FLORES

Offshore Renewable Energies partnership in the Pact for Skills

Analysis of future trends in the ORE occupations

February 2025

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About this Report

Forward Looking at the Offshore Renewables is promoting the core activity of the Large-scale partnership launching the Pact for Skills in the Offshore Renewable Energies (ORE) sector. FLORES support the most committed stakeholders in the ORE, underpinning the success of the offshore renewable energy strategy with the stimulation of dedicated training offers. The partnership promotes the skilling process for the new jobs expected in the sector, estimated to account for 124.000 new workers in the EU by 2030 and contribute to improve upskilling opportunities in the field of the actual ORE workforce.

Project duration: January 2023 – March 2025 (27 months)

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Document information	
Short description	This report completes the skills intelligence analysis conducted in the project by performing a skills foresight analysis. Combining desk research results and consultation activities, in identifies 18 trends and paradigm shifters to be impacting the sector in the short- and medium-term. These fall under three main categories: technological advances, policy changes and trends affecting market dynamics / evolution. For each of those trends, the impact to be imposed on the sector is evaluated, with emphasis on the relative implications on employment and skills development
Next steps	This report will inform the activities and deliverables of WP4, and particularly D4.3 – ORE Occupational Profiles update, while part of the results of the Delphi survey will be used in WP5 as input to D5.3 – Overcoming barriers to the creation of durable skills partnerships in the ORE
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1. Introduction

For advancing skills intelligence in the ORE sector and developing a well-informed ORE skills observatory, besides assessing current skills demand and supply and identifying existing mismatches and gaps, as performed and reported in D2.1, it is equally important to also develop skills foresight, identifying future trends and paradigm shifters that will be affecting the sector in the short, medium and long-term, and analyzing as a next step the impact they will be imposing on skills demand.

Such insights can be of real added value to both:

(a) *Industry actors*, shortening adaptation time to changing business practices that a new trend might trigger / create, thus maximizing the benefits to be gained in terms of operational efficiencies, market expansion, etc.; and

(b) *Educational and training providers*, enabling them to better plan and timely reform their programs and courses so that they can dynamically meet the industry's skills requirements and supply companies with well-qualified personnel that can make best use of the benefits emerging trends and paradigm shifters will be bringing along.

This is thus the focus of the present report which identifies, through a set of desk research and consultation activities, 18 trends and paradigm shifters that will be affecting the ORE sector, grouped in three thematic categories: (a) technological advancements, (b) policy changes, and (c) market dynamics / evolution. Identified trends were validated and assessed, in terms of their impact on skills, via targeted workshops and a two-round Delphi survey that was conducted, engaging selected experts with diverse but complementary expertise, representing both the skills demand and supply side.

2. Identification of future trends and paradigm shifters

2.1. Methodology

As depicted in Figure 1, a three-step approach was followed for the identification, validation and impact assessment of future trends and paradigm shifters in the ORE sector. More specifically:

- *Identification* was performed via desk research exploiting, as starting point, the knowledge basis that had been established as part of the skills demand analysis (see D2.1). Several information sources that had been collected (i.e. mostly grey literature) provided useful insights on new trends and paradigm shifters that will be impacting the sector in the future, which were complemented with additional information that was gathered from other online sources;
- *Validation* was performed via two targeted workshops that took place within the context of the 2023 and 2024 WindEurope annual events. Input provided by participants enabled (a) to update the list of identified trends and paradigm shifters, adding new ones that were recommended and validating the final set which consisted of 18 future trends and paradigm shifters, and (b) to deepen the understanding of the characteristics of those trends and paradigm shifters, as well as of their implications for the sector;
- *Impact assessment* of validated trends and paradigm shifters was performed via a two-round online Delphi survey that was conducted, where selected experts were presented with a set of targeted questions for analyzing (i) the scale and time horizon of the impact to be imposed on the sector, (ii) employment changes, (iii) new skill requirements, and (iv) affected and emerging occupational profiles.

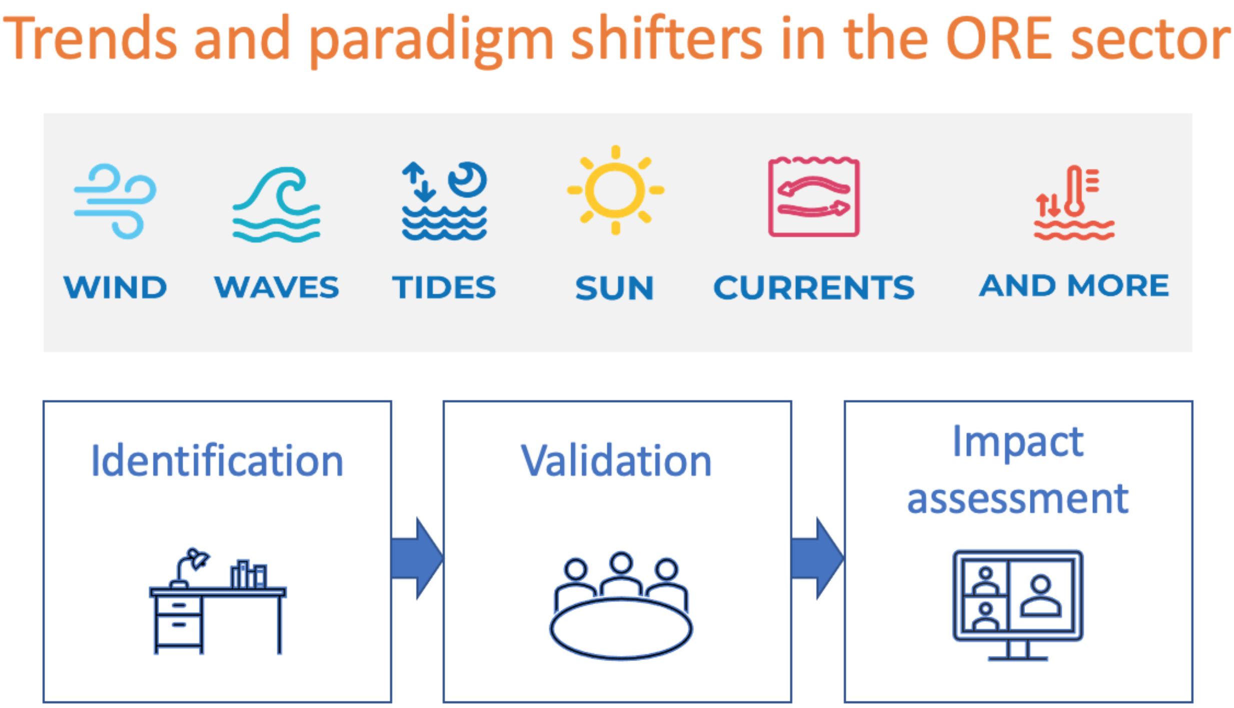

Figure 1: Methodology for the identification, validation and impact assessment of future trends and paradigm shifters in the ORE sector

A more detailed outline of the aforementioned activities is provided in Table 1 below.

