenance were considered to be missing for ORE engineer. All of the experts but one, considered all green skills are relevant for this occupation. Hat one considered that they are relevant, however, not all of the presented skills or knowledge considered by ESCO: knowledge on solar was suggested to be considered as optional by ESCO, and not essential.

9.4 Skills supply for the Green transition

Table 9.4 shows which are the minimum levels of education required for each of the occupational profiles identified as relevant for the green transition:

Table 9.4: Minimum levels of education required, own research and [9].

A/A	Occupational profile	Minimum level of education required		
		General Education EQF 1-4	VET EQF 3-5	Higher education EQF 6-8
1	Naval architect			X
2	Vessel engine assembler	X	X	
3	Alternative fuels engineer			X
4	ORE Engineer			X

9.4.1 Shipbuilding

In MATES project, a thorough review of relevant educational and training (E&T) programs was undertaken. In total, 482 E&T programs provided in 17 EU countries were identified for the academic year 2018-2019. They mostly spread between the 3rd and 7th EQF level, while several professional certificates and non-academic training offers were also found to exist (Figure 9.11).

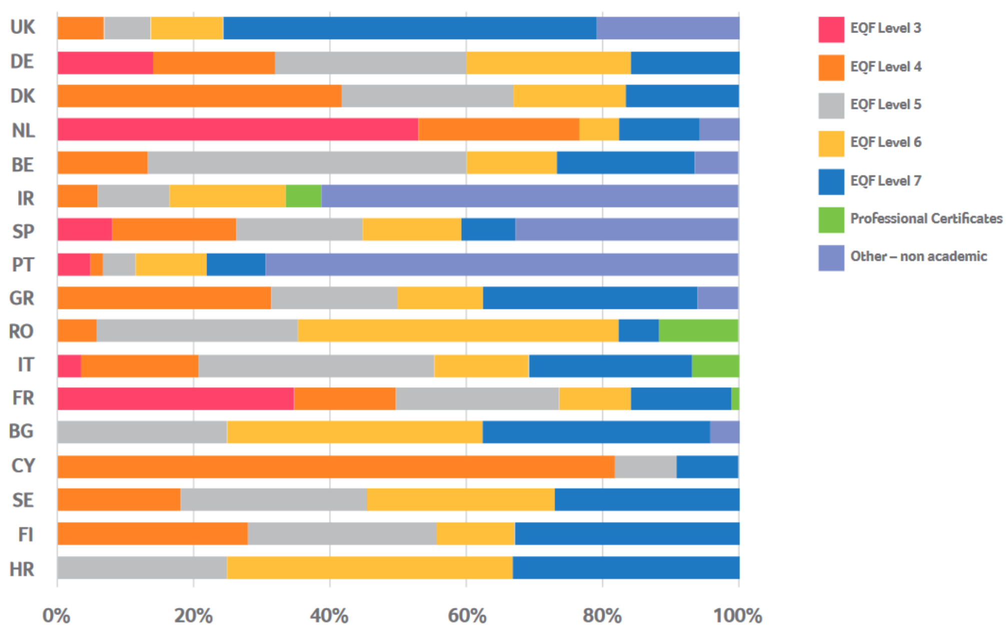


***Figure 9.11:** Distribution of E&T programs per EU country and EQF level [9]*

The large majority (48%) consisted of Vocational Education and Training (VET) programs addressing mainly technical occupational profiles specializing in metalworking (e.g. welders, shipwrights). Under- and post-graduate programs also accounted for a considerable share (37%) oriented mainly towards engineering fields (i.e. naval architecture, marine engineering). Most of these programs however do not provide direct specializations applicable to the shipbuilding sector, but more general qualifications that can be applied to several different sectors. As a result, on-the-job training is regarded as a prerequisite, while there is a need for a certain 'transition' period before new employees can start providing added value to their company. [9]

As expected, given their distribution per type and European Qualifications Framework (EQF) level, most of the identified E&T programs are offered only in the national language of each respective country. Just 17% of all programs are offered in English or are bilingual, and these are mostly under- and post-graduate programs. To this end, international participation opportunities are scarce, and may also not be attractive enough because of the lack, in several cases, of Europe-wide accreditation and recognition. [9]

Annex 9.2 provides more details on the analysis of the training offer in the three countries ranked as more relevant for the shipbuilding industry, as shown in figure 2: Italy, Germany and France.

9.2.2 Offshore Renewable Energy (ORE)

In MATES project, a thorough review of relevant educational and training (E&T) programs was undertaken. 551 relevant E&T programs in total were identified, offered in 12 different EU Member States. Though only a few directly address the ORE sector, most programs do include, within the overall framework of renewable energies, some courses specifically targeting offshore projects. [9]

Although they cover all EQF levels, the majority of consist of M.Sc. (43%) and B.Sc. (24%) programs, indicating that specialization in ORE is mostly provided at post-graduate level. VET programs (EQF 3, 4 and 5) accounted for approximately 10% of all programs. Non-academic programs and programs providing professional certificates accounted for a significant share (21%). Figure 9.12 below presents the distribution of the available E&T programs per country and EQF level. [9]

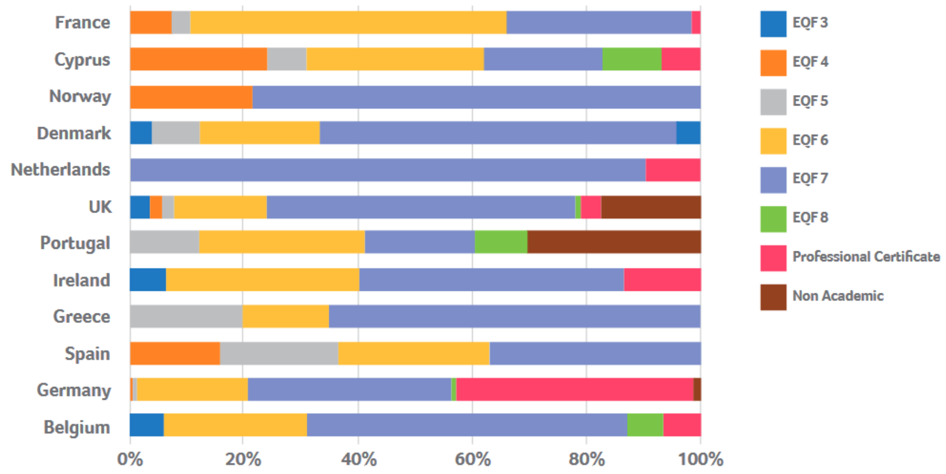


Figure 9.12: Distribution of E&T programs per EU country and EQF level [9]

Annex 9.3 provides more details on the analysis of the training offer in the three European countries ranked as more relevant for the offshore renewable energies, as shown in figure 9.2: UK, Germany and France.

Results of GREEN Focus group:
A discussion was held on the two sectors training trends and initiatives across the EU. The aim of this discussion was to assess those trends and initiatives and their strengths and weaknesses regarding green transition. The following questions were addressed in this section:

- Which areas do you think need more improvements in the training programs? (choose 3)
- How can the industry and the training providers joint efforts to ensure the preparation of the workers and students for the green transition? (choose 3)
- In order to accelerate the green transition, which group of occupations do you consider that should be trained before to improve their green skills? (prioritise)
- Type or training format would be better to ensure a timely preparation of the industry for the green transition for Managers and Heads of Education.
    - What type of approach would you look for in training for this group? (prioritise)
- Type or training format would be better to ensure a timely preparation of the industry for the green transition for Teachers and Middle-management, positions ind.
    - What type of approach would you look for in training for this group? (prioritise)
- Type or training format would be better to ensure a timely preparation of the industry for the green transition for Workers and Students.
    - What type of approach would you look for in training for this group? (prioritise)

Integration of sustainability *across disciplines* and ***Adaptation to rapid changes in technologies*** where considered the two main areas in which more improvements in the training programs are needed. Following them in importance, the following four areas were highlighted: *Promotion of innovation*, *measuring and assessing environmental impact*, *environmental issues*, and *legislation*. Communication skills and waste management were not considered relevant for this purpose.

The experts agreed on three methods to joint efforts from the industry and the training providers in the preparation of the workers and students for the green transition: the **collaboration of industry** experts in the elaboration of the curricula, the organisation of **internships**, the **apprenticeships** or **cooperative educational programs**, and the implementation of **collaborative projects between educational institutions and industry**.

The group of occupations considered as priority to be trained to accelerate the green transition are the **Industry Managers** and **Heads of Education**, followed by middle-management positions and teachers. Workers and students are considered in the last priority.
Regarding the identification of the best training format to ensure a timely preparation to the green transition, ***On the job training*** has been ranked first for all the groups of occupations considered. In the case of the Managers and Heads of Education, the second, third and fourth types of training format get similar rankings and include ***Webinars*** *combined with* ***on the job training*** *and* ***MOOCS, Blended apprenticeships (on-site and in-class),*** **and** ***Life long learning.***
In the case of the Middle-management positions and Teachers, the second and third types of training format get similar rankings to the first one, and include *Lifelong learning* and *Webinars combined with on the job training and MOOCS* .
As for the Workers and Students, the second, third and fourth training format identified are *Webinars combined with on-the-job training and MOOCS, Blended apprenticeships (on-site and in-class),* and *Regular educational programs.*

9.5 Maritime Technologies sector results and conclusions

The maritime technologies sector includes **shipbuilding (NACE CODE 30.11) and offshore renewable energy (NACE CODE 35.11**). These sub-sectors are strongly linked and require new capacities to succeed in an increasingly digital, green, and knowledge-driven economy. Even though almost all experts participating in the Focus Group **agreed that both sectors are important for the Green transition**, it was stated that there are more *traditional* sectors than the offshore renewable energy that should be studied, for example maritime transport, ports or any other sector important for energy transition.

The shipbuilding sector is a **synthetic industry, producing a unique product**, rarely in series, with a high unit value, long production periods, very sensitive to economic cycles, with almost permanent world over-capacity, and strongly exposed to international competition. The three most representative countries in the Shipbuilding and repair industry in Europe are Italy (17%), Germany (16%), France (14%), but most of the consulted experts considered that UK, Spain and the Netherlands should be included in the selection of most relevant countries for the shipbuilding sector. It was also highlighted that Finland should be taken into consideration in terms of innovation, and also Romania as one of the largest ship constructors with possibilities for improvement in relation to green practices.

The main trends for the green transition in shipbuilding are related to the **Exploitation of alternative fuels and Green retrofitting**. Exploitation of alternative fuels implies moving from fossil to non-fossil fuels, being these fuels produced with renewable or zero carbon energy resources. Green retrofitting consists of installing on-board ships innovative elements or systems to meet the new regulatory emission standards.

The offshore renewable energy sector includes **fixed offshore wind**, the most mature sub-sector, as well as **floating offshore wind and ocean energy** with different degrees of readiness. The main countries for offshore renewable energy vary depending on the type of technology. For fixed offshore wind energy, the UK has the largest installed capacity, followed by Germany. For ocean energy technologies and floating offshore wind projects, France leads the ranking, followed by the UK. The consulted experts pointed that Denmark, pioneer of the development of offshore wind power, should also be included, together with Portugal, due to its ambitious energy transition targets installing floating wind renewables.

Taking into account the occupations deemed to be most affected by the green transition and the demand in the job market, **four occupations from the shipbuilding value chain were selected for the analysis, together with one occupation from the ORE**:

- Naval architect
- Marine Engineer
- Alternative fuel engineer
- Vessel engine assembler
- ORE engineer

For each one of those occupational profiles, the associated skills, competences and knowledge, as listed in ESCO, have been summarised. All of them have a set of green skills and knowledges in their description, **which can be categorised in the following groups**:

- **Energy** : energy efficiency, analyse energy consumption, promote sustainable energy, design offshore energy systems, renewable energy technologies, solar energy, identify energy needs, conduct energy audit develop energy saving concepts.
- **Waste management:** develop waste management processes, dispose hazardous materials, prevent marine pollution, circular economy.
- **Design:** promote innovative infrastructure design, use sustainable materials and components…
- **Legislation:** maritime law, environmental legislation, ensure compliance with environmental

legislation, International Convention for the Prevention of Pollution from Ships, ship related legislative requirements.
- **Environment:** assess environmental impact, research locations for offshore farms, oceanography, prevent sea pollution

However, the **Naval architect, the Marine engineer and the Vessel engine assembler have most of the green skills as optional, while the alternative fuel engineer and the ORE engineer have also essential green skills and knowledge**. This could be related with the fact that they have been more recently included in ESCO database, but also that they have emerged as new occupations in the context of the green transition.

Additionally, the consulted experts proposed to add several green skills and knowledges in some of the occupations analysed: **Plants integration** and fuel **consumption knowledge** were suggested as relevant knowledge for vessel engineer assembler. **Knowledge on energy storage/batteries** was considered to be missing for alternative fuels engineer. **Knowledge on energy storage**, **new materials** and **offshore maintenance** were considered to be missing for ORE engineer.

Four of the occupations selected – **Naval architect, Marine engineer Alternative fuel engineer and ORE engineer – are considered as « white collars » and require having higher education** as minimum level (EQF 6-8). **Most of the available programs do not provide direct specializations** applicable to the maritime technologies, but more general qualifications that can be applied to several different sectors. As a result, **on-the-job training is regarded as a prerequisite**, while there is a need for a certain 'transition' period before new employees can start providing added value to their company.
The **vessel engineer assembler** is the « blue collar » occupation selected for the analysis. The minimum level of education required ranges from 1 to 5, being either included in the general education (EQF 1 to 4), or more specialised in the VET (EQF 3-5). It generally requires on the job specialisation. The expected innovations in the automated ships and the use of alternative fuels will require to update their skills in order to cope with the new necessities of the sector.

During the focus group discussions, experts delved into the training trends and initiatives within the two targeted sectors across the EU. The objective was to evaluate their effectiveness and identify areas for improvement in the context of the green transition.

Integration of sustainability across disciplines and *Adaptation to rapid changes in technologies* where considered the most critical areas for improvements in the training programs. Following them in importance, the following focus areas were highlighted: *Promotion of innovation*, *measuring and assessing environmental impact*, *environmental issues*, and *legislation*.

Experts advocated for three collaborative methods between industry and educational institutions: the collaboration of industry experts in the elaboration of the curricula, the organisation of internships, the apprenticeships or cooperative educational programs, and the implementation of collaborative projects between educational institutions and industry.

Industry Managers and Heads of Education were identified as the highest priority group for training, reflecting their influential roles in shaping industry practices and educational programs. Middle-Management Positions and Teachers followed closely in priority, recognizing their pivotal roles in disseminating knowledge and practices. Workers and students were considered in the last priority.

Regarding the optimal training formats to ensure a timely preparation to the green transition, *On the job training* has been universally acknowledged as the most effective format across all groups of occupations. The following types of training format selected include *Webinars combined with on-the-job training and MOOCS, Blended apprenticeships (on-site and in-class),* and *Lifelong learning. Regular educational programmes* are only considered relevant to prepare students and workers.

10. General results and conclusions

The GREEN project report directs its focus on six industrial sectors pivotal for steering the green transition. These sectors, categorized by their maturity, encompass well-established fields like defence and automotive, require a shift to more sustainable practices. Conversely, emerging sectors, such as batteries and additive manufacturing, present opportunities to embed sustainability from their inception, impacting diverse areas like defence, energy, and transportation.

In the green transition journey, the energy and marine technologies sectors form a hybrid category, amalgamating both traditional and emerging sub-sectors. This amalgamation demands a skilled workforce capable of orchestrating a seamless transition to sustainable practices. Across all these sectors, a unified effort from policymakers, educators, and employers is imperative to equip the workforce with the requisite skills for the challenges ahead.

Brief Descriptions of the Sectors:

Additive manufacturing is a new approach to industrial manufacturing where a physical object is created by overlaying layers of material. Although there are different 3D printing technologies and materials, all are based on the same principle: a digital model is turned into a solid 3D physical object by adding material layer by layer. Additive Manufacturing emerges as a versatile tool with applications across defence, energy, and transportation sectors. Key players include Germany, Spain, France, UK, Italy, and Belgium.

Automotive Industry: A substantial economic force, the automotive sector is undergoing.

The Automotive Industry includes a broad range of companies and organizations involved in the design, development, manufacturing, marketing, and selling of motor vehicles. It is one largest economic sector in terms of revenue.

As part of the Mobility industrial ecosystem, the automotive industry is undergoing a transformative shift driven by electric vehicles, connected and autonomous vehicles, and on-demand mobility services. Key employment hubs include Slovakia, Romania, Sweden, Czech Republic, Hungary, and Germany.

Lithium-based batteries power our daily lives from consumer electronics to national defence. They enable electrification of the transportation sector and provide stationary grid storage, critical to developing the clean-energy economy. Battery production itself is not without environmental impact, the battery production uses rare metals and significant energy and water resources during the manufacturing process. At the moment, the main trend in the green transition is to gain maximum use of existing batteries through circular value chain, especially through second life and recycling. Sweden and Spain are identified as primary advanced battery countries, with Germany anticipated to lead in this field.

Defence: Encompassing the design, construction, and maintenance of military systems, the defence sector adheres to rigorous military standards. The sector includes some large multinational companies collaborating with a large range of small companies all over the EU, and all of them usually also produce for the civil sector. Major players in Europe are distributed across Germany, the Czech Republic, Austria, UK, Sweden, and Poland.

Energy: A linchpin for the green transition, the energy sector embraces wind, hydro, and solar energy sources. **Solar energy** is showing an exponential rise in its usage over the last decade, comprising both the production of electricity through light energy and thermal energy. Leading countries include Germany, Spain, Netherlands, Denmark, and Cyprus, with emerging investments expected in Italy, Greece, and Latvia.