Table 1: Outline of the activities undertaken for identifying, validating and assessing the impact of future trends and paradigm shifters in the ORE sector

Activity	Objective	Details
Desk research	Identify future trends and paradigm shifters in the ORE sector	The following information sources were collected in addition to the knowledge basis established within the context and presented in D2.1: CorPower Ocean, 2024; Sustainable Energy Authority of Ireland, 2024; Foxwell, 2024; McCoy et al., 2024; Casey, 2024; European Court of Auditors, 2023; La Face, 2023; Lewis, 2023; US. Department of Energy, 2021; UTM Consultants, 2021; Interreg North Sea Region, n.d.;
Targeted workshops	Update, validate and discuss characteristics of identified trends and paradigm shifters	Wind Europe Annual Event 2023 (Copenhagen, DK) • Workshop on "*Informing the ORE sector skills observatory*"; 32 participants Wind Europe Annual Event 2024 (Bilbao, ES) • Workshop on "*Skills of the future: Anticipating Trends and Addressing Future Skills Gaps*"; 28 participants
Delphi survey	Assess the impact of validated trends and paradigm shifters on skills	First round was held via SurveyMonkey. Second round was held via an online excel-based form for addressing increased complexity in the structuring of some questions. Participants: 14 selected experts (9 male, 5 female) from 10 European countries. 50% of them represented industry actors, 29% consultants & researchers and 21% educational and training providers. Response rate in 2nd round: 65%

As depicted in Figure 2, the 18 validated trends and paradigm shifters were thematically grouped in three main categories. With technology advancing now a lot faster than ever before, often inducing disruptive changes to current operations, it is only natural that half of the validated trends fall under this category. Policy changes also impose considerable effects to the sector, and so do also market changes, with the ORE sector being very dynamic and growing at a fast pace, heavily supporting the decarbonization of multiple economic sectors, thus contributing to the vision of Europe becoming climate-neutral.

Figure 2: Thematic categories of validated trends and paradigm shifters

2.2. Technological advancements

2.2.1. Integration of smart grid technologies and sensors

The integration of smart grid technologies is key for the sector. More specifically, they comprise of (a) *advanced (high-speed) communication networks* (e.g. 5G, fibber optics) that enable real-time monitoring and control of energy flows between offshore energy sources and onshore grids, and (b) *automated control systems* that facilitate dynamic adjustments in energy production and distribution in order to balance energy supply and demand.

Sensors on the other hand can be used for (a) *environmental monitoring* (e.g. tracking weather conditions, ocean currents, etc.), (b) *structural health monitoring* (i.e. monitoring the condition of offshore structures), and (c) *energy flow monitoring* (i.e. measuring the amount of energy that is being produced, transmitted and consumed in real-time to enhance efficiency and reliability.

Smart grid technologies and sensors can contribute to:

- Grid integration and management (interconnectors & super grid)
- Predictive maintenance & asset management
- Condition monitoring and diagnostics
- Remote operations and control
- Grid resilience and flexibility
- Data-driven decision making
- Environmental monitoring & compliance

2.2.2. Energy storage systems

Energy storage systems (ESS) are essential for addressing the intermittent nature of ORE. Advanced battery energy storage systems are mostly used, with lithium-ion batteries dominating the market due to the high energy density, efficiency and decreasing costs that they present. However, new battery technologies (e.g. solid-state, flow batteries, etc.) are currently being developed and tested, offering longer storage duration and increased safety.

In addition, hybrid energy storage systems integrating different types of storage systems (e.g. batteries with flywheels or hydrogen storage) are also being investigated aiming to leverage the strengths of each system and provide a more robust and flexible energy storage solution.

2.2.3. Higher automation levels & advanced robotics

Increasing automation levels and integrating robotic systems in ORE are driven by the need to achieve higher efficiencies, reduce operational costs, enhance safety, and improve the reliability of renewable energy production. Both can be integrated across various parts of ORE projects, from installation and maintenance to energy management and environmental monitoring. More specifically, they include:

- *autonomous robots* for the installation, inspection & maintenance of ORE infrastructure;
- *drones* for aerial inspections, thermal imaging and monitoring of ORE installations;
- *autonomous underwater vehicles (AUVs)* and *remote operated vehicles (ROVs)* for subsea inspections, maintenance and repair of underwater components and cables;

- *automated surface vessels (ASVs)* used for surface surveys and data collection providing support to both AUVs and ROVs;
- *robotic arms and manipulators* used for precise tasks such as bolt tightening, welding and component replacement;
- *automated safety systems* monitoring potential hazards such as structural failures or environmental threats and trigger appropriate responses; and
- *remote operation centres* that control and monitor offshore installations from onshore locations reducing the need for personnel to be physically present in hazardous environments.

2.2.4. Digital twins

The digital twin technology is gaining significant traction also in the ORE sector. Digital twins can be used for:

- real-time monitoring of offshore assets, enabling early detection of potential issues and predictive maintenance reducing downtime and operational costs;
- optimized design and planning, simulating different scenarios of layouts and configurations of ORE projects. This assists in identifying the best design solutions and minimizing risks;
- virtual prototyping of offshore installations for testing performance under various conditions;
- performance optimization, enabling to adjust operational parameters for maximizing renewable energy production and efficiency;
- energy management, being effectively integrated with smart grid technologies enabling to properly manage energy flow, storage, and distribution ensuring a balanced and reliable energy supply;
- asset management, providing a comprehensive view of the asset's lifecycle from installation to decommissioning;
- risk management, simulating potential risks and emergency scenarios, helping in the development of effective risk mitigation and response strategies;
- regulatory compliance, ensuring that all safety and environmental regulations are successfully met utilizing detailed performance and operational data;
- environmental condition monitoring (e.g. wave patterns, wind speeds, marine life interactions, etc.), assisting in assessing the environmental impact of offshore installations.

2.2.5. Artificial Intelligence (AI), Internet of Things (IoT) & Quantum Computing

The integration of AI, IoT and quantum computing is transforming the ORE sector. These technologies are enhancing efficiency, reliability and sustainability through advanced data analysis, real-time monitoring, and optimization of energy systems. More specifically, AI (and generative AI) can contribute to:

a) infrastructure condition monitoring and failure prediction. AI algorithms can analyse sensor data from infrastructure to predict maintenance needs, reducing in that way downtime and extending the life of the equipment. Machine learning models can also predict equipment failures, allowing proactive maintenance;
b) performance optimization, including energy production forecasting (based on weather and historical data) and operational efficiency improvement (i.e. adjusting operational parameters in real-time for optimal performance and energy capture);

c) grid balancing and demand response, automating adjustments in energy use based on real-time conditions enhancing grid stability;
d) monitoring impact of ORE installations on marine and bird life, and predicting environmental conditions aiding operational planning

IoT devices collect real-time data on equipment performance, environmental conditions and structural integrity. These can be effectively used for remote monitoring, predictive maintenance (i.e. feeding AI algorithms and triggering automated alerts and maintenance actions), operational efficiency (i.e. optimizing energy distribution and storage), real-time asset tracking (enhancing logistics and inventory management) as well as for safety and risk management (i.e. hazard detection and emergency response).

Quantum computing can effectively handle more complex simulations and data analytics contributing to:

a) ORE system optimization, running complex simulations for enhanced design and operation of ORE projects as well as for energy flow and distribution;
b) big data processing and improved forecasting, analysing vast amount of data from AI and IoT systems;
c) new material design and structural optimization, for greater durability and performance;
d) advanced security, with quantum cryptography enhancing cybersecurity and quantum encryption ensuring safe and tamper-proof communication between offshore installations and control centres.

2.2.6. Big data

Big data in ORE enhances the ability to analyse vast amounts of data that are being collected from various sources for improving decision-making, efficiency and sustainability. Big data analytics can contribute to (a) predictive maintenance and performance optimization, (b) real-time operational monitoring (including remote monitoring) and management, (c) evidence-based decision-making exploiting data-driven insights and scenario analysis, (d) energy flow optimization and demand forecasting, (e) environmental monitoring and sustainability reporting, and (f) weather prediction and climate analysis. As mentioned above, big data are effectively integrated with AI and machine learning for further enhancing analytics and automating decision-making based on real-time data analysis.

2.2.7. Immersive technologies: Virtual and Augmented Reality (VR & AR)

Immersive technologies, such as VR and AR, are being increasingly adopted in the ORE sector, offering innovative solutions for training, maintenance, design and operational efficiency. More specifically, VR can contribute to:

a) simulation on safety procedures, creating realistic conditions of offshore environments allowing workers to practice safety procedures and emergency response;
b) virtual inspection of offshore facilities, enabling experts to assess the condition of equipment and infrastructure remotely;
c) 3D modelling of offshore installations during design phase, for exploring and evaluating different designs before construction;
d) creating collaborative workspaces where teams from different locations can meet, discuss and work together;

e) offering virtual tours of ORE facilities, helping to educate the public and interested stakeholders about the technologies and their benefits.