Maritime Technologies: Intertwining **shipbuilding and offshore renewable energy**, this sector demands new capacities for success in a digital, green, and knowledge-driven economy. Key trends for the green transition in shipbuilding involve the exploitation of alternative fuels and green retrofitting. Leading countries are Italy, Germany, and France, with the UK, Spain, the Netherlands, Finland and Romania. The offshore renewable energy sector includes fixed offshore wind, the most mature sub-sector, as well as floating offshore wind and ocean energy with different degrees of readiness. For fixed offshore wind energy, the major players are the UK, Germany and Denmark. For ocean energy technologies and floating offshore wind projects, France leads the ranking, followed by the UK, and the emerging Portugal.

Considering a **geographic cross-sectoral approach**, the leadership and contributions of specific countries stand out. **Germany** consistently emerges as a key player, notably in additive manufacturing and the automotive industry, reflecting its robust commitment to sustainable technologies. Spain and Sweden take the lead in advanced battery technologies, while the United Kingdom, with its expertise in offshore renewable energy, contributes significantly to the green landscape. France, renowned for its prowess in defence and offshore renewable energy, demonstrates a multifaceted approach to sustainability.
Moreover, Italy, Belgium, and the Netherlands feature prominently in the additive manufacturing and maritime technologies sectors, illustrating a collaborative European effort in the green transition. Eastern European countries, including the Czech Republic, Romania, and Poland, play pivotal roles in defence and automotive, underlining the distributed nature of sustainable practices across the continent.

Key occupations for the green transition

In each sector, the key occupations crucial for the green transition have been discerned through a comprehensive analysis of both the outcomes of previous blueprint projects and the insights gathered from the GREEN focus groups. The identification process resulted in the recognition of 45 occupations, with **engineering positions** emerging as the predominant category, closely followed by **managerial roles**. Notably, only one occupation— naval architect in defence and maritime technologies—was common across different sectors.

A deliberate consideration has been given to roles that can significantly drive the green transition. **Designers**, holding responsibility for material selection, manufacturing processes, and product design, emerged as pivotal contributors. **Engineers**, pivotal in assessing material suitability and devising solutions for environmental sustainability, also assumed crucial roles. **Research and development** roles are anticipated to wield substantial impact, particularly in emerging sectors, focusing on recycling for circular economy objectives and fostering innovation processes.
Digital and data specialists are identified as contributors, integrating digital solutions for efficient data management and ensuring the cybersecurity of green technologies and practices. Although in the most automated sectors it is considered that the **operational employees** can't significantly impact the environment, this group - including assemblers and other operational roles - has been included in additive manufacturing, defence, and maritime technologies, emphasizing their role in ensuring both efficiency and environmental consciousness in production processes. However, it's worth noting that training roles have been recognized as relevant only in the automotive sector, but their potential significance across sectors warrants consideration.

Table 10.1 List of most relevant occupations for the green transition in the six targeted sectors. Repeated occupations are marked with *

Sector	**Occupations**
Additive Manufacturing	AM Designer
	Metal AM Process Engineer
Automotive	Advanced powertrain engineer
	ECQA Certified Innovation Agent - Product Innovation
	e-powertrain engineer
	Innovation Manager
	Lean Manager
	Life Cycle Assessment Manager's
	Logistics and Supply Chain
	Machine Operator
	Powertrain Engineers
	Production Manager
	Quality Manager
	Recicling specialist
	Sustainability Managers
	Training Manager
Batteries	Battery System Engineer
	Chemical metallurgist
	Chemical process engineer
	Embedded system designer
	Energy systems engineer

	Environmental mining engineer
	HV Battery Engineer
	ICT system integration consultant
	Industrial engineer
	Manufacturing Engineer
	Mine planning engineer
	Mining engineer
Defence	Aerospace engineer
	Crew members
	Database designer
	Database scientist
	Mechanical engineer
	Naval architects*
	Software architect
Energy	Energy systems engineer
	ICT security engineer
	project engineer
	Research engineer
	Solar energy technician
Maritime technologies	Alternative fuel engineer
	Marine Engineer
	Naval architect*
	ORE engineer
	Vessel engine assembler

Out of the 45 occupations, two were highlighted for their cross-sectoral contribution to the Green Transition: The Innovation Manager and the Training Manager. A wide agreement was achieved when consulting the experts during the cross-sectoral focus group. Besides, a list of cross-sectoral occupations was proposed to be taken into consideration, including data scientists and AI, sustainability and environmental managers, reliability engineer, designers and repair and maintenance occupations.

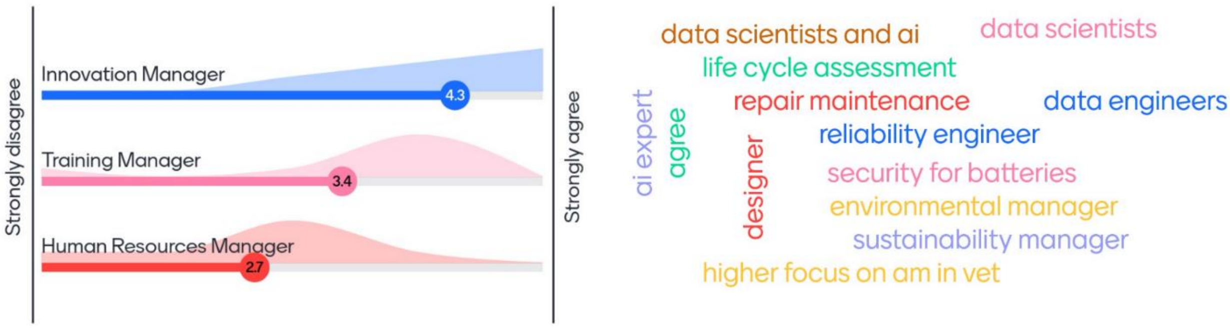


Figure 10.1 Degree of agreement of the cross—sectoral focus group experts with the three pre- selected cross-sectoral occupations with major contributions to (ranked from 1, strongly disagree to 5 strongly agree), and list of suggested occupations to be considered.

The occupations were grouped according to their main roles in the value chain, and three groups were pointed for their cross sectoral contributions to the GREEN transition: Sustainability and Environment Management, Innovation Management and Research. The experts in the cross-sectoral focus group agreed with this selection, and also pointed the relevance of the digital roles, life cycle and waste management, as well as operational processes.

Skills for the green transition

While specific skill needs for the green transition can be identified and anticipated, it is imperative to emphasize the necessity for an attitudinal and behavioural shift that complements the already identified skills within different qualification frameworks, as outlined in the GREENCOMP. The ESCO labelling framework emerges as a pivotal tool in this landscape, providing a standardized and comprehensive approach to recognizing and assessing individuals' proficiency in these critical fields. It is noteworthy, however, that not all selected occupations are encompassed within the ESCO database.

For certain sectors, diverse sources of information have been considered to delineate the skills for each occupation:

- **Additive Manufacturing:** 2 occupations from IAMQS + 2 occupations from ESCO
- **Automotive:** 3 occupations described by DRIVES + 1 occupation from ESCO
- **Batteries:** 3 occupations from real job descriptions + 7 occupations from ESCO

Each occupational profile's associated skills, competencies, and knowledge have been summarized. The skills labelled as GREEN in ESCO underwent thorough review, and discussions in the focus group led to the identification of new green skills proposed for addition to the selected occupations. Furthermore, there's a proposal to augment the list of ESCO green skills, on one hand by including new terms, and on the other by infusing a green approach into certain skills related to the selected occupations. This becomes particularly pertinent when addressing research and development roles. Finally, in the sectoral analyses for additive manufacturing, automotive, batteries and defence, a classification has been suggested, categorizing the remaining skills and knowledge as white and brown.

Additive Manufacturing (AM):

In the realm of Additive Manufacturing, the ESCO database initially tagged only two skills as green—"Ensure compliance with environmental legislation" and "Waste management," both corresponding to the AM Operator occupation. However, a comprehensive analysis identified a broader set of skills essential for embedding a green approach across the sector. A total of 20 skills and 16 knowledge areas have been identified as pertinent for the green transition. Notably, transversal skills such as creativity, critical thinking, and green thinking are deemed crucial across all AM occupations. Additionally, for white-collar positions, a focus on life cycle analysis and resource efficiency management is recommended.

Table 10.2: List of skills selected for their contributions to the Green Transition in Additive Manufacturing, indicating if they exist in ESCO tagged as green, if they are not considered in ESCO but could be tagged as green, or if they should embed a green approach.

	SKILLS/ KNOWLEDGE title	SKILL/KNOWLEDGE
Existing in ESCO, tagged green	Ensure compliance with environmental legislation	Skill
	Waste management	Knowledge
Not ESCO, could be tagged green	Resource efficiency management	Skill
	Reuse/recycling AM materials and products	Skill
Should embed Green approach	Adjust engineering designs	Skill
	Advise client on technical possibilities	Skill
	AM materials and properties	Skill
	AM processes	Skill
	Create solution to problems	Skill
	Creativity	Skill
	Critical Thinking	Skill
	Design principles for AM	Skill
	Determine suitability of materials	Skill
	Draft design specifications	Skill
	Engineering principles	Skill
	Ensure conformity to specifications	Skill
	Identify customer's needs	Skill
	Maintain additive manufacturing systems	Skill
	Manage corrective actions	Skill
	Perform machine maintenance	Skill
	Post Processing	Skill
	Set quality assurance objectives	Skill
	Simulation Analysis	Skill
	Simulation tools	Skill
	Think Additively	Skill
	Work safely with machines	Skill
	Create new or redesign existing 3D models using CAD tools taking advantage of AM	Knowledge
	Design AM parts	Knowledge
	engineering principles	Knowledge
	Interpret process specific part or assembly requirements	Knowledge
	Liaise with other technical areas	Knowledge
	Life cycle analysis	Knowledge
	Maintenance of printing machines	Knowledge

	Maintenance operations	Knowledge
	manufacturing processes	Knowledge
	metal joining technologies	Knowledge
	metalworking	Knowledge
	Provide solution-based approaches to redefine design problems (Design thinking) within AM processes and parts	Knowledge
	Quality assurance procedures	Knowledge
	Relate the capabilities and limitations of AM processes to design considerations	Knowledge
	Select simulation tools to be used in the Design of AM parts	Knowledge
	supply chain management	Knowledge
	types of metal manufacturing processes	Knowledge

Automotive:

In the Automotive sector, the ESCO database identifies 47 skills and 39 knowledge descriptors for the selected occupations. Moreover, a detailed examination led to the identification of 29 skills crucial for the green transition. These include skills not explicitly categorized as green in ESCO but are undeniably green in nature. The skills span various domains such as air and water pollution analysis, energy management, electronics recycling, and sustainability in the design process. The integration of these skills aligns with the sector's shift toward environmentally responsible practices, particularly in roles like sustainability managers, recycling specialists, powertrain engineers, and lean managers.

Table 10.3: List of skills selected for their contributions to the Green Transition in Automotive, indicating if they exist in ESCO tagged as green, if they are not considered in ESCO but could be tagged as green, or if they should embed a green approach.

	SKILLS/ KNOWLEDGE	SKILL/KNOWLEDGE
Existing in ESCO, tagged green	advise on corporate social responsibility	Skill
	advise on sustainability solutions	
	advise on sustainable management policies	
	advise on waste management procedures	
	analyse environmental data	
	assess environmental impact	
	assess the life cycle of resources	
	carry out environmental audits	
	carry out training in environmental matters	
	compare alternative vehicles	
	conduct research on food waste prevention	
	coordinate environmental efforts	
	coordinate shipments of recycling materials	

	describe electric drive system	
	design hybrid operating strategies	
	design indicators for food waste reduction	
	develop food waste reduction strategies	
	develop recycling programs	
	educate on recycling regulations	
	Ensure compliance with environmental legislation	
	evaluate vehicle ecological footprint	
	follow procedures to control substances hazardous to health	
	follow recycling collection schedules	
	identify new recycling opportunities	
	inspect recycling procedures	
	maintain recycling records	
	manage environmental management system	
	manage recycling program budget	
	measure company's sustainability performance	
	mitigate waste of resources	
	operate recycling processing equipment	
	promote environmental awareness	
	research recycling grant opportunities	
	train staff on recycling programs	
	train staff to reduce food waste	
	use sustainable materials and components	
	biodiesel	Knowledge
	circular economy	
	climate change impact	
	corporate social responsibility	
	electric motors	
	emission standards	
	energy efficiency	
	energy saving potential of automated shift systems	
	energy storage systems	
	environmental legislation	
	environmental management monitors	
	environmental policy	
	fuel cell types	
	global standards for sustainability reporting	
	green computing	
	hazardous waste storage	

	hazardous waste types	
	hybrid vehicle architecture	
	Waste management	
	lean manufacturing	
	sustainable finance	
	waste management	
Not ESCO, could be tagged green	analyse environmental data	Skill
	Leather Recycling	
	Life Cycle Management	
	Paper Recycling	
	Plastic Recycling	
	Sustainability in Design Process	
	Sustainability Management	
	Sustainable Design	
	Air and Water Pollution	Knowledge
	Electronics Recycling	
	energy management	
Should embed Green approach	Battery Outlook	Skill
	Innovation Vision 2030	
	Product Lifecycle Management	
	Textile Recycling	
	Advanced Powertrains	Knowledge
	Battery Management Systems	
	Battery Systems	
	Electric Powertrain	
	Electrical Energy Storage	
	Energy Transformation Systems	
	Environment and Society	
	Fuel Cell Powertrain	
	Fuel Cell Vehicles	
	Fuel Cells	
	hybrid control systems	
	Li-ion Batteries	
	New Upcoming Vehicle Technologies	
	teamwork principles	

Batteries:

The Batteries sector faces a unique challenge where certain key occupations lack explicit green skills in the ESCO database, possibly due to their primary existence in research and development. Emphasis on practical environmental topics, especially recycling and second-life processes, is recommended during training. A meticulous analysis identified 29 skills and knowledge areas vital for the green transition. While 15 skills and 7 knowledge areas are found in the ESCO database, there are two additional skills which are not included as such in ESCO, but that are clearly green skills, and five more for which we would recommend embedding a green approach.

Table 10.4: List of skills selected for their contributions to the Green Transition in Batteries, indicating if they exist in ESCO tagged as green, if they are not considered in ESCO but could be tagged as green, or if they should embed a green approach.

	SKILLS/ KNOWLEDGE title	**SKILL/KNOWLEDGE**
Already existing in ESCO and tagged as green	adapt energy distribution schedules	
	advise on heating systems energy efficiency	
	advise on safety improvements	
	analyse energy consumption	
	assess environmental impact	
	assess the life cycle of resources	
	carry out energy management of facilities	
	communicate on the environmental impact of mining	
	develop environmental policy	
	Ensure compliance with environmental legislation	
	identify energy needs	
	manage environmental impact	
	mine dump design	
	promote innovative infrastructure design	
	promote sustainable energy	
	biology	Knowledge
	electricity consumption	
	energy performance of buildings	
	environmental engineering	
	geology	
	renewable energy technologies	
	solar energy	
Not ESCO, could be tagged green	Design battery recycling systems	Skill
	Improve processing routes for battery primary resource extraction	
	adhere to safety procedures	Skill
	ensure compliance with legislation	

Should embed Green approach	ensure compliance with safety legislation	
	maintain standard specification documents	
	Prevent safety hazards	

Defence:

In the Defence sector, the review focused on essential skills and competencies, none of which were initially tagged as green in the ESCO database. However, an analysis revealed 18 skills and 11 knowledge areas that would benefit from embedding a sustainability approach to better address the green transition. Notably, two skills—Adjust engineering designs and manufacturing processes—were identified as common between the AM and Defence sectors. The transformation in Defence underscores the significance of transversal skills, often referred to as "21st-century skills," given the sector's focus on innovation and the development of new technologies.

Table 10.5: List of skills selected for their contributions to the Green Transition in Defence, indicating if they exist in ESCO tagged as green, if they are not considered in ESCO but could be tagged as green, or if they should embed a green approach.

SKILLS/ KNOWLEDGE	SKILL/KNOWLEDGE
Adjust engineering designs	Skill
Apply research ethics and scientific integrity principles in research activities	
Approve engineering design	
Build recommender systems	
Conduct research across disciplines	
Create data sets	
Create software design	
Deliver visual presentation of data	
Develop professional network with researchers and scientists	
Draft scientific or academic papers and technical documentation	
Ensure aircraft compliance with regulation	
Implement data quality processes	
Manage intellectual property rights	
Manage research data	
Mentor individuals	
Perform scientific research	
Promote open innovation in research	
Promote the participation of citizens in scientific and research activities	
Aerospace engineering	Knowledge

Aircraft mechanics	
Data models	
Engineering principles	
Industrial engineering	
manufacturing processes	
Production processes	
Statistics	
Systems development life-cycle	
Visual presentation techniques	
Web programming	

Energy:

The Solar Energy sector, using the ESCO database, identified 21 green skills and 6 green knowledge areas. information and working with computers skills. Additionally, hands-on occupations such as technicians in the field should also work with machinery and specialized equipment, either connected to the software or the hardware part.

Concerning the skills for each occupation, the managerial skills, marketing, power electronics and energy storage systems should be included in the Energy systems engineer, whereas for the solar energy technician it is very important to know data quality and processing skills.

Table 10.6: List of skills selected for their contributions to the Green Transition in Solar Energy. All of them are issued from ESCO and tagged as green in the database.

	SKILLS/ KNOWLEDGE	
Already existing in ESCO and tagged as green	adapt energy distribution schedules	Skill
	Analyse big data	
	carry out energy management of facilities	
	Design passive energy measures	
	Determine appropriate heating and cooling system	
	Determine the suitability of materials	
	Execute feasibility study	
	Follow health and safety procedures in construction	
	identify energy needs	
	Install automation components	
	Install concentrated solar power systems	
	Install electrical and electronic equipment	
	Install photovoltaic systems	
	Maintain solar energy systems	

	Mount photovoltaic panels work ergonomically	
	Perform energy simulations	
	Promote innovative infrastructure	
	promote sustainable energy	
	Provide information on solar panels	
	Use data processing techniques	
	Use measurement instruments	
	energy performance of buildings	Knowledge
	environmental engineering	
	renewable energy technologies	
	Smart grid systems	
	solar energy	
	Types of photovoltaic panels	

Maritime technologies

Maritime Technologies encompass a diverse set of skills, competencies, and knowledge areas listed in ESCO, emphasizing energy efficiency, waste management, design, legislation, and environmental impact assessment. Notably, while the Naval architect, Marine engineer, and Vessel engine assembler have green skills listed as optional, the Alternative fuel engineer and ORE engineer have essential green skills and knowledge. Expert recommendations further suggested adding specific skills and knowledge, such as plant integration and fuel consumption for the Vessel engine assembler and knowledge on energy storage and new materials for the Alternative fuels engineer and ORE engineer.

Table 10.7: List of skills selected for their contributions to the Green Transition in the Maritime Technologies, indicating if they exist in ESCO tagged as green, if they are not considered in ESCO but could be tagged as green, or if they should embed a green approach.

	SKILLS/ KNOWLEDGE	**SKILL/KNOWLEDGE**
Already existing in ESCO and tagged as green	advise on offshore renewable energies subjects	Skill
	analyse energy consumption	
	assess environmental impact	
	assess hydrogen production technologies	
	conduct energy audit	
	coordinate electricity generation	
	design offshore energy systems	
	develop energy saving concepts	
	develop waste management processes	
	dispose of hazardous waste	

	Ensure compliance with environmental legislation	
	execute feasibility study on hydrogen	
	identify energy needs	
	inspect offshore constructions	
	perform project management	
	prevent marine pollution	
	prevent sea pollution	
	promote innovative infrastructure design	
	promote sustainable energy	
	provide information on hydrogen	
	research locations for offshore farms	
	research ocean energy projects	
	use sustainable materials and components	
	circular economy	Knowledge
	energy efficiency	
	energy storage systems	
	environmental legislation	
	fuel cell types	
	International Convention for the Prevention of Pollution from Ships	
	marine technology	
	maritime law	
	oceanography	
	offshore constructions and facilities	
	offshore renewable energy technologies	
	renewable energy technologies	
	ship related legislative requirements	
	Smart grid systems	
	solar energy	
	Types of photovoltaic panels	
	types of tidal stream generators	
	types of wave energy converters	
	types of wind turbines	
Could be tagged green	ensure vessel compliance with regulations	Skill
Should embed Green approach	synthetic natural environment	Knowledge
	fuel gas	Knowledge

In total, 228 skills for the Green Transition have been identified: 49 skills and 25 knowledge areas labelled as green by ESCO have been identified as relevant for the selected occupations. An additional list of 13 skills and 4 knowledge areas deemed critical for the green transition, though not yet classified as green in the ESCO taxonomy, has been compiled. Moreover, a comprehensive list of 49 skills and 42 knowledge areas not tagged as green has been proposed for embedding a sustainability approach. Batteries, Energy, and Maritime Technologies emerge as sectors sharing significant commonalities in green skills and knowledge.

Only a group of six skills and knowledges have been identified as relevant for at least three sectors:

- Assess environmental impact
- Ensure compliance with environmental legislation
- Identify energy needs
- Promote sustainable energy, and knowledge of renewable energy technologies
- Renewable energy technologies
- Solar energy

The transversal skills and knowledge from this list have been analysed in the cross-sectoral focus group. From the six pre-selected, the experts highlighted the relevance of **Critical** and **GREEN thinkin**g, and also proposed to expand the list of transversal skills by adding **communication skills, leadership, teamwork, sustainability literacy** and **project management.**

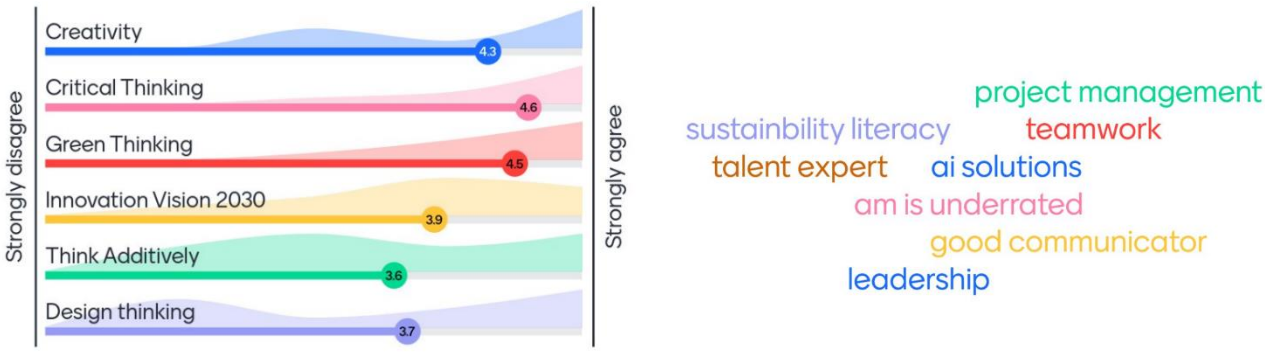


Figure 10.2 Degree of agreement of the cross—sectoral focus group experts with the relevance fr the green transition of the six transversal skills identified (ranked from 1, strongly disagree to 5 strongly agree), and list of suggested transversal skills to be considered.

Skills supply for the green transition

The skills supply analysis integrated an examination of existing training provisions for selected occupations, emphasizing the coverage of green skills. Specialized providers, particularly blueprint projects and sectoral alliances, played a key role in training for sectors like Additive Manufacturing, Automotive, and Batteries. **Sustainability integration across disciplines** emerged as a crucial area for improvement in regular training programs, with an emphasis on practical experiences fostering transversal skills. During the cross- sectoral focus group two other areas were also highlighted: **Measuring and assessing environmental impact**, and **Adaptation of rapid technologies changes**.

In fostering **collaboration between industry and educational institutions**, three methods were endorsed: collaborative projects, involvement of industry experts in curriculum development, and the organization of internships, apprenticeships, or cooperative educational programs.

Across all sectors, there was consensus on prioritizing the training of **Managers in the industry and Heads of Education**, to enhance their green skills and accelerate the transition. Recommendations included a **dual focus on raising awareness** and **motivation along with technical training for the green transition**. The sectoral focus groups didn’t showed consensus on the optimal training formats, Blended apprenticeships, on-the-job training, webinars, and MOOCs were among the most recommended to ensure timely industry preparation. When discussing this point in the cross-sectoral focus group, webinars combined with training on the job and MOOCs were ranked as the two preferred options.

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12. Annexes

12.4 Additive Manufacturing Annexes

- Annex 4.1 – Occupation Skills

	ESSENTIAL SKILLS AND COMPETENCES	GREEN SKILLS CLASSIFIER			ESSENTIAL KNOWLEDGE	GREEN SKILLS CLASSIFIER		
		GREEN	BROWN	WHITE		GREEN	BROWN	WHITE
AM OPERATOR	Ensure compliance with environmental legislation	X			Functionalities of machinery			x
	Apply health and safety standards			x	Machines tools		x	
	Follow work schedulle			x	Maintenaince operations	x		
	Liaise with engineers			x	Quality assurance procedures	x		
	Liaise with managers			x	Waste management	X		
	Manufacture metal additive manufacturing parts		x					
	Maintain additive manufacturing systems	x						
	Operate precision measuring equipment							
	Perform machine maintenance	x						
	Prepare parts for post processing		x					
	Remove processed workpiece		x					
	Set up additive manufacturing systems		x					
	Troubleshoot		x					
	Use personal protection equipment		x					
	Work safely with machines	x						
	Write production reports			x				

	ESSENTIAL SKILLS AND COMPETENCES	GREEN SKILLS CLASSIFIER			ESSENTIAL KNOWLEDGE	GREEN SKILLS CLASSIFIER		
		GREEN	BROWN	WHITE		GREEN	BROWN	WHITE
AM DESIGNER	AM materials and properties	x			Design AM parts	x		x
	AM processes	x			Interpret process specific part or assembly requirements	x		
	Think Additively	x			Create new or redesign existing 3D models using CAD tools taking advantage of AM	x		
	Design principles for AM	x			Associate the degrees of freedom of AM machines to the possibilities in terms of design			x
	Simulation tools			x	Relate the capabilities and limitations of AM processes to design considerations	x		
	Post Processing	x			Determine dimensional constraints and geometric tolerances required for AM parts design			x
	Engineering principles	x			Provide solution-based approaches to redefine design problems (Design thinking) within AM processes and parts	x		
	Simulation Analysis			x	Select simulation tools to be used in the Design of AM parts	x		
					Liaise with other technical areas	x		x
					Analyse simulation results			x

	ESSENTIAL SKILLS	GREEN SKILLS CLASSIFIER			ESSENTIAL KNOWLEDGE	GREEN SKILLS CLASSIFIER		
		GREEN	BROWN	WHITE		GREEN	BROWN	WHITE
METAL AM PROCESS ENGINEER	Estimate duration of work			x	types of metal manufacturing processes	x		
	Analyse test data			x	metalworking	x		
	Ensure conformity to specifications	x			supply chain management	x		
	Set quality assurance objectives	x			manufacturing processes	x		
	Manage corrective actions	x			quality assurance procedures	x		
	Determine suitability of materials	x			engineering principles	x		
	Draft design specifications	x			engineering processes	x		
	Create solutions to problems	x			metal joining technologies	x		
	Identify customer's needs	x						

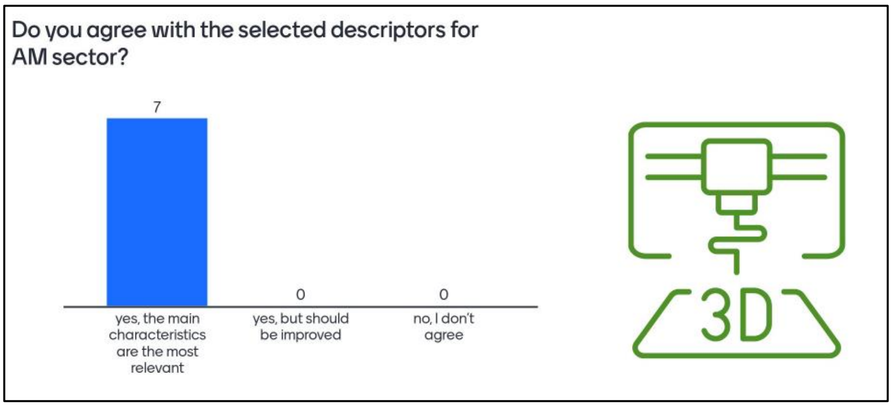
	ESSENTIAL SKILLS AND COMPETENCES	GREEN SKILLS CLASSIFIER			ESSENTIAL KNOWLEDGE	GREEN SKILLS CLASSIFIER		
		GREEN	BROWN	WHITE		GREEN	BROWN	WHITE
3D PRINTING TECHNICIAN	Adjust engineering designs	x			3d modelling			x
	Advise client on technical possibilities	x			3d printing process		x	
	Create solution to problems	x		x	Cad software			x
	Draft design specifications			x	Ict software specifications			x
	Identify customer's needs			x	Maintenance of printing machines	x		
	Operate 3D computer graphics software			x	Maintenance operations	x		
	Operate printing machinery		x		Printing materials		x	
	Use CAD software			x	Printing on large scale machines		x	
	Use technical drawing software			x	Printing techniques		x	

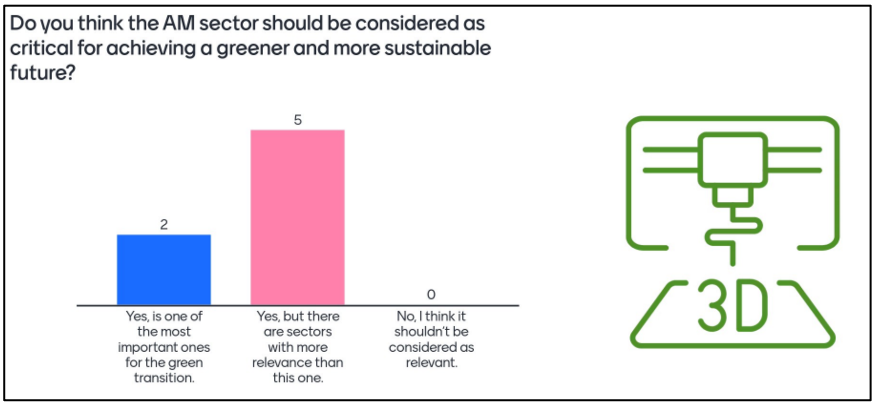
- Annex 4.2 Additive Manufacturing sector FG participant organisations

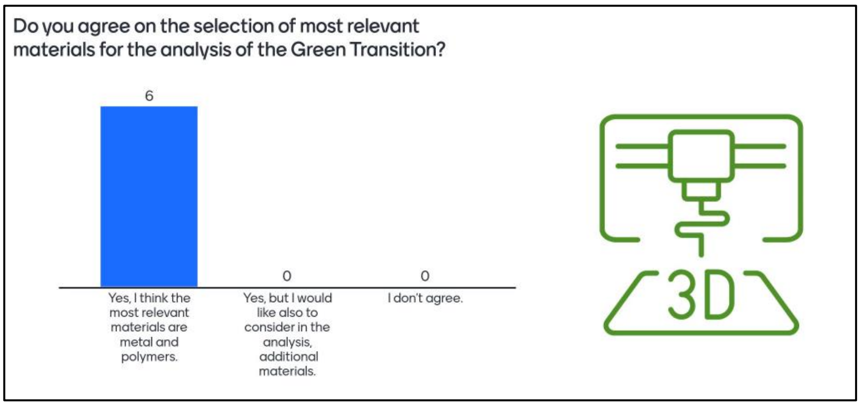
Position	Organisation	Type of Organism	Country
Project manager	EWF	Standardisation Body	Belgium
Doctoral Researcher	Brunel University	HIGH EDUCATION	UK
Researcher	IDONIAL	Research Centre	Spain
Head of Technology & Skills and Head of AMUK	MTA UK	Industry Representative	UK
Researcher	IMR	VET PROVIDER	IRELAND
Researcher	IDONIAL	Research Centre	Spain
Chief Technologist	MTC	VET PROVIDER	UK

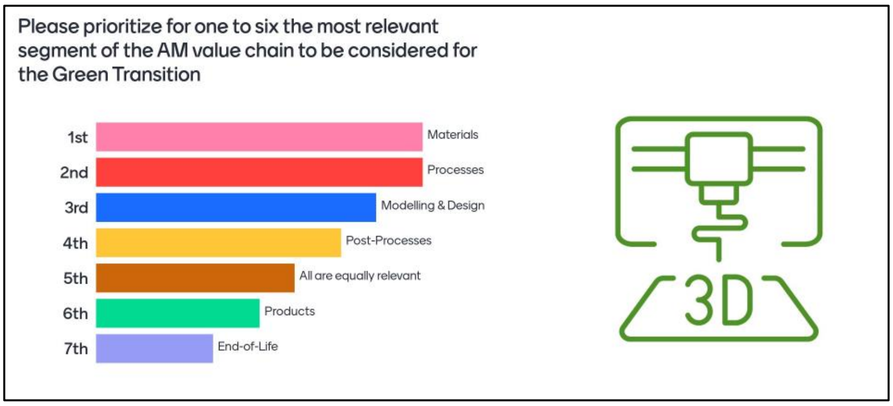
Project manager	MERCANTEC	-	Denmark
Professor	LAK	VET PROVIDER	Germany
Head of project and development	Dansk AM Hub	Industry Representative	Denmark

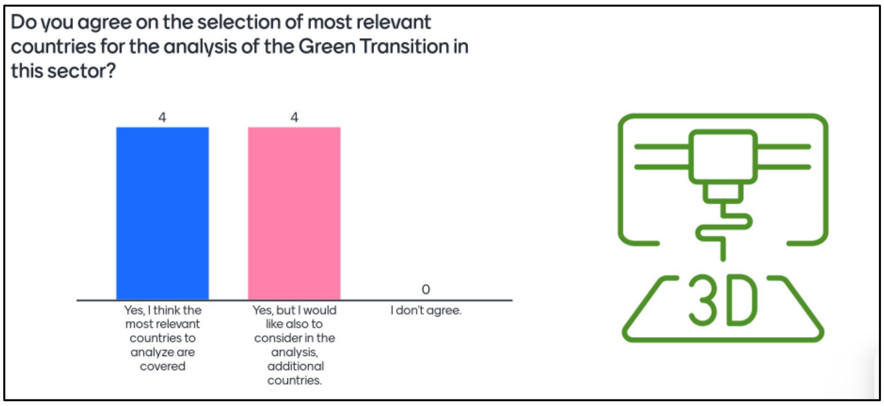
- Annex 4.3 – Focus Group Mentimeter Results