AR on the other hand, can contribute to:

a) on-site, hands-free training for technicians guiding them onto real-world equipment during maintenance or installation tasks;
b) maintenance assistance, with technicians equipped with AR glasses receiving real-time support from remote experts;
c) site planning, by overlaying data and models onto physical environments, assessing the spatial relationships that exist between different components;
d) improved situational awareness and decision-making, providing operators with real-time data overlays such as performance metrics and maintenance schedules;
e) interactive learning, making complex concepts related to ORE more accessible and engaging.

2.2.8. 3D printing

3D printing (also known as additive manufacturing) is increasingly being adopted in the ORE sector, enabling to produce complex components, reduce lead times and lower costs. It can contribute to:

a) remote (on-site) production of parts, reducing the need for long supply chains and thus minimizing waiting time for replacement parts, while also providing flexibility in maintenance and repairs enabling quick responses to unexpected issues;
b) custom parts production and rapid prototyping, testing and validating new designs (e.g. with complex geometries, lightweight structures, etc.);
c) the greater use of sustainable materials (e.g. recyclable, biodegradable), and to research for new materials, for producing components that are more durable and resistant to the harsh conditions of the marine environment.

2.2.9. Sustainable and smart materials

The use of sustainable and smart materials in the ORE sector is driven by the need to enhance performance, reduce the associated environmental impact and enhance the durability of ORE installations. These materials are essential for building a more resilient and efficient ORE infrastructure.

Sustainable materials mainly comprise of biodegradable, recyclable and low-carbon materials as well as of eco-friendly composites. *Smart materials* include self-healing ones, shape-memory alloys and sensing materials (i.e. that can monitor their own structural integrity and environmental conditions). *Advanced coatings* (i.e. anti-corrosion and anti-fouling) also play a key role, while *nanotechnology* can further enhance the mechanical (i.e. nanocomposites) and surface (i.e. nano-coatings) properties of materials.

2.3. Policy changes

2.3.1. Reform of relevant regulatory frameworks

There are several regulatory frameworks addressing directly the ORE sector as whole, as well as all different parts of the ORE value chain. At EU level, the most notable ones are (i) the *Renewable Energy Directive*, setting binding targets for Member States increasing the share of renewable energy (including offshore wind and ocean energy), (ii) the *EU strategy on ORE*, setting concrete targets of installed capacity for offshore wind and ocean energy by 2050, (iii) the *Marine Strategy Framework Directive (MSFD)*, that aims to protect the marine environment and ensure sustainable use of marine resources, including provisions related to ORE, and (iv) the *Maritime Spatial Planning (MSP) Directive*, setting an eco-system approach for managing the use of marine waters and promoting the sustainable development of maritime activities (see also B2).

At national level, EU Member States have set, in 2019 (updated in 2023), their *2030 National Energy and Climate Plans (NECPs)*, outlining how each one of them intends to meet the EU energy and climate targets for 2030, addressing energy efficiency, renewables, GHG reductions, interconnections and research & innovation.

Of course, many other regulatory frameworks addressing cross-cutting issues (e.g. waste management, data protection, cybersecurity, etc.) also have an effect on the sector, posing changes on the working conditions / practices of impacted occupational profiles.

2.3.2. Adoption of Maritime Spatial Plans (MSPs)

The adoption of Maritime Spatial Plans (MSPs) that is still pending in some EU Member States (e.g. Italy, Croatia, Greece) will unlock new investment opportunities for the ORE sector, untapping the high renewable energy production potential that the marine environment in those regions present, given the favourable conditions that exist there. Such a development will significantly rise the demand, at all different segments of the ORE value chain, for skilled workforce, both native (i.e. educated / trained in local institutions) as well as from other countries moving there, bringing together invaluable working experiences gained from their involvement in existing projects (e.g. in North Europe).

2.3.3. Standardization

As in all sectors, standardization is key for ensuring consistency, reliability and cost-efficiency in the deployment of ORE technologies. It covers:

- component standardization, with standardized components ensuring interchangeability and compatibility across different projects and manufacturers;
- modular designs, enabling easier assembly, transportation and maintenance of ORE systems, enhancing scalability and reducing costs;
- safety protocols, reducing the risk of accidents during installation, operation and maintenance and improving the overall safety for workers;
- environmental impact assessments, ensuring that ORE projects are developed responsibly, minimizing their ecological footprint;
- grid code compliance, standardizing technical requirements for connecting ORE systems to national grids ensuring seamless integration and stability of the power supply;
- data monitoring, sharing and reporting, for ensuring consistent performance tracking and regulatory compliance, thus facilitating collaboration between stakeholders.

2.3.4. EU-wide accreditation of training / skills

EU-wide accreditation of ORE-related training and skills is gaining momentum. The aim is to standardize qualifications across the EU, enhance workforce mobility, and ensure that workers possess the necessary skills and competencies to meet the demands of this rapidly growing industry. This involves:

a) developing harmonized curricula and training programs across EU Member States ensuring consistency in the quality and content of training for ORE-related occupational profiles;
b) establishing EU-wide certification schemes, covering all ORE-related occupational profiles;
c) cross-border recognition of qualifications and certifications, facilitating workforce mobility between different projects and regions.

2.4. Market dynamics / evolution

2.4.1. New structures

The ORE sector is experiencing significant advancements in the design and implementation of new structures, driven by the need for greater efficiency, durability and adaptability to various marine environments. These mainly comprise of *advanced foundation designs* (e.g. suction bucket, gravity-based, etc.), and *floating platforms* which by exploiting innovations in mooring systems and platform designs, enable wind turbines to be installed in deeper waters where wind resources are stronger and more consistent.

2.4.2. Scale and efficiency increases & security of energy supply

Advancements in technology and improved operational practices enable to achieve scale and efficiency increases, and thus better secure energy supply for successful meeting current levels of demand as well as coping with any potential peaks in demand. For example, those increases can be realized through:

a) Larger wind turbines and platforms, with capacities now exceeding 10 MW per turbine. Increases in blade length and rotor diameter enhance the efficiency of turbines by capturing more wind over a larger area;
b) High-voltage direct current (HVDC) transmission, which reduces energy losses during transmission over long distances, making ideal for transporting electricity from ORE facilities to onshore grids;

Of course, resource and labour availability are both important underlying factors for achieving such increases, and so is grid capacity so that energy supply is secured.

2.4.3. Hybrid projects

Hybrid projects combine multiple types of renewable energy sources on a single platform or within the same area. This approach offers several benefits and addresses various challenges associated with single-source energy projects. More specifically:

- offshore platforms are increasingly integrating wind turbines with solar panels, allowing for more consistent energy production, as solar power can complement wind during low-wind periods;
- pairing wind turbines with wave energy converters also contributes in increasing the overall energy production output and improve the stability of the energy supply;

- some ORE projects also incorporate battery storage systems for storing excess energy generated during peak production times, and release it during periods of high demand or low generation;
- offshore wind energy farms can also be combined with green hydrogen production facilities, or electrolysis units are placed on offshore platforms directly converting wind power to hydrogen at sea. This allows green hydrogen to be pipped or shipped directly to the shore.

2.4.4. New financing mechanisms

New financing mechanisms are essential for addressing the high capital costs and the long payback periods associated with large-scale ORE projects. They include green bonds, public-private partnerships (PPPs), crowdfunding platforms (e.g. Abundance Investment, Trine, etc.), corporate power purchase agreements (PPAs), Export Credit Agencies (ECAs), Development Banks, Pump-priming grants, etc. These mechanisms not only provide financial support but also align investment with broader sustainability goals, fostering a more resilient and sustainable energy future.

2.4.5. Energy price

The price of offshore renewable energy has declined over the past decade due to advancements, as mentioned before, on infrastructure, technology, policies, etc. allowing to achieve important economies of scale and cost reductions. Key factors influencing the price of offshore renewable energy include:

- the Levelized Cost of Energy (LCOE), which in offshore wind for example has decreased due to innovations in turbine technology;
- auction-based pricing, that many countries have opted for;
- subsidy-free projects, since implementation costs in some regions enable new projects to be developed without the need for government subsidies, relying solely on market prices;
- supply chain maturity and logistical improvements (e.g. advanced in installation techniques and use of specialized vessels, etc.);
- attractive financing terms (e.g. lower interest rates, increased availability of capital, etc.) and increased investor confidence, given the growing track record of successful ORE projects.

3. Impact assessment

The Delphi participants re-verified the representativeness of the thematic categories formulated and the completeness of the validated set of future trends and paradigm shifters. Impacts imposed were then assessed per thematic category.

3.1. Technological advancements

Validated trends and paradigm shifters were prioritized with regard to the level of impact they are likely to impose on the ORE sector (Figure 3). The integration of smart grid technologies and sensors was acknowledged as the most impactful trend, followed closely by the increase of automation levels and the greater use of advanced robotics. Energy storage systems was ranked third, completing the top 3, with those three trends clearly standing out as the most impactful, far ahead from the rest. The remaining trends, listed in descending order of impact, were (a) digital twin, (b) AI, IoT & quantum computing, which were acknowledged as impactful as (c) sustainable and smart materials, (d) big data, (e) immersive technologies and (f) 3D printing.

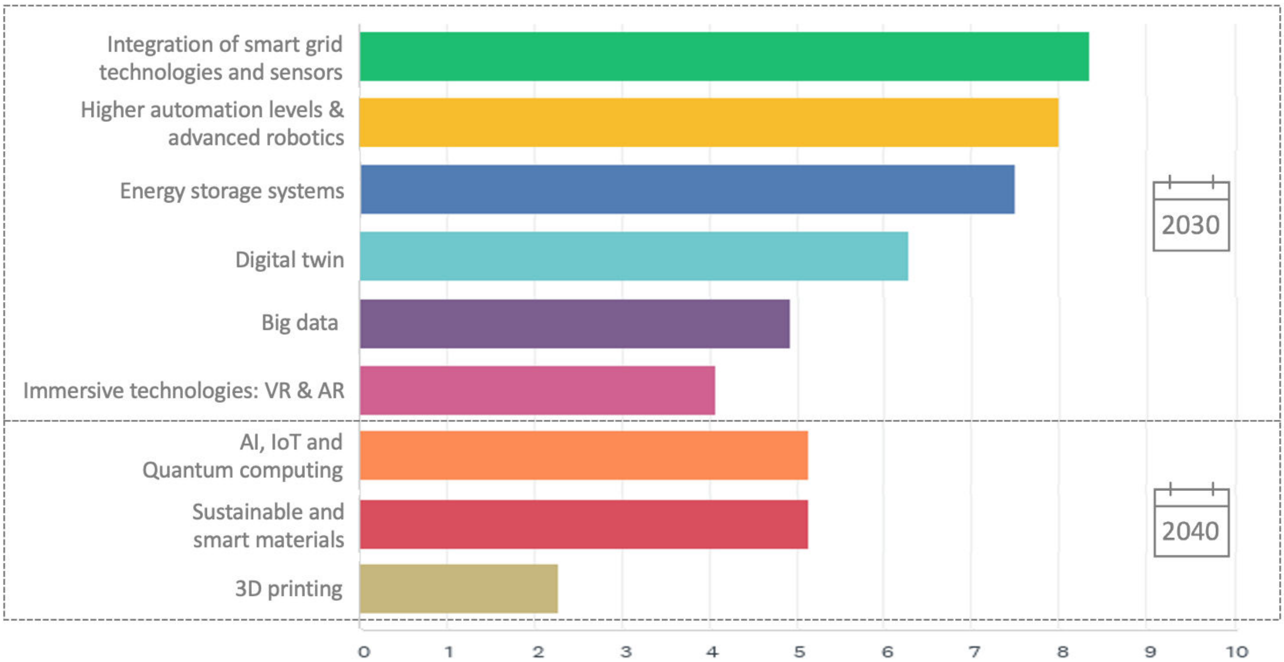

Figure 3: Prioritization (weighted average of experts' ranking) of technological advancements per their impact on the ORE sector (0=lowest impact, 10=highest impact)

As depicted, most of the validated technological advancements will be impacting the ORE sector in the short-term (i.e. 2030), with the exception of (a) sustainable and smart materials, (b) AI, IoT and quantum computing, and (c) 3D printing, whose impact is likely to be imposed in the medium-term (i.e. 2040). It is worth noting that according to the experts' opinion, none of those trends and paradigm shifters will be affecting the ORE sector in the long-term (i.e. 2050), indicating that all of them are already quite mature.

Emphasizing on how skills requirements will be affected, most technological advancements will create, according to the experts' opinion, upskilling needs predominately addressing hard skills, while for three trends (i.e. integration of smart grid technologies & sensors, higher automation levels & advanced robotics, as well as immersive technologies), upskilling of transversal skills will also be required. Advances in energy storage systems, and the further development and deployment of AI, IoT & quantum computing as well as of sustainable and smart materials will create requirements for new (hard) skills to be developed, so that the efficiencies those technologies can provide can be timely gained and maximized.

Effects on employment will be thus positive, though relatively modest. Four out of nine of the considered technological advancements (i.e. integration of smart grid technologies & sensors, big data, immersive technologies and 3D printing) are expected to create a low number of new job positions within Europe. For the former two, these positions would mostly be mid-level, while for the latter two, they are expected to be entry-level. For the remaining five technological advancements, more employment opportunities are likely to emerge, predominately at mid-level seniority.

The three occupational profiles to be affected the most by the technological advancements considered are listed below in Table 2 in descending order. Demand for all these occupational profiles is expected to increase, as the deployment of the considered technological advancements rises, while for materials engineers the need to upskill for effectively using sustainable and smart materials was also highlighted.

Table 2: Top 3 occupational profiles to be affected the most by technological advancements considered

Trend / paradigm shifter		Occupational profiles to be mostly affected		Type of impact
2030	Integration of smart grid technologies and sensors	ESCO-2149.9	Energy systems engineer	Rise in demand
		ESCO-2141.4.2.1	Automation engineer	Rise in demand
		ESCO-1321.2.3	Operations manager	Rise in demand
	Higher automation levels and advanced robotics	ESCO-2141.4.2.1	Automation engineer	Rise in demand
		ESCO-2149.11	Robotics engineer	Rise in demand
		ESCO-2151.11	ICT intelligent systems designer	Rise in demand
	Energy storage systems	ESCO-2149.9	Energy systems engineer	Rise in demand
		ESCO-2431.14	Pricing specialist	Rise in demand
		ESCO-2149.7	Energy engineer	Rise in demand
	Digital twin	ESCO-2149.2.3	Design engineer	Rise in demand
		ESCO-2511.4	Data scientist	Rise in demand
		ESCO-2511.14	ICT system architect	Rise in demand
	Big data	ESCO-2511.3	Data analyst	Rise in demand
		ESCO-2421.1	Business analyst	Rise in demand
		ESCO-2511.4	Data scientist	Rise in demand
	Immersive technologies	ESCO-2149.2.3	Design engineer	Rise in demand
		ESCO-2512.4	Software developer	Rise in demand
		ESCO-2151.11	ICT intelligent systems designer	Rise in demand
2040	AI, IoT and Quantum	ESCO-2151.11	ICT intelligent systems designer	Rise in demand
		ESCO-2511.4	Data scientist	Rise in demand

	computing	ESCO-2512.4	Software developer	Rise in demand
	Sustainable and smart materials	ESCO-2149.9.8	Materials engineer	Rise in demand and need for upskilling
		ESCO-1213.7	Health, safety and environmental manager	Rise in demand
		ESCO-2149.2.2	Component engineer	Rise in demand
	3D printing	ESCO-2149.2.2	Component engineer	Rise in demand
		ESCO-2149.9.8	Materials engineer	Rise in demand
		ESCO-2149.2.3	Design engineer	Rise in demand

The total number of occupational profiles to be most affected by the technological advances considered is 17 since, as depicted above, some occupational profiles are expected to be affected by more than one trend. More specifically, data scientists, design engineers and ICT intelligent systems designers are expected to experience the greatest impact, with three trends (two having a shorter impact and one a medium-term impact) driving increased demand for these professionals. Additionally, five occupational profiles are expected to be influenced by two trends, with all but one (i.e. software developers) being engineers - namely automation engineers, component engineers, energy systems engineers and materials engineers. Considering the trends' expected impact on the sector (Figure 3, greater will be the demand for automation engineers and energy systems engineers.