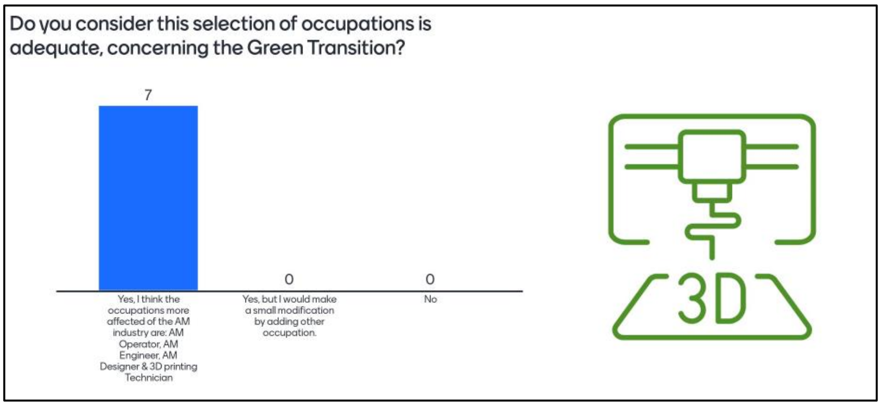


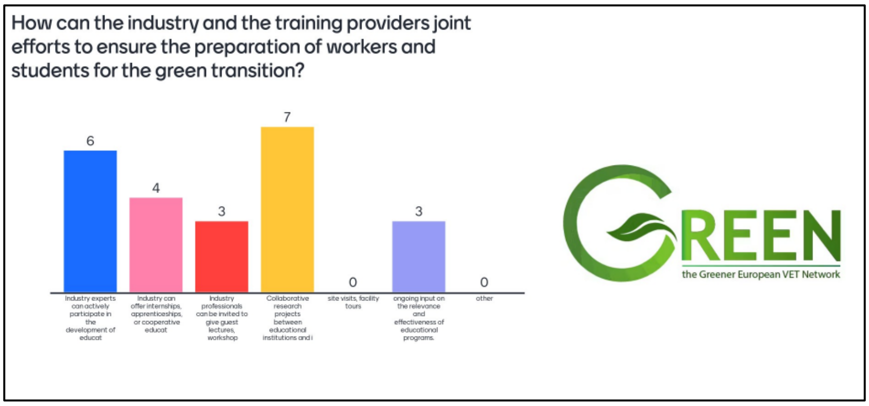


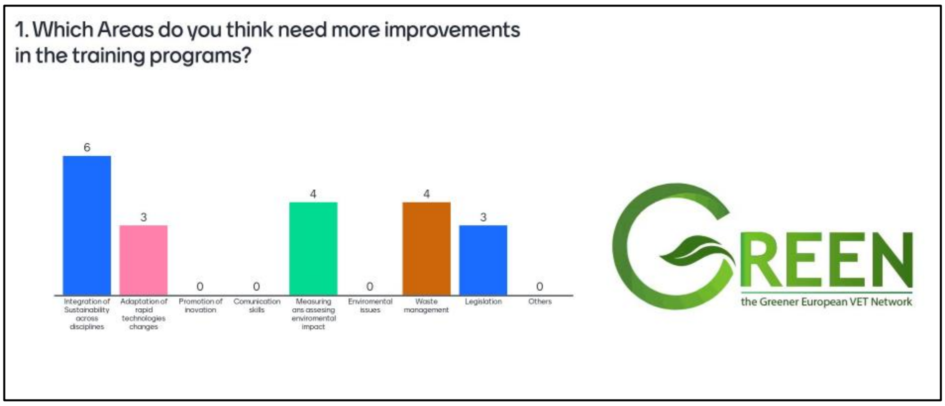


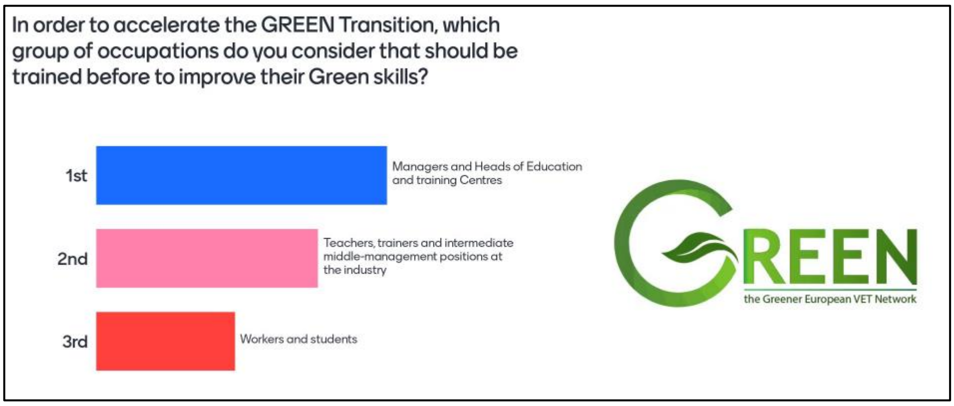

Please prioritize for one to six the most relevant segment of the AM value chain to be considered for the Green Transition
1st
2nd
3rd
4th
5th
6th
7th
Materials
Processes
Modelling & Design
Post-Processes
All are equally relevant
Products
End-of-Life
3D

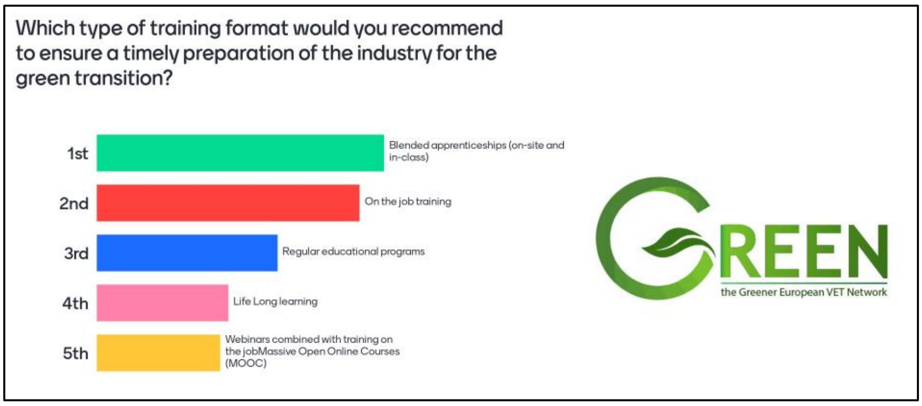

Do you agree on the selection of most relevant countries for the analysis of the Green Transition in this sector?
4
4
0
Yes, I think the most relevant countries to analyze are covered
Yes, but I would like also to consider in the analysis, additional countries.
I don't agree.
3D

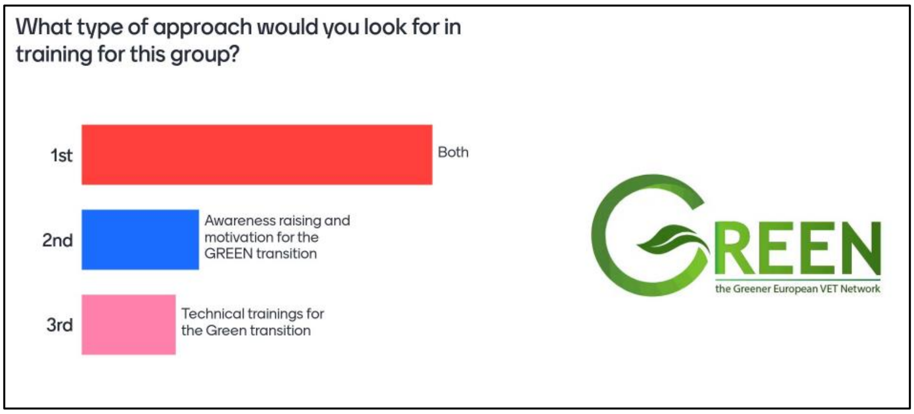

Do you consider this selection of occupations is adequate, concerning the Green Transition?
7
0
0
Yes, I think the occupations more affected of the AM industry are: AM Operator, AM Engineer, AM Designer & 3D printing Technician
Yes, but I would make a small modification by adding other occupation.
No
3D


How can the industry and the training providers joint efforts to ensure the preparation of workers and students for the green transition?
6
4
3
7
0
3
0
Industry experts can actively participate in the development of educat
Industry can offer internships, apprenticeships, or cooperative educat
Industry professionals can be invited to give guest lectures, workshop
Collaborative research projects between educational institutions and i
site visits, facility tours
ongoing input on the relevance and effectiveness of educational programs.
other
GREEN
the Greener European VET Network


1. Which Areas do you think need more improvements in the training programs?
6
3
0
0
4
0
4
3
0
Integration of Sustainability across disciplines
Adaptation of rapid technologies changes
Promotion of inovation
Comunication skills
Measuring ans assesing enviromental impact
Enviromental issues
Waste management
Legislation
Others
GREEN
the Greener European VET Network


In order to accelerate the GREEN Transition, which group of occupations do you consider that should be trained before to improve their Green skills?
1st
Managers and Heads of Education and training Centres
2nd
Teachers, trainers and intermediate middle-management positions at the industry
3rd
Workers and students
GREEN
the Greener European VET Network


Which type of training format would you recommend to ensure a timely preparation of the industry for the green transition?
1st
Blended apprenticeships (on-site and in-class)
2nd
On the job training
3rd
Regular educational programs
4th
Life Long learning
5th
Webinars combined with training on the jobMassive Open Online Courses (MOOC)
GREEN
the Greener European VET Network


What type of approach would you look for in training for this group?
1st
Both
2nd
Awareness raising and motivation for the GREEN transition
3rd
Technical trainings for the Green transition
GREEN
the Greener European VET Network

12.5 Automotive Annexes

- Annex 5.1 Automotive sector FG participant organisations

Organisation	Type of Organism	Country
InterTradeCards	SME, Consultant	Romania
Skelleftea	Municipality	Sweden
ISCN	SME, Consultant & Education and Training	Austria
TUG	HE Institution	Austria
Spin360	SME, Consultant	Italy
NEWTON University	HE Institution	Czech
elektromobilniplatforma.cz	Industrial Association, NGO	Czech
Autoklastr MSK	Industrial Association, NGO	Czech
University of Porto	HE Institution	Portugal
Vamia	VET Institution	Finland
Atec	VET Institution	Portugal
Eupportunity	SME, Consultant	Portugal
ACEA	Industrial Association, NGO	Brussels
SKODA AUTO University	HE Institution	Czech
IPV	HE Institution	Portugal
Continental	Industry, large company	Romania
Merinova	SME, Consultant	Finland
University of Maribor	HE Education	Slovenia
ISCN	SME, Consultant & Education and Training	Austria
Region of Trnava Slovakia	Public authority	Slovakia

12.6 Batteries Annexes

- Annex 6.1 Batteries sector FG participant organisations

Organisation	Type of Organism	Country
InterTradeCards	SME, Consultant	Romania
Skelleftea	Municipality	Sweden

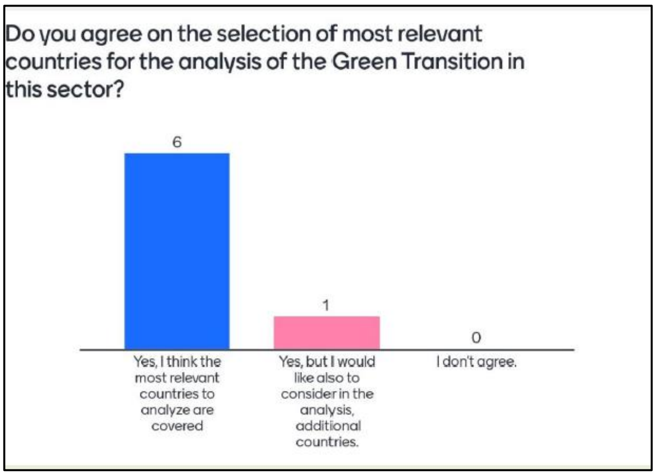
ISCN	SME, Consultant & Education and Training	Austria
TUG	HE Institution	Austria
Spin360	SME, Consultant	Italy
NEWTON University	HE Institution	Czech
elektromobilniplatforma.cz	Industrial Association, NGO	Czech
Autoklastr MSK	Industrial Association, NGO	Czech
University of Porto	HE Institution	Portugal
Vamia	VET Institution	Finland
Atec	VET Institution	Portugal
Eupportunity	SME, Consultant	Portugal
ACEA	Industrial Association, NGO	Brussels
SKODA AUTO University	HE Institution	Czech
IPV	HE Institution	Portugal
Continental	Industry, large company	Romania
Merinova	SME, Consultant	Finland
University of Maribor	HE Education	Slovenia
ISCN	SME, Consultant & Education and Training	Austria
Region of Trnava Slovakia	Public authority	Slovakia

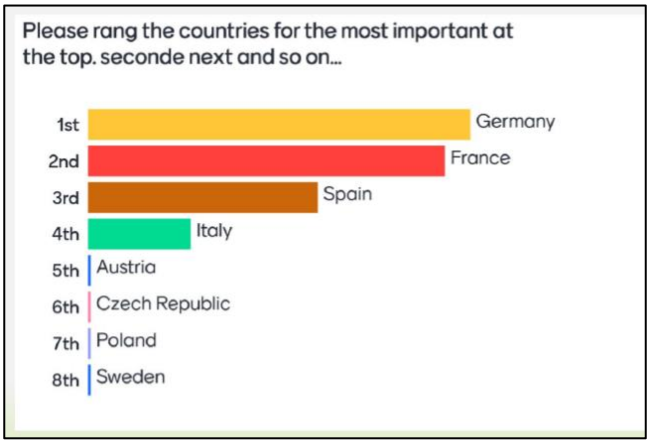
12.7 Defence Annexes

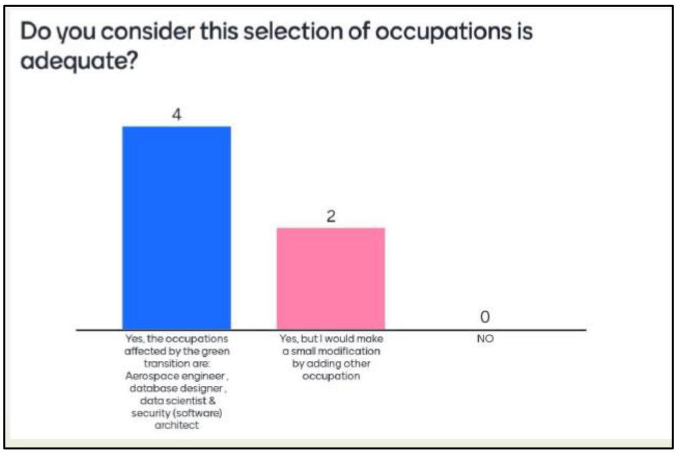
- Annex 7.1 Defence sector FG participant organisations

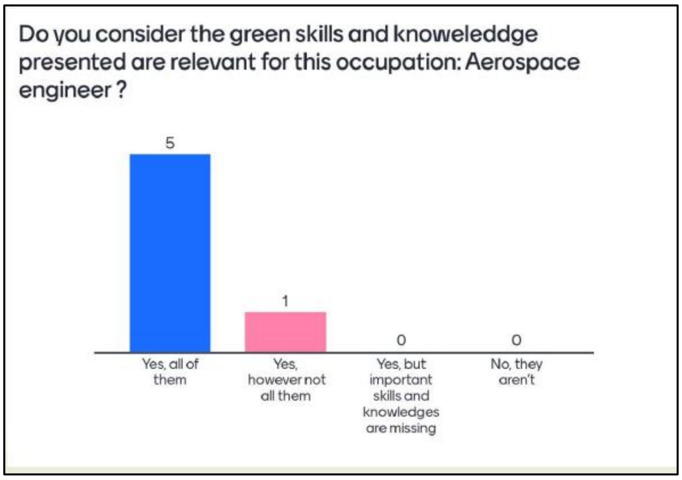
Position	Organisation	Type of Organism	Country
CEO	Asturias Defence Hub	Industry Representative/ Education and Training Provider	Spain
professor	LAK	VET PROVIDER	Germany
professor	BIL - IBS	VET PROVIDER	Belgium
Project Manager	CT Ingenieros	Industry Representative	Spain
Sales Manager for Aux. Industry	Navantia Seanergies	Other	Spain

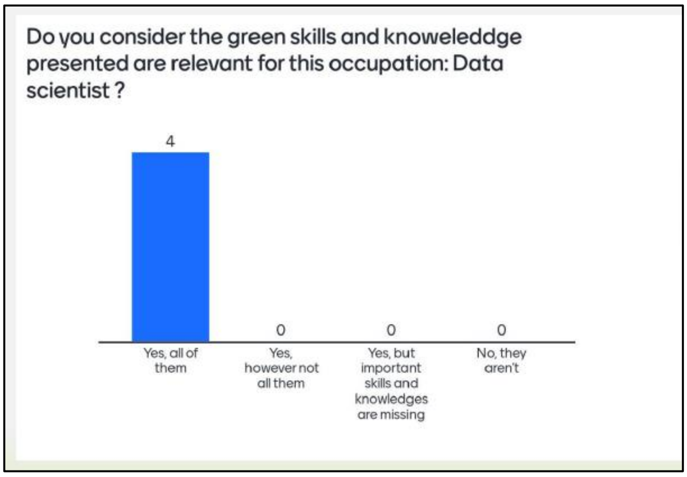
- Annex 7.2 Defence Focus Group Mentimeter result