For each one of the technological advancements taken into consideration, new requirements are expected to be set in terms of both hard and transversal skills. These are presented in Table 3 below.

Table 3: New requirements technological advancements will bring in terms of both hard and transversal skills

Trend / paradigm shifter		Hard skills	Transversal skills
2030	Integration of smart grid technologies and sensors	Expertise in: o Electrical grid components and sensor types used in grids (e.g. voltage, current, temperature); o Smart grid ICT infrastructure and sensor integration; o Advanced communication networks, considering applicable standards (e.g. IEC 61850, Modbonus, etc.); o Sensor data filtering and processing; o Systems and technologies for managing and optimizing energy generation, distribution and consumption in smart grids (e.g. load flow analysis); o Automated power control systems (e.g. SCADA, PID, etc.) and control algorithms.	o Inter- and cross-disciplinary communication & collaboration; o Strategic thinking o Adaptability; o Project management o Analytical skills; o Documentation and reporting; o Risk assessment; o Problem-solving.
	Higher automation levels and	Expertise in: o Human-machine interface / physical-cyber systems;	o Troubleshooting; o Inter- and cross-disciplinary

	advanced robotics	o Machine Vision System (MVS) o Programming and control of collaborative robots and robotic systems; o Industrial robotics; o Advanced sensor fusion; o AI and machine learning tools integration; o Relevant software development & programming.	communication & collaboration; o Collaboration in remote settings.
	Energy storage systems	Expertise in: o Design of electrical, mechanical and chemical storage systems (different types & characteristics) in the offshore environment (constraints, adaptations) using advanced simulation and modelling tools; o Hybrid storage systems; o Hydrogen storage systems; o Integration of energy storage systems into renewable energy set-ups; o Integration of energy storage systems into electrical grids, off-grid systems; o Relevant safety standards and compliance with their requirements; o Monitoring developments in battery technologies.	o Strategic and innovative thinking; o Inter and cross-disciplinary communication & collaboration.
	Digital twin	Expertise in: o 3D modelling and CAD for energy systems o Simulation tools for energy systems' real-time monitoring and predictive maintenance; o Asset performance optimization using digital twin models o Cybersecurity for digital twin models	o Inter- and cross-disciplinary communication & collaboration; o Stakeholder engagement; o Teamwork.
	Big data	Expertise in: o Data ethics; o Advanced (complex) data analysis visualization and data-driven decision making; o Real-time monitoring, processing and management of operational data; o Cloud-based data management; o Distributed computing; o Extract, Transform, Load (ETL) processes.	o Critical thinking; o Inter- and cross-disciplinary communication & collaboration.
	Immersive technologies	Expertise in: o 3D content design; o Virtual environment advanced setting (human-centred); o Dedicated VR/AR training or efficient integration of these technologies into existing training programs	o Creativity in applying VR/AR for covering practical uses; o Ability to work across different virtual platforms;

		o Scripting; o Spatial computing; o Hardware integration.	o Inter- and cross-disciplinary communication & collaboration;
2040	AI, IoT and Quantum computing	Expertise in: o Computer programming languages and machine learning; o IoT and quantum computing applications integration o Multiphysics modelling; Disruptive technologies training	o Inter- and cross-disciplinary communication & collaboration; o Analytical problem-solving; o Creativity.
	Sustainable and smart materials	Expertise in: o New and eco-friendly material design, characterization, testing, application, integration, recycling, etc. o Circular economy o Nanotechnology	o Creativity and innovative thinking; o Attention to detail in developing solutions; o Adaptability; o Inter- and cross-disciplinary communication & collaboration;
	3D printing	Expertise in: o CAD modelling; o Prototyping, testing and use of new and sustainable materials; o On-site 3D part production and integration; 3D printers' operational management and maintenance	o Flexibility in adapting designs quickly; o Problem-solving; o Inter- and cross-disciplinary communication & collaboration;

In addition to the demand that is expected to rise in the coming years for certain occupational profiles, as presented in Table 2, new occupational profiles are also likely to emerge as the deployment of the considered technological advancements progresses. These are presented in Table 4 below. It should be noted that for digital twins, no new occupational profile was acknowledged as likely to emerge. The experts believe that all relevant advancements can be well handled by the existing occupational profiles engaged in the use of this technology.

Table 4: New occupational profiles likely to emerge as a result of the technological advances considered

Trend / paradigm shifter		New occupational profiles likely to emerge	Most relevant occupational profile(s) listed in ESCO
2030	Integration of smart grid technologies and sensors	Smart grid designer and manager	N/A
		Smart grid systems analyst	N/A
		Sensor specialist	Sensor engineer (ESCO-2152.1.15)
	Higher automation levels & advanced robotics	Offshore robotics engineer	Robotics engineer (ESCO-2149.15)
		Subsea robot specialist	Robotics engineering technician (ESCO-3119.2.1)

			Industrial robot controller (ESCO-3139.2)
	Energy storage systems	Energy storage engineer	Energy engineer (ESCO-2149.9)
		Energy storage specialist	Energy systems engineer (ESCO-2149.9.2)
		Energy storage systems designer & installer	Energy systems engineer (ESCO-2149.9.2)
	Digital twin	-	-
	Big data	ORE data scientist	Data scientist (ESCO-2511.4)
	Immersive technologies	VR training developer	Corporate training manager (ESCO-1212.4)
		Spare parts modeler	Model maker (ESCO-2163.1.6)
2040	AI, IoT and Quantum computing	Use cases analyst, developer and implementor	Artificial intelligence engineer (ESCO-2511.11)
	Sustainable and smart materials	Alternative materials analyst	N/A
		Circular economy engineer	N/A
		Offshore environmental impact analyst	Aquaculture environmental analyst (ESCO-2133.2) Environmental scientist (ESCO-2133.7)
	3D printing	3D printing technology specialist	3D printing technician (ESCO-3118.1)

3.2. Policy changes

Policy changes that can affect the ORE sector were prioritized based on the level of impact they can impose (Figure 4). As expected, the reform of relevant regulatory frameworks, at both national and European level, was acknowledged as the most impactful trend as they can largely shape the sector's growth trajectory, given the targets set (e.g. in terms of productivity), the support provided (e.g. introduction of financial incentives, subsidies, etc.), any restrictions imposed, etc. The adoption of Maritime Spatial Plans, which is still pending in some Southern European countries, followed next. This change will unlock a wave of large-scale investments, significantly increasing demand for well-qualified personnel. In most cases, this demand would not be able to be fully accommodated domestically, and thus would probably trigger a north-south, intra-European mobility of ORE professionals. The introduction of relevant standards addressing different assets, resources and processes in the ORE value chain will also impact the sector, contributing towards ORE technologies being deployed in more consistent, reliable and cost-efficient manner. This is particularly important, especially given the scale of investments ready to be made, as mentioned in the previous point. The EU-wide accreditation of relevant training programs and acquired skills was ranked the lowest in priority, given that the ORE market, so far, is concentrated in certain regions. However, if investments in the Mediterranean region begin, and the aforementioned north-south, intra-European mobility of ORE professionals is initiated, this trend will gain greater attention. It should be highlighted that all trends included in this category received lower priority than those included in the previous category, denoting the disruptive character of technology development.

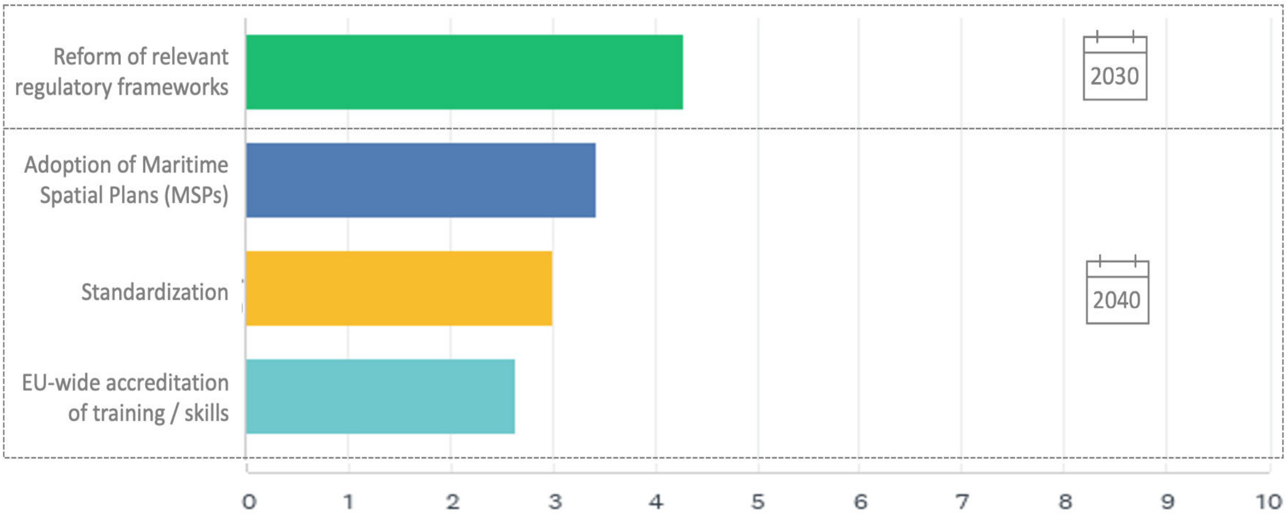

Figure 4: Prioritization (weighted average of experts' ranking) of policy changes per their impact on the ORE sector (0=lowest impact, 10=highest impact)

Given the lengthy processes that are required for investing and starting a new ORE project in an emerging market, such as the South European one where the adoption of MSPs is still underway[1], relevant implications on the sector will become more apparent in the medium-term (i.e. 2040). Same goes with (a) the introduction of new relevant standards, since the time lag for the industry embracing changes incorporated in them is often considerable, and (b) the EU-wide accreditation of training and skills, as it will take time for the industry to build the required trust and increase employment rates of foreign personnel. The impact to be imposed by the reform of a national or European regulatory framework is expected to be felt in a shorter timeframe, as transition periods (i.e. till the enforcement date) are not that long, while for meeting any new strategic targets, actions must be initiated as soon as possible.

Apart from the last trend which does not directly impact skills development – except in the sense that competition for employment may increase and thus job candidates will strive for the best skillset, all remaining trends are expected to create upskilling needs, addressing however different categories of skills. More specifically, with standardization covering a broad spectrum of assets, resources and processes, it would be required to advance both hard and transversal skills. The adoption of MSPs on the other hand, places more emphasis on the advancement of transversal skills related, for example, to consultation activities, negotiations, etc. Reforms of relevant regulatory frameworks at last address another category of skills i.e. meta-skills, which are higher-order skills that influence how we learn and adapt. To this end, they are essential when dealing with policy transformations.

All trends in this category are expected to have a positive, albeit low, impact on employment. Given the nature of the trends considered, the few employment opportunities to be created will target management-level professionals, or even professionals at the upper management level when reforms of relevant regulatory frameworks are considered.

The three occupational profiles expected to be most affected by the trends considered in this category are listed in Table 5 below, in descending order. Policy managers are anticipated to be

[1] Spain was the latest Member State to adopt its MSP on February 2023

impacted by all four trends considered, both in terms of increasing demand and the need to acquire new skills that build upon their existing skill sets. Such an impact applies to most of the occupational profiles listed below. In contrast, the occupational profiles discussed in the previous section – primarily influenced by technological advancements – were identified as experiencing only a rise in demand, without a corresponding need for significant skill development.

Table 5: Top 3 occupational profiles to be affected the most by the policy changes considered

Trend / paradigm shifter		Occupational profiles to be mostly affected		Type of impact
2030	Reform of relevant regulatory frameworks	ESCO-1213.2	Policy manager	Rise in demand & need for upskilling
		ESCO-2619.12	Regulatory affairs manager	Rise in demand
		ESCO-2619.5	Legal consultant	Need for upskilling
2040	Adoption of Maritime Spatial Plans (MSPs)	ESCO-2319.4.9	Marine biologist	Rise in demand
		ESCO-1213.2	Policy manager	Rise in demand
		ESCO-2114.1.8	Oceanographer	Rise in demand & need for upskilling
	Standardization	ESCO-1323.1	Construction manager	Rise in demand & need for upskilling
		ESCO-1219.6	Project manager	Need for upskilling
		ESCO-1213.2	Policy manager	Rise in demand & need for upskilling
	EU-wide accreditation of training / skills	ESCO-2423.3	Human resources officer	Rise in demand & need for upskilling
		ESCO-1213.7	Health, safety and environmental manager	Rise in demand & need for upskilling
		ESCO-1213.2	Policy manager	Rise in demand & need for upskilling

For each policy change taken into consideration, new requirements are expected to be set in terms of both hard and transversal skills. These are presented in Table 6 below.

Table 6: New requirements policy changes will bring in terms of both hard and transversal skills

Trend / paradigm shifter	Hard skills	Transversal skills

2030	Reform of relevant regulatory frameworks	o Strong understanding of applicable EU and national regulations; o Expertise in compliance with a range of applicable rules (e.g. environmental, cybersecurity, etc.).	o Negotiation; o Leadership; o Strategic thinking; o Relationship building o Community engagement and ethics o Inter- and cross-disciplinary communication & collaboration.
2040	Adoption of Maritime Spatial Plans (MSPs)	Expertise in: o Space analysis; o Geographic Information Systems (GIS) o Marine data collection and analysis: o Project and resource planning; o Environmental impact assessment	o Strategic thinking and foresight; o Stakeholder / community engagement and conflict resolution; o Relationship building; o Inter- and cross-disciplinary communication & collaboration.
	Standardization	Expertise in: o Component standardization; o Safety protocols; o Grid code compliance; o Data monitoring and reporting	o Detail-oriented; o Adaptability; o Inter- and cross-disciplinary communication & collaboration.
	EU-wide accreditation of training / skills	Expertise in: o Skill standardization; o Skills certification process in EU countries; o EU-common curriculum development	o Adaptability; o Inter- and cross-disciplinary communication & collaboration.

In addition to the demand that is expected to rise in the coming years for certain occupational profiles, as presented in Table 5, some new occupational profiles are also likely to emerge as a response to the expected policy changes. These are presented in Table 7 below.

Table 7: New occupational profiles likely to emerge as a result of the policy changes considered

Trend / paradigm shifter		New occupational profiles likely to emerge	Most relevant occupational profile(s) listed in ESCO
2030	Reform of relevant regulatory frameworks	Regulatory compliance consultant	Regulatory affairs manager (ESCO-2619.12)
2040	Adoption of Maritime Spatial Plans (MSPs)	Maritime spatial planner	N/A
		Transversal marine planner	N/A
	Standardization	Standards developer expert	N/A
		ORE skills certification coordinator	N/A

	EU-wide accreditation of training / skills	Offshore conditions trainer	Corporate training manager (ESCO-1212.4)

3.3. Market dynamics / evolution

Similarly to the previous two categories, trends affecting market dynamics / evolution were also prioritized based on the impact they are likely to impose on the ORE sector (Figure 5).