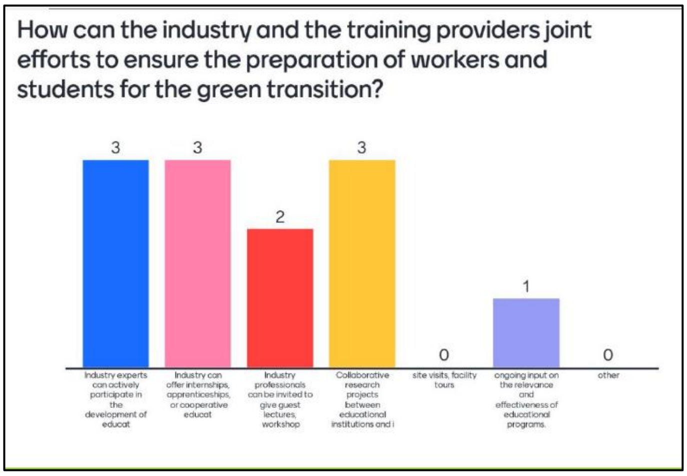


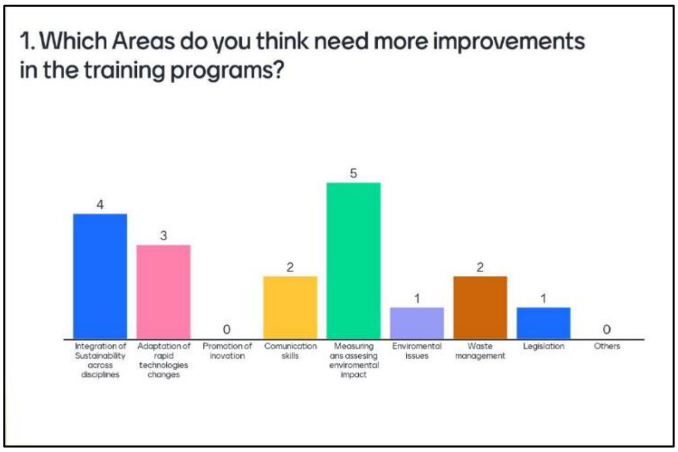


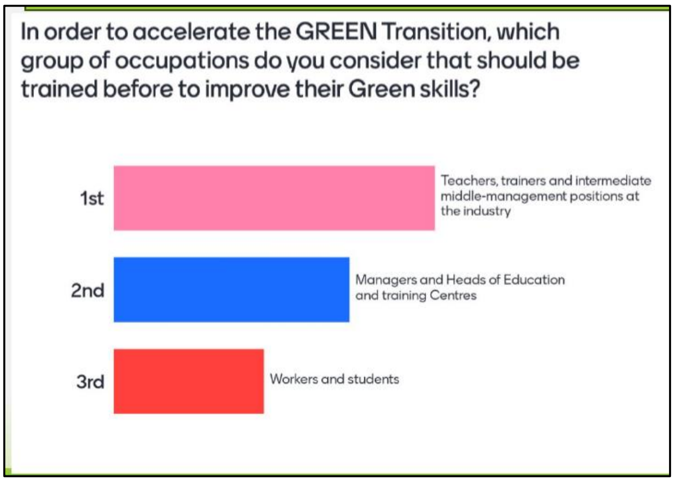


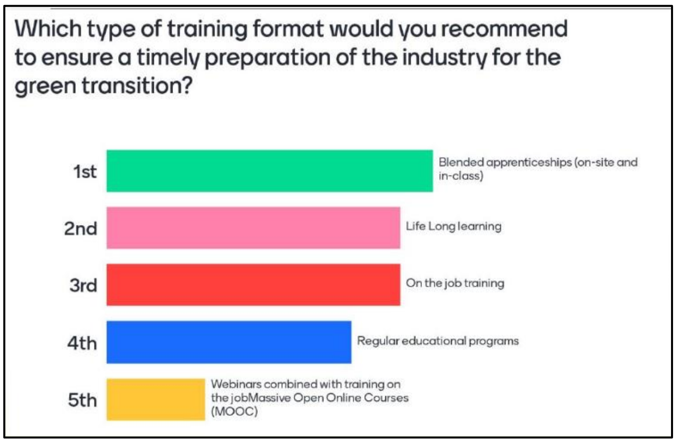

Do you consider the green skills and knoweleddge presented are relevant for this occupation: Aerospace engineer ?
5
1
0
0
Yes, all of them
Yes, however not all them
Yes, but important skills and knowledges are missing
No, they aren't

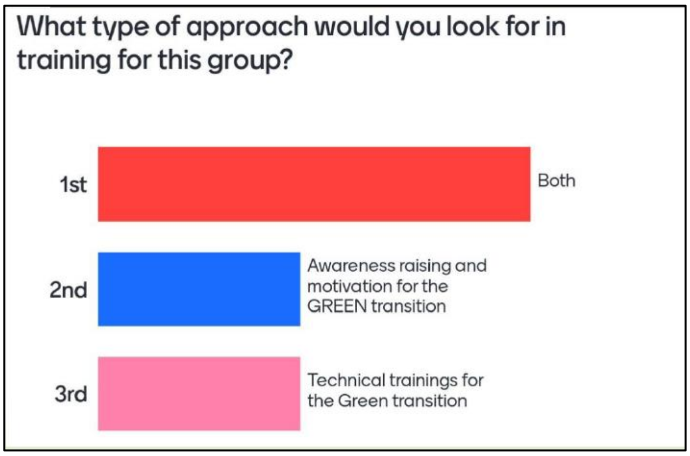

Do you consider the green skills and knoweleddge presented are relevant for this occupation: Data scientist ?
4
0
0
0
Yes, all of them
Yes, however not all them
Yes, but important skills and knowledges are missing
No, they aren't


How can the industry and the training providers joint efforts to ensure the preparation of workers and students for the green transition?
3
3
2
3
0
1
0
Industry experts can actively participate in the development of educat
Industry can offer internships, apprenticeships, or cooperative educat
Industry professionals can be invited to give guest lectures, workshop
Collaborative research projects between educational institutions and i
site visits, facility tours
ongoing input on the relevance and effectiveness of educational programs.
other


1. Which Areas do you think need more improvements in the training programs?
4
3
0
2
5
1
2
1
0
Integration of Sustainability across disciplines
Adaptation of rapid technologies changes
Promotion of inovation
Comunication skills
Measuring ans assesing enviromental impact
Enviromental issues
Waste management
Legislation
Others


In order to accelerate the GREEN Transition, which group of occupations do you consider that should be trained before to improve their Green skills?
1st
Teachers, trainers and intermediate middle-management positions at the industry
2nd
Managers and Heads of Education and training Centres
3rd
Workers and students


Which type of training format would you recommend to ensure a timely preparation of the industry for the green transition?
1st
Blended apprenticeships (on-site and in-class)
2nd
Life Long learning
3rd
On the job training
4th
Regular educational programs
5th
Webinars combined with training on the jobMassive Open Online Courses (MOOC)

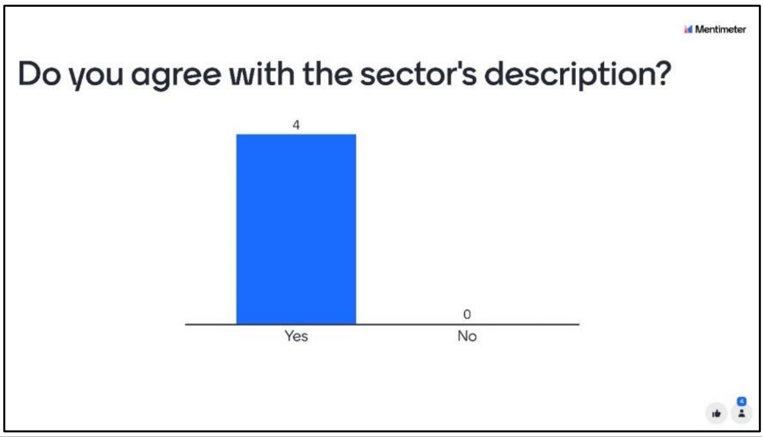


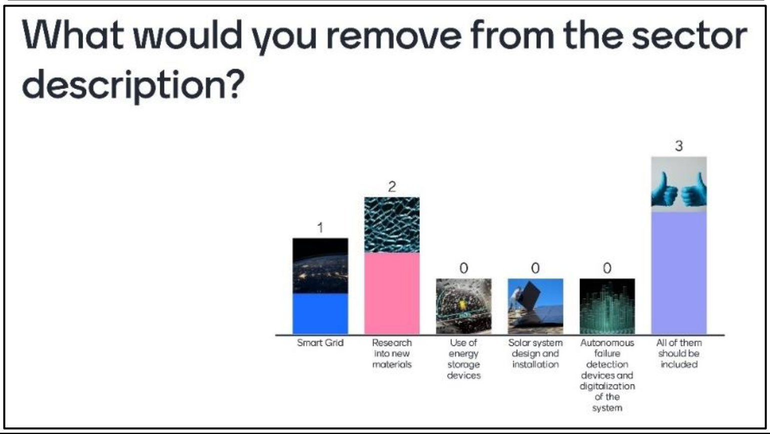
12.8 Energy Annexes

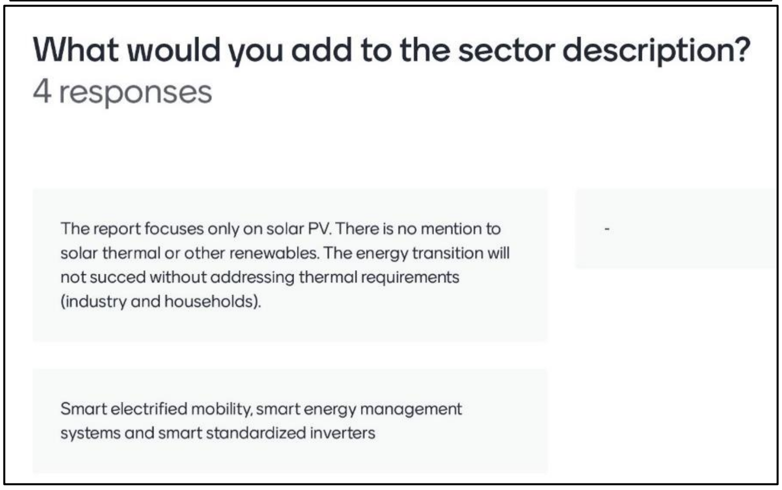
- Annex 8.1 Energy sector FG participant organisations

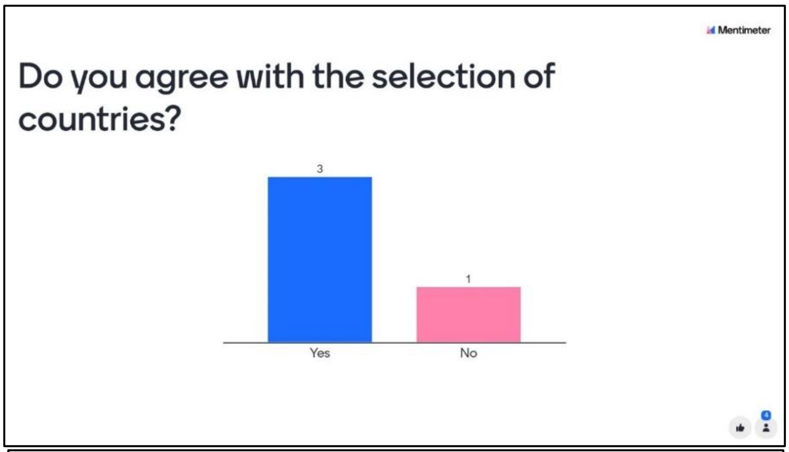
Position	Organisation	Type of Organism	Country
Managing Director/CEO	Alectris	Industry Representative	Greece
Chairman of Research Centre	EPL	Research Center	Cyprus
Professor	Universidad de la República	HIGH EDUCATION	Spain
R&D Coordinator	TSK	Industry Representative	Spain

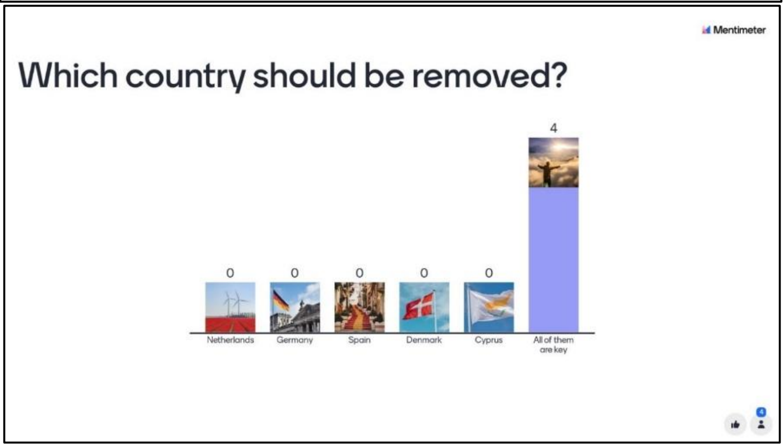
-Annex 8.2 Results of the FG Sector Meeting


Mentimeter
Do you agree with the sector's description?
4
0
Yes
No

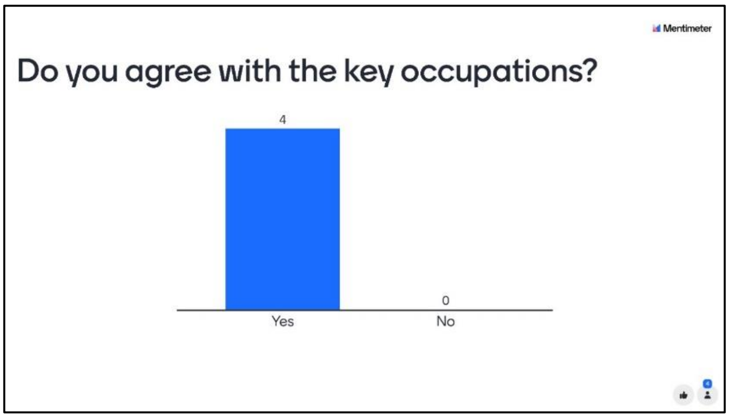

What would you remove from the sector description?
1
2
0
0
0
3
Smart Grid
Research into new materials
Use of energy storage devices
Solar system design and installation
Autonomous failure detection devices and digitalization of the system
All of them should be included

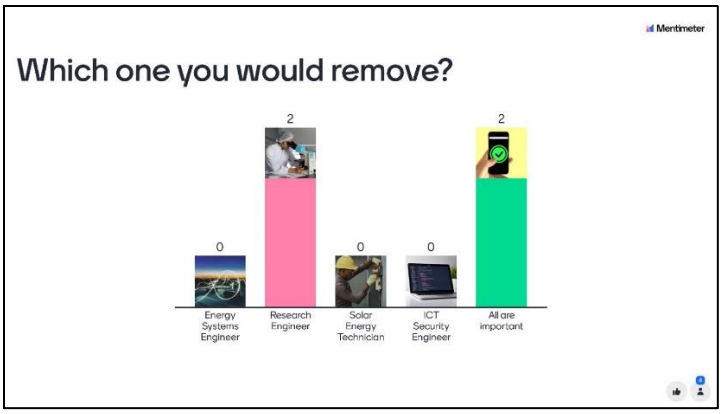

What would you add to the sector description?
4 responses
The report focuses only on solar PV. There is no mention to solar thermal or other renewables. The energy transition will not succed without addressing thermal requirements (industry and households).
-
Smart electrified mobility, smart energy management systems and smart standardized inverters

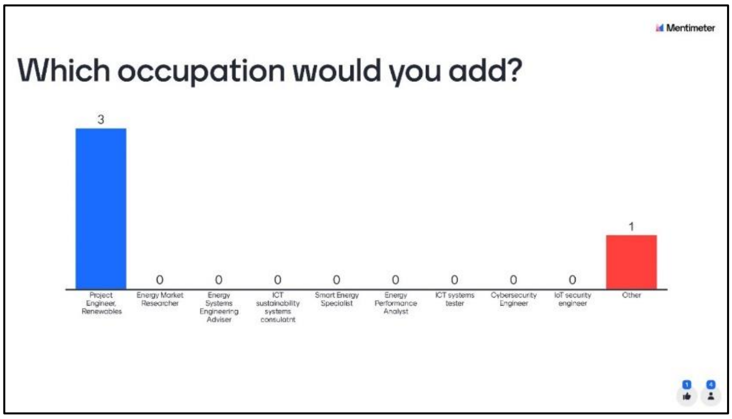

Mentimeter
Do you agree with the selection of countries?
3
1
Yes
No

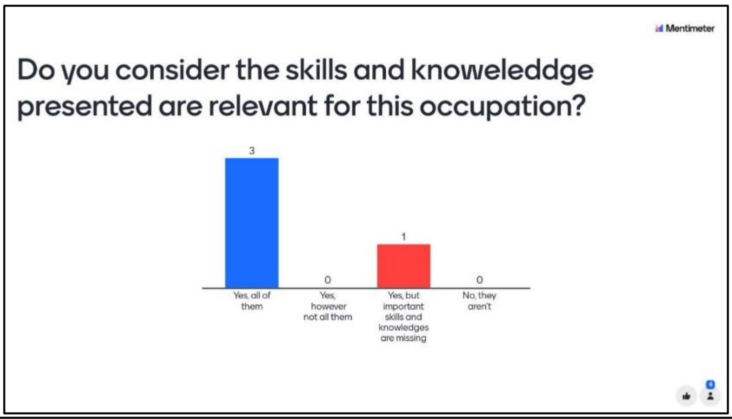

Mentimeter
Which country should be removed?
4
0
0
0
0
0
Netherlands
Germany
Spain
Denmark
Cyprus
All of them are key