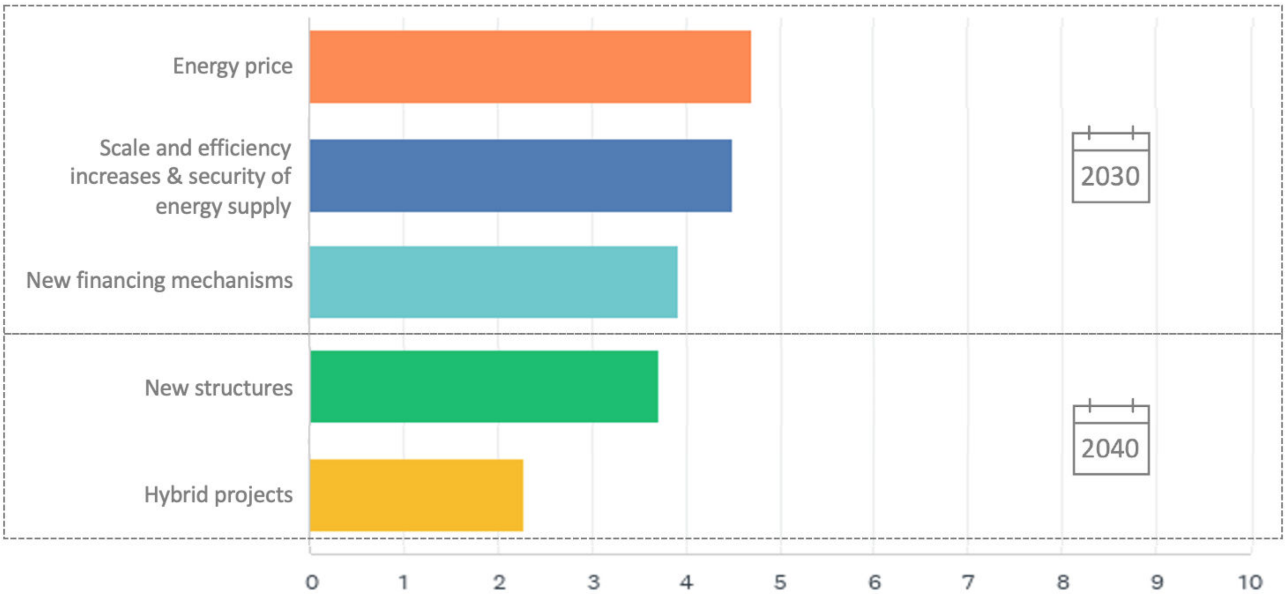

Figure 5: Prioritization (weighted average of experts' ranking) of trends affecting market dynamics / evolution per their impact on the ORE sector (0=lowest impact, 10=highest impact)

The price of offshore renewable energy was identified as the most disruptive trend among the five considered in this category, as it directly influences how quickly and widely the ORE sector can scale. Striking a balance between affordability, profitability and technological development is critical to ensure the sector's long-term growth. Almost equally important were trends driving scale and efficiency increases while securing energy supply for meeting current and future demand levels, and effectively responding to potential peaks in demand. New financing mechanisms were ranked next, as they are crucial for addressing the high capital costs and the long payback periods associated with large-scale ORE projects. To this end, investment interest can rise and thus the development of new ORE projects can be stimulated. Close in priority was the design and implementation of new structures (e.g. advanced foundation designs, floating platforms, etc.) which can enhance efficiency, durability and adaptability to various marine environments. Ranked lowest in priority were hybrid projects i.e. projects that combine multiple types of renewable energy sources. It should be highlighted that all trends included in this category received lower priority than those included in the first category, reconfirming the disruptive character of technology development. However,

Given that developments for new structures and hybrid projects are still ongoing, their impact is expected to become evident in the medium-term (i.e. by 2040). In contrast, due to their nature and characteristics, the remaining three trends are already affecting the ORE sector, with their implications expected to intensify in the short-term (i.e. by 2030).

Most trends are expected to create upskilling needs addressing both hard and transversal skills. Only for hybrid projects, new skills will be required to be developed given that technologies for some type of renewable energy sources are still in early stages of maturity / development. Energy price on the other hand, is expected to have a marginal impact on skills, addressing mostly transversal skills.

The impact of all trends on employment is expected to be positive, with new financing mechanisms and new structures accounting for most new job opportunities, primarily at mid- to upper management-levels. Fewer opportunities would be created by the remaining trends, mainly in management-level positions.

The three occupational profiles expected to be most affected by the trends considered in this category are listed in Table 8 below, in descending order. All but one occupational profiles will require upskilling, while demand is expected to increase for five of them. Notably, management-related roles and various types of analysts will be the most affected, aligning with the previously mentioned employment expectations.

Table 8: Top 3 occupational profiles to be affected the most by trends in market dynamics / evolution

Trend / paradigm shifter		Occupational profiles to be mostly affected		Type of impact
2030	Energy price	ESCO-2431.14	Pricing specialist	Need for upskilling
		ESCO-3311.3.1	Energy trader	Rise in demand & need for upskilling
		ESCO-3112.5	Energy analyst	Need for upskilling
	Scale and efficiency increases & security of energy supply	ESCO-2151.1	Electrical engineer	Rise in demand & need for upskilling
		ESCO-2151.1.1	Electric power generation engineer	Need for upskilling
		ESCO-3112.5	Energy analyst	Need for upskilling
	New financing mechanisms	ESCO-1211.1	Financial manager	Need for upskilling
		ESCO-2413.1	Financial analyst	Need for upskilling
		ESCO-2413.1.2	Investment analyst	Need for upskilling
2040	New structures	ESCO-1321.2.3	Operations manager	Rise in demand & need for upskilling
		ESCO-1321.2	Manufacturing manager	Need for upskilling
		ESCO-2619.5	Construction manager	Need for upskilling
	Hybrid projects	ESCO-1211.1	Financial manager	Need for upskilling
		ESCO-2619.5	Construction manager	Rise in demand & need for upskilling
		ESCO-1120.2	Business manager	Rise in demand

The total number of occupational profiles to be most affected by the trends affecting market dynamics / evolution is 12 since, as depicted above, three occupational profiles are expected to be affected by two trends. Two of them are management professionals, namely construction managers and financial managers, while the remaining one is energy analysts which represent the greatest need to upskill when considering the level of impact on the sector of the trends affecting this profile (Figure 5).

For each trend taken into consideration in this category, new requirements are expected to be set in terms of both hard and transversal skills. These are presented in Table 9 below.

Table 9: New requirements trends in market dynamics / evolution will bring in terms of both hard and transversal skills

Trend / paradigm shifter		Hard skills	Transversal skills
2030	Energy price	Expertise in: o Energy cost analysis; o Logistics and supply chain efficiency o Business management	o Critical thinking; o Decision-making o Inter- and cross-disciplinary communication & collaboration
2030	Scale and efficiency increases & security of energy supply	Expertise in: o Large-scale wind turbine design; o HVDC transmission; o Projects' strategic planning; o Management of logistics processes; o Energy data analysis and management.	o Addressing resource and labour challenges; o Inter- and cross-disciplinary communication & collaboration.
2030	New financing mechanisms	Expertise in: o Novel financing models and schemes; o Interactions with funding and development banks.	o Negotiation; o Inter- and cross-disciplinary communication & collaboration
2040	New structures	Expertise in: o Advanced foundation and floating platforms designs; o New structures characteristics and lifecycle; o Supply chain and financial management.	o Creativity in adopting innovative designs; o Problem-solving; o Inter- and cross-disciplinary communication & collaboration.
2040	Hybrid projects	Expertise in: o Innovative approaches for effectively combining different energy sources (including green hydrogen production) o Interactions between different technologies and uses in hybrid projects.	o Inter- and cross-disciplinary communication & collaboration.