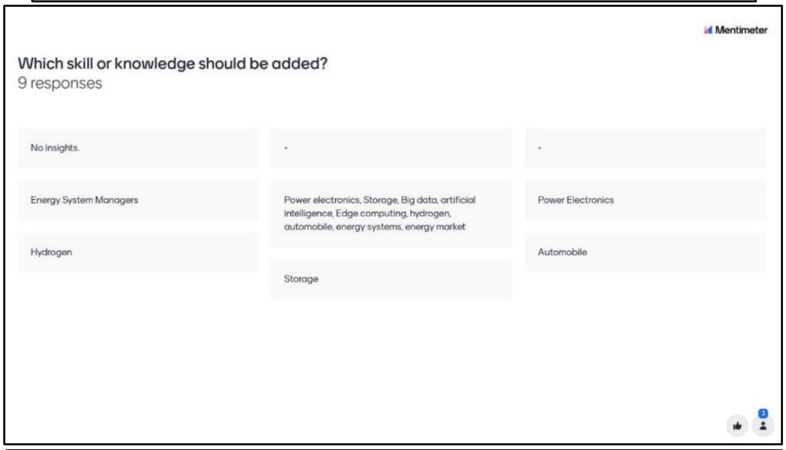

Mentimeter
Which country should be added?
7 responses
no insights
italy
france
greece
latvia

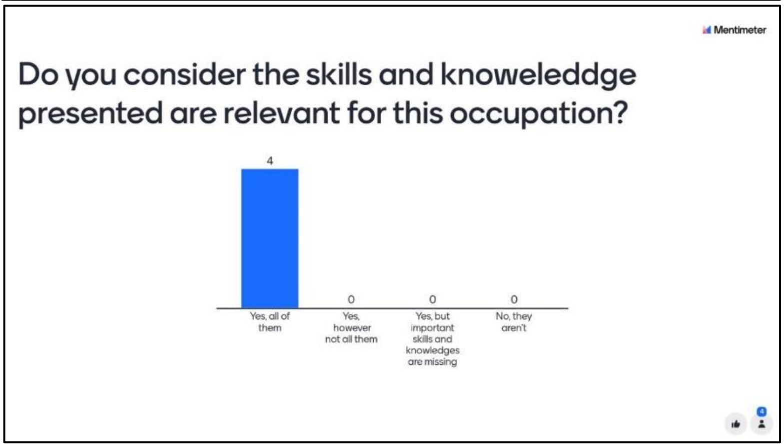

Mentimeter
Do you agree with the key occupations?
4
0
Yes
No

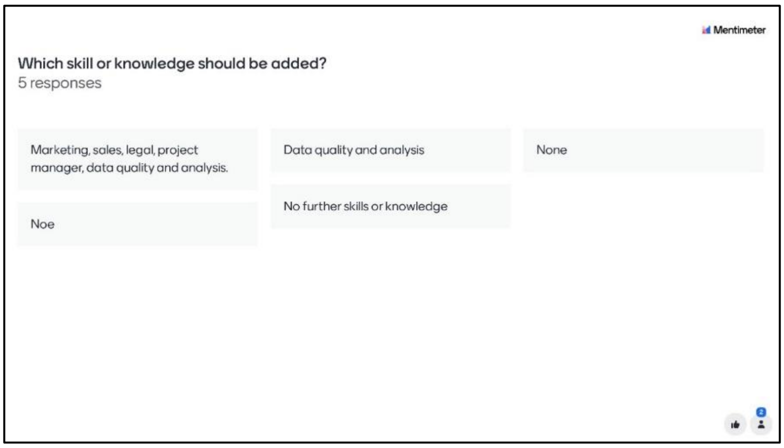

Mentimeter
Which one you would remove?
0
2
0
0
2
Energy Systems Engineer
Research Engineer
Solar Energy Technician
ICT Security Engineer
All are important

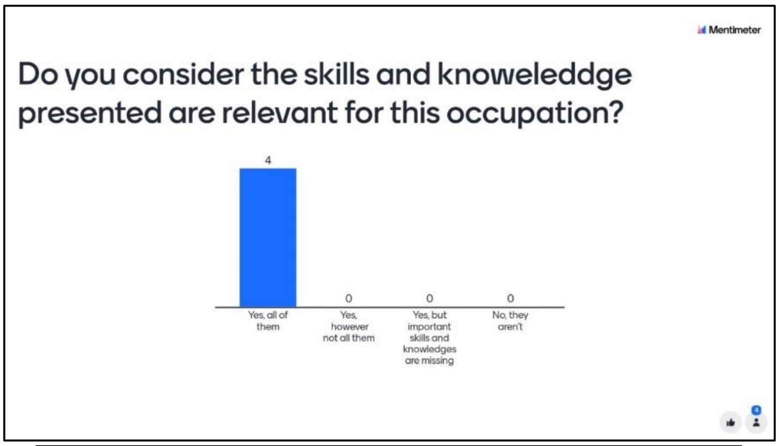

Mentimeter
Which occupation would you add?
3
0
0
0
0
0
0
0
0
1
Project Engineer, Renewables
Energy Market Researcher
Energy Systems Engineering Adviser
ICT sustainability systems consulatnt
Smart Energy Specialist
Energy Performance Analyst
ICT systems tester
Cybersecurity Engineer
IoT security engineer
Other

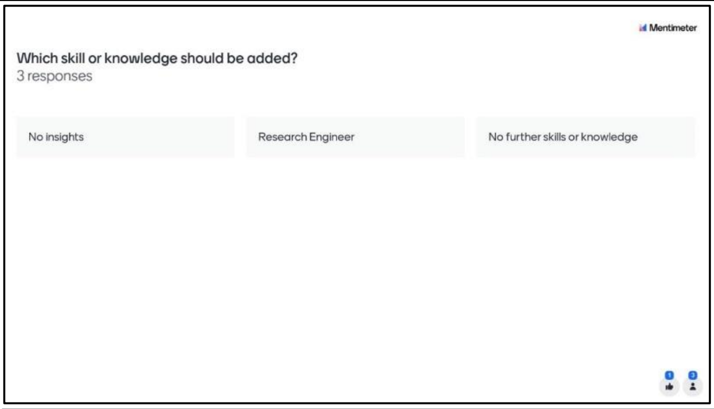

Mentimeter
Do you consider the skills and knoweleddge presented are relevant for this occupation?
3
0
1
0
Yes, all of them
Yes, however not all them
Yes, but important skills and knowledges are missing
No, they aren't

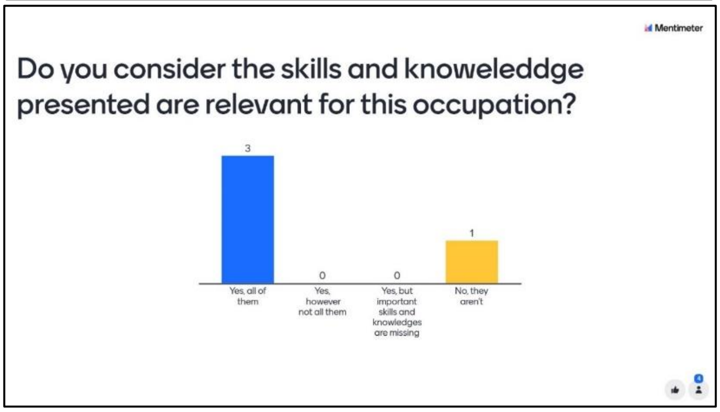

Mentimeter
Which skill or knowledge should be added?
9 responses
No insights.
-
-
Energy System Managers
Power electronics, Storage, Big data, artificial intelligence, Edge computing, hydrogen, automobile, energy systems, energy market
Power Electronics
Hydrogen
Automobile
Storage

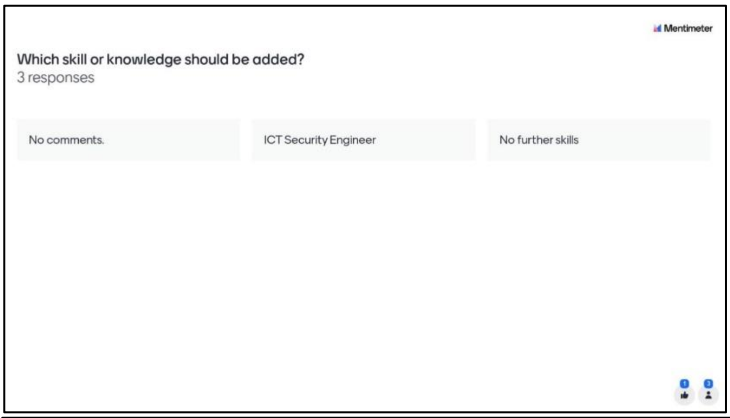

Mentimeter
Do you consider the skills and knoweleddge presented are relevant for this occupation?
4
0
0
0
Yes, all of them
Yes, however not all them
Yes, but important skills and knowledges are missing
No, they aren't


Mentimeter
Which skill or knowledge should be added?
5 responses
Marketing, sales, legal, project manager, data quality and analysis.
Data quality and analysis
None
No further skills or knowledge
Noe

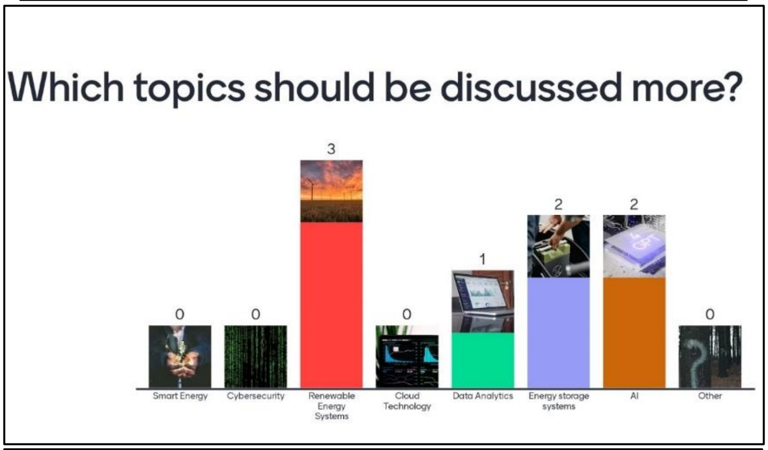

Mentimeter
Do you consider the skills and knoweleddge presented are relevant for this occupation?
4
0
0
0
Yes, all of them
Yes, however not all them
Yes, but important skills and knowledges are missing
No, they aren't

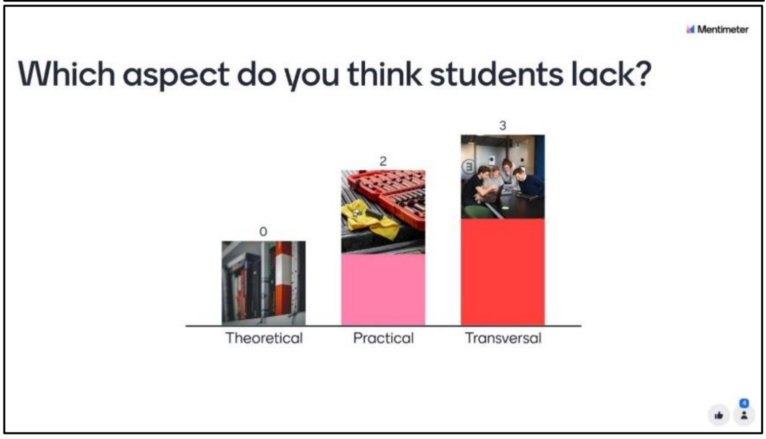

Mentimeter
Which skill or knowledge should be added?
3 responses
No insights
Research Engineer
No further skills or knowledge

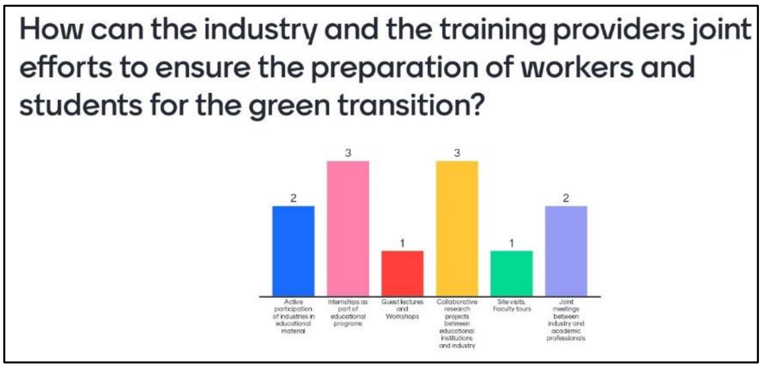

Mentimeter
Do you consider the skills and knoweleddge presented are relevant for this occupation?
3
0
0
1
Yes, all of them
Yes, however not all them
Yes, but important skills and knowledges are missing
No, they aren't

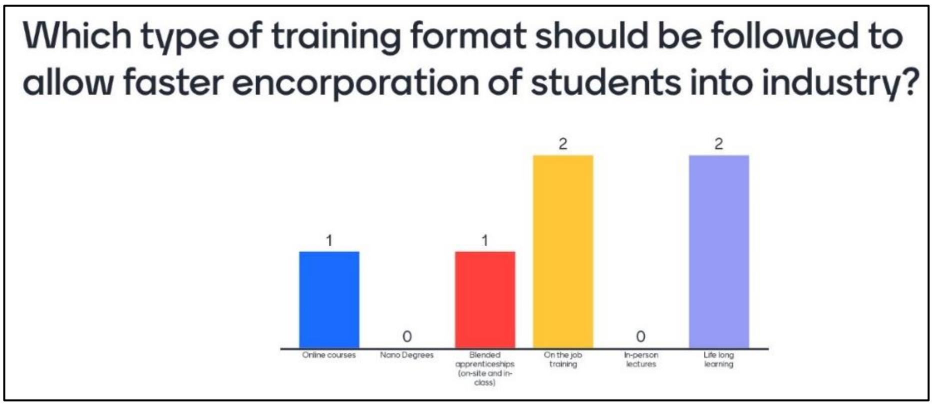

Mentimeter
Which skill or knowledge should be added?
3 responses
No comments.
ICT Security Engineer
No further skills


Which Areas do you think need more improvements in the training programs?
2
1
1
2
2
1
Integration of Sustainability across disciplines
Adaptation of rapid technologies changes
Promotion of innovation
Communication skills
Awareness of current enviromental issues
Other


Which topics should be discussed more?
0
0
3
0
1
2
2
0
Smart Energy
Cybersecurity
Renewable Energy Systems
Cloud Technology
Data Analytics
Energy storage systems
AI
Other


Mentimeter
Which aspect do you think students lack?
0
2
3
Theoretical
Practical
Transversal


How can the industry and the training providers joint efforts to ensure the preparation of workers and students for the green transition?
2
3
1
3
1
2
Active participation of industries in educational material
Internships as part of educational programs
Guest lectures and Workshops
Collaborative research projects between educational institutions and industry
Site visits, Faculty tours
Joint meetings between industry and academic professionals


Which type of training format should be followed to allow faster encorporation of students into industry?
1
0
1
2
0
2
Online courses
Nano Degrees
Blended apprenticeships (on-site and in-class)
On the job training
In-person lectures
Life long learning

12.9 Maritime Technologies Annexes

- Annex 9.1: Complete list of Maritime technologies occupations for the shipbuilding and offshore renewable energy sectors.

SHIPBUILDING primary and supporting occupations

Common occupations with the ORE value change are marked in bold

Shipbuilding Primary Occupations		
Group	Occupations	
Engineers	Naval architect Marine engineer	**Electromechanical engineer** Alternative fuels engineer
Technicians	Marine engineering technician **Electromechanical engineering technician** Electronics engineering technician	
Draughtspersons	Marine engineering drafter	**Electromechanical drafter**
Metalworkers	Welding inspector **Welder** Shipwright	Boilermaker Pipe welder (pipefitter) Sheet metal worker
Electricians & Electronics technicians	Marine electrician Marine electronics technician	**Electromechanical equipment assembler** **Electronic equipment assembler**
Mechanics	Vessel engine assembler	
Surface treatment	Surface treatment operator Transport equipment painter Abrasive blasting operator (sandblasting)	
Boat artisans	Marine upholsterer Boat rigger	Fiberglass laminator Made-up textile articles manufacturer (sail maker)
Machinists	Computer numerical control (CNC) machine operator	
Carpenters	Marine Carpenter	
Other	Vessel assembly supervisor Vessel assembly inspector Marine surveyor Construction scaffolder	Construction scaffolding supervisor **Mobile crane operator** **Production plant crane operator**

Shipbuilding Supporting		
Group	Occupations	
Managers	**Project manager** **Operation manager** **Construction safety manager**	
Economists	**Investment analyst**	
Database and system analysts	**Data analyst**	**ICT resilience manager**
Engineers	**Industrial engineer** **Mechatronics engineer** **Automation engineer** **Robotics engineer**	**Welding engineer** Electronics engineer **Telecommunications engineer**
Technicians	**Industrial engineering technician** **Mechatronics engineering technician** **Automation engineering technician** **Pneumatic engineering technician** **Robotics engineering technician**	**Power tool repair technician** **Industrial robot controller** **Pneumatic systems technician** **Drone Pilot**
Draughtspersons	**Fitter and turner**	
Other	**Mechatronics assembler** **Metal products assembler** **Metal furniture machine operator**	

ORE primary and supporting occupations

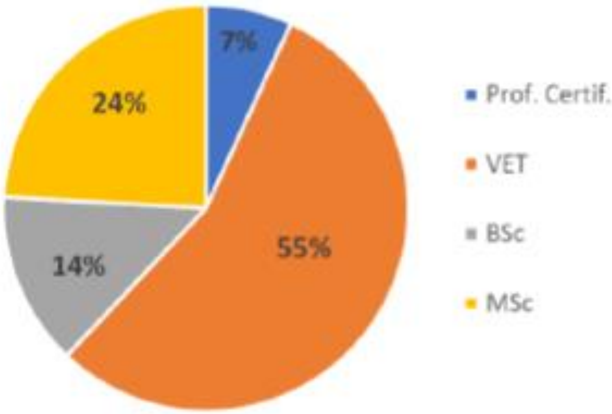
Common occupations with the shipbuilding value change are marked in bold

Shipbuilding Primary Occupations		
Group	Occupations	
Engineers	ORE engineer Renewable energy engineer Energy systems engineer Wind energy engineer	Solar energy engineer Power distribution engineer Electric power generation engineer Maintenance and repair engineer
Technicians	ORE technician Wind turbine technician Solar energy technician	Hydropower technician Tidal power technician Wave power technician **Electromechanical engineering technician**
Draughtspersons	**Electromechanical drafter**	
Metalworkers	**Welder**	
Assemblers	**Electromechanical equipment assembler** **Electronic equipment assembler** Printed circuit board assembler	
Installers	Cable installer	
Divers	Construction commercial diver	
Health and safety	Health and safety officer	
Plant operators	ORE Plant Operator Power production plant operator Solar power plant operator	

ORE Supporting		
Group	Occupations	
Managers	Policy manager **Project manager**	**Operation manager** Industrial maintenance supervisor **Construction safety manager**
Consutants	Renewable energy consultant Environmental expert	Solar energy sales consultant
Economists	**Investment analyst**	Energy trader
Marine suveyors	Oceanographer	Hydrographic surveyor
Database and system analysts	**Data analyst**	**ICT resilience manager**
Engineers	Design engineer Electrical engineer **Industrial engineer** **Mechatronics engineer** **Automation engineer** **Robotics engineer**	**Telecommunications engineer** **Welding engineer** **Electromechanical engineer** Instrumentation engineer
Technicians	**Industrial engineering technician** **Mechatronics engineering technician** **Automation engineering technician** **Pneumatic engineering technician**	**Robotics engineering technician** Instrumentation engineering technician **Power tool repair technician** **Industrial robot controller** **Pneumatic systems technician** Telecommunications technician **Drone Pilot**
Metalworkers	**Fitter and turner**	
Assemblers	**Mechatronics assembler** **Metal products assembler**	**Metal furniture machine operator**
Crane operators	**Production plant crane operator**	**Mobile crane operator**
Sales representatives	Renewable energy sales representative	
Plant operators	Electrical transmission system operator	
Installers and repairers	Electricity distribution worker Communication infrastructure maintainer Telecommunications equipment maintainer	
Legal professionals	Lawyer Corporate lawyer	Legal consultant

- Annex 9.2: Main training offers for Shipbuilding in the three more relevant countries for the sector in Europe: Italy, Germany and France

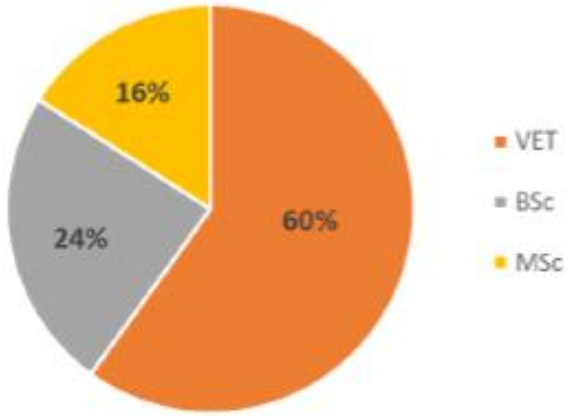
Italy

EQF Level	Across Italy, there were 29 relevant E&T programs with more than half (55%) being VET programs, similarly to other EU countries. However, B.Sc. and M.Sc. programs and programs providing professional certificates account for most of the remaining share, with the latter representing only 7% of all available programs. As was the case in Spain, several programs were concentrated in a specific region which, in this case, is the Friuli-Venezia Giulia region where a large and very active shipbuilding community is established. 
Specialization	Only 26% of the primary occupational profiles identified are targeted by the available E&T programs, with most of them specializing in marine engineering, naval architecture and marine drafting.
Occupational profiles	With regard to the aforementioned specialization, the relevant occupational profiles (i.e. marine engineers, naval architects, marine engineering technicians, marine engineering drafters and shipwrights) are addressed by the majority of the available E&T programs. Electro-mechanical engineering technicians and marine engineers are also targeted by a lower but still considerable number of programs. However, major gaps exist for all other primary occupational profiles identified (i.e. 74% of the total) since there was no E&T program that covers them providing the required knowledge and skills.
Value chain	As indicated above, there are major gaps in the current skills supply relating mainly to the production and post-production phases of the shipbuilding value chain. More specifically, 89% of all occupational profiles involved in those phases are not covered by any E&T program currently available.
Language	Out of the 29 E&T programs identified, only 7 are offered in English or are bilingual. 6 of these are M.Sc. programs and 1 is a VET program. All 7 are devoted to vessel design processes.

(Source: programs' websites; https://atlantelavoro.inapp.org/index.php)

Figure 9.4: Italy educational and training (E&T) programs results for shipbuilding [9]

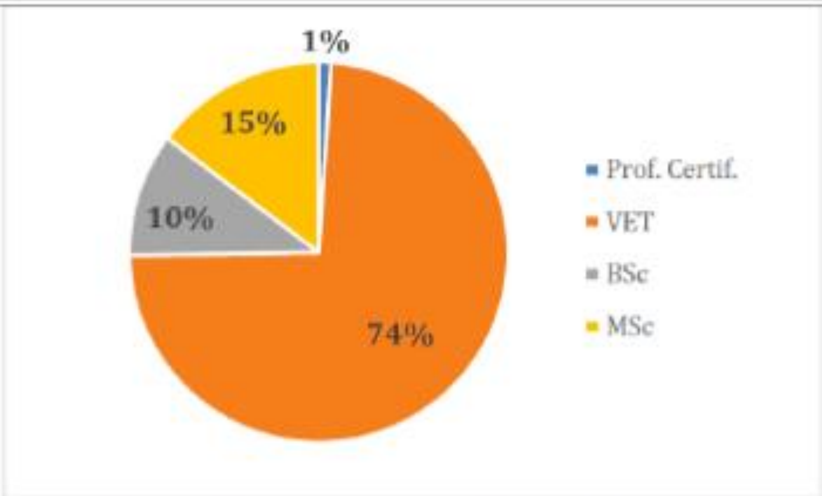
Germany

EQF Level	Germany also offers a considerable number of E&T programs targeting the shipbuilding industry (i.e. 50), supporting in that way the country's high productivity level within the European context. Similar to France, the majority of the available programs are VET programs (EQF 3-5) with B.Sc. and M.Sc. programs holding the remaining share.
	
Specialization	Almost 69% of the primary occupational profiles identified are addressed by available E&T programs in Germany. Several of these mainly target engineers such as marine engineers, naval architects and marine engineering technicians.
Occupational profiles	Besides the above, boilermakers, electro-mechanical engineering technicians, pipefitters, sheet metalworkers and welders are also addressed by a considerable number of the available E&T programs. A large majority of the primary occupational profiles identified are addressed by fewer than 10% of the available E&T programs while approximately 31% of them are not addressed by any program at all. The latter are mainly concerned with lifting and handling processes, technical and assembling procedures, drafting and surface treatment, etc.
Value chain	Existing shortages mainly related to the production and post-production phases of the shipbuilding value chain, with 65% of the primary occupational profiles engaged in those phases not covered by any E&T program available in the country.
Language	Approximately 20% of the available E&T programs in Germany are provided in English or are bilingual. All of them are either under-graduate or post-graduate programs (EQF 6-7).

(Source: programs' websites; https://kursnet-finden.arbeitsagentur.de/kurs/; https://www.bibb.de/)

Figure 9.5: Germany educational and training (E&T) programs results for shipbuilding [9]

France

EQF Level	As mentioned above, France accounts for the highest share of E&T programs identified for the shipbuilding sector. More precisely, 95 programs were identified the large majority of which are VET programs (i.e. EQF 3-5). A considerable number accounts for programs of higher education (B.Sc. & M.Sc.), while a few programs providing professional certificates related to different activities within the shipbuilding value chain were found to exist.
	
Specialization	Almost 26 of the 35 primary occupational profiles identified are addressed by the available E&T programs. Most of the latter however focus on metalworking and assembly activities.
Occupational profiles	None of the primary occupational profiles is addressed by more than 20% of the available programs. Therefore, there exists some diversity in the qualifications provided within the country, with marine engineers and welders however attracting greater interest. On the other hand, a series of other occupational profiles are not covered to a satisfactory extent by the available programs (i.e. boat riggers, boilermakers, carpenters, computer numerical control machine operators, electro-mechanical drafters, construction scaffolders, electro-mechanical engineers, construction scaffolding supervisors, electro-mechanical engineering technicians, electronic equipment assemblers, made-up textile articles manufacturers, marine electricians and electronics technicians, marine engineering drafters, marine upholsterers, marine engineering technicians, marine surveyors, pipe welders (pipefitter), naval architects, shipwrights, sheet metal workers, vessel engine assemblers, surface treatment operators, vessel assembly supervisors). The greatest gap in skills supply exists with regard to the following occupational profiles: electronics engineering technicians, welding inspectors, electronic equipment assemblers, transport equipment painters, abrasive blasting operators (sandblasting), vessel assembly inspectors, mobile crane operators, production plant crane operators. No program was found to address those occupational profiles which represent almost 26% of all primary occupational profiles identified.
Value chain	Since current gaps are spread over different parts of the value chain, there is not a specific segment where major shortages exist and for which immediate action should be taken.
Language	Only 8 of all available programs are provided in English or are bilingual. These mainly refer to under- and post-graduate programs (EQF 6-7).

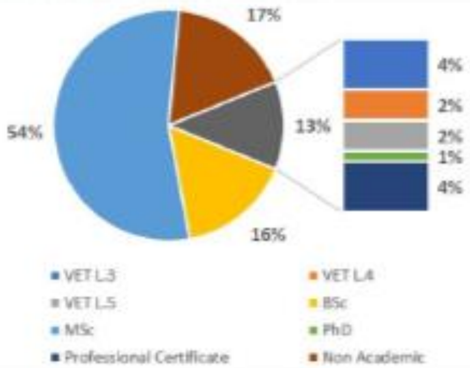
(Source: programs' websites; https://www.campusfrance.org/fr; http://ibcvet.paragonweb.eu/)

Figure 9.6: France educational and training (E&T) programs results for shipbuilding [9]

- Annex 9.3: Main training offers for the offshore renewables in the three more relevant countries for the sector in Europe: UK, Germany and France

EQF Level	In the UK, the majority of identified E&T programs were M.Sc. degree programs (54%), indicating that ORE specialization is mainly provided at post-graduate level. Very low (only 8%) was the number of available VET programs, which provide graduates with the necessary technical skills for supporting different technical procedures within the ORE value chain.

United Kingdom

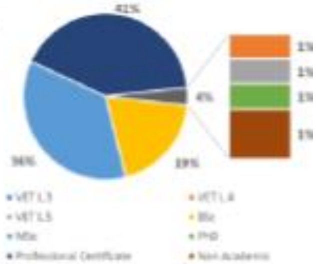


Specialization	The E&T programs identified in the UK adequately address the energy sector as a whole, covering different fields of specialization including: • *Offshore infrastructures* (4%), mainly following an engineering approach. • *Offshore renewables* (7%), including mainly marine energy technologies (wave energy, tidal energy etc.). • *Renewable energy* (54%), with some programs specializing in wind energy. Renewable energy programs cover mostly engineering aspects, policy and management issues, economics and different energy systems. A few have a more technological orientation (e.g. ICT and data security) • *Energy in general* (22%), covering both conventional and renewable energy technologies. The programs address diverse aspects of the energy sector such as engineering, energy systems, management and economics. • *Environmental and marine sciences* (6%), including subjects of economics, engineering, law, management, consultancy or planning. • *Other related fields* (7%) such as welding, electrical engineering, climate change and policies and legislation.
Occupational profiles	Over half of the primary occupational profiles are adequately addressed by the available E&T programs. Occupational profiles related to *engineering and operational activities* such as energy generation, cable installation and maintenance are covered to a greater extent. Less attention is paid to *assemblers and technicians*, *plant operators* and occupational profiles related to *power distribution*, with the latter accounting for the greatest shortage. Gaps in skills supply were found to exist for occupational profiles engaged in *technical procedures* (i.e. construction commercial divers, circuit board assemblers, electro-mechanical drafters, etc.) and *health and safety processes*.
Value chain	The phases of the ORE value chain affected to the greatest extent by the aforementioned shortages are *operation & maintenance* and *construction & installation*.
Language	The E&T programs identified in the UK are all offered in English, since this is the official language of the country. To this end, those programs favour and successfully attract a large number of international students.

(Source: programs' websites; https://www.ucas.com/about-us)

Figure 9.6: UK educational and training (E&T) programs results for the ORE [9]

Germany	**EQF Level**	The vast majority of the relevant programs in Germany provide either a professional certificate (41.4%) or a M.Sc. degree (35.8%). To this end, the required knowledge, skills and competences are provided mostly through specialized programs targeting white collar occupations. B.Sc. degree programs are fewer but still considerable (19.3%) while non-academic, VET and Ph.D. programs take up only a very small share. In particular, the small number of VET programs rolls back opportunities to respond swiftly to new industry requirements as a result, for example, of the introduction of new technologies.

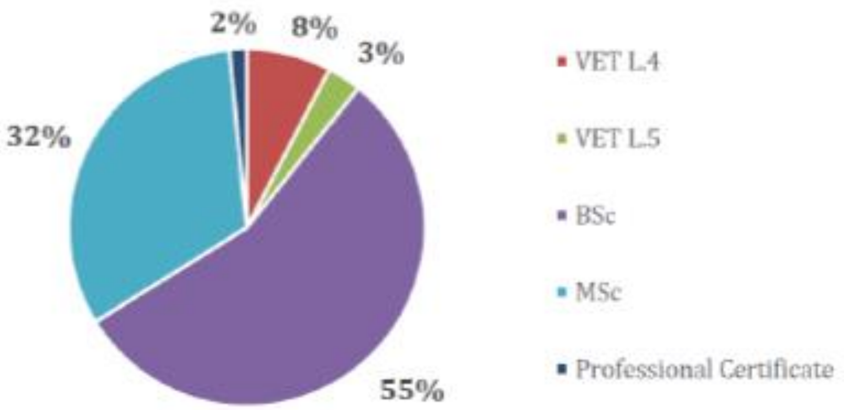


Specialization	About 30% of the E&T programs identified provide expertise in *renewable energies*. However, their curricula have been structured from the perspective of different disciplines such as *engineering*, *economics*, *management* or *consultancy*. More general programs focusing on the *energy sector as a whole* account for 19% of all programs, while those emphasizing in *wind energy* alone comprise 15%. Programs addressing *solar energy* account for only 5% of all programs, though with no specific knowledge on *offshore solar technologies* being provided. Only 6 out of the 145 relevant programs identified in Germany, directly address *offshore technologies*, while 5 specialize in *offshore wind*. The remainder provide education and training in *ocean / marine surveying methods*, *crane operations*, *plant operations*, *environmental sciences* and other supporting activities related to offshore renewables.
Occupational profiles	Most of the primary occupational profiles identified are covered to a considerable extent by the available programs, while supporting occupational profiles are addressed to a smaller extent. More specifically, the relevant programs in Germany mostly target *engineers and technicians of renewable energies*, *engineers of electric power generation*, *maintenance and repair engineers* and *plant operators*. To this end, renewable energies and electric power generation and management are fields adequately covered by the available E&T programs. The primary occupational profiles most covered are *hydropower technicians* and *solar power plant operators*. To this end, greater emphasis on supporting managerial activities designed to boost the sector and induce additional improvements in the value chain is evident. The greatest shortages in skills supply relate principally to occupational profiles engaged in the *construction of offshore infrastructures* and *health & safety procedures*, both of which are vital for the successful implementation of ORE projects. Of equal importance is the low number of programs addressing occupational profiles which are related to *power distribution and transmission* (both blue and white collar). Though a shortage of *ocean energy technicians* was observed, its importance depends on the future growth rates of the ocean energy sector in Germany. Some primary occupational profiles in the fields of *metalworking* (i.e. welders), *reparation* and *electro-mechanics* (i.e. electro-mechanical drafters) are not covered by any of the available E&T programs. This is a clear indication that increased attention should be paid to the provision of new programs addressing *welders* and *electro-mechanical drafters*. Both of these occupational profiles are vital for the successful implementation of ORE projects.
Value chain	Considering the aforementioned shortages, the main needs in the ORE value chain concern the phases of *construction & installation* and *operation & maintenance*.
Language	The E&T programs provided in Germany are mainly taught in German (72.4% of all programs). About 22% of the identified programs are offered in English, while the rest (about 5%) are bilingual.