In addition to the occupational profiles to be mostly affected by the trends considered in this category, as presented in Table 8, new occupational profiles are also likely to emerge, driving and supporting their deployment and operationalization. These are presented in Table 10 below.

Table 10: New occupational profiles likely to emerge as a result of the trends shaping market dynamics / evolution

Trend / paradigm shifter	New occupational profiles likely to emerge	Most relevant occupational profile(s) listed in ESCO

2030	Energy price	Energy market strategist	Energy trader (ESCO-3311.3.1)
	Scale and efficiency increases & security of energy supply	Energy supply security analyst	Energy trader (ESCO-3311.3.1)
		Energy systems analyst	Energy analyst (ESCO-3112.5)
	New financing mechanisms	ORE investment analyst	Investment analyst (ESCO-2413.1.2)
2040	New structures	Floating offshore wind (FOW) specialist	Offshore renewable energy technician (ESCO-3119.11)
		Offshore asset integrity engineer	Offshore renewable energy engineer (ESCO-2149.9.5)
	Hybrid projects	Hybrid energy systems engineer	Energy systems engineer (ESCO-2149.9.2)
		Energy systems designer	Energy systems engineer (ESCO-2149.9.2)
		Offshore technologies integration engineer	Integration engineer (ESCO-2511.17)

4. Skill development methods

Taking a step further, the most appropriate methods for addressing the requirements set above, in all three categories of trends, for both hard and transversal skills were investigated. Results are presented in Tables 11 and 12 below, considering two time horizons: short-term (i.e. 2030) and medium-term (i.e. 2040). As depicted, the effectiveness of the identified methods remains consistent over time, except for blended apprenticeships in pioneering companies and educational programs integrating industry boards. The latter gains priority over time, and is considered more effective for addressing the new requirements for hard skills in the medium-term.

Table 11: Most effective methods for addressing new requirements in terms of hard skills in the short- and medium-term

In the short-term (2030)	In the medium-term (2040)
1 Blended apprenticeships in pioneering companies	1 Educational programs integrating industry boards
2 Educational programs integrating industry boards	2 Blended apprenticeships in pioneering companies
3	3

Curricula reform – introduction of new relevant courses	Curricula reform – introduction of new relevant courses
(4) Online courses that exploit new learning methods	(4) Online courses that exploit new learning methods
(5) Online tutorials enabling self-training	(5) Online tutorials enabling self-training
(6) Short courses with a blended approach	(6) Short courses with a blended approach

Table 12: Most effective methods for addressing new requirements in terms of transversal skills in the short- and medium-term

In the short-term (2030)	In the medium-term (2040)
(1) Experiential learning (e.g. scenario-based learning, simulations, etc.)	(1) Experiential learning (e.g. scenario-based learning, simulations, etc.)
(2) Interactive workshops and training programs	(2) Interactive workshops and training programs
(3) Gamified learning (e.g. point systems to encourage participation)	(3) Gamified learning (e.g. point systems to encourage participation)
(4) Coaching and mentoring	(4) Coaching and mentoring
(5) Technology-enhanced learning (e.g. e-learning platforms)	(5) Technology-enhanced learning (e.g. e-learning platforms)

The methods presented above, clearly mark the need for a greater involvement of industry actors in education and training activities. For being supplied with well-qualified personnel, companies need to allocate time and resources in (a) having management-level executives sitting in advisory boards of relevant educational and training programs, sharing practical insights on current practices and their views and forecasts on anticipated developments and how these will be shaping skills requirements, and (b) planning and offering apprenticeship positions, allowing students to get hands-on operational experiences that can support them in better steering their educational path. Educational and training providers should concentrate their efforts on reducing the time lag that exists before new developments are effectively integrated into existing curricula, making best use of emerging learning methods and tools, such as AI, that are reshaping the educational landscape. Online tutorials enabling self-training (i.e. allowing students to learn at their own pace) as well as short courses with a blended approach (i.e. online and on-site) were ranked the least effective in addressing the new hard skill requirements.

For soft skills, experiential learning (e.g. scenario-based learning, simulations, etc.) was recognized as the most effective method for developing the new required skills, followed by participation in interactive workshops and training programs. Both approaches enable a deeper understanding of the context, allowing learners to engage in a feedback-loop format to grasp the implications of multiple decisions. Gamified learning ranked next in effectiveness, due to its positive impact on engagement, motivation, and practical application. In contrast, coaching and mentoring, as well as technology-enhanced learning, were considered less effective. The effectiveness of the former depends on the quality and availability of the coach or mentor, and carriers the risk of learners adopting a passive learning approach. Meanwhile, the latter lacks immersive practice and real-time social interaction, limiting its impact on soft skill development.

5. Conclusions

The ORE sector in Europe is very dynamic, having experienced significant growth over the last years, and projected to grow intensively in the upcoming years. New markets are emerging (e.g. in the Mediterranean region), new projects are constructed and additional efficiencies are introduced, with the sector acting overall as a major contributor to the vision of Europe becoming carbon-neutral till 2050.

The human element is critical in driving this growth. Employees engaged in all different phases of the ORE value chain need to possess the necessary skills and competences for successfully undertaking and concluding their tasks, as optimally as possible, embracing the dynamic character of the business environment and continuously staying up to date so that they can timely adhere to any new developments. Given though that the time lag before industry advancements are properly reflected in existing educational and training programs and courses is still considerable, skill intelligence activities have largely increased in importance, for generating valuable insights that can contribute into minimizing the aforementioned time lag to the best possible extent. Foresight analysis is a key part of those activities, generating valuable feedback for the educational and training providers.

Such an analysis was presented herein, making best use of both desk research and consultation activities, engaging in the latter selected experts that are dealing, through different capacities, with the topic of skills. Trends and paradigm shifters likely to impact the sector in the short-, medium- and long-term were identified first and underwent a validation process, resulting in 18 trends been finally considered. These fall under three major categories: i.e. technological advancements, policy changes and trends affecting market dynamics / evolution. The main results of the impact assessment that was undertaken are summarized in the following bullet points:

- Technological advances naturally accounted for the largest number of trends given that technology is now outpacing developments in any other field, most often with disruptive implications. This was also confirmed herein since technological advancements were acknowledged as the most impactful, with the majority of them expected to affect the ORE sector in the short term. Trends affecting market dynamics / evolution and policy changes followed next in order, with their impact expected in the medium-term (i.e. 2040);
- Trends in all categories are expected to have a positive, albeit low, impact on employment, with technological advances creating opportunities mostly for mid-level positions whereas the two other categories of trends are expected to trigger jobs in management and upper management-levels, given the more strategic character of the trends considered;
- The three occupational profiles to be mostly affected by each trend were presented for all three categories, with technological advances mainly expected to increase demand for those occupational profiles, whereas trends in the other two categories are expected to mainly trigger the need to upskill;
- New requirements, in terms of both hard and soft skills, are identified for each trend. Technological advances account for the majority of them, with a good balance between the two types of skills. For soft skills, particular emphasis is placed on the inter- and cross-disciplinary communication and collaboration, given labour characteristics of the ORE sector;
- A number of new occupational profiles that are likely to emerge in the future, as the identified trends become more mainstream or more widely deployed, are identified. These are currently not included in the ESCO database, hence effort will be made to communicate them with the team responsible for it so that they are considered in its next planned update. All corresponding information will be included, building upon the information presented herein;
- The most appropriate methods to address the new skill requirements are identified for both hard and transversal skills considering two time horizons i.e. 2030 and 2040. For hard skills, blended apprenticeships in pioneering companies was acknowledged as most effective in the short-term, while in the medium-term, educational programs with industry boards were believed to have the most positive impact. For transversal skills, experiential learning was acknowledged as the most effective method in both horizons.

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