(Source: programs' websites; http://www.marinetraining.eu/; https://kursnet-finden.arbeitsagentur.de/kurs/; https://ec.europa.eu/ploteus/el)

Figure 9.7: Germany educational and training (E&T) programs results for the ORE [9]

France

EQF Level	65 relevant E&T programs were identified in France, the majority of which were higher education and VET programs. More specifically, B.Sc. and M.Sc. degree programs made up 87% of all programs, indicating that the relevant skills and qualifications are mainly provided at under- and post-graduate level. VET programs (EQF 4-5) accounted for 11% of all programs, strongly suggesting that there should be a greater focus on blue-collar occupational profiles. 
Specialization	Only 7% of all identified programs directly address the ORE sector, focusing on ocean energy (3 programs), offshore wind energy (1 program), or both (1 program). In addition, 3 programs covering marine and offshore engineering and project management, provide, according to their curricula, skills and qualifications of direct relevance (and value) to the ORE sector. 24% of all programs focus on renewable energies, and 43% address the energy sector as whole. Offshore-related information is thus very limited in those programs.
Occupational profiles	*Engineers with expertise in renewable energies* are most covered by the available programs, while occupational profiles related to *plant operations* are also targeted by a considerable number of programs. Key shortages exist for *metalworkers* (i.e. welders), *technicians* (i.e. wind turbine technicians, solar energy technicians, hydropower technicians, tidal power technicians, wave power technicians and electro-mechanical engineering technicians), *electro-mechanical equipment assemblers* (i.e. printed circuit board assemblers), *installers* (i.e. cable installers) and occupational profiles related to *health and safety* aspects (i.e. H&S officers), while significant gaps were found for *draughtspersons, divers* and *plant operators* which are not addressed by any of the available E&T programs.
Value chain	The phases of the ORE value chain impacted to the greatest extent by the existing gaps and shortages are *manufacturing, construction & installation* and *operation & maintenance*.
Language	The majority of the available E&T programs are taught in French. Only 6% of all programs are offered in English, while 5% are bilingual.

(Source: programs' websites; http://www.marinetraining.eu/; https://data.education.gouv.fr/pages/accueil/; https://ec.europa.eu/ploteus/en/splash)

Figure 9.8: France educational and training (E&T) programs results for the ORE [9]

- Annex 9.4 Maritime Technologies sector FG participant organisations

Position	Organisation	Type of Organism	Country

Professor & Researcher	UDC	HIGH EDUCATION	Spain
Project manager	MAREfvg	Other	Italy
CEO	Sea Topic	Industry Representative	France
Science Communicator	MAREfvg	Industry Representative/ Education and Training Provider	Italy
Technical Staff	CT Ingenieros	Industry Representative	Spain
Technical Leader	CT Ingenieros	Industry Representative	Spain
Consultant	Consulting Engineering	Industry Representative	Denmark
Naval Architecture Manager	Techno pro	Other	Spain
Junior Project Engineer	Submariner	Other	Germany
Social manager	Naturgy	Industry Representative	Spain
Managing Partner	BALance Technology Consulting	Industry Representative	Germany
Senior Project Manager	Maritime technology Cluster FVG	Other	Italy
Co-founder DEFTIQ	DEFTIQ	Other	Netherlands

- Annex 9.5 Maritime Technologies sector FG results

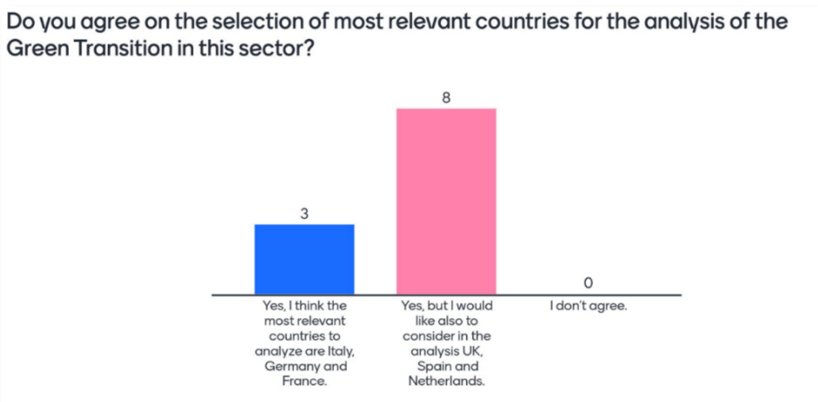


Figure 9.5.1: Degree of agreement of the Focus groups experts with the selection of UK, Spain and the Netherlands as the most relevant countries for the shipbuilding sector in Europe.

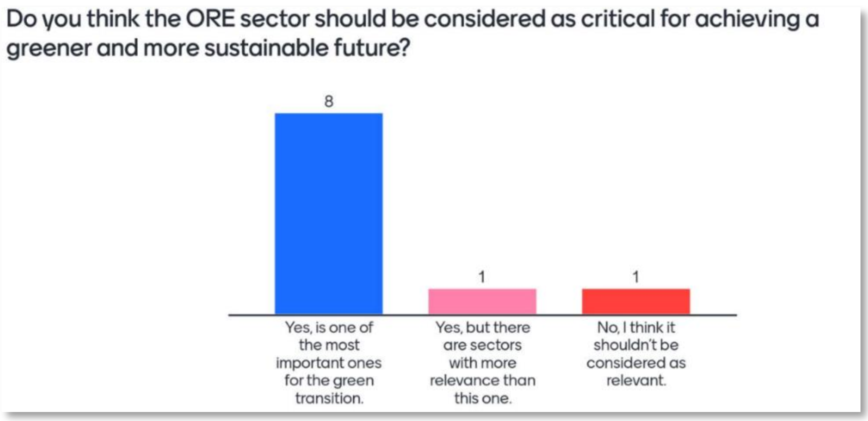


Figure 9.5.2: Degree of agreement of the Focus groups experts with the selection of the ORE sector as one of the critical sectors for the green transition.

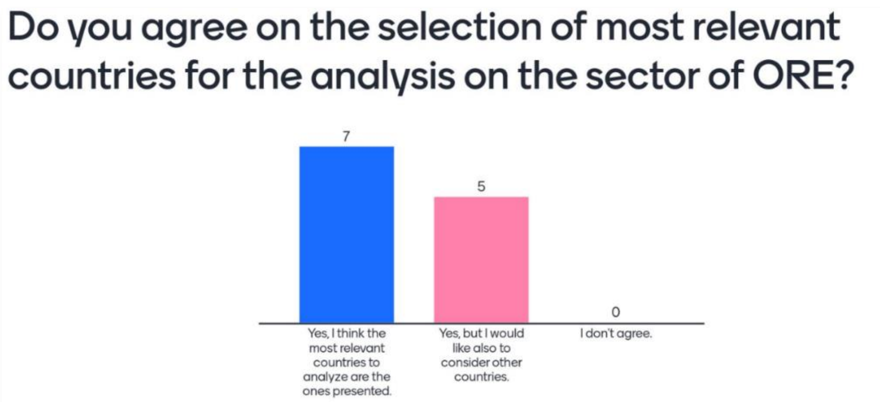


Figure 9.5.3: Degree of agreement of the Focus groups experts with the selection of UK, Germany and France as the most relevant countries for the shipbuilding sector in Europe.

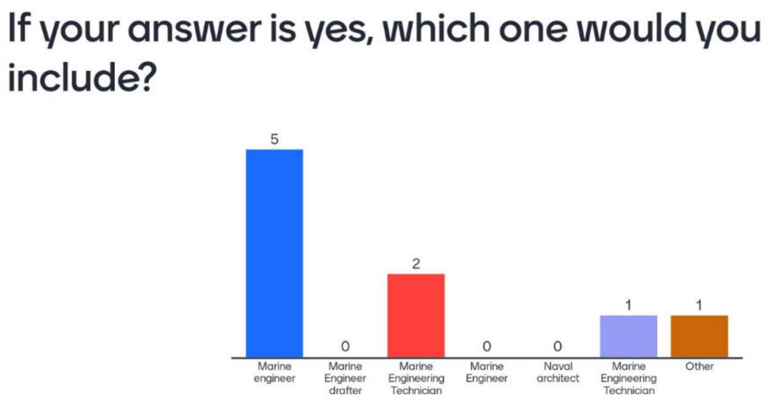


Figure 9.5.4: suggestions for the inclusion of further occupations in the analysis of the shipbuilding sector.

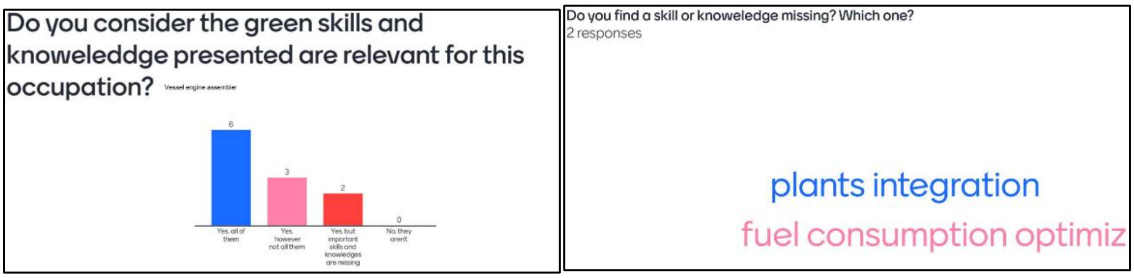


Figure 9.5.5: Degree of agreement of the experts with the relevance of the green skills presented for the vessel engine assembler, and suggestions of green skills to be added.

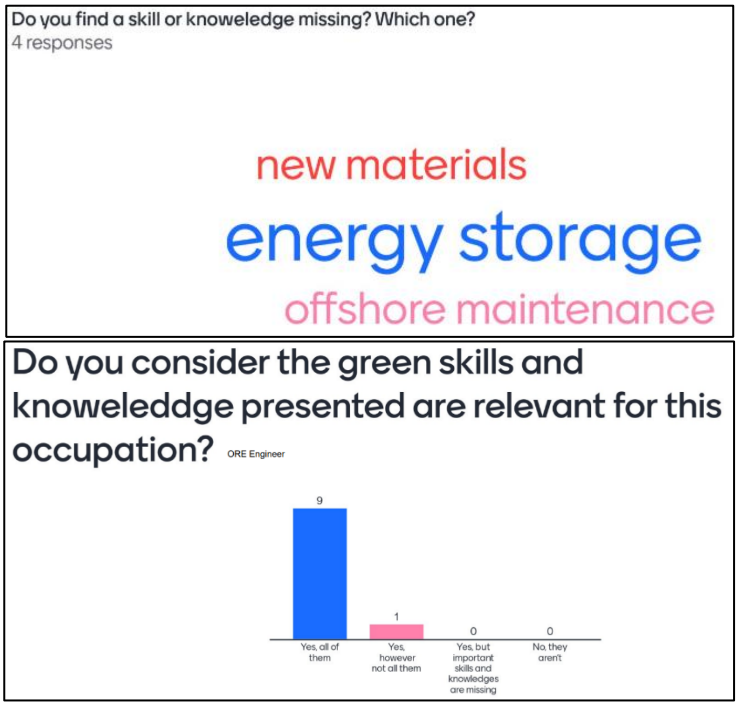


Figure 9.5.6: Degree of agreement of the experts with the relevance of the green skills presented for the vessel ORE engineer, and suggestions of green skills to be added.

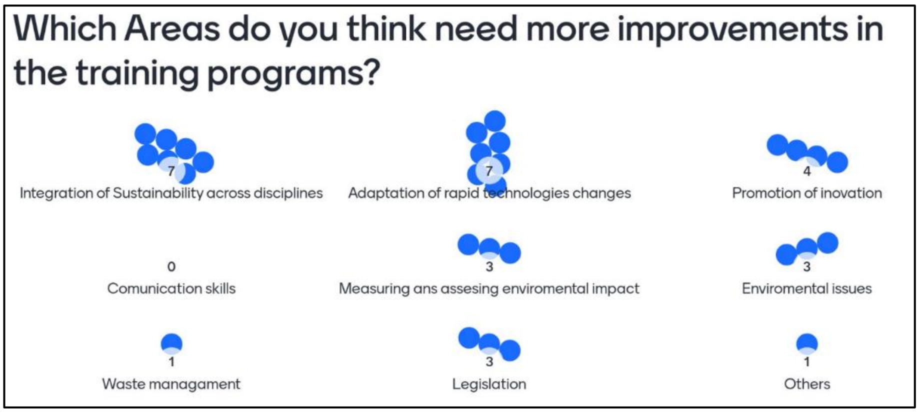


Figure 9.5.7: Identification of the areas that would need more improvements in the training programs

to boost the green transition.

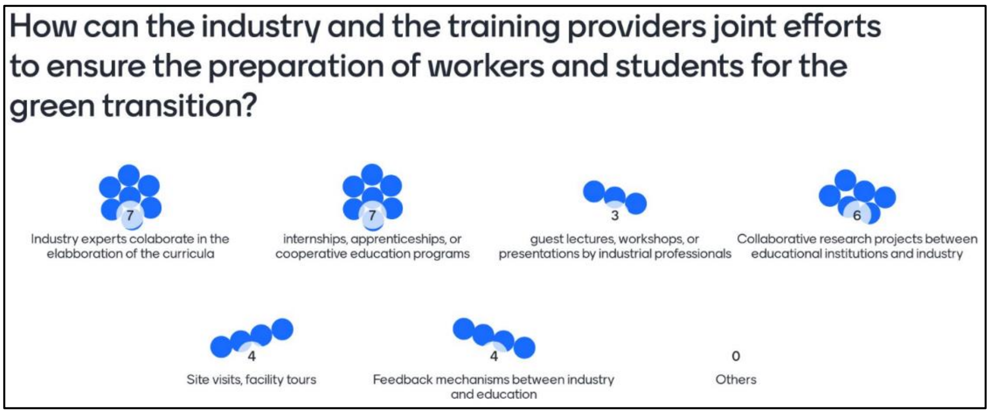


Figure 9.5.8: Identification of the most recommended methods to encompass efforts of the industry and the training providers to ensure the preparation of workers and students or the green transition.

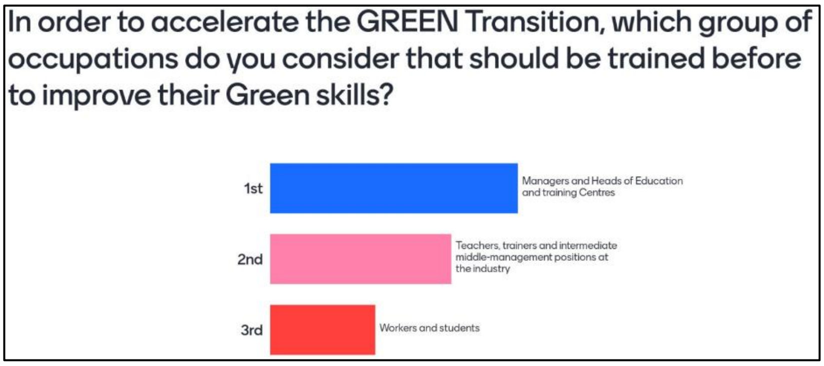


Figure 9.5.9: Ranking of the groups of occupations that should be trained before to improve their green skills, in order to accelerate the Green Transition

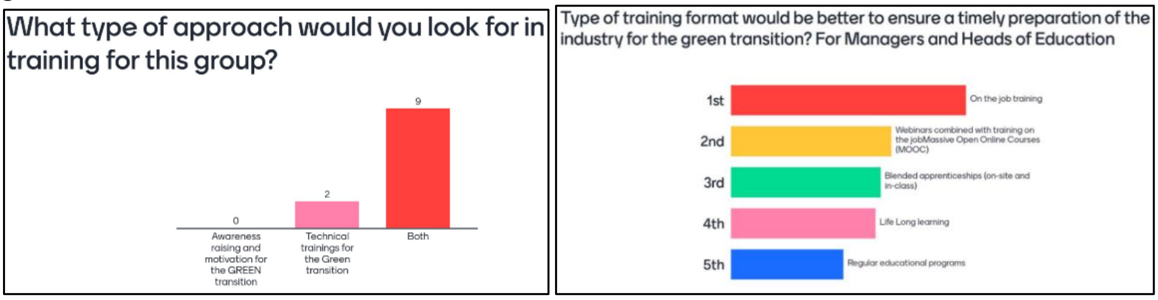


Figure 9.5.10: Type of training format and approach preferred for Managers and Heads of Education

Figure 9.5.11: Type of training format and approach preferred for teachers and middle-management positions

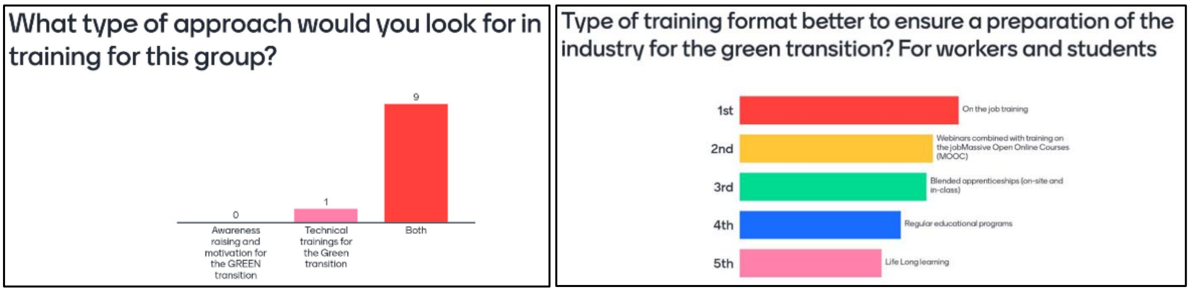


Figure 9.5.12: Type of training format and approach preferred for workers and students

12.10 Cross-sectoral Annexes

Cross-sectoral Focus Group participant organisations

Position	Organisation	Type of Organism	Country
Technical Leader	CT Ingenieros	Industry Representative	Spain
Project manager	MAREfvg	Other, please specify below	Italy
Professor	Laser Akademie	VET Provider	Germany
Chief Technologist	MTC	VET Provider	United Kingdom
Project Manager	Autoklastr	Industry Representative/ Education and Training Provider	Cyprus
Innovation, Research and Development Projects Area Coordinator	APET	Research Center	Portugal
	InterTradeCards	European Organisation	Romania
Senior Vice President	Skyfri	Industry Representative	United Kingdom
professor	CIFP	HIGH EDUCATION	Spain
professor	Videncenter håndværk	VET PROVIDER	Denmark
Regional development (Canary islands)	Naturgy	Industry Representative	Spain